APRIL 2022

Authors: Professor Zoe Robinson
Dr Adam Peacock | Dr Maddy Thompson
Dr Phil Catney | Keele University, UK

Keele UNIVERSITY

CONSUMER PERCEPTIONS OF BLENDED HYDROGEN IN THE HOME: LEARNING FROM HYDEPLOY

ACKNOWLEDGEMENTS

The authors would like to thank Professor Marylyn Carrigan at Herriot Watt University and Professor Victoria Wells for contributions to this research in relation to the study carried out at Keele University. The authors would like to thank the HyDeploy consortium partners for their support in undertaking this research. The authors would also like to thank the residents of Keele University and Winlaton for taking part in the interviews and surveys that are at the core of this research.

CONTENTS

EXECUTIVE SUMMARY

The HyDeploy project has developed the safety case and delivered a hydrogen blend via the gas network into customers' homes in the UK. This report presents findings of research into the perceptions of consumers who received the hydrogen blend in their homes as part of the HyDeploy demonstrations at Keele University in Staffordshire, North Midlands, and in Winlaton in NE England. The key findings are summarised below:

1. Despite very different demographics for the two areas of the HyDeploy trials, the research carried out on consumer perceptions of the use of blended hydrogen in the home linked to both trials demonstrates similar findings, suggesting that these findings may be generalisable to the wider UK population.

2. Overall, the research findings show high levels of acceptance of the use of blended hydrogen in the home and a willingness to experience new energy technologies that support action on climate change.

3. Within both trial areas high levels of place attachment were evident, leading respondents to express pride that 'their' area was at the vanguard of new innovations. This highlights that if blended hydrogen or other energy technologies are rolled out on an area basis, placing the area at the forefront of new innovations may have a positive impact on public engagement.

4. The public associations with hydrogen are mixed. Within our research, negative views associated hydrogen with explosivity, and positive views associated hydrogen with being 'clean.' Many associations with hydrogen are relatively neutral or exhibit a level of uncertainty regarding the science and technological innovation behind blending hydrogen in the home. Overall, this research shows there are low levels of understanding of hydrogen as an energy technology, including for some, an assumption of the 'green-ness' of hydrogen with limited awareness of the implication of different hydrogen production methods. This highlights the need for increased public education around hydrogen with clear and transparent communication around hydrogen sources in hydrogen projects.

5. One key area of difference between the Keele University and Winlaton trial locations was a greater concern pertaining to the cost implications for residents' energy bills in Winlaton. They related both to a) the use of hydrogen throughout the demonstration (although the trials led to lower bills due to specific billing arrangements during the trial) and b) the longer term cost associated with the future use of hydrogen. This highlights that the degree of public acceptance of blended hydrogen at a renewable energy technology is mediated by the implications for energy bills, with limited tolerance to increased costs and the need to ensure that new innovations do not adversely impact those already vulnerable to the price.

INTRODUCTION

1

This report presents the results of research into consumer perceptions and the subsequent degree of acceptance of blended hydrogen in domestic properties. Evidence from two trial sites of the HyDeploy programme: i) a private site trial at Keele University, North Staffordshire; ii) and a public site trial at Winlaton, Gateshead are discussed.

1.1 THE HYDEPLOY PROGRAMME

Hydrogen is recognized as a central technological pillar of the UK's decarbonisation strategy featuring in the UK Government's Ten Point Plan for a Green Industrial Revolution (BEIS, 2020a), the Heat and Buildings Strategy (BEIS, 2021a), the Net Zero Research and Innovation Framework (BEIS, 2021b), and supported by the Hydrogen Strategy (BEIS, 2021c). There are plans in the UK for a hydrogen neighbourhood trial by 2023, followed by a large hydrogen village trial by 2025, and a policy decision on hydrogen blending into the existing gas grid by 2023 (BEIS, 2021c). The HyDeploy programme is the UK's first live demonstration of the distribution of blended hydrogen with natural gas, up to 20% (by volume), in homes, and evidence gathered through HyDeploy will form a key input into government policy and decision making. Blended hydrogen can provide the opportunity to lower the carbon content of gas used within the current gas distribution system, while also acting as a key enabler of the hydrogen economy. The HyDeploy programme represents a significant milestone in the regulatory and technical journey to enable wider scale roll-out of hydrogen blending in the gas distribution system.

The HyDeploy programme represents a significant milestone in the regulatory and technical journey to enable wider scale roll-out of hydrogen blending in the gas distribution system.

The key objective of the first two phases of the HyDeploy programme (HyDeploy1 and HyDeploy2) was to develop the safety and technical evidence base, first through the use of blended hydrogen in a private gas distribution network (HyDeploy1 - Keele University) and subsequently in a public gas distribution network (HyDeploy 2 - Winlaton). An exemption to the 0.1 mol% hydrogen limit imposed by the Gas Safety (Management) Regulations (GS(M)R)) was awarded from the Health and Safety Executive enabling the legal transportation of up to 20% hydrogen in the gas network. In both phases, up to 20% (by volume) hydrogen has been blended into a live gas grid serving domestic properties for heating and cooking as well as a range of commercial boilers. The HyDeploy programme commenced in

2017 with blending at the Keele University site starting in October 2019 and finishing in March 2021. The time-limited blending started at the Winlaton site in August 2021, scheduled for trial completion in summer 2022.

The first live phase of the HyDeploy programme was at Keele University, a campus university in Staffordshire. The trial site encompassed approximately 100 homes and 30 university buildings. A significant part of the trial period took place during the COVID-19 pandemic, and blending took place between October 2019 and March 2021, with a 10 week operational hiatus due to the first national lockdown. A full report on the first phase of the HyDeploy project is available here (HyDeploy, 2021).

> We can use key lessons for the successful rollout of other sustainable energy technologies across the UK

The second live phase of the HyDeploy programme is in part of Winlaton, a small town in Gateshead, in North East England. Winlaton is a more typical residential area by UK standards and provides the opportunity to explore the results of the Keele study with a different demographic. The Winlaton trial encompasses 668 homes and several small businesses and community facilities. Blending commenced in August 2021. It is ongoing at the time of writing this report.

Combined, studying the perceptions of consumers affected by the HyDeploy trial helps develop understanding as to the likely consumer acceptance of hydrogen in the home as part of a net zero transition, and can help inform communication and engagement approaches to support future place-based hydrogen projects and use key lessons for the successful rollout of other sustainable energy technologies across the UK.

1.2 CONSUMER PERCEPTIONS OF HYDROGEN FOR HEATING

There is a recognition by the UK government that there is a need for increased public and consumer awareness and acceptance of hydrogen use. The UK government's Hydrogen Strategy (BEIS, 2021c) outlines the need to understand and address critical consumer barriers to the use of hydrogen, and the need to secure the engagement and acceptance of consumers and civil society in the use of hydrogen, to enable hydrogen to become a "widely accepted" decarbonised energy source by the mid-2030s. The UK Government's Net Zero Research and Innovation Framework (BEIS, 2021b) highlights the need to understand public attitudes towards low carbon technologies such as hydrogen and the need to identify measures that build consumer confidence. The role of the local context is also highlighted in the Net Zero Framework, in response to calls for place-based approaches to a net zero transition.

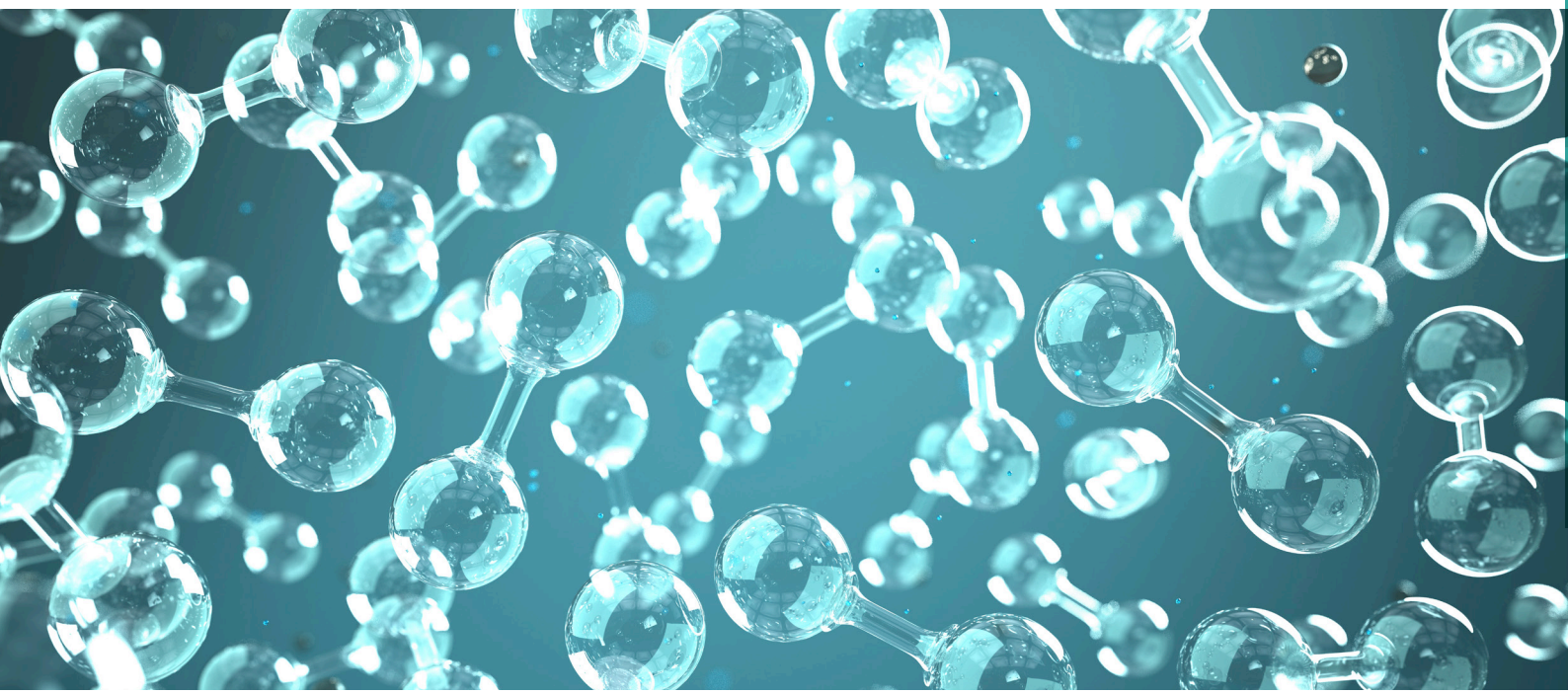
Here, research seeks to uncover consumer perceptions of hydrogen in domestic settings of those who are about to experience hydrogen blends in their own homes

Despite the desire for consumer-focused, place-based research that considers the importance of local context, the lack of live hydrogen projects and limited public understanding of hydrogen means that most existing research has taken a hypothetical scenario approach (e.g. BEIS, 2020b; Fylan et al., 2020; Scott and Powells, 2019), and has not been conducted with those who are currently (or are about to) experience hydrogen in the home or their local context. Here, research seeks to uncover consumer perceptions of hydrogen in domestic settings of those who are about to experience hydrogen blends in their own homes.

Developing better understanding of consumer perceptions of hydrogen is important as the national roll out of hydrogen in a road map to a net zero future is considered. The results from the HyDeploy trials at Keele University and Winlaton represent the first UK-based opportunities to explore at the time of writing, perceptions of consumers whose home gas supply is blended with hydrogen, both before (Keele and Winlaton) and after blending occurred (Keele).

1.3 REPORT OVERVIEW

THIS REPORT IS STRUCTURED INTO FOUR PARTS.



Part 1

is the report introduction

Part 2

outlines the results of the consumer research at the Keele University HyDeploy trial where residents' perceptions before and after the blending of hydrogen in their homes were collected.

Part 3

outlines the results of the consumer research at the Winlaton HyDeploy trial where residents' perceptions before the blending of hydrogen in their homes were collected.

Part 4

provides wider conclusions and recommendations drawn from the evidence from across the different trial sites.

2 | KEELE UNIVERSITY TRIAL

2.1 KEY FINDINGS FROM THE KEELE UNIVERSITY TRIAL

This section documents the perceptions of residents associated with the HyDeploy trial at Keele University, which took place between October 2019 and March 2021. In total, 16 interviews were held with residents prior to the trial commencing, and eight interviews held with residents towards the end of the trial.

There was strong support for the use of blended hydrogen in the home, in response largely to the perceived environmental benefits and the lack of disruption to households, and for some, a sense of being able to contribute to 'something bigger'.

There was strong support for the use of blended hydrogen in the home, in response largely to the perceived environmental benefits

Although safety concerns arose for some participants, these views were not expressed by all, with several expressing implicit trust in the process to be managed safely. Where safety concerns were expressed these reduced over time, through the opportunity to engage in discussion with members of the project team. Early, extensive project engagement therefore proved critical to residents' acceptance of the trial.

Even where residents themselves said they were happy to take part, several residents expressed dissatisfaction about the principle of the inability to 'opt out' of the project due particularly to the nature of the project involving people's personal property and families.

Other than one resident, no reference was made in the interviews to changes being experienced in the gas services provided to their homes once the trial had started. This one resident claimed they had noticed changes before the trial had begun.

Some residents referred to an increased environmental awareness and consciousness brought about by the HyDeploy project communications. No interviewees reported increasing their gas use in the knowledge that it manifested a lower carbon footprint (although this was self-reported not recorded behaviour).

A key area of dissatisfaction for some residents arose from a desire for more communication about the project as time passed (which included over the time of the COVID-19 pandemic lockdown), in contrast to the extensive communication during the initial stages. Several participants demonstrated a genuine curiosity about the project and desire to be kept informed about progress, findings and achievements of the project. These participants saw themselves as key, engaged stakeholders in the project with a right to be kept informed, rather than passive participants.

Participants were largely supportive of the prospect of 100% hydrogen in the home, although there would be a need for reassurance across a wide range of issues from safety, to cost implications associated with changing appliances and home disruption, as well as the need for a persuasive case to be made for hydrogen when compared to other low carbon solutions. The positive views of the potential use of 100% hydrogen were supported by residents' positive experiences of blended hydrogen in their home during the HyDeploy project.

2.2 METHODS

2.2.1 Trial location

Keele University is a rural, campus-based university in North Staffordshire, two miles from the nearest town of Newcastle-under-Lyme, on the western edge of the Stoke-on-Trent conurbation. The university has approximately 10,000 students and 2,000 staff. The campus is 600 acres in area and includes over 3,000 study bedrooms in university-owned student halls of residences, over 160 domestic properties, and a variety of academic and commercial buildings. The university owns its own utilities network including the gas grid. The HyDeploy trial took place on a portion of this gas grid provisioning the range of buildings shown in Figure 1 which included 100 domestic properties (from flats to detached houses), 30 commercial buildings including student halls of residences, a sports centre and several commercial catering facilities.

Figure 1: The domestic and commercial properties included in the Keele HyDeploy trial (marked in green)

2.2.2 DATA COLLECTION

The research during the Keele University trial site adopted a longitudinal, qualitative approach using semi-structured interviews with individual householders both before the blending trial commenced and close to the completion of the blending trial. Data were collected in two phases:

I) Pre-blend: July 2019. This phase of data collection was carried out four months before the trial started (October 2019), but after residents had received significant information about the trial

- 16 interviews with residents were conducted in total, face-to-face.
- Two of these interviews were with leaders of the local Residents' Association, who acted as gatekeepers, providing access to other residents and provided a broader view of resident perceptions.
- One of the Residents' Association representatives did not live in a property on the HyDeploy network.

II) End of blend: January 2021. This phase of data collection was carried out two months before the blending trial ended.

- Eight online (due to COVID-19 restrictions) interviews with residents were conducted in total.
- Seven interviews were with residents who were also interviewed during the pre-blend data collection, allowing a longitudinal approach.
- The final participant moved to the area after the trial had begun.

All interviews were recorded, transcribed, and analysed into a coding database. The interview schedules can be found in Appendix 1. The first set of interviews were deductively analysed, looking for key themes which emerged in the data. The second set of interviews were then inductively analysed against these key themes to assess changes in attitudes throughout the trial. Some new themes emerged from the end-of-trial analysis due to additional questions asked by the research team (i.e., willingness to support the use of 100% hydrogen after experiencing the trial).

While the participant sample was small and qualitative in nature (16 out of 100 households on the HyDeploy network), it was felt that data saturation was achieved. The data are robust as a consequence of the deep nature of the conversations held, which is a suitable approach for unpacking the wide range of possible reactions towards and perceptions of the hydrogen blending project.

This research was funded by Keele University and received approval from the Keele University Humanities and Social Sciences Ethical Review Committee.

Sample Characteristics

The age range of interviewees was broad, representing views from those in their twenties to their eighties. Similarly, the length of time in their property was varied, ranging from less than a year to over 21 years. There was a mix of residents in rental properties and private ownership. Respondents interviewed for phase one were 12 males and four females and for phase two, seven males and one female. Although all living on the Keele campus, participants included current employees, partners of employees, and former employees of Keele University.

Limitations

This small-scale study represents over 10% of households involved in the HyDeploy trial on the Keele University campus and covers a diversity of property and individual attributes. However, it must be acknowledged that the Keele campus resident community are not representative of the wider public. On average, participants in this study were likely have a higher level of education and be more economically advantaged than the average UK population. In addition, complex, multi-faceted relationships between Keele University as an employer (for some), landlord (for some), energy provider (for all) and key project stakeholder, will inevitably influence some residents' views of the HyDeploy project in both negative and positive ways.

2.3 RESULTS

Description of the results below draws on both the pre-blend and end-of blend phases of data collection. Quotations from interviews are used throughout to illustrate key points.

Results are structured into:

i. Overall views of the HyDeploy trial.

ii. Areas of concern.

iii. Resident experiences of the trial.

iv. Views on 100% hydrogen.

v. Lessons for effective communication.

2.3.1 Overall views of the HyDeploy trial

Overall, participants expressed largely positive views of their households being part of the HyDeploy project at Keele University. Residents generally acknowledged and welcomed the perceived decarbonisation benefits of the trial. Most participants reported little disruption both prior to and during the trial and valued the feeling of contributing to climate action without needing conscious effort.

"Thinking about how little I've had to think about it means that..., that's part of why it's such a great project...it's just something that the work is not put in by the consumer...oh I'm contributing by doing nothing. Where else do you get to do that?" (Pre-trial, HYDEP114)

"I'm really glad to have been part of a trial that's like, actually I didn't even notice it was happening most of the time...It's not caused problems. It's not been a significant inconvenience" (End-of-trial, HYDEP113)

Some participants viewed the trial and their (and Keele University's) involvement in an extremely positive light, going beyond just acceptance of the trial to expressions of excitement.

"Just excited. I was excited as you can be about hydrogen gas"
(Pre-trial, HYDEP118)

"Environmental sustainability is something that I feel quite passionately about personally. And so actually to be able to be involved in something that could have quite a far-reaching impact longer term was quite exciting"
(End-of-trial, HYDEP 113)

Such positive reactions may be linked to pride in a place to which they feel attached (place attachment), in this case the University, and the distinctiveness that the project gives to the place (Devine Wright, 2011), or the 'psychological reward' and 'warm glow' that can be associated with acting in a way which is seen to be 'environmentally friendly' (Taufik et al., 2015).

"The fact that it's been all over the news across the world that we've seen, and seen that high level engagement is great. Because you're part of that, even if it's just your boiler and your fireplace getting it you're still part of it...Yes, I think pride and I think it's a great thing, A, for the university, but, B, from a technological aspect going forward in terms of energy. It's a great thing, and it's great to see the university on the map for positive things". (End-of-trial, HYDEP118)

2.3.2 Areas of concern

Despite the overall positive views of taking part in the HyDeploy project some areas of concern were articulated. These relate to two primary areas: safety concerns about the experimental nature of the project; and the compulsory nature of participation. While we discuss cost implications as a third point, it is notable that few participants explicitly expressed concerns about cost.

2.3.2.1 Safety and experimental nature of the project

Some residents reported initial anxiety about the project, including reporting the anxiety of others. Anxiety appeared to be associated with a lack of understanding of the risks associated with hydrogen, concerns about the degree to which the project was experimental and the lack of ability to opt out. However, it was also noted, in the context of reflecting on others' anxiety, that as time had gone on, this anxiety reduced significantly.

Key areas of anxiety expressed by interviewees included safety concerns and negative associations with hydrogen.

"I think there was this initial kind of flurry of anxiety and yeah concerned that they were going to have this enforced on them, you know, how experimental was it, was it going to actually do what they said it was going to do, why were they doing it, a little bit of suspicion I suppose and anxiety but, you know, I think that's largely died away" (Pre-trial, HYDEP 117)

"What the dangers are, I don't know. But I know that it's—if they are testing it, it's because it cannot be deployed immediately everywhere" (Pre-trial, HYDEP119)

Key areas of anxiety expressed by interviewees included safety concerns and negative associations with hydrogen. This is clear in the language used by some participants.

"Safety, yeah that was the other thing that I remember being concerned about just, you know, is this going to make my house more likely to blow up. So, I think there was a bit of concern about safety" (Pre-trial, HYDEP117)

"I know more about HyDeploy because you're putting stuff into my gas system that might've blown up. So, I did quiz that one when it was suggested, but only because you might blow my house up and kill my dogs. So that was really what was interesting me" (Pre-trial, HYDEP120)

"But there was a lot of concern, as I say, especially with hydrogen, because it's regarded, and it is a very unstable gas that just goes. With the slightest mistake, it just explodes. Same can be said with natural gas. Obviously, we use those gases because they burn quite easily, but hydrogen burns perhaps too easily"
(End-of-trial, HYDEP119)

A specific area of concern articulated towards the end of the trial by one resident related to the initial uncertainty over where the hydrogen production was taking place, and concern over the potential proximity to the residential area. Early clarity in communication about the location of the hydrogen production may have helped reduce some early concerns.

"If from the onset they had said, the hydrogen is going to be produced there, where it is produced, that would've been more… It would've calmed quite a few people. As I say, when the rumours spread that hydrogen would be produced almost under our houses… If rumours are spreading, that means it's not well communicated" (End-of-trial, HYDEP119)

Previous research shows that potential increases in the cost of energy is the most important concern people have when asked about their views on using hydrogen blends in the home

Other residents, however, did not share such concerns, expressing an underlying assumption that in order to get to the implementation stage the project had to be safe.

"I was sure and certain enough that the project wouldn't be allowed to go ahead if it wasn't safe or safe enough to be in domestic properties and buildings that they are. That was never really a concern, although I know for some people that was concerning" (End-of-trial, HYDEP113)

For some, seeing safety checks being carried out in their homes added an extra level of reassurance. Similarly, the resident who moved into the property after the start of the blending trial was reassured that no issues had previously been reported.

"But I think I moved in after the project had started and no one had suggested there were any problems, so I think, in that sense, I've come in at a more reassuring stage." (End-of-trial, HYDEP131)

2.3.2.2 Cost implications

Previous research shows that potential increases in the cost of energy is the most important concern people have when asked about their views on using hydrogen blends in the home (Scott and Powells, 2019). However, in the interviews with residents in the Keele University HyDeploy trial, cost was not a major area of concern.

It should be noted that residents on the HyDeploy network received reduced bills during the trial as they were not billed for the hydrogen component of their supplied gas. The pre-trial interviews took place before residents had been informed of this, and this information was not part of the early stages of communication about the project to residents. Residents were not explicitly asked about cost concerns as part of the interview.

In total in the pre-trial interviews, only three residents reflected that cost was a concern for some, notably in terms of potentially being of concern to others.

"So, I think if there's any conversation it will be how does HyDeploy effect the cost of energy" (Pre-trial, HYDEP120)

"[there] was bit of concern and uncertainty about that and whether it would make things more expensive" (Pre-trial, HYDEP117)

In the interviews undertaken towards the end of the blending trial, only one resident mentioned cost, expressing concern about how they might have been financially affected by the trial. This demonstrates a lack of awareness of the billing arrangements meaning that they were paying less for their energy bills during the project, and the need to reinforce the cost implications through continued communication.

"And then, when I get bills in the door or get my readings taken, I always wonder, my God, is HyDeploy costing more or costing less? Or am I paying for this project?" (End-of-trial, HYDEP120)

The relatively limited expression of concern about cost may be due to the likely relatively economically advantaged status of the Keele campus community, meaning concerns about bills are likely lower than in other communities. It is also possible that cost was rarely mentioned as a specific concern due to other concerns being more strongly articulated and focused upon during the interviews.

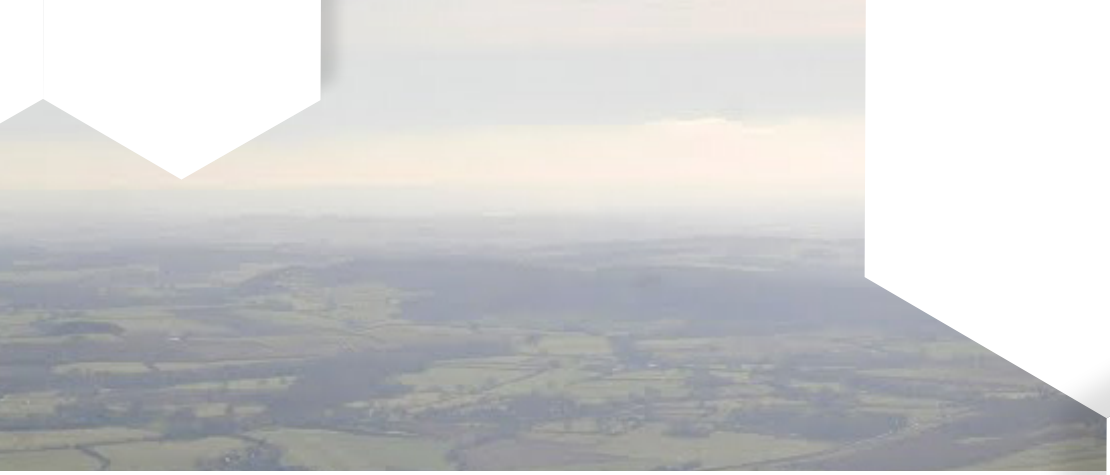
2.3.2.3 Compulsory participation

A small number of interviewees expressed concerns at the compulsory participation in the HyDeploy trial. These participants tended to take an ethical stance that projects such as this should allow households to opt-out.

"It is again back to people being consulted and not treated as guinea pigs; you actually need to have their consent to do this" (Pre-trial, HYDEP115)

"I think it should be more voluntary particularly to the people who own their own houses, you know, they really should have a choice on what they do and what's the source of energy. I think if you're going to be a trial subject, it's ethical to be allowed to decide whether you're a trial subject or not" (Pre-trial, HYDEP120)

Raising questions of compulsory participation through the language of ethics may reflect the academic background of some of the residents, many of whom may undergo regular ethical review processes as part of their employment and own research activities.



Two residents discussed the need for compensation for taking part in a trial while another felt that there was too much pressure put on households through the process.

"Because of the fact that there was no option to opt out, it was too pushy… in the end I just gave up because as I say, there was no way out. So, it was not a choice, it was imposed". (Pre-trial, HYDEP119)

In the phase two interviews, which came towards the end of the trial, one resident noted that if they had been aware of the compensation through reduced gas bills at the beginning of the process they would have been more positively disposed towards the project from the outset. This highlights the importance of the timing at which information of this type is released to participants.

"Had it been advertised in a way that you're going to save money during the trial, then we would've looked at it with different eyes, because at least the risk would have some kind of compensation for it, and that was not made clear from the onset. We found out much later on.... As I say, the timing about the discount would've helped at least feel that you are not a guinea pig. You are a paid guinea pig. Paid guinea pigs are happier than unpaid guinea pigs" (End, HYDEP119)

Nonetheless, some participants were very positive about having the opportunity to take part in the project, while others, highlighting the importance of the project and lack of disruption to the consumer, expressed views that an opt-out option is not required.

"Nothing has to be done by the consumer. You just have to consent to it. I don't think an opt out was necessary for this" (Pr-trial, HYDEP114)

2.3.3 Resident experiences of the trial

Interviewees had little to say about their experiences of the trial itself, as they largely experienced no disruption and were rarely conscious that the blending was happening. Just one respondent claimed to notice a difference in the energy service provided.

"In order to reach the normal temperature, in order to get the hot water, it takes a bit longer" (End-of-trial, HYDEP119).

It should be noted that during the trial the heat delivery capacity of the supplied gas, did not stray outside of the accepted range for natural gases as stipulated by GS(M)R. Any other concerns around disruption to daily lives were related to the lack of flexibility around timings for visits to carry out boiler checks.

However, it is necessary to examine whether the partial decarbonising of the gas network through blended hydrogen could lead to households increasing their gas use due to knowledge of the lower carbon footprint, and thus, negating the environmental benefit.

Residents interviewed towards the end of the trial were asked whether they believed their behaviour had changed in relation to their gas use. The majority of residents felt that their attitude towards gas use had not changed, although for those where COVID-19 had necessitated home working, gas use had increased. Four respondents reported that through engaging with HyDeploy communication about the environmental impact of their heating, they became more energy conscious.

"Yes, I think it's made me think about it more. Got me thinking generally about when the heating's on, perhaps just a little bit more than I would have previously, yes…Yes, probably. I'd say that receiving those letters, or seeing even just the HyDeploy logo, or colours in whatever form of communication, I've got that. It might be just sitting at the back of my head then to think a little bit more, in terms of my energy use"
(End-of-trial, HYDEP114)

In one case this led explicitly to an adjustment of heating controls by one resident, in order to: **"do a little bit extra to help"** (End-of-trial, HYDEP111).

"If 20% makes a significant inroad on CO_2 emissions, then 100% is going to make a bigger impact, so yes, in principle, I'd want to be part of a pilot"
(End-of-trial, HYDEP123)

2.3.4 Views on 100% hydrogen trials

The eight residents interviewed towards the end of the trial were asked whether they would be willing to have 100% hydrogen gas in their homes, after an explanation that 100% hydrogen would involve a greater level of disruption through changes to infrastructure and appliances. As with responses to other topics, views on 100% hydrogen were mixed, although six participants said they would be willing to have 100% hydrogen in the home, although with several caveats about the need to be convinced that it would be safe and effective.

"If 20% makes a significant inroad on CO_2 emissions, then 100% is going to make a bigger impact, so yes, in principle, I'd want to be part of a pilot" (End-of-trial, HYDEP123)

"If the science is saying that it's going to work and it's good for us, and it's better for the planet. Then, absolutely, I'd be so ready for 100%" (End-of-trial, HYDEP114)

"If the suggestion was that 100% was safe and that the equipment was effective, fine" (End-of-trial, HYDEP131)

2.3.4.1 Concerns about 100% Hydrogen

Despite the support for 100% hydrogen shown above, concerns were raised about the implications of such a transition, even from those who responded positively. Residents felt that they needed more reassurance about safety and effectiveness because of the more significant changes required. The main concerns articulated were:

- The 'unsustainability' associated with potential material and resource waste linked to the need to change and hence dispose of appliances to enable compatibility with 100% hydrogen.
- Questions regarding who would cover the cost of boiler replacement, with more acceptance if the cost is borne by another party such as a landlord.
- Cost concerns relating to the potential for redecoration needed if pipe infrastructure was replaced, and the potential for the disruption to (particularly new) housing interiors.

Furthermore, one resident, who was unsure about whether they would be willing to have 100% hydrogen in their home, questioned whether other alternatives to decarbonising heating services may be a better form of investment. This highlights consumer awareness of different potential domestic technological pathways to net zero, and the need to ensure governmental decision making that considers holistic implications and whole life cycle costs of alternatives, and transparent communication to ensure consumer trust.

2.3.4.2 The impact of HyDeploy participation on perceptions of 100% hydrogen

Residents were also asked specifically about whether taking part in the HyDeploy trial affected their views about 100% hydrogen. For all the residents who were positive about the idea of 100% hydrogen, they felt that having taken part in the HyDeploy trial had positively influenced this view.

"But certainly, the not noticing a difference in the supply over the time has reinforced that [willingness to take part in a 100% project] and certainly I've been much more open to being involved in a more significant trial on this basis having done one thing and probably learnt a little bit about how I would engage with it, as well as how the project might engage with me" (End-of-trial, HYDEP113)

"So, yes, the experience has been good so far, and that would give me confidence" (End-of-trial, HYDEP 123)

Interviewer: "Do you think that answer has been influenced having taken part in the HyDeploy trial already?"

Resident: "Yes, without a doubt. Again, that proof of the pudding. It works. There's been no impact in terms of us, we've not lost gas at all, there have been no issues with heating or whatever to the house. So yes, fantastic." (End-of-trial, HYDEP118)

Experiencing hydrogen in the home through a 20% blend could help pave the way to greater acceptance of 100% hydrogen. However, one resident saw the 20% blend as separate to the proposition of 100% hydrogen and was not in favour of taking part in a 100% trial.

"You would have a much more uphill struggle with a more radical project without doubt…I think what's been done has been at such a low level with such minimal level of intrusion, zero intrusion, that you'd be starting again entirely about perceptions and working with people if you were to increase the hydrogen level. And I don't know if it's known what the effect on your heating would be like in a cold winter with 100% hydrogen or 80% hydrogen… People would want to know." (End-of-trial, HYDEP120)

Experiencing hydrogen in the home through a 20% blend could help pave the way to greater acceptance of 100% hydrogen

This resident was also concerned about having less efficient heating, the loss of comfort in the home, and the loss of a gas cooker, and questioned the degree of disruption in heating services that people would be willing to undergo for what was seen as 'an environmental research project'.

"When you have children, your first thought is I'm not going to be cold in the winter for some environmental research project. I think, whatever point you come to that your boiler is taken out, that's when you're going to get serious resistance." (End, HYDEP 120)

2.3.5 Lessons for effective communication

Communication can influence public perceptions of technologies where there are low levels of public understanding (i.e., Brunsting et al., 2011), such as hydrogen. 'Communication' is used here to denote the intentional passing of information by a project implementor to end-users, although it should also be noted that communication takes place in different forms including through the traditional and social media channels, and between end-users, which may impact how communication from project implementors is received by end-users.

2.3.5.1 Communication strategy

Effective communication with the public is key to their engagement with and acceptance of a new technology, particularly one that carries some possible inconvenience or potential negative perceptions, or is being installed in people's homes.

The HyDeploy communication strategy at Keele University had three distinct levels of engagement.

1. The first level was through passive methods of communication, essentially leaflets and letters that explained the rationale of the project, as well as communicating an array of important technical, scientific, and logistical information.

2. The second level of communication took a more open, 'resident-initiated' approach whereby the team responded to specific questions and/or concerns about the project and organised outreach events to discuss the project with concerned (or engaged) residents.

3. The third level involved a more personalised, one-to-one approach from the HyDeploy Community Liaison Officer, aimed at continuing to check residents' level of engagement and comfort with the project.

Most residents reported that they found the initial communication of the project to be very effective in addressing any concerns

Most residents reported that they found the initial communication of the project to be very effective in addressing any concerns. Residents appreciated the wealth of information given to them, which provided them with the opportunity to choose their level of engagement later. This initial communication stage was also highlighted as important in combating negative discussions within the community or initial poor reactions to the project.

"The communication strategy, that's very good. Because I would—in my judgment, everybody's on board, but it's quite difficult to get everybody on board for something they basically can't say no to" (Pre-trial, HYDEP123)

"I mean I remember us getting the initial letter. And there had been lots of discussion about what this letter meant and, you know, what exactly was going on. And yeah, I think it was probably the most important just in terms of explaining things. You know, I probably sat and read that in more detail than I read anything later on I have to admit…I think just making sure that there's lots of information as early as possible so that rumours are minimised - anxiety is minimised is good." (Pre-trial, HYDEP117)

Only a few residents said that they had sought out additional information beyond the initial letter. Additional sources of information sought that were mentioned by residents included Google, other residents, and the project information 'drop-ins'. Although a limited number of residents attended the consultation events, they provided important opportunities for some residents to talk to people face-to-face.

"Knowing people who went to some of the open sessions and actually talked to people and felt reassured and having those conversations with people was also quite important …I think having those drop-in sessions and explaining things was quite helpful as well." (Pre-trial, HYDEP117)

For 11 residents, the Community Liaison Officer's one-to-one approach appeared a particularly effective method of communication in continuing to alleviate any concerns about the project that residents had. Participants referred explicitly to the value of one-to-one (sometimes face-to-face) communications with the Community Liaison Officer:

"He [Community Liaison Officer] was passionate about it. He was knowledgeable and he was ready to answer questions. In fact, he was ready to tell me things I didn't know I wanted to know." (Pre, HYDEP114)

2.3.5.2 The need for ongoing communication with residents

"I think it'd be useful to see some sort of fairly short, concise state of play documents."

(Pre-trial, HYDEP123)

One aspect that residents were less positive about was the reduction in communication after the high level of initial interaction and communication activity at the start of the project where residents were asked to give consent to enable access to their homes for appliance checks. This area of dissatisfaction was expressed by five residents in interviews both prior to the trial starting and towards its completion.

"I think it'd be useful to see some sort of fairly short, concise state of play documents. So, we're whatever, we're a year, 18 months into the project, where are we, what progress has been made, what remains to be done and just a kind of reiteration of what it's all about and what the objectives are I think actually quite helpful." (Pre-trial, HYDEP123)

"I think the lack of consistent communication has made me slightly less engaged and a little bit more dissatisfied with the project as a whole. Somebody mentioned to me that actually the project because of COVID had stopped the mix of gas. I know I wasn't aware of that or whether that is even true, and it felt that some of that communication would be good to make sure it was clear and transparent" (End-of-trial, HYDEP113)

Some participants expressed the view that given their role as trial subjects in the project, the project team had an ethical responsibility to provide participants with regular status updates.

"If you have like I know if we were test subjects of any other experiment, we would be entirely informed, kept up to date throughout the entire process of the test, of the study. You'd be getting regular communication, we'd be told things about when it's going to kicked in, we'd be told things what you might expect…" (Pre-trial, HYDEP120)

There is clearly a balance to be found between too little and too much communication. There was an appetite from some residents for more regular communication and updates about the project progress and findings, and specifically about the carbon savings achieved.

More communication during all phases of the project (e.g., interim status reports) including live project website updates could help continue to allay concerns and provide residents with a clearer understanding of the challenges of the project as a first of its kind, which could further emphasise the ground-breaking nature of the trial and continue to foster their sense of pride in being part of such a project.

2.3.5.3 Future messaging for hydrogen in the home:

Participants were asked for recommendations to improve communication for future trials/rollout of blended hydrogen in the home, reflecting on the communication they had received. The residents gave a range of responses, citing different priorities for communications, and a variety of opinions on how the same issue should be communicated.

There were contrasting views around the importance of emphasizing safety. For one resident this was a priority, while another resident (who moved into a property on the HyDeploy network after blending had started), cautioned against too much emphasis on safety, as this could stimulate distrust.

"As silly as it might sound, you probably can't drive that home enough how it's safe" (End-of-trial, HYDEP114)

"Because I think the more you tell people about how safe things are, the more that people then think, well, why are they telling me how safe it is?" (End-of-trial, HYDEP131)

Demonstrating that blended hydrogen has been used safely (at Keele) was seen as important in future communication. One respondent cautioned about the use of 'hydrogen' in the language used, suggesting just 'blended gas' as an alternative.

Other key areas of messaging that people felt were important and potentially influential included:

- the climate benefits and how these linked to national targets and the 'bigger picture,'
- the impacts on cost,
- the impact on existing appliances and potential of disruption of supply,
- information about the process, for example how the hydrogen was being produced.

3 | WINLATON TRIAL

3.1 KEY FINDINGS FROM WINLATON HYDEPLOY TRIAL

This section documents the perceptions of residents whose properties are part of the HyDeploy trial in Winlaton in Gateshead. Residents' perceptions were gathered via survey (130 respondents) and follow-up interviews (11 respondents) conducted prior to the blending trial commencing.

1. Survey respondents were largely positive about the use of hydrogen in the UK energy supply (52%). However, a large proportion of survey respondents expressed uncertainty about this (22%). This suggests a need for greater communication and learning about the benefits of hydrogen within the energy supply.

2. Most survey respondents (66%) were pleased to be part of the HyDeploy project, 30% were ambivalent about their involvement, and very few were unhappy about being part of the project.

3. The perceived climate change implications of the project were positively received by 82% of respondents. However, 27% of respondents did not understand what the project is trying to achieve.

4. Survey respondents appeared to report themselves as becoming more positive about being part of the project over time. About a third of survey respondents reported themselves as relatively ambivalent about being part of the project from hearing about the project initially.

5. 27% of survey respondents expressed some concerns about their involvement in the trial. Concerns related to costs, a lack of information and updates, safety, and impacts on equipment, contracts and warranties etc.

6. Residents identified that they would have liked more information related to cost, safety/risk, the start date, environmental benefits, and more technical detail about the trial.

7. These survey and interview datasets suggest that more detailed and frequent information may help allay some residual concerns about hydrogen-blend projects; that timing of information, particularly about key concerns around cost are important to consider.

8. Overall, the public are willing for changes to occur to their energy systems to be part of the energy transition to tackle climate change, but cost as well as other issues remain a key concern.

3.2 Methodology

3.2.1 Trial location

Winlaton is a village situated in the Metropolitan Borough of Gateshead (Figure 2). The Winlaton HyDeploy trial comprises 668 domestic properties, a primary school, a church, and several small businesses. The area of the trial sits within the Winlaton and High Spen ward which is classed as rural. Housing in the ward is of mixed age and tenure with three quarters in private ownership. 19% of the population of the ward is over 65, and there are high levels of community cohesion reported (Gateshead Council, undated).

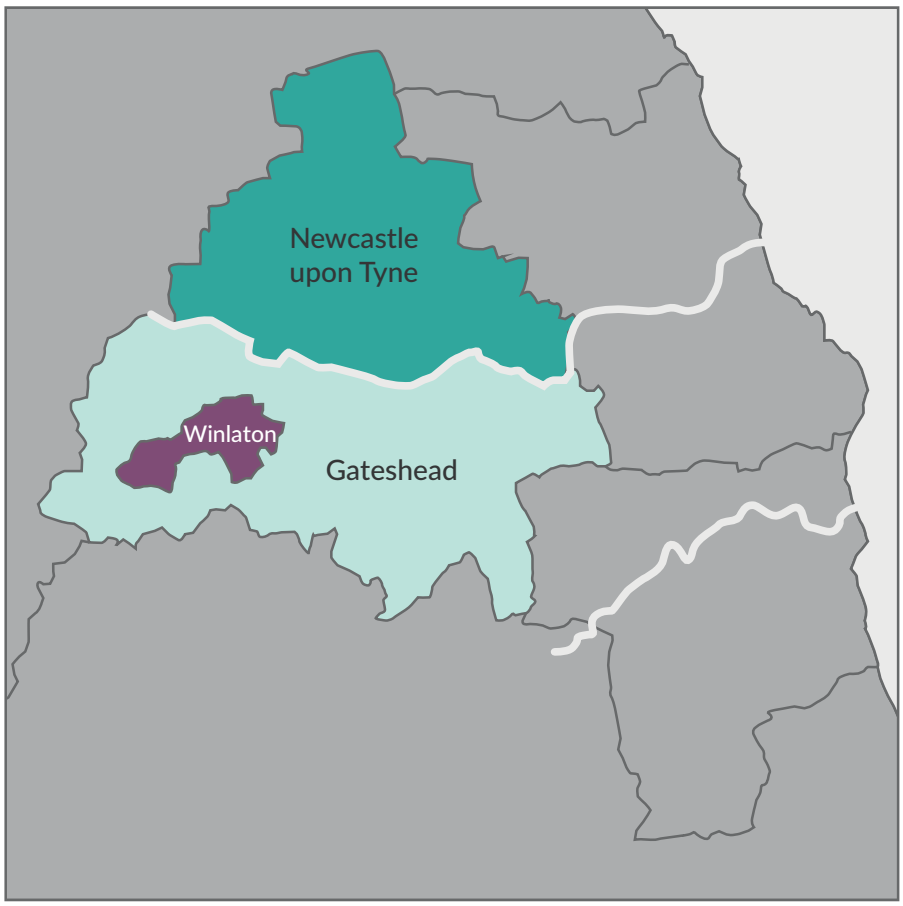


Figure 2: The location of the Winlaton ward in relation to Newcastle-upon-Tyne, United Kingdom

3.2.2 Data collection and timing

This report is based on 130 survey responses and 11 interviews. The survey questions are found in Appendix 2.

- Five survey responses were completed online in April 2021 following a letter with a link to the survey delivered by hand by Northern Gas Networks, the area's Gas Distribution Network provider and lead organisation for the HyDeploy project in Winlaton.

- A slightly abbreviated survey was created for data collection in July 2021. 83 surveys were completed on customer doorsteps over four days between 9-5 in the week commencing 12th July 2021, and a further seven of these abbreviated surveys were carried out online independently using a link in a letter left at households who were not in or wished to complete the survey in their own time. The last recorded survey was completed on 1st August 2021.
- 35 responses were completed as a hard copy survey that was distributed along with a stamped addressed envelope at the same time as the door-step survey completion.
- 11 respondents engaged in a follow-up interview conducted via phone in the week commencing 7th August 2021. These lasted 20-30 minutes. A copy of the interview schedule is in Appendix 3.

The survey response represents 19% of the total population of households (668) involved in the Winlaton HyDeploy trial.

Initial communication with residents about the HyDeploy project started in the autumn of 2019. At the time the door-step survey was carried out (July 2021) the last update letter had been sent in April 2021, and previous updates had been sent in July, September and December 2020, in addition to a customer drop-in session in October. Shortly following the doorstep survey residents received a letter to tell them that the blending would start imminently. The blending started on 4th August 2021.

This research was funded by Keele University and received approval from the Keele University Humanities and Social Sciences Ethical Review Committee.

3.2.2.1 Survey sample characteristics

The sample comprises 49% Men, 50% women, and 1% non-binary (n = 124).

The sample (n = 128) was skewed towards older age groups, with 69% of respondents over the age of 60 (figure 3).

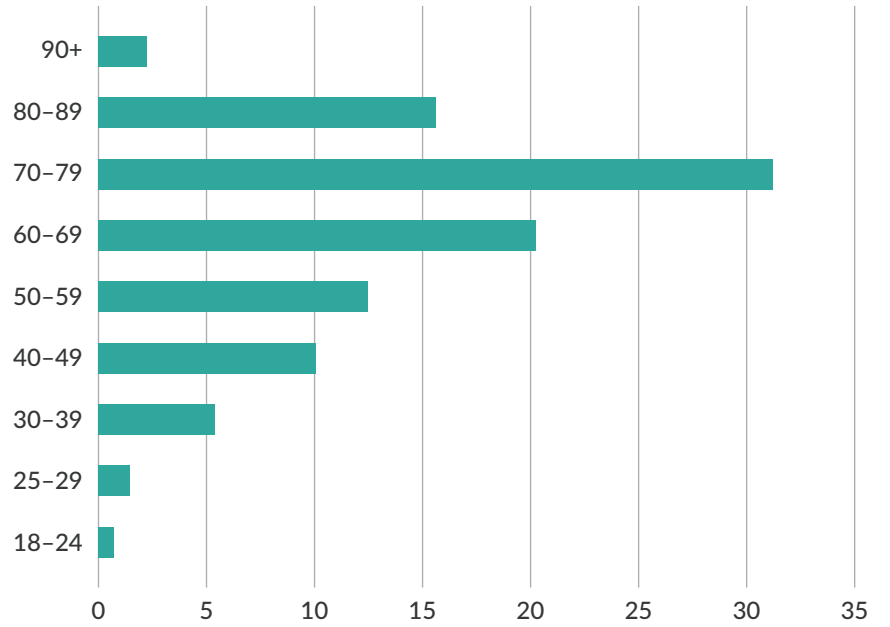


Figure 3: Age distribution of respondents (%, n = 128)

63% of respondents (n = 126) were owner occupiers, 32% were tenants in social,

council, or housing association properties, and 6% were private rental tenants. The largest group of respondents lived in semi-detached properties (49%) (figure 4).

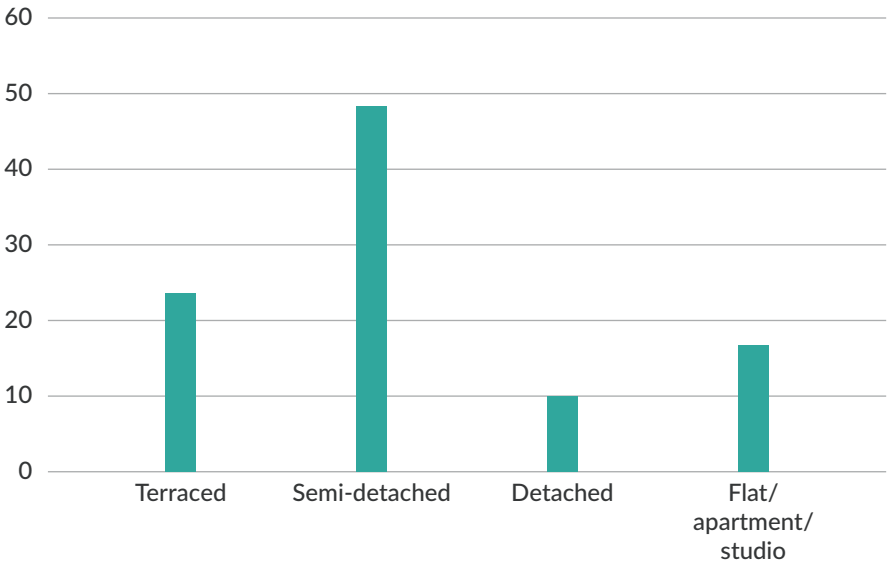


Figure 4: Property type of respondents (%, n = 129)

Most respondents have lived in their properties for a long time (as may be expected from the higher age demographics), with 61% having lived in their property for over 10 years (figure 5).

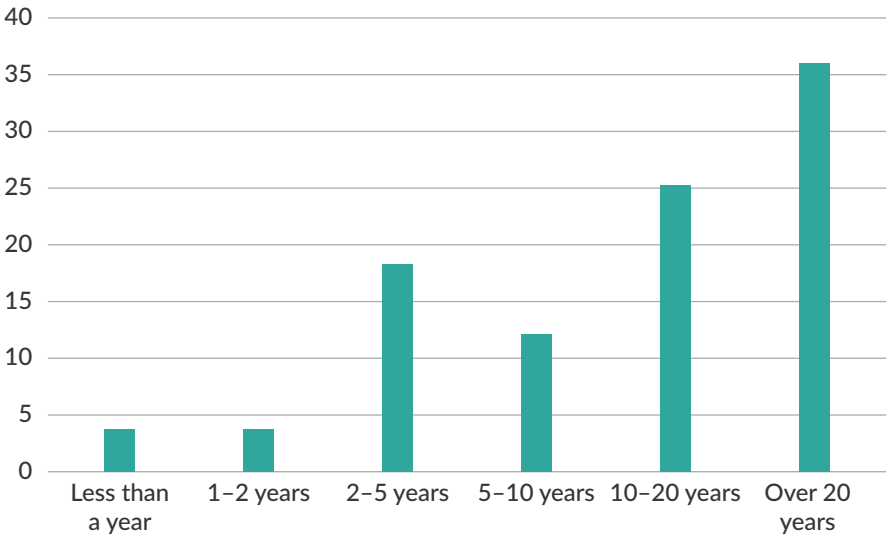


Figure 5: Length of time respondents have lived in their property (%, n = 130)

85% of respondents had no children living in their homes. 48% of homes had one adult living in the property, 45% of homes had two adults living there.

57% of respondents stated to never having difficulty paying energy bills. 6% reported having difficulty paying energy bills often and 3% having difficulty all of the time (figure 6).

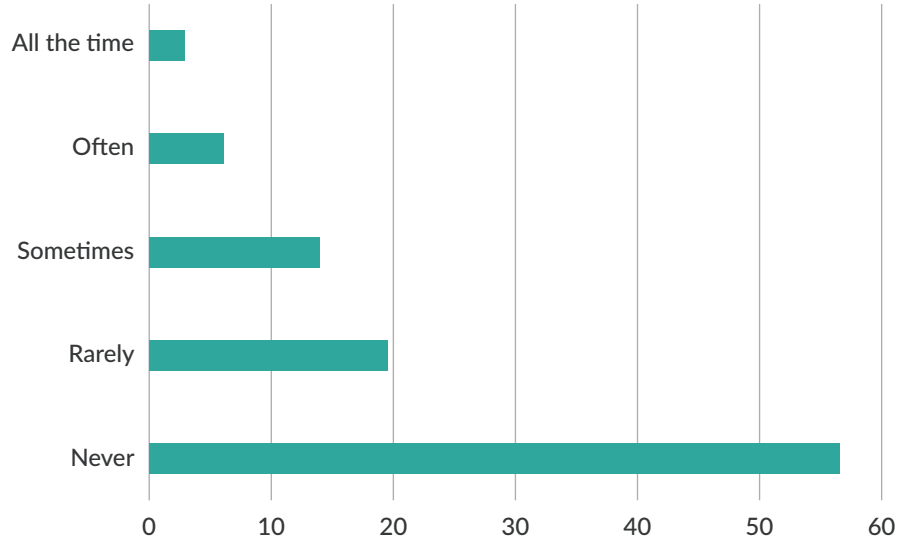


Figure 6: How often respondents worry about paying their energy bills (%, n = 127)

3.2.2.2 Interview sample characteristics

8 out of 11 interview respondents were owner occupiers, with 2 tenants in social, council, or housing association properties, and one private rental tenant. 8 of 11 interviewees lived in their property for over 10 years. 4 out of 11 interviewees were from single households, 5 households had 2 adults, one household had 3 adults, and one household had two children. 8 participants were males, with one male participant being under 50 and the remainder being aged 60+. 3 participants were females; two were aged under 40 and one was aged 60+.

3.2.3.3 Limitations

The age profile of respondents is not representative. However, the dominant age group (over 60) is the group most sensitive to cost implications of the energy transition.

3.3 RESULTS

DESCRIPTION OF THE RESULTS BELOW DRAWS ON BOTH THE SURVEY AND INTERVIEW DATA.

Results are structured into:

i. Perceptions of hydrogen.

ii. Views on involvement in the HyDeploy trial.

iii. Changes in perceptions of taking part in the HyDeploy project over time.

iv. Areas of concern.

v. Information provision about the HyDeploy project.

3.3.1 Perceptions of hydrogen

To gauge survey respondents' perceptions of hydrogen, they were asked to give the first two words that occurred to them when they heard the word 'hydrogen.'

These words were then categorized as either negative, positive, or neutral (Table 1).

- 61% of words were classed as neutral – 'gas' was the most common neutral word.
- 27% of words had negative associations – 'bomb' was the most common negative word.
- 12% of words had positive associations – 'clean'/'cleaner' were the most common positive words.

50% of respondents gave only neutral words, 22% of respondents gave only negative words, 10% of respondents only positive words, and 18% of respondents gave a mixture of words of different classifications.

Classification	Words provided by respondents	Broad themes
Positive	cleaner energy, less emissions, clean, safe, saving energy, clean more green, areet, cleaner air, cheaper than carbonisation, sustainable, future, saving money	• Clean/green nature of hydrogen • Lower costs • Safety
Negative	bomb, cost, fire, atomic bomb, explosion/explosive, big bangs, hydrogen bomb, my god, volatile gas, highly volatile, flammable gas, highly combustible, dangerous, nuclear bomb	• Explosion/ bomb • Volatility • Flammable
Neutral	gas most common, chemical table, air, normal, washing, water, don't know, nothing, this project, squeaky voices, atomic, power, fuel, chemistry, energy, hydrogen car, power, future fuel, hot air balloon, when are you going to start, vast quantity, new technology, economy, compatibility, clouds, natural, chloride, oxygen, very light, why hydrogen	• Chemical/scientific element • Water • Power • New technology

Table 1: Examples of words given by respondents categorized as having positive, negative, or neutral associations with the word hydrogen.

Survey respondents were asked for their views on whether hydrogen should be increasingly used for energy supply in the UK (figure 7). Most respondents (52%) were positive about the increasing use of hydrogen in the UK's energy supply. However, 22% of respondents replied that they did not know. Drawing on the interview data, this uncertainty likely reflects both a lack of knowledge about the potential role of hydrogen, and a scepticism of the longer-term role of blended hydrogen in a net zero pathway.

"It's all well and good about 20%, but that doesn't get us to carbon neutral and not using gas. So, it's longevity [...] At some point, boilers are going to become obsolete anyway, because the governments then talk about new properties being built with no gas supply and no boilers in place." (Pre-trial, WIN2)

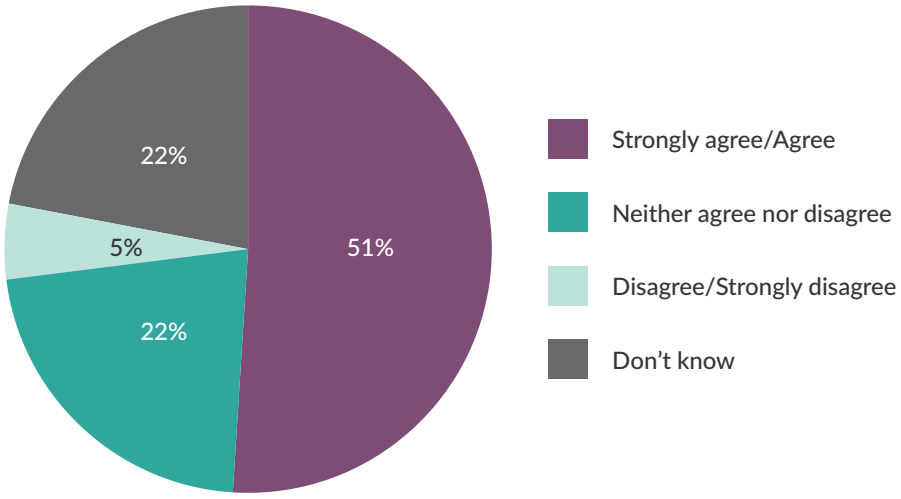


Figure 7: Survey responses to the statement 'Hydrogen should be increasingly used for energy supply in the UK' (%, n = 128)

3.3.1.1 Perceptions on the safety and costs of Hydrogen

There appears to be little difference in perceptions of the safety of hydrogen and natural gas (figure 8):

- 58% of survey respondents had no concerns about the safety of natural gas while 20% responded that they disagreed or strongly disagreed with the statement 'I have no concerns about the safety of natural gas.'
- 46% of respondents had no concerns about the safety of hydrogen, and 23% responded that they disagreed or strongly disagreed with the statement 'I have no concerns about the safety of hydrogen.'
- The percentage of respondents responding 'don't know' to this question about the safety of different gases was higher in relation to hydrogen (9%) compared to natural gas (1%), indicating uncertainty and a lack of knowledge about hydrogen more broadly and in relation to natural gas.

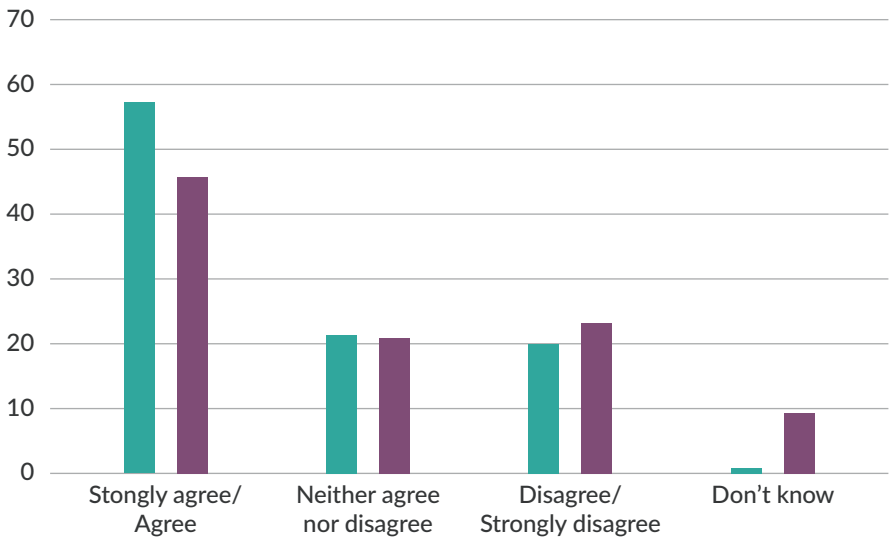


Figure 8: Survey responses (%) to the statements 'I have no concerns about the safety of natural gas' (green, n = 125) and 'I have no concerns about the safety of hydrogen' (purple, n = 128).

Regarding concerns about the costs of hydrogen, survey respondents showed significant variation in their perceptions:

- 33% of respondents were concerned about the effect that using hydrogen in the home would have on fuel costs.
- 36% of respondents were not concerned about the effect on fuel costs.
- 31% of respondents neither agreed or disagreed, or responded that they didn't know, when asked about their views on the impact of hydrogen in the home on fuel costs.

This variation in responses highlights the importance of clear consideration and communication about the cost implications of hydrogen, both as part of trial implementation and longer-term cost implications.

3.3.2 Views on involvement in HyDeploy

Most survey respondents were pleased to be part of the HyDeploy project and claimed to understand its key objectives.

- 66% of respondents were pleased to be part of the HyDeploy project. 30% neither agreed nor disagreed with the statement 'I am pleased to be part of the HyDeploy project', while only 4% disagreed with the statement.
- 74% of respondents agreed or strongly agreed that they understood what the HyDeploy project is trying to achieve, whereas 13% of respondents disagreed or strongly disagreed, and 13% neither agreed nor disagreed.
- 82% of participants were pleased to be part of what was perceived to be new climate change solutions by being part of the HyDeploy project, 16% neither agreed nor disagreed, while only 2% disagreed or strongly disagreed. This highlights the positive public support for perceived climate change solutions.

Interviewees generally self-acknowledged or demonstrated limited understanding of the project, with reference to assumptions of the environmental benefits.

Interviewer: **"What is your understanding of how HyDeploy helps to reduce greenhouse gas emissions?**

Interviewee: **I assume, it's because it's a cleaner fuel than what it is using the fossil fuels, natural gas."** (Pre-trial, WIN1)

Interviewer: **"Do you have any understanding of how it helps to reduce greenhouse gases?**

Interviewee: **So, so. No. I just assumed it must do so, so I was in favour of it."** (Pre-trial, WIN6)

3.3.2.1 Views on Winlaton as a trial site

While the survey responses demonstrated around a third of survey respondents were largely ambivalent about being part of the HyDeploy project, other resident views about Winlaton being chosen as the location for the first public site trial of blended hydrogen were varied, ranging from pride in their area being at the forefront of an energy innovation, through to suspicion.

"Quite pleased that we are trying to do something about energy, and quite interesting that Winlaton was one of the places chosen [...] it's normally projects like this tend to all go down South, and you often find that anything North of the Watford Gap doesn't exist." (Pre-trial, WIN1)

Interviewer: **"How do you feel about Winlaton being chosen as the trial area for the UK for this project?**

Interviewee: **This might sound corny, but privileged."** (Pre-trial, WIN8)

Interviewee: **"I'm proud to be part of it because there was photographs taken on Facebook and it was on Facebook as well only the other day, yesterday. And I said to [unclear], oh look, there's the side of our bungalow and I say, we're part of the project.**

Interviewer: **You like the fact that you're participating in it?**

Interviewee: **Oh yes. I'm really proud to be part of it, yes**. (Pre-trial, WIN5)

A number of survey responses and interviewees also questioned why Winlaton had been chosen.

Interviewer: **"So obviously you've said you're a bit concerned about Winlaton's been chosen. Do you think that's shared between other people as well? Do you think there is a bit of a "why us"?**

Interviewee: **Well this is it. We're all bungalows up here and nine times out of ten there are elderly people in them. And I can't understand why they've picked this area, the whole area." (**Pre-trial, WIN9)

This reflects a need for clear transparency of the logic behind trial sites being chosen. Our data illustrated how within place-based solutions and trials, there are clear concerns and scepticism interspersed with pride and place attachment. Therefore, clearly articulating why certain solutions are being trialled/ implemented in specific locations could reduce local anxiety and increase pride of place.

3.3.3 Changes in perceptions of taking part in the HyDeploy project over time

Survey respondents were asked to think back to when they were first informed of Winlaton's involvement in the HyDeploy project and to give three words that described what they felt about taking part in the project. The words were classified into positive, neutral, and negative words (Table 2).

- Out of 201 total words 41% were classed as positive, 41% were neutral, and 18% negative.
- Out of the 122 people responding to this question, 30% of people gave only positive responses, 34% neutral responses, 11% only negative responses, and 25% mixed responses.

Respondents were then asked to give three words that described how they felt about taking part in the project now. Where respondents answered 'same', they were given the same number of classifications as previously. The results show a positive shift in attitudes:

- Out of 196 words, 55% were classed as positive, 31% as neutral, and 14% as negative.
- Out of the 122 people responding to this question, 45% of people gave only positive responses, 30% neutral responses, 11% only negative responses, and 14% mixed responses.

Figure 9 (see below) outlines the difference in percentage of people's overall self-reported feeling about taking part in the HyDeploy project between first hearing that Winlaton residents were taking part in the project and their feelings at the time of taking the survey.

Table 2: Words classified as positive, negative, and neutral used by respondents to describe what they felt when they first heard of Winlaton's involvement in the HyDeploy project (left) and words that describe what they felt about taking part in the project at the time of the survey, just before the trial started (right). NA = Not applicable.

Positive before	Broad themes	Positive after
Happy for environment, agree with minimising climate change, something being done, presumed for good, sustainable, it's a good idea.	Climate change/ sustainability measure	If good for env then good, better way, considering environment, good thing, but happy for cleaner, something being done, good to cut down on natural gas, want to help with climate change, still in favour to help atmosphere, sustainable, it's a good idea, helping the environment.
Excited, very keen, good to be pilot, interesting experiment, interested, curious, very interesting idea, intrigued.	Excitement/ interest	Interested, interested to see, still looking forward, open minded, curious, excited, a worthwhile investigation, interested with new ideas.
On the map, good for area, makes a change, NE as market leader, something new around, proud.	Privilege/pride for local area	Canny that piloted up here, on the map, good to be pilot, pilot is good, privileged, fabulous that it is in our area.
Positive, pleased, great, happy to take part, absolutely fine, quite happy really, areet, champion, good, I felt fine, took in stride, ok, good, feeling good response, that is good, not a problem, quite happy to, optimistic, happy to assist, willing, no problem with it, fine.	Happiness	Happy, positive, very happy, quite happy, still happy, no problems so ok, fine, good idea, absolutely fine, areet, champion, I felt fine, good, happy to take part, definite positive, great, yeah still fine, quite happy to, agreeing to, willing, positive, ok, over the moon, not a problem, content, no problem, again no problem, quite happy about it.
Looking forwards, progress, glad trying, grandkids benefit, move on with the times, gotta move on, for progress, good thing to move forwards.	Progress/ innovation	Move on with the times, younger generation, for progress, good thing to move forwards, hopeful.
Glad to feel looked after, happy with checks, peace of mind over boiler, harmless.	Safety	Peace of mind over boiler, certain, confident, safe, relaxed, unconcerned, reassured, positive if safe and works.
The HyDeploy was going to be a lot cheaper, happy if cheaper, if a benefit happy to be benefitting.	Cost reduction	Hopeful for bill reduction, happy if cheaper.
Informed.	Knowledge	Lots of knowledge, knowledgeable.

Negative before	Broad themes	Negative after
Very wary, apprehension, slightly worried, concerned, wary, no one explained, worried, quite nervous, going into unknown, apprehensive, worried, slightly apprehensive, nervous, very worried indeed.	Apprehension	Still concerned, still wary, worried.
Costs, unhappy about price, cost, price increase, will it cost more.	Costs	Still concerned about fuel rise and reimbursement.
Concern about smell, fire running but slight worry of explosion, how safe is it, safety.	Safety	Are safety checks still valid.
Don't like not having a choice, but no choice, resigned, no consultation, no choice, concerned at lack of consultation.	Lack of choice/ consultation	No choice to, we've no choice.
Not enough info, don't know enough, is this going to be a pain for me?	Lack of information/ understanding	Not enough info, haven't given local people info and is disrespectful, feel there's been minimal info.
NA	Delay in roll out	Disappointed taken so long, lose interest, slow confirmation, delay means no info, taking too long.
NA	Unhappiness	Unhappy, not good attitude, upset about having to get gas company out as burning too high, gas board uninterested.
NA	Other	Concern about society, don't like shed.

Neutral before	Broad themes	Neutral after
Unsure, wait and see, mixed, unsure about boiler, unsure if good, uncertain, confused as just 1 area took while to realise, not quite sure, perplexed, not sure, surprised.	Uncertainty	Still unsure, unsure, happy but some reservations, have to try it first, uncertain, waiting for results.
Wanted to know about safety and env, why us, why here, when are you going to start, the effect is, safety, beneficial?, why us?, why us as guinea pigs, didn't really know what it was, will it cost more, didn't fully understand but not negative, misunderstanding, effectiveness, assume no harm would happen.	Questioning/Lack of knowledge	Don't understand science, glaze over info, doing my best, more information required, don't really understand, don't know or understand it, don't know enough until it happens.
Not phased, didn't really think about it, not bothered, not really bothered, can't remember, indifferent, unbothered, didn't really think, no real thought, ambivalent, not bothered either way, didn't care, not usually involved, wasn't bothered, nothing, didn't think anything, didn't mind either way, unconcerned, neutral, didn't feel anything, no problem, alright, no concerns.	Ambivalence/ Apathy	Not bothered, unbothered, don't really think about it, no problems, alright, unaffected, no problem, partner deals with it, not really bothered, not fussed, indifferent, no concerns, not bothered either way, didn't care, forgot, never thought about it, no real thought, whatever, not quite sure, neutral, not a lot, didn't feel anything, nothing's changed, minimal impact, feel unaffected, on the fence.
Going to happen, gonna happen anyway, sigh..., had to do it, do what say, trust it to be us, give it a go.	Resignation	Can't stop it.
Went to meeting, letter through the door, researched, brother reassured, not involved family did.	Communication	Not heard much, never heard much since, waiting for it to happen, when are you going to start, start-date.
New, research, experiments to be tried out.	Research-nature	Research
Never been informed, surprised.	Lack of awareness	NA
NA	Questions about environmental benefits	Unsure if best way forward, environmental cost.

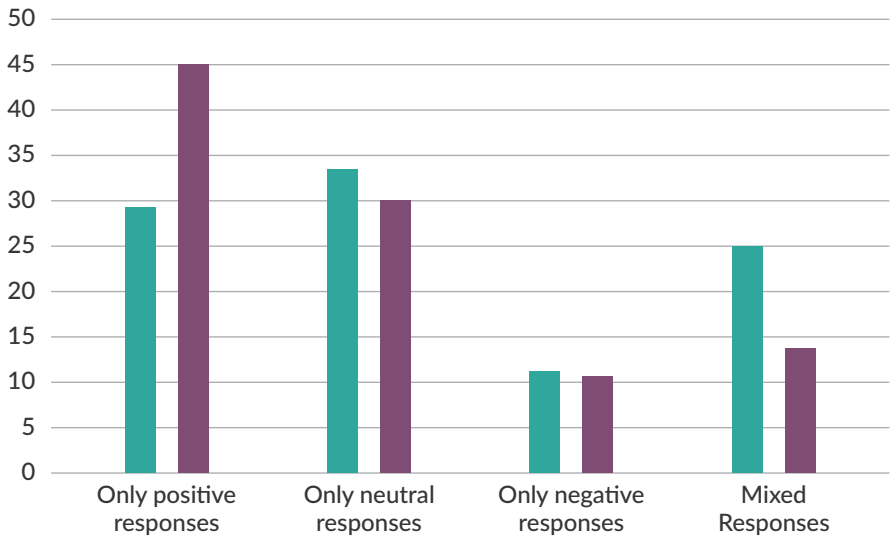


Figure 9: Percentage of people with overall responses based on the positive, negative, or neutral classification of words given by respondents about what they felt about taking part in the HyDeploy trial when they first heard about Winlaton's involvement (green) and what they felt about taking part in the project at the time of the survey just before blending started (purple).

A key factor for respondent's views improving from negative to neutral was that so far, no impact to their daily lives had been noted. Many stated that as long as this remained the case (i.e., no additional costs, no need to change equipment, no change to how they use gas), that they had no objection to taking part in the HyDeploy project. This emphasises the benefit of the lack of disruption of using blended hydrogen.

A key factor for respondent's views improving from negative to neutral was that so far, no impact to their daily lives had been noted.

"So, just as long as it doesn't actually affect my bill in any shape or form. So, in effect, that I'm no worse off during this test period than if I had have been having just natural gas on its own." (Pre-trial, WIN7)

However, this does suggest that if further roll out of hydrogen does lead to increased costs this energy transition solution may be less well received (also see table 3 below) and may meet more resistance.

The interviews with Winlaton residents gave an indication of what the interviewees perceived as other people's responses to the project as well as highlighting the importance of peer communication in sharing information and providing reassurance about the project.

Interviewer: **"Did you say you went to a few meetings at your community centre as well?**

Interviewee: **Well, no, I go there because I go sometimes for lunch, you know, and bingo and things. So, people there, you know, and you talk to them about what's happening any road, you know. So, all my neighbours have to go so therefore you get a chance to have a chat with them, really.**

Interviewer: **And do you think, in general, people are relatively on board then?**

Interviewee: **Oh, I think so."** (Pre-trial, WIN10)

Interviewer: **Have you spoken to anyone else about the project? People you live with or…**

Interviewee: **I did, in all honesty. We have some friends down the road who are a bit unsure about it. And I just said, well, it's coming. You can't really avoid it. But it is for your benefit.** (Pre-trial, WIN11)

Nonetheless, community interest in the project was not uniform:

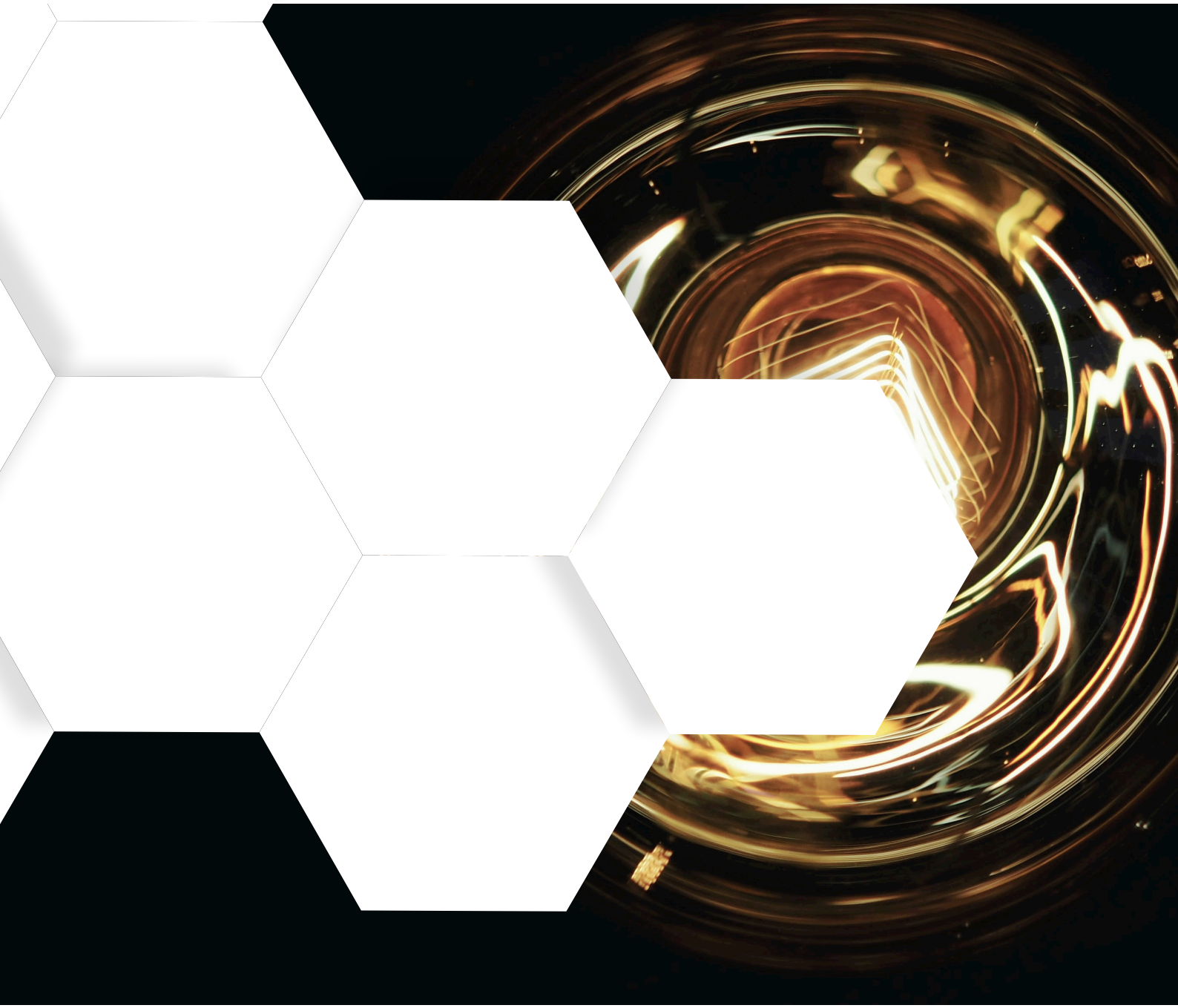
Interviewer: **"Do you have any gauge on how the community in Winlaton have received the project?**

Interviewee: **I haven't, actually. Nobody else has mentioned it to me, which is quite surprising. Nobody in the area has mentioned it. It doesn't seem to come up in discussions with anyone, because obviously I'm friends with a lot of people in the area, but it never seems to come up in conversation."** (Pre-trial, WIN7)

3.3.2 Areas of concern

Respondents were asked whether they had concerns about taking part in the HyDeploy project. 73% of respondents stated that they had no concerns about taking part, while 27% said that they did have concerns. Many of these concerns are reflected in Table 2 above.

Several respondents articulated several different areas of concern, rather than just a single concern. The most frequently mentioned concerns were costs (20% of concerns mentioned), lack of information/consultation (15%), safety (13%), general concerns about the uncertainty associated with a trial or new technology (10%), the potential effect on appliances (7%), the lack of choice to take part (6%) and whether blended hydrogen is an effective response to climate change (6%). Table 3 outlines the range of different categorised concerns articulated by respondents and examples of the wording used.



Categorised area of concern	% of concerns articulated in survey responses (n = 71)	Examples of articulated concerns (from surveys and interviews)
Cost (both immediate during the trial and longer term)	20%	*"gov grants to be used and policy to prevent price hikes"* *"Hydrogen is costly to produce."* *"We don't know if they decide to roll it out is the cost going to be more? […] Because once you're on it that's it, you've got to use your gas, haven't you?"* *"how is it going to work from a billing perspective?"* *"If something goes wrong, will my insurance cover it?"*
Lack of information/ consultation	15%	*"No time to understand"* *"Like to have all and very specific info, ha[ve] some questions"* *"Not enough information given to residents"* *"Insufficient information prominently provided relating to safety - clear pros and cons with authoritative scientific sources"* *"Although I probably received info about the project it seems a long time ago."*
Safety/trial nature	13%	*"How dangerous might it be!?"* *"The fact that it is a trial seems to indicate safety concerns from the company handling all of this"* *"More attention to safety in the home, everyone would like cheaper fuel but not at any price"* *"The hydrogen plant is only half a mile away from my home"* *"What if new problems since appliances checked for gas safety"* *"At the end of the day, anything that's in a trial, no matter how safe people will say it is, for a fact, it's trial and error, if that makes sense?"* *"I just thought well why do you need to do a safety check if there are no concerns about it?"*
Uncertainty	10%	*"As long as we know what we are doing"* *"Run before can walk"* *"As new technology and a pilot scheme there may be problems that we are unaware of"* *"An unproven entity"*
Potential effect on appliances	7%	*"Effects on equipment in long run"* *"Needing to update/replace equipment at own cost."* *"Effect of hydrogen on combi boiler"*
The lack of choice to take part	6%	*"No real say over it""* *"Forced on people"* *"Well, you were backed into a corner really"* *"Because once you're on it that's it, you've got to use your gas, haven't you?"*
Whether it is an effective response to climate change	6%	*"Concern about wider approach to climate change, not all working"* *"Is it truly decarbonizing or a step."* *"How 'green' is it in reality"* *"From what I've read, it's a very expensive process […]. Yes, it might be fine for a demonstration like this test, but I'm not sure whether, could we produce enough to feed the whole country? I don't know."*
Potential interference to supply	1%	*"Will interfere with supply"*

Table 3: Different categories and examples of articulated concern.

Nonetheless, in general, participants' concerns were fairly minimal, shown by the high numbers who are happy to participate in the project. Some concerns may be due to how residents have engaged with information provided (see section 3.2.2 for details), for example:

- A few new residents to the area who may have not received all information.
- Residents who may have forgotten information provided.
- A lack of engagement with information by residents – as a result of apathy, or difficulty engaging with the information provided.

The areas of concerns for some, were for others, aspects where they felt reassured, or were even seen as positive aspects of participation in the project, as outlined in Table 4.

Aspect of concern	Example of concern	Example of reassurance/positive aspect
Safety	Gas checks made some residents feel there were significant safety risks that had to be assessed	Gas checks made other residents feel reassured they were being looked after
Trial nature	Untested nature, safety concerns	Pride in being trailblazer
Information	Not enough information to fully understand the project	The right amount of information to satisfy their curiosity
Environmental impact	Questioning sustainability of Hydrogen	A step in the right direction, assumptions of environmental benefits
Communication	Not had enough communication/ unsure how to communicate	On attending community meeting/calling NGN usually very positive

Table 4: Examples of aspects of concern for some but areas of reassurance or a positive aspect of the project for others.

Key areas of concern (for some) are explored in more detail in the following sections.

3.3.2.1 Cost concerns

The impact of the project on individual energy bills was a concern for some survey respondents and interviewees. For some, support for the project was dependent on them not incurring any cost increase as individual households:

"just as long as it doesn't actually affect my bill in any shape or form [...] As long as that is not affected at all, I really don't [have] any issue whatsoever. I think it's a good experiment." (Pre-trial, WIN7)

The impact of the project on individual energy bills was also an area of uncertainty for some survey respondents and interviewees, with several expressing a lack of understanding of how the project would affect individual energy bills.

Interviewer: **"They're covering the cost of all the hydrogen for the duration of the trial.**

Interviewee: **That's interesting to know, you see, because I spoke to a few people, and nobody was able to give me that kind of answer. And I was like, well, how is it going to work from a billing perspective?"** (Pre-trial, WIN2)

One interviewee who was initially less positive about HyDeploy due to concerns about cost, referred to how receiving additional information (through the letter sent in late July after the door-step survey was carried out) was central to reducing their concerns.

"But I did get an information letter earlier this week to explain [the costs…]. I thought that was quite a good explanation, and answered any questions I previously had, so I'm quite happy to proceed, and I'm happy with it [HyDeploy]." (Pre-trial, WIN1)

One interviewee who was initially less positive about HyDeploy due to concerns about cost, referred to how receiving additional information was central to reducing their concern

Some interviewees expressed concern and uncertainty about the longer-term implications of a transition to hydrogen in the wider energy system on cost, linked in some case to scepticism and suspicion of energy providers.

"The only concern I had, and you may well get this across the board from other people, is that, obviously, this has to be produced separately by a dedicated manufacturer…And then sold to the relevant gas supply companies. Good. My only concern is that the gas supply companies will then stick their tariff on top and then increase our gas bills considerably […] the people that produce it will sell it to the independent gas suppliers of the UK and they will immediately double their tariffs on top of what the poor people are paying. And that's my concern. A benefit should be a benefit and not a penalised benefit. Do you know what I'm saying?" (Pre-trial, WIN11)

Interviewer: "What do you think's going to happen cost wise?

Interviewee: I really don't know, it just said while you're in the scheme you'll not pay for the 20% of the hydrogen, or whatever it is that goes into it, but we don't know if they decide to roll it out is the cost going to be more?

Interviewer: And is that something that you're concerned about as well?

Interviewee: Because once you're on it that's it, you've got to use your gas, haven't you?" (Pre-trial, WIN9)

3.3.2.1 Trial nature of project and associated safety concerns and trust

For a number of residents safety concerns were associated with the notion of the HyDeploy project as a 'trial' or 'first of kind' with the implication for them that the technology was 'unproven' and came with inherent risk.

"I've heard through conversations, and what have you, that we're having that, actually, hydrogen is more unstable than the gas. So, it makes me think, well, how, with this just being just the launch at the moment, launch project, what's the risks involved using this?" (Pre-trial, WIN2)

"Well at the beginning I was really concerned because I was a bit like what they're going to do if something goes wrong within these houses, because it's obviously a test the thing they're doing?" (Pre-trial, WIN9)

Some residents expressed positivity in relation to safety elements, feeling reassured from safety checks conducted as part of the initial HyDeploy project stages:

"I think the fact that they've done safety checks, I think that reassures an awful lot of people, the fact is that, well that's a good thing regardless of what's happening. I think that's made the project even more acceptable to people, and more welcoming if you know what I mean? Because it just shows that safety was the number one step before anything else happened." (Pre-trial, WIN1)

However, for others the safety checks heightened concerns about the project being a trial and for them what were implied safety concerns:

"They came in and tested all our appliances and things like that and they keep saying that we're okay to go on it. And that's another thing that concerns us [...] I just thought well why do you need to do a safety check if there are no concerns about it?" (Pre-trial, WIN9)

One survey respondent demonstrated their concern by buying an electric cooker (to replace a gas one) after hearing about being part of the HyDeploy trial. When asked what they felt now (at the time of the survey) about being part of the HyDeploy project, this respondent expressed disappointment and annoyance at the 'attitude of gas board' and uncertainty about the safety implications, hence choosing to do what they could to reduce the risk that they perceived. It should be noted that it is not clear which specific organisation the respondent is referring to as the 'gas board.'

Some of the residents noted that conversations with neighbours and community groups shaped their perceptions and minimised initial fears and misunderstandings related to safety. During the door-to-door surveys, many of the residents in assisted local authority-run housing, noted that conversations with neighbours in their common socialising spaces shaped their perceptions and minimized initial fears and misunderstandings related to safety. These spaces are managed by health care workers, who had either arranged for Northern Gas Networks (NGN, the HyDeploy Winlaton trial lead) to come and talk to residents or gathered relevant information from NGN to pass onto their residents. These residents due to age and disability were more likely to have problems digesting information and/or accessing the internet. However, this more personalised approach appeared to work well.

Only 20% of social housing tenants (n = 40) had concerns about taking part in the HyDeploy project compared to 32% of owner occupiers (n= 77). Those living in local authority housing tended to trust that the Council would not put them in a dangerous situation:

Interviewer: How did you feel about that then, about Winlaton being the pilot?

Interviewee: Well, I thought it was quite... I was quite proud that they were doing that, to be honest with you. I wasn't frightened because they wouldn't have done anything that was going to frighten you.

Interviewer: Well, that's good. So, do you feel that you've got quite a bit of trust in the Council, and that they wouldn't do something bad, or is it that you've got trust in the gas board works, or both?

Interviewee: I've got trust in both, to be honest with you. I'm hoping that's the way it is, you know. (Pre-trial, WIN10)

3.3.2.3 Lack of choice in participation in trial

Only 6% of the articulated concerns from survey respondents were about the lack of choice in being part of the HyDeploy trial. As with the Keele residents interviewed, some interviewees in Winlaton disagreed with the principle of being unable to opt out, rather than wanting to have been able to have opted out per se.

Interviewer: **"Do you think if you were given the choice, you would have opted out?**

Interviewee: **Not necessarily, but I would have liked the approach of actually having control over my own supply, if that makes sense."** (Pre-trial, WIN2)

Whereas others would have preferred to have been able to have opted out, due to nervousness about being part of a 'first of kind' trial.

Interviewee: **We didn't really have a choice but to go with it because they said we're going to have our gas turned off if we didn't.[...]**

Interviewer: **Do you think if you did have the choice do you think you would have agreed to it or do you think you would have said no?**

Interviewee: **I can't see how I would have agreed to it at this time, I think I would have wanted them to have it tested a bit more because that's the first time I've heard of it. They don't use it in other places and things like that, so it's the first I've heard of it."** (Pre-trial, WIN9)

It is notable that most respondents simply accepted the environmental benefits of hydrogen, displaying little awareness that the environmental benefits are reliant on the production methods of the hydrogen.

3.3.2.4 Uncertainty and scepticism

Many of the words classified as neutral given by survey respondents in response to the request to give three words reflecting their feelings of being part of the HyDeploy project, reflected uncertainty about, or ambivalence to the project. Some people questioned why their area had been chosen, others felt they did not know enough about the project to have an opinion. Others, who were generally more informed about climate change and sustainability, expressed ambivalence about using hydrogen more broadly.

"I've always been a bit on the fence. Obviously, because it's the type of work I do, there's been a lot of talk around nuclear energy uses. There's been a lot of talk around the hydrogen, and what have you. And it's all well and good, but again, it all goes back to what I was saying before, it's not what you use only, it's also about the methods that you use. Because you can go around and say that hydrogen itself is better to use than gas, but, actually, it depends on how clean your methods are used to produce it." (Pre-trial, WIN2)

This interviewee demonstrated a high level of understanding about the relative climate impact of hydrogen dependent on its production methods. It is notable that most respondents simply accepted the environmental benefits of hydrogen, displaying little awareness that the environmental benefits are reliant on the production methods of the hydrogen.

Another interviewee appeared sceptical of how blended hydrogen fitted into the overall government approach to tackling climate change and what were perceived as inconsistencies in approach (although seemingly based on a misunderstanding of the ban on gas boilers in new homes).

"I think the 20% in the gas is a funny one, because the government have stated, categorically, they want all the gas boilers out of houses, so we wouldn't have gas to mix the hydrogen with." (Pre-trial, WIN3)

This reflects a critical point regarding both transparency as to how hydrogen is produced for consumers, and transparency in communication around the use of particular energy transition technologies within an overall net zero road map, which might influence the degree of local acceptance.

3.3.3 Information provision about the HyDeploy project

65% of survey respondents were happy with the amount of information they received about the HyDeploy project. Survey and interview responses refer positively to the amount of information as well as the range of different information and communication formats, allowing households to engage with information at different levels and to allay specific concerns. Several respondents referred positively by name to individuals involved in the HyDeploy project that they had had communication with.

"I think the information that was out there was on Facebook, it was on leaflets, it was in booklets, and it wasn't rammed down your throat. If you wanted to read up about it, it was quite easy to read up about it and if you didn't want to well a leaflet just came through the door and it just gave you a description, told you exactly what it was, how safe it was, and I'm quite happy with it, the information that was provided." (Pre-trial, WIN5)

It [the information sent via post] gave us the basics, which is all I needed to know. I'm not technically minded so if there was too much technical involved I wouldn't understand it. […] If it were too technical it would be way over my head. […] We're not bombarded, which is good. (Pre-trial, WIN6)

I think it's fine. I've got no complaints at all. They've kept us informed. I've said, they've sent us letters and we went up to the club, saw the layout of the plans and everything. (Pre-trial, WIN11)

However, 19% of survey respondents said that they were unhappy with the amount of information they had received about the HyDeploy project. Respondents were asked if additional information would have been useful. 35% of respondents said that there was information that they would have liked to have received but had not. Of the 74 responses (several responses were given by some individuals) detailing what information they would have liked to have received:

- 15% related to more information on cost.
- 8% wanted more information related to safety or risk.
- 8% wanted more information on the start date and timing of the trial.
- 7% of referred to wanting more information on the environmental benefits.
- 7% wanted to know more about all aspects of the project.

- 7% expressed a desire to receive information more frequently.
- 5% wanted more information on how the trial worked or more technical aspects of the trial.
- 4% wanted more information about the reason for the trial, including the choice of location.
- 4% wanted more information about the end date and future beyond the trial.

Additionally, 5% noted that they could not articulate what they wanted to know more about but felt unclear or just generally curious about the project. Table 5 outlines the range of different categorized responses and gives examples for each.

Table 5: Examples of aspects of concern for some but areas of reassurance or a positive aspect of the project for others.

Category of response	% of survey responses	Examples of responses
Cost	15%	*"Will there be a price increase"* *"Savings costs for use of new gas?"*
Safety/risk	8%	*"Will there be a price increase"* *"Maybe more on wider implications and risks compared to gas"* *"Any dangerous aspects for new gas supply?"*
When/timing	8%	*"Exact dates of things of it happening"* *"When is it going to start. I have made contact on numerous occasions over the last 2 years. Had the boiler checked etc. And here we are still waiting!!!!!"*
Environmental	7%	*"Bring environmental thing more obvious"* *"How 'green' is it in reality"* *"How much pollution will be reduced"*
Everything	7%	*"Everything, safety, timing, let us know, don't treat us like mushrooms (manure in the dark)"* *"I would like a full explanation i.e., about bills cost etc"* *"More detail about whole thing"*
More frequently	7%	*"Long time of nothing happening so no info."* *"More info more often"*
How/technical	5%	*"How it works… Overall plan"* *"Technical advice. How it's mixed in with the gas. Burning capability. Does it burn hotter/colder? How is it produced and where"?* *"Would like to know more about hydrogen and the positive effects of it."*
Don't know	5%	*"Don't know if they have the answers. Curious but don't know what curious about"* *"Haven't had much but unsure what would be useful"*
Why	4%	*"Why introduced… Why it's better"* *"The purpose of introducing 20% of light gas, is it cheaper fuel?"*
End/future	4%	*"How long it will run for, vague if permanent or not"* *"Permanency. Efficiency, costs. What happens if they decide not to continue"?* *"What happens if this is a success up here, what to expect. Is it going to be rolled out in the whole area, or if it's going to be dearer and cheaper, we just don't know"*

Some other areas of information deficit raised by respondents included uncertainty about the implication to gas odour, the impact on appliances, and the lack of knowledge their energy supplier had about the project. One person who had only recently moved in said they would like to have had the initial information. This reflects the importance of providing regular information and reminders to residents, particularly for those who may have missed initial communications.

One participant brought attention to the exclusionary nature of directing people online for access to additional information, particularly given Winlaton's demographics (although phone numbers were provided and also clearly used by some residents for more information):

"Well yes, a bit more in-depth information. No doubt if you're going online and things like that, but especially up here where there's a majority of old people, not everybody goes online." (Pre-trial, WIN9)

Individuals who felt engaged with the project tended to have higher expectations of regular communication:

"Yes, it did go a little bit quiet, mind you. It went a bit quiet probably from the communication I've received recently. I don't know whether it's maybe about six months in between the last communication, but yes. Maybe could do with a little more updates. Maybe one more update, just to have a look at some results." (Pre-trial, WIN7)

Several brought attention to periods in which no communication had occurred as causing undue concerns:

"[there was a] time when we were getting nothing, thinking, what on earth's happening? But we have had quite a few bits of communication lately." (Pre-trial, WIN3)

Several brought attention to periods in which no communication had occurred as causing undue concerns

The length of time over which communication about the project has needed to have occurred as well as gaps in communication, has also inevitably led to some residents forgetting what information they have been provided with, which suggests a need to repeat information on known key areas of concern or interest. Effective communication also needs the recipient of information to engage with the information provided.

"I've been reading elements I've forgotten about, and what have you. So, they may, as well, have communicated those elements...but I also know there was elements that weren't communicated, or there was long gaps [...] there was a time when a lot of things went quite quiet, and it was before COVID hit. ... I think I've just got a letter this week about it, but I haven't read it. (Pre-trial, WIN2)

In a minority of cases, the delay in the project roll-out and lack of recent information and updates meant that initial excitement and curiosity had waned:

In a minority of cases, the delay in the project roll-out and lack of recent information and updates meant that initial excitement and curiosity had waned

"When this started, over two years ago now, I was very, very enthusiastic about it [...]. And yet, everything seems to have come to a stop with this plant down at Low Thornley, and I've gone off the boil a bit [...] maybe I have lost interest, but it's just because we keep getting reports and mail about it, and nothing seems to happen." (Pre-trial, WIN 3)

Many of the more negative phrases in response to the survey question about what respondents felt about taking part in the HyDeploy project at the time of the survey (just before blending started) referred to delays or lack of information. Respondents questioned why there was a delay when other work had continued during COVID-19 restrictions, and why communication appeared to have stopped.

Several participants were upset about the building of structures in the local area (referred to as a governor house and shed) which they saw as related to the project, of which they claim that had received no prior warning, and in their view contradicts earlier communication about impact of the project to the local area.

"When we had the initial talks about the plant, about the hydrogen, we were told it would make no physical or obvious difference to our lives, you wouldn't know it was there, in other words. And so, we were all enthusiastic about that. The next thing we know, they're building a house, which we didn't know what it was at the time, it turns out it's a governor house. They've built it on, probably, our one and only beauty spot in the area [...]. And, of course, we were told, 'oh, it's only temporary', and then when we queried again, we were told then, 'oh, it could be here permanently' [...]. But, relatively recently, we were told, 'oh yes, we're going to move it into the farmer's field, so it's over the hedge and you won't be able to see it'. But it hasn't happened, that hasn't happened. (Pre-trial, WIN 3)

4 | CONCLUSIONS

FINDINGS AND RECOMMENDATIONS

Although the results have been presented as two independent data sets it is possible to draw some wider conclusions while presenting results from the two trial sites separately avoids the potential of misleadingly "generalising between places and across time" (Walker, 1995, p. 49; Aas et al., 2014). This is particularly important as the two sites have clear differences in both the composition of the resident populations, the demographics of respondents, and the relationships between resident homes and project implementors. Nonetheless, it is possible to draw key conclusions and recommendations from the two sites and although neither trial sites or sample populations are representative of the general population the diversity between the two sites implies that these findings may be generalisable across the wider UK population.

4:1 FINDINGS

ANALYSIS

ANALYSIS OF THE INTERVIEWS WITH KEELE UNIVERSITY AND WINLATON RESIDENTS AND THE PRE-TRIAL SURVEY OF WINLATON RESIDENTS INVOLVED IN THE HYDEPLOY HYDROGEN BLENDING TRIAL SHOW A WIDE DIVERSITY OF RESPONSES ABOUT MANY ASPECTS OF THE TRIAL.

THE RESULTS DEMONSTRATE:

1. A largely positive or ambivalent response from residents to taking part in the trial, with high levels of public acceptance to blended hydrogen in the home being attained at both trial sites.

2. Strong support for being part of a trial is possible where individuals see the benefits of the trial associated with putting their local area 'on the map.'

3. Limited understanding and high levels of unfamiliarity of the public in relation to hydrogen and its potential role in the energy system.

4. Concerns about taking part in a blended hydrogen trial, and the role of blended hydrogen as an energy transition technology more generally, relate primarily to potential implications to cost and safety, with other concerns including the potential impact on appliances, insurance and warranties and the extent to which it is a genuine solution to climate change. Concerns were compounded where there was a perceived lack of information and concern over the inability to opt out.

5. Concerns of residents were higher upon first learning that they were part of the trial, but tended to reduce over time, often associated with gaining further information formally from the project or informally through peer networks.

6. Priority areas where further information was desired included cost and safety, but also a desire to understand more about the timescales and technical detail about the project. There is a desire to understand more about the benefits of the use of hydrogen, and for many, a desire for more frequent information. We saw demand for more passive, information-related engagement than was perhaps initially expected from project implementors.

4:2 RECOMMENDATIONS

FROM THE FINDINGS

DRAWING FROM THE FINDINGS OF THIS STUDY THE FOLLOWING RECOMMENDATIONS ARE MADE. MANY OF THESE RECOMMENDATIONS MAY BE APPLICABLE TO OTHER ENERGY TRANSITION TECHNOLOGIES WHERE THERE ARE LOW LEVELS OF PUBLIC UNDERSTANDING.

1. Communication to engage support for blended hydrogen should highlight the potential environmental benefits and the lack of disruption, while also addressing potential concerns around safety, the direct implication to households of cost, and impacts on appliances.

2. Communication for trials or roll-out of innovations on a local area basis could utilise the potential sense of pride in a place/locality/region being at the forefront of technical innovations, and transparently explain why a region has been chosen. As more areas experience an innovation this approach becomes less applicable. However, as more places experience an innovation there may be less need to engage support through this means due to successful demonstration elsewhere providing reassurance and support.

3. Transparency about the source of hydrogen, how it is produced, and the respective environmental benefit/impacts(s) is essential to maintain public trust in hydrogen as a pathway to net zero. Our data reflect public support for blended hydrogen because of an assumed environmental benefit, with relatively few individuals explicitly making a link between the environmental benefit and the method of hydrogen production. As public literacy around hydrogen increases the environmental benefits are less likely to be assumed by the public, and a lack of transparency in hydrogen production methods may erode public confidence in the role of hydrogen as an energy transition technology.

4. Resourcing of individuals to support communication on a one-to-one discussion basis should be prioritised to support customers with concerns and to address queries.

5. To minimise concern about the inability to opt out of receiving a hydrogen blend, communication should not be positioned as a 'trial' or 'experimental' which may trigger safety concerns, and more neutral terms such as 'project' should be used. This more neutral language was used in HyDeploy communication, although was negated by messages around the project being a 'first of kind,' which for some, creates positivity.

6. Some financial benefit to individuals taking part in a trial can be of benefit to a more positive response by some. Communication of any 'compensation' measures should be clearly communicated in early stages of project communication in order to encourage early support, with repeat reminders so as to reduce cost anxieties.

7. Where residents have received significant communication in the initial stages of a project and are likely to feel personally invested in the project, for example where project communication has tried to stimulate a sense of excitement and positive participation, regular communication about the project should be carried out with interim updates about progress and findings, helping to maintain trust, engagement and a positive sense of involvement.

8. Project communication can be used to stimulate further environmental awareness including around energy behaviours to maximise the potential benefits of the project and support further steps towards a more sustainable future, beyond the immediate scope of the project activity.

9. Technical projects should build in the resource and capacity for research to explore participants' perceptions - increasing the learning of the project in a different, but important realm. Where possible communication approaches could be co-created with the community, adopting a 'user-centric' approach, increasing participant engagement and support.

REFERENCES

Aas, Ø., Devine-Wright, P., Tangeland, T., Batel, S. and Ruud, A., 2014. Public beliefs about high-voltage powerlines in Norway, Sweden and the United Kingdom: A comparative survey. Energy Research & Social Science, 2, pp.30-37.

BEIS (2020a) The ten point plan for a green industrial revolution. Available at: https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

BEIS (2020b) Exploring the evidence on potential issues associated with trailing hydrogen heating in communities. BEIS Research Paper Number 2020/018. Available at: Exploring the evidence on potential issues associated with trialling hydrogen heating in communities (publishing.service.gov.uk)

BEIS (2021a) The Heat and Buildings Strategy. Available at: https://www.gov.uk/government/publications/heat-and-buildings-strategy

BEIS (2021b) Net Zero Research and Innovation Framework. Available at: https://www.gov.uk/government/publications/net-zero-research-and-innovation-framework

BEIS (2021c) UK Hydrogen Strategy. Available at: https://www.gov.uk/government/publications/uk-hydrogen-strategy

Brunsting, S, Upham, P., Dütschkee, E, De Best Waldhobera, M., Oltraf, C., Desbarat, J., Riesch, H., Reineri, D. (2011) Communicating CCS: Applying communications theory to public perceptions of carbon capture and storage. International Journal of Greenhouse Gas Control, 5, 1651-1662.

Devine Wright, P. (2011) Enhancing local distinctiveness fosters public acceptance of tidal energy: A UK case study, Energy Policy, Volume 39, Issue 1, Pages 83-93.

Fylan, F., Fletcher, M., and Christmas, S. (2020) H21: Public perceptions of converting the gas network to hydrogen: Social Sciences study. Available at: SBT2251-Leeds-Beckett-Leeds-Sustainability-Institute-H21-Report-Singles.pdf

Gateshead Council (undated) Winlaton and High Spen Ward Factsheet. Available at: https://www.gateshead.gov.uk/media/2555/Winlaton-and-High-Spen/pdf/Winlaton_and_High_Spen.pdf?m=636807256020000000. Accessed on: 21st December 21

HyDeploy (2021) HyDeploy: Demonstrating non-disruptive carbon savings through hydrogen blending. Available at: https://hydeploy.co.uk/app/uploads/2018/02/21063_HyDeploy_Carbon_Savings_Report1_DIGITAL.pdf

Scott, M. and Powells, G. (2019) Blended Hydrogen: The UK Public's Perspective. Available from: https://www.ncl.ac.uk/media/wwwnclacuk/geographypoliticsandsociology/files/news/blended-hydrogen-the-uk-publics-perspective.pdf

Taufik, D., Bolderdijk, J. & Steg, L. Acting green elicits a literal warm glow. Nature Clim Change 5, 37–40 (2015). https://doi.org/10.1038/nclimate2449

Walker, G., 1995. Renewable energy and the public. Land use policy, 12(1), pp.49-59.

Appendix 1: Keele University Interview Questions

Appendix 1a: Pre-trial interview questions

General background

- How long have you lived in this house/on the Keele campus?
- Is this a private or rented property?
- What is your connection with Keele (for how long?)
- What is the composition of your household?

Attitudes towards and knowledge of energy and climate change

- How important and how urgent do you think the need to reduce greenhouse gas emissions is?
- How do you think the changes that are needed will affect you directly? Over what sort of timescale?
- Attitudes and behaviours relating to energy use in the home
- How important do you think how we use energy in our homes is to reducing greenhouse gas emissions?
- What areas of energy use in the home are most important to reducing greenhouse gas emissions do you think?
- What energy sources do you use in your own home for heating and cooking?
- Do you take any steps to reduce your energy use in your home?
- Have you installed any renewables?
- Have you made any major energy efficiency changes?
- Do you think about energy saving in any of your daily practices?
- Why do you take these steps to reduce your energy use?
- What do you find makes it difficult to reduce your heating use?
- What, if anything, would help you to reduce your heating use?
- What different ways can we reduce greenhouse gas emissions from home energy use?
- What approaches do you think are the most important or will be the most effective?
- Do you think we are making enough progress towards reducing carbon emissions in the home?
- Why?
- Where should the progress be coming from?
- What sort of activities as an individual, or from government or companies would you be willing to support?

- How much disruption do you think people are prepared to put up with to improve carbon emissions?

Knowledge of and attitudes towards HyDeploy

- What do you know and think about Keele's low carbon energy projects? (SEND, HyDeploy, major renewables, eventually bring these up specifically if they are not mentioned).
- What is your understanding of how HyDeploy helps to reduce greenhouse gas emissions?
- When did you first hear about HyDeploy?
- How did you first hear about it?
- What did you think about it when you first heard about it?
- If you can remember back to when you heard that your household was going to be part of the HyDeploy project, what were your initial reactions to being involved?
- How has the HyDeploy project affected your household so far? Has this affected how you feel about the project?
- Has the way that you feel about the project changed over time?
- Why?
- Did you talk to anyone about the project (people you live with, other people in the trial, others)
- What were people's thoughts about it?
- Were they any different to yours?
- How do you feel the community here at Keele received the project?

Views on HyDeploy communication

- How much communication, and in what forms, have you had about the HyDeploy project?
- What information about the HyDeploy project that you received was most important to you?
- Did you receive all the information that you think was important to you?
- Did you engage with any consultations and stakeholder events about the HyDeploy project? Why? How?
- Did you make further contact with any of the HyDeploy team once the scheme was first announced?
- [If yes] Who did you talk to?
- [If yes] How did you talk to them? (e.g. phone; email)
- [if yes] What did you talk to them about?

- [If yes] Were they able to provide you with the information you required? Why/ how?
- Did you try and access further information about the HyDeply project?
- What methods/sources of information (ie website, contacts)
- Did you feel you were kept informed about the progress of the project? Was this important to you?
- Were you happy with the amount of technical information you were given?
- What did you think about the methods used to communicate with you about the HyDeploy project and your involvement?
- Do you have any other thoughts about how you were approached about the project?
- What do think was well handled?
- Was anything not handled so well?

Conclusion on thoughts of being part of HyDeploy

- How do you feel about being part of a trial?
- How do you feel about Keele University being used for a trial such as HyDeploy?
- Have your thoughts about the HyDeploy project changed over time:
- How? Why?
- Has being involved in the HyDeploy project affected your views or behaviours relating to other energy or environmental issues?
- Would you be willing to be contacted again to talk about your experiences as the trial progresses?

Appendix 1b) End of trial interview schedule

These questions were slightly modified for the interviewee who had not been interviewed during the first phase.

General background (although will have this information from previous interview, just confirmation of these key characteristics)

a. How long have you lived in this house/on the Keele campus?

b. Is this a private or rented property?

c. What is your connection with Keele (for how long?)

d. What is the composition of your household?

e. Is this your permanent place of residence?

Section 1: Knowledge of and attitudes towards HyDeploy:

1. Before we start let's just see what you remember about the HyDeploy project as

it has been a number of years now since the initial communication. What is your understanding of the aims and technology of the HyDeploy project?

2. Can you remember what you thought about the HyDeploy trial when you first heard about it? What were your first impressions? What did you think about actually being part of the trial?

3. What did you feel when you heard that the trial had gone live and hydrogen was now part of the gas mix being supplied to your home? Has this view changed over time?

4. Have your feelings or attitudes towards the HyDeploy project changed over time?

5. Were there any specific factors which influenced these changes in your views? [consider mentioning cost, environment, understanding etc. if prompt required)

6. Has your understanding of HyDeploy changed in any way? (Scientific, technical, implementation, cost (?), etc.). What has influenced this understanding?

7. Do you think your behaviour (or anyone in your home) is different at all as a result of knowing that hydrogen is now part of the gas mix being supplied to your home? [if prompt needed ie greater use of energy as felt it was 'green'; more cautious about use due to safety concerns]

8. How do you think your views compare to other residents and households involved in the trial? How do you think the views of others have changed over time? [prompt to get a feel of where these views come from – ie conversations with neighbours]

9. Given your experiences of being involved in the HyDeploy trial, to what extent would you be willing to participate in other domestic energy related trials?

Section 2: Views on HyDeploy communication:

10. What are your views about the communication you have received about the HyDeploy trial? (prompt about amount and frequency of communication, content and depth of information, form of communication)

11. Is there information that you feel you have not received and would like to have? [If prompt needed could give example, ie more technical information]

12. Did you try to access additional information either from the team involved in HyDeploy directly or from other sources? [Prompt to expand on why, what and what sources]

13. What do you think the important messages were for you in the communication that you received about the trial? [Prompt to expand on reasoning]

14. If blended hydrogen was to be rolled out across the UK what do you think the important messages would be in any communication to develop public acceptance and support for the roll out? Do you have other advice for future communication about the use of hydrogen and blended hydrogen?

Section 3: HyDeploy influence on environmental attitudes:

15. Would you say that your involvement with the HyDeploy project has influenced your outlook on the environmental challenges facing the world? In what ways?

16. Do you think your involvement in the HyDeploy project has affected how you think about energy use in the home?

17. To what extent do you think projects such as HyDeploy are central to addressing the climate crisis? What more do you feel needs to be done?

    Whilst the HyDeploy project has only used up to a 20% blend of hydrogen, there are future discussions around the potential 100% hydrogen use across the country. Although one difference with a higher percentage of hydrogen is the need for changes to the gas infrastructure and appliances, unlike the up to 20% blend. Despite these differences, we are interested in exploring how the HyDeploy project may have shaped your perception of this low carbon solution. At present there are no plans for 100% hydrogen in domestic houses at Keele.

18. Should the opportunity arise, do you think you would be willing to have 100% hydrogen gas in your home? Has this answer been influenced by taking part in this Keele trial? In what ways? [If no] Is there a lower percentage of hydrogen (blend or otherwise) might you consider?

Appendix 2: Survey questions for Winlaton Trial

1. What are the first two words that occur to you when you hear the word 'hydrogen'?

2. Hydrogen should be increasingly used for energy supply in the UK

3. I am concerned about the effect that using hydrogen in the home will have on fuel costs

4. I have no concerns about the safety of natural gas

5. I have no concerns about the safety of hydrogen

6. Are you aware of the HyDeploy project that your home is part of? (not in April 2021 survey)

7. Thinking back to when you were first informed of Winlaton's involvement in the HyDeploy project. Give three words that describe what you felt about taking part.

8. Now give three words that describe what you feel about taking part in the project now.

9. I am pleased to be part of the HyDeploy project

10. I am pleased by the press coverage that Winlaton is getting due to the HyDeploy project

11. I am pleased to part of new climate change solutions by being part of the HyDeploy project

12. Do you have any concerns about taking part in the HyDeploy project?

13. If you do have concerns, what are they?

14. I understand what the HyDeploy project is trying to achieve

15. I am happy with the amount of information I received about the project

16. Is there any information that you did not receive about the HyDeploy project that

you would like to have received?

17. What sort of information would you like to have received about the project?
18. Do you think your involvement in the HyDeploy project has affected how you think about energy use in the home?
19. Please explain your answer to question above (optional)
20. With which gender do you identify?
21. What age group do you belong to?
22. Which of the following best describes your current living arrangement?
23. Which of the following best describes where you live?
24. How long have you lived in your property?
25. How many adults (18 and over) live in your home?
26. How many children (under 18) live in your home?
27. How often do you worry about paying your energy bills?

Appendix 3: Interview Schedule for Winlaton Trial

General background

- How long have you lived in this house/Winlaton?
- Is this a private or rented property?
- How many people live in your house? [Prompt for composition, but without using that term!]

Attitudes towards and knowledge of energy and climate change

So, the first section is to talk to you about what you think about energy and climate change.

- What are your feelings about environmental issues and climate change? Do you think we as a society should be doing anything about it?
- Are you worried about the implications of climate change? What do you think the implications/effects might be?
- How important and how urgent do you think the need to reduce greenhouse gas emissions is? Specific timescales?
- How do you climate change solutions will impact you directly?

Attitudes and behaviours relating to energy use in the home

- How important do you think how we use energy in our homes is to reducing greenhouse gas emissions? What areas of energy use in the home are most important to reducing greenhouse gas emissions do you think?
- What energy sources do you use in your own home for heating and cooking?
- Do you take any steps to reduce your energy use in your home and daily

activities? Why?

- Do you think we are making enough progress towards reducing greenhouse gas emissions linked to home energy use? Why?
- Where should the progress be coming from?
- What sort of activities as an individual, or from government or companies would you be willing to support to see a reduction in greenhouse gas emissions from the home?
- How much disruption would you be prepared to put up with to reduce greenhouse gas emissions? Do you think this is similar to other people?
- What sort of disruptions? Limitations on what you can do? Fines/surcharges? Policy changes? Etc.

Knowledge of and attitudes towards HyDeploy

- What do you know about the HyDeploy project?
- What is your understanding of how HyDeploy helps to reduce greenhouse gas emissions?
- When did you first hear about HyDeploy? How did you first hear about it?
- What did you think about it when you first heard about it? What were your initial reactions to being involved?
- How has the HyDeploy project affected your household so far? Has this affected how you feel about the project?
- Have you talked to anyone else involved in the project (people you live with, other people in the trial/local area, family members, others)?
- What were people's thoughts about it?
- Were they any different to yours?
- How/why did you talk about the project?
- How do you feel the community in Winlaton has received the project?
- How do you feel about Winlaton being chosen as the trial area for the UK?
- What are your key remaining concerns, if any? [Potential issues to question if not noted: pricing, timescales, safety, feeling of having no choice]

Views on HyDeploy communication

- How much communication, and in what forms, have you had about the HyDeploy project? Is this the right amount?
- Was it accessible/understandable?
- What information about the HyDeploy project that you received was most important to you?
- Did you receive all the information that you think was important to you?
- Did you engage with any consultations and stakeholder events or meetings about

the HyDeploy project? Why? How? What did you think about them?

- Did you try and access further information about the HyDeploy project?
- What methods/sources of information (i.e., website, contacts)
- To what extent do you feel you have been kept informed about the progress of the project? Was this important to you?
- Were you happy with the amount of technical information you were given?
- What did you think about the methods used to communicate with you about the HyDeploy project and your involvement?
- Do you have any other thoughts about how you were approached about the project?

HyDeploy and climate change

- Do you think blending hydrogen is a suitable climate change solution?
- What other solutions are you aware of, and do you approve of them?
- Do you think HyDeploy will be sustainable in the long term?

Learning from HyDeploy

Consumer Perceptions of Blended Hydrogen in the Home