



Department for
Business, Energy
& Industrial Strategy

Exploring the evidence on potential issues associated with trialling hydrogen heating in communities

A Literature Review and Focus Group Study

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Executive Summary

Introduction

Replacing natural gas with hydrogen in an everyday setting – piping hydrogen to homes and businesses through the existing gas network – is a new and untested proposition. At the same time, piloting this proposition is an essential ingredient to a well-managed low carbon transition.

The Department of Business, Energy and Industrial Strategy (BEIS) has commissioned CAG Consultants to undertake a literature review and conduct a set of four focus groups to inform the development of work to assess issues associated with setting up a hypothetical community hydrogen trial. This report sets out the findings from the research and presents reflections on the implications of the findings for any future community hydrogen heating trials.

The literature review was a short, focused review aimed at identifying evidence relevant to members of the public being asked to take part in a hypothetical community trial. Based primarily on Quick Scoping Review principles, the review involved the analysis of evidence from 26 items of literature.

The four focus groups were held in-person in two city locations, Manchester and Birmingham in November 2019. They involved consumers who either owned or rented houses (i.e. not flats) connected to the gas grid. Two of the focus groups involved owner-occupiers, one was with private landlords and the other was with a mixture of tenants (private, social and student).

Literature review findings

The 26 pieces of literature covered learning from sustainable energy trials, attitudinal studies and choice experiments as well as literature reviews and case studies concerning the promotion and adoption of new energy technologies. Emphasising the need for a hydrogen heating trial, we did not find any literature on a hydrogen heating trial. Lessons on trials are necessarily drawn from those evaluating smart heating controls, heat pumps and new gas central heating. Information on the public's attitude to hydrogen heating is drawn from research which relies on consumers being able to envisage hydrogen heating and is as reliable as the information given to these consumers and their interpretations.

Who to involve?

The hypothetical hydrogen trial is at a community level. Experiences of developers promoting projects at a local level as well as experience from other energy trials, suggests that:

- There is no one convenient organisation that represents the community – rather there is work involved in identifying and accessing a broad and representative section of the community.
- Positive public attitudes don't always translate into local support for individual projects and the public is complex and varied in its predispositions and preferences – both to the message and the message medium.

- Endorsement by local organisations can be helpful, notably a local authority, and the involvement of relatable project staff and/or community advocates can be powerful. Research also suggests that individuals are more likely to trust face to face advice from community peers or tradespersons.
- The public has a paradoxical view of government involvement. On one level national government involvement is expected, giving credibility and authority. On another, there is frustration over mixed messaging (e.g. the previous promotion of diesel cars) and distrust of double standards when public representatives fail to lead by example.

Encouraging participation

Evidence on how best to encourage trial participation very much aligns to findings on who should be involved. Namely that relatable project staff, face-to-face contact and social endorsement all drive up trial recruitment levels. Studies which look at willingness to adopt green technology show positive associations with, variously, good education and income and, unsurprisingly, an environmental outlook. However, adoption cannot be guaranteed, due to the differences between what people say they value, and what they do in practice.

It is difficult to establish why consumers refuse to participate in trials as their refusal is often coinciding with a desire to disengage with the recruitment process. Anecdotally, cited reasons for refusal include health worries around a new heating regime, disruption to routine, potentially higher rents and lack of endorsement from recognised organisations.

When asking people what is theoretically important to them, key themes are: a desire to minimise household disruption; familiarity and a requirement to maintain equivalence or improvement in utility of any replacement technology; and cost.

Potential trial participants may also be screened for household compatibility with the technology (e.g. space requirements, communications infrastructure) and for vulnerability (e.g. would be at risk if heating malfunctions). Participants might voluntarily drop out, often not giving a reason. Data sharing arrangements may be linked to one particular supplier, in which case householders that change supplier can no longer participate. Or a householder may move house during the course of a trial.

A key lesson from trials is the need to keep participants engaged and informed for the full duration. Other measures to mitigate the impacts of trials include provision of back-up heating, provide compensation for any inconvenience, ensuring installers are well trained and installations well managed and provision of accessible and accurate information.

There is very little in the literature that tells us how consumers might respond to safety concerns. Focus group work suggests that people are able to take a balanced view on the severity versus the likelihood of an adverse event. But risks outside of personal control, such as those associated with large energy installations, tend to be more negatively perceived than personally selected risks such as skydiving. We simply do not know how consumers will respond to any perceived risks of hydrogen in the home – surveys and focus groups which have explored hydrogen heating ask participants to accept that it is safe.

Finance and trial participation

In this section we have explored what kind of incentives might be effective in encouraging trial participation. The first is in fact the government's own motivation for conducting a hydrogen trial, to contribute to a nationwide energy transition and in so doing improve the environment.

Given that national public attitudes recognise the need for, and are generally favourable towards environmental improvements, this might be expected to translate down to the local level.

Attitudes, intentions and actions, however, are not always consistent. The literature cites examples where good intentions are over-ruled by cost considerations. One study considered the impact of information on people's attitudes, noting that it can encourage people to see the need to make their own personal contribution. But again, this is in theory rather than in practice.

There is some evidence that where local social, economic or environmental benefits accrue from a project, then attitudes can be more favourable – such as the use of community ownership models or the provision of local jobs. This desire for 'relevant' local benefits extends to organisations – for example a local authority investing in a district heating scheme needs to demonstrate that it offers good value for them. The evidence suggests that financial incentives can be important, and there are many examples of this in the promotion of local renewable energy schemes. However, developers need to be careful to offer meaningful benefits, as some communities and individuals can be sceptical of motives.

Focus group findings

Hypothetical trial

Focus group participants were responding to a hypothetical hydrogen trial scenario. Participants were told the trial would involve switching over the mains gas supply to hydrogen for an entire neighbourhood (approximately 300 homes). Other key elements of the hypothetical trial were that:

- Participation in the trial would be mandatory, although consumers could opt out by terminating their gas supply and switching to electric heating instead
- The switchover would take place in the summer and would take 3-4 days, over which time hydrogen-ready home appliances (boilers, cookers, hobs, fires and meters) would be fitted in people's homes
- People taking part in the trial would not be financially disadvantaged – i.e. there would be no cost to be borne by the people taking part
- Any problems with appliances would be remedied quickly, at no cost to the consumer
- At the end of the trial, a decision would be made about whether the community remained on hydrogen or would be converted back to methane gas (at no cost and with the same level of disruption as the original switchover).

A more detailed overview of the scenario presented to focus group participants can be found in Appendix 5.

Key findings

The key findings of the focus groups are set out in Table 1 below.

Table 1 Focus group findings

Key topics	Findings summary
Willingness to participate: reasoning	<p>Reasons for being willing to participate:</p> <ul style="list-style-type: none"> • Let's do it for the planet • Why not I've got nothing to lose • There's something in it for me <p>Reasons for not being willing to participate:</p> <ul style="list-style-type: none"> • I will lose out • It sounds too good to be true, so it probably is • People don't like change • Why should we do it
Safety	<p>Most participants felt reassured by the knowledge that safety tests would have been conducted, however, key concerns included:</p> <ul style="list-style-type: none"> • Combustibility of hydrogen • The colour and smell of hydrogen gas • Whether carbon monoxide poisoning was possible • Where hydrogen is stored • How hydrogen is produced • Whether hydrogen could run out
Communications	<p>Communication and meaningful engagement were seen as key to the success of a trial. Key themes included:</p> <ul style="list-style-type: none"> • The timing of initial communications • Overcoming technology unfamiliarity and uncertainty • Winning hearts and minds; making the case for undertaking the trial • Building trust • Tailoring communications and engagement to individual needs • Managing landlord and tenant communications
Property values & sales	<p>Property values and issues around selling homes was a theme raised, particularly for homeowners and landlords. Key concerns included:</p>

	<ul style="list-style-type: none"> • Difficulty buying and selling homes during the trial period • Less interest from potential buyers (because of uncertainty and wariness about buying a home that was part of a trial) • Increased legal paperwork and more complicated conveyancing process • Potential drop in property value
<p>Switchover</p>	<p>Switchover was the most discussed element of the trial. Concerns centred around four main themes:</p> <ul style="list-style-type: none"> • Disruption during the switchover (including work related disruption, living arrangements and street level disruption) • The welfare of participants, particularly vulnerable people (including the elderly, the young and those with medical conditions) • The process of the switchover, including timing, delivery timescales (and consequences if timescales slipped), access to homes and coordination and appliances. • Costs and compensation, including the question of whether the trial was genuinely cost neutral, whether there would be any compensation (particularly for tenants and business owners).
<p>User experience & support</p>	<p>Some participants were reassured by the message that appliances would be replaced with 'like-for-like', whilst others wanted further reassurance, including:</p> <ul style="list-style-type: none"> • Equivalence of utility, i.e. that there would be minimal impact on day to day routines • That all appliances would be at least as functional and usable as their current appliances • That appearance would be considered • That appliances would be of equal value to their current appliances • That any problems with appliances would be fixed • That special needs would be met (e.g. the needs of those with special requirements) <p>In relation to support, participants suggested it should include:</p> <ul style="list-style-type: none"> • A 24-hour helpline and a quick response • Quality services if faults occurred, including ensuring enough trained and available engineers

	<ul style="list-style-type: none"> • Effective support for anyone with special requirements • A dedicated community support team • A log of problems and solutions • Proactive checks on equipment and appliances
<p>Post-trial arrangements</p>	<p>The two key themes regarding post-trial arrangements were:</p> <ul style="list-style-type: none"> • The end of the trial technology decision, particularly regarding what would happen to consumers' heating, and whether there would be further disruption if it was decided to go back to methane gas heating; • Post-trial maintenance and customer service, particularly regarding availability, quality and costs and any guarantees and service cover beyond the duration of the trial.
<p>Tenant-landlord issues</p>	<p>Issues specific to landlords and tenants included:</p> <ul style="list-style-type: none"> • Costs (covered in following section) • Liabilities, if for example, something went wrong and also for appliance checks etc. • Responsibility to provide a fully functioning home • Communications (covered in communications section) • Tenant welfare, particularly during the switchover period • Rental values, and whether they would be impacted by the trial
<p>Costs & compensation</p>	<p>Some participants believed they could incur financial and non-financial costs as a result of the trial, which included the following:</p> <ul style="list-style-type: none"> • Loss of income for those that worked from home • Increase in energy prices beyond the end of the trial • Compensation for tenants • Implications for existing boilers (including existing service packages that have already been paid for) • Post installation repair costs • Appliance storage costs • House and rental value costs <p>Some participants felt that compensation would fulfil the following:</p>

	<ul style="list-style-type: none"> • Cover uncertainty • Act as a safeguard against failure to deliver the trial as promised • For the inconvenience imposed • For additional costs, e.g. electric heaters
<p>Incentives</p>	<p>Focus group participants considered both community-wide incentives (e.g. a new community centre or new local park) and individual incentives (an iPad for each household).</p> <p>Positive responses to community incentives included:</p> <p>Unconditional support:</p> <ul style="list-style-type: none"> • It has the potential to help others in the community and convince people to take part in the trial • Not necessary at all, they would take part anyway <p>And conditional support:</p> <ul style="list-style-type: none"> • It should be tailored to meet the community’s needs rather than a ‘generic’ incentive • It needs to have sufficient funding for staff and maintenance into the long-term • To be built in time to provide support and refuge for those that need it during the switchover process. <p>Negative responses to community incentives included:</p> <ul style="list-style-type: none"> • Such community facilities should be provided anyway • It is a form of bribery • It would only benefit some of the population • It already exists • It would not be maintained or funded in the long term • Safety concerns, e.g. vandalism and violence • Lack of community so people will not identify with a community-wide benefit <p>There was little support for iPad as an incentive, with key issues as follows:</p> <ul style="list-style-type: none"> • It is not universally liked or useful to consumers and a lot of households already own one • Concerns about choice over the type

	<ul style="list-style-type: none">• Who would own it, i.e. which member of the household?• Some consumers may just sell it. <p>Alternative suggestions for incentives included:</p> <ul style="list-style-type: none">• Providing free or reduced energy bills for some or all of the trial period• Waiving or reducing council tax for some or all of the trial period• Cash payments.
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Key themes

We have identified a number of key themes emerging from the findings:

Making the case

The responses to the hypothetical trial scenario highlight that consumers will have different motivations and the way in which any future trial is pitched will need to take account of this. Building a strong, 'bigger picture' case (e.g. environmental) will be sufficient to convince some households to participate. Others, however, were focused more on the impact of the trial on the individual. Some participants said they could tolerate minor disruption as long as they could be reassured that overall, they would not be worse off as a result of their participation. Others took more of a 'what's in it for me' view.

Human dimension, not just technical

It is apparent that a trial should not just focus on the technical logistics of replacing heating and appliances but recognise there is a strong human and social dimension too. Multiple different human needs will need to be addressed, and every household is potentially different. It is important to ensure any trial takes this into account e.g. tailoring communications, engagement, support and, potentially, compensation tailored to individual household needs. This human dimension may not be reflected in existing data, so technical surveys may need to expand to include this extra level of information.

Uncertainty and unfamiliarity

A significant theme of the focus groups was the uncertainty about, and unfamiliarity of, hydrogen heating. This implies a need for a focus on awareness-raising, information provision and demonstration.

Trust, honesty and transparency

There was some scepticism about government, about some of the messaging provided to focus group participants (e.g. would it really be like-for-like swap, can they really do a switchover in 3-4 days), and about the rationale for the trial and potential benefits. There was also a strong desire for straightforwardness, honesty and transparency in trial communications.

This highlights the need to think about ways to build trust (e.g. involving trusted local organisations, consumer testimony, dedicated community support teams) and ensure messaging is accurate, realistic, straightforward and devoid of spin. There is a danger that 'over-selling' a trial could backfire.

Reassurance

Linked to the above, there was a common theme of reassurance, especially in areas about which participants were sceptical: about the benefits of the hypothetical trial, about switchover timescales and the process involved in the switchover, about key claims that appliances would be 'like-for-like', that consumers would not be financially worse off and that their lives would be able to continue as normal. Any future trial would need to address such claims. Suggestions included writing assurances into contracts with consumers, providing guarantees, and providing compensation if claims were not met.

Equivalence

There is a desire for participants' daily lives to not be affected. Participants want the same (or better) utility and benefits than they currently get from natural gas.

Costs and compensation

There is some scepticism about whether participants would genuinely be no worse off. Focus groups highlight many areas where consumers could lose out, including appliance value, home repairs, maintenance costs, energy prices, income loss, business loss, 'hassle' time, etc. It will be important to think carefully about all of these areas – and more – if any future trial is to be genuinely cost-neutral to the consumer. It is difficult to imagine that at least some compensation won't be required to help cover potential losses.

Incentives

There is likely to be opposition from some without incentives. However, the suggested hypothetical community incentives were not well-received. If community incentives are offered, they need to be tailored to meet community needs and wants, and then they are more likely to be better received. The focus groups tested the idea of iPads being offered by way of compensation, but this was not a popular idea. There was relative consensus that an individual incentive, such as discounted energy bills, or cash, would be best received. Consumers could then use the savings/cash as they see fit rather than having a benefit 'imposed' on them.

1 Introduction

This report presents findings from research examining consumer and stakeholder attitudes towards setting up and participating in a hypothetical community hydrogen heating trial. Here we outline the key research objectives.

Overview

The Department of Business, Energy and Industrial Strategy (BEIS) has commissioned CAG Consultants to undertake a literature review and a set of focus groups to inform the development of work to assess issues associated with setting up a community hydrogen heating trial.

This report sets out the findings from both the literature review and the focus groups before reflecting on the implications of the findings for any potential future community hydrogen heating trials.

Research questions

BEIS asked CAG to explore a number of research questions. These are set out below, framed around three key themes.

Table 2: Research questions

Theme	Research questions
Who will be involved?	1.1 Which stakeholder groups and organisations need to be informed and supportive for a community level hydrogen trial to go ahead?
	1.2 Who would consumers expect/need to see endorsing a community level trial for them to be on board with participation?
How can we encourage participation?	2.1 How open to participating in community scale trials are stakeholders*?
	2.2 What affects consumer/local authority willingness to participate in trials?
	2.3 What are barriers and challenges to participation and/or commitment to trials, including trials involving hydrogen? Which of these can be overcome and which are insurmountable?
	2.4 What are possible solutions to barriers and concerns around participation?
	2.5 What are the conditions of acceptance for consumers in taking part?
	2.6 What do consumers expect from taking part in a trial?

	2.7 What lessons can be learnt from previous/existing community level trials where there is significant disruption to local neighbourhoods e.g. installation of subsurface utilities and modification of utility provision within homes?
	2.8 What safety concerns do consumers have and what assurances are needed to overcome these?
Finance and trial participation	3.1 How do stakeholders value local/environmental issues relating to heating? E.g. how important are local carbon reductions, local air quality, moving to 'greener' fuels for heating as a community?
	3.2 Are stakeholders willing to contribute to the costs of delivering a community level hydrogen trial?
	3.3 Are incentives** necessary for stakeholders to be supportive of a community hydrogen trial? E.g. improvements to neighbourhood (community centres, green spaces etc.)

*Note that for the purposes of this review, BEIS defined the term 'stakeholders' as including both individual consumers and organisations such as local authorities, community groups and other relevant bodies.

**The project steering group anticipated that, in a trial scenario, participating households would be fully compensated and would not face any costs for installation or other aspects of the trial.

The literature review was undertaken initially, and the questions then refined for the focus groups, according to which topics required further exploration and what was appropriate for a focus group.

2 Method

This section provides an overview of the methods used to conduct the literature review, as well as outcomes from the search and screening process.

Approach

Literature Review

Prior to designing and undertaking the focus groups, CAG has undertaken an initial, focussed review of the literature, with a specific focus on identifying evidence relevant to members of the public being asked to take part in a potential community trial.

The methodological approach to the review was based primarily on Quick Scoping Review (QSR) principles. Appendix 1 sets the approach and methods used for the literature review in detail.

Screening

On completion of the search, we screened the results. This was done in two phases. The first phase of screening involved reading only the title or headline of the evidence found. The second phase involved reading the abstract or first paragraph (or more if necessary) of the clearly relevant or uncertain evidence to identify those that meet the inclusion/exclusion criteria. Those marked clearly relevant were then moved to the critical appraisal phase.

Table 3 sets out the search and screening results.

Table 3: Search and screening results overview

	ScienceDirect	Google search	Grey literature, steering group consultation, snowballing & other sources	Totals
Literature identified before screening	1505	100	44	1649
Literature after Phase 1 screening	192	12	34	238
Literature after Phase 2 screening	15	1	21	37

Assessing the Relevancy of the Evidence

All evidence marked clearly relevant after phases 1 and 2 of the screening phase were assessed to evaluate the relevancy of evidence in relation to the research questions.

Shortlisting and review

30 individual pieces of literature were shortlisted for review. We then adopted a staged process for reviewing the literature. This involved reviewing the list after 12 pieces of literature had been reviewed (and again after 20) in order to:

- Assess any gaps against the literature review questions
- Identify whether any new evidence has been identified through 'snowballing' (i.e. literature that has been identified during the review itself), and
- Revise and prioritise the shortlist.

In total, 26 items of literature were reviewed.

Focus Groups

Four in-person focus groups were held with homeowners, tenants and landlords who use mains gas for heating. The focus groups were segmented according to these categories in order to focus on the issues that might impact those groups and to avoid potentially contentious issues that are not relevant to the aim of the focus group. The focus groups were held in Manchester and Birmingham in November 2019.

Recruitment

Recruitment experts, DJS Research, were employed to recruit participants for the focus groups. Individuals were recruited to be representative of the wider population, particularly in terms of attitudes towards energy and levels of participation in their communities. Whilst the focus groups were not 'fully representative', they did provide a mix of people based on gender, age, ethnicity and income.

To boost recruitment rates, basic costs associated with attendance were covered and incentive payments of £60 for homeowners and tenants and £100 for landlords were made. Maximum attendance, with no dropouts, was achieved, with 10 participants at three of the focus groups and 9 at the other (the number was reduced because of limited room size).

Delivery

Ahead of the focus groups all participants were sent briefing materials that included a two-page overview of hydrogen heating and an indication of what would be covered in the focus groups, see Appendix 4.

The focus groups were supported by two facilitators, recorded and transcribed. Each focus group ran for 2 hours and followed the same format as follows:

- Scene setting and ground rules
- Individual introductions
- Presentation about hydrogen heating and the hypothetical trial scenario

- A series of questions/topics for discussion, based on the research questions as follows:
 - Participants' first reactions to the presentation on hydrogen heating and a hypothetical trial
 - Detailed reactions to the hypothetical trial (benefits, concerns, barriers)
 - Thoughts on overcoming concerns
 - Reactions to ideas for incentives.

3 Literature review: findings

This section collates findings from the literature review under the main research themes, with analysis for each sub-question where the evidence allows.

Table 4 provides an overview of the evidence against the key relevant parameters of the hypothetical hydrogen trial, namely whether the literature:

- Reviews a real trial of energy interventions
- Considers hydrogen heating (these first two categories are mutually exclusive i.e. we have not been able to review any real hydrogen heating trials)
- Is set in a local, national or international context

It shows the number of individual pieces of literature covering each of the headline areas. A fuller version of this table, characterising each piece of literature can be found in Appendix 2.

Table 4: Summary of literature coverage

Trial	Hydrogen	Local	National (UK/GB)	International
5	3	9	8	2

As shown in Table 4, there was limited literature on trials comparable in nature to a hydrogen heating trial and none which is directly comparable at the community level, involving disruption, new technology and, crucially, there being no choice in loss of natural gas heating.

3.1 Who will be involved?

RQ1.1 Which stakeholder groups and organisations need to be informed and supportive for a community level hydrogen trial to go ahead?

This question is framed within the context of a community-level trial, exploring whether there are community influencers and representative organisations whose support would facilitate a successful trial.

Involving communities

In the context of consulting and informing on planning developments, a study on the provision of community benefits of a wind energy project highlighted that there is a “*well-rehearsed*” problem of defining ‘the community’ in the first place¹. Often developers look for “*convenient place-based organisations*” typically the community or parish council². A case study in the same paper found that local councils can be under-resourced and struggle to access and

¹ Macdonald, Catriona; Glass, Jayne; Creamer, Emily, 2017. What Is the benefit of community benefits? Exploring local perceptions of the provision of community benefits from a commercial wind energy project. *Scottish Geographical Journal*. Volume 133, 2017 - Issue 3-4.

² Macdonald, 2017. What Is the benefit of community benefits? 1

represent all views. The authors spoke to a number of individuals that they had identified as influential in the community. They recommended that developers should be “*proactively recruiting a variety of different community members and welcoming a diversity of individual and collective preferences,*” including those who, because of their opposition to a scheme, lack the motivation to engage.³ They emphasised the importance of a pro-active engagement push, which takes time to get to know and understand the community. This may or may not increase the chance of success for a development, but it is procedurally robust and minimises disengagement which could continue through the operational phase of a project.

Involving the public

The UK Committee on Climate Change (CCC) looked at the public’s understanding of hydrogen heating as part of its ongoing work on the role of hydrogen in meeting long-term carbon reduction targets. It found that whilst there is public support for the decarbonisation agenda in general, there is a low level of understanding of what this actually means for heating systems. Around half of those surveyed for the CCC had never heard of hydrogen-fuelled boilers.⁴

Even for technologies that have wider public understanding, there are no guarantees that this translates into adoption of the technology. There were examples in the literature of technologies with a high approval rating amongst the general population - for example wind power - but that were objected to at a community level. The term ‘NIMBY’ has been coined for local opposition to developments (for which there is a general level of public approval), but the mechanisms underlying this “*syndrome*” are poorly understood.⁵ For hydrogen heating, however, the implication is that even if there is general public approval for the technology, or the principle of a trial of the technology, there might be local opposition to the concept in areas subject to technology trials or roll-outs.

The literature also highlights that the public is not homogenous in its attitudes. Consumers have different influences, dispositions and preferences for new and novel forms of energy. Consumer engagement can be designed to take this into account: consumer segmentation, targeted messages, using a wide variety of print and electronic communication methods and interactive communication with stakeholders can all help to ensure that communications meet the needs of different consumer types and that two-way information flows are developed^{6, 7}.

One study on attitudes to energy efficiency interventions recommended engaging with residents to familiarise them with the measures and promote their compatibility with existing lifestyles. They felt that this should result in positive changes in attitudes and intention to adopt the interventions, based on the finding that householders were more positive towards, and more likely to adopt, interventions with which they were familiar.⁸

³ Macdonald, 2017. What is the benefit of community benefits? 1

⁴ Williams et al, 2018. Public acceptability of the use of hydrogen for heating and cooking in the home. Results from qualitative and quantitative research in the UK. Madano for the Committee on Climate Change.

⁵ Frank J.van Rijnsoever, Allard van Mossel, Kevin P.F. Broecks, 2015. Public acceptance of energy technologies: The effects of labeling, time, and heterogeneity in a discrete choice experiment. *Renewable and Sustainable Energy Reviews*, Volume 45, May 2015, Pages 817-829.

⁶ Rijnsoever, Public acceptance of energy technologies, 5

⁷ Danielle Barrios-O’Neill, Geertje Schuitemac, 2016. Online engagement for sustainable energy projects: A systematic review and framework for integration. *Renewable and Sustainable Energy Reviews* Volume 54, February 2016, Pages 1611-1621.

⁸ Scott, F. L., Jones, C. R., & Webb, T. L. (2014). What do people living in deprived communities in the UK think about household energy efficiency interventions? *Energy Policy*, 66, 335-349

RQ 1.2 Who would consumers expect / need to see endorsing a community level trial for them to be on board with participation?

Local and national government

The literature highlighted a paradox about the public's view of government in relation to the decarbonisation agenda. On the one hand, there is an expectation that government should show leadership or vision on important issues, putting in place the policies necessary to tackle climate change.⁹ In one study, for example, online focus group participants felt that on low carbon heat, government should lead by example, starting with government buildings.¹⁰

On the other hand, government is not always trusted to choose the right policies. Reporting on focus groups run for the CCC, the authors noted that:

“Some of the participants in the focus groups referred to the government’s previous promotion of diesel cars, which the government is now strongly discouraging, in order to demonstrate that the government does not always make the right decisions in this area.”¹¹

Mixed signals were also an issue in the context of the behaviour of individuals in civic life, citing a desire to see both individuals as well as government to lead by example.¹²

The CCC’s public attitudes work on hydrogen found no particular preferences on whether a decision to switch from natural gas is made at a local or a national level. But in the same study focus groups revealed some concern about being a “guinea pig” if there are limited local trials rather than a national rollout. Others felt that a national rollout would be more “streamlined”, because it would dictate a consistent approach rather than allow local variations.¹³

This notion of being a UK-wide ‘test bed’ can lead to feelings of marginalisation: in wide-ranging deliberative focus groups on energy transitions, some Scottish participants talked in terms of toxic waste and the poll tax being imposed on, or trialled in, Scotland. The same kind of idea, but in the context of onshore wind, came up in Welsh groups. There was a sense that the devolved governments can mitigate this feeling by giving credibility to policies that might otherwise have been imposed by Westminster.¹⁴

The literature highlighted that the involvement of local government can support positive engagement with the public. During telephone recruitment for an Energy Systems Catapult smart controls trial, for example, up-front endorsement by a city local authority correlated with a 10% higher questionnaire response rate than in an area where the borough council had not felt able to endorse the trial. The endorsing council, Newcastle City Council, added their logo to the trial website and allowed their involvement to be mentioned in the opening passage of the telephone survey. They also included some basic information about the trial on its website. Bridgend County Borough Council, on the other hand, did not initially endorse the trial, as they

⁹ Butler, C., Parkhill, K.A. and Pidgeon, N. 2013. Deliberating energy transitions in the UK – Transforming the UK Energy System: Public Values, Attitudes and Acceptability. UKERC: London.

¹⁰ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. Report of the Sciencewise Sounding Board pilot. Sciencewise

¹¹ Williams et al., 2018. Public acceptability, 4

¹² Butler et al., 2013 Deliberating energy transitions, 9

¹³ Williams et al., 2018. Public acceptability, 4

¹⁴ Butler et al. 2013, Deliberating energy transitions, 9

did not think they had the resources to field calls on the project, resulting in lower response rates.¹⁵

Expert and interested organisations

International research on the social acceptance of renewables talks about the importance of engaging with NGOs, experts, policymakers and professional associations as influencers of public opinion. It highlights the value of organisations that can support communities with trusted information, financial support and advice, for example Community Energy Scotland which supports communities developing their own renewable energy projects, provides grant funding and access to consultancy expertise.¹⁶

In a community smart meter trial in London focusing on vulnerable groups, partnering with a respected local community organisation facilitated recruitment of project staff from within the community. In turn, this is thought to have been key in recruiting trial participants from otherwise hard-to-reach households.¹⁷ This example is discussed further under trial recruitment (RQ 2.1).

Project collaborators and facilitators

In any future potential hydrogen heating trial, there are certain groups of actors that by necessity will need to be informed and involved. Although not directly comparable, in the example of district heating development, local authorities are cited as key for both developing schemes as well as co-ordinating across the multiple agencies and organisations involved in realising a scheme. Local authorities are responsible for some degree of strategic planning and can potentially assist with identifying areas of suitability for new technologies, working alongside infrastructure and energy utilities. Again for the case of district heating, local authorities are more likely to have taken concrete actions (for example heat mapping), whereas the local gas network operator and energy suppliers, whilst aware of district heating, may not have gone beyond simply considering it.¹⁸ The same may be true of hydrogen, suggesting the need for some awareness-raising of any hydrogen trial amongst relevant existing energy industry players.

A focus group study on district heating found that participants value association of the technology with well-known and respected energy companies.¹⁹ By contrast, in a study on the broader topic of energy transitions, participants were sceptical of energy companies as profit-driven.²⁰ A literature review on the use of social media as an engagement tool on sustainable energy suggested that consumers may object to an organisation promoting a particular technology more so than the technology itself. Or consumers may over-identify with the technology, for example the wires and pipes of energy infrastructure, and in so doing 'dehumanise' the infrastructure companies (academics call this "*organisational invisibility*").²¹

¹⁵ Chambers, K., 2017. D17 SSH Phase 2 Smart Heating Controls Winter Recruitment Trial. Energy Systems Catapult.

¹⁶ Ruggiero, S., Onkila, T., & Kuittinen, V. (2014), Realizing the social acceptance of community renewable energy: A process-outcome analysis of stakeholder influence, *Energy Research and Social Science*, 4 (December), 53-63.

¹⁷ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. Lessons from trial 1 recruitment and installation.

¹⁸ Ruth E. Bush, Catherine S.E. Bale, Peter G. Taylor, 2016. Realising local government visions for developing district heating: Experiences from a learning country. *Energy Policy* Volume 98, November 2016, Pages 84-96.

¹⁹ Paul Upham, Chris Jones, 2012. Don't lock me in: public opinion on the prospective use of waste process heat for district heating. *Applied Energy* 89 (2012) 21-29.

²⁰ Butler et al., 2013. *Deliberating energy transitions*, 9

²¹ Barrios-O'Neill and Schuitemac, 2016. *Online engagement for sustainable energy projects*, 7

For a future community hydrogen heating trial, this suggests the trial might benefit from a personalised, human-facing approach which draws on associations with well-respected national and/or local organisations.

Peers

A 2013 UK survey of owner-occupiers found that when homeowners are making changes to their heating systems, the majority (80%) rely on word of mouth from either their friends, a builder or from the person who services their boiler, even if this person is employed by a large company. Workshop participants in the same study indicated that advice given in a face to face context is more impactful than information in print or online form.²²

3.2 Encouraging participation

RQ 2.1 How open to participating in community-scale trials are stakeholders?

Trial recruitment

A review of a smart meter trial found that for hard-to-reach households (in the case of ethnic minorities where English not the first language, high rise living and often elderly or young families), employing local, trained, relatable staff for the project was important in facilitating recruitment. It drove up recruitment of trial participants through face-to-face home visits and helped to enable access for installation of technology. The top five reasons for residents signing up to the trial were:^{23, 24}

1. Opportunity to save money
2. Better visibility of energy bills
3. Offer of free devices
4. Easier top up for prepay customers
5. Taking part in an interesting project.

When the Energy Systems Catapult ran an open Google and Facebook campaign for recruitment to a heat pump trial (part of a wider trial called the *Living Lab*), 6.2 million adverts (23,000 people clicked, 15,000 remained long enough to read the introduction, 36 people registered interest of which 13 did not respond to follow-up, 8 provided incorrect contact details and 6 did not want to take part), generated just nine leads, all of which were unsuitable for the trial. A much more targeted approach to 18 existing participants in a smart controls trial (and where previous survey work had indicated they might be positively disposed to heat pumps) proved more successful, resulting in 5 installations.²⁵ In another smart controls trial, the Energy Systems Catapult found that willingness to take part was influenced by similar activities taking

²² Ipsos Mori, Energy Saving Trust, 2013. Homeowners' willingness to take up more efficient heating systems. Research report. Department of Energy and Climate Change. March 2013.

²³ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

²⁴ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

²⁵ Chapter, S., 2019. SSH Phase 2+ (Living Lab) Learnings from Heat Pump Recruitment and In-Home Surveys. Energy Systems Catapult.

place in an area, noting that successful recruitment was higher in an area with a number of other residential energy trials.^{26, 27}

Even a trial which involved offering free gas central heating to 1,181 elderly residents in a London borough resulted in just a quarter of those approached accepting the offer. The main reason given for this was out of date records on eligible participants, resulting in flawed targeting. Eligible participants also refused (because of the disruption or fear of higher rental costs following the upgrade) or misunderstood (reportedly believing they had full central heating when in fact they only had partial central heating) the offer.²⁸

Other findings on trial recruitment included the need for telephone or face to face recruiters to be well informed and able to answer questions, and to reflect the gender and ethnic diversity of the target population.²⁹ For telephone-only recruitment, avoiding a long introduction limited early cessation of calls. Detailing the benefits to householders, over and above any inconvenience payments, was found to be important in an Energy Systems Catapult smart heating controls trial.³⁰

RQ 2.2 What affects consumer / local authority willingness to participate in trials?

Consumer preferences and choices

There is some overlap between this and the previous question, so here we have focused on proxy measures of 'willingness to participate', for example, survey and focus group preferences and opinions and academic interpretations.

We looked at studies which gauged people's preferences by offering theoretical choices. These include choices between heat pumps or hydrogen heating (heat pumps were more popular, discussed in further detail under RQ 2.4)³¹; between two scenarios – moving house to a new low carbon residential zone, or replacement of an in situ heating system;³² and between different energy efficient heating technologies.³³ These choices can reveal what people value (or, more accurately, what they say they value). So, in a choice between heat pumps and hydrogen heating, those who wish to avoid the disruption associated with installation of hydrogen heating say they would prefer a heat pump, and those that value least change to their gas heating regime opt for hydrogen heating. When considering a new low carbon residential zone based on district heating, those that already live in densely populated areas are more able to accept the concept of shared, district heating.

Framing of the choice is important – in two out of three of these studies costs were either not mentioned or the new technologies are assumed to offer savings, so we don't know what choices consumers would make if real costs were part of the equation. Where costs are unknown, answers can be caveated – for instance an offer to move home for cheaper heating was described as "*in principle*" an attractive offer. In the third study, and where cost was mentioned, households surveyed on their willingness to adopt more efficient heating systems

²⁶ Energy Systems Catapult, 2019. Delivering an effective field trial: Lessons from the Living Lab, Energy Systems Catapult

²⁷ Chambers, 2017. Smart Heating Controls, 15

²⁸ Armstrong, D., Winder, R. and Wallis, R., (2005), Impediments to policy implementation: The offer of free installation of central heating to an elderly community has limited uptake, Public Health, Vol 120, 161-166.

²⁹ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

³⁰ Chambers, 2017. Smart Heating Controls, 15

³¹ Williams et al., 2018. Public acceptability, 4

³² Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

³³ Ipsos Mori, Energy Saving Trust, 2013. Homeowners' willingness, 22

overwhelmingly preferred to replace their existing gas boiler with a new gas boiler as and when it needed replacing, cost being the key determinant.^{34, 35, 36}

In focus groups on the acceptability of district heating, participants valued “*cost, reliability, simplicity, efficiency and convenience in their heating systems.*”³⁷ In a survey of 2,440 German consumers who had adopted renewable heating systems, subsidies were unsurprisingly a more important motivational factor where systems were expensive and for low income households. Environmentally motivated consumers were more likely to be university-educated men, and were also more likely to purchase full renewable systems rather than hybrid systems. Women were more likely to value the convenience of a heating system.³⁸

In some UK focus group research on long term energy transitions, participants showed understanding and acceptance that costs need to rise. However, the authors caution that:

*“This is unlikely to be meaningful in real world contexts because many other things enter into the formulation of views on this issue. For example, our participants raised more fundamental questions about whether transitions should be financed through consumer bills at all.”*³⁹

In a literature review of studies which look at the willingness to adopt innovative technologies, there is a trend where higher income, longer education, positive environmental attitudes, urban living and social endorsement are individually or in combination associated with a willingness to adopt. Social endorsement is mentioned as particularly important, citing studies that existing Photovoltaic (PV) installations increase the chance of more installations (chiming with the previously mentioned Energy Systems Catapult Living Lab smart controls recruitment drive).⁴⁰

RQ 2.3 What are the barriers and challenges to participation and / or commitment to trials, including trials involving hydrogen? Which of these can be overcome and which are insurmountable?

Reporting on RQ 2.3 and RQ 2.4 has been combined as barriers to participation and the solutions to these barriers are interlinked.

RQ 2.4 What are possible solutions to barriers and concerns around participation?

Literature on sustainable energy trials and on hydrogen heating has been reviewed, but no literature on hydrogen heating trials was identified. Experience with previous energy trials shows that there is a lot that can be done at the recruitment stage to improve participation. We have reviewed literature on this under RQ 2.1.

Some barriers to participation are attitudinal and some practical. It is difficult to state which of these are more or less surmountable: some attitudes may be intractable; some technical

³⁴ Williams et al., 2018. Public acceptability, 4

³⁵ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

³⁶ Ipsos Mori, Energy Saving Trust, 2013. Homeowners' willingness, 22

³⁷ Upham and Jones, 2012. Don't lock me in, 19

³⁸ Carl Christian Michelsen, Reinhard Madlener, 2013. Motivational factors influencing the homeowners' decisions between residential heating systems: an empirical analysis for Germany. Energy Policy 57 (2013) 221-233.

³⁹ Butler et al., 2013 Deliberating energy transitions, 9

⁴⁰ Kowalska-Pyzalska, 2018. What makes consumers adopt to innovative energy services in the energy market? A review of incentives and barriers. Renewable and Sustainable Energy Reviews 82 (2018) 3570-3581. Elsevier.

challenges that could not be overcome in previous trials may be resolvable in another, depending on the set up and levels of funding.

Refusal to participate in trials

In real trials, reasons given for not accepting new technology into the home were: ^{41, 42, 43, 44}

- Disruption and, for elderly people in particular, the loss of control participation in a trial entailed
- Potential for rent increases if property considered more valuable as a result of heating upgrade
- Health worries arising from new heating regime
- Size of new heating system (heat pumps)
- Desire for association with a recognised supplier
- No reason given i.e. some householders may simply refuse or drop out of trials, for unknown reasons.

Overall, however, there was a lack of evidence on why consumers did not take up real-life trials. For the most part, those running the trials simply did not know why consumers had refused participation.

Trial issues, concerns and solutions

Trial issues and practical barriers included:^{45, 46, 47, 48}

- High drop-out rates following successful recruitment (for example in the UK Power Networks (UKPN) smart meter trial, drop-outs after a 40% sign-up a rate resulted in a 23% participation rate)
- The presence of vulnerable householders who may be at risk from the experimental nature of the trial i.e. if heating fails
- Incompatibility of a customer's smart meter with the technology (a hybrid heating system with smart control)
- Incompatibility of a customer's home and surroundings – noise and structural concerns for heat pumps, meter inaccessibility for smart meter trial
- Householders moving home
- Householder changed supplier (in order to access smart meter data, participants needed to be signed up with the UKPN Energywise partner supplier)

⁴¹ Chambers, 2017. Smart Heating Controls, 15

⁴² Chapter, 2019. Learnings from Heat Pump Recruitment and In-Home Surveys, 25

⁴³ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

⁴⁴ Armstrong, Impediments to policy implementation, 28

⁴⁵ Chambers, 2017. Smart Heating Controls, 15

⁴⁶ Chapter, 2019. Learnings from Heat Pump Recruitment and In-Home Surveys, 25

⁴⁷ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

⁴⁸ Energy Systems Catapult, Delivering an effective field trial, 26

- Installation contractors unfamiliar with the technology, leading to problems and delays

In focus groups and surveys, concerns expressed around adoption of new heating technologies included: ^{49, 50, 51, 52, 53, 54}

- Cost (upfront, running, lifetime and tariff structure) and confidence that stated or promised savings would be realised
- Infrastructure to support and facilitate use of new technologies (e.g. equivalent to ‘range anxiety’ for electric vehicles)
- Reliability of new system and inevitable issues that will arise in a pilot (the guinea pig effect again)
- Longevity of fuel source
- Ability to control indoor air temperature
- Disruption (although concern was not universal – in the context of district heating, disruption was not judged as a major issue and seen as “*equivalent to installation of fibre or water mains*”)
- System lock-in (raised in the context of signing up to a district heating scheme and cited as 1-2 years)
- Concerns around noise (heat pumps)
- Appearance (retrofitting heat pumps in a conservation area)
- Structural (retrofitting heat pumps in old buildings)
- Complaints from consumers about being left without cooking facilities during a gas conversion on the Isle of Man
- Adverse publicity about the technology conversion process as a result of consumer complaints about ineffective cooking appliance upgrades

The public’s concerns about the guinea pig effect are valid, as trials are by definition an opportunity to test solutions and measure effectiveness. Potential solutions employed or suggested in the literature include: ^{55, 56, 57, 58, 59, 60}

⁴⁹ Upham and Jones, 2012. Don’t lock me in, 19

⁵⁰ Williams et al., 2018. Public acceptability, 4

⁵¹ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

⁵² Butler et al., 2013 Deliberating energy transitions, 9

⁵³ Lipson, M., Energy Technologies Institute (2015), Smart Systems and Heat: Consumer challenges for low carbon heat, Energy Technologies Institute.

⁵⁴ Gov.im (2003), Gas conversion service concerns, 3 October 2003. Available at: <https://www.gov.im/lib/news/oft/gasconversion.xml> [Accessed 28 October 2019]

⁵⁵ Chapter, 2019. Learnings from Heat Pump Recruitment and In-Home Surveys, 25

⁵⁶ Armstrong, Impediments to policy implementation, 28

⁵⁷ Energy Systems Catapult, 2019. Delivering an effective field trial, 26

⁵⁸ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

⁵⁹ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

⁶⁰ Butler et al., 2013 Deliberating energy transitions, 9

- Providing experimental technology for free – such as in Energy System Catapult heat pump and smart controls trials
- Financial incentives for new technology – such as the UK’s former promotion of photovoltaics through Feed-in-Tariffs
- Payment for participation or other incentives such as vouchers – for example in the UKPN smart meter trials
- Training of project staff and installers – a key part of both Energy System Catapult and UKPN trials
- Open and accessible communication channels with participants throughout the trial – something which a number of trials reviewed attempted to do and which is recommended as key learning point
- Temperature monitoring for vulnerable customers – part of the UKPN smart meter trials.
- Back-up heating for any disruption in supply – part of the Energy System Catapult trials where relevant.
- A long lead-time for adoption – suggested in wide ranging discursive focus groups
- Government accreditation of suppliers and installers - suggested in wide ranging discursive focus groups
- Provision of accurate, trusted information - suggested in wide ranging discursive focus groups.

Commentary on solutions

The CCC has recently updated its analysis of the future of hydrogen in a transition to net zero emissions. It says there are uncertainties associated with both a hydrogen-dominated or electricity-dominated future energy system, and advocates for a “hybrid” heat pump / hydrogen boiler solution, using a heat pump for baseload heat and a hydrogen boiler for topping up at peak times:⁶¹

“Unlike a shift straight to an electric heat pump, a switch to hybrid heat pumps would enable people to experience unchanged characteristics of the heating service they receive and avoid disruption (e.g. by replacing radiators), while reducing emissions substantially and increasing familiarity with the technology. It could also make a switchover to hydrogen easier, as there would be a back-up heat source”

Consumer research for the CCC found a preference for “*dual fuel*” appliances that can use both natural gas and hydrogen. A long lead time to switch over may also aid adoption, comparable to the digital switchover – albeit heating is seen as a more major change.⁶²

By way of overcoming barriers, much of the research we reviewed concludes with a call for better or more information for consumers to help them make informed decisions – some saying it is essential that this is provided transparently, with another presenting evidence that

⁶¹ Committee on Climate Change, 2018. Hydrogen in a low carbon economy.

⁶² Williams et al., 2018. Public acceptability, 4

consumers are discerning and can spot the “*glossy promotional material*.”⁶³ A wide review of online engagement methods observes that the requirement for transparent, accurate information which tells consumers what they need to know can conflict with the requirement for information to be clear, concise and not too overwhelming for consumers.⁶⁴

Previously mentioned work for the CCC on the public acceptability of hydrogen heating uses heat pumps as a comparator. Heat pumps are the most popular (theoretical) choice (63% of 1,029 survey respondents selected heat pumps and 37% chose hydrogen heating), but this is based on “*negative*” aspects of hydrogen heating, principally the disruption to heating supplies during the hydrogen changeover. The authors imply that these preferences are influenced by information provision⁶⁵:

“Knowledge of low-carbon energy alternatives is low and public opinion is certainly not fixed. Even within this study, changes made to explanatory materials between each phase and methodological differences appears to have had an impact on heating technology preferences.”

To improve the acceptability of hydrogen they suggest:

“Articulating how the heating technology adds value or utility for the consumer in order for a switchover period of up to two weeks to be seen as acceptable.”

The report is based on a direct comparison between hydrogen and heat pumps, where hydrogen may benefit from stressing the similarity of utility with natural gas. It does not however offer insight into a switch to hydrogen from natural gas, where there may in fact be no added utility.

Kowalska-Pyzalska reviewed different models of the adoption and diffusion of innovative technologies, discussing the various and wide-ranging ways in which these can be made more realistic. The paper discusses barriers related to consumer expectations, the availability of supporting systems to fix faults in new technologies, levels of disengagement in energy and the lack of a level playing field between different technologies. The author recommends promoting different novel solutions such as renewable energy and demand-side-response in combination, to allow the benefits of adoption to accrue collectively and to overcome adoption barriers.⁶⁶

Project ownership

There is some limited evidence from focus groups on district heating that “community-owned” schemes might be more positively received⁶⁷. The exact meaning of “community-owned” isn’t clear but the associations made by focus groups participants were with ideas of nationalised public services, so perhaps might be better described as publicly owned. Barriers to the adoption of community-owned (where the community raises funds to develop its own project), commercial-scale renewable energy projects are discussed in another paper, but there is little of relevance to a domestic hydrogen trial other than to note that communities will tend to mobilise around a clear government framework and market support structures.⁶⁸

⁶³ Macdonald et al., 2017, What is the Benefit of Community Benefits? 1

⁶⁴ Barrios-O’Neill and Schuitemac, 2016. Online engagement for sustainable energy projects, 7

⁶⁵ Williams et al., 2018. Public acceptability, 4

⁶⁶ Kowalska-Pyzalska, 2018. What makes consumers adopt, 40

⁶⁷ Upham and Jones, 2012. Don’t lock me in, 19

⁶⁸ Ruggiero et al., 2016. Realizing the social acceptance, 16

Organisational barriers

A study on developing district heating found that barriers for key organisational stakeholders, local authorities and network companies, included⁶⁹:

- Low levels of local strategic energy planning
- Conflicting priorities, e.g. developing commercial schemes which need consistent and reliable energy load, and addressing fuel poverty where load is suppressed
- Lack of resources, staff and in-house expertise.

RQ 2.5 What are the conditions of acceptance for consumers in taking part?

Nothing in the literature directly addresses this question, in terms of there being any clear contingencies for consumer participation. The literature tells us more about what consumers don't like, and what they want in a heating system.

Distilling findings from focus groups and quantitative surveys for the CCC on preferences between hydrogen and heating, a report on the public acceptability of hydrogen heating in the home highlighted three “overarching factors...influencing preferences”. These are⁷⁰:

- Disruption to heating of up to two weeks⁷¹ for hydrogen boilers was seen as the “most unreasonable” and the need to discard old appliances and acquire new ones was also seen as disruptive for both hydrogen boilers and heat pumps.
- Familiarity in the user experience, especially for heat pumps as people did not all understand how they would heat the home. Hydrogen boilers were perceived as a more like-for-like replacement with natural gas.
- Comfort and convenience, again with more concerns expressed around heat pumps space requirements and delayed responsiveness, although ability for heat pumps to also cool the house was seen as progressive. Overall though hydrogen heating was seen as offering the most like-for-like outcomes.

The fact that heat pumps were favoured overall in this study shows perhaps just how important potential disruption to heating supplies and everyday lives was to consumers.

Similar wants and needs are raised in other studies around the utility (flexibility, control) and control. Cost is clearly a condition where users are paying for the technology, and for community-wide access to technology, financial incentives can be essential (for example, feed-in-tariffs in the UK have been the driving force for community-owned assets).⁷² Safety is rarely discussed in focus groups, but when it is, participants have stated they would need to see quality assured technology.⁷³ In the context of wind energy developments, health and safety contributes to community anxieties (in this case the impacts of electromagnetic radiation on health). A study looking at how these concerns are managed by developers stresses the need

⁶⁹ Bush et al., 2018 Realising local government visions for developing district heating, 18

⁷⁰ Williams et al., 2018. Public acceptability, 4

⁷¹ It should be noted that the two weeks' disruption period was used in Williams' research as the anticipated length of disruption. We do not know exactly for how long heating would be disrupted in a community hydrogen trial.

⁷² Ruggiero et al., 2016. Realizing the social acceptance, 16

⁷³ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

for “procedural” and “distributional” justice (ensuring proper process and equity of treatment amongst groups and areas), as well as using trusted contractors.⁷⁴

Heating and smart controls trials being run by the Energy Systems Catapult had their own in-built conditions for participation, screening out any households which were identified as vulnerable, including mental health issues identified through householder surveys.⁷⁵ This then raises the question of how vulnerability could be addressed for a compulsory trial and indeed how it could be identified if households are not self-identifying. None of the literature offers answers to this question, although the UKPN smart meter trial comes close by specifically targeting vulnerable households and doing this by using project officers from the local community who were associated with a trusted local organisation. Households also had temperature monitors to alert project staff if temperatures dropped to unsafe levels, although the literature does not tell us if this happened and if so, how the project responded.⁷⁶

RQ 2.6 What do consumers expect from taking part in a trial?

Some focus group participants in the CCC work comparing heat pumps with hydrogen heating expressed disbelief that up to a two-week gas disconnection period would be allowed to happen for the latter. Back-up options such as portable gas stoves did not allay these concerns.⁷⁷

Other than this there is no evidence in the literature of consumer expectations of trials.

RQ 2.7 What lessons can be learnt from previous/existing community level trials where there is significant disruption to local neighbourhoods e.g. installation of subsurface utilities and modification of utility provision within homes?

The literature is extremely light on this question. The literature search identified just one relevant source, looking at lessons learnt from Energy Systems Catapult householder trials. This addressed the issue of disruption, and specifically minimising disruption. Recruited heating contractors were unfamiliar with some aspects of new technologies and went up a “learning curve.” Proper training was essential and over time the project team attempted to schedule the most risky and time-consuming elements of the work first and maintain information flows with the householder to manage expectations.⁷⁸

RQ 2.8 What safety concerns do consumers have and what assurances are needed to overcome these?

Again, the literature is very light on this question. As previously mentioned, the literature references specific safety concerns of those running trials (UKPN providing temperature monitoring for vulnerable customers, Energy Systems Catapult screening out vulnerable customers).

In wide ranging deliberative focus groups on energy transitions, some participants spoke about risk uncertainties (the example given is CO₂ leakage from a Carbon Capture and Storage facility) and showed an ability to trade off the severity and likely frequency of safety breaches

⁷⁴ Landeta-Manzano, B., Arana-Landín, G., Calvo, P., & Heras-Saizarbitoria, I., 2018. Wind energy and local communities: A manufacturer’s efforts to gain acceptance. *Energy Policy*, 121, 314-324.

⁷⁵ Energy Systems Catapult, Delivering an effective field trial, 26

⁷⁶ UKPN, undated. Energywise. Engaging fuel poor and hard to reach households on energy initiatives. 17

⁷⁷ Williams et al., 2018. Public acceptability, 4

⁷⁸ Energy Systems Catapult, Delivering an effective field trial, 26

against the ability for them to personally control this risk. The focus group findings highlight the element of personal control over risk, citing that imposed risks are more negatively perceived than freely selected risks (such as sky diving).

“The notion that large-scale supply technologies are not an aspect public(s) have choice over, may thus result in a greater tendency for risk to be viewed more negatively with regard to these aspects of system change”⁷⁹

Consumers may naturally have concerns about their own safety, even if this is not something that has been introduced into surveys and focus groups on hydrogen heating. This concern extends to contractors, with one study on the acceptance of wind energy noting that *“Workplace accidents of local workers have a negative impact on the acceptance of WF projects.”*⁸⁰ This is something of which community hydrogen trials can take note.

3.3 Finance and trial participation

RQ 3.1 How do stakeholders value local/environmental issues relating to heating? E.g. how important are local carbon reductions, local air quality, moving to ‘greener’ fuels for heating as a community?

The gap between understanding and action

The literature revealed that understanding the need to decarbonise does not necessarily translate to consumers recognising a need to change their heating system.⁸¹ Added to this is the ‘intention-behaviour gap’, whereby even if a community is pro-environment, this does not necessarily follow through in their actions.⁸²

In a study looking at public opinion on the prospective use of waste process heat for district heating, the authors draw on environmental psychology literature, to re-iterate the point that the growing awareness of environmental issues does not necessarily translate to attitudes. They conclude that potential developers need to look to other motivations for signing up to district heating, as awareness alone is not enough. This was backed up by focus groups that were conducted as part of the study, whereby the environment was deemed a low priority when considering the valued attributes of heating systems.⁸³ In fact, it was found that consumers are generally more concerned with the heating technology (how the heating system works) than the impact of the heating system on reducing carbon emissions.⁸⁴

“Respondents were also asked which elements of the heating technologies they would like to know more about. Nearly two thirds (64%) stated that they would like to know more about how heat pumps work in their home; over half (56%) stated the same for hydrogen. Three in five (61%) also stated that they would want to know more about how and when hydrogen heating and heat pumps would be installed. In contrast, only around one in three (31% heat pumps; 28% hydrogen) were interested in knowing more about the impact of the heating technology on reducing carbon emissions.”⁸⁵

⁷⁹ Butler et al., 2013 Deliberating energy transitions, 9

⁸⁰ Landeta-Manzano, 2018. Wind energy and local communities, 74

⁸¹ Williams et al., 2018. Public acceptability, 4

⁸² Kowalska-Pyzalska, 2018. What makes consumers adopt, 40

⁸³ Upham and Jones, 2012. Don't lock me in, 19

⁸⁴ Williams et al., 2018. Public acceptability, 4

⁸⁵ Williams et al., 2018. Public acceptability, 4

In a study that explored local government perspectives on developing district heating, the authors found that whilst social and environmental drivers may be key when it comes to motivational drive for developing district heating, economics is the key factor when it comes to decision criteria for developing district heating.⁸⁶

The link between knowledge and attitudinal change

Two studies (one of which involved face to face workshops and the other online conversations with stakeholders) presented the participants with information and scenarios to discuss on transforming the UK's energy system and low carbon heat technologies.^{87 88} Both of these studies reveal a relationship between information and attitudinal shift. When presented with the UK's climate change challenge, its objectives for reducing carbon emissions and progress to date, participants' responses included an understanding of their personal responsibility for climate change and enthusiasm for innovation and supporting emerging technologies (although this was primarily related to supporting innovation, new technologies and tackling pollution, rather than addressing climate change).

“Many participants acknowledged that the information provided about climate change and the impact the UK's target could have on the gas grid could influence their choice of a heating system; one participant said, ‘I would like to do my personal bit to reduce my personal impact’, and another participant said that ‘everyone should play their part in reducing carbon emissions’.”⁸⁹

It should be noted that the participants responding to the UK's climate change challenge, were asked to respond as if finance was not a barrier.

A further study considered how stakeholders can influence the development of a community renewable energy scheme and in turn be influenced by its outcome. The study cites a paper by Rogers et al. (2008), which found that residents in rural areas supported community energy projects because they expected that a local energy project could enhance community cohesion, promote sustainable use of natural resources and bring about socio-economic changes. The paper states:

“Environmental sustainability benefits of CRE [community renewable energy] schemes may be obtained because CRE projects can significantly increase the overall RE [renewable energy] capacity (Hain et al., 2005), they promote pro-environmental behaviour (Rogers et al., 2012) or they contribute to the expansion of the RE technology market (Walker et al., 2007).”⁹⁰

Furthermore, the authors found individuals might support a community energy scheme because they felt a need to do something for the natural environment and reduce their CO2 emissions, whilst a community might get involved because it fitted with the general goal of a local community to promote sustainable development.

⁸⁶ Bush et al., 2018 Realising local government visions for developing district heating, 18

⁸⁷ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

⁸⁸ Butler et al., 2013 Deliberating energy transitions, 9

⁸⁹ Beaglehole, J. and Patel, R., 2016. Public views on low-carbon heat technologies. 10

⁹⁰ Ruggiero et al., 2016. Realizing the social acceptance, 16

RQ 3.2 Are stakeholders willing to contribute to the costs of delivering a community level hydrogen trial?

Consumers

The literature did not reveal specific findings on stakeholders' willingness to contribute to the costs of delivering a community level hydrogen trial, but rather on concerns with associated costs that consumers might bear. In one study that explored public acceptability of the use of hydrogen for heating and cooking, survey respondents felt government should introduce a compensation scheme to help pay for new appliances required as part of a switchover, rather than expecting households to factor in new appliances as part of routine replacement cycles.⁹¹ It was felt that compensation would be recognition for the effort required of households to purchase and install numerous appliances. Whilst others felt that an improvement in utility would go some way to justifying personal cost.

When examining the Renewable Heat Incentive, the Public Accounts Committee recommended that greater consideration should be given to households and businesses that could not pay the high upfront costs of renewable and low-carbon heating equipment.⁹² This was deemed especially pertinent given the relatively lower cost and popularity of gas and oil boilers.

Local authorities

One study cited an example of a district heating scheme in Aberdeen, Scotland, which only became possible because the scheme developers were able to redefine the local government's understanding of 'best value' within its cost-benefit analysis of the scheme.⁹³

"The long payback period for investments on many DH infrastructure investments is driving interest in alternative business models that enable leverage of finance into the projects."⁹⁴

The paper goes on to point out that, in the UK at least, local authority budgets, and therefore staffing levels, have faced significant cuts in recent years, which has resulted in limited financial resources for procuring much-needed feasibility studies and other consultancy services, legal advice, which are in addition to the significant upfront capital costs required for a scheme.

RQ 3.3 Are incentives necessary for stakeholders to be supportive of a community hydrogen trial? E.g. improvements to neighbourhood (community centres, green spaces etc.)

The literature revealed that broadly incentives are seen to be necessary, although there is some disparity regarding what form those incentives should take, and current gaps between what developers and stakeholders think is reasonable and the processes for defining the incentives.

⁹¹ Williams et al., 2018. Public acceptability, 4

⁹² Prior, M. (2019) Public attitudes on clean growth: A Sciencewise Programme Social Intelligence Report

⁹³ Bush et al., 2018 Realising local government visions for developing district heating, 18

⁹⁴ Bush et al., 2018 Realising local government visions for developing district heating, 18

Social incentives

Social incentives ranged from improved employment opportunities to social regeneration, tackling fuel poverty and awareness raising of renewable energy.

*"The main positive outcomes for the communities are the OEM's [Original Equipment Manufacturers] contribution to society through the creation of direct and indirect employment, the promotion of training programs, and in some countries the generation and maintenance of infrastructure."*⁹⁵

'Social' investment in communities was seen to include rental income for the landowner (in the case of a wind farm development), training programmes, ecosystem restoration and awareness raising on the benefits of wind; it was however felt to be the smallest contribution, in terms of outcomes.⁹⁶

Another study on the social acceptance of community renewable energy, referred to 'social sustainability benefits', which it said related to:

*"The generation of stable income and social regeneration (Hain et al., 2005); Walker et al., 2007) or the tackling of fuel poverty in rural areas (Van der Horst, 2008)."*⁹⁷

In a study on local government visions for developing district heating, it was recognised that whilst some local authorities valued social outcomes such as affordable heating, others had different values, such as developing district heating for regional economic benefit for example. In addition, local authority priorities varied across different geographic areas, suggesting that they were influenced by local context and circumstances.⁹⁸

Financial incentives

One study that looked specifically at community benefit payments, associated with the development of a commercial wind energy project, found a degree of scepticism regarding the developers' offer of benefits.

*"Whilst perceived personal benefit was the most significant factor explaining local residents' support for projects, there was widespread scepticism and dismissal of the benefits on offer from developers. As Cowell et al (2011) highlight, in the UK, where national planning priorities appear to limit local influence over development decisions, 'the role of community benefits in fostering an acceptable outcome is more complex'."*⁹⁹

Included in this scepticism is the perception that locally negotiated community benefits might be perceived negatively as a bribe and providing information on financial benefits before planning permission can be perceived as attempting to buy planning permission.

The paper suggests that one potential solution to this is to provide both community benefits and employ participatory development of community benefits as a method for defining the community benefits.

"The evaluation of our case study data suggests that the value of a community benefits package may be diminished if the outcomes are not perceived to be local and collective"

⁹⁵ Landeta-Manzano et al., 2018, Wind energy and local communities 74

⁹⁶ Landeta-Manzano et al., 2018, Wind energy and local communities 74

⁹⁷ Ruggiero et al., 2016. Realizing the social acceptance, 16

⁹⁸ Bush et al., 2018 Realising local government visions for developing district heating, 18

⁹⁹ Macdonald et al., 2017, What is the Benefit of Community Benefits? 1

and the process through which it is arranged is not considered open and participatory."¹⁰⁰

Within the UK, the Scottish Government has led the way in actively encouraging greater community involvement in the energy transition, and there are a range of policies^{101 102 103 104} that commit to improving local engagement in planning decisions and delivering greater local benefits from renewable energy developments.¹⁰⁵

"The Scottish Government encourages developers to offer communities a stake in the project wherever possible and they have championed the establishment of a minimum rate of community benefit payments 'equivalent to at least £5,000 per MW per year' (Local Energy Scotland, 2015). This, they believe, has 'transformed industry practice across the UK' (Scottish Government, 2015a). It is worth noting, however, that in England the industry-developed 'Community Benefit Protocol' commits wind developments over 5 MW to provide 'no less than £5,000 per MW per year or benefits-in-kind to an equivalent value' to the community (RenewableUK, 2013) and that some companies in Wales were exceeding the £5,000 per MW payment before 2010 (Cowell et al, 2012)."¹⁰⁶

In theory a participatory approach should provide the developer with an opportunity to identify particular needs and wants of the community in question and in turn to deliver an appropriate benefits package, however, the authors cite Cowell et al (2011) who question whether 'just outcomes' can be achieved through such negotiations between what are often large corporations and small rural communities, given inequalities of power and resources between them. As such, the process is crucial in ensuring the benefits negotiated are actually of benefit to the community.¹⁰⁷

*"A transparent process, which provides sufficient and timely information to the public and enables the public to understand how and why decisions are being made, has been identified as a key criterion for 'good' public participation in policy and planning (Rowe and Frewer 2000). [...] Transparency can work towards building and improving relationships of trust between the developer and communities (Frestone et al 2012), alleviating suspicions that are often held towards commercial developers (Jones and Eiser 2009) and avoiding claims of hidden agendas and ulterior motives."*¹⁰⁸

Again, Scotland is referenced for good practice, where, under the terms of Planning Advice Note 3/2010, all renewable energy providers are required 'to consult with relevant community councils and hold at least one public event which is advertised in the local press'. In Scottish Government's 'Good Practice Principles' on community benefits, developers are advised to discuss benefit packages with communities in the early, pre-consent, stages of development,

¹⁰⁰ Macdonald et al., 2017, What Is The Benefit Of Community Benefits? 1

¹⁰¹ Scottish Government (2015a) Community Empowerment (Scotland) Act 2015 (online), available at: <http://www.legislation.gov.uk/asp/2015/6/contents/enacted>

¹⁰² Scottish Government (2015b) Community energy policy statement – Final version (online), available at: <http://www.gov.scot/Resource/0048/00485122.pdf>

¹⁰³ Scottish Government (2016) Land Use Strategy 2016-2021 (online), available at: <http://gov.scot/Topics/Environment/Countryside/Landusestrategy>

¹⁰⁴ Scottish Government (2017) Scottish Energy Strategy: The future of energy in Scotland (online), available at: <http://www.gov.scot/Resource/00513466.pdf>

¹⁰⁵ Macdonald et al., 2017, What is the Benefit of Community Benefits? 1

¹⁰⁶ Macdonald et al., 2017, What is the Benefit of Community Benefits? 1

¹⁰⁷ Macdonald et al., 2017, What Is the Benefit Of Community Benefits? 1

¹⁰⁸ Macdonald et al., 2017, What Is The Benefit Of Community Benefits? 1

through 'flexible, well-planned consultation processes, which are inclusive, meaningful and which respond to the communities' needs.'¹⁰⁹

In this particular study the developer perceived the community benefits on offer to be generous, whereas the stakeholders thought them to be minimal, a 'tick box exercise' which they compared to the significant profits the developer would make.

The scheme was further criticised because the benefits fund was limited to grants of £1,000, which was not thought to be particularly meaningful or likely to have any long-lasting impact.

Criticisms of this particular scheme were further compounded by the fact that the community fund was operated from a constituted organisation run by four individuals, perceived not to be representative of the community.

"The way in which the benefits are being distributed, and the types of projects being funded (described as intangible, invisible and/or short term, rather than legacy projects) has served to highlight - rather than resolve - issues of equity and powerlessness amongst those members of the community who are not linked directly with those involved in managing the fund."¹¹⁰

In another study examining local government visions for district heating¹¹¹, the challenges associated with district heating (including uncertainty and perceived high risk surrounding the long-term future of district heating in the UK) were felt to be too high to justify financial investments at present. However, the establishment of the Heat Networks Delivery Unit (HNDU), within the UK Government's (previously) Department for Energy and Climate Change which provides support to local authorities in developing heat network schemes to overcome barriers, including financial support, has been recognised as stimulating increased interest in the potential of district heating from local governments.

"All of the local governments interviewed were new to the process of DH [district heating] development and clearly valued the support and guidance available from HNDU. It also offered them connections to other local governments facing similar challenges around DH development, allowing peer-learning relationships to be built for sharing experiences on key issues such as financing of schemes, business models and governance."¹¹²

¹⁰⁹ Macdonald et al., 2017, What Is The Benefit Of Community Benefits? 1

¹¹⁰ Macdonald et al., 2017. What Is The Benefit Of Community Benefits? 1

¹¹¹ Bush et al., 2018 Realising local government visions for developing district heating, 18

¹¹² Bush et al., 2018 Realising local government visions for developing district heating, 18

4. Focus groups: findings

This section presents the findings from four focus groups. Each group was presented with a hypothetical community hydrogen heating trial.

4.1 Introduction

Four consumer focus groups were conducted to test the concept of participating in a community hydrogen heating trial. Two of the focus groups were with owner-occupiers, one with tenants (a mixture of private, student and social housing tenants) and one with private landlords. Screening of the participants was conducted to ensure a mix of participants by key demographic characteristics, including income, age, gender and ethnicity. Note that no screening was done of participants' environmental motivations and views.

About the research

Note that these are qualitative findings and therefore is a presentation of the different views and experiences of focus group participants. It does not aim to quantify the number of participants who held particular views or had particular experiences. This is because “the purpose of qualitative research is not to measure prevalence, but to map range and diversity, and to explore and explain the links between different phenomena”.¹¹³ The focus groups were not representative of the national population, so we cannot generalise these findings to population level. However, the recruitment of the focus groups used a number of quotas for various factors to ensure a range of people participated.

Trial scenario

In each focus group, participants were given a two-part presentation.

The first part provided them with an overview of the policy context: the UK target to reduce carbon emissions to net zero by 2050, the need to decarbonise heating and the option of using hydrogen to help achieve this. An overview of hydrogen heating and cooking was also provided.

The second part set out the concept of a hypothetical hydrogen heating trial involving approximately 300 homes. The trial would involve switching over the mains gas supply to hydrogen for an entire neighbourhood. Key elements of the hypothetical trial were that:

- Participation in the trial would be mandatory, although consumers could opt out by terminating their gas supply and switching to electric heating instead
- The switchover would take place in the summer

¹¹³ Ritchie, J., Lewis, J., McNaughton Nicholls, C. and Ormston, R., (2014), *Qualitative Research Practice* (2nd edition.). London: SAGE.

- Communication about the trial would happen at least a year in advance, would involve multiple communication methods and would be inclusive
- Home surveys would be carried out in advance of the switchover
- The switchover would take 3-4 days, over which time hydrogen-ready home appliances (boilers, cookers, hobs, fires and meters) would be fitted in people's homes
- People taking part in the trial would not be financially disadvantaged – i.e. there would be no cost to be borne by the people taking part
- People would pay the same for their (hydrogen) gas as they would for (natural) gas - and pay their bill in exactly the same way
- People could still buy and sell their homes during this time
- There would be a helpline specific to the trial so that anyone could ask questions and get assistance if required
- Any problems with appliances would be remedied quickly, at no cost to the consumer
- At the end of the trial, a decision would be made about whether the community remained on hydrogen or would be converted back to methane gas (at no cost and with the same level of disruption as the original switchover).

A more detailed overview of the scenario presented to focus group participants can be found in Appendix 5.

Participants were then asked to imagine that the home (or homes) in which they lived or which they leased, were in the trial area. The findings below, grouped by theme, present a summary of their reactions and responses to being mandated to take part in this hypothetical trial.

4.2 General views on trial participation

In each focus group, there was a variation in focus group participants' willingness to take part in the hypothetical trial presented to them, from unwilling to very willing. This was the case when participants were asked to rate their willingness to take part both before and after the focus group discussion.

A theme throughout was that participants' willingness to take part was influenced by both 'global' factors (i.e. the extent to which trial participation might impact on their local, national or global environment, positively or negatively) as well as individual motivations (i.e. the extent to which they felt trial participation would affect them, positively or negatively).

Reasons for being willing to participate

Amongst those willing to take part in the hypothetical trial, there were three main types of response:

'Let's do it for the planet'

The environmental and climate imperative to decarbonise the UK's heating was a strong motivating factor amongst many of those willing to take part in the trial. These were participants who were convinced of the need to switch away from natural gas for climate

change reasons and were willing to take part in a project that might help address the Net Zero challenge.

I think if it's going to have a positive impact on the environment, then why not? Do you know what I mean? At the end of the day, we need to do something for our kids' futures and for our futures (Homeowner)

It's worth noting that the presentation at the outset of the focus group highlighted the environmental rationale for decarbonising the UK's heating and the role the hypothetical trial might have in supporting this transition. What is not clear is the extent to which focus group participants in this group were already environmentally motivated or the extent to which the opening presentation helped to convince them of the environmental case.

What the findings do imply, however, is that if a clear and compelling environmental case for a hydrogen heating trial is made, this could play an important role in convincing some – but not all (see below) - consumers to willingly participate.

'Why not, I've got nothing to lose'

Another response was from participants who felt that as long as they would not lose out – financially or otherwise – from taking part in the hypothetical trial, they were prepared to participate.

As long as my house is warm and I can get a warm shower, it's fine. It won't make any difference to me (Homeowner)

This response implies that there are consumers who would be prepared to 'go along' with a hydrogen heating trial of this nature if there was a perceived global need (even if they weren't strongly motivated themselves by this need), provided they felt there would be no major negative consequences for them.

If you can give me a guarantee that it's not going to cost more money, and it's just basically a conversion from one gas to another, then why should we find any issues with that? (Tenant)

There was also a view that mandating the switch to hydrogen – removing any element of choice – was helpful in that it made it easier somehow for them to accept they needed to 'go along' with the trial.

The compulsory element in that sense makes it easier for us. So, this is not something we've got a choice about. So, "We need for you to do this," that makes it easier in that sense (Landlord)

This was not a universally shared view, however. There were also participants who resented the idea of 'being forced' to do something, particularly if there was no compensation involved.

'There's something in it for me'

Another group of focus group participants were willing to take part for more individualistic reasons. In other words, they felt they had something to gain by taking part in the hypothetical trial. The attractions for this group were either that they would be getting free appliances and free maintenance, or that they felt the impact of the trial would have a positive effect on the value of their home.

I'm getting maintenance for probably two years at no cost, I'm getting a new boiler at no cost, so that's big pluses (Landlord)

Note that participants in this group were all homeowners and landlords. This might have been because the perceived benefits (free appliances and increased house values) were not things that tenants would feel they would benefit directly from.

Reasons for not being willing to participate

Amongst those who thought they would be less willing to take part in the hypothetical trial, there were a number of reasons for this:

'I will lose out'

First of all, there was a belief from participants that they might lose out in some way. This ranged from concerns about potential financial losses (e.g. homes losing value, loss of income as a result of taking time off work, compensation needing to be paid to tenants, a belief that energy bills would rise) to non-financial losses (e.g. concerns about the hassle, stress, disruption and inconvenience of the works, or concerns that replacement appliances would not be as good as their current ones). These issues are explored in more depth in the sections below.

I've only just had my boiler done about a month ago and cleaning all that mess. Just having the work done to the house, I find it really stressful. I don't think I want it done (Homeowner)

'It sounds too good to be true, so it probably is'

A second type of response was characterised by scepticism. There were participants who felt that whilst the explanations and reassurances provided in the presentation about the trial in the hypothetical scenario sounded reasonable in themselves, there were doubts as to the extent to which it would happen in the way it was explained.

It does sound like that old saying, "It's too good to be true." It costs you absolutely nothing. Your cooker is exactly the same. Your heating is exactly the same. Your hot water, your shower works exactly the same. Your boiler works exactly the same." To me, I just think, "Hmm." (Tenant)

These doubts focused on a range of different aspects of the trial, explored in more detail in the sections below. They included doubts about the extent to which replacement appliances would genuinely be like-for-like, doubts about whether there would be no financial costs to consumers, distrust about the environmental benefits of hydrogen and scepticism about whether disruption would be limited to 3-4 days.

I had my doubts when you said there won't be any increase in charges, like for like, that's a very bold statement (Homeowner)

Whilst the source of participant scepticism was not clear in all cases, for some participants, doubts about the trial running as explained in the hypothetical trial scenario (Appendix 5) appeared to stem from a wider distrust of government and of environmental schemes.

Then you've got these ghastly things – [solar panels] - on your roof that actually can bring the value of your house down. I wouldn't buy one with those on the roof. No chance. That was a little bit of a con, I think, in the first place (Landlord)

‘People don’t like change’

There were concerns that people would oppose a trial because they are resistant to change. This was felt likely to be the case in particular for elderly residents.

You need to cater for the elderly who are set in their ways. I mean, they will be a bit nervous about change as well (Tenant)

Participants felt that resistance to change could lead to access issues in some cases (explored further below).

‘Why should we do it’

Just as some participants took a ‘why not’ attitude to participation (see above), others took a ‘why should we’ view.

There’s no real incentive. It’s almost like, “Well, why should I?” (Landlord)

This view was similar to the ‘I will lose out’ type response in that it was typified by a ‘what’s in it for us’ response. In other words, whilst participants didn’t necessarily feel they would lose out hugely, they also felt that there was insufficient reward or justification for them to undergo the disruption or hassle involved.

Linked to this, was a ‘why us’ or ‘why *this* type of trial’ view from some participants in response to the hypothetical scenario. Questions included:

- Why has this area been chosen? Why can’t it take place in another area?
- Why does it have to take place with existing homes? Why can’t you trial it on a new estate where there would be less disruption?
- Why aim efforts to cut carbon emissions at housing? Why not target other areas instead?

What are the main causes of climate change? Aeroplanes... What are you doing about that? (Tenant)

- Why does the trial need to last two years?
- Why does the trial need to involve 300 homes?

That goes back to what I said about why does it need to be two years, where do these figures come from? Why 300 houses, why two years, why 300 houses? What’s the benefit of that figure? Why can’t it just be 10 houses? Why has it got to be 300 over two years? (Homeowner)

Why should I do it for the planet’

There were also participants for whom displayed environmental antipathy, for whom the environmental rationale was not a persuasive argument for them to take part.

I think if there was a way to show something is going to benefit me sooner, a lot sooner and a lot further, then I’d probably be more on board. 2050 to me is just going to go through one ear and out the other (Tenant)

Or in some cases, it made them wary of the trial or even triggered negative reactions.

I'm not into all this carbon neutral kind of... It's going to sound awful, but it just does my head in. Really it does (Landlord)

4.3 Safety

At the outset of the focus groups, participants were told that tests would have been conducted ahead of the hypothetical trial to ensure that hydrogen heating was at least as safe as methane gas. Whilst findings from focus groups are not representative of the wider population, it is worth noting that safety concerns were not subsequently a common theme of the focus groups.

Some participants appeared reassured by the messages about safety provided during the focus groups, implying that similar messaging may be beneficial in assuaging any safety concerns.

Like you said, it would be on par or even safer. I'd probably want a bit of reassurance that that was the case (Homeowner)

Of those that raised concerns, the main worry was about the combustibility of hydrogen compared with methane gas.

My main concern is hydrogen is highly flammable in comparison. How would they have regulated that by then (Tenant)

Queries were also raised about:

- The colour and smell of hydrogen gas compared with methane
- Whether carbon monoxide poisoning was possible from hydrogen gas and how it could be detected if so
- Where hydrogen is stored
- How hydrogen is produced, and
- Whether hydrogen supplies could ever 'run out'.
- More generally, there was a sense from many focus group participants that hydrogen was an unfamiliar heating and cooking fuel.
- This implies that an important part of any future trial will be educating consumers about hydrogen gas and providing reassurances about its safety.

4.4 Communications and engagement

Communication and meaningful engagement with would-be trial participants was seen as a key determinant of success for a hydrogen trial. Key themes of discussion were:

Timing

There was general agreement amongst focus group participants that communications about the hypothetical trial should begin well in advance of the trial start date. Participants agreed

that a range of different communication methods would be important in order to effectively communicate messages about the trial to all affected households. This was regarded as important both in terms of acclimatising consumers about the idea of taking part in the trial, as well as raising awareness about hydrogen heating, the rationale for the trial and the trial process.

Start drip-feeding and start giving people that awareness of it is an alternative method that they're thinking of. Let's tell you a bit about it before we then say, "It's mandatory now. We're going to have to switch you over for two years." Just to get people used to the idea like years before it's being out there (Homeowner)

Technology unfamiliarity and uncertainty: raising awareness

Linked to the previous section on safety, participants highlighted that hydrogen heating was an unfamiliar technology with an element of the unknown. With this in mind, participants raised a range of queries about hydrogen heating, including how the technology would work, its safety, what the benefits were, how it compared to methane gas and what using it would be like.

This underlined a need to help provide a range of information in the future to potential trial participants – to help 'acclimatise' them to hydrogen heating - and to provide them with reassurances where they had concerns.

It's happening in your home. You're bringing something new into your home and you want to know about it. And you were saying it's as safe as gas, but it's what we don't know. You like what you know, don't you? You get comfortable with what you use. And you're asking us to bring something new into our home, so just tell us a bit more about it. And the people that are really against it might then feel more comforted... (Homeowner)

There was a desire to see the technology working, or to hear from previous users of hydrogen heating systems. Suggestions included:

- **Having a 'demonstration house'** where consumers could see what having hydrogen heating (and the associated appliances) might look and feel like;
- **Having cooking demonstrations** on hydrogen hobs;

If there is no change visibility, physically, look, I'm standing here in the show home cooking on this gas. Then I'm standing in that show home, two houses, I'm cooking on that gas, exactly the same, people will be like, "Oh yes, brilliant. No change there (Tenant)

- **Receiving testimony or reviews from consumers** that have already used hydrogen heating and other appliances.

Issues about the technology itself that **participants asked for reassurance** on included:

- That hydrogen heating and associated appliances would work in a similar way to their current methane gas systems i.e. they wanted assurance their daily lives would not be compromised as a result of the switch;

If there aren't any major changes, then people will be willing: "You know what? I can spare four days of disruption" (Tenant)

- That using hydrogen gas would be at least as safe as methane gas.

There was also a desire to understand the environmental benefits and to be reassured that their 'sacrifice' in trialling the technology would be worthwhile in these terms.

Making the case for the trial

Whilst the initial presentation given to participants in the focus groups included an overview of the rationale for the hypothetical trial, there were nonetheless participants who either were unconvinced of the need for a trial or wanted further reassurances about why a trial was necessary (see for example the 'why *should* we do it' response to the trial, above). This suggests that pre-trial communications will need to involve a process of explaining the rationale for the trial and convincing consumers of its importance.

Some of those sceptical about the environmental benefits of the trial suggested that more quantitative evidence to demonstrate why there was a need for a trial and what potential difference it could make might help to convince them of its importance.

Just more clear statistical evidence of what this is actually for, what we're going to gain through it. What the future generation is going to gain, not necessarily us because we probably never will gain anything but what is going to happen in 2050. What are we going to see? Is the ice going to melt less? Have we got actually clear evidence to say that's what's happened? (Homeowner)

There was also a view that the stronger the rationale for a trial, and the more this was explained to consumers, the less likely consumers might be to expect incentives to participate.

If you explain the reason, you might not necessarily have to give them some reimbursement, if you see what I mean. It's like a balance. The more you educate them, the less you're likely to need to pay (Homeowner)

Building trust

Trust, honesty and transparency were key themes of the focus groups overall.

Participants emphasised the importance of honesty and transparency in communications: on why the hypothetical trial was necessary, what would be involved, how long it would take, etc. They valued straightforward information and preferred this over 'PR spin'.

Don't beat about the bush. We want facts. "This is how it is." Like this lady said here, if somebody asks you a question, you need to know. You need to be honest. It's what people want; do you know what I mean? (Tenant)

The implication was that if consumers felt misled about what they were told – for example if the switchover process took longer than first claimed – consumers' willingness to cooperate – and their trust - in a trial would be negatively affected.

As highlighted in section 4.2, a related theme was distrust of government.

Well, this government, or any government, you can't believe everything they promise you (Homeowner)

This indicated that communications and engagement might be better received if they came from more trusted local sources (the literature review, for example, highlighted local community

organisations as trusted sources in one trial). One focus group suggestion was that participants wanted to hear from contemporaries who had already trialled hydrogen.

Building personal relationships, face-to-face, was another suggestion for building trust with consumers. There was a suggestion that the hypothetical trial should employ dedicated, well-informed, project officers who stayed associated with the same participants for the duration of the trial.

I'd prefer to see the same face. If I were on something like that, I'd want to see the same person, because they'd know if you'd had that issue before, after, whatever. (Tenant)

Communicating with vulnerable consumers

None of the participants expressed concerns about themselves, but cited relatives, friends and neighbours who might struggle with the disruption or change in routine – this is covered in more detail in Section 4.6 on the switchover process. None thought this would be catastrophic but emphasised the need to take time to understand the community as individuals, and in so doing identify and mitigate any issues associated with vulnerability on a bespoke basis. One participant thought that the local authority could help with this.

My niece is autistic....Change is a no-go area ... it's vulnerable people. You've got to really convince them more than me, or really any of us in here... It's your vulnerable people who really, really need a bond or a trust with someone first. (Tenant)

Bespoke, clear in-trial communications

Once the hypothetical trial is underway, it was thought important to maintain clear and open lines of communication, through a variety of means, on progress. There was also a view that communications and engagement should be tailored to individual household needs. Participants emphasised the need to take time to understand the community as individuals, and in so doing identify and mitigate any issues associated with vulnerability on a bespoke basis.

You've got to adapt to each individual's needs as well. If you start with all the jargon to someone who's got learning difficulties, they're not necessarily going to understand, so you have to break it down. You have to have someone who will tailor-make each bespoke statement to them (Homeowner)

Managing landlord and tenant communications

A final communications theme centred on managing communications with and between landlords and tenants. Participants – particularly landlords – expressed concern about the communications triangle between the organisation responsible for delivering the hypothetical trial, landlords and tenants and whether it could be managed effectively.

Landlord concerns included:

- To whom would communications be directed in tenanted properties: the landlord, the tenant, or both, and
- Concerns that tenants can sometimes be difficult to liaise with.

One landlord wanted communication with tenants to be routed through them, but others wanted to be informed but not involved. These landlords suggested it would be better - once initial trial consent had been received from the landlord – for the trial to communicate directly with tenants: both about the trial and, when underway, for the trial itself to arrange home visits, field calls and queries and to fix any problems.

“If the government want to trial it, they need to do the legwork and not expect the landlords to do the legwork.” (Landlord)

4.5 Property values and selling homes

Property values and issues around selling homes was a recurring theme in the focus groups, particularly for homeowners and landlords. A common worry was that it would be more difficult to buy and sell homes during the trial period set out in the hypothetical scenario. Specifically, concerns were that:

- **Potential buyers would** – given the choice between a gas or hydrogen-served house in a similar area at a similar price – **opt for the ‘safer’ option and go with natural gas;**

I must admit if I was buying a house, I would avoid it like the plague. It’s a trial, you don’t know if you’re going to have stress at the end of it (Homeowner)

- **Potential buyers would be nervous about joining a trial mid-way through**, as well as about any uncertainty and disruption associated with switching back to natural gas;

Because you’re in the middle of a trial, so that new person then has to take on that risk, and then they don’t know what’s going to happen at that two-year period. And solicitors, conveyancers would hate it (Homeowner)

- **The trial might negatively impact on the sale value of properties;**
- **Distressed sellers would be particularly disadvantaged** – one example given was of a householder needing to sell their home to fund nursing home costs;

Like my elderly parents, they might be in a position where we need to sell the house for them to go into a nursing home. How would that impact? What’s that going to do to the value of the house? And what would they get out of it? (Homeowner)

- **Both buyers and sellers could incur higher conveyancing costs.**

It’s more legal paperwork for the solicitor to do if you’re going to sell it. So, there’s more cost involved (Landlord)

4.6 Switchover process

The switchover process was the most discussed element of the hypothetical trial scenario in each of four focus groups. Concerns centred around four main themes:

Disruption

Participants highlighted a number of disruption-related concerns. These included worries about:

- **Uncertainties about the level of overall household disruption** that would be required. There were concerns that for some households the switchover process could involve relatively major works (e.g. large-scale pipe replacement, floorboards being taken up, plasterwork being taken down, modifications to aspects of properties) that might involve a lot of disruption.
- **Living arrangements during switchover.** Participants were uncertain whether the level of disruption involved would make it necessary or desirable to move out of their homes whilst the switchover took place. Some suggested that this would be possible or feasible if needed, whilst others highlighted it might be more challenging for vulnerable consumers or those needing to stay in the local area (e.g. to access local schools).
- **Work-related disruption**, including concerns about how much time homeowners and tenants might have to take off during the switchover process, particularly if switchover times changed or took longer than expected, and the extent to which some people would lose income or paid holiday time as a result.

All the installations of all the swap-overs and the changes, that tenant has got to give their time or take time off work to be there. Like you say, are the workmen going to make contact? Are the workmen going to turn-up? Is it all going to run smoothly? Because the last thing that tenant wants is for all the appointments to go pear-shaped. Then they get annoyed halfway through the installation and go, "No, I'm not having any more time off work." (Landlord)

- **Business disruption.** One participant ran a childminding business from home and was concerned about the impact that the switchover process would have on her business. She was uncertain how long she might have to close her business, whether switchover timescales could be guaranteed so that she could effectively plan for the disruption and whether she would be compensated for any loss of income as a result of the process.

What would I do? Because my business, I run from home. I'm a childminder, so I just thought how I would I have four days without hot water? (Homeowner)

- **Street-level disruption**, including the extent to which there might be parking and access issues for the duration of the switchover process if there were multiple homes being worked on at the same time.

Whilst disruption concerns were a common theme, there were also participants who expressed pragmatic acceptance about any disruption they would face. These were consumers who felt that the level of disruption for them would be relatively minor and that there were ways to address inconveniences during the switchover process, for example by using electric appliances instead, or staying with friends or family temporarily.

I had it recently when I had a problem with my boiler, so I'd just go to my mum's. It's just three days, four days, isn't it (Homeowner)

Welfare

The welfare of trial participants, particularly vulnerable people, was a key concern raised in all focus groups and included the following themes:

- **Welfare of vulnerable people.** Concerns related to the welfare of vulnerable people included concerns about the elderly, young children and those with medical conditions. It was felt that even if the switchover happened in the summer months, many of these people would still need heating and hot water.

My concern is the elderly that are really elderly. It might be summer, but vulnerable groups, like for example when you are really old you feel the cold still, so that three or four days might not be a long time, but to not have hot water when you are that elderly, there are people who are 92 that still live on their own. (Tenant)

- **Distress to vulnerable participants.** The distress caused by the hypothetical change was also recognised as a concern, particularly for the elderly.
- **Welfare of tenants.** Landlords expressed specific concern for the welfare of their tenants being expected to live without heating and hot water, again, particularly those with young children and the elderly. Some landlords said they would be fine with going through the hypothetical trial themselves but felt it to be unacceptable to impose such disruption on their tenants who they felt a strong sense of responsibility towards.

The only thing that worries me is the tenants left without heating and cooking for three to four days. What's the tenant going to? The tenant will not stay in that property. Ours have got children. There's no way I would expect them to stay in that property. How are they going to sort that out? They can't just leave the tenants without hot water and cooking for three to four days. There's no way you can do that. (Landlord)

But there's no way I could do it for them. None whatsoever. I think it's totally unrealistic to expect one of your tenants to not have hot water. To be honest, it's annoying me a little bit. Because I wouldn't expect it myself. I would do it myself, because I could go somewhere else to do it. But I wouldn't expect them to. Why should I? Why should they? (Landlord)

Tenants themselves also raised concerns about the switchover process, particularly those with children.

My issue is the up to four days with no hot water, no heating, not being able to cook. Not as much my eldest. He is 21 in January. It's my youngest daughter, and I just think from hygiene wise. I would definitely have to move out, because I couldn't leave my daughter or myself for four days without any hot water. You are talking showering; just washing your hands after you go to the toilet and stuff. (Tenant)

- **Welfare of pets.** Concern about pets was raised by some participants, particularly regarding what to do with them if they had to move out of their home during the switchover and also the potential distress of having workpeople in the house for three or four days.

If you have got pets as well... If you have got a good few pets in your home, where are you taking them as well? Because some dogs... Maybe you've got a dog and they don't like strangers. They have got to come in. I assume they've got to work in your kitchen obviously, every room in your house. You can't keep your dog locked outside in the back garden in the summer when you want to do it. (Tenant)

- **Trust.** Two key areas regarding trust were raised; distrust about timescales and concerns around letting strangers into their home.

Yes, it's like one of you guys said before, when the council have said or someone has said, "Oh, it's going to take six weeks to do this project," and actually it doesn't. It takes three months. How is a tenant expected to carry on if it is not guaranteed at three days or four days? (Landlords)

You're trusting someone that you don't know, leaving your keys for people, it's just all a bit- I think some people would find that quite unnerving. (Homeowner)

Welfare solutions

Potential solutions to the issue of welfare were discussed with participants and included the following. Participants suggested that the hypothetical trial could:

- Provide meals to householders, where appropriate
- Provide temporary accommodation (although it was recognised this had potential complications)

Because if the school is around the corner and you say, "Right, I drop the kid off there, I jump in my car and I go to work," now you've got a one-mile journey to the Ramada hotel... That's not good. That's a pain in the bum. (Homeowner)

There's an easy way around it, just ... hire out Snoozepods, which basically [are] like a little house¹¹⁴. They usually have two bedrooms, bathroom, shower, cooker. It has got its own hot water system. (Landlord)

- Provide alternative heating, if required, such as an electric heater, and cover the costs of using any replacement heaters
- Provide alternative hot water facilities, if required, such as an urn

If you had one of those for an elderly person to keep them warm and provided a hot meal every day so they could stay in their own home, that could alleviate one of your problems, and something to provide them with some hot water. It's just really tackling those little issues they are going to come up against to get through that period. It's like you say it's only three to four days, but that can be a lifetime for some people. (Tenant)

- Work with utility companies and the local authority to identify those in need via the Priority Services Register and similar registers of vulnerable householders

¹¹⁴ The participant did not specify what solution they were referring to but we assume it was something akin to a welfare cabin: <https://www.nixonhire.co.uk/hire/p/snoozepod-sleeper-welfare-cabin>.

- Provide a liaison officer to assess each individual circumstance and check in on vulnerable people every day.

Process

The hypothetical switchover process was a common theme of discussion. Key discussion points focused on the following:

- **Switchover timing.** The timing of the switchover could be relevant, for example, doing it in the summer months might be preferable both in terms of weather and school holidays.

I do think about the disruptions as well with three small kids and having to take time off work but if you're doing it in the summer, I'd be alright with that because I work term time only. If it's in the six weeks holidays I'd be off anyway.
(Homeowner)

- **Delivery timescales.** There were significant concerns about the delivery timescales, and whether it was realistic to complete the switchover in four days. Achieving the switchover given the scale of the trial was a concern for some participants. There was also some confusion about the details of the trial, with some participants believing it meant all 300 properties would be simultaneously converted to hydrogen in four days. More generally, participants were concerned that the logistical challenge of switching over 300 properties might make the timescales difficult to meet.

The logistics, imagine a turning or a street of 100 houses, you've got to turn the regular gas off and simultaneously all of those gases have got to be fitted with the new gas and then they move on. It's almost the thrust of it is very hard to visualise. You can't see all of it being done at the same time. You made me see a slight problem there.
(Homeowner)

In light of this, participants expressed a desire for some kind of assurance about timescales, including clear guidelines about what would be delivered and by when.

There's got to be clear, defined guidelines that I can read and believe them and know that if any of that happens, I'm not going to basically just be shut down, and be like "Tough, you've got to deal with it." (Homeowner)

There were suggestions that these could be tied to contractual obligations between the delivery contractor and the householder.

Customer compensation if the event contractors went over agreed timescales or failed to meet other delivery criteria was also identified as a potential 'reassurance' measure.

So, having them to put pressure on them to say, 'Look, roll it out, this is the timeframe we give people, will you stick to it? If not, there's a penalty for you' and then also for me as the homeowner 'here's your compensation that sorry we didn't meet the target of the four days'. That's I think logistically the only way around it because how are you going to put faith in me other than that.
(Homeowner)

- **Access to homes and coordination** of the switchover was a further concern, and in particular the logistics of this. There were concerns, for example, that tenants might be difficult to get hold of, that some people might not be willing to provide access to their

homes and that arranging convenient times to provide access might prove to be challenges.

During the trial and the transition, the other thing I've just thought about is the access for you lot to do that. Everybody's lives are not regulated. How are you going to get in and do all these changes? They can't even do council changes on windows because people aren't in, never mind the hydrogen and the gas piping change. Do you see what I mean? (Tenant)

- **Appliance storage.** Some participants questioned what they would do with their current appliances during the hypothetical trial, feeling they would not necessarily want to get rid of them in case at the end of the trial they were to be converted back to methane gas, whilst others questioned what would happen to appliances if they moved house within the trial period.

A two-year trial, a year in you move. You're taking your appliances with you. Obviously, you're not taking your boiler, but your cooker and what have you, and you're moving to an area which is back to natural gas... The person that's moving in is moving in from a natural gas to a hydrogen, midway through a trial. How is that coped with? (Landlord)

Have you got to store it? Or if they move out, could they take that stuff with them? Where would that... Then if it's the two years and then it has to go back, who replaces that? Because like you say, if they've got no option but to change, but it's their property in terms of their gas cooker, oven, whatever, what happens then? (Landlord)

Costs and compensation

Key concerns around costs and compensation included:

- **Is it genuinely cost neutral?** Participants questioned whether they really wouldn't incur any costs as a result of the hypothetical trial, expressing particular concerns about damage caused during the switchover that would require fixing, for example decorating and rendering. Broadly the participants accepted that damage can happen but wanted reassurance that any damage would be rectified.

What about redecorating if they... you know, the most careful people that come to do jobs at your home can disturb things, like, perhaps they'll lift carpets and wallpaper and stuff like that? Would they be making good anything like that? (Homeowner)

- **Would tenants be compensated?** The question of compensation was a particular concern for landlords, in relation to their tenants, and is covered in more detail in section 4.11.

I know my tenants would be quite happy with a cash incentive, knowing they've only got to boil a kettle to cope for three to four days, as long as they guarantee that period. (Landlord)

- **Business compensation.** Homeowners also raised the issue of compensation and particularly those who run a business from their home, which they would have to close down during the switchover period.

I think what they'd probably have to do is literally shut your business for four days and just reimburse you for it... (Homeowner)

4.7 The user experience

At the outset of the focus groups, participants were told that the replacement boilers and other appliances would be 'like-for-like'. (see Appendix 5 for hypothetical scenario) Some participants were reassured by this message. Others felt that the trial might be an opportunity to upgrade current appliances or replace aged systems.

As highlighted above, however, there was also a desire from some participants to witness the technology working in practice and to be reassured that there would be an equivalence of utility i.e. that there will be minimal impact on day to day routines. This equivalence extended to:

- **Function** i.e. participants wanted boilers and other appliances to be at least as functional and usable as their current appliances.

As long as my house is warm and I can get a warm shower, it's fine. It won't make any difference to me (Homeowner)

- **Appearance.** Aesthetics mattered to some, noting that appliances are often chosen in the context of an overall kitchen scheme (e.g. in terms of colour and the use of integrated appliances).

What if you've got [a certain] colour, people sometimes [have] green ovens, that are lovely green, what if that one is now discontinued (Homeowner)

- **Value.** There were concerns that replacement appliances might be of a lower financial value than their current appliances.
- **Maintenance.** Although facilitators told participants that any faults would be fixed during the trial, there was concern that in reality this might be a problem, and that there may not be sufficient numbers of trained engineers – both to fix appliances as well as area-wide interruptions in gas supply.
- **Meeting special needs.** There were concerns about whether vulnerable consumers and those with special requirements, who required adaptation to appliances, could be accommodated.

There was scepticism that a trial could truly offer real equivalence in these terms, with some suspecting that replacements would be bulk-purchased, basic and not bespoke enough to satisfy individual needs and wants. To help address these concerns, there was a suggestion that would-be hypothetical trial participants should have some choice over what appliances they were provided with.

4.8 Support

Focus group participants were told that participants in the hypothetical trial scenario would receive support, including a helpline specific to the trial so that anyone could ask questions and get assistance if required. Concerns about this included:

- **The availability of the helpline.** There were concerns about whether the helpline would be available 24/7, in case faults and issues arose 'out of hours'
- **The speed of response.** Related to the above, there were also concerns about the speed of response and the availability of engineers to fix faults, to ensure household disruption was minimised if faults occurred
- **Meeting individual household needs.** Participants also stressed the importance of tailoring support to meet individual household needs, so that it met the needs of the vulnerable and those with special needs.

Suggestions to make the helpline and associated support effective included:

- Ensuring the helpline was available 24 hours a day
- Providing reassurances or guarantees about the speed of response times
- Providing reassurances about the quality and level of service that would be provided if faults occurred (e.g. ensuring a sufficient number of trained and available engineers)

If it's a new style of boiler and the gas engineers need to be trained, is there going to be a shortage of hydrogen trained gas engineers, and then there's a delay in the coming out because there isn't as many of them (Homeowner)

- Ensuring effective support was available for anyone with special requirements
- Establishing a dedicated community support team who help to establish relationships, trust and confidence with householders
- Keeping a log of problems and solutions, to ensure that engineers learn as they go along, so a problem that took a day to fix the first time, might be much quicker to fix the second and third time
- Conducting proactive checks on equipment and appliances in order pre-empt or spot potential issues e.g. through a programme of post-installation checks.

4.9 Post-trial arrangements

In terms of post-trial arrangements, focus group participant views clustered around two themes:

The end-of-trial technology decision

There were concerns and queries about what would happen to consumers' heating at the end of the hypothetical trial.

- One concern was that if the decision was made to leave hydrogen heating in place in the area, there may be consumers who are left with a system they are unhappy with, with limited options to change to alternative systems.
- There were also concerns that if the decision was made to switch consumers back to natural gas at the end of the trial, consumers would have to go through a second wave of disruption, involving similar issues to those covered above.

The thought of having to have it all undone again, I wouldn't be happy with that (Homeowner)

Post-trial maintenance and customer service

If the decision was taken at the end of the trial that homes should continue with hydrogen heating, participants raised concerns about post-trial maintenance and customer service. Specifically:

- Participants wanted reassurance about the availability, quality and costs of ongoing maintenance services.
- Participants also wanted to know if appliance guarantees and service cover would be extended beyond the duration of the trial.

4.10 Tenure-specific issues

Landlords and tenants

Concerns were raised about the additional cost to landlords to pay compensation to their tenants; this issue is covered in section 4.11. Other key issues that were raised included the following:

We have a responsibility to our tenants

The issues of landlords' responsibility to tenants and potential liability was also raised.

If you have a burst in the house and it's uninhabitable, I can claim on my insurance, but I've got to rehouse them to do the repair and everything else. So, if they're not moving out and they haven't got any heating or hot water, or there's disruption, then they're going to expect me as landlord to be responsible and compensate. (Landlord)

One landlord pointed out their responsibility to house their tenants in suitable housing and questioned whether participating in the trial was really worth the 'hassle'.

Like this lady said, we're liable to put them in a property that provides everything. That's what they're paying for. So, they're either going to want a reduction in the rent, because they're not getting what they're paying for, we're going to get loads of hassle over it, and for what purpose? (Landlord)

How will liabilities work post trial?

There were various issues raised relating to liability.

Concerns expressed were primarily around the landlords' responsibility to their tenants.

It worries me that would be- The legalities in relation to, would the checks be the same? Would all the legalities and that be the same? My responsibility as a landlord and people with young children etc... That's a concern. How much control they'd have over what went in. Effectively, it's their house and their home, and it has always been my responsibility to look after that. But it's their home. They should have that control about what goes on within it, I think. (Landlord)

Concerns were also raised that they would be liable in the case of increased running costs. Added to this, one landlord explained that they wouldn't actually know if it was costing more or if their tenant was using more gas.

I've replaced the boiler, told her it was going to be more efficient etc and she comes back after a couple of months, saying, "It's costing me a fortune, this boiler." Now, you don't know whether it's actually hotter, or they're using it more. I don't know what realistic feedback you can have from tenants. (Landlord)

Another landlord asked what would happen if something went wrong, that then falls to the landlord to rectify.

I wouldn't be happy with that, because if they get free bills, I don't get anything. Then if something goes wrong with the trial then I'm going to be liable, and I don't know how insurance would work if something happened. A fire from the new cooker. I wouldn't know if it was covered. Just things like that. (Landlord)

Tenant welfare

Landlord concerns about tenant welfare during the switchover process are covered in Section 4.6.

What will happen to rental values?

Questions were raised about rental values being impacted by the hypothetical trial, although mostly landlords agreed that rental values should not be affected.

Once the initial switch is done, I don't think it will have any effect. If the price stays the same as the current gas is, it shouldn't make any difference to the tenant once a switch has been done. (Landlord)

These concerns were also raised by tenants, although one tenant reasoned that if nothing is going to change, cost wise, the rent should not change.

If it's true to the word and nothing can change, your expenses will not change with regards to your gas. It's not going to cost you any more to shower, any more to cook your children's dinner, your rent should not be affected, if it's true. (Tenant)

Concerns were however expressed by some tenants, with one expressing scepticism about their landlord increasing the rent as a result of the switchover.

But this is the thing, because it's a trial, so we kind of get a free run at this. My landlord will be thinking, "Right. I'm on a trial. Eventually when this is commercially viable, and if it's going to be just that bit more of an expense but I've got it for free, I can start charging another £50, £100 a month. (Tenant)

Tenant communication relating to the trial was also expressed as a key concern, as covered in section 4.4.

Homeowners and landlords

Concerns about the impact of buying and selling homes is covered in section 4.5.

4.11 Costs and compensation

Costs of participation

Not all consumers thought that they would face costs as a result of their participation in the hypothetical trial. Or, if they did, they felt the costs would be relatively minimal (see, for example, the [“I’ve got nothing to lose”](#) type of response to trial participation in section 4.2).

Nonetheless, the financial and non-financial costs of participation were a common theme in the focus groups. Many of the perceived financial and non-financial costs of participation have already been covered in the previous sections.

Financial costs

Participants that worked from home (including those that worked remotely from their company and those that ran businesses from home) expressed concern about loss of income during the hypothetical switchover period.

Realistically if you take out four days of your salary that you’ve got to have someone in your house messing your stuff and then like you say, it might go over. They might not be able to get there one day. There’s no compensation on that side, all be the whole thing is free and it is benefiting the environment which is great. I think it’s a lot to ask of people that need that income as well. It’s nearly a week off work. (Homeowner)

Participants were also concerned about energy prices increasing beyond the end of the trial.

My guess is it would stay as hydrogen and the prices would creep up, I would imagine. The same as when you get a water metre fitted and everyone says, “This is the best thing you can do.” Then within 13 months when you’re allowed to have it changed back, everything seems cheap and then suddenly it’s not. You can’t then change it back to the normal water when it’s so many people living in the house. So, four people, that’s your price. But I’ve found that my water is more expensive than it used to be. A lot more expensive. (Landlord)

One participant expressed suspicion about increased prices being used to cover the costs of installation and the perceived cost of hydrogen being higher than methane gas.

I think it’s got to be more expensive because they’ve got to find a way of paying for it, haven’t they, because when they’re putting it in, they’re going to find more problems, they’re going to find it’s more expensive than they first thought. (Homeowner)

I’ve got to be honest, I researched before, and hydrogen is much more expensive [...] I don’t understand how they are going to try and equate that value to balance it. I just don’t see how it’s going to happen without a cost to us, the customer. (Tenants)

Participants expressed a need for reassurance about energy prices going forward.

I still need to be convinced around the charges going forward (Homeowner)

Some remained sceptical about costs to the consumer.

I had my doubts when you said there won’t be any increase in charge like for like, that’s a very bold statement. (Homeowner)

Questions were also raised about running costs and in particular if they would be able to shop around in terms of providers to find the best price. Similarly, there were concerns about maintenance and repair costs, and whether there would be a limited number of tradespeople that would have the skills to undertake work on the new boilers.

Costs specific to landlords

There were several issues raised that were specific to rental situations.

Concerns were expressed by landlords that tenants would want compensation for the hypothetical switchover period when they are without heating and hot water, and that this cost would fall to the landlord to meet.

They're going to want some deduction or some compensation. Or, like you say, whoever said, they're going to want to be put in a hotel or somewhere else. Because I wouldn't accept that as a tenant (Landlord)

One landlord suggested that this should be dealt with by those delivering the trial.

But the actual conversion... This is no disrespect to anyone, but my tenants tend to be on benefits, and as soon as they get a whisper of, "I can get a hotel. I can get compensation," or whatever, it goes around like wildfire. I would want that dealt with. Nothing to do with the landlord. It's got to be whoever is doing this.

Another landlord expressed unease with the notion of 'bribing' their tenant.

The tenant who is going to share the brunt of it, or you want to convince the tenant to go along with this, they get nothing. They get an inconvenience, and I'm not bribing them.

Implications for existing boilers

Questions were raised about participants' existing boilers and service packages, including a boiler that had not yet been fully paid for and a service plan that was paid for upfront.

I'm still paying my boiler off, so if this was to happen right now, would I still have to pay that boiler that you're going to take out? It might sound like a stupid question but would you be compensated for that; would they just pay the rest of it off because they're taking it? (Homeowner)

I've got a Worcester boiler and I pay a service plan upfront and I think it was for seven years or so. Anything that goes wrong, they just come out, literally phone them, come out, just sort it straight away. So, I guess talking of cost, two-year trial which you said they would give you the support and whatever, it's beyond that, what would be in place around helping you if you had problems after the trial. So, is there like a service plan equivalent that you'd get that after maybe? (Homeowner)

Other concerns raised included:

- Tenant compensation costs (see above)
- Liability costs (see above)
- Temporary costs resulting from switchover process (see switchover)
- Post-installation repair costs

- Appliance storage costs
- House and rental value costs
- Add others mentioned in previous sections

No concerns about costs

Whilst there were a significant number of concerns about costs, some participants trusted the promise of no additional costs being incurred as part of the trial:

You've said it's going to be reassured, like, safe and... yes? I can't see anything that's the downside. It's not going to cost me anymore. I'll give it a go. (Homeowner)

There's no cost. And, obviously, they're going to give you new appliances. That's not at a cost to yourself, so if you do eventually change over, you've already got the appliances in place. So, I'm assuming there will be no cost to the people that are trialling it. (Homeowner)

Yes. If it's true to the word and nothing can change, your expenses will not change with regards to your gas. It's not going to cost you any more to shower, any more to cook your children's dinner, your rent should not be affected, if it's true. (Tenant)

Reasons for wanting compensation

The main reasons for wanting compensation were to cover direct and indirect financial costs of trial participation. For landlords, the key concern was having to compensate tenants and cover potential liabilities (covered in section 4.10), but there were also other concerns.

For some, it was to cover uncertainty.

I think because everyone's being forced into it, they should give something as an incentive. If it was the fact that you put your hand up and said, "Yes, I want to be a part of it then maybe you shouldn't expect anything." You're picking this area, uprooting people in ways that they may not want to necessarily be uprooted (Homeowner)

For others, it was to act as a safeguard against failure to deliver the trial as promised.

There's no compensation for those three or four days which I think will probably go to well over a week actually of disruption, which a lot of people for very various reasons will find very difficult to cope with. (Homeowner)

Whilst others felt they should be compensated for the inconvenience imposed on them.

Homeowner: Uncertainty and hassle factors mean compensation is important. It's that gamble of being part of a trial and that upheaval I guess is being compensated in some way to go actually what have you had as a personal gain for doing that.

Facilitator: So, it's the upheaval and the uncertainty that you'd want to be compensated for?

Homeowner: Yes

There was some discussion about providing temporary replacement heating during the hypothetical switchover period, however it was felt that if this was the case, the cost of using such a heater should be covered.

Basics like the council do, but if you are giving somebody an electric heater because their heater has gone out, please also give them a card with some extra electric on it, because some people aren't in a position. (Tenant)

For some participants, there was an expectation that trials of this nature should automatically involve compensation, as other projects do.

There should be an incentive because like when people, like if land has to be demolished, like, HS2 is running through, they get compensation for their home. So, you're coming into my home, chopping up, putting in, whatever you want to do, where's my compensation, where's my four days off work that I've got to put back in? (Homeowner)

With one participant referring to them as 'guinea pigs'.

So, money needs to be given across the table, some sort of an incentive because you're a guinea pig aren't you, really? (Homeowner)

4.12 Incentives

In each focus group, prompts were used to seek focus group participant views on potential incentives for participating in the hypothetical community hydrogen heating trial. This was done through presenting examples of potential incentives:

- Community-wide incentives, such as the provision of a new community centre or a new local park
- Individual incentives, specifically the provision of an iPad for each household

Community incentives

Participants were asked the extent to which they thought a community incentive would improve their willingness to take part in the hypothetical trial. Specifically, they were asked to consider whether the provision of some form of community centre or the installation of a new local park would alter their willingness to participate.

There were three main types of positive response to the concept of a community benefit:

- Unconditional support for a new community facility, either for altruistic reasons (e.g. it had the potential to help others in the community, such as the vulnerable) or because they thought it would help convince others in the community to take part in the trial
- Support for a new community facility, but with an emphasis that it was 'not necessary' to offer this to persuade them to take part

You shouldn't have to force us into doing. I'll do it without you doing that. (Homeowner)

- Conditional support for a community benefit. Conditions included:
 - The need to tailor any community benefit to the community's needs, rather than offer 'generic' top-down incentives. This could be in the form of a new facility (e.g. a GP surgery) or an upgrade to an existing community facility. The implication was that a new community benefit should be developed in consultation with the community and tailored to specific community needs

- The need to ensure that any new community facility is provided with sufficient funding to staff and maintain it in the long-term. There was a concern that community facilities rely on continual investment and funding, which could be cut in future years

You need a guarantee to say, "Okay. We are going to make a community centre, and we are going to give a guarantee of a 10-year lease that it will be filled with a budget. Everyone will be able to use it the whole time (Tenant)

- Support for a community centre, but with the suggestion that it be used as a point of support and potential refuge for those that needed it during the switchover process.

There were a number of negative responses to the concept of a community incentive to participation. These included:

- The view that community facilities such as parks and community centres should be provided by governments as a matter of course

Those are the things that we pay for anyway with taxes that should be provided anyway. That's not an incentive. That's quite annoying to say, "You can have a community centre (Landlord)

- Linked to the above, the notion that the offer of a community facility was a form of 'bribe' or cynical manoeuvre to win them over, implying that it could backfire and negatively impact on their willingness to participate

It's kind of emotional blackmail in a way (Homeowner)

- A concern that a community facility would only benefit some of the population but not all. With a park, for example, there was a view that it might only benefit those with children

Actually, if you look at both options, I don't think it's going to suit everyone (Homeowner)

- A view that a community centre or park was needed in the local area because they already existed (this links to the point above about the need to tailor benefits to a community's needs)
- Concerns that a new facility would not be maintained or funded in the long-term (linked to the point above about the need for long-term financial support for new facilities)
- Worries relating to safety (e.g. that local parks could get vandalised or that the elderly would not visit community centres because of safety fears)
- The view that some areas lack a sense of community and therefore that community members would not identify with the concept of a community-wide benefit.

Suggestions for alternative, more acceptable community incentives, focussed on ensuring that any community incentive was tailored to local needs and developed in consultation with the local community. Specific examples mentioned in the focus groups included addressing local homelessness and improving local safety, but the emphasis here was on identifying locally supported, locally needed solutions.

Individual incentives

Participants were asked the extent to which they thought a free iPad for each household participating in the hypothetical trial would incentivise consumers to take part in the trial. The proposition was that each household would be given an iPad and in return consumers would be asked to provide trial feedback through the iPad for the duration of the trial. The household could then keep the iPad post-trial.

There was little support for this suggestion. Issues highlighted by focus group participants included:

- The view that an iPad would not be universally liked or useful by consumers. Participants highlighted, for example, that many households already owned iPads, elderly or IT illiterate consumers may not find a tablet useful or usable
- Concerns about agency and choice over the type of incentive offered to consumers. Participants questioned why an iPad was chosen as an incentive instead of, for example, the equivalent in cash or other potential incentives. The implication was that imposing a certain product or incentive type on consumers removed their agency and made it less likely consumers would appreciate it
- A question about whom ownership might be ascribed to (e.g. which member of a household would it belong to; in tenanted properties, would it belong to the landlord or the tenants). There was also the question of who the iPad belonged to in instances where householders moved homes during the trial; should the iPad remain in the trial property or could it a householder take it with them
- Concerns that some consumers may abuse the incentive, for example by selling the iPad before the trial was over.

Focus group participants made a range of different suggestions for alternative individual incentives. These included:

- Providing households with free or reduced energy bills for some or all of the trial period. This was the most commonly suggested incentive.
- Waiving or reducing council tax for some or all of the trial period.
- Cash payments
- Other individual incentives.

5. Conclusions and recommendations

Summary of conclusions by Research Question

Replacing natural gas with hydrogen in an every-day setting – piping hydrogen to homes and businesses through the existing gas network – is a new and untested proposition. At the same time, piloting this proposition is an essential ingredient to a well-managed low carbon transition. These ‘novel’ and ‘necessary’ themes run through our research.

The literature review uncovered no directly comparable pure hydrogen trials from which lessons could be learnt. Instead, insight has been drawn from mainly low carbon energy trials as well as studies on consumer perceptions and attitudes. There is some focus group work which asks consumers directly about hydrogen in the home. We also ran a series of focus groups around the hypothetical proposition of a community-level hydrogen trial. These are, however, reliant on the best available information, gaps in which the trial itself is of course seeking to address. Inevitably then there are questions of trust in the information, and trust in government itself.

Given these key limitations, there are some key themes running through our overall findings which are organised here under each research question.

RQ 1 Who will be involved?

Which stakeholder groups and organisations need to be informed and supportive for a community level hydrogen trial to go ahead?

This question is essentially probing who needs to be informed and supportive of a community-level trial for it to proceed with buy-in from the community. Clearly, participating households and businesses are top of this list, with the evidence suggesting the need to carefully consider the diversity of attitudes and preferences on both the message (hydrogen heating) and the medium (print media, social media, word of mouth). There is no one-size-fits-all, with trial promoters needing to be flexible in how they communicate and respond to the community, perhaps understanding and mapping differences through a consumer segmentation approach.

Who would consumers expect/need to see endorsing a community level trial for them to be on board with participation?

Stakeholder mapping should serve to identify key organisations and community representatives. Evidence suggests that endorsement from relatable, trusted organisations and individuals can improve trial recruitment rates. Whilst the hypothetical hydrogen trial would involve a whole community converting to hydrogen gas on a mandatory basis (with the option of electric heating as an opt out), carefully selected endorsements could go a long way to improving levels of trust. Whilst consumers might expect trials to be led by government, there is a level of scepticism and distrust of top-down initiatives, which is where involvement of local government and local organisations could help.

RQ 2 Encouraging participation

How open to participating in community scale trials are stakeholders?

Literature review material focuses on the ability to recruit trial participants, which is interesting but not directly relevant to the hypothesised mandatory conversion trial. More important is the ability to win people over and to allay their concerns.

Our focus groups identified participants of all tenure and ownership type – homeowners, tenants and landlords – who were genuinely willing to participate in a community hydrogen on the terms presented to them. Participants were engaged and interested. Of those who could be classed as ‘willing recruits’, attitudes ranged from enthusiasm, to acceptance of the need for a trial, through to ambivalence. Others said they would be unwilling to participate or would have concerns that would need to be addressed or, potentially, compensated.

What affects consumer/local authority willingness to participate in trials?

The literature review and focus groups found that some consumers are likely to be motivated by the opportunity to make their own meaningful contribution to the transition to low carbon energy. The literature review suggests that these kinds of environmental motivations are more prevalent in certain groups (such as higher income groups) and that these sentiments can disappear when presented with a real prospect. That is, environmental messaging may well be helpful and effective, but cannot be relied upon in isolation.

Generally, consumers value familiarity and minimal disruption to daily routines. There will likely be a proportion of participants who are unwilling to undergo the inconvenience of a trial and there is a need to consider how to respond to this (with an incentive or otherwise). Vulnerable consumers may be especially anxious about change.

What are the barriers and challenges to participation and what are the solutions?

Consumers’ concerns will need to be addressed in an open and honest way. A number of studies conclude that concerns can be overcome with more and better information – but in the case of hydrogen heating and cooking, there is clearly a limit to the reliable information that is available. BEIS should expect consumers to question material that is more promotional than informative, and to be able to understand that issues will arise throughout the trial. Given this, the reassuring response is likely to be to show that concerns have been rigorously addressed as far as possible.

Primary concerns, and solutions, are:

Concerns	Possible solutions
Disruption in the switchover and scepticism that this can be kept to 3-4 days.	Training for contractors, schedule multiple tasks for same visit, use of local project officers to co-ordinate home visits. Good and ongoing communication with householders.
Loss of heating and cooking, especially for vulnerable households	Provision of alternatives for heating, hot water and cooking needs, where appropriate. Careful identification and mapping of vulnerable households, consider re-housing during switchover. May need specially adapted

	appliances. After installation, provide ongoing monitoring for vulnerable households to guard against self-disconnection.
Availability of qualified technicians who can repair faults	Ensure sufficient trained technicians, provide 24-hour hotline
Safety – both of consumers and contractors	Clear evidence that safety is primary focus, provide evidence of safety tests and safety record of hydrogen sector
Comparable utility to natural gas	Provide evidence that this will be the case, provide advice and support on use of new appliances
Higher running costs	BEIS intends that there will be no change in running costs but it is not yet clear how this will be achieved in practice. This should be resolved.
House sale value negatively impacted	Reassure householders that the switchover is fully reversible at the end of the trial
Landlord responsibilities to maintain the property, including heating, hot water and cooking appliances, could result in liability and reputational issues	Consider trial rollout in areas where there are known to be fewer rental properties, e.g. avoid student housing areas and areas of lower income. Look at legal obligations to tenants and consider need for legal protections.

What are the conditions of acceptance for consumers in taking part?

There were no clear ‘showstoppers’ identified through the literature or in focus groups, although some low carbon energy trials do screen out participation of vulnerable households. Affordability is a clear precondition for some trials, although should not be an issue in the current context. Otherwise consumers will expect disruption and change to daily lives to be minimised, both during the switchover and thereafter. Some consumers will also need to be convinced of the rationale for the trial and see that their ‘sacrifice’ has been worthwhile in environmental terms.

What do consumers expect from taking part in a trial?

Given the unfamiliarity of hydrogen heating and cooking, consumers appear to have no pre-formed expectations. There is some distrust of government messaging, having learnt from previous experiences such as the promotion of diesel cars.

What lessons can be learnt from previous/existing community level trials where there is significant disruption to local neighbourhoods?

Contractors need to be properly trained in the new technology. Careful scheduling of contractor’s work is essential to minimise disruption to households and neighbourhoods. In the focus groups some participants were sceptical that the trial would keep its promises on the level of disruption.

What safety concerns do consumers have and what assurances are needed to overcome these?

Generally, people are able to understand safety messages and consider the risk and likelihood of a catastrophic event. Focus group participants were largely accepting of reassurances that safety issues would be addressed. Where there was concern it was around the combustibility of hydrogen.

RQ 3 Finance and trial participation

How do stakeholders value local/environmental issues relating to heating?

There is certainly value placed in the environmental benefits of hydrogen heating, with some focus group participants being willing to participate on these grounds alone. However as already alluded to, the literature reveals that there can often be a disconnect between attitudes 'in theory' and 'in practice'. There is some evidence that support for new energy schemes can be boosted by community-level benefits (see below) but there is very little evidence on any specific link with local environmental improvements.

Are stakeholders willing to contribute to the costs of delivering a community level hydrogen trial?

Consumers are concerned to avoid additional costs of trial participation – directly from purchase of new equipment and indirectly such as loss of house value. Other stakeholders such as local authorities may be willing to support the project if framed as 'best value', but many may be short of staff and funds.

Are incentives necessary for stakeholders to be supportive of a community hydrogen trial?

Focus group participants were largely dismissive of the provision of what they perceived to be token benefits such as a community park. This view is also reflected in the literature which shows that to be well received, such "incentives" need to be meaningful and impactful and determined with the input of the community. Developers can otherwise be perceived as bribing the community in support of commercial interests. Financial incentives are seen as the most effective, and in the case of a trial such as this, focus group participants felt that lower energy costs would be the most appropriate incentive. In other contexts, such as renewable energy, socio-economic benefits (local jobs) or even community ownership of a project, are perceived as impactful and more likely to engender positive attitudes.

Key recommendations for a potential future hydrogen trial

Pre-trial:

- Establish key project partners including the local supply chain and engage early on their knowledge on and experience of hydrogen. Arrange for training where necessary
- Undertake stakeholder mapping and consumer segmentation exercises
- Survey the trial population for vulnerable households, possibly in tandem with technical surveys

- Develop relationships with the relevant local authority and key community organisations and representatives; consider whether they can provide endorsements
- Provide information about the trial, the reasons and benefits of it and the impact on participants. Develop the material in a visually appealing manner and in Plain language, accessible to all
- Provide information at an early stage, allowing for a reasonable lead-time and open channels of communication for questions
- Establish best available information on disruption, safety, utility etc. and incorporate into communication materials accordingly
- Take a multi-faceted approach to publicising the trial (e.g. hard copy leaflets, social media, word of mouth) ensuring working in partnership with local community organisations and representatives
- Identify a community liaison officer(s) who will make themselves known to all trial participants, to gain a better understanding of individual needs and provide participants with the appropriate assurances and contact details (e.g. the helpline). The community liaison officer(s) could be identified via one of the local community organisations
- Establish which residents will not be able to stay in their home during the switchover and make necessary arrangements
- Establish specific needs of vulnerable residents who will be able to stay in their homes and make necessary arrangements
- Establish agreed channels of communication with trial participants
- Provide clear guidelines on how the new system works and details of the helpline
- Provide detailed catalogues of replacement appliances with clear guidelines as to what participants can choose, and
- Arrange demonstrations of new appliances and establish the availability of testimony from previous users or advocates.

During the trial

- Provide a 24-hour helpline
- Provide alternative accommodation during the switchover for those that need it
- Provide regular updates via the agreed communication channels
- Ensure the community liaison officer(s) maintains direct contact with vulnerable residents throughout the switchover and responds to their needs accordingly including co-ordinating access visits
- Schedule work during the switchover to minimise household access requirements and time
- Keep a logbook of all faults and issues that are raised and details of what was done to address them

- Monitor welfare of vulnerable participants, ensuring they can operate the new technology and are able to maintain a safe indoor temperature; take mitigating action if welfare is at risk
- Ensure any damage caused during the installation process is rectified
- Ensure all participants have fully functioning heating system, hot water and cooking facilities
- Make arrangements for participants to change their mind and switch to electric heating, and
- Assist those selling their homes, consider providing support for extra conveyancing costs.

Post-trial

- Ensure all participants are included in the decision as to whether to remain with hydrogen heating or convert back to methane gas heating
- If converting back to methane gas heating, ensure comprehensive communication and explanation of the reasons and make necessary arrangements for the switchover, and
- If not switching back, ensure participants are aware of ongoing maintenance and service needs and plans and ensure they have appropriate guarantees.

Appendix 1 – Detailed methodology

Approach

The methodological approach to the review was based primarily on Quick Scoping Review (QSR) principles (see Table 5¹¹⁵).

Table 5: Main attributes of different types of evidence review

Attributes	Literature Review	QSR	REA	SR
Time duration*	1-2 weeks	3-5 months	5-8 months	10-18 months
Used to	Inform on a specific topic	Identify evidence available on a topic and summarise	Identify evidence available on a topic, summarise and provide a critical assessment of the evidence	Comprehensive review and assessment of evidence available on a topic
Search published data	✓	✓✓	✓✓	✓✓✓
Search additional sources of information		✓	✓✓	✓✓✓
Systematic map of evidence		✓	✓	✓✓✓
Informed conclusion upon completion	Maybe	✓	✓✓	✓✓✓
Critical assessment of evidence			✓	✓✓✓
Input from external experts	Maybe	Maybe	✓	✓✓✓
Estimated cost	<5,000	10-30,000	20-50,000	80-120,000

*Typical completion time after contract has been established and the project has commenced

A QSR type approach was chosen because it balanced the requirement for rigour with the limited timescales and budget available for the review.

¹¹⁵ Taken from: Collins A., Coughlin, D., Miller, J., and Kirk S. (2015), The Production of Quick Scoping Reviews and Rapid Evidence Assessments: A How to Guide, December 2015. A report for Defra and NERC.

Search protocol

PICO

In addition to the research questions set out above, the research was framed with a primary question, bounded by relevant Population, Intervention, Control, Outcome (PICO) elements. Identifying the PICO elements helped to ensure that the review was clear and focused. The PICO for this review is set out in Table 3.

Table 6: Hy4Heat Literature Review PICO

PICO Element	Description
Primary question	What is the evidence around good practice in relation to community trials involving low carbon heating systems or other relevant energy-related trials?
Population The subject or unit of study	Domestic dwellings (involving owner-occupiers, tenants and landlords of domestic dwellings). Stakeholders who would need to be involved in and supportive of a community trial
Intervention/exposure The proposed management regime, policy or related intervention/exposure applied or investigated	An offer to households within a specified area (community) to participate in a community hydrogen heating trial, involving the replacement of existing heating systems and/fuels with hydrogen-based equivalents
Comparator The control with no intervention or an alternative to the intervention	Not applicable
Outcome The effects of the intervention	All households within the specified area agree to participate in the community hydrogen heating trial

Scope: inclusion/exclusion criteria

We used the following inclusion and exclusion criteria to help focus the review.

Table 7: Inclusion/exclusion criteria

Criteria	Description
Geography	UK OECD
Language	English only (restricted timescales and budgets preclude other language inclusions)
Dates	Only literature produced post-2009
Evidence type	Evidence that includes empirical evidence (as opposed to evidence that is solely theoretical)
Sector/population	Only studies focused on residential properties and/or householders to be included Studies involving geographical communities of homes and householders to be given highest priority
Intervention & technology	Evidence in relation to public attitudes and views towards hydrogen heating Evidence relating to schemes, projects and trials involving the recruitment or engagement of households and/or local authorities in physical home energy interventions (i.e. involving the installation/replacement of energy measures, but not including behavioural measures)
Access	Publications available for free We will log publications that are not free and that we don't have access and discuss with the steering group whether access could be facilitated if the evidence is worthy of inclusion for the shortlist
Other restrictions	Selection of academic papers limited to those which reach a minimum of ten overall citations (with an exception for those publications which were published in 2018-2019 as they will have had limited time to receive citations)

Search locations

We included academic, unpublished and grey literature in our search.

Table 8: Search locations

Literature type	Locations
Grey literature	Consultation with project steering group ScienceDirect Google CAG team knowledge British Library Doctoral theses search: https://ethos.bl.uk/Home.do British library Explore: http://explore.bl.uk/primo_library/libweb/action/search.do?vid=BLVU1 http://www.opengrey.eu/ https://hydeploy.co.uk/about/document-library/
Unpublished literature	Consultation with project steering group
Academic literature	ScienceDirect

Search keywords

For our searches, the following search terms were identified, based on the PICO and research questions.

Table 9: Search keywords

Population terms	Technology terms	Intervention terms	Recruitment and engagement terms	Attitudinal terms
Community(-based)	Heating	Trial(s)	Marketing	Attitudes
Area-based	Energy	Initiative(s)	Recruitment / recruiting	Views
Household(er)	Energy efficiency	Scheme(s)	Participation / participant / participation	Challenges

Consumer	Heat pump(s)	Intervention(s)	Engagement / engaging	Barriers
Domestic	Smart meter(s)	Pilot(s)	Support/ing	Perceptions
Local authority / local authorities	Hydrogen heating			Lessons
Council(s)	Boiler(s)			Learning
Residential	Appliance(s)			Disruption
Tenant(s)	District heating			Occupied

Search and screening process

Keyword search trial

Combinations and different conjunctions of these terms were trialled. Each search included at least 3 to 5 different terms to ensure a high level of relevance. Test searches involved reading titles only and keeping a numerical record of all relevant results so as to design better follow-up searches.

The results of initial search trials are detailed in our interim literature review report.

Full search process

Following the trialling of search terms:

- 15 combinations of search terms were applied to ScienceDirect
- 2 combinations of search terms were applied to Google
- Further ad hoc searches were conducted in other locations.
- Together with the literature identified through consultation with the steering group and partners in CAG, 1,647 items of literature were identified.

The details of the individual pieces of evidence were recorded in Mendeley¹¹⁶.

¹¹⁶ Mendeley is a reference management tool <https://www.mendeley.com/>

Screening

On completion of the search, we screened the results. This was done in two phases.

Phase 1

The first phase screening involved reading only the title or headline of the evidence found.

The evidence sources were marked as: clearly relevant, clearly not relevant or uncertain. Evidence that was clearly not relevant (based on the inclusion/exclusion criteria above) were excluded. If the evidence was found to be clearly relevant or uncertain at this first stage, it passed through to the second phase.

Phase 2

The second phase involved reading the abstract or first paragraph (or more if necessary) of the clearly relevant or uncertain evidence to identify those that meet the inclusion/exclusion criteria. Those marked clearly relevant were then moved to the critical appraisal phase.

Table 10: Search and screening results overview

	ScienceDirect	Google search	Grey literature, steering group consultation, snowballing & other sources	Totals
Literature identified before screening	1,505	100	42	1,647
Literature after Phase 1 screening	192	12	32	236
Literature after Phase 2 screening	15	1	19	35

Assessing the Relevancy of the Evidence

All evidence marked clearly relevant after phases 1 and 2 of the screening phase were assessed to evaluate the relevancy of evidence in relation to the research questions.

To do this, the evidence was reviewed and ‘tagged’ according to its:

- Relevance to each of the main research questions or themes (see research questions above)

- Relevance to the target populations/sectors (e.g. interventions aimed at multiple households in a geographical area being most relevant)
- Relevance to the technologies (e.g. hydrogen heating being most relevant), and
- Relevance to the interventions (e.g. recruitment for heating trials being most relevant).

Against each of the above, the evidence received a relevancy rating:

- Highly relevant
- Medium (some relevance, but not the focus of the evidence)
- Low (only very loosely relevant)

The evidence will also be tagged according to geography:

- UK
- Europe
- International

Shortlisting and review

Using the process above, we shortlisted 29 individual pieces of literature review.

We then adopted a staged process for reviewing the literature. This involved reviewing the list after 12 pieces of literature have been reviewed (and again after 20) in order to:

- Assess any gaps against the literature review questions
- Identify whether any new evidence has been identified through 'snowballing' (i.e. literature that has been identified during the review itself), and
- Revise and prioritise the shortlist.

In total, 25 items of literature were reviewed.

Coding and analysis

A coding spreadsheet – based on the research questions - was developed to capture and code the findings from the review. The results were then analysed thematically against the research questions.

Appendix 2 – Literature coverage

Paper	Trial	Hydrogen	Low carbon energy	Scale	Research methods
1		X			Literature review Workshops Stakeholder engagement
2		X	X	National	Focus groups Workshop Survey
3	X		X		Field trial
4			X		Literature review
5		X		City	Literature review Presents methodology for evaluation
6			X	National	Online focus groups – deliberative scenario planning
7			X		Literature review
8			X	International	Literature review Interviews
9	X		X	Community	Trial report
10			X	National	Workshops Survey Interviews
11			X	National (city-based workshops)	Deliberative workshops

12			X	National	Literature review Workshops Home visits Energy monitoring Survey
13	X		X	National	Field trial Telephone survey
14	X		X		Recruitment campaign Survey
15			X	Community City	Literature review Survey Focus groups
16			X	National	Literature review Stakeholder workshops
17			X		Literature review Survey
18			X	Community	Literature review Interviews
19			X	International	Literature review Discrete choice experiments Survey
20			X		Literature review Narrative synthesis framework
21			X	National	Interviews
22			X	Community	Interviews
23			X	Community	Interviews Focus groups

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24	X			Community	Trial fieldwork Interviews Survey
25			X	Community	Quantitative survey Theory of Planned Behaviour analysis
26				Community	N/a – newspaper article

Appendix 3 – Further research and evidence gaps

This section highlights evidence coverage and gaps in the literature review findings in relation to the research questions. It also sets out how the findings, and our analysis of evidence gaps, informed the design of the focus groups that followed this review.

Evidence coverage and gaps

Table 11 summarises the extent to which the evidence reviewed in this literature review covered the individual research questions posed by the project steering group.

Table 11 Coverage of the research questions by the literature reviewed

Research question	Detailed research question	Paper
RQ1: Who will be involved?	1.1 Which stakeholder groups and organisations need to be informed and supportive for a community level hydrogen trial to go ahead?	1, 2, 9, 19, 20, 21, 22
	1.2 Who would consumers expect/need to see endorsing a community level trial for them to be on board with participation?	2, 9, 10, 11, 15, 20
RQ2: How can we encourage participation?	2.1 How open to participating in community scale trials are stakeholders?	2, 11
	2.2 What affects consumer/local authority willingness to participate in trials?	2, 5, 6, 8, 9, 10, 11, 13, 14, 15, 17
	2.3 What are barriers and challenges to participation and/or commitment to trials, including trials involving hydrogen? Which of these can be overcome and which are insurmountable?	1, 2, 4, 6, 8, 9, 10, 11, 12, 15, 16, 17, 18, 20, 21, 24, 25
	2.4 What are possible solutions to barriers and concerns around participation?	1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 15, 18, 19, 20, 22, 23, 24, 25
	2.5 What are the conditions of acceptance for consumers in taking part?	2, 3, 6, 7, 18
	2.6 What do consumers expect from taking part in a trial?	2
	2.7 What lessons can be learnt from previous/existing community level trials where there is significant	3

	disruption to local neighbourhoods e.g. installation of subsurface utilities and modification of utility provision within homes?	
	2.8 What safety concerns do consumers have and what assurances are needed to overcome these?	3, 7, 11
RQ3: Finance and trial participation	3.1 How do stakeholders value local/environmental issues relating to heating? E.g. how important are local carbon reductions, local air quality, moving to 'greener' fuels for heating as a community?	2, 4, 6, 11, 15, 18, 21
	3.2 Are stakeholders willing to contribute to the costs of delivering a community level hydrogen trial?	2, 8, 21
	3.3 Are incentives necessary for stakeholders to be supportive of a community hydrogen trial? E.g. improvements to neighbourhood (community centres, green spaces etc.)	7, 18, 21, 22

The table indicates there was generally good coverage against most research questions, particularly 2.2, 2.3 and 2.4.

Research questions with relatively little coverage included 2.1 (willingness to take part in community trials), 2.6 (consumer expectations about taking part), 2.7 (lessons from previous trials involving significant disruption), 2.8 (safety concerns) and 3.2 (willingness of stakeholders to contribute to delivery costs).

The focus groups provided supplementary evidence in relation to 2.1, 2.6 and 2.8. Evidence in relation to 2.7 was not a focus group priority as they focused on a hypothetical future trial rather than a previous trial. Further research might be required in order to ascertain stronger evidence about stakeholder willingness to contribute to trial cost (3.2). This could be done, for example, through qualitative research with local authorities and other stakeholders deemed likely to be important in any community trial.

Focus group recommendations

The need for focus groups

As highlighted in chapter 3, this review highlighted that there is limited literature on trials comparable in nature to a hydrogen heating trial and none which is directly comparable at the community level, involving disruption, new technology and, crucially, there being no choice in loss of natural gas heating. This underlines the need for, and importance of, running focus groups to test reactions to a potential community hydrogen heating trial.

Implications for focus group research questions

Table 12 sets out the research questions that were highlighted by the steering group at the project outset as important for the focus groups. We reviewed these questions in the light of the literature review and the 'draft scenario' for the hypothetical trial, submitted separately by the project steering group. In response, Table 12 sets out the recommendations we made prior to the focus groups on the extent to which the focus groups should explore each question.

Table 12 Research questions for the focus groups

Detailed research question	Comment following literature review
1.2 Who would consumers expect/need to see endorsing a community level trial for them to be on board with participation?	Good evidence in literature review but include as probe in topic guides
2.2 What affects consumer/local authority willingness to participate in trials? [consumer willingness only]	Good evidence but this will be a central theme of the focus groups (i.e. it was agreed with the steering group that a primary focus will be understanding why consumers would/would not want to take part in a potential trial). Use findings to inform core topic guide questions
2.3 What are barriers and challenges to participation and/or commitment to trials, including trials involving hydrogen? Which of these can be overcome and which are insurmountable?	Good evidence but this will be a central theme of the focus groups (i.e. it was agreed with the steering group that a primary focus will be understanding why consumers would/would not want to take part in a potential trial). Use findings to inform core topic guide questions
2.4 What are possible solutions to barriers and concerns around participation?	Good evidence but this will be a central theme of the focus groups (i.e. it was agreed with the steering group that a primary focus will be understanding what would help address barriers to participation). Use findings to inform core topic guide questions
2.5 What are the conditions of acceptance for consumers in taking part?	Testing conditions of participation should be revealed as part of the discussion on the above
2.6 What do consumers expect from taking part in a trial?	Testing expectations from participation should be revealed as part of the discussion on the above
2.8 What safety concerns do consumers have and what assurances are needed to overcome these?	Safety won't be tested specifically in the trial, but perceptions of safety might arise as a barrier to participation. Include probes on safety assurances in topic guides, to be used if safety concerns are highlighted
3.1 How do stakeholders value local/environmental issues relating to heating? E.g. how important are local carbon reductions, local air quality, moving to 'greener' fuels for heating as a community?	Suggest we don't ask this explicitly in the focus groups but instead monitor the extent to which views on environmental issues affect views around participation

<p>3.2 Are stakeholders willing to contribute to the costs of delivering a community level hydrogen trial?</p>	<p>Does not feel relevant for this focus group research, having reviewed the draft scenario. Suggest removing as a question for the focus groups. But to be considered as part of any future research as literature review evidence limited</p>
<p>3.3 Are incentives necessary for stakeholders to be supportive of a community hydrogen trial? E.g. improvements to neighbourhood (community centres, green spaces etc.)</p>	<p>Good evidence but this will be a central theme of the focus groups (i.e. it was agreed with the steering group that a primary focus will be understanding what would help address barriers to participation). In particular, agreed to include example of individual and community benefits to prompt discussion of the types of incentives/benefits that might help encourage participation</p>

Overall, the table highlights that most of the questions were still relevant and important. Nonetheless, we prioritised these for the purposes of the focus groups given the limited time available for discussion. Our focus group design was therefore based around two key themes:

- Barriers and benefits to participation in a community hydrogen heating trial, and
- Exploring solutions to overcoming barriers to participation.

As highlighted above in the table, focusing the sessions on these two main themes – together with developing suitable prompts and probes in the topic guides – enabled us to draw out relevant findings for all of the research questions that were still relevant (i.e. all but 3.2).

Appendix 4 – Focus group participant handout

Focus group on trialling hydrogen heating systems

Thank you for taking the time to take part in our focus group on alternative home heating systems. Before we meet, we thought it would be useful to give you a bit of background information ahead of the focus group session.

Don't worry – you don't need to know need to be an expert on hydrogen heating for the focus group! But we would be grateful if you could familiarise yourself with this short introduction before you arrive.

What will you be asked to talk about?

During the focus group, we would like you to imagine that you and your neighbours have been asked to take part in neighbourhood 'hydrogen heating' trial. For all homes on the trial area, the trial would involve the replacement of existing gas heating systems and appliances with like-for-like hydrogen alternatives.

As the UK considers the future of home heating in a low carbon world, the purpose of the trial would be to test the feasibility of rolling out hydrogen heating in other parts of the UK and to understand the customer experience of using hydrogen heating and appliances.

We will tell you more about this hypothetical trial in the focus group itself. We then want you to be yourselves and think about how your family, friends and neighbours might respond if asked to take part. What might the benefits of taking part be? What challenges do you foresee? And how willing would you be to participate?

What is hydrogen heating?

Heating is the single biggest reason we consume energy in our society and is responsible for over a third of the UK's greenhouse gas emissions. In 2019 the UK government set a legally binding-target to achieve net zero greenhouse gas emissions from across the UK economy by 2050. Meeting our net-zero target will require virtually all heat in buildings to be decarbonised, including homes. One way to help achieve this might be using hydrogen, a low carbon gas, as a way of providing heat in homes.

Hydrogen heating is using hydrogen as an alternative to natural gas, as it has very low carbon emissions when burned. The hydrogen gas would be supplied in the same way that natural gas is now – through the same pipes if they were suitable (or replacement ones if needed) directly into your boiler at home. Using hydrogen for heating would therefore be similar to current gas central heating, except that you would have a hydrogen boiler burning hydrogen, not natural gas. Heat would be provided through the radiators as usual, and also hot water.

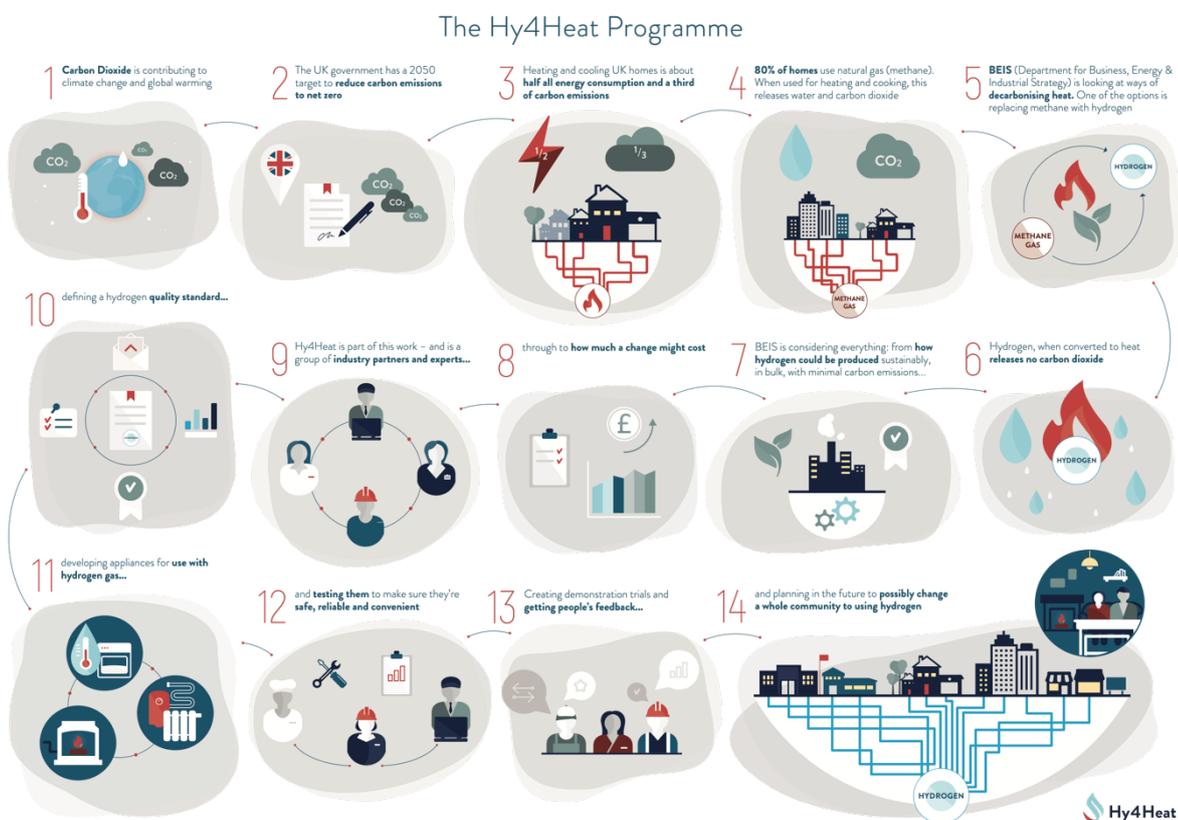
Other sources of heat, like gas cookers and gas fires, would be supplied in the same way, through the pipes in the house, but using hydrogen instead of natural gas. To allow them to use hydrogen, these appliances would need to be replaced with hydrogen-ready ones.

We look forward to seeing you soon. Thank you again for agreeing to help us.

Background: about the Hy4Heat programme

This information is not essential reading for the focus group but is provided in case you'd like to know more about the research programme these workshops will inform.

Hy4Heat is part of a programme of work being undertaken by the government department of Business, Energy and Industrial Strategy (BEIS) to explore and test different approaches to decarbonising heat in the UK. Heating will need to be almost completely decarbonised if the UK is to meet our target of reducing emissions to net zero by 2050. Hydrogen is just one of the approaches being looking at. Other options include heat pumps, which use electricity instead of gas to produce heat, and heat networks, where heat is supplied to buildings through pipes in the ground.



This study is part of the government's Clean Growth Strategy, aimed at stimulating developments in a range of technologies which could form part of the solution to decarbonise heat. These include biogas, energy efficiency and storage solutions, carbon capture and use, heat pumps, heat networks, nuclear technology and hydrogen gas a replacement for methane.

If you would like to know more about the government's work on heat decarbonisation you can visit <https://www.gov.uk/government/publications/heat-decarbonisation-overview-of-current-evidence-base>

The Hy4Heat programme also has its own website www.hy4heat.info.

Appendix 5 – Hypothetical scenario for a community trial – to support focus group discussions

Document Verification		
Role	Name	Signature
Author	Liliana Cadau	

Revision history	
Revision	Description of Amendments
1.0	First draft for comments – 07/08/2019
2.0	Second draft – incorporating comments – 10/09/19
3.0	Final draft – 16/10/.19

Purpose

The purpose of this document is to outline a possible scenario for a hypothetical community trial, so that Focus Group have something to base their discussions on.

This scenario is based on a number of assumptions made exclusively for the purpose of the Focus Groups.

It is not suggested that this document is used in its entirety for focus groups but rather to assist and inform the agency appointed to run the groups.

Community Trial Scenario

The following list includes a range of statements and assumptions for a hypothetical community trial scenario to support discussion in the focus group.

Context

Heat accounts for over a third of the UK’s greenhouse gas emissions. Meeting the Government’s 2050 net-zero target will require heat in buildings to be almost completely decarbonised.

There is no clear consensus on the best approaches to decarbonising heat at scale. However, there are a number of options with potential to play an important role, including heat networks, heat pumps, hydrogen and biogas. We need to continue exploring and testing different approaches to heat decarbonisation and this may involve hydrogen trials in the future.

Purpose of the trial, safety aspect and stakeholder engagement

The purpose of the hypothetical community trial would be to test the technical and logistical feasibility aspect of using hydrogen in domestic setting (e.g. for heating), as well as getting an insight on the customer experience of using simple hydrogen domestic appliances. The feedback provided by the customer would provide useful information for any future development of hydrogen appliances, as well as on the overall convenience of using hydrogen as an alternative energy source.

The purpose of the trial would not be to test any safety aspect of using hydrogen in domestic setting: all the necessary tests and certification of compliance with relevant safety standards (both related to the appliances and to the distribution of hydrogen) would be completed ahead of the potential trial. To this regard, and for the purpose of the trial, it is envisaged that:

- Like methane, hydrogen is a flammable gas, and there will need to be strict controls and safety measures around its use - these will be defined and agreed ahead of any potential trial.
- Appliances such as boilers, cookers and fires, are being developed specifically for use with hydrogen and will be tested, accredited and licensed for use in the same way appliances are now
- The gas will smell the same – and any leaks should be reported as they are now

Note to CAG moderators: underline that the trial would not be about safety trialling – all testing, validation, certification, etc would be done in advance of any trial.

The hypothetical trial would take place in a suitable area where a reliable source of hydrogen can be provided. Appropriate consultation with the relevant local authorities, the public and other key stakeholder would be part of the planning for the trial. More specifically:

- A significant amount of communication would take place to ensure that all local residents in the homes that are to be part of the community trial (and also in the neighbouring roads and area) were aware, understood and accepted the temporary change from natural gas to hydrogen.
- The communication would begin more than a year in advance of the changeover happening
- The communication would include:
 - Letters / postcards / radio adverts / local newspaper articles / doorstep visits / face to face meetings / local townhall meetings / etc
 - Activity would be inclusive to ensure that any vulnerable people (elderly, non-English speakers, etc) were communicated with appropriately

What would be tested?

- How an end-to end system (i.e. from hydrogen source to domestic appliances) works in reality
- Real-world learning about technical and logistic challenges associated with the switchover process
- Refined estimates of the likely costs associated with the switchover (not consumer costs)
- Appliances acceptability and the user experience.
- What useful learning could be gained for a potential future national rollout

The switchover/conversion process

- A community trial would last for around two years
- The switchover to hydrogen would take place in summer... (as this is the season when energy use for hot water / heating is lowest)
- A community trial would take place in a suburban town / village area and comprise around 300 homes (and maybe one or two small commercial buildings – e.g. fish and chip shop / pub, library etc.)
- All homes and properties on the gas network would need to change to use hydrogen gas
- It would not be possible for anyone in the area to remain using natural (methane) gas
- The actual switchover conversion to hydrogen from methane gas – would involve a number of visits to every home:
 - An internal survey to inspect internal pipework, etc., this would likely take approximately an hour or two – there may be remedial work to gas pipework required there and then, or at a later date.
 - A changeover of home appliances (boiler, cooker, gas fireplace) – this would likely be a few hours – approximately half a day
 - A visit to complete the conversion - length may vary but target would be that it does not require more than half-day
- The gas conversion process for a community trial would mean that householders would be without a gas supply (i.e. heating and hot water, gas for cooking) for around three to four days. Consideration would need to be given to potential provisional measures used during the changeover.
- There may be some other disruption in the lead up to the switchover, for example roadworks, if any work on the gas network infrastructure is needed

Supporting people during the trial

- There would be a helpline / specific to the trial so that anyone can ask questions / get assistance

- Any problems with appliances would be remedied / replaced quickly [at no cost]
- Consumers would be asked to provide feedback on their experience at regular intervals. There may be some level of monitoring of appliance performance/usability.
- After the trial – it may be that they stay on hydrogen if the wider gas network is being converted to hydrogen – or they would be converted back to using methane gas once again (once again, at no cost but we assume at the same level of disruption)

Cost & compensation

- People taking part in the trial will not be financially disadvantaged – i.e. there would be no cost to be borne by the people taking part
- There would not be a direct financial incentive for those taking part in the trial
- People would pay the same for their (hydrogen) gas as they do today for (natural) gas - and pay their bill in exactly the same way
- Everyone taking part would be given hydrogen appliances (boilers, cooking hobs, cookers, meters, etc) and shown how to use them
- Any work carried out would be made good
- People could still buy / sell homes during this time
- Anyone not wishing to convert from methane to hydrogen gas could choose to convert to electricity (at any time before or during the trial)

User experience

- Gas central heating systems would be very similar. Although the boiler would be changed, it would be replaced by one of a similar shape and size, in the same location. Radiators would not be changed.
- Controlling the heating system would also be similar, using a thermostat and timer to set temperatures and when the heating comes on and goes off.
- The gas would come into the house in the same way as it does now, through the gas meter. A new gas meter would be fitted in place of the old one for the trial.
- Other appliances that use gas (cookers and gas fires) would be replaced with ones that match as closely as possible to the existing.

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