STREAM 1, PHASE 1 - HEAT PUMP READY: CAMBRIDGESHIRE

FINAL PROJECT REPORT

CITY SCIENCE
delivering decarbonisation

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Prepared by:

Joe McQuillen MEng (Hons)	Principal Energy Consultant
Dominique Campbell BSc (Hons)	Project Manager

Approved by:

Simon Drake BA (Hons) ACA BFP	Director

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1 Executive Summary

The UK Government has committed to ensuring that the transition to low carbon buildings is affordable and achievable for all and has committed to delivering a package of measures to scale up deployment of heat pumps to 600,000 per annum by 2028 (BEIS, 2022). This is a sizeable challenge that requires new innovations to overcome widespread barriers to large-scale heat pump deployment.

This report presents the key findings and evidence developed in the Stream 1 Heat Pump Ready: Cambridgeshire Phase 1 project and will be used by the Department for Business, Energy and Industrial Strategy (BEIS) to understand the opportunities and challenges of coordinated, high-density heat pump deployment.

The objectives of the project included understanding the viability of achieving high-density heat pump deployment in Fenland, Cambridgeshire. For the purposes of this report, high-density heat pump deployment is defined as installing heat pumps in at least 25% of domestic properties connected to either a primary electricity substation, a secondary electricity substation or a low voltage network.

This project ran from July 2022 to November 2022 (referred to as Phase 1) and investigated the feasibility of high-density heat pump deployment. In November 2022, Phase 1 projects were invited to submit a proposal for an approach to achieving high-density heat pump deployment in Phase 2 within their targeted location, based on evidence gained from the feasibility study in Phase 1.

This report provides the evidence gained and key findings from the feasibility study, as well as the recommendations for high-density heat pump deployment, should the project progress to Phase 2.

1.1 Summary of Work Packages

The work carried out in the feasibility study was split into seven work packages, which have been detailed in the table below.

Work Package	Lead	Objective	Key activities
1. Project Management	City Science	Ensuring project delivery and reporting to BEIS.	Reporting to BEIS, project management
2. User Research/Co-Design	PECT	Engage with potential participants to understand perceptions, barriers, and trigger points to switching to heat pumps. Develop evidence base for uptake expectation.	Online survey, focus groups, door-to-door engagement
3. Site Prioritisation Process	City Science	Identify the area within the county where the deployment of heat pumps will be focussed.	Development of heat pump deployment site prioritisation process, engagement with DNOs to understand electrical infrastructure connections

4. Building Pathways and Costs	City Science	To provide evidence that our holistic approach can deliver tangible cost reductions to consumers, while providing a deliverable, standardised model that can be implemented by the supply chain in Phase 2.	Heat pump retrofit cost modelling, installer experiences and challenges interviews, technology horizon scan
5. Financing Recommendations	City Science	Collect and evaluate evidence to confirm whether PACE-style financing is suitable for the UK, is deliverable within existing structures and will add value to consumers and BEIS as a delivery vehicle in Phase 2.	Financial recommendations report
6. Customer journey	Growth Guides	Simplify and de-mystify the customer journey sufficiently and provide evidence that our approach addresses the critical barriers to heat pump deployment.	Customer journey research and barriers identification
7. Reporting and Phase 2 Application	City Science	Final project reporting and development of Phase 2 approach.	Final Project Report, development of high-density heat pump deployment approach for Phase 2

1.2 Key Findings

The following sections detail the key findings from the individual work packages and the resulting recommendations that have been developed for achieving high-density heat pump deployment. Work packages 1 (Project Management) and 7 (Reporting and Phase 2 Application) have been deliberately excluded as their outputs do not contribute to the key findings of the study.

1.2.1 WP2: User Research

Key Challenges Identified

This work package was led by PECT and was designed to build evidence on the user perceptions, barriers, and potential trigger points towards switching to heat pumps. It had three key activities: an online survey, a set of four groups and door-to-door engagement within the targeted area. Some of the key findings from each activity have been detailed below.

Online survey key findings:

- Upfront cost is the biggest concern to consumers, with 60% being very or somewhat concerned.
- Over 75% of people think knowing someone with a heat pump might make them more comfortable having one installed.

Focus group key findings:

- The majority of people had heard of heat pumps, although didn't know the specifics and if it was right for them or where to find information.
- The lack of knowledge around heat pumps was seen as a challenge about what system would be right, the additional measures and what trades were needed.
- A list of trusted and reputable suppliers from the local authority was seen as positive addition.

- Cost was seen by all people as the largest barrier.
- Several people would like to see a heat pump in-person and speak to someone who has been through the process of installing heat pump in their home.
- Several felt that some form of assurance such as a guarantee on the quality of installation and the ability to talk with a suitably qualified/registered installer who can be trusted to advise homeowners would be advantageous.

Door-to-door engagement key findings:

- 42% of those surveyed felt that additional financial support around a low interest loan or increased council tax would encourage them, although over 57% wouldn't consider this.
- Over half of people would like to have an independent advisor support them with the next step in obtaining a heat pump.

Relevant Recommendations to Overcome Challenges

- **Provide access to financial lending options to help consumers overcome the high upfront cost of heat pumps.**
- **Provide trusted advice on heat pumps that is simple-to-understand for consumers**. Our user research demonstrated that lack of knowledge was a key barrier.
- **Provide a single web platform as a place to access trusted information** – preferably backed by government or local authority (as this builds trust).

1.2.2 WP3: Site Prioritisation

Key Challenges Identified

The objective of this work-package was to identify an optimal area to target within Fenland to target for the high-density heat pump deployment and was led by City Science. Optimal in this context would be an area that fulfilled the requirements of the Heat Pump Ready programme, but also had a good chance of heat pump uptake. A methodology was developed that made use of publicly available datasets that could provide metrics on each primary and secondary substation which could be used to filter and rank each substation for heat pump deployment.

Deployment prioritisation key findings:

- A replicable methodology for prioritising the deployment of using openly available data with a national coverage was successfully developed.
- The Distribution Network Operator (DNO) UK Power Networks (UKPN) could not immediately provide headroom and catchment area data at secondary substation level. UKPN were required to undertake further analysis to obtain this data.
- The further analysis found that it is likely that all substations within our targeted area (Friday Bridge) will most likely need reinforcement to accommodate a heat pump deployment density of 25%.
- DNOs are currently unlikely to have systems in place to deal with bulk simultaneous heat pump connection applications (as would be required for high-density heat pump deployment), as this is not a situation they have had to prepare for yet. DNOs should be engaged in advance of high-density heat pump deployment so that they can put the necessary processes in place to deal with this.

Relevant Recommendations to Overcome Challenges

- **Engage with the DNO early** to:
- Determine data available on electricity networks, and where data is not available undertake further analysis as necessary.
- Agree on how bulk simultaneous heat pump connection requests should be managed.
- **Reinforcement of the local electrical network may be necessary** to accommodate the extra load associated with high-density heat pump deployment. Engage with the DNO to understand the timeline implication of this.

1.2.3 WP4: Building Pathways and Costs

Key Challenges Identified

Led by City Science, this work-package aimed to identify the series of measures and the associated costs of retrofitting an existing property with an Air Source Heat Pump (ASHP). It also aimed to identify any new technologies or methods which could bring down these costs or improve the experience for the consumer.

There were three key components of this work-package: firstly, a cost model of a heat pump retrofit was built, interviews with local installers were conducted to determine the challenges associated with heat pump retrofit, and finally a review of new heat pump technologies was conducted.

Cost modelling key findings:

- In all archetypes investigated, on a total lifetime cost basis, retrofitting an existing property with an ASHP is probably going to cost significantly more than sticking with a gas boiler (even under the new energy price guarantee).
- The addition of solar PV will improve the financials of the heat pump retrofit if the owner is willing to make a long-term investment.
- The impact of different energy tariff scenarios is substantial.

Installer interview key findings:

- It is surprising that one installer completely replaces the full wet heating system for new when retrofitting a heat pump. They will replace all pipework, all radiators, circulation pumps and hot water cylinders, reusing none of the existing system. This will cause extra cost to the consumer both for removal of old system and for cost of the new system.
- The space for the outdoor unit of a heat pump is a concern, particularly with terraced and semi-detached properties.
- Bungalows have been reported to be a preferable building archetype for heat pump retrofits, particularly if it is a detached bungalow.

Technology horizon scan key findings:

- A review of latest heat pump technologies on the market did not bring about anything radically new for consideration for Phase 2 of the project.
- The most interesting heat pump technologies found, that were also at a good enough level of commercial development, were those from well-known manufacturers, but they came with either longer than usual warranty or claimed low noise (which helps with fulfilling planning requirements).

Relevant Recommendations to Overcome Challenges

- **Be transparent with consumers on the assumptions used in any cost modelling**. The impact of energy tariffs on the total lifetime cost of heat pump ownership is substantial, therefore, being transparent with the assumptions made in any cost estimations is critical.
- **Provide the option for solar PV to be installed alongside the retrofit**, as this could save the consumer money (if they are willing to invest).
- **Develop standardised technical specifications for heat pump installs**. The local installers took different approaches to heat pump retrofits, with one completely replacing the existing heating system, whilst another would attempt to maintain as much of the existing as possible (which is preferable from a cost to consumer and sustainability perspective).

1.2.4 WP5: Financing Recommendations

This work-package was designed to develop recommendations on suitable lending schemes to help consumers overcome the high upfront cost of heat pumps. It was led by City Science with Lendology acting in an advisory capacity. The work started with a focus on researching the American PACE lending model, then an evaluation of other heat pump suitable lending models was conducted.

PACE research key findings:

- It is not considered feasible to offer the PACE model in the UK in the short term, due to additional legal and regulatory alterations that would need to be made.
- The ability to spread the capital cost/repayments over a 10-15 year period to make it affordable to most households.
- Association with the local authority/government is valuable in building trust/reducing perceived risk.
- Lending secured against the property to reduce default risk, resulting in lower interest rates (and lower cost to the consumer).

Financing mechanisms key findings:

- Green mortgages were an attractive option that allowed homeowners to put the cost of the heat pump on their mortgage, with some lenders offering some kind of benefit (often a reduced interest rate for a period of time) for having done something "green" to their house.
- However, with retail mortgage rates significantly increasing in the Autumn of 2022, the cheapest form of borrowing, and the option most aligned with recommendations from the user research, is a model offered by Lendology. As such, this has been deemed our preferred lending; however, this will remain under review as the wider lending market stabilises. The Lendology model is considered highly suitable for the following reasons:
- The Lendology model utilises funding from local authorities and can therefore be advertised as a government scheme (similar to PACE) which will provide consumers with confidence.
- The interest rates achievable are less than retail mortgages at 4-4.5%.

Relevant Recommendations to Overcome Challenges

- **Providing a lending option that gives the ability to spread the capital cost/repayments over a 10-15 year period to make it affordable to most households**.
- **Provide a trustworthy financial lending services**. Part of the success of the American PACE model was its association with the local authority/government which reduced perceived risk to consumers.

1.2.5 WP6: Customer Journey

This work-package was led by Growth Guides and built upon the user research evidence gained from work package 2. The objective of this work package was to simplify and de-mystify the customer journey sufficiently, and provide an evidence base for developing an approach to maximise heat pump uptake. The key components of this work-package were conducting user interviews and mapping out the consumer journey of a switching to a heat pump.

User interviews key findings

- If upfront costs are significant, these would need to be affordable - a significant challenge for fuel poor - but they would still consider financing if on good terms and viable with a payback over the life of the heat pump (ideally inside 10 years).
- Because heat pumps are still relatively new and unknown to most respondents, there is concern over how long they are likely to last and how much they will cost to maintain - facts and figures on this will be important to reassure them.
- Local authorities and relevant charities (such as PECT) in particular were seen as having a role to play and seeing more people and organisations using heat pumps would lower the perceived risk considerably. Examples of heat pumps being used more widely will help increase uptake (or minimise journey drop off), not just in homes but more widely across society (e.g. in commercial properties, government buildings, schools etc).
- A website is seen as the natural place to find out more about heat pumps, but it will need to be professional, trustworthy and 'super-simple' to use.
- Several respondents suggested as well as a plan, they would appreciate an independent consultation with an expert to talk the plan through and address any questions they have.
- Overall, paying for and installing a heat pump is attractive to many but feels like it carries a high risk for the relatively early adopters. Normalising heat pump use and providing safety nets if things go wrong will be important to escalate uptake, both for fuel-poor and able-to-pay customers.

User journey mapping key findings

- Age plays a large factor in a consumer's considerations in switching to a heat pump, therefore, our consumer journeys were split by age, as well as by those that are fuel poor and those are able-to-pays.
- The journey was segmented into five key steps: Awareness & interest, Active Consideration, Online Suitability Assessment, Detailed Home Plan, Procurement. Potential reasons for consumer drop-off and mitigation methods for preventing drop-offs were developed for each stage of the consumer journey.

Relevant Recommendations to Overcome Challenges

- **Local authorities and relevant local charities are seen as having a key role to play.** Users want trusted advice.
- **Breakdown the consumer journey on switching to a heat pump and develop mitigations methods for preventing drop-offs.** Our mapping of the user journey highlighted a several potential reasons for users to drop-off on their switch to a heat pump.
- **Conduct extensive hyper-local engagement.** Achieving high-density deployment will require high awareness of heat pumps in the local community. Consumers also noted that they require trusted advice and want to be aware of examples of heat pumps being used. Local engagement, either through door-to-door consultations or through local events can be used to simultaneously raise awareness but also as place to provide advice and examples of heat pump usage.

1.3 Overarching Approach for High-density Heat Pump Deployment

Phase 1 developed a wealth of evidence on the requirements to achieve high-density heat pump deployment. The findings of the project highlighted that heat pump uptake remains challenging; it is comparably expensive to the predominant incumbent domestic heating system (gas boilers) and potential consumers are unfamiliar with the technology, so it is perceived as risky (building trust was a key theme of the user research).

However, the project highlighted that potential consumers are interested in switching, and the environmental benefits of moving away from their existing fossil fuel systems is appealing. Furthermore, we have discovered a series of measures that should bring cost reductions to consumers and have proposed engagement activities that should expand their current understanding of these systems, building trust in heat pumps as a technology. Whilst high-density heat pump deployment will be challenging, these measures offer the potential to achieve it. This project therefore pursued an application in November 2022 for high-density heat pump deployment in Phase 2. A summary of our key recommended measures in our suggested approach for high-density heat pump deployment which we feel will increase success of achieving high-density deployment include:

- **Trusted, Local Authority Backed Web Service**: A single web platform service that offers simple and unbiased guidance on heat pumps combined with safe channels of procurement.
- **Consumer-centric Approach**: Simplified and enhanced consumer journeys by providing a simplified, trusted, local authority backed service for heat pumps and energy efficiency measures, coordinated through existing local networks.
- **Deep Localised Engagement**: Building on existing deep local engagement, utilisation of a hyper-local, community-based engagement strategy in the targeted area.
- **Supply Chain Capacity Building and Standardisation**: Through partnership with the local supply chain, standardisation is to be embedded throughout the process, taking a rigorous and detailed approach to the surveying, specification and quality assurance of heat pump installations, using standardised commercial technology components.
- **Innovative Financing**: Innovative financing will be employed to fund the high upfront cost, unlocking the possibility of heat pumps to a wider demographic.

2 Introduction

This report presents the key findings and evidence developed in the Heat Pump Ready Cambridgeshire Phase 1 project and will be used by the Department for Business, Energy and Industrial Strategy (BEIS) to understand the opportunities and challenges of coordinated, high-density heat pump deployment.

The project was conducted within Stream 1 of the Heat Pump Ready (HPR) programme funded by BEIS (BEIS, 2021). The key objective of this programme was to develop innovative approaches to delivering high-density deployment. High-density heat pump deployment (under the Heat Pump Ready programme) is defined as deploying heat pumps in at least 25% of domestic properties under an electricity supply area. The electricity supply area could have been either of that covered by a primary electricity substation, secondary electricity substation, or a low voltage network.

A total of 11 of these projects were conducted across Great Britain, this specific project focussed on achieving high-density heat pump deployment in the district of Fenland, Cambridgeshire. This project was rural in its focus, other projects had either an urban or urban with a significant element of rural focus. A key theme of this project was to investigate financial lending options which could help consumers overcome the high upfront cost of heat pumps.

This project ran from July 2022 to November 2022, with the intention that a number of these feasibility projects will be taken forward into Phase 2 throughout 2023 and 2024. In Phase 2, BEIS propose to fund up to £5,000 of the heat pump installation cost, provided the 25% density target is met (HPR BEIS, 2022). In November 2022, Phase 1 projects were invited to submit a proposal for an approach to achieving high-density heat pump deployment for Phase 2 within their targeted location identified.

Sections 3 and 4 of this report detail the work conducted in Phase 1, along with the key findings. The subsequent sections detail the recommendations for achieving high-density heat pump deployment given the findings from the feasibility in Phase 1.

The project was led by City Science, with key contributions by Cambridgeshire County Council (CCC), Fenland District Council (FDC), Peterborough Environment City Trust (PECT), Growth Guides, and Lendology. The project's organogram is shown in Figure 1 below.

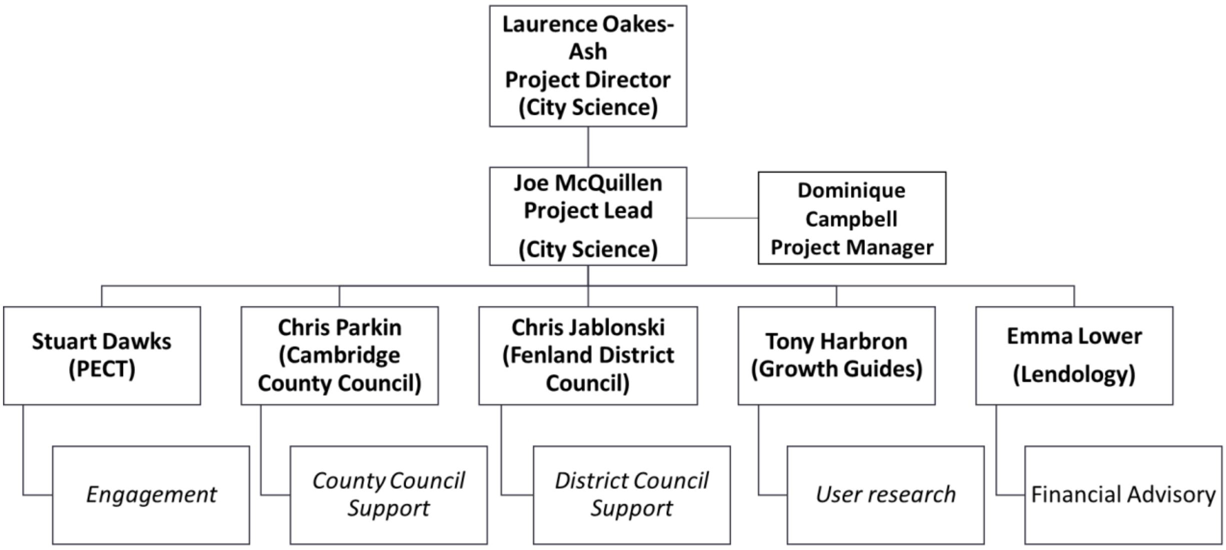

Figure 1 - Heat Pump Ready Cambridgeshire Organogram

2.1 Aims, Expected Outcomes & Objectives

The aims and expected outcomes of the Stream 1, Phase 1 feasibility studies were to:

- Help the government make the transition to net zero affordable and achievable for all by reducing costs to consumers.
- Overcome widespread barriers of large-scale heat pump deployment.
- Improve repeatability of heat pump performance.
- Understand implications of large-scale heat pump deployment on the grid, including mitigation methods.

A total of 11 Stream 1, Phase 1 projects were awarded by BEIS in the summer of 2022. Each project took a unique approach in exploring the feasibility of high-density heat pump deployment. The specific objectives of this Cambridgeshire Stream 1, Phase 1 project were to:

- Identify favourable locations for heat pump deployment via a repeatable methodology.
- Engage consumers to understand perceptions, barriers, and trigger points to switching to heat pumps.
- Engage with the supply chain to understand the costs and challenges of heat pump installs.
- Explore financing models (in particular, the PACE model) to help consumers overcome the high upfront cost of heat pumps.
- De-mystify and map out the consumer journey towards installing a heat pump.

3 Summary of Work Packages

A summary of the work packages set out for this project are detailed in Table 1 below, complete with their objectives and outputs.

Work Package	Lead	Objective	Outputs
1. Project Management	City Science	Ensuring project delivery and reporting to BEIS.	Interim Report, Project Close Meeting
2. User Research/Co-Design	PECT	Engage with potential participants to understand perceptions, barriers, and trigger points to switching to heat pumps. Develop evidence base for uptake expectation.	User Research Workshop, User Research Report, Take-Up Expectation Report
3. Site Prioritisation Process	City Science	Identify the area within the county where the deployment of heat pumps will be focussed.	Site Prioritisation Workshop, Site Prioritisation Report, Detailed Visualisation of Core Sites.
4. Building Pathways and Costs	City Science	To provide evidence that our holistic approach can deliver tangible cost reductions to consumers, while providing a deliverable, standardised model that can be implemented by the supply chain in Phase 2.	Heat Pump / Retrofit Challenges and Experiences Workshop, Horizon Scan Prioritisation, Report Expected Impact on Cost Benchmarks.
5. Financing Recommendations	City Science	Collect and evaluate evidence to confirm whether PACE-style financing is suitable for the UK, is deliverable within existing structures and will add value to consumers and BEIS as a delivery vehicle in Phase 2.	Draft Proposal Review, Final Recommendations Report.
6. Customer journey	Growth Guides	Simplify and de-mystify the customer journey sufficiently and provide evidence that our approach addresses the critical barriers to heat pump deployment.	Initial Pathway Review, Pathway Agreed.
7. Reporting and Phase 2 Application	City Science	Final project reporting and development of Phase 2 approach.	Phase 2 Application, Final Project Report

Table 1: Summary of Phase 1 Work Packages

4 Methodology and Findings of Work Packages

This section provides a summary of the deliverables and key findings from the individual work packages. Work packages 1 (Project Management) and 7 (Reporting and Phase 2 Application) have been deliberately excluded as their outputs do not contribute to the key findings of the study. Some of the key deliverables from these work packages have been provided as appendices for reference.

4.1 Work Package 2: User Research & Engagement (PECT)

This work-package was led by Peterborough Environment City Trust (PECT) and was designed to build evidence on the user perceptions, barriers, and potential trigger points towards switching to heat pumps.

The work started with the production of an online survey that posed questions regarding heat pump awareness, heat pump barriers, potential enablers, and the demographics of the respondents. The survey was distributed via multiple social media channels including PECT's, local authorities and community groups in the local area, hence many of the survey respondents were based in, or very close to Cambridgeshire. A total of 802 responses were received.

Research was also conducted on how our customer base would be segmented into fuel poor vs able-to-pay. Fuel poverty can be defined in several different ways; the chosen definition for this project was decided as that which aligns with the eligibility criteria for the Green Homes Grant Local Authority Delivery scheme in Cambridgeshire. This stipulates that a household must be in receipt of means-tested benefits or be able to provide evidence of an annual gross income below £30,000, and the property must have an EPC rating of D, E, F or G (South Cambridgeshire District Council, 2021).

To build further evidence beyond the online survey, PECT conducted four focus groups with members of the public, one was conducted in-person in Peterborough, the other three were conducted online. The in-person group had two attendees, the virtual groups had attendances of 6, 8 and 11 people. No attempt was made to create any distinct demographics within the groups, however, all participants were from the UK. Feedback from the focus groups developed evidence on reactions towards heat pumps.

PECT then conducted door-to-door engagement within the targeted area of Friday Bridge (by the time of the door-to-door engagement in October 2022, the village of Friday Bridge had been chosen as our targeted area of heat pump deployment under work package 3). The door-to-door engagement aimed to build further user research upon that gained from the online survey, but the data gained would be specific to the targeted area for heat pump deployment. The engagement also served as a useful exercise in raising awareness of project within the village. Prior to the door-to-door engagement, all households in the area were sent a letter from the local authority (Fenland District Council) informing them that surveyors would be conducting the door-to-door research. The intention of this was to build trust with the community and give credibility to the surveyors. Engagement with a total of 682 households was attempted, with 102 surveys being successfully undertaken.

The key findings from this work package have been broken down by each engagement below. A more detailed set of key findings, and the outputs of the online survey, the focus groups and the door-to-door engagements have been provided in Appendix A.

4.1.1 Online Survey Key Findings

- Only 50% of respondents currently used a gas boiler (possibly due to rural nature of Cambridgeshire).
- 20% of respondents would switch to heat pumps even if it's more expensive, 60% would switch only if it saved them money.
- Upfront cost is the biggest concern to consumers, with 60% being very or somewhat concerned.
- For those that knew others with a heat pump, the majority, over 53%, were recommended them.
- Over 75% of people think knowing someone with a heat pump might make them more comfortable having one installed.
- When choosing a heating system over 90% think reliability is the most principal factor, followed by lower running cost.
- Out of a set of price ranges, the most popular category for what consumers thought to be an acceptable price for a heat pump was between £2,000 and £5,000, with 45% of respondents selecting this option. Only 14% of respondents stated that they thought that between £5,000 and £10,000 was an acceptable price.

4.1.2 Focus Group Key Findings

- The majority of people had heard of heat pumps, although they didn't know the specifics and if it was right for them or where to find information.
- There were concerns around the length of time for installation, the process to ensure all parts of the installation were done correctly and the retrofit of existing systems.
- Most felt they would like a trusted supplier to do the installation, backed by a trade guarantee scheme. They valued expertise and experience.
- The lack of knowledge around heat pumps was seen as a challenge about what system would be right, the additional measures and what trades were needed.
- A list of trusted and reputable suppliers from the local authority was seen as positive addition.
- Cost was seen by all people as the largest barrier.
- Several people would like to see a heat pump in-person and speak to someone who has been through the process of installing heat pump in their home.
- Several felt that some form of assurance such as a guarantee on the quality of installation and the ability to talk with a suitably qualified/registered installer who can be trusted to advise homeowners would be advantageous.

4.1.3 Door-to-door Engagement Key Findings

- 68% of people had heard of a heat pump, which was lower than the those who had taken part in the online survey. Just over 50% knew that gas boilers are being phased out.

- Over half of consumers would only look to replace their current heating system if it was broken or if it was cheaper to install and run a heat pump than their existing heating system.
- 42% of those surveyed felt that additional financial support around a low interest loan or increased council tax would encourage them, although over 57% wouldn't consider this.
- Over half of people would like to have an independent advisor support them with the next step in obtaining a heat pump.

4.2 Work Package 3: Site Prioritisation Process (City Science)

The objective of this work-package was to identify an optimal area to target within Fenland to target for the high-density heat pump deployment and was led by City Science. Optimal in this context would be an area that fulfilled the requirements of the Heat Pump Ready programme, but also had a good chance of heat pump uptake.

The Heat Pump Ready programme aimed to develop solutions that would be applicable to the majority of domestic housing stock in the UK. The programme therefore placed limits on the types of buildings in which heat pumps could be deployed to (see Figure 2 below).

Building type	Permitted in Stream 1 trial?	Limit for Stream 1 trial (as % of total heat pumps deployed in trial)
Social housing **New Build (pre-occupancy)** **Non-domestic**	Yes	**Maximum of 30% in total (i.e. for all three categories)**
Off-gas grid homes	Yes	**Maximum of 15%**

Figure 2: Permitted housing/building type deployment limits

A site prioritisation methodology was developed that was able to identify priority substation areas given building typologies and the deployment limits. The methodology determined several relevant characteristics on each individual building within the county. These characteristics were then aggregated up to develop metrics for each primary and secondary substation in Fenland. The metrics were used to filter and rank each substation.

Two models were built: firstly, a simple Excel model was used to develop a scoring for a variety of building typologies based on their expected financial performance of switching to a heat pump vs remaining with a gas boiler (see more on the model below and in Appendix B). The output from the Excel model was a score for each typology at 10, 20 and 30 year periods from the current year. These scores, along with a variety of geographic data (detailed in the flowing paragraphs) were processed together with Python to develop metrics for each primary and secondary substation within Fenland. The code was developed such that it could be easily re-ran for another area, provided that relevant EPC, AddressBase and DNO datasets are loaded for that area.

For each property, the following was determined:

1. Whether it had mains gas connection (as determined from EPC or off-gas postcodes database)
2. Listed building, or in other protected status area (as determined from Historic England datasets)
3. Domestic or Non-domestic (as determined from AddressBase)
4. Social housing status (as estimated from EPC data)
5. Financial scoring of building typology (as determined from initial financial model which tapped into EPC data).

6. Which primary and secondary substation it was connected to (using substation data from the DNO and estimated catchment areas for secondary substations).

Once the above was determined, a number of metrics on each primary or secondary electricity supply area could be determined (an example for a secondary substation shown in Table 2 below).

Electricity substation name	Number of addresses	Number of domestic addresses	% on-gas	% social housing
GREEN ST-MARCH	196	193	93%	21%
% HPR priority	**Domestic EPC coverage (%)**	**Average 10 year score**	**Average 20 year score**	**Average 30 year score**
82%	61%	-66	-70	-50

Table 2: Example Metrics for a Secondary Substation

The methodology made use of openly available datasets such as EPC and protected buildings data from Historic England (see Appendix B for datasets). The methodology also required geographic data from the District Network Operator (DNO) on the catchment areas for each electricity supply substation.

The DNO for Cambridgeshire, UK Power Networks (UKPN) were able to provide this for primary substations, however, they did not have this data available at a secondary substation level, therefore, we estimated these areas for the analysis. The catchment areas were estimated by generating Voronoi polygons around each secondary substation (these can be easily generated by any GIS software, or in this case by using the Python package geovoronoi).

By generating these polygons, it is effectively assumed that any household is connected to the nearest substation in terms of proximity. This will not be the case in reality, as there are pragmatic limitations such as whether there is a direct route to the nearest substation. Underground cables and overhead power lines often run in accordance with roads, therefore they do not always take the most direct route to the nearest substation in terms of absolute proximity. However, in lack of any further information, these polygons are considered a reasonable estimation for which substation a household is connected to.

Through discussions with the Innovation team at UKPN, they offered to undertake further analysis to determine the available headroom and more accurate catchment areas for 15 substations. However, there are 1,900 substations within Fenland, therefore, it was required that the prioritisation analysis was run using the estimated substation areas. A favoured 15 substations were then sent to UKPN for further analysis.

A scoring was developed for a variety of different building typologies based on the expected lifetime cost of switching that property to an ASHP (assuming it was already using a gas boiler). From the financial analysis, some priority trends emerged:

- **Flats and bungalows scored better than houses**: given the gas and electricity tariffs used in the model, it was more expensive to operate an ASHP vs a gas boiler, therefore the difference in annual energy costs grew as the space heating requirement of the property increased. Smaller properties (with lower space heating demands) therefore scored better. However, flats may be problematic for heat pump install due to space availability for installation (this was not accounted for in the scoring).
- **Properties needing less energy efficiency retrofit scored better:** the typologies were split between those than had an energy efficiency equivalent to an EPC B property, and those needing EPC D. Building fabric upgrades were applied to the EPC D properties, which incurred greater cost to the whole retrofit.
- **Properties with cavity walls were favourable over solid walls:** the housing typologies were split between those that had cavity walls and those that had solid walls. For the EPC D properties, external wall insulation was applied to the solid wall properties as it was assumed that prior to a heat pump install, solid wall properties would be upgraded for more effective heat pump operation. This is expensive (circa £10k) and has a long payback time, and therefore it negatively impacted the financing scoring of these properties.

The analysis generated by this methodology was presented to all project partners in late July 2022. The analysis presented three favourable areas for heat pump deployment as three clusters secondary substations were identified. Targeting a secondary substation was favoured over a primary substation, as the latter would typically cover thousands of customers, meaning that to achieve 25% density would require the deployment of several hundred heat pumps which was thought to be too optimistic. Using the partners' local knowledge led to the conclusion that the village of Friday Bridge was to be the targeted area of heat pump deployment (see Appendix B for more information of prioritisation process).

The targeted area of Friday Bridge covered approximately 700 domestic addresses, 97% being on-gas properties and just 6% were estimated to be social housing. The number of domestic properties in each substation area varied from around 35 up to 176, requiring between 9 and 44 heat pumps to be deployment to reach the 25% density respectively.

UKPN undertook the further analysis on the selected 15 substations in Friday Bridge. Unfortunately, the results identified that nearly all substations will most likely need reinforcement to accommodate a heat pump deployment density of 25%. Only two substations may be capable of 25% deployment without reinforcement, however, it was estimated that they could only accommodate circa 30% deployment. This leaves little room beyond 25%, so it was assumed that they may also require reinforcement.

Discussions were held with UKPN to understand the cost and timelines for substation reinforcement. It typically takes in the region of four months to upgrade the substation. From April 2023 onwards, the cost of the upgrade is added to the Distribution Use of System (DUoS) charges to all consumer's electricity bills under the DNO's catchment area, and not borne directly by the consumers within the catchment area of the reinforced substation.

Should high-density heat pump deployment be achieved, the DNO will need to prepare for a bulk load of simultaneous requests for heat pump connections to the grid. The DNO will need to undertake analysis of the substation transformer and lower voltage assets to determine whether the local network has sufficient capacity to accommodate the increasing electrical load from the heat pumps. Due to the historically low uptake of heat pumps, this is not a situation that they have yet had to prepare for. It was found that DNO's do not currently have processes in place for bulk simultaneous heat pump connection applications, instead, only one-at-a-time applications exist. Discussions were had with UKPN about how high-density heat pump could be managed. It was agreed that in such situations, UKPN should be notified in advance that a bulk application of heat pump connections is due to be submitted.

See Appendix B for more detail on the methodology employed and the visualisations developed.

4.2.1 Deployment Prioritisation Key Findings

- A replicable methodology for prioritising the deployment of using openly available data with a national coverage was successfully developed.
- The DNO (UKPN) could not immediately provide headroom and catchment area data at secondary substation level. UKPN were required to undertake further analysis to obtain this data.
- The further analysis found that it is likely that all substations within our targeted area (Friday Bridge) will most likely need reinforcement to accommodate a heat pump deployment density of 25%.
- DNO's are currently unlikely to have systems in place to deal with bulk simultaneous heat pump connection applications (as would be required for high-density heat pump deployment), as this is not a situation they have had to prepare for yet. DNO's should be engaged in advance of high-density heat pump deployment so that they can put the necessary processes in place to deal with this.

4.3 Work Package 4: Building Pathways and Costs (City Science)

Led by City Science, this work-package aimed to identify the series of measures and the associated costs of retrofitting an existing property with an Air Source Heat Pump (ASHP). It also aimed to identify any new technologies or methods which could bring down these costs or improve the experience for the consumer.

4.3.1 Heat Pump Cost Modelling

A detailed financial model was developed which for a total of 13 building archetypes determined the lifetime cost (capital costs, fuel costs, servicing and replacement) of retrofitting an existing property with an air-to-water heat pump (ASHP) over a 30-year period. The model also determines the equivalent lifetime cost of a gas boiler and makes comparisons against the two heating systems. Further detail on the modelling approach and the assumption used have been provided in Appendix C1; the key assumptions include the following:

- Capital cost of heating plant (boiler or ASHP), plus installation labour
- Replacement of the heat pump and gas boiler after 15 years
- 40% grant for the capital cost of the heat pump retrofit applied in first year to replicate that which is offered under the Heat Pump Ready programme.
- Annual fuel costs (gas or electricity)
- Annual service
- For the heat pump retrofit, cost of heat emitter upgrades (replacement of all radiators, plus installation labour)
- For the heat pump retrofit, cost of the following building fabric upgrades (plus installation labour):
    - Draught proofing
    - Top-up loft insulation
    - External wall insulation (for solid wall houses)
- For solar PV, cost of panels (assumed to last 30 years), inverter (replacement at 15 years), fitting and labour
- For batteries, cost of batteries (replaced at 15 years) and installation labour
- Costs were not discounted for simplicity.

The model allowed for several scenarios to be considered including energy efficiency of the household, energy tariff projections, the 2035 gas boiler ban, the use of a loan to cover upfront retrofit costs and the inclusion of solar PV and battery technologies.

Two key energy price scenarios were modelled which used different gas and electricity tariffs. The low tariff scenario used the UK Government's 2021 Green Book projections which are pre-energy crises tariffs, with prices varying between 4-5p/kWh and between 13-15p/kWh for gas and electricity respectively for each year between 2022 and 2051 (HM Treasury, 2021). The high tariff scenario used flat tariffs out to 2051 which are the caps under the Energy Price Guarantee announced in September 2022, which were 10p/kWh and 34p/kWh for gas and electricity respectively (BEIS, 2022).

The ratio between the gas and electricity price determines whether the gas boiler or the ASHP is cheaper to run. In both scenarios, the electricity price is greater than the gas price, however, the ratio is more favourable for heat pumps under the high tariff scenario. With an electricity price of 34p/kWh, and a gas price of 10p/kWh (the high tariff scenario), an ASHP with a SCOP of 2.8 will cost the same in terms of fuel costs as a gas boiler with an efficiency of 85%. ASHPs can achieve higher SCOPs than this; we modelled a SCOP of 3.0, therefore, under the high tariff scenario, the ASHP cost slightly less to run than the gas boiler. If this price ratio between electricity and gas declines over time, heat pumps will become more favourable in terms of fuel costs.

A key finding from the modelling was that the total lifetime cost of ASHPs was substantially more than gas boilers under both scenarios, but the Energy Price Guarantee improves the economics of heat pumps in comparison to pre-energy crises tariffs (due to the differential between the electricity and gas price). Another finding was that the incorporation of solar PV onto a household with a heat pump greatly improves the economics of switching to a heat pump, particularly under the Energy Price Guarantee tariff scenario as the PV displaces a higher electricity tariff.

A summary of the key results from the financial modelling has been provided in Table 2 and Table 3 below, for further results and more information on the methodology, see Appendix C. The numbers provided in the tables are the percentage difference in lifetime cost of the heat pump retrofit against lifetime cost of a new gas boiler. The negative percentages (red cells) are where the heat pump retrofit is more expensive than the gas boiler, the positive percentages (green cells) are where the heat pump retrofit breaks even (0% difference) or it is cheaper.

Building Typology	Low tariff: Green Book Projection			High tariff: Energy Price Guarantee 2022		
	Lifetime Cost % diff – 10 years	Lifetime Cost % diff – 20 years	Lifetime Cost % diff – 30 years	Lifetime Cost % diff – 10 years	Lifetime Cost % diff – 20 years	Lifetime Cost % diff – 30 years
small_flat	-60%	-70%	-54%	-18%	-26%	-17%
ground_floor_flat	-66%	-75%	-57%	-18%	-27%	-16%
top_floor_flat	-71%	-78%	-59%	-21%	-28%	-16%
bungalow	-66%	-71%	-53%	-17%	-23%	-13%
mid_terrace_solid	-108%	-90%	-63%	-35%	-29%	-14%
mid_terrace_cavity	-81%	-86%	-64%	-26%	-31%	-20%
end_terrace_solid	-105%	-80%	-52%	-29%	-19%	-4%
end_terrace_cavity	-86%	-89%	-66%	-27%	-32%	-19%
semi_detached_solid	-93%	-69%	-44%	-22%	-13%	0%
semi_detached_cavity	-78%	-80%	-59%	-22%	-26%	-16%
detached_solid	-145%	-113%	-75%	-49%	-36%	-16%
detached_cavity	-134%	-133%	-96%	-51%	-54%	-34%

Table 2: Results of Lifetime Cost Modelling of Heat Pump Retrofit

From Table 2 above it is clear that the heat pump retrofit costs more than the gas boiler replacement. The lifetime cost at the 20-year mark is often scores more negatively as replacement of the heat pump and gas boiler is required at 15 years. The heat pump has a much higher capital cost and does not gain a £5,000 (or 40%) grant as it did in the first installation (which was implemented to replicate the benefit offered under the Heat Pump Ready programme).

There is a large difference between the two scenarios; this is due to the differential between the gas and electricity price. Under the Energy Price Guarantee, the heat pump makes a saving in terms of operational fuel cost against the gas boiler scenario. However, this operational cost is not enough to overcome the high capital costs between the two technologies. A breakeven in lifetime cost is only seen for the semi-detached property with solid walls after 30 years. The external wall insulation applied to this typology makes a substantial space heating saving which over time it begins to pay itself back, though it requires a substantial amount of time as the cost of solid wall insulation is high (circa £10k). A 24% reduction space heating was applied model in for external wall insulation as determined from data collected from BEIS's National Energy Efficiency Data-Framework (NEED) (BEIS, 2021).

Table 3 below shows the results when adding solar PV to the heat pump retrofit. The optimal capacity of solar PV for each property was determined based on which capacity between 1kWp and 5kWp (in 0.5kWp increments) produced the lowest lifetime cost. Capacities higher than 5kWp were not explored as this starts to occupy a roof area beyond which may not be available for typical households. The model could also return no PV capacity as a possible optimal outcome. With the low tariff, inclusion of PV was never found to be optimal at the 10-year point, however, this changes at 20 years, when inclusion of PV is optimal for all archetypes (this means that payback for PV system is greater than 10 years). Under the high tariff scenario, PV is optimal at 10, 20 and 30 years. The results of the 10-year optimum sizes have been provided below. The inclusion of solar PV onto flats was not modelled as it was assumed that they would not be in ownership of roof space to accommodate PV.

Building Typology	Low tariff: Green Book Projection				High tariff: Energy Price Guarantee 2022			
	PV System Size (kWp) - optimal for 20 years	Lifetime Cost % diff – 10 years	Lifetime Cost % diff – 20 years	Lifetime Cost % diff – 30 years	PV System Size (kWp) - optimal for 10 years	Lifetime Cost % diff – 10 years	Lifetime Cost % diff – 20 years	Lifetime Cost % diff – 30 years
bungalow	4.5	-88%	-60%	-27%	3.0	-10%	-3%	13%
mid_terrace_solid	4.5	-126%	-79%	-39%	3.0	-28%	-11%	9%
mid_terrace_cavity	5.0	-103%	-73%	-37%	3.0	-18%	-12%	6%
end_terrace_solid	5.0	-121%	-68%	-27%	3.5	-22%	-1%	20%
end_terrace_cavity	5.0	-103%	-74%	-38%	3.5	-19%	-11%	7%
semi_detached_solid	5.0	-108%	-56%	-19%	3.5	-15%	5%	24%
semi_detached_cavity	5.0	-93%	-66%	-32%	4.0	-14%	-5%	12%
detached_solid	5.0	-163%	-102%	-51%	3.0	-43%	-20%	6%
detached_cavity	5.0	-151%	-120%	-69%	3.5	-43%	-35%	-9%

Table 3: Results of Lifetime Cost Modelling of Heat Pump Retrofit with Solar PV

It was also explored whether the addition of a battery may improve the economics of the solar PV and heat pump retrofit. The battery could charge from any excess solar PV generated (rather than it being exported to the grid) and discharge when the solar PV is less than the demands of the household (displacing the cost of grid electricity). The inclusion of the battery was never found to be optimal at 10 or 20 years. In some instances, it was optimal at 30 years under the high tariff scenario. Further work is required to understand the economics of including the battery with a dynamic time of use tariff under which it may be beneficial for the battery to charge at times when grid electricity is low and discharge when the cost is high.

4.3.2 Cost Modelling Key Findings

- In all archetypes investigated, on a total lifetime cost basis, retrofitting an existing property with an ASHP is probably going to cost significantly more than sticking with a gas boiler (even under the new energy price guarantee).
- The addition of solar PV will improve the financials of the heat pump retrofit if the owner is willing to make a long-term investment.
- The impact of different energy tariff scenarios is substantial.

4.3.3 Installer Interviews

The model used costs gained from desktop research (see Appendix C for references used) and our best understanding of the measures required for a ASHP retrofit. These costs and the challenges of heat pump installs were discussed with local installers via two 1-to-1 interviews.

These interviews were quite revealing, as installers had different approaches to heat pump installs, with one installer stating that they will completely remove the existing wet heating system (all pipework, radiators, hot water cylinder, pumps) and replace for new. Whereas another installer would try to use as much of their customer's existing system as possible, as this reduces the cost of the retrofit and causes less disruption. The latter approach is obviously preferable, but the first installer had justification in that they cannot guarantee that the heat pump will work effectively if they re-use some of the existing heating system.

4.3.4 Installer Interview Key Findings

- It is surprising that one installer completely replaces the full wet heating system for new when retrofitting a heat pump. They will replace all pipework, all radiators, circulation pumps and hot water cylinders, reusing none of the existing system. This will cause extra cost to the consumer both for removal of old system and for cost of the new system.
- The space for the outdoor unit of a heat pump is a concern, particularly with terraced and semi-detached properties.
- Household owners typically do not want to install the outdoor unit at the front of their property for aesthetic reasons.
- Bungalows have been reported to be a preferable building archetype for heat pump retrofits, particularly if it is a detached bungalow.

4.3.5 Technology Horizon Scan

Research was undertaken to determine if there are any new, but commercially available technologies that could be used to either bring down costs to the consumer or improve their experience. The review of technologies did not bring about anything radically new that was at a level of commercial development to be considered for deployment within the next year.

The most interesting heat pump technologies found, that were also at a good enough level of commercial development, were those from well-known manufacturers, but they came with either longer than usual warranty or claimed low noise during operation (which helps with fulfilling planning requirements). Some heat pump manufacturers were claiming very high COPs from their units, some claimed as high as 5, which could bring about huge savings to consumers even when compared to gas boilers. However, manufacturer's claims should be taken with critical scepticism and further investigation is needed to determine what the likely seasonal COP would be (which is the average COP achieved across a full year).

4.3.6 Technology Horizon Scan Key Findings

- A review of latest heat pump technologies on the market did not bring about anything radically new for consideration for Phase 2 of the project.
- The most interesting heat pump technologies found, that were also at a good enough level of commercial development, were those from well-known manufacturers, but they came with either longer than usual warranty or claimed low noise (which helps with fulfilling planning requirements).

4.4 Work Package 5: Financing Recommendations (City Science, Lendology)

This work-package was designed to develop recommendations on suitable lending schemes to help consumers overcome the high upfront cost of heat pumps. It was led by City Science with Lendology acting in an advisory capacity.

The research into lending options has been broad, though there has been a particular focus on the American, Property Assessed Clean Energy (PACE) programme (US Department of Energy, 2022). Research on the PACE programme and its implementation in the US has been conducted. Evidence was found that it would be problematic to implement such a system in the UK due to its different system of property taxation and municipal finance (Brown, et al., 2019). Further information on the research conducted on PACE has been provided in Appendix D2. There are some key learnings that can be taken from the success of the PACE system when identifying a suitable financing approach for heat pump deployment.

Lendology conducted analysis via a desktop review and their best understanding of the market on the several lending options that might be available to heat pump consumers. This included a review of mortgage lending, unsecured borrowing and their own personal loan model (more detail on the Lending options has been provided in Appendix D). The analysis included for the differing consumer options for those in fuel poverty (likely to have poor credit rating) vs an able-to-pay customer (likely to have a much better credit rating). The analysis has found that the options available to those in fuel poverty are much less attractive, with extortionately high interest rates under some lending models (see Appendix D for more information).

Furthermore, City Science conducted engagement with 12 potential lenders to establish what products were currently being offered, as well as their openness to developing new products suitable for domestic energy improvements (the list of lenders and their offerings has been provided in Appendix D3). Out of the 12 potential lenders, some were large banks and some were smaller building societies. From this engagement, "green" mortgages seemed like an attractive proposition as they offered the cheapest interest rates, and it is thought that consumers would be less opposed to putting the cost of a heat pump install onto a mortgage due to its relative size. However, the financial environment in the UK changed dramatically in September 2022, causing interest rates to spike, leading us to rethink our proposed financial offering. A summary of recommendations is provided in the sections below.

4.4.1 PACE Research Key Findings

The ability for PACE financing to fund heat pump retrofits, and spread this cost over a 10-15 year term is highly suitable as it has the potential to make the installation affordable and potentially match the repayments against any energy cost savings achieved. However, the PACE mechanism, where funds are typically provided by the local government authority and recovered through property taxation (such as Council Tax in the UK), is not considered feasible in the short term, due to additional legal and regulatory alterations that would need to be made. Despite this, there are key learnings that we can use to select the closest alternative which may provide many of the benefit of PACE. These learnings/selection criteria include:

- The ability to spread the capital cost/repayments over a 10-15 year period to make it affordable to most households.
- Association with the local authority/government is valuable in building trust/reducing perceived risk.

- Lending secured against the property to reduce default risk, resulting in lower interest rates (and lower cost to the consumer).

4.4.2 Changes in the financial market

During our research and engagement with lenders, the UK lending market experienced a significant shock following the Government's 'mini budget' on the 23rd September 2022. Up until this point we were beginning to form the opinion that Green Mortgages may provide the optimum funding solution as they provided the cheapest form of borrowing. However, following the 'mini budget' mortgage rates jumped significantly, with the average 2 year fixed rate increasing from around 4.5% at the end of September 2022, to 6.5% in October 2022 (Bloomberg UK, 2022) . As a result of this significant increase, retail green mortgages suddenly became more expensive than alternative lending sources. This has led us to alter our immediate conclusion, but has highlighted the need for funding offerings to be flexible to market changes, so that the cheapest form of funding can be offered to the consumer at all times.

4.4.3 Proposed financing mechanism

With retail mortgage rates significantly increasing, the cheapest form of borrowing, and the option most aligned with PACE, is the Lendology model. As such, this has been deemed our preferred lending; however, this will remain under review as the wider lending market stabilises. The Lendology model is considered highly suitable for the following reasons:

- The model utilises funding from local authorities and can therefore be advertised as a government scheme (similar to PACE) which will provide consumers with confidence.
- The interest rates achievable are less than retail mortgages at 4-4.5%.
- The lending term can be flexible to suit the needs of the consumer and their personal finances.
- Lending can be secured against the property, resulting in reduced credit risk for the lender and lower rates for the consumer.
- Consumers have the option to repay the borrowing early with no early repayment fees, meaning they can extinguish the debt using savings, proceeds of a property sale, or roll it up into a re-mortgage if this becomes a cheaper method of borrowing.

4.5 Work Package 6: Customer Journey (Growth Guides)

This work-package was led by Growth Guides and builds upon the user research evidence gained from work package 2. The objective of this work package was to simplify and de-mystify the customer journey sufficiently, and provide an evidence base for developing an approach to maximise heat pump uptake. The user research raised many potential barriers to heat pump deployment (see summary of user research in Appendix E). The aim was to understand a consumer's thought process so that it is understood what will make them engage with the idea of switching to a heat pump and what might make them lose interest.

These journeys detail the considerations of the consumer at each stage of the process, complete with the barriers that may make them drop off from the journey, and methods of mitigating these drop off events.

Further user research was undertaken as part of this work package in the form of five one-to-one interviews. Three of the respondents were from the target location, two further sessions were arranged (one with a known fuel-poor respondent and one with a known able-to-pay respondent). These interviews were designed to draw out user considerations at five stages of the customer journey as defined by Growth Guides to be:

1. Awareness & Interest
2. Active Consideration
3. Online Suitability Assessment
4. Detailed Home Plan
5. Procurement

The original intention was to have two customer journeys; one for a 'fuel poor' customer, and one for an 'able-to-pay' customer. However, based on the user research, Growth Guides recognised that age plays a large factor in a consumer's thought process, therefore, they segmented both fuel poor and able-to-pay into younger and older customers, resulting in considerations for four types of customers. Age can play a factor in a number of ways, younger consumers are often more engaged with environmental issues, however, older consumers can often have more disposable income at hand. Consumers in retirement may be less interested in heat pumps due to concerns over reliability of the heat pump (ensuring a warm home is of great importance to the elderly), but also due the necessary time to make the investment worthwhile. Elderly consumers nearing end-of-life may not be so concerned with investing in a new heat pump with an expected 15 year lifespan.

The four consumer types mapped out have been:

- Green Blingers: able-to-pay (younger)
- Enlightened Empty Nesters: able-to-pay (older)
- Concerned Parents: fuel-poor (younger)
- Security Seekers: fuel-poor (older)

A description of the customer personas and the customer journeys considerations have been provided in Appendix E.

4.5.1 User interviews key findings

- Most respondents would consider a heat pump on the environmental benefits if they were reassured of the performance/data and it left them no (or not much) worse off than their current system or an alternative.
- If upfront costs are significant, these would need to be affordable - a significant challenge for fuel poor - but they would still consider financing if on good terms and viable with a payback over the life of the heat pump (ideally inside 10 years).
- Because heat pumps are still relatively new and unknown to most respondents, there is concern over how long they are likely to last and how much they will cost to maintain - facts and figures on this will be important to reassure them.
- Local authorities and relevant charities (such as PECT) in particular were seen as having a role to play and seeing more people and organisations using heat pumps would lower the perceived risk considerably. Examples of heat pumps being used more widely will help increase uptake (or minimise journey drop off), not just in homes but more widely across society (e.g. in commercial properties, government buildings, schools etc).
- A website is seen as the natural place to find out more about heat pumps, but it will need to be professional, trustworthy and 'super-simple' to use.
- Several respondents suggested as well as a plan, they would appreciate an independent consultation with an expert to talk the plan through and address any questions they have.
- Overall, paying for and installing a heat pump is attractive to many but feels like it carries a high risk for the relatively early adopters. Normalising heat pump use and providing safety nets if things go wrong will be important to escalate uptake, both for fuel-poor and able-to-pay customers.

4.5.2 User journey mapping key findings

- Age plays a large factor in a consumer's considerations in switching to a heat pump, therefore, our consumer journeys were split by age, as well as by those that are fuel poor and those are able-to-pays.
- The journey was segmented into five key steps: Awareness & Interest, Active Consideration, Online Suitability Assessment, Detailed Home Plan, Procurement

5 Recommended Methodology for Coordinating High-Density Heat Pump Deployment

A recommended approach for coordinating high-density heat pump deployment has been provided in the following sections. The proposed approach makes use of the learnings gained from Phase 1.

5.1 Key stakeholders and Roles

In coordinating the high-density deployment of heat pumps, an Integrated Stakeholder Model has been proposed that has the following key stakeholders and roles as set out in Figure 3 below. This organisational structure has been informed by our findings from Phase 1, particularly from the discovery that a consumer needs a simplified journey and a single, trusted point of contact for information and procurement of services.

Our approach has therefore suggested the development of a digital web platform that acts a single source of informational material and for the procurement of services and of the heat pump itself. It is envisaged that this web platform would be backed by the local authority and will have their branding, to build trust with the consumer.

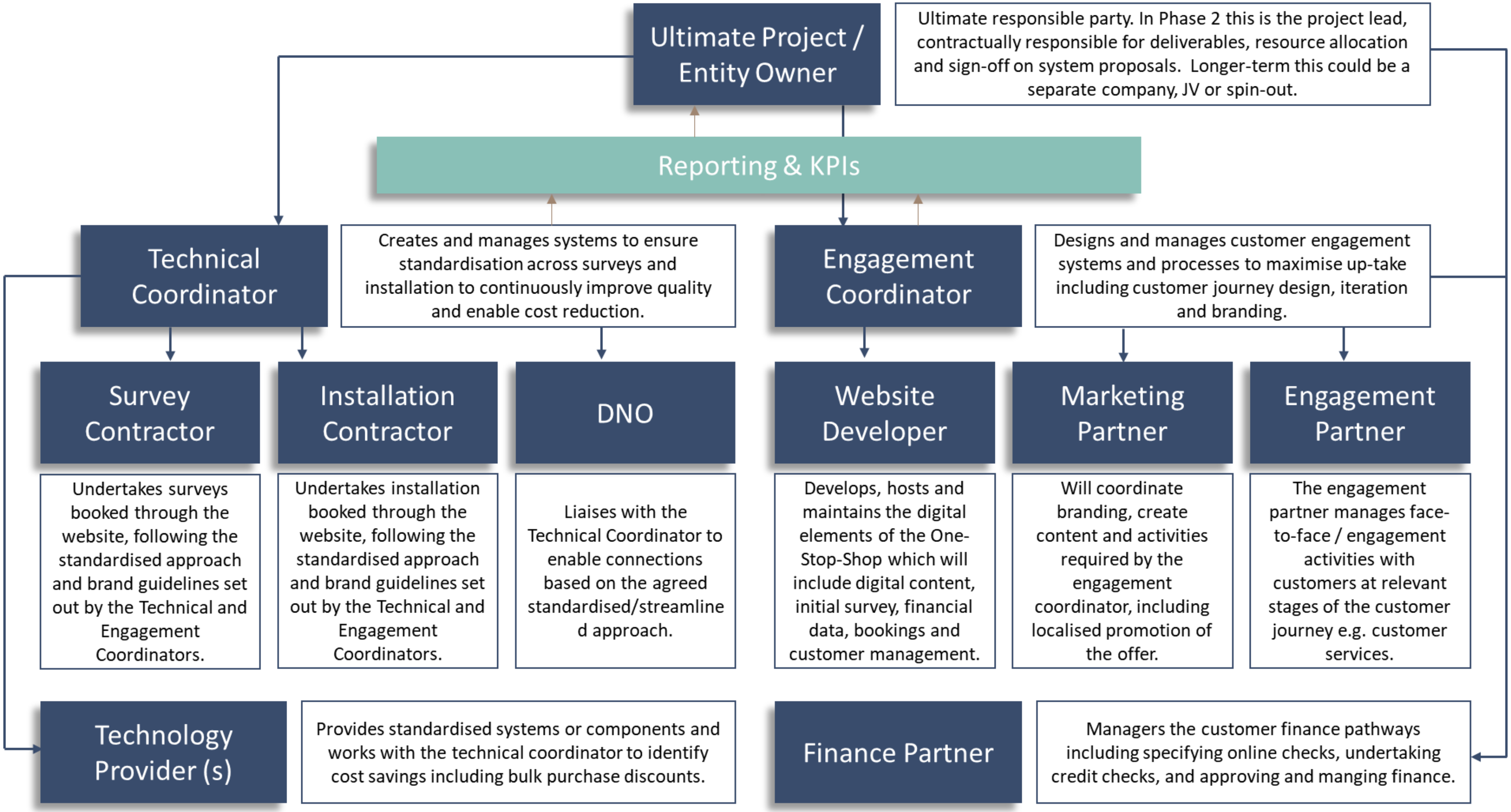

Figure 3: Organogram of Proposed Recommended Approach to High-density Heat Pump Deployment

5.1.1 Entity Owner

The Entity Owner is the organisation that manages the entire solution and process. We recommend that they are "Place-based", meaning that they are local situated and therefore have an understanding of the local issues, demographic and organisations.

It is envisaged that this would be constituted as a not-for-profit entity with the local authority as a core partner to maximise trust to the consumer (as informed by findings from the user research). Key roles for the Entity Owner:

- **Ownership/Leadership:** Own the overall targets and ultimate responsibility for the delivering heat pump deployment.
- **Contractual/Commercial Management:** Secure partners and procure sub-contractors to perform the necessary roles within the Integrated Stakeholder Model.
- **Resource Allocation:** Prioritise resources to maximise the likelihood of high-density heat pump deployments.
- **Process Management:** Own and manage the overall Integrated Stakeholder process to maximise the likelihood of high-density heat pump deployments.
- **Customer Care:** Own the overall customer experience including engagement, quality assurance and customer satisfaction throughout the customer journey.
- **Coordination:** Ensure the necessary coordination between stakeholders including partners and sub-contractors
- **Cost-Reduction and Continuous Improvement Initiatives:** Coordinate cost-reduction activities and continuous improvement including through procurement, finance models, technical specifications and through programme learnings.

5.1.2 Engagement Coordinator

The Engagement Coordinator manages the end-to-end customer experience of the Integrated Stakeholder Model. From the user research, lack of knowledge of heat pumps was found to be a key barrier to their uptake. Another common theme was that from the research was that consumers would like to talk to someone who owns a heat pump or see a heat pump in operation.

Engagement activities offer the opportunity to placate consumers concerns by giving the opportunity to speak to heat pump advisors or other consumers who own heat pumps. Engagement activities are also necessary for raising maximum awareness (ideally 100% of residents) of the heat pump deployment campaign.

This includes:

- **Engagement Strategy & Allocation:** Allocation of resources to specific locations and customer channels to maximise engagement and support uptake of heat pumps at high density.
- **Digital Customer Journey:** Development, management and maintenance of the customer journey, linked to the existing local authority website.
- **Engagement Marketing:** Development of marketing content, place-based activities and in-person events to maximise interest and sign-ups in relation to the high-density target areas.

- **Place-Based Engagement:** This includes management of the place-based activities such as local events or door-to-door campaigns necessary to drive engagement sufficient to deliver high-density heat pump deployments.
- **Customer Services:** The Engagement Coordinator will also manage the customer journey including the provision of the customer service offer and customer service centre.

5.1.3 Technical Coordinator

The Technical Coordinator plays a critical leadership role in the standardisation of the advice to customers, the selection of standard technology, the delivery of standardised specifications, the standardised installation process and coordinating the quality assurance audits and remedial work.

A key finding from the local heat pump installer interviews was that installers took different approaches to heat pump retrofits. Notably in one example where one installer would completely replace the existing heating system, whilst another would attempt to maintain as much of the existing as possible (which is preferable from a cost to consumer and sustainability perspective). Standardisation of the approach to heat pump installation is therefore necessary to ensure that customers receive the same, high-quality installs.

The role includes:

- **Standardised Advice to Consumers**: Our user research highlighted the need for users to have access to simple to understand guidance on heat pumps. Standardised advice should be provided that is simple-to-understand for consumers, while also being technically rigorous.
- **Technology Selection:** The Technical Coordinator works with heat pump and component manufacturers, defining a preferred technology blueprint for the heat pump installations. The use of a single, preferred technology selection allows for bulk discounts and streamlined customer care (e.g. approach to warranties).
- **Contractor Specification:** The Technical Coordinator will specify the minimum requirements for contractors and support the technical evaluation of procurement responses.
- **Standardised Specifications:** Using a standardised process of data input (digital data capture), output and processing allows for both streamlined delivery of high-quality advice to consumers, but also a scientific approach to be applied to specification to drive up standards.
- **Training:** The Technical Coordinator will ensure consistency of skills across the supply chain through the development and coordination of a training package associated with the standardised deployment model.
- **Handover Pack:** Based on the standardised approach, the Technical Coordinator will provide standardised handover packs covering the standard technology selection, improving the quality and detail of the information provided to the consumer at the handover stage.

- **Coordinating Quality Assurance:** The Technical Coordinator will coordinate quality assurance activities on an audit basis. This will include specifying the quality assurance standards, in-home tests and quality thresholds for the programme. They will then analyse the data to inform process improvements and continuous technical learnings.

5.1.4 Contracted Services

Core contracted services include the delivery of on-site surveys using the standardised method and delivery of installations following the standardised processes. Contracted services should be procured by the Place-Based Entity Owner, in particular to ensure/guarantee sufficient delivery capacity within the local area. Contracting these services enables best-value to be assured, technical capability to be assessed and confirms that contractors can meet the branding, process and technical requirements necessary to deliver the Integrated Stakeholder Model. Once contracted, suppliers will be responsible for:

- **Attending Booked Time-Slots:** To deliver a seamless and reliable consumer experience, the Integrated Service needs to manage bookings and ensure that contractors arrive within the designated time-slot, sufficiently prepared for the required tasks.
- **Meeting Service Standards/Processes:** To deliver a seamless and reliable consumer experience, the contracted suppliers will need to meet service standards throughout all their interactions with consumers, including adherence to core messaging (e.g. many contractors have tried to advise us against a heat pump even within this project), adherence to brand guidelines, adherence to training requirements, adherence to standardised survey processes and adherence to standardised quality process.
- **Warranting Work:** Contractors will need to warranty the work such that a fixed agreed fee can be agreed with the consumer and financing arranged.

5.1.5 Finance Partner

As evidence from the user research, providing a trusted financial lending option to overcome the high upfront cost is seen as necessary to facilitating heat pump deployment. We recommend that a dedicated Finance Partner is therefore brought into the process to provide funding for the costs of heat pump retrofit. Responsibilities include:

- **Adherence to/Management of FCA Regulations:** It is necessary that the finance partner is approved by the Financial Conduct Authority (FCA) to undertake regulated credit activities such as lending.
- **Arranging Finance:** Applying processes to assess customer suitability for lending and to make appropriate lending decisions based on the customer's circumstances. Where suitable, providing an offer for finance to fund the residual heat pump costs.

5.1.6 Technology Provider

Standardisation of technology and processes through the deployment will involve close working with the provider of heat pump technology (the Technology Provider). They will provide heat pumps and associated components.

5.1.7 Distribution Network Operator (DNO)

As we determined from work package 3, it is unlikely that the DNOs will have systems in place to deal bulk simultaneous connection applications for heat pumps. Engagement with the DNO is therefore necessary to manage the bulk applications and to coordinate any reinforcement required to the local electrical network (if required). The DNO will provide data and advice on the network to help inform priorities and manage the connection processes to enable high-density heat pump deployments.

5.2 Managing Interactions Between Partners

A simple, streamlined consumer journey is necessary to mitigate drop-off. Underpinning the coordinated methodology should be a series of systems that enable data sharing and the management of interactions between partners. Systems also allow for a standardised approach to the service, ensuring the Place-Based Entity Owner is provided all the necessary information at each stage to correctly allocate resources to achieve high-density heat pump deployment.

The following key systems enable the management of interactions between partners:

5.2.1 CRM System

A centrally-accessible Customer Relationship Management (CRM) system, linked to the digital channels, is essential to ensuring that all partners have the necessary information regarding the customer, the specification, offer and stage within the customer journey. The CRM system will also allow for automated messaging and continued contact with customers at each stage of the customer journey. The CRM is critical for supporting interactions between the Place-Based Entity Owner, the Place-Based Engagement Coordinator, the Technical Coordinator, providers of Contracted Services, the Finance Partner, the Distribution Network Operator (DNO) and the customer.

The CRM system has multiple purposes which are detailed in following sections. It is recommended to be used throughout the user journey from recruitment of customers (via logging contact details and implementing automated follow-up), through to aftercare where details on the customer specific installation will be stored. The latter point will be useful in sending the consumer annual reminders for maintenance and for providing a tailored handover pack specific to their heat pump (this meets the consumer’s needs for trusted advice).

5.2.2 Standardised Surveys

A standardised approach to surveying is critical to ensuring that key on-site information is captured by Contracted Services, and that the performance of these services can be monitored effectively. This allows for on-site information to be combined with remotely captured data within a standardised process that ensures best-practice and continuous improvement based on user experiences. This ensures that there is a standard process, irrespective of sub-contractors and provides confidence to the customer that advice will be consistent. Standardised surveys are critical for supporting interactions between the Technical Coordinator, providers of Contracted Services and the customer.

5.2.3 Single Technical Specification

Using a single set of technologies allows control on what is deployed on-site, ensures clear communication of technical details between partners and enables a systematic approach to the assessment of performance. The Single Technical Specification is critical for supporting interactions between the Technical Coordinator, providers of Contracted Services and the Technology Provider.

5.3 Customer Recruitment Journey

Our consumer journey mapping (see work package 6) highlighted that there are many potential drop-offs along the consumer journey. A recruitment plan should be developed that aims to mitigate these drops offs. Our suggested approach to this plan has been detailed below, it is informed by the consumer journey mapping shown in Appendix E1.

5.3.1 Stage 1: Awareness

The first step is to identify the targeted area (which can be achieved by our approach developed in work package 3), once the targeted location has been decided, the awareness stage should commence within that area.

To maximise awareness, this should involve a range of engagement and marketing activities of heat pumps within the local area. Our phase 1 user research identified that having a local authority backed approach builds credibility and trust with the consumer. We therefore suggest that prior to any door-to-door engagement the local authority should send a letter round the households to inform the residents that surveyors will be knocking on their doors.

Using a variety of communication channels will increase likelihood of success, from this feasibility study we found that consumers of different ages and demographics will be more responsive to different forms of communication. The approach should therefore use a mix of digital marketing, place-specific events and door-to-door recruitment processes to maximise awareness within the target area.

5.3.2 Stage 2: Capture

The capture stage involves the acquisition of basic customer information to the Customer Relationship Management (CRM) system. The use of a shared CRM system is a core mechanism for the management of the coordinated methodology. The CRM allows for continued, automated and cost-effective follow-up, in the case that the consumer doesn't fully complete the necessary details for initial application. It also allows consumers who are interested, but time-poor to be logged and followed-up with at a more appropriate time, thereby mitigating drop-off.

5.3.3 Stage 3: Initial Assessment and Offer

Following the Capture stage, the core goal is to progress the customer to the Initial Offer. This requires them to undertake a basic online survey which is combined with other (e.g. EPC) data to provide a tailored recommendation for the property with indicative capital and operational cost implications. The customer is also able to understand the impacts of the solution with and without financing.

The progression from Stage 3 to Stage 4 will require the customer to agree a date for the physical survey and add their credit card details. This is an important step to ensure the customer is sufficiently serious regarding their desire to progress, and to protect the service against missed appointments/sunk costs.

5.3.4 Stage 4: Detailed Assessment and Offer

The provider of contracted survey services will undertake the detailed survey on the date agreed with the customer, following the standardised approach set out by the Technical

Coordinator. The details of the survey will then be processed, and a standardised survey report and quote provided to the customer. At this stage the customer can apply for financing, if this is required as part of the offer. The final offer is then approved and presented to the customer.

The progression from Stage 4 to Stage 5 requires the signing of a contract, which will include a cancellation fee. Again, this is necessary to ensure the customer is serious and also protects the service against missed appointments/sunk costs.

5.3.5 Stage 5: Installation & Commissioning

The installation and works will then be booked. The Technical Coordinator should manage the bulk load of applications to the DNO to secure connections. Installation will then take place and standardised confirmation steps (e.g. images of hardware in-situ) will then be undertaken and uploaded to the CRM. The uploaded details will be used to create a standardised Installation and Handover report for the customer. Throughout the installation and handover stage, the customer should have access to a helpdesk to assist with any queries or booking amendments.

5.3.6 Stage 6: Handover

The Installation and Handover Reports will both be uploaded to the customer's online account and presented to them in-person. Quality Assurance will then be undertaken. Following confirmation that the installation is in order, the handover stage will be complete, and the customer informed that they have now progressed to the aftercare stage.

5.3.7 Stage 7: Aftercare

The aftercare stage will be as automated as possible to minimise costs. This will include access to online information, through their personalised/tailored account. This will also enable the customer to access warranty details for both the manufacturer and installer. The CRM system will also be used to send annual reminders, for example, to undertake maintenance and servicing, providing details on approved providers.

6 Recommended Approach for Mobilisation & Development

6.1 Number of Customers Targeted

Phase 1 explored the feasibility of high-density heat pump deployment in Fenland, a district in Cambridgeshire, in the East of England. The district has a population of 101,850 and a population density of 480/sq mi, with around 70-75% of these inhabitants living in the market towns of Chatteris, March, Whittlesey and Wisbech. Phase 1 identified the village of Friday Bridge as an optimal location for high-density heat pump deployment in Phase 2.

A total of 569 domestic properties lie within the finalised targeted secondary substation electricity supply areas in Friday Bridge. Therefore, to achieve a minimum of 25% density heat pump deployment across all substation areas, at least 143 heat pumps must be installed.

6.2 Strategy for Recruitment

The strategy for High-Density Heat Pump deployment is built on the following key steps, the first two steps were completed in Phase 1:

1. Use data-led, geospatial process to identify areas most likely to enable high-density deployment of heat pumps.
2. Undertake quantitative prioritisation process with stakeholders (in particular the DNO and local stakeholders) to include additional local information such as grid capacity and presence of active stakeholder networks.
3. Undertake hyper-local marketing activities within the identified areas (see below).

6.2.1 Hyper-Local Marketing

The next step in the strategy is the use of Hyper-Local Marketing. In Phase 1 we have undertaken further market research in the identified areas to generate a strong understanding of the local area and populations. Building on the key themes of our user research that consumers need trusted education on heat pumps, our strategy for generating interest and stimulating demand would be as follows:

1. Early marketing enabling registration of interest. This should use multiple channels including the council's social networks, location-targeted marketing (such as local events) and traditional marketing methods (social media, leaflets etc).
2. The full launch should be targeted at the specific area. This should include additional marketing, local events (this could include the use of a Mobile Showroom to demonstrate a heat pump in operation within the targeted area). Specifically, an official letter should be circulated to all residents in these areas informing them of the event schedule and when they can expect a consultant to visit their property.
3. One of the key engagement methods should be door-to-door within the locations identified. The door-to-door engagement will allow for residents to discuss heat pumps, retrofit and cost saving measures with a consultant and find out more about the programme and how they can get involved.
4. Once customers are captured, use a range of automated digital communication techniques to prompt them to progress to the next stage of the customer journey. For example, if a customer starts filling in details of the online survey, but stops, the system will email them to remind them of the benefits and prompt them to continue through to completion of the stage.

6.2.2 Mitigating Drop-off

Our user research on the consumer journey (see Appendix E) clearly demonstrates there are numerous points along the customer journey where customers may choose to drop out. Therefore, to maximise the likelihood of high-density deployments the strategy needs to address two core issues:

1. **Ensuring as many households as possible enter the core sales/capture funnel**: This can be achieved through a multi-channel awareness method which should include door-to-door engagement, as well as local events and traditional engagement (social media, leaflets etc). While highly manual, door-to-door consultation is the only way to truly guarantee that each household has been visited. Our Phase 1 has evidenced that an official local authority letter, sent in advance to households, will maximise the chance that they will be available during the door-to-door phase and that they will engage positively. The household capture process should therefore include a direct mailing, an initial door-to-door engagement and a secondary door-to-door engagement (to try to capture any remaining households that weren't captured in the initial stage), in addition to other local events and activities.
2. **Supporting households/customers to continue the customer journey and complete each stage**: Here the use of digital tools and automated digital communications can be used to provide tailored and targeted messaging to help customers progress through the customer journey. Our Phase 1 analysis has identified several customer decision steps (see Appendix E) that need to be overcome to get the consumer through to the point of installation. Our analysis has also identified targeted messaging and support that can be provided at each of these stages to maximise the likelihood of continuation to the next step.

6.3 Ensuring Quality Assurance

We found that consumers perceive heat pumps as risky, because it is a technology they are unfamiliar with. It is therefore essential that customer protection, quality assurance and monitoring is embedded throughout the approach.

6.3.1 Stage 1: Awareness

Engagement and customer protection starts at the awareness stage. It is critical that appropriate advice is provided for consumers based on their needs (the need for trusted, easy to understand guidance was a key theme of our user research in Phase 1). Consumer protection requires that claims are not misleading, and that advertising is clear and honest regarding areas of uncertainty.

6.3.2 Stage 2: Capture

At the capture stage it should be as easy as possible for consumers to sign up, however, engagement tactics need to be fair and consultative. Customers need to understand how their data will be used, understand that their data will be treated in line with GDPR and that their rights will be protected. As we have suggested using a CRM system, customers need the right to opt-out and unsubscribe with all their data being deleted in response to such a request.

6.3.3 Stage 3: Initial Assessment and Offer

The Initial Assessment and Offer stage aims to provide the customer with a true and fair quote based on the information provided remotely via the web platform. This is the first stage in the process where quality assurance should be carried out to ensure the analysis is as accurate as possible based on the information provided, and that the customer report is of the highest quality. At the system level, quality assurance procedures include extensive testing and test coverage of automated system, use of highly-qualified staff, use of automated quality control systems (such as continuous integration) and applying multiple sense checks of the system outputs. At the output level, quality control should include user testing of output designs, testing of initial outputs before they are passed to customers, and continued auditing of outputs to ensure consistent levels of quality.

As in previous stages, to build trust with the consumer (a need highlighted from the user research in phase 1), open and transparent presentation of information, including uncertainties, are important at this stage. References, sources and additional detailed behind calculation assumptions, should be made clear to enable customers to make informed decisions.

6.3.4 Stage 4: Detailed Assessment and Offer

At the detailed assessment stage, all customers should have an in-person interaction with a surveyor arranged by through the web platform. It is really important for the ease of the customer experience that they are able to book a time for the survey that suits them, and be confident that the survey will take place at the agreed time, without inconvenience.

Survey contractors should be provided training in the core brand messages and the process when on-site with customers. This training should cover professionalism and customer care to ensure a consistent level of advice throughout this important interaction with customers.

A standardised system for the survey would enable a consistent approach to quality in the survey output. By using digital tools at this stage, this would ensure evidence gathered associated with the survey that can be reviewed and tested independently (e.g. copies of heating bills, images of heat sources etc.). This will allow for an additional layer of quality assurance checks that verify the information captured within the survey. The standardised system will then allow best-practice approaches to the processing of survey data. The customer offer presented should then be reviewed and signed-off by both the Installation Contractor and the Technical Coordinator prior to presentation to the customer.

6.3.5 Stage 5: Installation & Commissioning

The system should use a standardised installation and commissioning process that should align to or exceed requirements of MCS. All contractors should be MCS certified and supported by additional training by the technology provider and in the standardised approach, to ensure consistency and quality across the supply chain.

Quality checks: We suggest that quality checks on the installation are to be provided in two forms:

1) Randomised audit-based quality checking by a third party (based on a sampling method covering different property types and sub-contractors)
2) Optional additional check (customer can choose for third party to inspect installation).

Warranty checks: Warranties are be provided to the customer for both the equipment (manufacturer warranty) and installation.

6.3.6 Stage 6: Handover

The suggested standardised method would allow for the provision of detailed, automated handover documentation that is tailored to the specific property. This will include a clear, easy-to-understand document, tailored towards homeowners that describes the operation of the equipment.

Customers should be provided with warranties for installation and equipment. All documents should be uploaded to the customer's online account so that they can be easily retrieved if required.

6.3.7 Stage 7: Aftercare

The aftercare stage should comprise the following key services provided to the customer:

- Online FAQs and information on heat pump operation.
- Contact details including for the platform service desk and contact details in relation to warranties.
- List of local heat pump installers/maintenance providers.
- Automated service reminders, sent automatically via the CRM to prompt consumers to service the heat pump.
- A dedicated customer service desk for the duration of the project.

6.4 DNO engagement

The DNO will need to be informed about every heat pump installed as they draw a significant power from the grid. The Technical Coordinator should ensure that heat pump electrical load calculations are passed to DNO so that they can perform localised network analysis to determine whether the substation and further low voltage assets) require reinforcement.

Ahead of high-density deployment, the technical coordinator should engage with the DNO to see how best to manage a bulk load of applications for heat pump connections. As discovered in Phase 1, DNO's currently have systems in place to manage applications one at a time, however, a process is unlikely to exist for a simultaneous bulk application.

7 Recommendations on Areas for Innovation

7.1 Consumer Engagement Innovation

7.1.1 Consumer Awareness

To overcome lack of consumer awareness (a key barrier identified in our user research), we suggest a place-based approach that combines face-to-face and digital engagement to coordinate a targeted consumer awareness campaign across regional stakeholders, including Council Councils, District Councils, schools and colleges, through community groups and through street-by-street direct marketing.

7.1.2 Single Digital Web Platform

The best-practice digital engagement techniques from private sector websites such as 'webuyanycar.com' and 'moneysupermarket.com' should be leveraged within a trusted branding mechanism. The web platform would address consumer awareness, advice, tailored pathways, booking, financing and aftercare all within an integrated digital-physical system to maximise engagement.

7.1.3 Use of Trusted Public Sector Brand

To address the key barrier of trust (as highlighted in the Phase 1 user research), our suggested model seeks to mirror the PACE model by promoting an official brand linked to the local authority. The non-profit nature of the model as a differentiator also promotes trust (similar to trusted consumer brand 'Which!').

Our engagement has evidenced the benefits of advanced contact with consumers via an official letter from the local authority to position the programme – a technique that should be used to ensure maximum awareness-raising ahead of engagement activities. The focus groups ran by PECT in Phase 1 identified that a local, trusted and accredited supplier would be the preference, with communication and support from the local authority preferable. The door-to-door engagements identified that the majority of consumers wanted to see a government approved installer, ideally from a local supplier which can help with longer term maintenance and any issues.

The method should embed the local authority as a key partner, which provides the incentives to ensure ongoing customer care and the confidence to consumers that the stakeholders will maintain a relationship within the target locations.

7.1.4 Place-Based Approach/Leveraging Local Partners:

The place-based approach should leverage local partnerships, existing community groups and interested parties to build local momentum. By using the place-based approach within targeted geographies, it should be possible to identify local champions and case-studies that will support word-of-mouth/informal networks to maximise promotion, while reducing direct costs.

7.2 Customer Retention Innovation

7.2.1 Shared CRM System

The use of a shared CRM system that clearly links to the customer journey to enable communication between stakeholders and to enable customers to be targeted appropriately to support progression through the stages.

7.2.2 Automation

Following the Capture stage, automation should be used throughout the customer journey to maximise uptake. This is a highly effective technique used in websites that require detailed customer data (e.g. 'webuyanycar.com') to ensure consumers are encouraged to return to complete the steps required to progress to the next stage.

7.2.3 Pricing Techniques / A/B Testing:

Fine tuning of the customer journey, in particular the customer commitments at each stage, is a core consideration to maximise uptake. Progress to each subsequent stage requires some form of commitment from the customer (e.g. paying a deposit or signing a contract). However, these commitments may also present a barrier to progress. It is therefore important to fine-tune these to minimise drop-off rates. The platform should be set up to enable A/B testing and fine tuning of customer commitments to ensure these decisions are evidence-based. A/B testing refers to the process whereby two versions (of a web page in this instance) are shown to two different segments of website visitors at the same time, the results are then analysed to determine whether webpage A or B was more effective.

7.3 Financial Innovations

7.3.1 Cost Reduction Incentive

The Entity Owner, Installation Contractor and Technology Provider should all be incentivised through contracts to continuously monitor and take action to reduce costs associated with the supply chain, the financial packages available and the overall process/customer journey design. This should be monitored continuously through data.

7.3.2 Trusted Lending Services

Our research in Phase 1 found that the public sector backed approach would build trust with consumers. Whilst it was found that a PACE financing mechanism would be difficult to implement in the UK (due to laws and regulations), a lending mechanism could however be developed to mimic PACE in look and feel. The payments may not be paid back through property taxes, but instead they could be coordinated such that they are officially public sector branded and it could be explored how it could work alongside council tax.

7.4 Technical Innovations

7.4.1 DNO Bulk Applications

A finding from Phase 1 was that DNO's are currently unlikely to have systems in place to deal with bulk simultaneous heat pump connection applications (as would be required for high-density heat pump deployment), as this is not a situation they have had to prepare for yet. A key innovation will be to work closely with the DNO to streamline the application and connection process to enable fast-tracked, bulk applications to enable the high-density deployment of pumps.

8 Recommendations on Cost to Consumers

A number of opportunities to achieve cost reductions have been identified, both to the consumer, and during the mobilisation and customer acquisition phases of high-density heat pump deployment. Examples of these cost savings have been provided below.

8.1 Digital, Data-led Approaches

8.1.1 Site selection

We developed a desktop-based approach to site prioritisation using openly available data as part of work package 3. The target area is therefore pre-validated to ensure it incorporates the key characteristics suitable for heat pump deployment. This desktop-based approach is far more efficient, and therefore cost effective, than other labour-intensive consumer surveying. It is therefore the first opportunity to reduce the cost of customer acquisition, by ensuring follow on marketing activity is focused on a higher probability area of heat pump uptake.

8.1.2 Remote Survey

Surveys can be a wasted cost where they identify a property is not suitable for a heat pump. To reduce costs, a remote/customer completed survey into the user journey could help to filter out any unsuitable properties at an early stage.

8.2 Bulk Purchasing and Grouping

8.2.1 Single suppliers

Using a single supplier for the provision of equipment, materials and installation for the entire project provides much greater buying power than purchasing for a single property.

8.2.2 Survey grouping

Through focusing on a hyper-local area, the delivery or surveys and heat pump/retrofit installations can be grouped together to avoid travel time. This will lead to reductions in the installation cost to the consumer.

8.3 Targeted, Hyper-local Marketing

Research undertaken during Phase 1 identified a variety of motivations for installing a heat pump, with the prevalence of these motivations varying significantly between different geographic areas. By having an area specific marketing strategy, that will ensure that marketing materials and engagement methods are tailored towards the likely motivations of the chosen areas, property types and demographic profile. In doing so, uptake is likely to be higher – which reduces the average cost of customer acquisition.

8.4 Cost Savings through Solar PV Deployment

The cost modelling undertaken in work package 4 identified that the addition of solar PV to a heat pump retrofit has the potential to significantly reduce the annual electricity costs to the consumer compared to the installation of a heat pump in isolation.

The savings are achieved through the generation and utilisation of electricity on site, which displaces the cost of purchasing energy from the grid. Additional savings are also achieved through the sale of surplus energy back to the grid – particularly in summer months when the most electricity is generated, but the least amount of heating is required.

For the archetypes which were deemed suitable for solar PV, the following annual electricity cost savings (against a heat pump installed without PV) were determined from the cost modelling (see Appendix C1 for more info). Note that the cost modelling used the current Energy Price Guarantee electricity tariff of 34p/kWh. The percentage savings below the are annual reduction in electricity bills, it was found that the payback time to overcome the capital cost of the PV systems was in the region of 8 years.

- Bungalow – 24% saving
- Mid-terrace with cavity walls – 23% saving
- Mid-terrace with solid walls – 19% saving
- Compact semi-detached – 25% saving
- End-terrace with cavity walls – 23% saving
- Semi-detached with solid walls – 20% saving
- Detached with cavity walls – 21% saving
- Detached with solid walls – 17% saving

More information and results on the cost modelling is provided in section 4.3 and in Appendix D.

8.5 Sources of Funding

It is widely known that one of the key barriers to uptake is the high upfront capital cost of heat pumps, and any associated property retrofit measures. Whilst lending options, which require repayment with interest, do no reduce the overall cost to consumer, repayment via monthly installations is likely to be much more achievable for the typical consumer. The provision of a lending scheme is therefore recommended for high-density heat pump deployment.

9 Recommendations on Long Term Sustainability

9.1 Building a Sustainable Model for High-Density Deployment

By designing a replicable model, with the engagement of the supply chain, financiers, DNO and local authorities, a model for high-density heat pump deployment can be developed that will be sustained beyond the life of the project.

9.1.1 Business Model and Commercial Offering

The business model is to establish a Place-Based Offering, working in partnership with local authorities to utilise the platform and process to deliver heat pump deployments and retrofit. This partnership model de-risks delivery and growth of the platform by using a partnership with the local authority, but also benefits the platform by establishing this as the "official", trusted platform within each region in which it is established.

It is recommended that the Place-Based Entity Owner is constituted as a Community Interest Company (CIC). A CIC is a special type of limited company which exists to benefit the community rather than private shareholders. As a CIC uses profits for community benefit, it is a highly valued model with local authorities which will act to ensure that the model developed is highly attractive to other regions. Other than restrictions on the use of profits as defined by the articles, the CIC will operate commercially within the market which will include generating sufficient income to cover operating overheads and consumer acquisition costs.

From the perspective of the consumer, the CIC will be fully commercial, with the caveat that consumers will have confidence that any profits generated are re-invested in the community interest. Note that trusted consumer brand 'Which!' operates as a CIC, as do Lendology. This type of model can lead to a higher level of trust and confidence in consumer protection.

9.1.2 Organisations Responsible

The CIC will be a joint venture between the local authority, and project partners constituted as an independent entity. The local authority and project partners will be responsible for taking forward the model beyond project through the new entity. The operation of activities will, at this point, be run out of the new entity, which will include dedicated staff.

9.1.3 Financial Sustainability

Following high-density heat pump deployment the core capital costs of establishing the platform will have been invested, meaning that there will be limited further investment costs required. Post the completion of the project, it is envisaged that costs to maintain operation the platform will fall substantially as a result of the following:

- Set-Up: Set-up costs will have been invested, meaning that the main focus will be system maintenance. Maintenance will be a fraction of the cost of set-up.
- Marketing: Following the project the platform will be re-focused toward maximising the overall quantity of heat pumps, rather than high-density deployments, while using many of the effective localised techniques to catalyse localised activity. By allowing a broader focus, this will have the effect of reducing the overall marketing/engagement spend by relying more heavily on digital, county-wide channels.
- Project Costs: Project costs, such as reporting and participation in evaluations, will cease and not become a feature of the operational entity.

9.2 Building a Replicable Model for High-Density Deployment

Phase 1 developed a strong, collaborative partnership and designed replicable methodologies by:

- A replicable, GIS-based resource prioritisation process was developed that used open data and can be readily applied to other regions. This is replicable through the use of national datasets and so enables ready extension of analysis to the whole of the UK.
- Phase 1 has identified numerous potential financial partners and, working with Lendology, has identified a replicable financial model that can be rolled out regionally, ensuring replicability of the model over the long-term without BEIS funding.

Our methodology is highly replicable with the potential to deliver significant carbon impacts across the UK and has been designed with replicability in mind throughout.

Our suggested approaches for developing a replicable approach for high-density heat pump deployment are as follows:

- **Platform and process:** Development of a digital platform that can be easily ported to future locations. Remote processes should utilise nationally available data so that they are not constrained by regional geography.
- **Documents:** Material should be developed to support the customer across all stages of the customer journey including processes for the production of standardised documentation. These documents will be designed for replicability across regions and embedded into the digital platform with a simple, central config file controlling all deployment options (e.g. branding, regional names, fees etc.). As a result, this will highly flexible and replicable to other regions.
- **Procurement Approach:** The documents used for procurement of Contracted Services, should be re-usable in different locations. The installation contractors themselves may be local, but the project should establish a strong partnership with a network of qualified installers.
- **Standardised Technical Approach:** The standardised approach, based on MCS, will be replicable to other UK regions. Based on standard technology and wide-spread housing typologies, the standardised approach should be replicable across the UK building stock. The approach should also use common, national data sources for remote elements.

9.3 How Many Heat Pumps need to be Deployed Under a High-Density Model

There are currently 285,520 domestic properties within Cambridgeshire. The characteristics of the built environment within Fenland are typical of the rest Cambridgeshire which also has a high proportion (67.6%) of detached and semi-detached properties, alongside the majority of properties (66.5%) being withing EPC band C and D.

Under a net zero scenario it is expected that 80% of properties will need to be upgraded to an EPC rating of B and 80% of properties will need to be retrofitted with a heat pump. This equates to 228,416 properties in need of upgrade prior to 2050. Assuming activity is commenced in full across Cambridgeshire in 2025, this would imply that circa 9,136 properties would need to be retrofitted with a heat pump every year. This represents a significant increase in activity compared to today.

High-density deployment models will act as a catalyst to help propel heat pump retrofitting activity to the targeted level. Assuming by 2028, high density deployment models capture a conservative 20% share of heat pump retrofitting activity within Cambridgeshire, then this would equate to 1,827 heat pumps retrofits annually.

10 Conclusions

Phase 1 developed a wealth of evidence on the requirements to achieve high-density heat pump deployment. The findings of the project highlighted that heat pump uptake remains challenging; it is comparably expensive to the predominant incumbent domestic heating system (gas boilers) and potential consumers are unfamiliar with the technology, so it is perceived as risky (building trust was a key theme of the user research).

However, the project highlighted that potential consumers are interested in switching, and the environmental benefits of moving away from their existing fossil fuel systems is appealing. Furthermore, we have discovered a series of measures that should bring cost reductions to consumers and have proposed engagement activities that should expand their current understanding of these systems, thereby building trust in heat pumps as a technology.

Whilst high-density heat pump deployment will be challenging, we feel that our measures offer the potential to achieve it. The project therefore pursued an application in November 2022 for high-density heat pump deployment in Phase 2 using the recommended approaches detailed in the previous sections.

The key recommended measures in our suggested approach for high-density heat pump deployment which we feel will increase success of achieving high-density deployment include:

- Trusted, Local Authority Backed Web Service: A single web platform service that offers simple and unbiased guidance on heat pumps combined with safe channels of procurement.
- Consumer-centric Approach: Simplified and enhanced consumer journeys by providing a simplified, trusted, local authority backed service for heat pumps and energy efficiency measures, coordinated through existing local networks.
- Deep Localised Engagement: Building on existing deep local engagement, utilisation of a hyper-local, community-based engagement strategy in the targeted area.
- Supply Chain Capacity Building and Standardisation: Through partnership with the local supply chain, standardisation is to be embedded throughout the process, taking a rigorous and detailed approach to the surveying, specification and quality assurance of heat pump installations, using standardised commercial technology components.
- Innovative Financing: Innovative financing will be employed to fund the high upfront cost, unlocking the possibility of heat pumps to a wider demographic.

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Appendix A1 – Summary Findings of User Engagement

The following section provides a summary of the key findings of the user research conducted by PECT throughout this feasibility study.

Summary Findings of User Engagement

During Phase 1 of the delivery programme, PECT has undertaken a range of engagements to gather the public's thoughts on heat pumps and to help find any barriers to them being adopted.

These engagements have included a digital survey with a reach of over 18k with responses from 802 participants, 4 in depth focus groups and door-to-door research within the target area, Friday bridge, speaking directly to 102 households.

The engagements have focused on the awareness and interest of heat pumps, explaining how they work and why they are being considered as a replacement to traditional heating systems.

The feedback from each stage of the customer engagement has been used to inform the next level of engagement and refine the information being communicated.

The take up of heat pumps into phase two could be achieved by addressing some of the barriers identified in the initial research and through building on the key requirements of the users.

Barriers

Several potential barriers have been raised by households during the engagement process that need to be mitigated or information supplied to help increase the take up rates, these include:

- Initial upfront cost
- Retrofitting requirements to make heat pumps efficient
- Installers and installation process
- Accurate ongoing running costs and maintenance requirements
- Noise and space requirements
- Operating procedures and risk of redundant technology

Opportunities

There were several key opportunities found through the research, to support the switch to a heat pump, these include:

- Financial support for the upfront investments, ideally a grant.
- Technical and financial support for any retrofit works.
- Clear breakdown of the cost and requirements including suitability for their homes.
- Opportunity to see heat pumps in action from a trusted source such as a neighbour.
- All services provided through one reputable supplier backed by the government/ local authority
- Increased access to information about heat pumps, installation processes and running

USER JOURNEY

Awareness / interest

There has been genuine interest in heat pumps and the need to switch, with 80% of people being aware of the upcoming changes to domestic gas boilers. The majority of those engaged with would only switch if their current system broke, or if there were financial savings to be made. Some were interested in the environmental benefits; however, this was not the main reason for them willing to switch system.

Consideration

As heat pump installation and retrofit works are typically more expense that traditional boilers, the cost savings are either minimal or negative, therefore the switch needs to take place for those energy systems at the end of their life or as part of a wider retrofit package.
A longer-term program across Friday Bridge would allow people to transition systems when their system needed replacing or as well as the opportunity to save money for an investment. The ability to access other funding for more installation and retrofit works will also support the transition. A long-term engagement plan would help support residents through the shift.

Suitability

There was genuine concern that heat pumps were not right for certain households, based on the age, size and level or insulation needed. These concerns were not typically backed up by any technical ability, more from what people had researched themselves or what they had heard.

People want to see a system in operation or speak to someone who had a heat pump installed. An open house within Friday Bridge and 'ask the homeowner' sessions would help to alleviate the miss information about heat pumps.

Detailed Plan

There is an opportunity to undertake a more detailed survey of properties to supply further information for households to be able to make a considered and informed decision. Several residents asked for a formal quote to be supplied so they could decide.

When surveys and professional advice was discussed, most households wanted a reputable local supplier, backed by a guarantee or recommendation from government or the local authority. There was fear of 'cowboy' installers with people being left with a heating system that was not fit for purpose.

Several households considered heat pumps to be a recent technology, and therefore there was also concern about being miss sold systems as there is lack of awareness about what is required including changes to existing heating arrangements such as radiators and insulation.

Commission

The price of heat pumps and who was going to pay for them was a significant barrier for most households. Many didn't realise they were so expensive and without any financial savings through switching many were reluctant to change until they were forced to.

Those who were open to switching wanted someone to manage the entire process and only deal with one supplier / organisation, including for any other retrofit works needed. There was also a requirement that the work be guaranteed and maintained.

Project Highlights

CURRENT HEATING

50% of households surveyed across the region heat their homes using gas boilers, within Friday bridge this increased to **75%**

Heat pumps made up **7%** of heating systems currently used across the county, of those surveyed, with this dropping to **2%** within Friday Bridge.

SYSTEM CHANGE

Most households have not changed heating systems or thought about it

50% of people would only change their current system if it were broken or cheaper

4 out of 5 people were aware that gas boilers will not be sold from 2035

7 out of 10 people did not know where to go to get information on heat pumps or who to contact

AWARENESS

90% of people had heard of a heat pump, with most thinking they are better for the environment

Most people do not know anyone with a heat pump, with **75%** of people feeling knowing someone with one would help their decision making

COSTS

The average cost across the wider survey for a heat pump was **£6,300**, this increased to **£9,400** within Friday bridge

60% felt the upfront cost was the biggest barrier to switching, this increased to 80% within Friday Bridge

BARRIERS

Upfront cost was the biggest barrier to switching

Other potential barriers included retrofit (45%), Installation (40%), Noise (38%) and operation (40%)

TAKE UP

75% wanted to see a government approved installer, ideally from a local supplier which can help with longer term maintenance and any issues

Households suggested that they would like a **'one stop shop'** approach to installation

Most suggested they would switch if it were cheaper to run and if a **grant** were to be paid for installation.

Consumers would be willing to spend on average **£3,300** for installation.

Appendix A2 – Consumer Insight Report

The following section provides a summary of the responses received from the online survey that was distributed in August 2022 by PECT.

FRIDAY BRIDGE CUSTOMER ENGAGEMENT

BACKGROUND

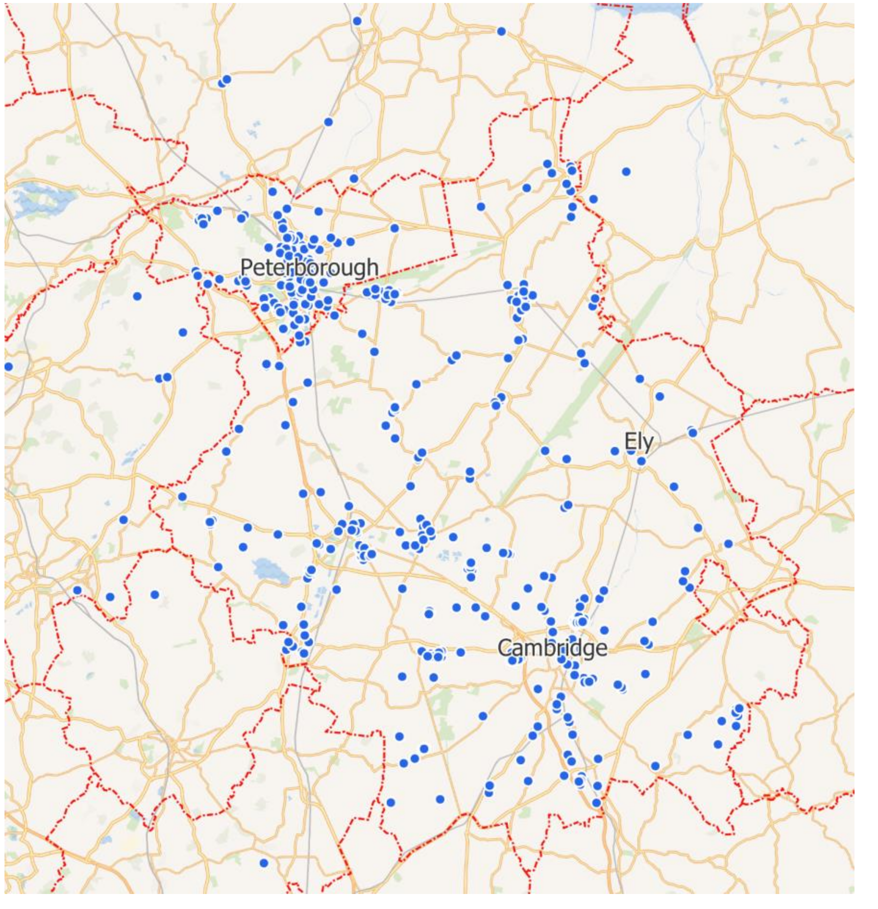
Between the end of July and middle of August 22, PECT undertook a consumer engagement survey about attitudes towards heat pumps. The survey focused on the understanding of heat pumps and the perceived barriers, as well as collation of demographic data to help analyse the results. The survey focused on the Cambridgeshire area, with the results used to inform the user profiles and journey, as part of the pilot programme.

The survey was shared through social media and by a range of organisations, including:

- PECT
- Local Authorities (Fenland and Peterborough)
- Cambridgeshire County Council
- Partner and community groups
- Social Housing Groups
- Parish and Ward Councillors

18,864 people reached through social media

802 responses received

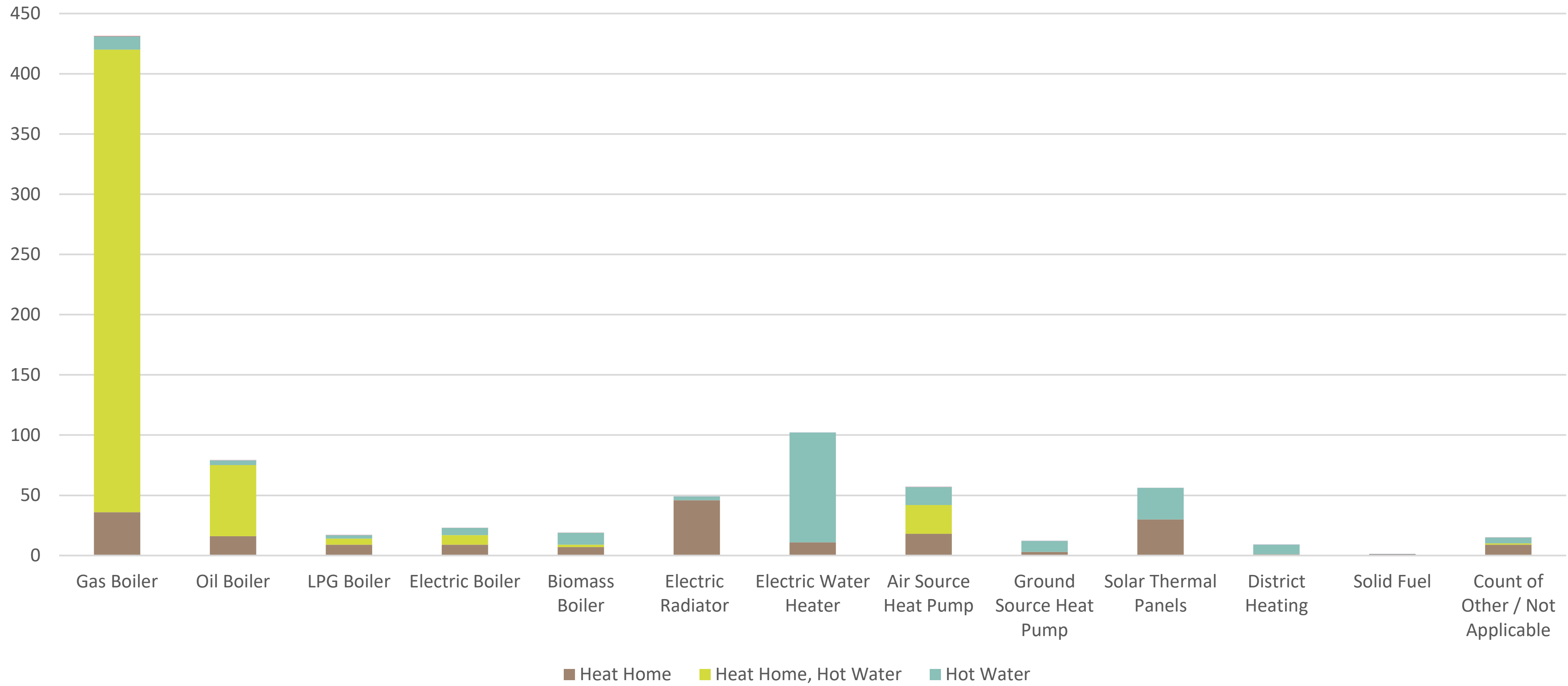


SURVEY RESULTS

HOW DO YOU HEAT YOUR HOME?

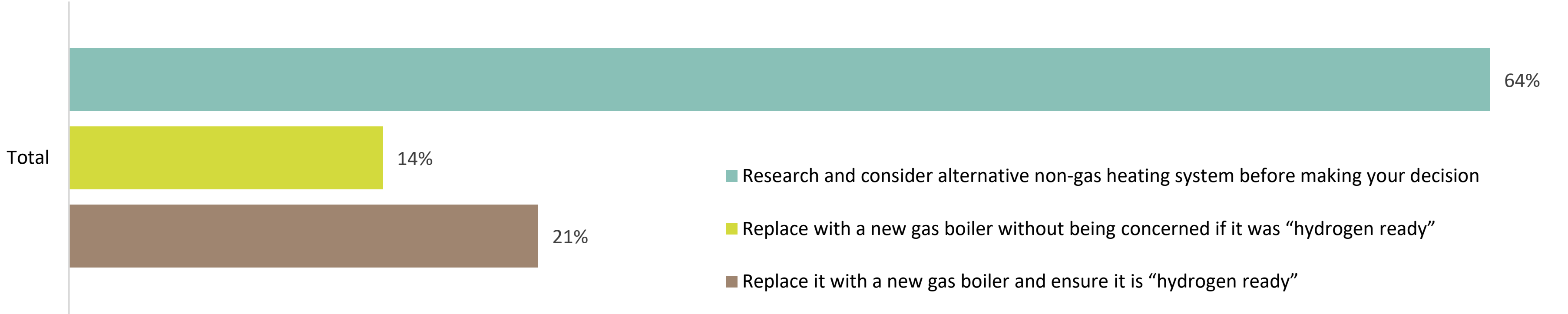
50% of households heat their property and water through gas boilers. Oil boilers are used by 9% of consumers with the majority using it to heat their property. 10% of households heat their water through electric water heaters.

Currently air source heat pumps make up 7% of heating sources.

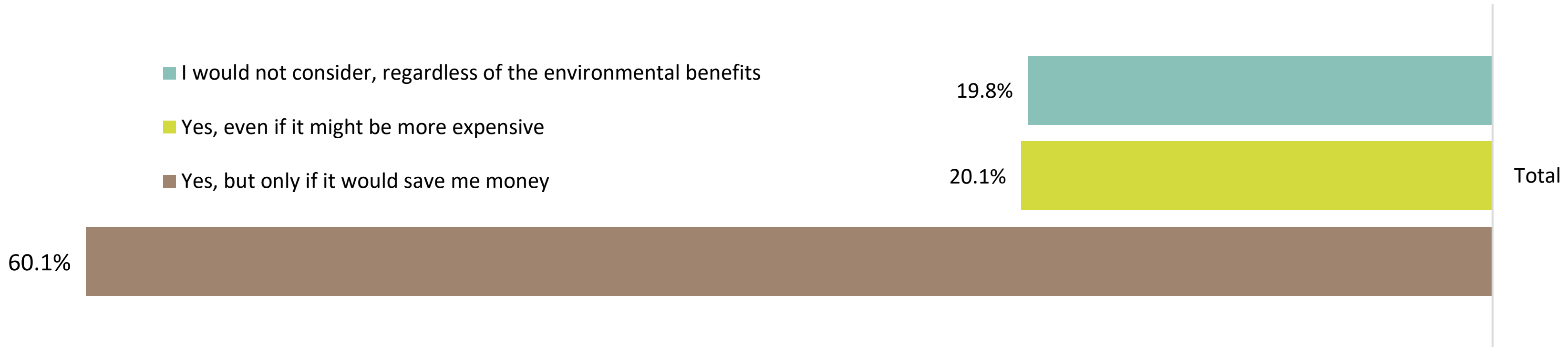


HEAT PUMPS

80% of respondents knew that gas boilers will not be sold from 2035. 3 out of 4 would research and consider an alternative to a gas boiler. The majority would research before replacing a gas boiler with a hydrogen boiler



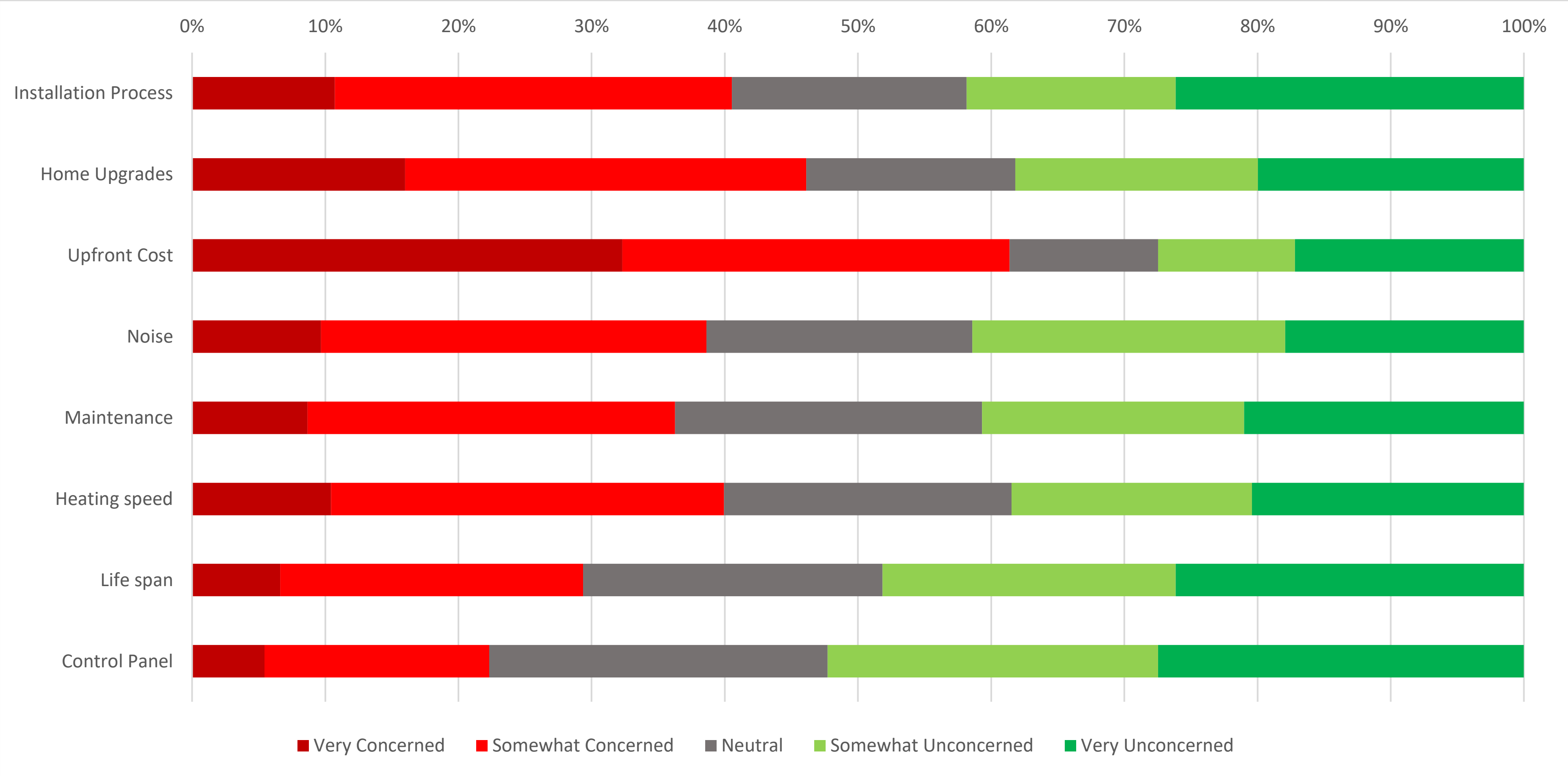
9 out of 10 had heard of a heat pump before completing the survey, with 72% thinking heat pumps are better for the environment. 7% think they are worse. The majority would only switch if it saved them money.



Over 50% of people believe a heat pump costs between £2,500 and £10,000. The average cost was **£6,300.**

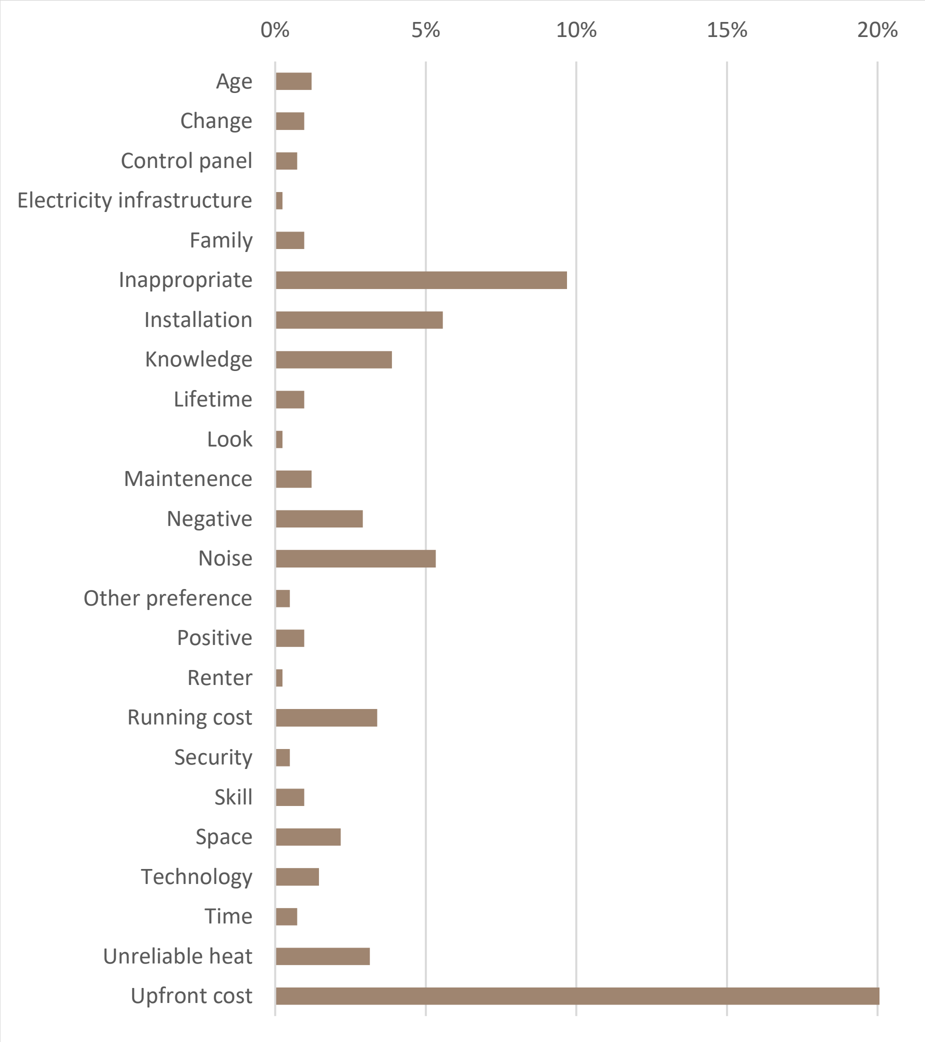
BARRIERS

The biggest consideration preventing the installation of a heat pump appears to be the upfront cost, with over **60%** being very or somewhat concerned. The additional home upgrades, installation process and heating speed are other concerns.



Consumers were asked to elaborate on their concerns, these results have been coded into twenty-four sub-groups.

Upfront costs came out as the biggest reason, with the inappropriateness of the technology for resident's properties, followed by noise, installation, running costs and knowledge about the systems.



Code	Explanation
Age	Return on investment due to participant's age
Change	Having to adjust to change; will it affect lifestyle
Control panel	Understanding controls; issues with controls
Elec infrastructure	UK needs better electricity network; fossil fuels
Family	Impact on the family
Inappropriate	Not appropriate for the property
Installation	Disruption/hassle of the installation process; retrofitting needed in property; damage done by installation
Knowledge	Complicated to understand how it works or how to use
Lifetime	Return on Investment
Look	The look of the ASHP
Maintenance	Concerns about upkeep, repairs, and/or lifespan
Negative	Negative view or experience
Noise	Noise of ASHP when working; will disrupt resident
Other preference	Preference for other systems such as solar PV
Positive	Positive view or experience with heat pumps
Renter	Lives in rental property and so cannot decide
Running Costs	Cost of running the system
Security	Security concerns, such as vandalism, theft
Skill	Lack of installers/risk of "cowboy" installers
Space	Lack of space to house it or close to neighbours and do not want to disrupt them
Technology	Tech needs further developing before would be adequate in the UK
Time	Time of installation
Unreliable heat	Unreliable heat source, may need additional source in the winter; believe it is slower to heat; property will not be as warm
Upfront cost	Upfront costs of installation

HEAT PUMPS IN YOUR COMMUNITY

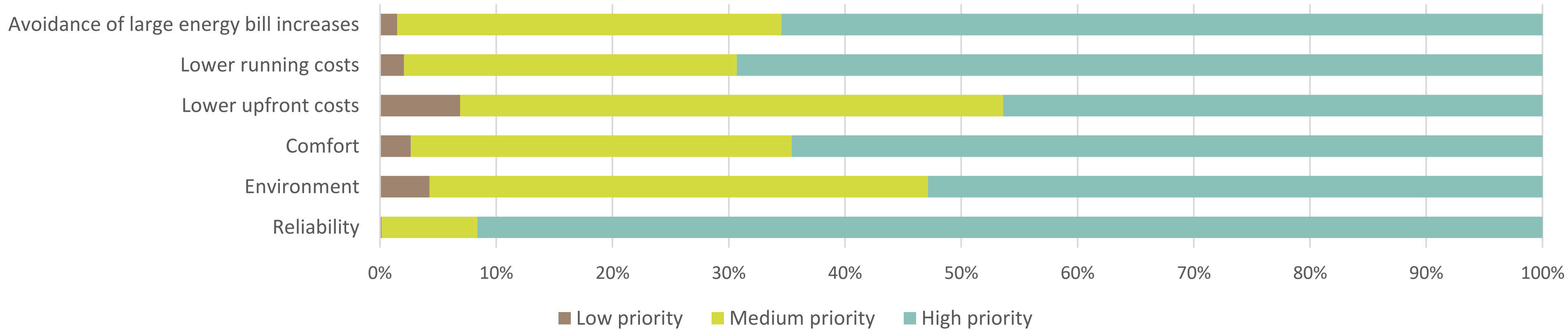
Over 40% of people do not know anyone with a heat pump. 35% know between 1-3 people with one, with the remaining knowing 3+. For those that knew others with a heat pump, the majority, over 53%, were recommended them.

Over 75% of people think knowing someone with a heat pump might make them more comfortable having one installed.

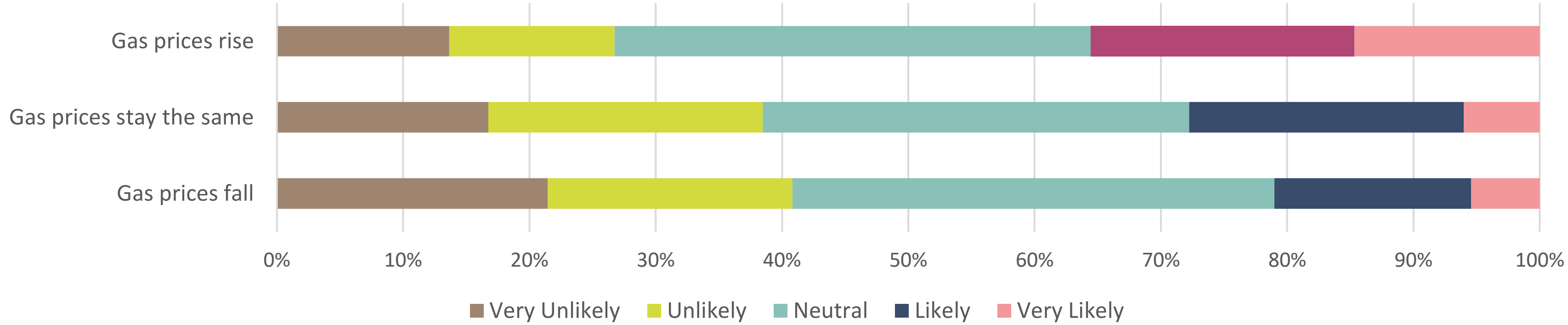
TYPE OF CONSUMERS

1 in 5 are early adopters with **2 in 5** are early majority users.

When choosing a heating system **over 90%** think reliability is the most principal factor, followed by lower running cost

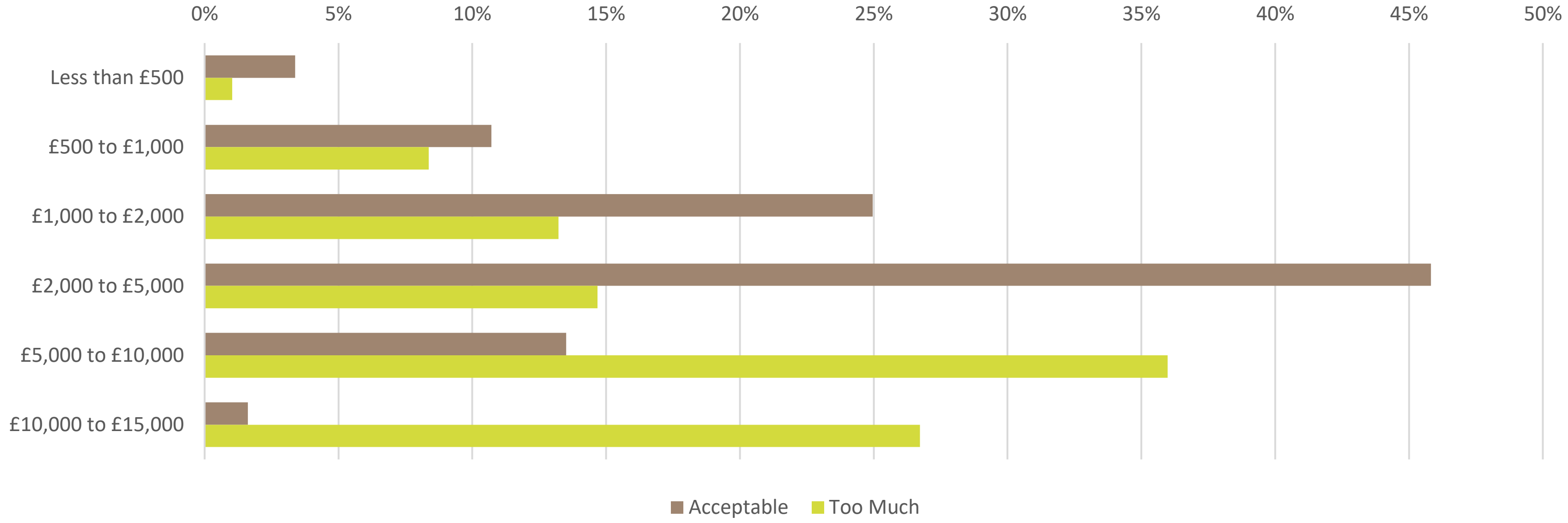


Many people were neutral when considering the circumstance when considering a heat pump. A slight increase if gas prices increased and a slight decline if they were to fall.



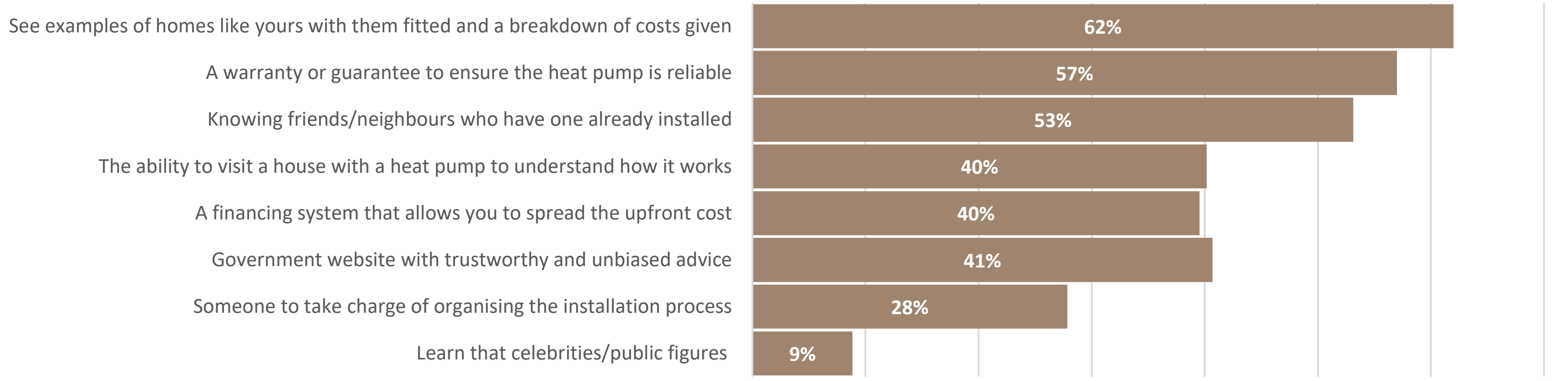
On average consumers would be **happy to pay** between £2,000 and £5,000 for a heat pump, an **average of £3,290**

Most people think that between £5,000 and £10,000 is **too much to pay** for a heat pump, with the average amount being recorded at **£6,820**, which is comparable to the previous question asking how much they thought a heat pump would cost (£6,300).



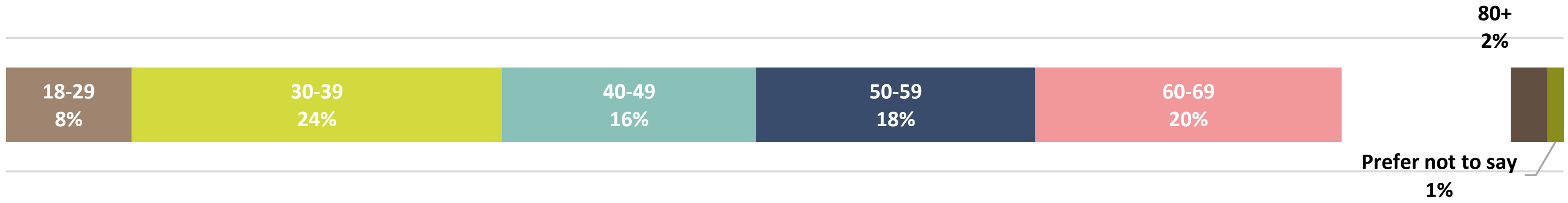
Only 30% of respondents felt fairly or completely confident in where to find information on Heat pumps

Most people are looking for real life examples, from people they trust along with a guarantee.

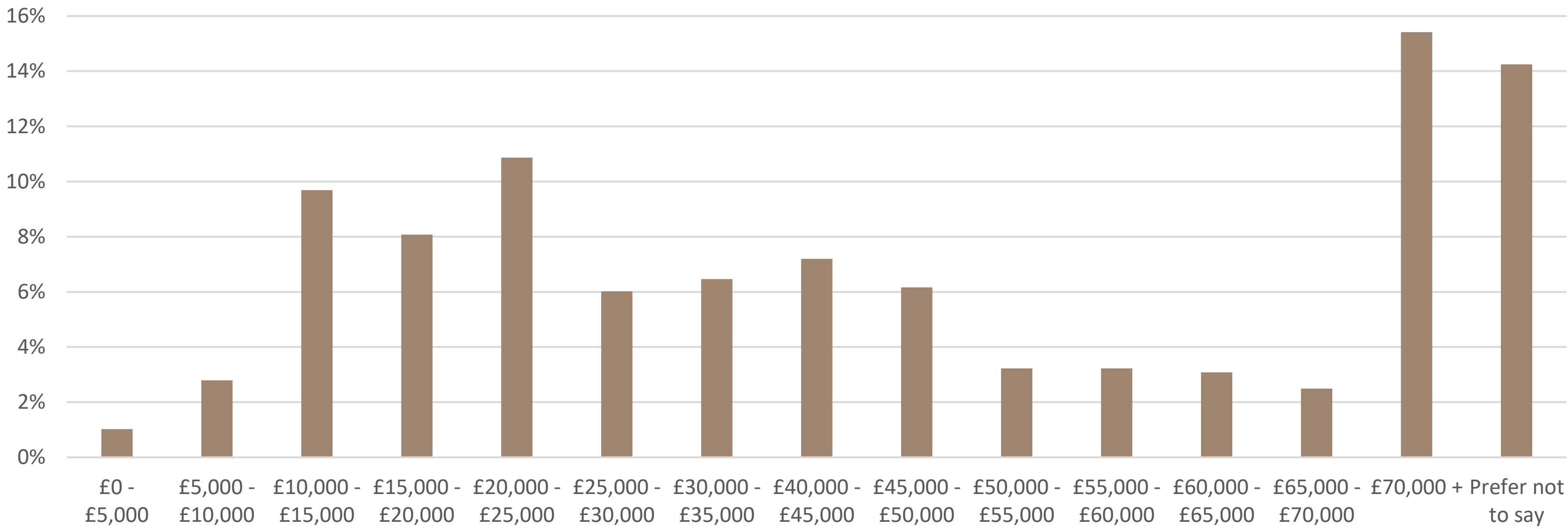


DEMOGRAPHICS

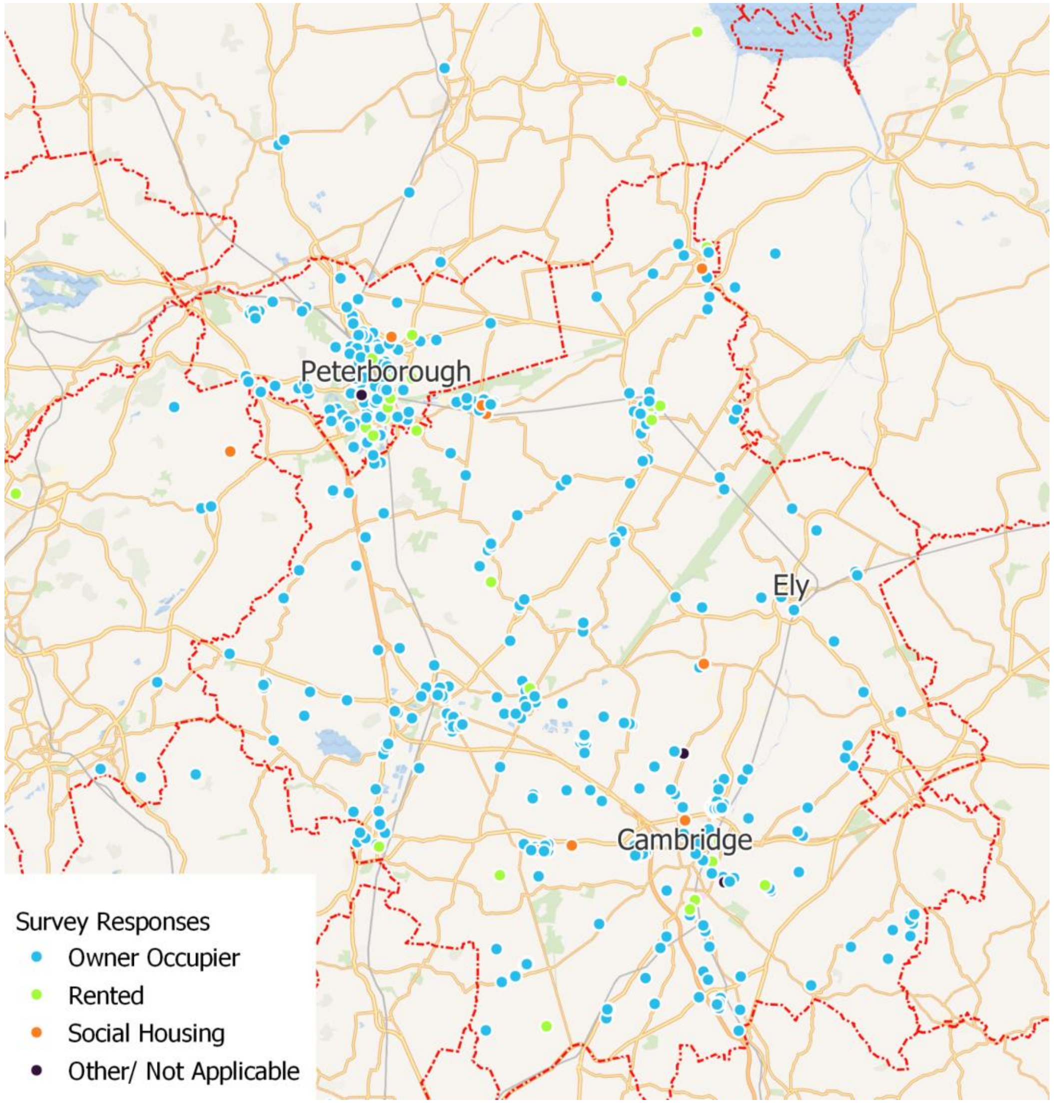
AGE PROFILE

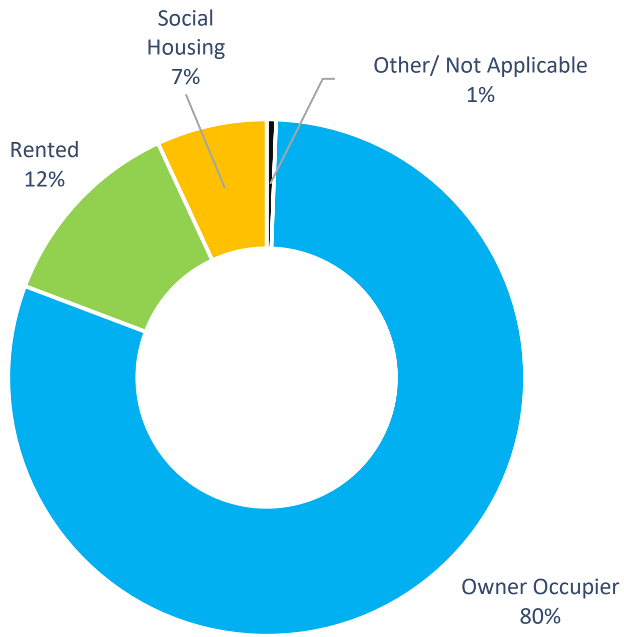


HOUSEHOLD INCOME

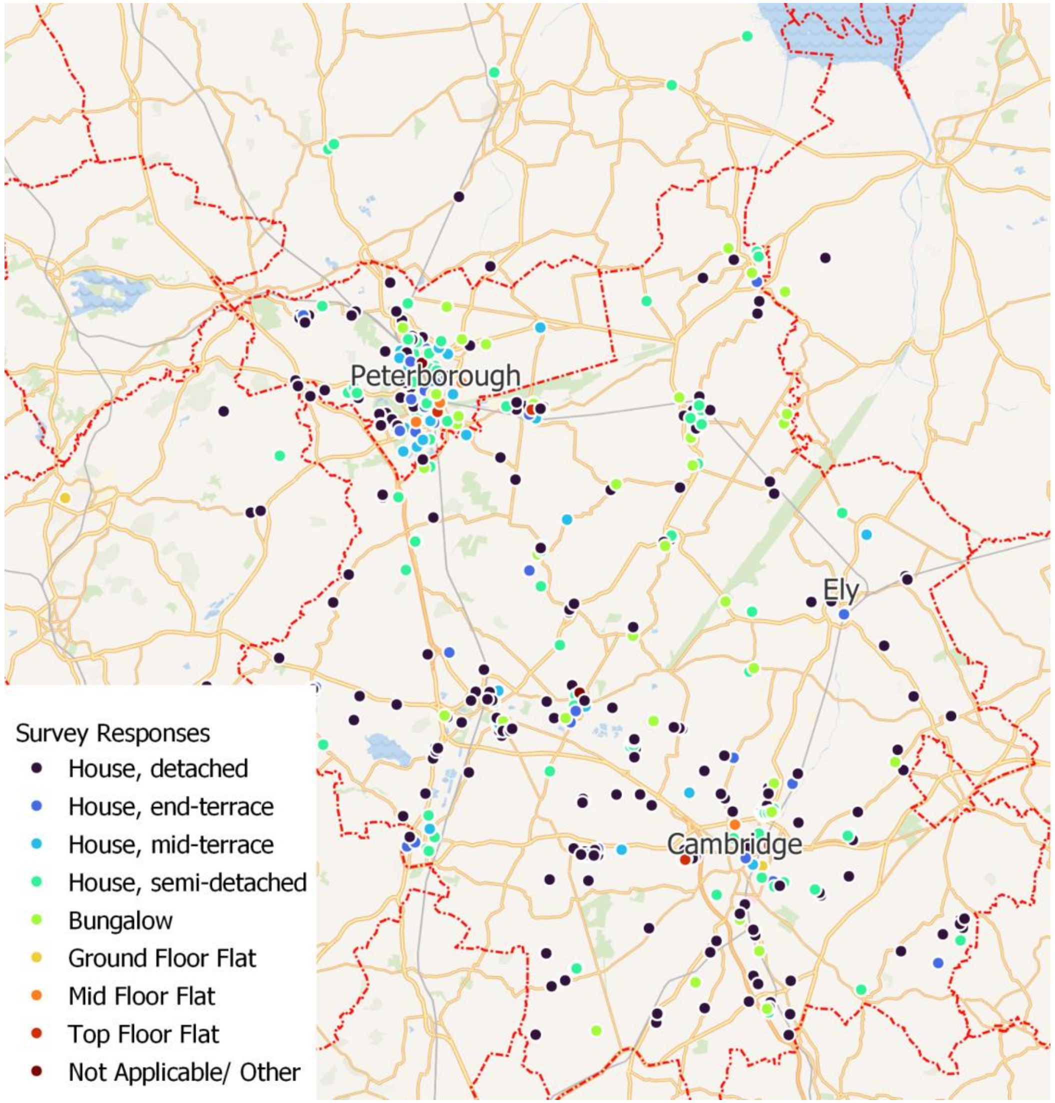


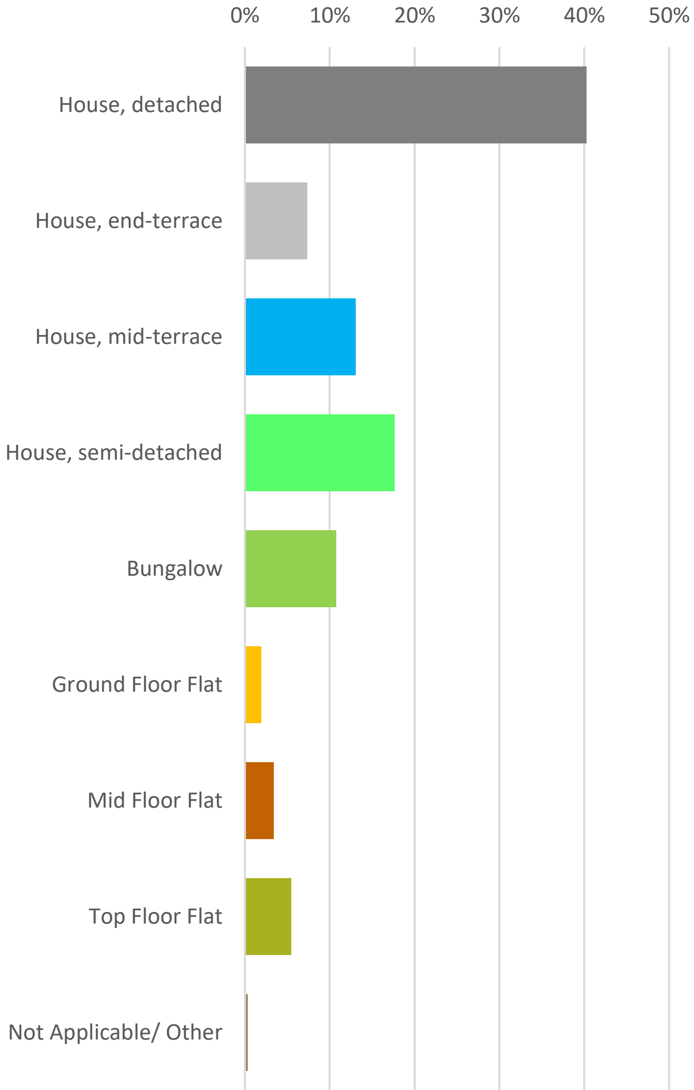
PROPERTY OWNERSHIP





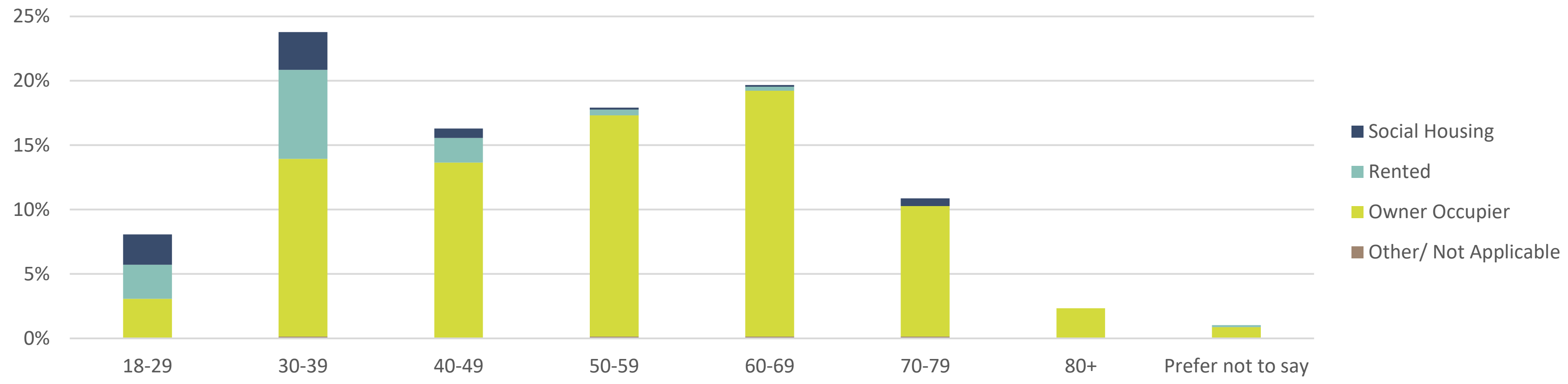
PROPERTY TYPE



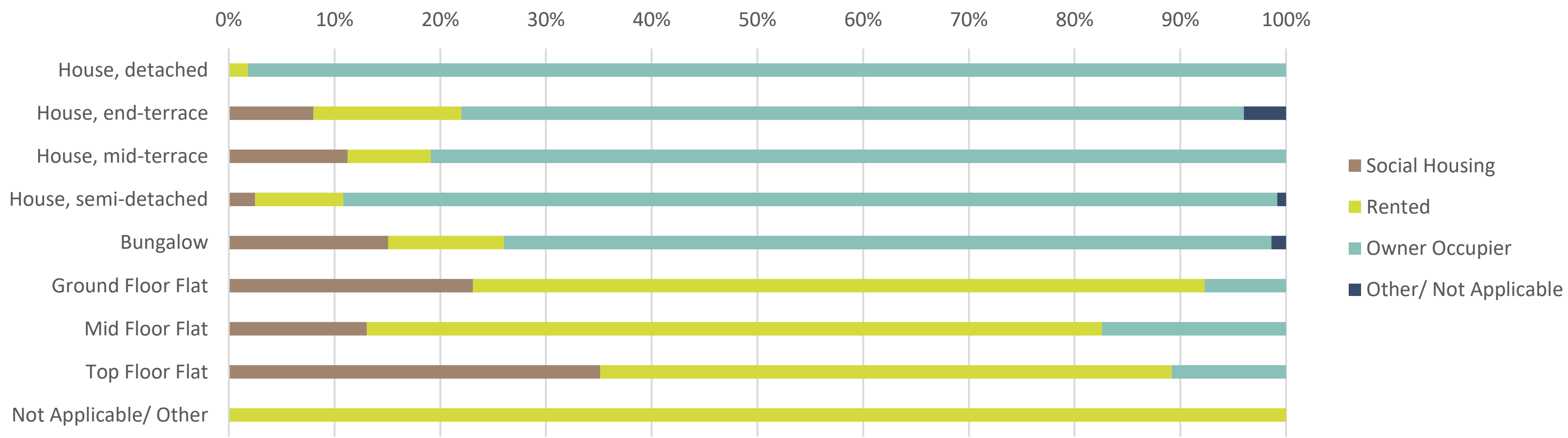


DEMOGRAPHICS ANALYSIS

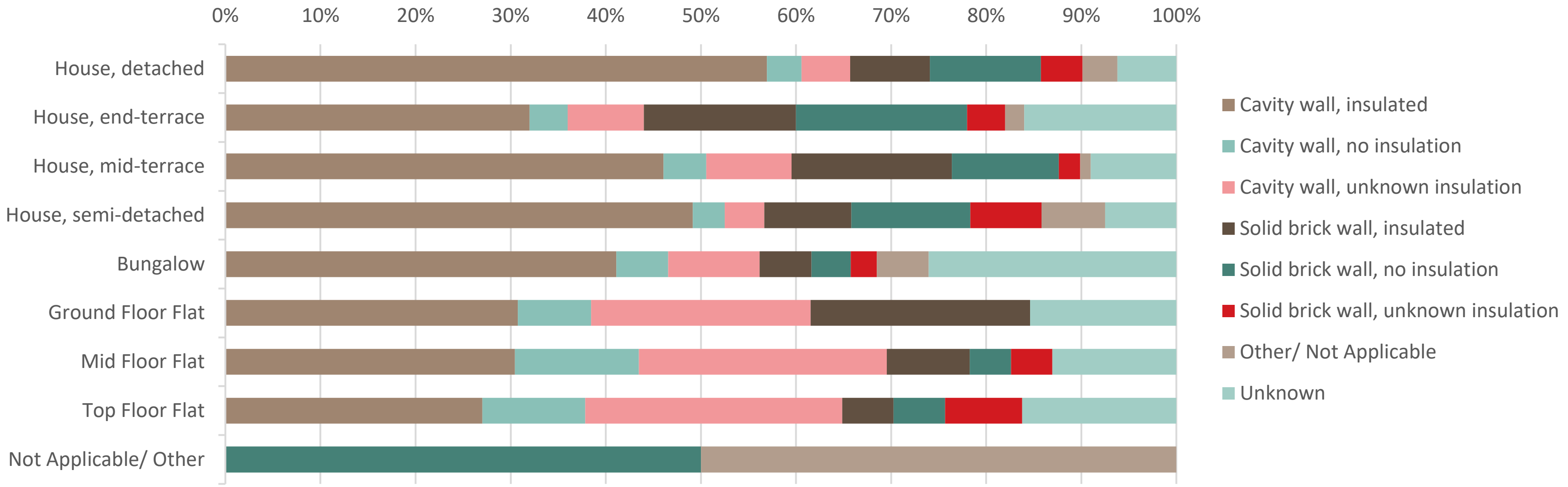
OWNERSHIP BY AGE



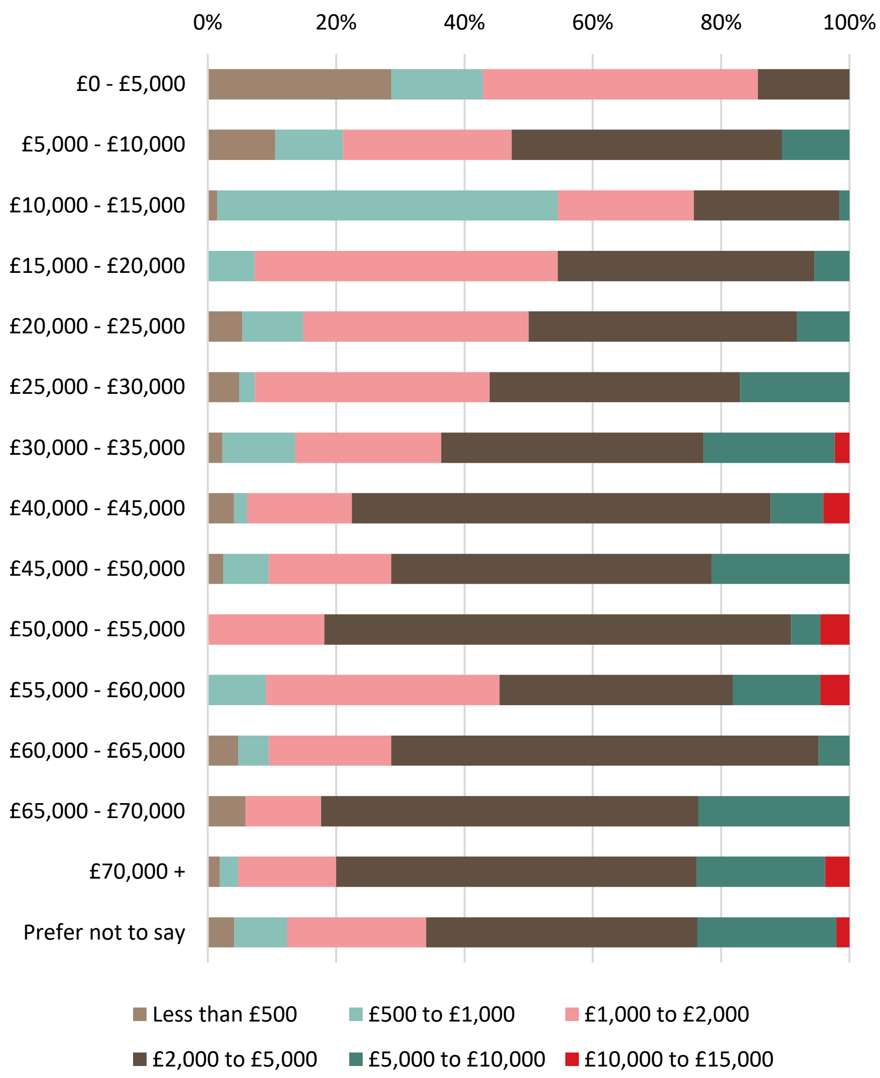
HOUESE TYPE BY OWNERSHIP



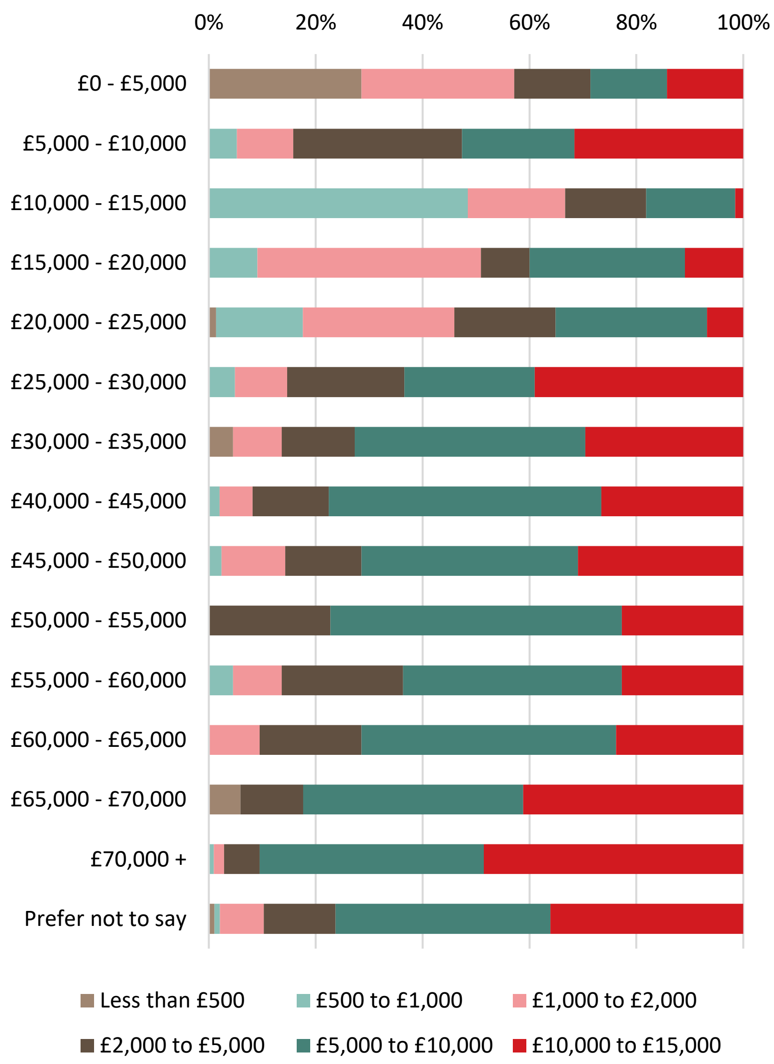
HOUSE TYPE BY INSULATION



ACCEPTABLE TO PAY BY HOUSEHOLD SALARY

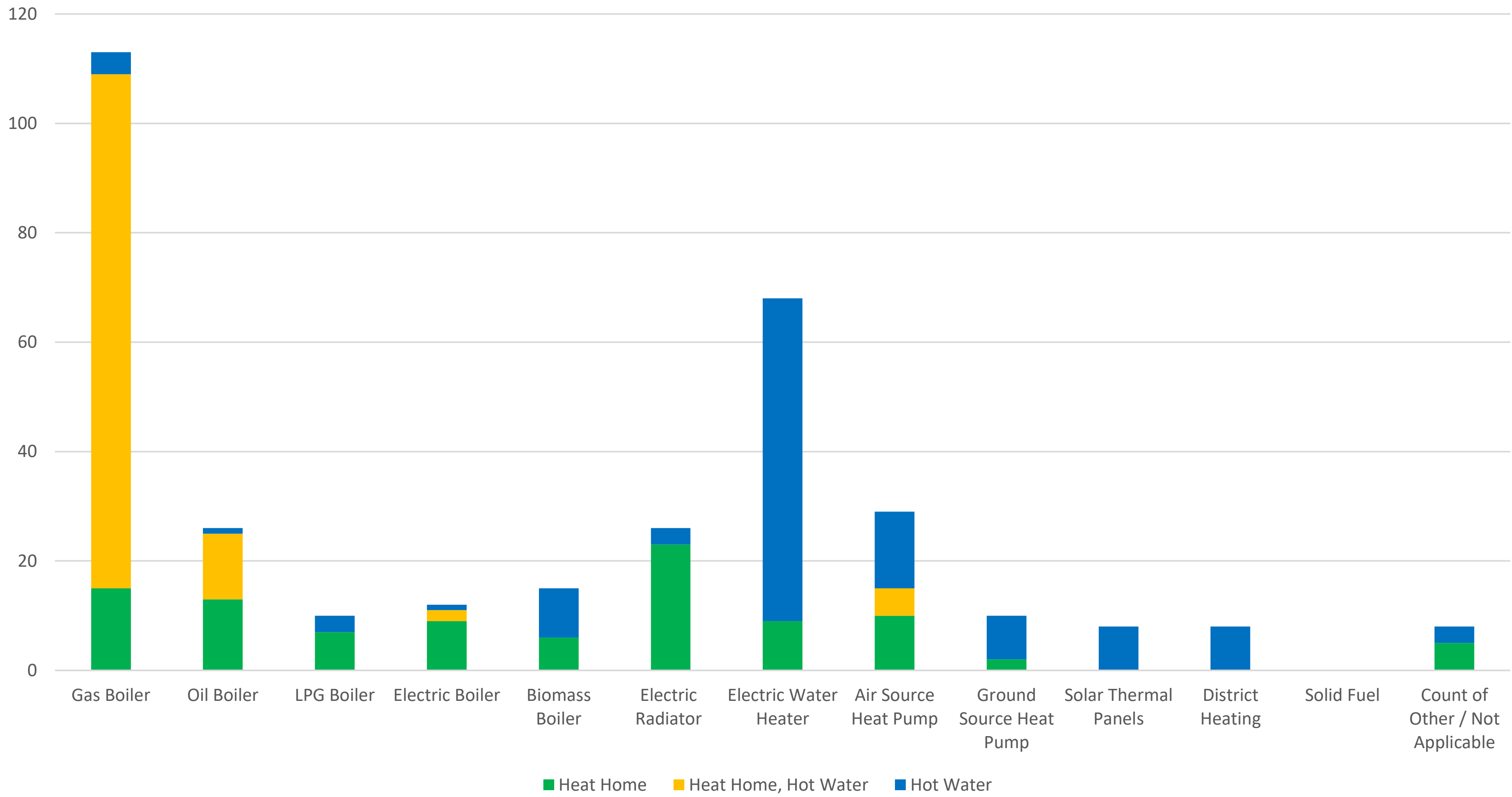


TOO MUCH TO PAY BY HOUSEHOLD SALARY

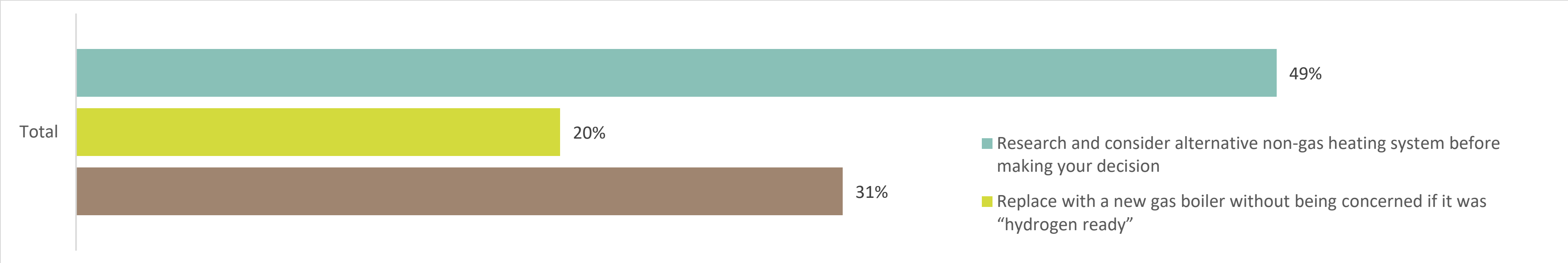


HOUSEHOLD INCOME ANALYSIS

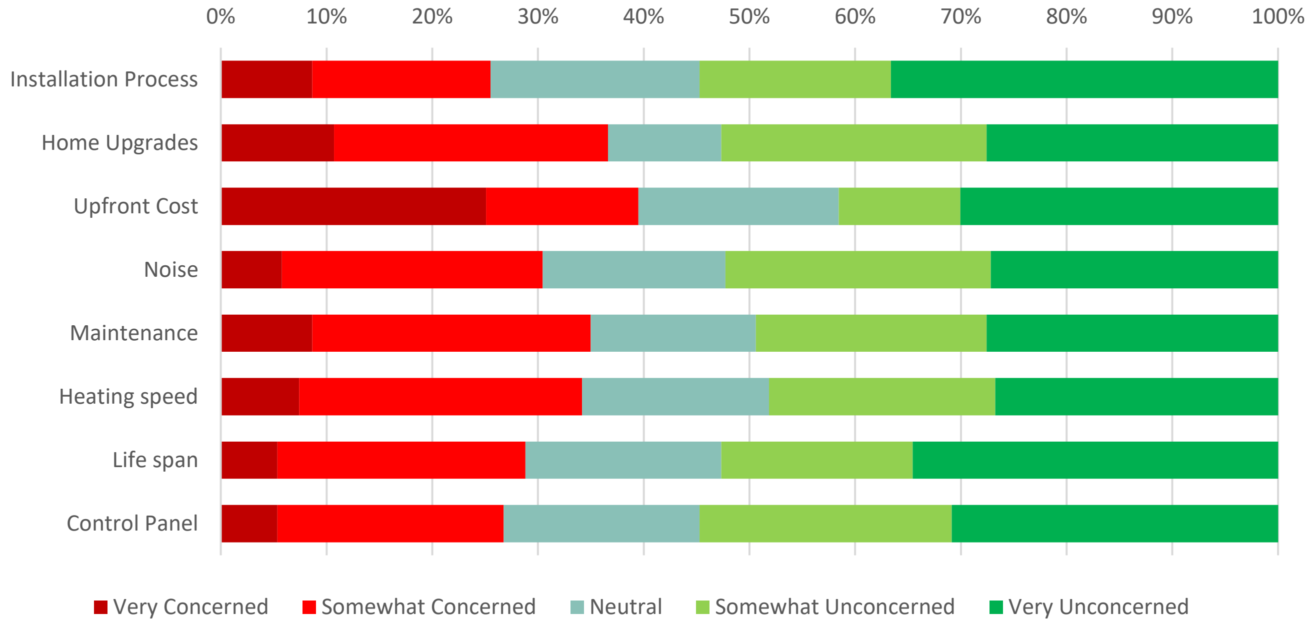
HOW DO YOU HEAT YOUR HOME / HOUSEHOLD INCOME <£30K



REPLACEMENT OPTIONS / HOUSEHOLD INCOME <£30K

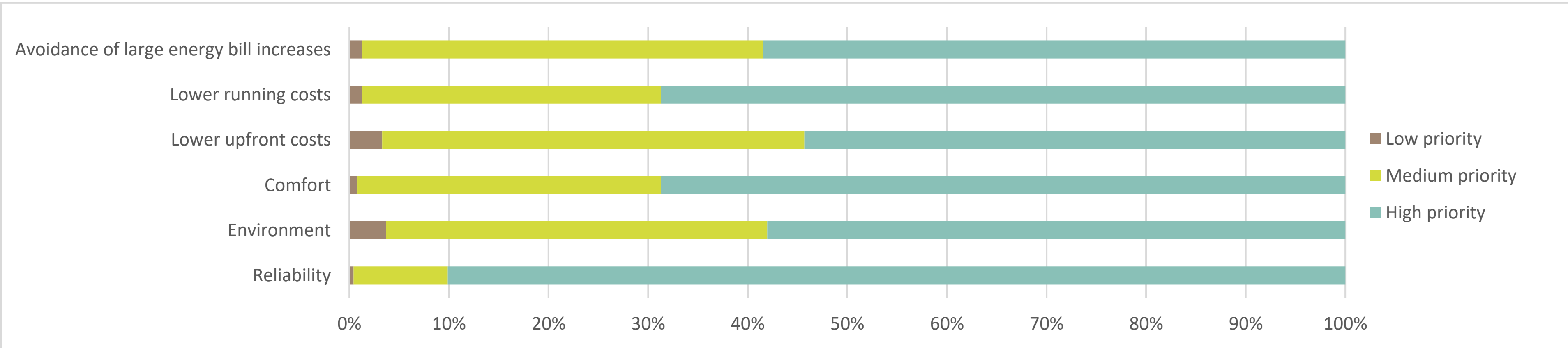


BARRIERS TO HEAT PUMP / HOUSEHOLD INCOME <£30K

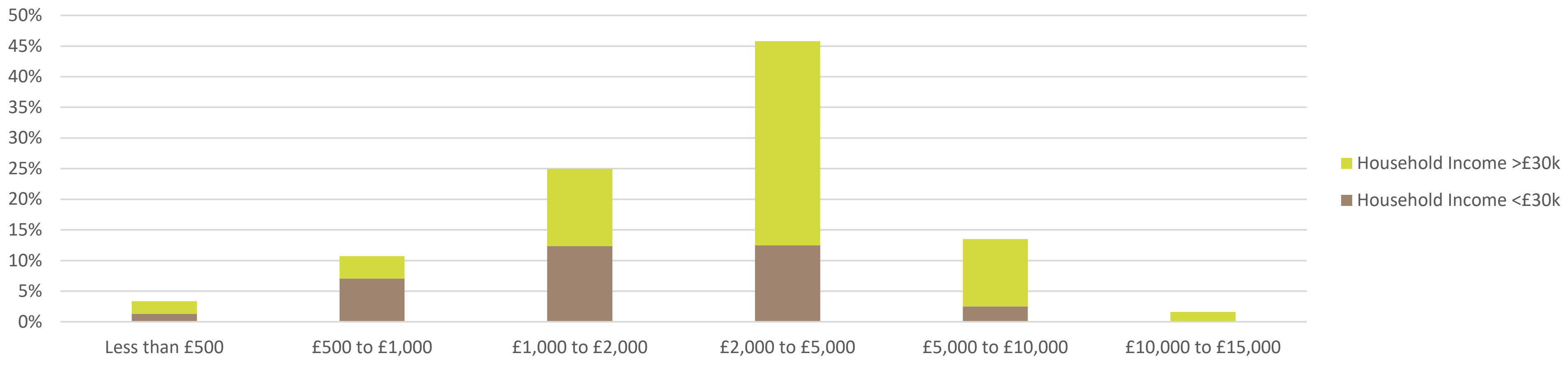


HOW MUCH DOES A HEAT PUMP COST

FUEL POOR ONLY: WHEN CHOOSING A HEATING SYSTEM, WOULD YOU PRIORITISE?



ACCEPTABLE PRICE TO PAY FOR A HEAT PUMP?



TOO MUCH TO PAY FOR A HEAT PUMP?

Appendix A3 – Focus Group Insight Report

The following section provides a summary of the feedback from the focus groups held by PECT in September 2022.

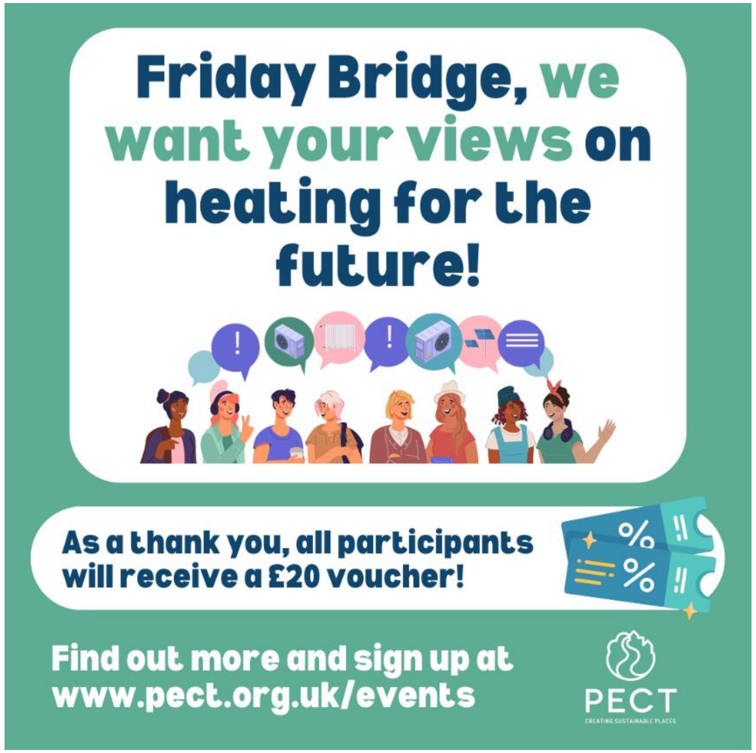
FRIDAY BRIDGE CUSTOMER ENGAGEMENT

PROJECT BACKGROUND AND OBJECTIVES:

Finding alternatives to natural gas for heating our homes is a crucial part of meeting the UK's carbon reduction targets. Public acceptability is essential for enabling a smooth transition to a new energy source. As such, this research was interested to understand initial public reactions to heat pumps as alternatives to traditional heating in the home.

Key Research Objectives:

- Understand householders' attitudes towards heat pumps as energy sources for heating.
- Describe attitudinal differences between different economic groups.
- Identify likely barriers to acceptability of widespread deployment, and how significant these will be to overcome; and
- Provide recommendations for how the project could engage with households to overcome these barriers and what type of content and materials would be effective in doing so.



FOCUS GROUPS

In total six focus groups were planned, including two in person sessions and 4 online sessions.

Date	Locations	Signups	Attendees
7th Sep 2022 – 18.30 – 20.00	Peterborough	5	2
8th Sept 2022 – 18.30 – 20.00	Friday Bridge (cancelled)	2	0
14th Sept 2022 – 18.30 – 20.00	Virtual	10	8
15th Sept 2022 – 18.30 – 20.00	Virtual (cancelled)	12	0
16th Sept 2022 – 12.00-13.30	Virtual	14	11
21st Sept 2022 – 18.30 – 20.00	Virtual	10	6
Total		**53**	**28**

Participants were recruited from a range of sources including those who agreed to be contacted again as part of an earlier heat pump survey, social media advertising as well as Eventbrite. Posters were also displayed across the target area of Friday Bridge, although uptake within the area was low.

One of the 'in person' focus groups was cancelled due to lack of uptake and the event on the 15th of September was also cancelled due to participants being from outside the project focus group area. An additional focus group was therefore held on the 21st of September.

The demand for the online focus group was high, with a waiting list developed for participants, with around 70% attending for the sessions.

The focus group were made up of a small group led through an open discussion by a PECT moderator. The focus group moderator nurtured disclosure in an open format.

The focus groups typically lasted around 90 minutes, and participants were rewarded with a £20 e-voucher.

DISCUSSION STRUCTURE

Section	Subject	Objective	Timing
1	Introduction	Introduction of the team, and explain purpose of research and how the focus group will run	5 min
2	Current Energy behaviours and preferences	Explore how participants currently use and understand energy and heating	20 min
3	Knowledge & awareness of decarbonisation	Gauge the level of people's awareness of decarbonisation and how they see their role	5 min
4	Introduction of the heat pumps – initial reactions	Introduce initial reactions to heat pumps. To build up their understanding of heat, and gauge reactions to different factors and implications	10 min
5	Detailed reactions to the heat pumps: benefits, concerns, barriers	Specifically identifying participants' perceptions of heat pumps, challenges, and barriers.	30min
6	Communications & engagement	To explore ways in which the project could engage households with the switchover. To identify materials and content that would facilitate understanding and overcome any barriers.	15min

CURRENT ENERGY BEHAVIOURS AND PREFERENCES

OBJECTIVE

To explore how participants currently use and understand energy and heating

CURRENT ENERGY BEHAVIOURS

- Most participants monitor their energy use, either through bills or smart meters.
- Those with smart meters had a better understanding of where their energy was being used and believed it had altered how they used energy.
- Cost was important to all groups, although comforts were equally as vital
- Most participants were not aware how much of their energy was used for heating, estimates varied between 30-50%
- Some did not know the cost of gas vs electricity
- All groups have become more aware of their energy use and price of bills in the last couple of months.

Switching energy systems

- Generally, participants had not switched energy systems. Some older participants recalled the switch to gas.
- Some participants have switched appliances from gas to electric, reason was for safety, efficiency, environmental as well as aesthetics.
- A barrier around switching was the cost of gas compared to electricity
- Some would switch for environmental reasons however the costs are a barrier as well as the type of property / age of existing systems
- One participant, who is currently looking at switching energy systems was advised against it by their builder / trades

KNOWLEDGE & AWARENESS OF DECARBONISATION

OBJECTIVE

To gauge to what extent people are aware of decarbonisation and how they see their role in it

AWARENESS OF ENERGY

- Participants across all groups did think about where their energy came from. Most had opted for green tariffs.
- Some participants have solar panels or were thinking of investing, as a renewable source of energy
- One participant, in a new flat particularly struggled to know about their energy, due to the location of meters and were 'encouraged' to use the same supplier as the rest of the building.
- Some found the energy market quite confusing, and not aware where their energy comes from.

Current understanding and awareness of de-carbonisation

- All participants knew about climate change and agreed that carbon emissions needed to be refused, citing science and recent events such as summer heatwave and flooding in Pakistan.
- One group felt that the cost of change was a bit threat to carbon mitigation
- Some confusion about what 'green' energy was as not all green energy if from renewables i.e., nuclear and biomass

Their own role and the role of the general public

- Most groups felt that they did have a role to play in reducing carbon emissions and greenhouse gases.
- Some felt that it was the responsibility of 1st class countries to support 3rd class countries.
- Many felt they had started to 'do their bit' through green energy tariffs, recycling and thinking about their impact. One participant has started using a slow cooker and air fryer.
- One group felt that role of education and particularly in schools should be a key focus area.
- One participant as part of the parish council had reviewed their villages EPC rating for all properties, in an attempt to help the homeowners, understand what they could do to improve energy efficiency

HEAT PUMPS - INTRODUCTION TO HEAT PUMPS

OBJECTIVE

To introduce and understand initial reactions to heat pumps. To build up their knowledge on what this means and understand reactions to different factors and implication

AWARENESS OF HEAT PUMPS

- One participant has three children who all have heat pumps, one with newer property works better but the second child has an older property and a lot more work has gone into insulating. They also struggled with controlling the temperature the year.
- One participant felt they were expensive and needed a well-insulated house.
- One resident had been investigating if they could have a community ground source heat pump.
- Majority of people had heard of heat pumps, although didn't know the specifics and if it was right for them or where to find information.

HEAT PUMPS THOUGHTS

- Majority of people had heard of heat pumps, although didn't know the specifics and if it was right for them or where to find information.
- One group wanted to ensure that they could continue to heat their homes as they currently do, with a level of flexibility and control and were not sure a heat pump would allow this.
- Most agreed heat pumps look like a good solution for the environment, however there were a range of other challenges they present including cost, installation, services and the unknown.
- The cost of a heat pump was seen as a barrier, although most thought that the price would decrease with increased uptake
- The safety of them was noted in a couple of groups, with the ability to remove gas from their home seen as a benefit.
- One participant felt they were very expensive and the need to insulate a limiting factor.

HEAT PUMPS - SCENARIOS

OBJECTIVE

To put participants in scenarios, to understand more detailed reactions to the new technologies the benefits, challenges, and barriers

SCENARIOS

Finance

- Cost was seen by all groups as the largest barrier.
- All groups would favour a grant for the cost of purchase as the overall price was seen as a barrier.
- Several participants felt they would wait until the price dropped, but didn't feel the option of grant currently available would sway them
- One group outlined the need to see the ROI
- Several older participants were concerned about the length of payback period for loans and green tax options due to their ages
- One participant felt that despite the large cost, it shouldn't be a barrier for a transition to a green heating system
- One participant felt funding should be proportional to income.
- A large proportion were not keen on having a large up-front cost and wanted the cost to be relative to that of a gas boiler

Suitability / Complexity / Disruption

- The suitability of the property was raised by several participants and the works needed to make a heat pump a feasible solution. Many felt this additional cost and hassle would put them off a heat pump.
- There were concerns around the length of time for installation, the process to ensure all part of the installation were done correctly and the retrofit of existing systems.
- The timing of activities was also discussed in several groups, most people replace equipment when it is broken, therefore never the best time to have additional work done, if for example without any heating.

Installation Process

- Most felt they would like a trusted supplier to do the installation, backed by a trade guarantee scheme. They would value expertise and experience
- The lack of knowledge around heat pumps was seen as a challenge about what system would be right, the additional measures and what trades were needed
- A list of trusted and reputable suppliers, from the Local Authority was seen as positive addition.
- All groups wanted the same installer to do all the works to ensure compliance and ease.
- There was some concern about how long the process would take and if they would be without heating and hot water during the process.

Changes in home

- The ability to easily control the temperature and comfort was a large focus of discussion.
- The switch to an electric cooker was not seen a barrier and in fact a positive for safety and environment.
- One group expressed they would want to see lower homes and therefore the ability to keep their home at their desired temperature.
- Noise and size of the equipment was not seen as a barrier to most.

COMMUNICATIONS & ENGAGEMENT

OBJECTIVE

To explore ways in which the project could engage households with the switchover. To identify materials and content that would facilitate understanding and overcome any barriers.

EXAMPLES

- Several groups would like to see a heat pump and speak to someone who has been through the process
- Several felt that some form of assurance such as a guarantee and registered installer, who can be trusted to advise homeowners would be advantageous
- Several people felt the environmental message should be the focus
- Need to reassure people about the noise, servicing and the retrofit required
- One participant suggested that communication be targeted specifically to the type of homes so they can see what the cost and impact would be for them more specifically.
- An online website to help advice and provide some of the answers based in inputs i.e., Current heating, insulation, size, and age of property
- One person discussed the switch from Coal to Gas and felt that the government should be doing the same, working street by street to switch people

Appendix A4 – Friday Bridge Customer Engagement

The following sections provides a summary of the feedback gained from the door-to-door engagement held in the village of Friday Bridge, Cambridgeshire in October 2022 by PECT.

FRIDAY BRIDGE CUSTOMER ENGAGEMENT

BACKGROUND

Between the 17th and 24th of October, PECT undertook a round of face-to-face surveys with the residents of Friday Bridge. The aim of the engagement was to gain opinions about their current heating sources, knowledge of heat pumps, any concerns and potential future involvement in further research.

682 households within the target area

102 surveys undertaken

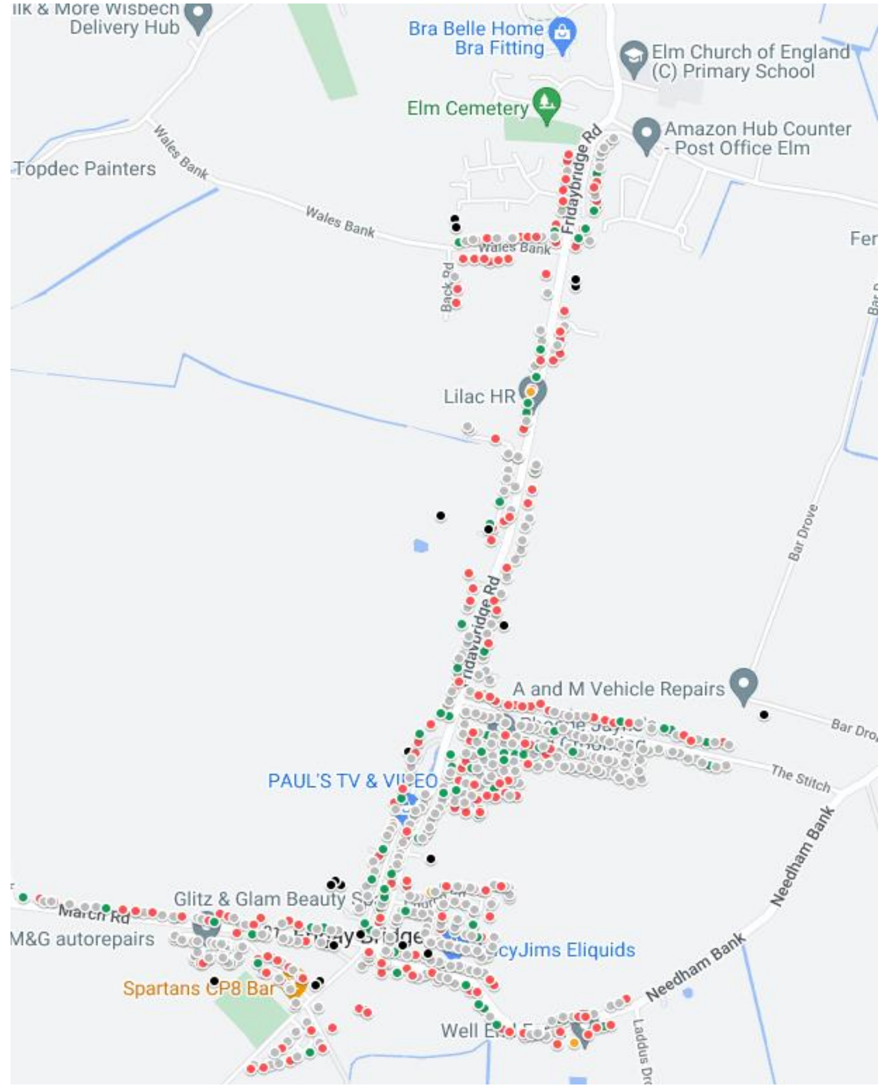
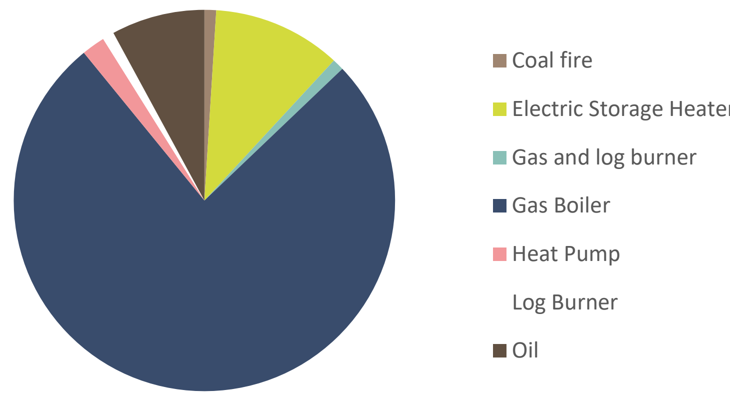


Figure 4 - Survey Completed (Green) Not in (Grey) Come back later (Orange) and No Survey (Red)

SURVEY RESULTS

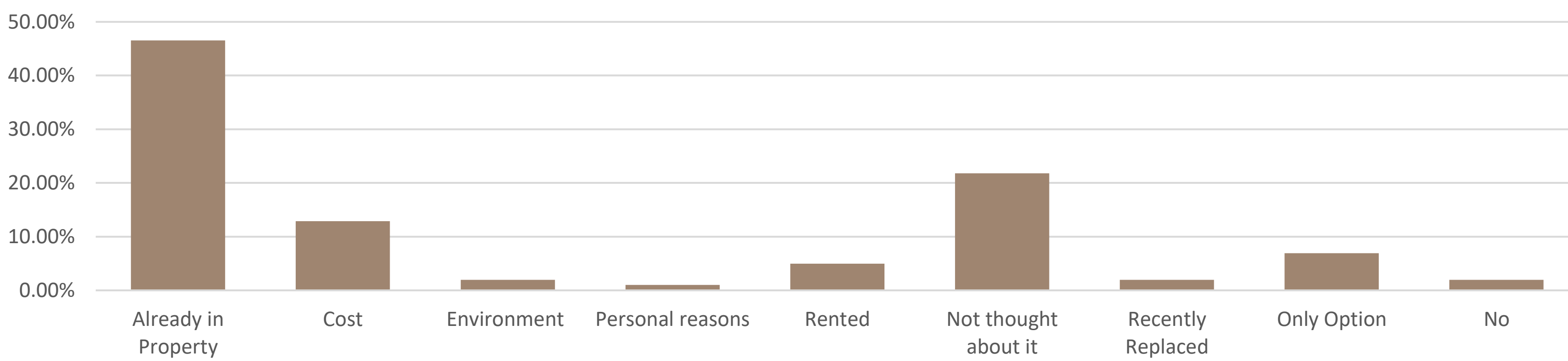
HOW DO YOU HEAT YOUR HOME?

Over 75% of households heat their property using a gas boiler, with electric storage heaters 11% and oil 8% being the next popular. Currently air source heat pumps make up 2% of heating sources in the community.



WHY?

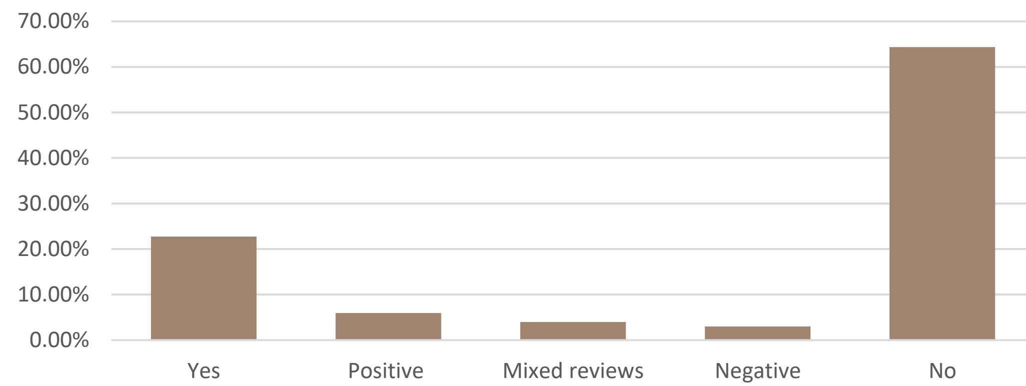
Most households 46% have not changed their heating system since they moved into their property, with over 20% not thinking about it.



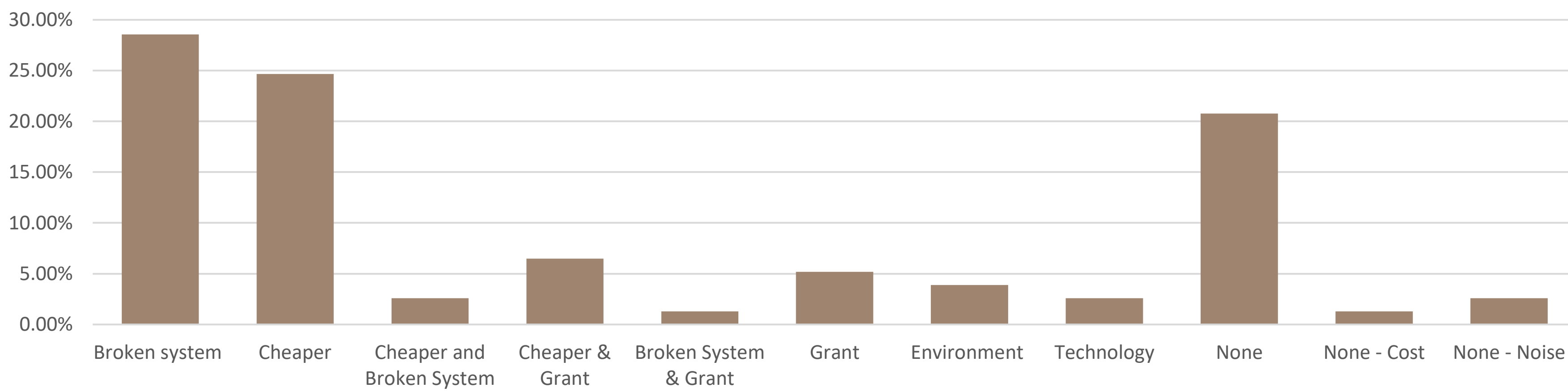
HEAT PUMPS

68% of people had heard of a heat pump, which was lower than the those who had taken part in the county wide survey. Just over **50%** knew that gas boilers are being phased out

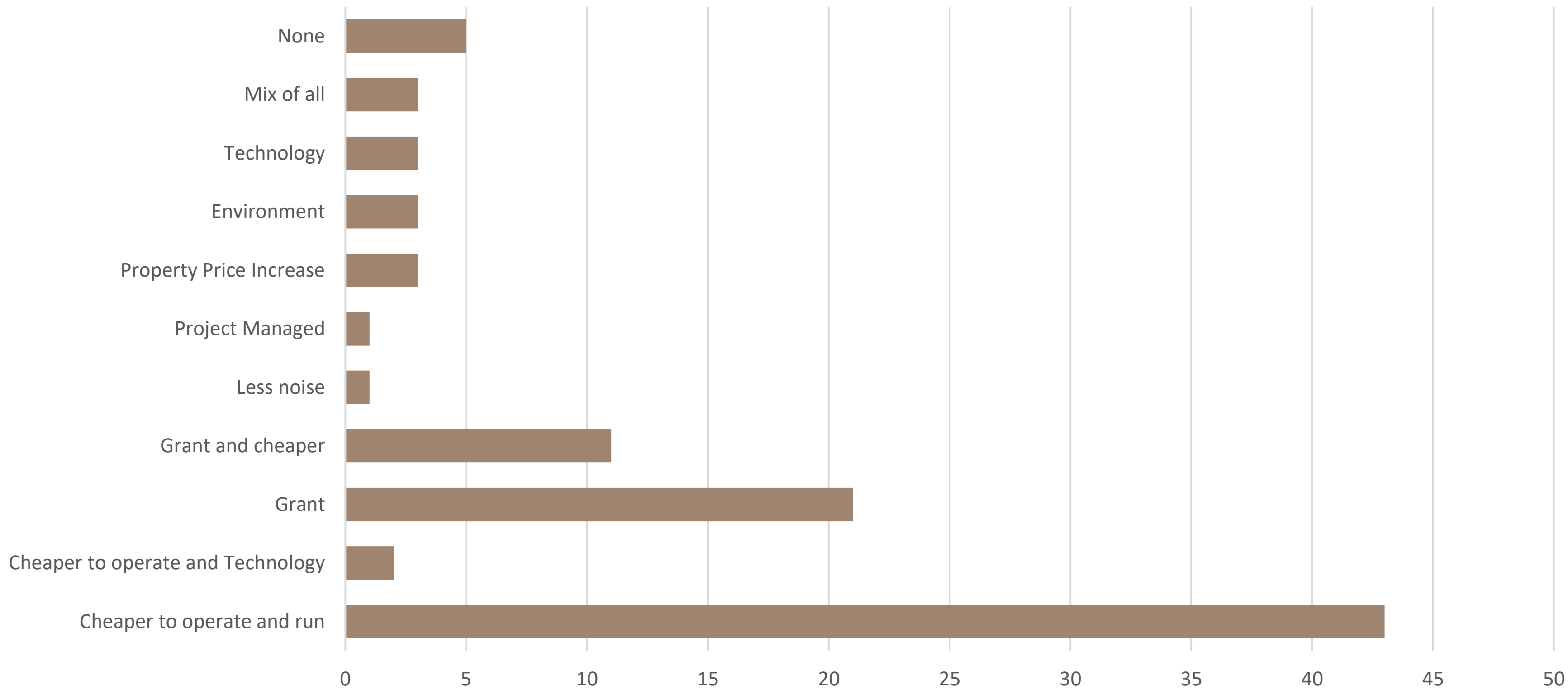
Around **23%** know someone with a heat pump with around **65%** not knowing anyone. These interactions were mixed between positive and negative.



Over half of consumers would only look to replace the system if it were broken or if it was cheaper to install and run a heat pump than their existing heat system. Around **20%** of people did not feel there are any circumstances which they would consider changing to a heat pump. Several reasons were given for not considering switching including the noise and cost. **5%** would like to have a grant and **4%** would switch for environmental reasons.

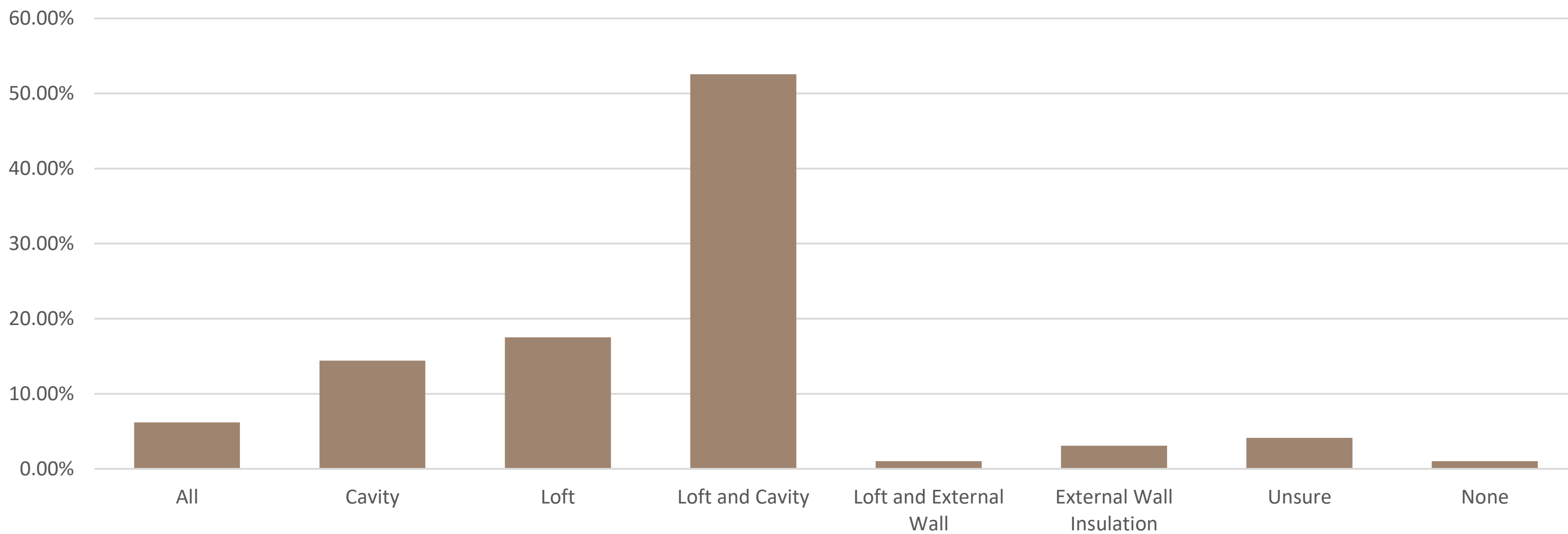


There were a range of reasons participants gave that would encourage them to switch to a heat pump. These included improved technology for the heat pump, heat pumps being less noisy and increasing their property price, however the prominent factor was if they became cheaper to run and operate, and if they came with a grant.



INSULATION, INSTALLATION AND GREEN TECHNOLOGY

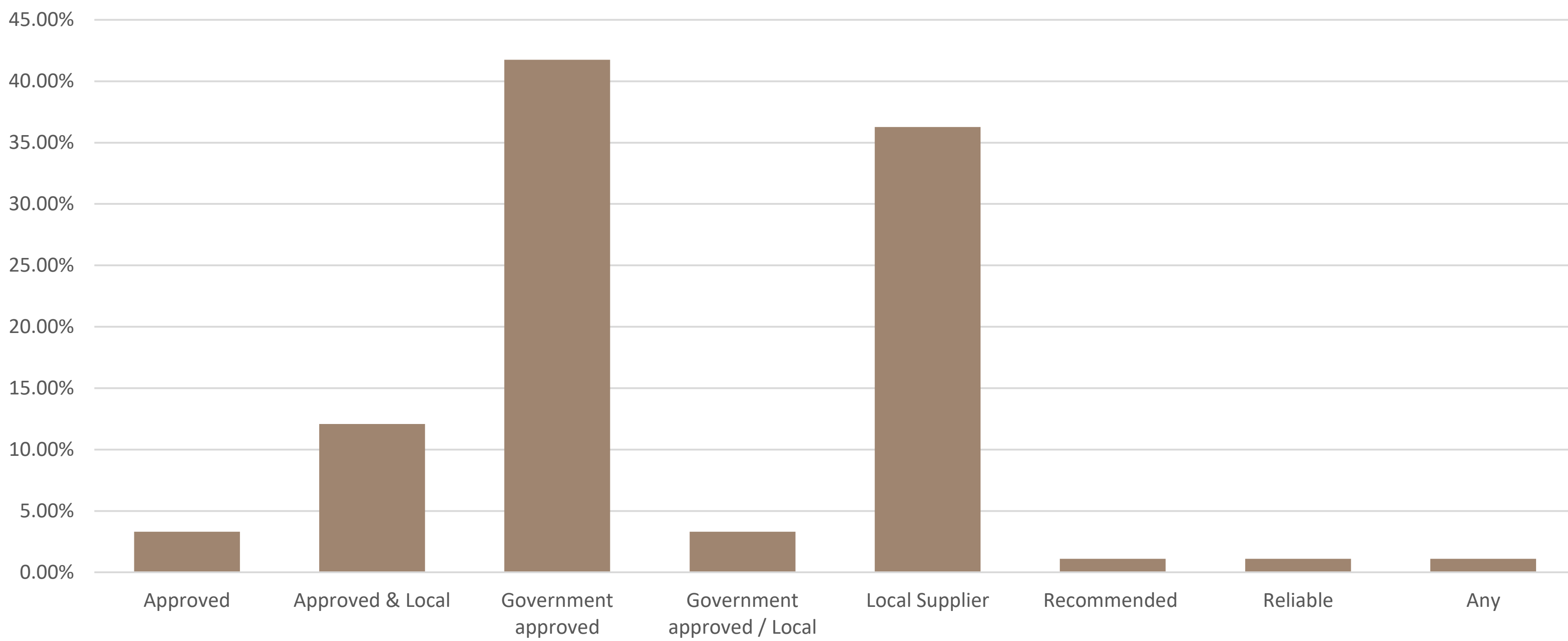
Most households within Friday Bridge that were surveyed had both loft and cavity insulation. Plus, several of the households stated they needed additional loft insulation. A number of the properties also had external wall insulation, with around **4%** unsure what, if any insulation they had.



Over **80%** of people preferred that any additional remedial work was undertaken at the same time as any installation.

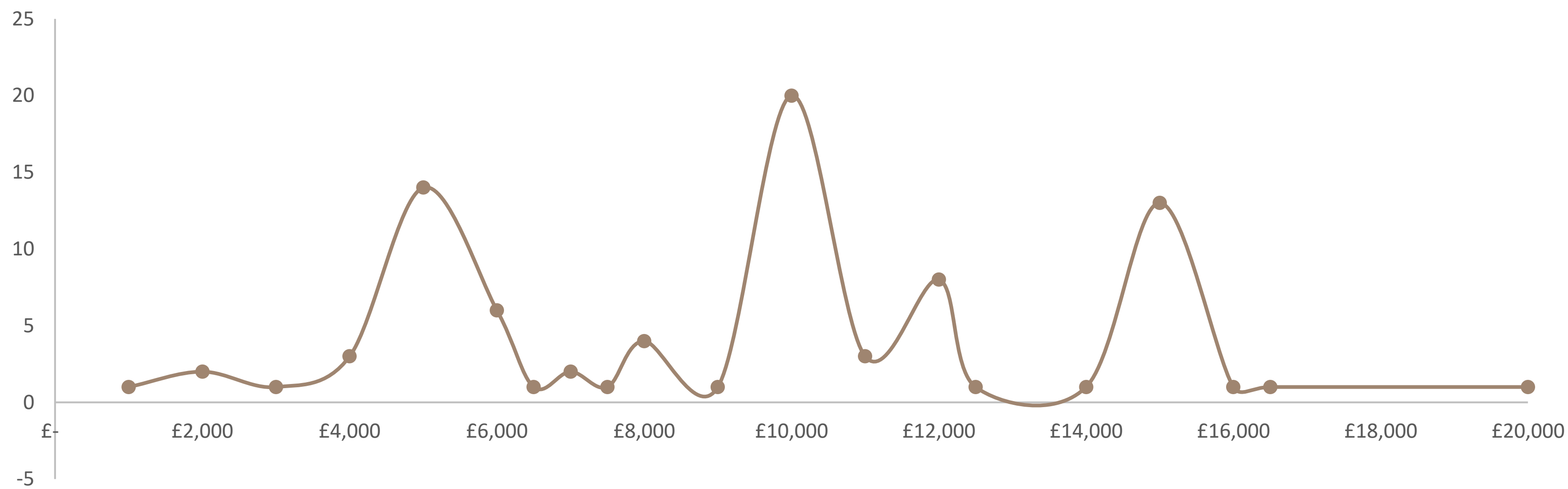
7% of people surveyed already had solar panels, with several households currently considering having them installed. Only 1 household had an electric car charger.

The bulk of those surveyed would like to have any installation undertaken by a local supplier, who is back and verified by the government.



COSTS

On average people thought a heat pump would cost around **£9,400** to install with **16%** thinking it would cost around **£5k** and **23%** thinking it would cost **£10k**, and a further **15%** thinking it would be nearer **£15k**.



80% of people felt this price was a barrier for them, with only **15%** saying it wasn't a barrier. **21%** felt that a 40% / £5k grant would encourage them to switch, with a further **53%** thinking it would maybe influence their decision.

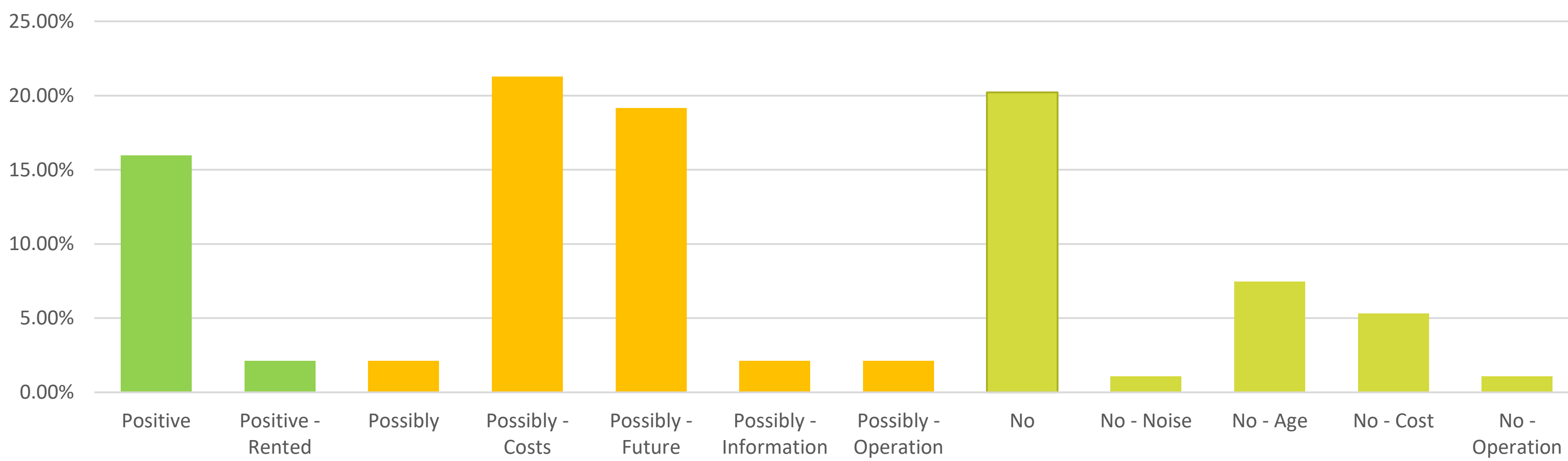
42% of those surveyed felt that additional financial support around a low interest loan or council tax would encourage them, although over **57%** wouldn't consider this.

TAKEUP

Over half of people would like to have an independent advisor support them with the next step in obtaining a heat pump, various requesting access to further information including around **12%** thinking a formal quote would be the next step.

30% of people didn't feel they needed any further information, with around **1%** thinking access to a website would be needed to make an informed choice.

Around **17%** of people were positive about having a heat pump installed based on discussions, with a further **47%** open to the idea of switching



Appendix B – Site Prioritisation Summary Slides

The following pages present a summary of the prioritisation process developed as part of this project. The analysis generated by this methodology was presented to the project partners, including Fenland District Council and Cambridgeshire County Council, in July 2022. The analysis and the local knowledge of the partners concluded that the village of Friday Bridge would be selected for high density heat pump deployment for Phase 2.

CONTENTS

PROJECT OBJECTIVES & SCOPE
CRITICAL PROJECT CONSTRAINTS ("DENSITY RULES")

A key focus for Heat Pump Ready is demonstration of effective methodologies for roll out of high-density of heat pumps in a locality – to reflect the density of heat pumps that may be required to meet Net Zero requirements.

Therefore, *Stream 1 - Solutions for High-density Heat Pump Deployment* project teams must deploy heat pumps to either:

- **Category A**: Heat pumps will be deployed in **at least 25% of the domestic buildings** on **at least one low-voltage network** within their chosen LAU Level 1 deployment trial locality; and/or
- **Category B**: Heat pumps will be deployed in **at least 25% of the domestic buildings** served by **at least one single secondary sub-station** within their chosen LAU Level 1 deployment trial locality; and/or
- **Category C**: Heat pumps will be deployed in **at least 25% of the domestic buildings** served by **at least one primary sub-station** within their chosen LAU Level 1 deployment trial locality.

Specific Exclusions

Table 6: Permitted housing/building type and deployment limits under Heat Pump Ready *Stream 1 - Solutions for High-density Heat Pump Deployment.*

Building type	Permitted in Stream 1 trial?	Limit for Stream 1 trial (as % of total heat pumps deployed in trial)
Social housing **New Build (pre-occupancy)** **Non-domestic**	Yes	**Maximum of 30% in total (i.e. for all three categories)**
Off-gas grid homes	Yes	**Maximum of 15%**

SITE PRIORITISATION PROCESS
DATASETS

We have gathered data on:

Building stock data

- Ordnance Survey AddressBase data - locations of all properties (domestic and non-domestic), identified by Unique Property Reference Number (UPRN)
- EPC data (domestic)

Geospatial

- Historic England protected buildings/sites data: Listed buildings, archaeological sites, conservation areas
- Xoserve Off-gas postcodes
- UK Power Networks Primary Substation Electricity Supply Areas (ESAs)
- UK Power Networks HV Substation point coordinates

Financial Prioritisation (variety of sources used, though heavily used BEIS's Cost Optimal Domestic Electrification (CODE))

- Heat pump costs
- Heating system upgrade costs
- Energy efficiency measures costs, and energy savings

SITE PRIORITISATION PROCESS
PRIORITISATION RULES

Site prioritisation ranking considerations:

1. On-gas (as determined from EPC or off-gas postcode)
2. Not listed building, or in other protected area (as determined from relevant datasets)
3. Domestic (as determined from Addressbase or EPC)
4. Ranking of building typology as determined from initial financial model.
5. *Preference to target towns/clusters of properties to increase chance of building local momentum – NOT BUILT INTO MODEL*

SITE PRIORITISATION PROCESS
FINANCIAL ANALYSIS

- Simple financial model has been built to rank building archetypes on their economics of switching to heat pumps vs sticking with gas boilers.

- The ranking is used to guide which areas may be favourable.

- Financial model considers:
  - Cost of heat pump install
  - Cost of enlarging radiators
  - Cost of energy efficiency measures (for buildings with EPC rating less than B)
- Archetypes split by EPC band, those with EPC rating B or A, considered to require little energy efficiency retrofit.

Building type	Retrofit required
Small flat	Little retrofit / Significant retrofit
Ground floor flat	Little retrofit / Significant retrofit
Mid-floor flat	Little retrofit / Significant retrofit
Top floor flat	Little retrofit / Significant retrofit
Bungalow	Little retrofit / Significant retrofit

Building type	Wall construction	Retrofit required
Mid-terrace	Solid/Cavity	Little retrofit / Significant retrofit
End-terrace	Solid/Cavity	Little retrofit / Significant retrofit
Semi-detached	Solid/Cavity	Little retrofit / Significant retrofit
Detached	Solid/Cavity	Little retrofit / Significant retrofit

SITE PRIORITISATION PROCESS
FINANCIAL ANALYSIS

- Lifetime cost of heat pump is compared to cost of sticking with gas boiler.
- Scoring is the percentage difference in lifetime cost over 10, 20 and 30 years.
- Some priority trends emerge:
  - Flats and bungalows better than houses.
  - Properties needing little energy efficiency retrofit.
  - Properties with cavity walls.

	Little Retrofit (EPC B)			Significant Retrofit (EPC D)		
Archetype	10_YEAR_SCORE	20_YEAR_SCORE	30_YEAR_SCORE	10_YEAR_SCORE	20_YEAR_SCORE	30_YEAR_SC
Small_flat	-38	-51	-41	-62	-73	-53
ground_floor_flat	-45	-58	-47	-64	-74	-53
mid_floor_flat	-41	-53	-42	N/A	N/A	N/A
top_floor_flat	-53	-65	-51	-71	-78	-56
bungalow	-46	-55	-43	-61	-66	-48
mid_terrace_solid	N/A	N/A	N/A	-106	-87	-59
mid_terrace_cavity	-51	-61	-48	-76	-80	-58
end_terrace_solid	N/A	N/A	N/A	-100	-75	-47
end_terrace_cavity	-60	-70	-54	-82	-84	-60
semi_detached_solid	N/A	N/A	N/A	-92	-67	-41
semi_detached_cavity	-61	-69	-52	-75	-76	-54
detached_solid	N/A	N/A	N/A	-97	-67	-41

SITE PRIORITISATION

- Model outputs results for each electricity supply area from which we can start to apply filters.
- HPR priority buildings are those that are: domestic, on-gas, not protected/listed, not social housing
- Financial scoring is only possible where an EPC is available.

Area name	Number of addresses	Number of domestic addresses	% on-gas	% social housing	% HPR priority	Domestic EPC coverage (%)	Average 10 year score	Average 20 year score	Average 30 year score
GREEN ST-MARCH	196	193	93%	21%	82%	61%	-66	-70	-50

PRIMARY SUBSTATION ANALYSIS DATA AVAILABLE

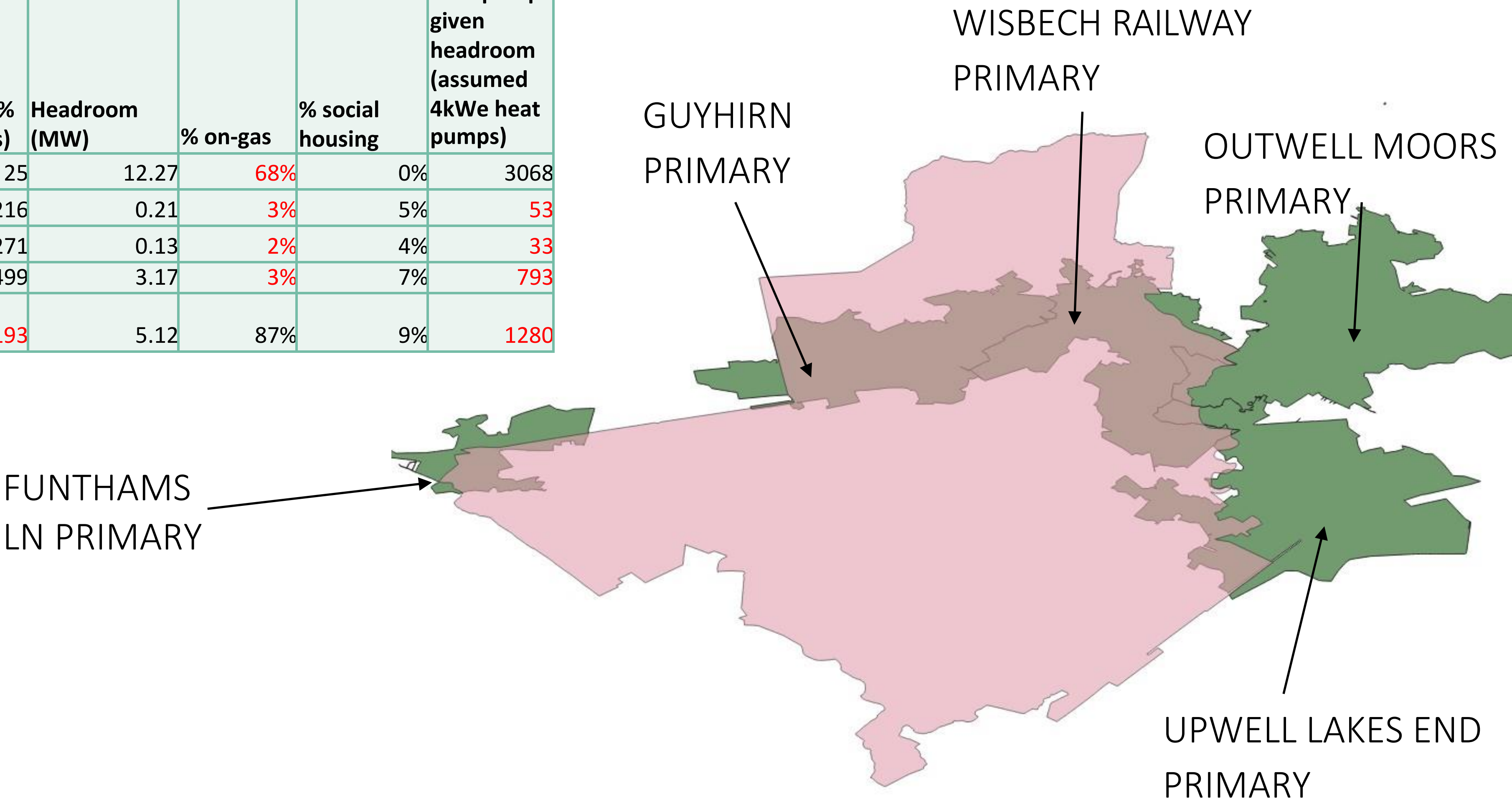
- UKPN have openly available data on the electricity supply areas served by primary substations, complete with number of customers served and headroom available.

- Primary ESAs have thousands of customers, most have >2000 customers, requiring >500 heat pumps to be deployed.

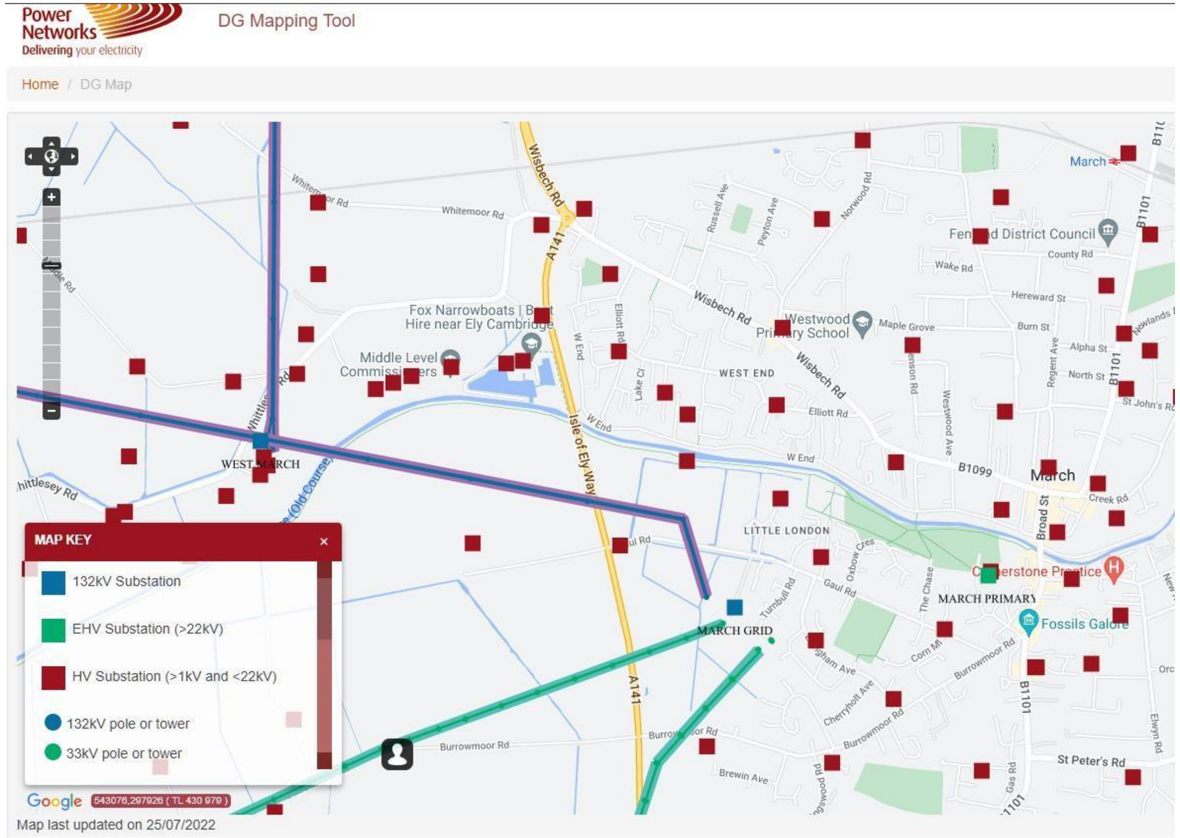
- There are 14 areas that that overlap with Fenland’s boundary and circa 60 that overlap with Cambridgeshire county.

PRIMARY SUBSTATION ANALYSIS
RESULTS

UKPN Primary Area	Number of customers	Number of Heat pumps required (25% of customers)	Headroom (MW)	% on-gas	% social housing	Available number of heat pumps given headroom (assumed 4kWe heat pumps)
FUNTHAMS LN PRIMARY	101	25	12.27	68%	0%	3068
UPWELL LAKES END PRIMARY	864	216	0.21	3%	5%	53
GUYHIRN PRIMARY	1085	271	0.13	2%	4%	33
OUTWELL MOORS PRIMARY	1995	499	3.17	3%	7%	793
WISBECH RAILWAY PRIMARY	4770	1193	5.12	87%	9%	1280



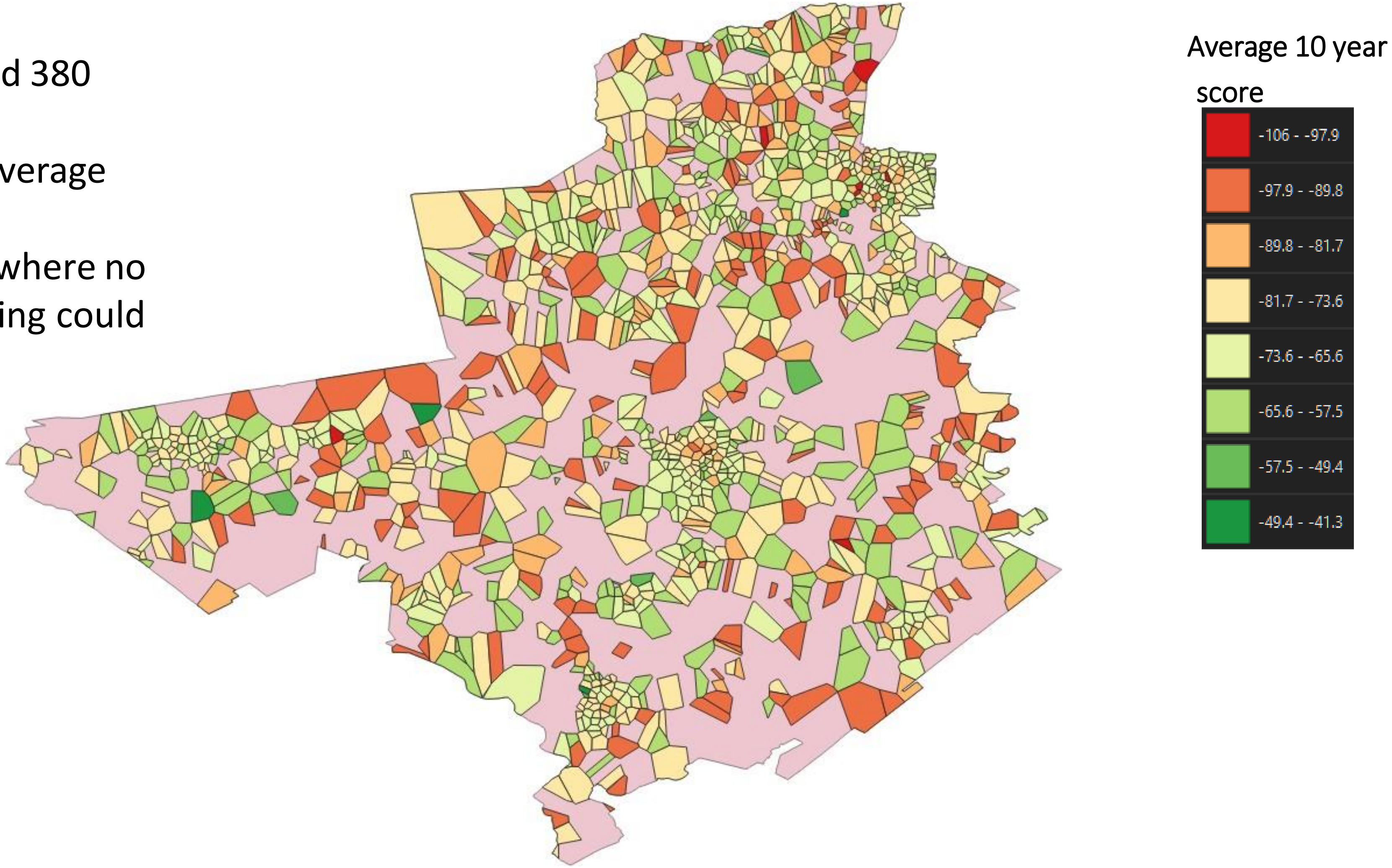
SECONDARY SUBSTATION ANALYSIS
DATA AVAILABLE



- UKPN have openly available data on the coordinates of High Voltage (HV) substations – between 1kV and 22kV.
- Within Fenland there are circa 1900 of these substations.
- Data is not available on the catchment area that each HV substation serves, its number of customers, or the headroom available at each substation.
- UKPN would need to generate this data which they have described as quite a manual process. They have offered to run this analysis for us for 15 HV substations.
- We have created estimated supply areas around each substation coordinate.

FINANCIAL SCORING ANALYSIS

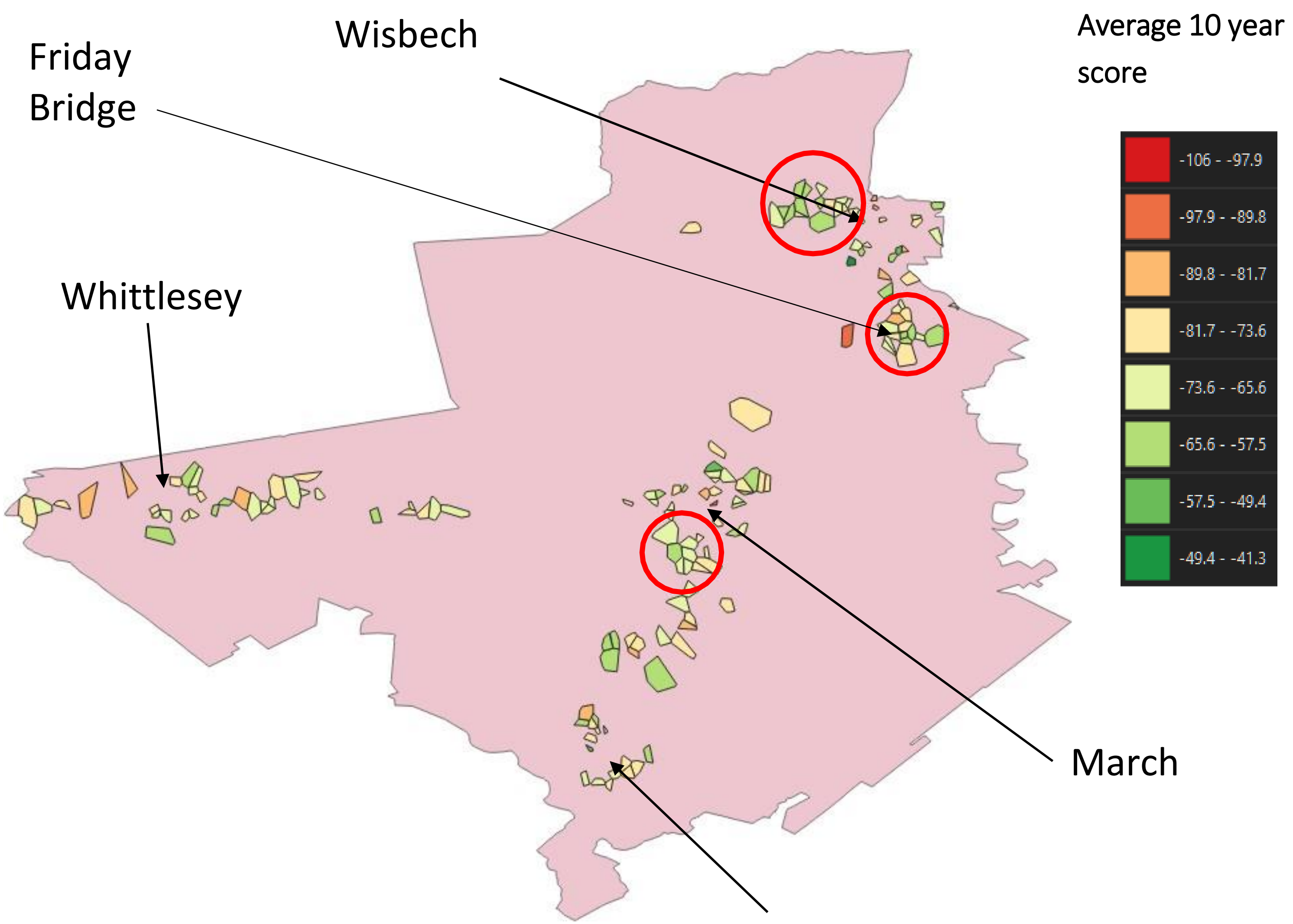
- Each supply area has between 0 and 380 addresses.
- No particular geographic trend in average financial scoring across the district.
- Areas without colouring are those where no domestic EPCs were available, scoring could not be determined.



FILTERED SET OF SUBSTATION AREAS

Filtering conditions:
Number of addresses < 100
% on-gas > 85%
% social housing < 20%
% HPR-priority > 80%

- 141 areas remain
- Some clusters of areas are present
- Targeting a cluster of areas would build in redundancy if further analysis finds an area unsuitable.



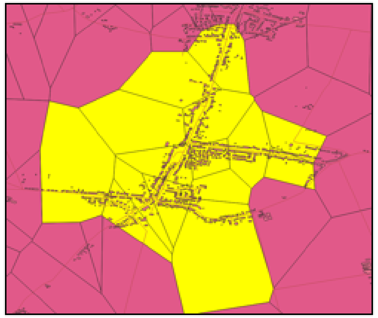
TOP THREE SUBSTATION AREAS

All three areas taken forward for further investigation have good metrics:

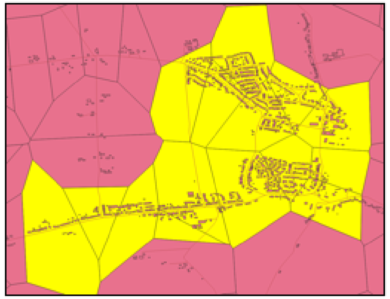
- High on-gas %
- Low social housing
- Similar average score

Area name	Friday Bridge	Leverington	South March
Number secondary areas selected (yellow highlight)	15	15	11
Number of addresses	707	1031	362
Average number of addresses per area	47	69	33
% domestic addresses	96%	96%	93%
Domestic EPC Coverage	54%	63%	60%
% on-gas	97%	97%	94%
% social housing	6%	9%	2%
Average 10 year score	-69	-68	-71
Archetype mix			
detached_cavity_little_retrofit	7%	3%	17%
bungalow_significant_retrofit	43%	46%	34%
semi_detached_solid_significant_retrofit	7%	4%	3%
semi_detached_cavity_significant_retrofit	11%	16%	1%
detached_solid_significant_retrofit	8%	3%	10%
detached_cavity_significant_retrofit	16%	12%	26%

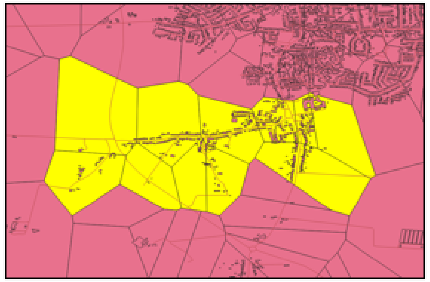
Friday Bridge



Leverington



South March



CONCLUSIONS

Friday Bridge chosen as selected area for targeting

Rationale:

- Proceeding with a secondary substation area is favourable over the single suitable primary substation identified.

- Input from the locally based project partners (PECT, Fenland District Council) has suggested that Friday Bridge is thought to have favourable community characteristics over South March due to its village nature.

FRIDAY BRIDGE
UKPN Capacity Analysis

- UKPN (the DNO for Cambridgeshire) offered to provide substation capacity analysis for 15 secondary substations.
- We requested that 15 substations covering the Friday Bridge area were analysed.
- The analysis found that 3 of the point coordinates that were listed as secondary substations were not in fact substations, meaning that we actually have 12 substations covering the Friday Bridge area.
- UKPN provided updated catchment areas for each substation (we estimated the catchment areas previously).
- UKPN provided estimates of available headroom on each secondary substation.
- We have taken the headroom and estimated how many heat pumps could feasibly be installed on each substation.
- Given our calculations, we estimate that only two of the substations could manage with 25% heat pump deployment without reinforcement.

FRIDAY BRIDGE

UKPN Capacity Analysis

- Assumes 5kVA electrical load per heat pump, no diversity factor applied.
- Only two substations could take >25% density (the third only serves 3 customers).
- But even those two can only handle circa 30% heat deployment.
- Reinforcement of substations is likely needed

UKPN Analysis				City Science Analysis		
substation_name	voltage	Customer numbers	Estimated Headroom (kVA)	Number of Heat Pumps Needed to Meet 25% Density Target	Estimated Number of Heat Pumps (assumed 5kVA electrical load per heat pump)	% density achievable
BACK TO BACK	11kV	60	0	15	0	0%
BAR DROVE	11kV	3	20	1	4	133%
ELM SOUTH P8	11kV	46	8	12	1	3%
FRIDAYBRIDGE CLOCK TOWER	11kV	176	27	44	5	3%
FRIDAYBRIDGE P S P38	11kV	1	0	1	0	0%
FRIDAYBRIDGE WATER TOWER	11kV	1	0	1	0	0%
MARCH RD P4	11kV	53	10	14	2	4%
MILLWAY- ELM	11kV	98	35	25	7	7%
REDMOOR FM P33	11kV	NO PMTX	-	-	-	-
REDMOOR HOUSE- ELM	11kV	87	140	22	28	32%
THE STITCH P25	11kV	NO PMTX	-	-	-	-
WELL END P35	11kV	35	30	9	6	17%
CHURCH RD P30	11kV	NO PMTX	-	-	-	-
CHURCH VIEW	11kV	67	64	17	12	19%
COLDHAM BANK	11kV	52	75	13	15	29%

Appendix C1 - Heat Pump Cost Benchmarking Summary Slides

The following pages present a summary of the detailed cost modelling that was developed as part of this project to compare the lifetime cost of an Air Source Heat Pump (ASHP) against a gas boiler. The cost modelling was used to inform the cost to consumer analysis for Phase 2. Under this work package a series of interviews were held with heat pump installers which informed the works accounted for in the development of this model.

HEAT PUMP READY COST BENCHMARKING

1. Key assumptions
2. Counterfactual scenario
3. Heat pump scenario
4. Prosumer scenario (heat pump with PV/battery)
5. Results
6. Conclusions

KEY ASSUMPTIONS

- BEIS have released a set of typical cost benchmarks for heat pump installation and building fabric measures for a set of building archetypes which are representative of the country's building stock.

- Two key pieces of research were used to build these archetypes:
  - [Cost Optimal Domestic Electrification (CODE), BEIS 2021]
  - [The Cost of Installing Heating Measures in Domestic Properties, Delta-EE 2018]

BEIS Archetypes	
Small flat	Compact semi-Detached
Ground-floor flat	End-terrace with cavity walls
Mid-floor flat	Semi-D with solid walls
Top-floor flat	Detached with cavity walls
Bungalow	Detached with solid walls
Mid-terrace with cavity walls	Compact semi-Detached
Mid-terrace with solid walls	

KEY ASSUMPTIONS

Using the building archetypes developed by BEIS, cost modelling has been carried out to compare the cost of gas boiler systems vs a heat pump retrofit.

- We imagine a scenario where an existing property needs to replace their existing gas boiler system this year (2022).
- Owner can either replace for new gas boiler, or opt for an air-to-water heat pump (ASHP) retrofit.
- Owner can add solar PV and batteries to the heat pump retrofit (prosumer scenario).
- We assess the total cost of running these systems over a 10, 20 and 30 year period.

KEY ASSUMPTIONS - COSTS

Modelling has been carried out on a lifetime cost basis which includes for:

- Capital cost of heating plant (boiler or ASHP), plus installation labour
- Annual fuel costs (gas or electricity)
- Service every year
- In HP scenario, cost of heat emitter upgrades (replacement of all radiators, plus installation labour)
- In HP scenario, cost of building fabric upgrades (plus installation labour):
    - Draught proofing
    - Top-up loft insulation
    - External wall insulation (for solid wall houses)
- For solar PV, cost of panels, inverter, fitting and labour
- For batteries, cost of batteries and installation labour

Costs have not been discounted for simplicity.

KEY ASSUMPTIONS - ARCHETYPES

- The modelling has been carried out on 13 building archetypes which were informed by previous work from BEIS.
- Building attributes such as floor area, wall area and peak heat demand were taken from the BEIS study. Where attributes were not available, these were estimated.
- The heating energy consumption was determined by analysing EPC data of these archetypes. Energy consumption isbased on properties that achieve EPC D rating (which is the most prominent rating in our targeted area).
- The annual and peak demands are based on the energy intensity determined from EPC data from Fenland, these demands are before any level of building fabric upgrade has been applied.

Building Archetype	EPC D Gas Energy Intensity (kWh/m2)	Floor Area (m²)	Assumed Loft Area (m²)	Assumed Roof Area (m²)	Gross Wall Area (m²)	Annual Gas Demand (kWh)	Peak Heat Demand (kW)
small_flat	267	42	42	0	39	11,210	6.3
ground_floor_flat	226	67	67	0	53	15,144	8.5
mid_floor_flat	#N/A	69	69	0	55		
top_floor_flat	242	69	69	0	62	16,682	9.4
bungalow	229	78	78	101	80	17,882	8.7
mid_terrace_solid	236	91	46	117	56	21,432	12.4
mid_terrace_cavity	215	91	46	117	56	19,582	10.1
end_terrace_solid	243	103	52	132	126	24,978	13.1
end_terrace_cavity	220	103	52	132	126	22,633	11.9
semi_detached_solid	234	113	57	144	135	26,394	12.0
semi_detached_cavity	217	113	57	144	135	24,488	11.1
detached_solid	211	115	58	147	163	24,312	20.3
detached_cavity	203	115	58	147	163	23,359	19.5

KEY ASSUMPTIONS - TARIFFS

Two energy tariff scenarios have been modelled:

- **Low**: Government Green Book Projections 2021 – prices are pre-energy crises levels, prices are variable until 2040 after which they are flat.
- **High**: New Energy Price Guarantee.Prices are flat for 30 years.

- The model assumes that the ASHP will achieve an SCOP of 3.0, and the gas boiler has an efficiency of 85%.
- Using the low tariffs, an ASHP will cost more to run in terms of fuel costs than a gas boiler.
- However, under the new energy price guarantee, the ASHP will cost slightly less to run than the gas boiler.

	Energy Price Guarantee 1 October 2022 - 1 October 2024
Electricity per kWh	£0.34
Gas per kWh	£0.10
SCOP Required for Price Parity	2.8

	Green Book Energy Prices (p/kWh)		SCOP Required for Price Parity
Year	Electricity	Gas	
2022	21.5	4.51	4.0
2023	21.4	4.55	4.0
2024	21.1	4.59	3.9
2025	21.3	4.63	3.9
2026	21.5	4.66	3.9
2027	21.1	4.69	3.8
2028	21.0	4.73	3.8
2029	20.9	4.75	3.7
2030	21.3	4.77	3.8
2031	21.2	4.79	3.8
2032	20.7	4.82	3.7
2033	20.2	4.83	3.6
2034	19.9	4.86	3.5
2035	19.6	4.89	3.4
2036	19.5	4.92	3.4
2037	19.4	4.92	3.4
2038	19.3	4.91	3.3
2039	19.6	4.91	3.4
2040	19.3	4.90	3.3
2041	19.3	4.90	3.3
2042	19.3	4.90	3.3
2043	19.3	4.90	3.3
2044	19.3	4.90	3.3
2045	19.3	4.90	3.3
2046	19.3	4.90	3.3
2047	19.3	4.90	3.3
2048	19.3	4.90	3.3
2049	19.3	4.90	3.3
2050	19.3	4.90	3.3
2051	19.3	4.90	3.3

COUNTERFACUAL SCENARIO

Counterfactual scenario proposes that the gas boiler needs to be replaced this year (2022)

- Gas boiler is replaced for new at 15 years.
- Annual service of £109 applied every year.

Example: Bungalow

Tariff	Building Type	Gas Boiler Installation	Gas Fuel Costs – 10 year	Gas Fuel Costs – 20 year	Gas Fuel Costs – 30 year	Lifetime Cost – 10 year	Lifetime Cost – 20 year	Lifetime Cost – 30 year
Low: Green Book	bungalow	£ 2,568	£ 8,347	£ 17,083	£ 25,850	£ 12,005	£ 24,399	£ 34,256
High: Energy Price Guarantee	bungalow	£ 2,568	£ 18,419	£ 36,838	£ 55,256	£ 22,077	£ 44,154	£ 63,662

HP SCENARIO

HP scenario proposes that property is fitted with air-to-water heat pump this year (2022)

Retrofit measures:

- Building fabric measures are applied which reduce annual and peak heating demands:
  - Draught proofing
  - Top-up loft insulation
  - External wall insulation (for solid wall houses)
- Heating system upgrades: Replacement of all radiators for larger size (assumed that hot water cylinder is already present and doesn't need to be replaced, no enlargement of pipework)
- 40% heat pump ready grant for capital costs (or max £5,000).

Building Type	Draught Proofing Cost	Loft Insulation Cost	Draught Proofing Energy Saving	Loft Insulation Energy Saving	Heat Pump Capital and Installation Cost	Enlarged Radiators Cost	Total Upfront Cost	Heat Pump Ready Grant (40% or £5k)	Consumer Upfront Cost
bungalow	£ 400	£ 643	2.5%	6%	£ 10,840	£ 1,350	£ 13,233	£ 5,000	£ 8,233

HP SCENARIO

HP scenario proposes that property is fitted with air-to-water heat pump this year (2022)

- ASHP is replaced at 15 years.
- Annual service of £182 applied every year.

- Green cells indicate where costs are lower than the counterfactual gas boiler scenario
- Red cells indicate where costs are greater.
- Despite ASHP fuel costs being lower in the high tariff scenario, it is not enough to overcome high upfront costs of ASHP retrofit.
- % diff is the percentage difference in total lifetime cost between ASHP and gas boiler – negative means ASHP costs more.

Tariff	Building Type	Elec Fuel Costs – 10 year	Elec Fuel Costs – 20 year	Elec Fuel Costs – 30 year	Lifetime Cost – 10 year	Lifetime Cost – 20 year	Lifetime Cost – 30 year	Lifetime Cost % diff – 10 year	Lifetime Cost % diff – 20 year	Lifetime Cost % diff – 30 year
Low: Green Book	bungalow	£ 9,856	£ 18,993	£ 27,936	£ 19,909	£ 41,706	£ 52,469	-66%	-71%	-53%
High: Energy Price Guarantee	bungalow	£ 15,788	£ 31,576	£ 47,365	£ 25,841	£ 54,289	£ 71,898	-17%	-23%	-13%

PROSUMER HP SCENARIO

Prosumer HP scenario investigates adding solar PV and/or a battery to the retrofit.

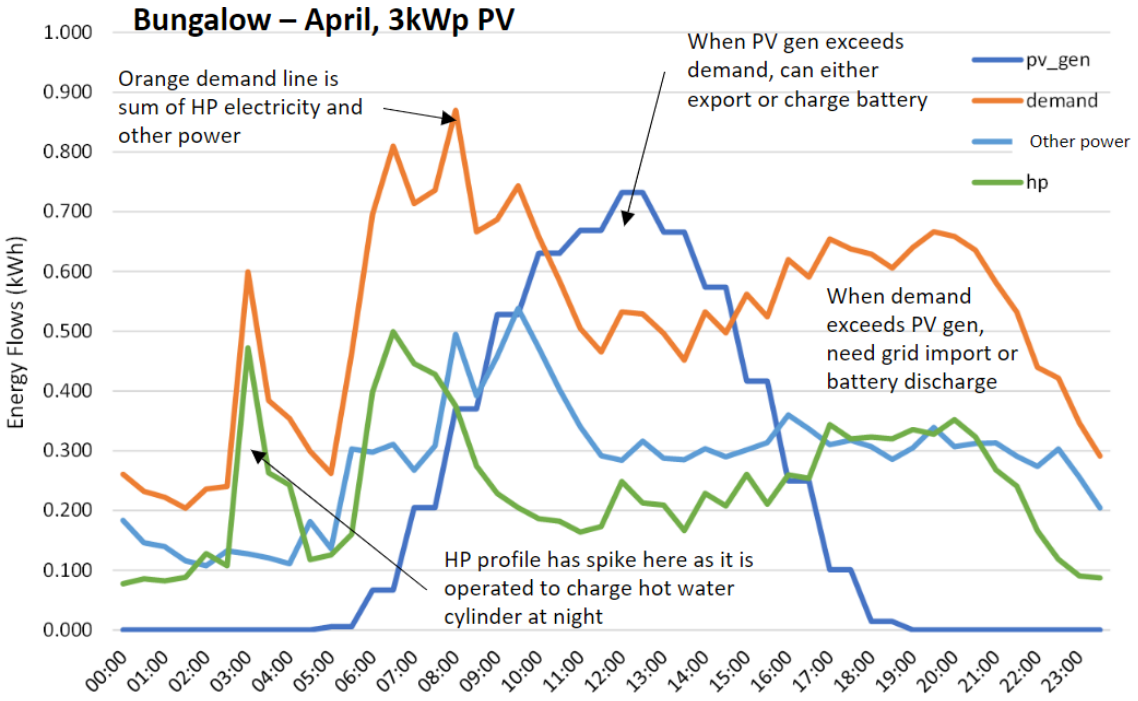
- Flats are not included in analysis, assumed no roof space for PV and no space for battery.
- Assumed PV panels last for full 30 years, inverter needs to be replaced at 15 years.
- Battery needs to be replaced at 15 years.
- Upfront costs of solar PV and battery cannot be included in the 40% heat pump ready grant.

Building Type	PV System Size (kWp)	Battery Size (kWh)	PV Capital and Installation Cost	Inverter Cost	Battery Cost	PV + Battery System Cost – 10 years	PV + Battery System Cost – 20 years	PV + Battery System Cost – 30 years
bungalow	3.0	8.0	£ 5,628	£ 1,000	£ 6,003	£ 12,631	£ 19,633	£ 19,633

- The economics of the PV and battery system depends greatly on <u>when</u> you use electricity.
- Solar PV generates during the day, but electricity consumption often peaks in the evening.
- A battery can complement a solar PV system as it will charge when there is excess PV, and discharge when demandexceeds PV generation.

PROSUMER HP SCENARIO

- Typical monthly electricity profiles have been applied for the heat pump, and for other household electricity consumption (lighting, appliances etc).
- PV system will save on electricity costs by displacing that imported from the grid.
- PV system will generate revenue by exporting electricity to the grid (assumed 5.5p/kWh).
- Battery will charge from the PV system when there is excess generation, this is more economical than exporting electricity.



Tariff	Building Type	PV System Size (kWp)	Battery Size (kWh)	PV Generation (kWh)	HP Electricity Demand (kWh)	Other Power Demand (kWh)	PV Exported (kWh)	PV + Battery System Savings – 10 year	PV Export – 10 year	Lifetime Cost % diff – 10 year
High: Energy Price Guarantee	bungalow	3.0	0	2,855	4,644	5,538	546	£ 7,849	£ 300	-10%
High: Energy Price Guarantee	bungalow	3.0	8.0	2,855	4,644	5,538	0	£ 9,706	£ 9,706	-30%

RESULTS – HP ONLY

- HP system always costs more than gas boiler.
- Substantial difference between the two tariff scenarios.
- Smaller properties scoring better than the larger.
- % difference can be worst at 20 years due to replacement of ASHP at 15 years.
- Solid wall insulation has large % energy saving; hence these properties perform better in the long run.

	Low tariff: Green Book Projection			High tariff: Energy Price Guarantee 2022-2024		
Building Type	**Lifetime Cost % diff – 10 year**	**Lifetime Cost % diff – 20 year**	**Lifetime Cost % diff – 30 year**	**Lifetime Cost % diff – 10 year**	**Lifetime Cost % diff – 20 year**	**Lifetime Cost % diff – 30 year**
small_flat	-60%	-70%	-54%	-18%	-26%	-17%
ground_floor_flat	-66%	-75%	-57%	-18%	-27%	-16%
mid_floor_flat	-	-	-	-	-	-
top_floor_flat	-71%	-78%	-59%	-21%	-28%	-16%
bungalow	-66%	-71%	-53%	-17%	-23%	-13%
mid_terrace_solid	-108%	-90%	-63%	-35%	-29%	-14%
mid_terrace_cavity	-81%	-86%	-64%	-26%	-31%	-20%
end_terrace_solid	-105%	-80%	-52%	-29%	-19%	-4%
end_terrace_cavity	-86%	-89%	-66%	-27%	-32%	-19%
semi_detached_solid	-93%	-69%	-44%	-22%	-13%	0%
semi_detached_cavity	-78%	-80%	-59%	-22%	-26%	-16%
detached_solid	-145%	-113%	-75%	-49%	-36%	-16%
detached_cavity	-134%	-133%	-96%	-51%	-54%	-34%

RESULTS – HP ONLY VS PROSUMER

- With the low tariff, inclusion of PV was never found to be optimal at the 10 year point, however, this changes at 20 years, when inclusion of PV is optimal for all archetypes (i.e. payback for PV system is greater than 10 years)
- Inclusion of battery was never found to be optimal at 10 or 20 years, but was optimal at 30 years for some archetypes under the high tariff scenario.
- Under high tariff scenario, we start to see some archetypes breakeven at the 20 year mark, with savings made by 30 years.

	Low tariff: Green Book Projection				High tariff: Energy Price Guarantee 2022-2024			
Building Type	**PV System Size (kWp) Optimal for 20 years**	**Lifetime Cost % diff – 10 year**	**Lifetime Cost % diff – 20 year**	**Lifetime Cost % diff – 30 year**	**PV System Size (kWp) Optimal for 10 years**	**Lifetime Cost % diff – 10 year**	**Lifetime Cost % diff – 20 year**	**Lifetime Cost % diff – 30 year**
bungalow	4.5	-88%	-60%	-27%	3.0	-10%	-3%	13%
mid_terrace_solid	4.5	-126%	-79%	-39%	3.0	-28%	-11%	9%
mid_terrace_cavity	5.0	-103%	-73%	-37%	3.0	-18%	-12%	6%
end_terrace_solid	5.0	-121%	-68%	-27%	3.5	-22%	-1%	20%
end_terrace_cavity	5.0	-103%	-74%	-38%	3.5	-19%	-11%	7%
semi_detached_solid	5.0	-108%	-56%	-19%	3.5	-15%	5%	24%
semi_detached_cavity	5.0	-93%	-66%	-32%	4.0	-14%	-5%	12%
detached_solid	5.0	-163%	-102%	-51%	3.0	-43%	-20%	6%
detached_cavity	5.0	-151%	-120%	-69%	3.5	-43%	-35%	-9%

RESULTS – CARBON SAVINGS

- % differences are the difference in fuel emissions from gas boiler vs ASHP (gas vs electricity).
- ASHP will save a huge amount of GHG emissions over its lifetime compared to gas boiler.
- Addition of PV saves even more as we are displacing electricity from the grid.

	HP Only			HP + PV			
Building Type	**Lifetime CO2e Emissions % diff – 10 year**	**Lifetime CO2e Emissions % diff – 20 year**	**Lifetime CO2e Emissions % diff – 30 year**	**PV System Size (kWp)**	**Lifetime CO2e Emissions % diff – 10 year**	**Lifetime CO2e Emissions % diff – 20 year**	**Lifetime CO2e Emissions % diff – 30 year**
small_flat	87%	92%	94%	-	-	-	-
ground_floor_flat	87%	92%	94%	-	-	-	-
mid_floor_flat	-	-	-	-	-	-	-
top_floor_flat	87%	92%	94%	-	-	-	-
bungalow	87%	92%	94%	3.0	95%	97%	98%
mid_terrace_solid	88%	93%	95%	3.0	95%	97%	98%
mid_terrace_cavity	86%	91%	94%	3.0	94%	96%	97%
end_terrace_solid	89%	93%	95%	3.5	96%	98%	98%
end_terrace_cavity	86%	91%	94%	3.5	94%	96%	97%
semi_detached_solid	89%	93%	95%	3.5	96%	97%	98%
semi_detached_cavity	86%	91%	94%	4.0	94%	96%	97%
detached_solid	90%	94%	95%	3.0	96%	97%	98%
detached_cavity	86%	92%	94%	3.5	94%	96%	97%

Uses Government Green Book projection of electricity grid carbon intensity.

SENSITIVTIES EXPLORED

Archetypes with EPC B gas consumption

Annual and peak heating demands adjusted to expected level of EPC B properties. Makes a small negative difference in high tariff scenario as HP is slightly cheaper to run. Makes a significant positive difference under low tariff, but still much more expensivethan gas boiler.

Gas boiler ban in 2035

Counterfactual now includes replacement of gas boiler for heatpump retrofit after 15 years (without the HPR 40% grant).

Lifetime costs become closer from 20 years, but still 15-20% cheaper to stick with gas boiler for now.

Heat pump market maturity

Decreased heat pump replacement cost after 15 years by 20%. HP system still more expensive after 20 and 30 years, but % difference is about 10 % points more favourable to the existing heat pump scenario.

No building fabric upgrades (for EPC D properties)

Helps for some archetypes at the 10 year mark, but longer term ends up costing more as building fabric upgrades pay themselves back.

Personal loan to cover heat pump upfront cost – 4.2% interest, 5 year payback

Makes upfront cost more palatable, between £70-260/month for 5 years vs £4k-14k upfront (even with 40% HPR grant). However,interest adds more to lifetime cost, negatively impacts % lifetime difference by 8-14 percentage points.

Increasing grant funding levels

Under low tariff scenario, we need about 90% of upfront retrofit costs covered to be at breakeven after 10 years. Under high tariff scenario we need about 70% of upfront retrofit costs covered to breakeven at 10 years.

Increasing SCOP

An SCOP of 4.0 almost breaks even for some archetypes at the 10 year point under high tariff scenario, does not break even under low tariff scenario.

CONCLUSIONS

- Retrofitting an existing property with an ASHP is probably going to cost more than sticking with a gas boiler.
- The addition of solar PV will improve the financials of the heat pump retrofit if the owner is willing to make a long term investment.
- The prosumer HP model is still likely to cost more than the gas boiler in the short term, but we could see a breakeven point long term if energy prices stay high (20 years plus).
- Impact of different energy tariff scenarios is substantial.

Appendix C2 – Heat Pump Installer Experiences and Challenges

The following section provides a summary of the feedback gained from conducting interviews with local installers to determine the common experiences and challenges when installing heat pumps and other retrofit measures.

1 Summary

As part of work-package 4, engagement was to be held with heat pump and retrofit measures installers to gain the latest market understanding on the costs, barriers and works required when retrofitting existing properties. This exercise also serves as a chance to make ourselves aware of any unknown barriers and challenges in delivering heat pump retrofits.

A first task in work-package 4 was to develop a cost model that determines the total cost to consumer of a heat pump retrofit package considering heat pump installation, associated heating system upgrades, building fabric upgrades and optional inclusion of PV and batteries. The engagement with the installers sought to validate this cost model and ensure all likely works required had been accounted for.

Engagement with installers has been sought via two avenues; firstly, the project partners were contacted to see if they had any installer contacts in the local area, secondly, using a known list of installers operating in the south of England, an email was sent round using the list of addresses.

The structure and questions of the installer data gathering exercise has been detailed in section 2 below. Installers were offered to either provide this information via a virtual interview, or via completion of a spreadsheet populated with the questions below. Since the vast majority of heat pump retrofits installed under this Heat Pump Ready project will likely be retrofits to existing gas boiler heated properties with air-to-water heat pumps, the installers were asked to frame their responses given this context. The feedback received has been detailed in section 3, some of the key takeaways are listed in section 4.

2 Experiences and Challenges Questionnaire

The below sections detail the structure and questions posed to the installers which were either delivered via virtual interview, or provided in a spreadsheet for the installer to respond at their convenience.

2.1 Existing heating system removal (assumed gas boiler system)

- Are there any costs associated with the removal of an existing gas boiler?
- When removing an existing gas boiler system, do you recommend removal of gas cooking and disconnection of the gas supply?
- Is there a cost associated with a disconnection of the gas supply? Does this have to be conducted by a Gas Safe engineer?

2.2 Heat Pump installation (with focus on air-to-water heat pumps)

- Any challenges/barriers to installation that we should be aware of in regard to:
  - Noise/planning restrictions
  - Mounting of outdoor unit
  - Mounting of indoor unit
  - Running refrigerant lines between outdoor and indoor units
- DNOs need to be notified of heat pump systems connected to the grid, in your experience has this process created any barriers or incurred any costs?
- Do you have a recommended maintenance regime for heat pumps?
- Do you know the cost of a heat pump service?

2.3 Heating system upgrades

- What are the most common heating system upgrades required when retrofitting an ASHP to an existing boiler system?

  e.g. replacing heat emitters (larger radiators), enlarging pipework, new hot water cylinders, installation of buffer tank, new circulation pumps, new system controls, any other works required?
- Assuming some replacement of heat emitters is required, what proportion of the existing emitters are replaced for larger, or more effective alternatives (such as fan assisted)?
- Where a hot water cylinder is already present in the current heating system, how often can this be utilised, or does the retrofit often require replacement with a larger hot water cylinder to suit the lower flow temperatures of the heat pump?
- How often is lack of space for a hot water cylinder an issue for heat pump retrofits? Where there is lack of space for a hot water cylinder, do you recommend the installation of heat pumps with instantaneous electric heaters for hot water?
- How often is lack of space for a buffer tank an issue for heat pump retrofits? Where is there lack of space for the buffer tank, how does this affect the design of your system, do you recommend a larger size heat pump (in order to satisfy the peak heating demands)?

2.4 Building fabric upgrades

- When installing a ASHP in an existing property what is the minimum EPC rating, or what are the minimum energy efficiency measures which should be installed prior to installation of a heat pump?
- In your experience what are the most cost-effective energy efficiency measures?
- Are there any energy efficiency measures which you would not recommend?

- Any notable barriers when installing energy efficiency measures?

2.5 Solar PV

- Beyond the PV panels, mounting PV panels, inverter and associated wiring, are there any other components or associated works required when installing PV systems?
- DNOs need to be notified of solar PV systems connected to the grid, in your experience has this process created any barriers or incurred any costs?
- Are there any considerations when installing solar PV systems for properties that use heat pumps for heating?

2.6 Batteries (li-ion)

- Beyond the batteries, mounting the batteries and associated wiring, are there any other components or associated works required when installing batteries?
- Are there any considerations when installing batteries to work with solar PV systems?
- Are there any considerations when installing batteries to work with heat pumps?
- DNOs need to be notified of battery systems connected to the grid, in your experience has this process created any barriers or incurred any costs?

2.7 Miscellaneous

- Any other costs or works which have not been accounted for in previous sections?

3 Feedback received

3.1 Existing heating system removal (assumed gas boiler system)

- A registered gas safe engineer is needed to disconnect an existing gas supply.
- Disconnection of existing gas supply will likely cause additional delays to retrofit works.
- The gas supplier may charge a fee for disconnecting the existing gas supply, capping off the gas supply may not be possible within the house, instead works may be required in road.
- The household owner must talk to their gas supplier to initiate this process and understand costs and works required.
- Removal of boiler flue may need the erection of scaffolding (entailing extra cost and disruption).
- One installer completely strips out the whole existing wet heating system (boiler, pipework, circulation pumps, hot water cylinders). This installer refuses to use any of the existing heating system due to fears that it will not be of sufficient size to be compatible with the lower temperatures of a heat pump. This installer conceded that this will cause extra disruption to the consumer (e.g. removal of floorboards to access pipework) and come extra cost (they charge £2000-3000 for complete removal of existing system). However, they believe that to guarantee compatibility with a heat pump, they must install a completely new wet heating system.

3.2 Heat Pump installation (with focus on air-to-water heat pumps)

- Lack of outdoor space for outdoor unit is key barrier to heat pump installation. This is made worse by noise restrictions which place limits on the proximity of the outdoor units to adjacent properties. This is particularly problematic for terraced and semi-detached properties. Detached properties rarely suffer from this issue.
- Property owners often do not want to place the outdoor unit at the front of their properties for aesthetic reasons.
- The placement of the indoor unit is not usually an issue, often it can be fitted where the gas boiler used to be, or fitted in place of an existing hot water cylinder.
- The running of refrigerant lines between outdoor and indoor unit of the heat pump is rarely an issue for installation – the refrigerant pipework is small.
- Gaining approval from the DNO for connection of heat pump is not usually a barrier.
- Detached properties and bungalows were reported as favourable building archetypes for heat pump retrofits. As above, semi-detached and terraced properties suffer from lack of space to adjacent neighbours considering noise restrictions. Detached properties suffer less from this issue and are often larger, which lend themselves well to having more space for enlarged radiators. Bungalows were identified as a particularly suitable archetype, where the loft has not been converted, this serves as useful space for a hot water cylinder. Bungalows are reported to have room dimensions larger than other archetypes, thereby lending themselves well to enlarged radiators.
- Complaints can often be received after commissioning of heat pumps from customers that believe the lower temperatures of the radiators is a sign that the heating system is not working correctly. This installer believes that education to properties owners on this matter is a barrier to heat pump uptake.

3.3 Heating system upgrades

- There is often resistance from residents on installing larger radiators in their homes. Residents do not want to sacrifice their internal space.
- One installer recommended that **all** radiators must be enlarged after installation of heat pump. They did not think that replacement of a proportion of the household's radiators would be sufficient to achieve desired heat output.

- An installer reported that most of their heat pump systems are not designed with a thermal store. This installer reported that is preferable to install systems without a thermal store because there usually isn't enough space for its installation. Households often have space for a hot water cylinder, but do not have another suitable space for a thermal store.
- As above, one installer replaces the whole wet heating system when fitting a heat pump. They are not confident in existing heating systems being compatible with the lower temperatures delivered by heat pumps.
- Space for hot water cylinder is not often an issue, as it is common for a household to already have one fitted.
- One installer noted that even when there is not a typical space available for hot water cylinder (such as airing cupboard), they have been successful in finding alternative spaces such as bedrooms and lofts.
- Bungalows were noted as favourable building archetypes for heating system upgrades, smaller distances between heat pump and radiators within bungalows results in less new pipework to be installed. Room dimensions in bungalows can be larger, owing themselves better to larger radiators.

3.4 Building fabric upgrades

- One installer insisted that building fabric should always be treated prior to heat pump installation. At a minimum, the walls and loft should be insulated as much as possible.
- Topping up loft insulation is usually not an issue.
- The installation of cavity wall insulation was also reported to be a measure that is relatively easy to carry out.
- Warnings have been provided on the cost of insulating solid walls. One installer noted that to externally insulate solid walls to the standard required by that to gain government funding (such as the Local Authority Delivery scheme) requires a higher level of install compared to that set out in building regulations. This installer quoted that the government funding standard of external wall insulation often costs in the region of £27k per household, whereas the building regulation standard typically costs in the order of £20k.
- The most cost-effective measures were reported to be loft insulation, cavity wall insulation, draught proofing (only worthwhile in single glazed properties) and roof insulation for flat roof properties.
- The least recommended measures were reported to be solid floor insulation and suspended floor insulation, both were reported to not be cost effective.
- Bungalows were reported to be a favourable archetype for the effectiveness of building fabric upgrades. In comparison to two-storey buildings, bungalows have a greater loft area to household volume ratio, meaning that the loft insulation is more effective in saving energy. Also, the walls of bungalows are easier to insulation as there is no need to get access to a second storey, thereby requiring no extra expense and works to erect scaffolding.
- It was noted that the fabric upgrades for flats can cause issues due to ownership/responsibility disagreements between the occupier, the lease holder and landlord.
- Terraced properties can be an issue for roof upgrades, access to roof maybe required via an adjacent property.

3.5 Solar PV

- Issues and extra costs can be incurred to the installation of solar PV due to access issues. Poor access can increase labour costs and additional scaffolding costs.
- One installer noted that they have had not issues with households gaining approval from the DNO on connection of the PV system to the grid.

- No issues of interoperability between heat pump and PV have been noted.
- It was reported that households with very old electrics may want replacement with installation of PV system.

3.6 Batteries (li-ion)

- A special inverter is needed for battery systems connected directly to solar PV. Inverters that are supplied with solar PV systems are not compatible with to charge a battery.
- It was reported that connected of heat pump to the battery could increase its charging and discharging cycling rate, which degrades the lifetime of the battery.
- No issues reported on gaining approval from the DNO on connecting the battery to the grid.
- Space for mounting the battery can sometimes be an issue. They can be mounted in lofts. They can also be mounted externally, however, a suitable weather resistant housing is required which comes at extra cost.

3.7 Any other costs or works which we have not accounted for?

- One installer believes that one of the key barriers to the uptake of heat pumps is the education of household owners. They believe that the steep learning curve required to understand such an unfamiliar technology will put most people off making the switch from their existing heating system.
- The current supply chain has been noted to be an issue for solar PV and batteries, the recent energy crises has driven a surge in demand for solar PV.
- The supply chain for building fabric upgrades was reported to be poor 12 months ago due to covid disruptions, but it has stabilised now. However, the material cost of loft insulation was reported to have doubled against the cost 12 months ago.
- No issues were reported for the supply chain for heat pumps.

4 Key takeaways

- A benefit of switching to a heat pump for heating is that a consumer could disconnect their gas supply and therefore negate paying a standing charge for their gas connection (provided their cooking is electric). However, the process to disconnect the gas supply will come at a cost, will require the services of a registered gas safe engineer, and one installer reported that works may be required in the road (not just in the household) to disconnect the gas supply. Given these extra complexities, the benefit of disconnecting a gas supply must be evaluated against the necessary costs and disruption.
- It is surprising that one installer completely replaces the full wet heating system for new when retrofitting a heat pump. They will replace all pipework, all radiators, circulation pumps and hot water cylinders, reusing none of the existing system. This will cause extra cost to the consumer both for removal of old system and for cost of the new system. Also, this will come at extra disruption to the consumer, as removal of floorboards will likely be required to access pipework. This approach feels wasteful, as it is possible that some of the existing system could be used, however, the installer justifies their approach by claiming that the only way they can be confident in guaranteeing adequate heat pump operation is by completely replacing the existing heating system for new.
- The space for the outdoor unit of a heat pump is concern, particularly with terraced and semi-detached properties. Noise restrictions stipulate minimum distances between the outdoor unit and an adjacent neighbouring household.
- Household owners typically do not want to install the outdoor unit at the front of their property for aesthetic reasons.
- Bungalows have been reported to be a preferable building archetype for heat pump retrofits, particularly if it is a detached bungalow. The typical dimensions of a bungalow are suitable for a few reasons: larger rooms sizes are suitable for enlarged radiators, smaller distances between heating plant and rooms results in less pipework to be fitted, being a single storey negates any complications for installing wall insulation to a first floor, being single storey increases the loft area to building volume ratio increasing effectiveness of top-up loft insulation, and there is often space in the loft for installation of a hot water cylinder.
- The most cost effective and easy to implement building fabric upgrade measures have been reported to be top-up loft insulation and cavity wall insulation.
- Solid wall insulation is more expensive than previously thought, with one installer reporting that it can cost between £20-27k for a typical house.
- Gaining approval from a DNO for the connection of a heat pump, solar PV or battery to the grid has not reported to of been an issue.
- Poor access to the roof can increase the cost of solar PV installations due to additional labour and scaffolding costs.
- The supply chain for solar PV has been reported to be particularly bad at the moment. The energy crises has led to a surge in their demand. No supply chain issues have been reported for heat pumps.

Appendix D1 – Financial Options Summary

The below table summarises the variety of financial lending options which were explored as part of work package 5. Please note that the interest rates given below were sourced prior to the interest rate spike seen in September 2022.

Financial Option	General Rate	Timescale	Summary
Mortgage Lending	3.09% plus fees - APRC, 4.1%	4-8 weeks if re-mortgaging. Quicker if borrowing via an advance	Obtaining a (minimum) advance of £10,000 is relatively straightforward if the consumer is in the 'able to pay' market, already has an established mortgage and over 15% available equity overall.
Unsecured Borrowing	2.8% - 24.9% (rates are higher outside of 'high street' lending – in excess of 49%)	Decisions can be made and funding paid very quickly, often same day, if more information required longer.	If the consumer is in the able to pay market the rates will be attractive without intervention.
Interest Free Borrowing	0%	As it will be subject to additional checks, if not managed this could increase the timescale from 1 week to however long the checks are anticipated to take and additional staffing capacity capability. Will require two quotes.	Most attractive option for the consumer but requires extensive public sector funding, and the additional checks can cause delays that ultimately push the consumer elsewhere.
Equity Release	4.43% - 7.39%	Around 8 weeks, similar to a re-mortgage as same security	Only available to homeowners over 55 and usually requires a minimum amount of borrowing which will likely be in excess of the sums required.
Credit Unions	4.9% - 42.6%	1-7 days	Attractive rates are possible, but the funding mechanisms are unlike to be scalable without support as deposits are generally localised and insufficient.
PACE Model	6-10%	Data unavailable. Anticipated to take in excess of 4-8 weeks mortgage timescale	Becoming an increasingly popular option in the US. However, to implement in the UK will require extensive legal changes to UK law and council tax mechanisms. Some mortgage companies in the US will not lend if a PACE loan is in place.
Asset Leasing	Looking at the car leasing market, a rate is generally unavailable as it is complex to calculate, often requires a	A car lease – 1-7 days for finance approval dependent on consumer queries	There have only been trials conducted to date and consumer costs are unavailable. Consumers may appreciate the ability to effectively rent a heat pump for a monthly sum, especially if it is bundled with a servicing plan.

	deposit and comes bundled with servicing and fair usage.		
Lendology Model	4% (influenced by amount of public sector subsidisation in terms of capital funding and funding towards running costs)	The timescale varies depending on the preparedness of the client with financial documentation and council policy and checks. Can be assessed within 1 day if everything is in place.	Flexible lending in partnership with councils. The public sector backing allows successful lending at lower rates to enable the fuel poor to afford energy saving measures typically out of their reach from the standard forms of credit.

Appendix D2 – Summary of PACE Research

The following section details a summary of the research conducted on the Property Assessed Clean Energy (PACE) lending model.

What is PACE?

'Property Assessed Clean Energy' (PACE) programs were developed in the U.S. in 2007 as a financing mechanism that enables low-cost, long-term funding for energy and water efficiency, renewable energy, health and safety upgrades, electrical system upgrades, roof repairs, and seismic retrofits projects through a special assessment placed on the property tax bill 1. Only permanent fixture items can be financed, not portable items.

Unlike other forms of property assessments and long-term repayment mechanisms such as mortgages, PACE assessments are attached to the property, and not the owner.

The U.S. is the most established user of PACE financing, with the Department of Energy funding $4.3B in domestic (R-PACE) and $583M in commercial (C-PACE) applications, cumulatively since 2018. R-PACE lending volume exceeds C-PACE by 7-fold, despite only being operational in 3 states (California – the largest market, Missouri and Florida), compared to 33 for C-PACE [2].

Despite the limited availability of R-PACE (only available in 3 states), it is still the fastest growing segment of the US lending industry[3].

The PACE assessment is structured around the tax lien being connected to the property, and the position of the lien (a debt attached directly to your house) being equal to other tax and assessment liens and senior to non-tax debt on the property such as mortgages, which creates high security for investors as in the event of bankruptcy the R-PACE is paid first.

PACE programs must pass legislation that permits local governments to set up PACE assessment districts, and once set up can be administered by private or public entities, with the majority of funding coming from the private sector[4].

Bill 1284 also requires complete transparency with costs and prohibits participation of people who have filed for bankruptcy within a specified time period.

How does it work in practice for consumers?

R-PACE terms cover both hard (i.e., equipment purchases and installation) and soft costs (i.e., administrative and legal).

In the U.S. property owners are required to install high quality and efficiency equipment such as Energy Star label heating and cooling systems[5] (this seems similar to UK heat pumps having to be installed by MCS installers).

PACE eligibility criteria includes a review of property ownership (must have a clear title to the property), property location (must be located in the financing district), homeowner income, existing debt obligations, property tax payments (have not been late in last 3 years), mortgage payments (have not been late in last year), applicants have not had any bankruptcies in the last seven years, and credit score[6].

PACE assessments cannot exceed $30,000 or 15% of assessed property value[7].

Some PACE programs require projects to achieve a 'savings to investment' ratio (SIR) of 1 or greater. SIR is defined as the value of expected bill savings over the lifetime of an improvement or PACE assessment divided by the project's upfront costs[8].

In terms of the impact of PACE improvements on property's value, an analysis 773 PACE loans and properties found a net positive impact on the resale value, ranging from $199 to $8,882[9].

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[1] PACE. Property Assessed Clean Energy.

[2] National Association of Energy Professionals. Residential Property Assessed Clean Energy (R-PACE): Key Considerations for State Energy Officials. 2018

[3] Investopedia. Property Assessed Clean Energy (PACE) Loan. 2021

[4] Brown et al. Worth the risk? An evaluation of alternative finance mechanisms for residential retrofit. 2019.

[5] US Energy Department. Updated Guidelines for Residential PACE Financing Programs. 2016.

[6] Department of Energy. Best Practice Guidelines for Residential PACE Financing Programs. 2016.

[7] US DOE. Better buildings residential network peer exchange call series: The return of residential PACE. 2016.

[8] Berkeley National Laboratory. Current Practices in Efficiency Financing: An Overview for State and Local Governments. 2016.

[9] Journal of Structured Finance. PACE loans: Does sale value reflect improvements. 2016

R-PACE cannot be used for new constructions by developers. C-PACE can however ne used for new construction in 19 states[10].

It can be combined with other grants and incentives.

Different local authorities in the U.S. have different rules regarding PACE – Michigan's PACE statute requires contractors to guarantee net savings for projects over $250,000 (this is for C-PACE and not R-PACE)[11].

What is a typical payback period?

Typical repayment periods range from 5-30 years.

What are the typical interest rates?

An analysis by the U.S. Energy Programs Consortium (EPC) of PACE data found the average R-PACE loan to be $20,000, with interest rates ranging from 6-10%. Although some providers such as Renovate America offer rates as low as 3%[12].

A cost-benefit analysis by the Rocky Mountain Institute (relatively basic) found that the costs of installing solar and energy efficiency measures via PACE (over 20 year contract) were outweighed by average annual net savings to homeowners. On average, the analysis found the average PACE homeowner investing in net zero energy measures (heat pump, solar, LEDs, insulation etc) to benefit by $160 annually (after the deduction of their PACE obligations)[13]. The total net zero measures funded by PACE came to ~$19,495 and PACE contracts would be paid over 20 years with a 7% interest rate.

R-PACE loans are tax deductible (from income tax liabilities)[14].

How is it billed to consumers?

Unlike traditional mortgages, PACE financing does not require upfront down payment and lack a regular monthly payment routine. Instead, loads are paid through property assessments as an addition to the owner's regular property taxes, which is spread between 5-25 years [15].

Penalties for not paying

Penalties for late or non-payment are the same as non-payment for other property tax bills.

What needs to be considered when selling the property?

It can be difficult to sell a property with a PACE loan attached as the loan stays with the property and transfers to the next owner[16].

People trying to get a mortgage on a house with a PACE loan attached may struggle (Investopedia), similar to solar PPAs when this was first rolled out.

R-PACE loans are tied to the property, however, are usually paid off in full during the property sale – the efficiency improvements add value to the house. Research found 45% of PACE assessments to transfer with the property sale, and 55% to be paid off at the time of sale[17]. The average remaining PACE balance taken up by the new property owners was $8,501 (from a PACE dataset of 773 loans)[18].

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[10] https://rmi.org/our-work/buildings/residential-energy-performance/faq-pace-for-homes/
[11] Rees Blanchard. Property Assessed Clean Energy (PACE) Renewable Energy Program Plan and Pilot Project. 2017.
* Masters project
[12] National Association of Energy Professionals. Residential Property Assessed Clean Energy (R-PACE): Key Considerations for State Energy Officials. 2018
[13] RMI. R-PACE: A GAME-CHANGER FOR NET-ZERO ENERGY HOMES. 2017.
[14] https://assetsamerica.com/pace-financing/
[15] Investopedia. Property Assessed Clean Energy (PACE) Loan. 2021
[16] Investopedia. Property Assessed Clean Energy (PACE) Loan. 2021
[17] Electricity Markets and Policy Group. Assessing the PACE of California residential solar deployment. 2018.
[18] Journal of Structured Finance. PACE loans: Does sale value reflect improvements. 2016.

Advantages and disadvantages

Advantages	Disadvantages
PACE can be offered at the point of sale of retrofit upgrades	Minimal credit and ability to pay checks are conducted
PACE is streamlined – retrofit contractors can offer procurement for retrofit and PACE	Retrofit contractors aren't formally trained in finance which is problematic as PACE contracts are very complex
PACE contracts can be signed for immediately meaning retrofit energy savings benefit property owners immediately	Property owners' houses are used as collateral in the case they cannot pay
No upfront cost with low-interest repayments being possible between 5-30 years	Contractors may use deceptive sales tactics
Domestic energy cost savings can be greater than PACE payments	No formal and third-party energy audits are required so the cost-benefits cannot be formally presented to property owners[19]
Tax deductible in some situations	It is uncertain whether PACE upgrades will lead to great energy savings than PACE payments
PACE upgrades generally increase the value of properties	Interest rates can be very high
Low interest rates available due to the lien on the property which is an attractive security feature for lenders	Not suitable for investments below $2,500
Zero upfront costs make projects more cash flow positive	Potentially high legal / admin fees
Helps local authorities decarbonise the domestic sector	Complications when selling a property with a PACE lien attached, or getting a mortgage on a house with PACE
The process is very simple and quick – energy savings can be ascertained within a few days to weeks[20].	Problematic refinancing mortgages without paying off PACE loan first
	The U.S. Federal Housing Finance Agency issued statements concluding that PACE programs present safety and soundness concerns, leading to slowed implementation in the residential sector [21]
	A key concern of property owners is that they will not recoup the costs of PACE energy efficiency upgrades prior to future sale[22]

PACE in Europe

Several European countries are developing feasibility studies based on the U.S. PACE model such as the Euro PACE programme. The main difference is that the European programme is investigating 'demand aggregation financing' which aims to retrofit multiple homes in a given location at the same time to increase the savings per unit with measures funded through low interest loans, purchase agreements, or energy service providers[23].

[19] https://www.theguardian.com/tv-and-radio/2021/jun/21/john-oliver-last-week-tonight-pace-loans
[20] Brown et al. Worth the risk? An evaluation of alternative finance mechanisms for residential retrofit. 2019.
[21] WSGR. Innovations and Opportunities in Energy Efficiency Finance. 2014.
[22] Rachel Treger. Residential PACE programs: A path forward. 2013.
[23] BEIS. Heat Pump Ready: Supporting Information. Background on innovation needs. 2021.

Whilst EuroPACE is mainly under feasibility study, but it appears it is now starting to become operational in the EU. The main factors slowing down implementation include complex legal processes and first-lien complications which must be addressed at the EU level[24].

PACE in the UK

PACE loans are not yet operational in the UK according to BEIS in July 2021[25] - it will be problematic implementing such a system in the UK due to its different system of property taxation and municipal finance[26].

BEIS conclude the PACE model used in the U.S. could be trialled in the UK, as it is an owner-occupied model for financing heat pumps and other energy efficiency measures that could be made possible in the UK[27].

BEIS research related to the factors influencing UK households adopting rooftop solar PV found that in order to drive adoption more products and services supporting financing and the temporal distribution of upfront costs is required. A potential solution highlighted is PACE style loans. Whilst this research is directed towards solar PV, it is very transferrable to heat pumps[28].

The Energy Saving Trust also highlight the potential use of PACE in the UK, but hint at the need to flag other available funding to property owners when it is available, such as Green Home Grants or heat pump grants. This will be important to protect customers from unnecessary bills[29].

NESTA research on increasing heat pump uptake (representative sample of 8,106 UK homeowners who currently use a gas boiler) found that an interest free loan over 6-12 to significantly increase uptake in driving uptake by ~9%. The research assumed the full installation cost to be £10,500 and to be paid over 12 years interest free, which represents ~£75 per month. It is also cheaper to service an interest free loan than provide subsidies which is an added benefit for local authorities[30].

Not profits organisations in the UK such as Lendology provide households additional funds to top of the difference with grant funding. For example, if the Renewable Heat Incentive grant provided £5,000, Lendology would provide the remaining £5,000 for a heat pump with fixed interest rates. The typical loan terms are 4.2% APR to be repaid over a maximum of 15 years. Likewise, the lowest loan available is £500[31]. Whilst this isn't the same as PACE, it is a fixed rate loan style system aimed at increasing energy efficiency adoption.

The Scottish Government piloted the 'Home Energy Efficiency Equity Loan' scheme between 2017-2022, which allowed homeowners to borrow up to £40,000 against the value of their property (average pilot loan was £18,323) to fund eligible energy efficiency and heat lost reduction measures[32] [33]. Loan owners were required to repay the loan in full when they sold their homes. The amount repaid is the lesser of the Scottish Gov equity share of the sale price, or the loan amount at 2.5% APR.

[24] Bertoldi et al. How to finance energy renovation of residential buildings: Review of current and emerging financing instruments in the EU. 2019.
[25] BEIS. UK Rooftop Solar Behavioural Research. 2021.
[26] Brown et al. Worth the risk? An evaluation of alternative finance mechanisms for residential retrofit. 2019.
[27] BEIS. Heat Pump Ready: Supporting Information. Background on innovation needs. 2021
[28] BEIS. UK Rooftop Solar Behavioural Research. 2021.
[29] https://energysavingtrust.org.uk/we-must-seize-the-opportunity-for-improved-home-energy-efficiency/
[30] NESTA. How to increase the demand for heat pumps. 2022.
[31] https://www.lendology.org.uk/loans/energy-efficiency-loans/
[32] Gov. Home Energy Efficiency Equity Loan pilot: homeowner feedback survey - analysis of responses. 2022.
[33] https://www.gov.scot/publications/equity-loan-scheme-call-evidence/pages/3/

Appendix D3 – Summary of Lender Offerings

As part of work package 5, a total of 12 lenders were engaged to understand their financial lending offerings which could be used to facilitate heat pump retrofitting. A summary of the lenders contacted and their offerings in provided in the following pages.

Leeds Building Society

Product	Brief Description
Green Mortgages	Fixed Rate Green Mortgage products are for properties with an Energy Performance Certificate (EPC) rating of A-C. Fixed rates available for LTVs up to 85% and separate rate for LTVs up to 90%. Lending to whole properties or re-finance options.
Further Advance	Allows borrowers to add to their mortgage for a range of needs, however applications require new valuation etc. and so may not be fully streamlined.

Hinckley & Rugby Building Society

Product	Brief Summary
Green Mortgages (for existing borrowers)	Green mortgage products allow existing members to access additional funding to carry out green retrofitting improvements to improve their EPC rating. Members can take advantage of these competitive rates by pledging to use at least 50% of the additional funds borrowed for energy-efficiency improvements. Provide a list of acceptable measures: https://www.hrbs.co.uk/wp-content/uploads/2021/06/Acceptable-green-measures.pdf

Yorkshire Building Society

Product	Brief Description
Home Improvement Loans	Existing mortgage customer can add to the mortgage. As long as the affordability is there they do.

Santander

Product	Brief Description
Lower Rate Green Additional Loan	Whole loan (existing mortgage plus new borrowing) needs to be below 85% LTV. Borrowing needs to be for a minimum of 5 years. Offer loans for Heating, Energy Efficiency and Solar.

Natwest

Product	Brief Description
Green Mortgage	NatWest Green Mortgages are available to over 18s purchasing or re-mortgaging a home with a valid Energy Performance Certificate (EPC) rating of A or B. Onus is on the user to enter details before being presented with relevant savings.
Green Buy to Let Mortgage	A Green Buy to Let Mortgage gives you a discounted 2 year or 5 year fixed rate Buy to Let mortgages if you're re-mortgaging or purchasing a Buy to Let property with a valid Energy Performance Certificate (EPC) rating of A or B. Onus is on the user to enter details before being presented with relevant savings.

The Co-operative Bank

Product	Brief Description
Green Additional Borrowing Facility	Existing customers of The Co-operative Bank can now apply for one of its Green Additional Borrowing products to help them make improvements to their home that will reduce their energy consumption and help tackle the climate emergency. Uses Energy Saving Improvement Tool, powered by Energy Saving Trust, to create a personalised Energy Saving Improvement Plan. 2-Year or 5-Year Fixed term.

BNP Paribas

Product	Brief Description
Unsecured Borrowing Direct to Consumer	BNP Paribas provide unsecured borrowing to consumers. Rates were stated as being between 6-7% depending on credit history.
Unsecured Borrowing B2B2C	BNP also offer consumer finance products via third parties. This enables other businesses to lend direct to consumer.

Perenna

Product	Description
30-year fixed rate mortgage	A long-duration mortgage backed by covered bond issuances. Long-dated fixed loans aim to provide certainty to homeowners. Loans will be originated through a fully-digital channel. Spread over gilts expected to be 50-100bps over. Aim to make additional borrowing easier through the mortgage.

Property Master

Product	Description
Mortgage Broker	A mortgage brokerage service specialising in buy-to-let mortgages.

Scroll

Product	Brief Description
Second Mortgage	Fast-approval Home Equity Loan with a view of reducing the processing time for personal borrowing. Indicative rates are higher than primary mortgage rates 5-8% APR. State that rates start from 6.25%.
Refinance	Future potential products include a full re-finance option to reduce the rate further.

Impact Rewards

Product	Brief Description
Employee Reward Scheme	Reward scheme for employees. The reward scheme is currently a bespoke point-system for staff that encourages employees to take positive climate action and be rewarded for it.

Add To My Mortgage

Product	Brief Description
Additional Borrowing on Existing Mortgage	Works with other mortgage providers to add finance to the existing mortgage. Within heat pumps the goal is to close the cost-differential between gas and electric.

Appendix E1 – Consumer Journey Summary

The following pages present a summary of the customer personas and the customer journey developed as part of work package 6. The stages in the customer journey were used to inform the approach the recommended approach for high-density deployment for Phase 2.

Heat Pump Ready Cambridgeshire - Customer Personas (fuel-poor & able-to-pay)

Able-to-Pay

Green Blingers
Able-to-Pay (younger)

Younger/middle aged professionals who are socially conscious and want to be seen as being so. They drive (or aspire to drive) an electric vehicle and promote environmental causes whilst living a fairly affluent lifestyle.

- Ayesha is 44 and married to Arun. They have three children aged 18, 16 and 12. Ayesha works part-time as an accountant and Arun works full-time as a dentist.
- Ayesha and Arun own a 5-bedroom house in a suburb of a major city. They are reasonably comfortable financially, but they have significant mortgage payments and spend a lot on their children's education and hobbies.
- Ayesha likes to look good and spends on designer clothes for work and leisure. Largely as a result of pressure from the children, Ayesha has become increasingly concerned about the environment and it is important to her that she is seen to be doing the right things.
- She recently traded her car in for an EV and is active on social media supporting local environmental causes.
- Ayesha reads the Guardian online and uses Facebook and Instagram.

Enlightened Empty Nesters
Able-to-Pay (older)

Older professionals or retired professionals. Reasonably well off with grown-up children. They aren't conspicuous consumers but buy quality things. They are concerned about the future for their grandchildren and want to do what's right environmentally.

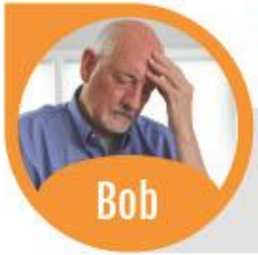
- James, 66, and his wife Alison have three children aged 39, 37 and 35 and several grandchildren. James is a retired company director and Alison is a retired HR manager.
- James and Alison own a 5-bedroom period house in a village. They have paid off the mortgage and have a reasonable income from their private pension. They provide some occasional financial assistance to their children.
- James and Alison are fit and active and enjoying the early years of their retirement with regular overseas travel. However, they appreciate they have done well in life and are increasingly driven by the desire to leave a positive legacy, both to their own family and society more broadly, including a recognition of the climate emergency.
- James has an online subscription to the Times and uses Facebook to keep in touch with family and friends.

Younger ← → Older

Concerned Parents
Fuel-Poor (younger)

Younger parents who are struggling to make ends meet but care about the environment and want to make things better for their children - but can't afford to pursue many of the options for decarbonising their lifestyles because of budget restrictions.

- Gemma is 33 years old and married to Jack. They have two children, aged 12 and 10. Gemma works part-time as an office administrator and Jack works full-time as a telecoms engineer.
- Gemma and Jack own a small 3-bedroom house in a town near a large city and are very concerned about the cost of living crisis, especially rises in their energy bills and worry that their mortgage payments might start to go up soon too.
- They have already made cutbacks to their regular costs, cancelling some of their TV/film subscriptions and cooking at home instead of getting regular takeaways.
- Gemma worries about the damage we are doing to the environment and wants to do all she can to leave a better planet for her children.
- Gemma enjoys TV, especially soaps, and social media, especially Instagram.



Security Seekers
Fuel-Poor (older)

Older homeowners with grown-up children who own their own homes but have modest fixed incomes. They are struggling with cost of living crisis and want to minimise their outgoings and their vulnerability to price fluctuations.

- Bob is 56 and a widower, having lost his wife to illness a few years ago. He has two children aged 32 and 28 who both have their own homes and children.
- Bob owns a two-bedroom bungalow in a town. The mortgage is paid off but Bob took early retirement after his wife died and his income is very modest.
- Bob is very concerned about rising costs. He wants to feel secure that he will be able to cover his costs, but recent hikes to his monthly bills have left him worried this might not be the case.
- Bob knows he has a valuable asset in the bungalow but wants to protect the value to leave to his children.
- Bob enjoys watching the news on TV and buys a copy of the local paper every day.

Fuel-Poor

GROWTH GUIDES

Heat Pump Ready Cambridgeshire - Customer Pathway (fuel-poor & able-to-pay)

STAGE	Awareness	Active consideration	Online suitability assessment	Detailed survey & plan	Decide to go ahead
TARGET JOURNEY FOR THE STAGE	To take prospective customers from little or no existing awareness of heat pumps and get them to a state where they are keen to learn more and prepared to take action to do so	From having the interest and curiosity raised to a more understanding of what heat pumps are and what relative benefits they deliver and wondering whether they might be a viable solution for them	From wondering whether heat pumps might be an option to having completed an online tool giving them an indication of whether heat pumps would work along with an idea of their costs and benefits	From having an initial online assessment to commissioning a home survey and receiving a full report on costs and benefits, equipment/supplier recommendations and financing options	From receiving a detailed report and recommendations to pushing the button and committing to a heat pump installation at their property
KEY TOUCH POINTS	Direct mail, leaflets, posters, advertisements and editorial (PR) in local media, social media and other targeted online activity	A purpose built website ideally supported by some in-person options such as drop in events locally	An online tool built into the purpose-built website. An email address will probably be needed to receive the report	A written report with, ideally, an in person consultation to talk it through and address questions	In person contact either through a portal, email or telephone
DESIRED ACTIONS	Visit recommended website	Click to start online suitability assessment	Consider a home survey	Consider recommendations Review supplier/hardware options	

GROWTH GUIDES

Appendix E2 – Customer journey and drop-off mitigation research findings

The following section provides the summary report of the evidence gained from the one-to-one interviews conducted by Growth Guides to gather evidence on the heat pump user journey.

Heat Pump Ready Cambridge

Customer journey and drop-off mitigation research findings

3rd November 2022

Version 01

Contents

Executive summary

- Respondents were concerned about carbon emissions and the environment and are open to learning how they can take action to help
- Most respondents would consider a heat pump on the environmental benefits if they were reassured of the performance/data and it left them no (or not much) worse off than their current system or an alternative.
- If upfront costs are significant, these would need to be affordable - a significant challenge for fuel poor - but they would still consider financing if on good terms and viable with a payback over the life of the heat pump (ideally inside 10 years).
- Some issues - like cost and financing - are relevant throughout the customer journey and ongoing reassurance will need to be provided through every stage
- Awareness of heat pumps is still low and this in itself is a barrier because it is not a heating choice that seems normal yet. Sustained communication through different channels to make heat pumps appear more relevant will be important
- That said, heat pumps were seen to be 'the future' by some and something that would make them less dependent on any particular fuels and therefore less vulnerable to energy price swings
- Because heat pumps are still relatively new and unknown to most respondents, there is concern over how long they are likely to last and how much they will cost to maintain - facts and figures on this will be important to reassure them
- Local authorities and relevant charities (such as PECT) in particular were seen as having a role to play and seeing more people and organisations using heat pumps would lower the perceived risk considerably
- A website is seen as the natural place to find out more about heat pumps, but it will need to be professional, trustworthy and 'super-simple' to use
- Some would want an additional stage with greater human contact - maybe a drop-in centre at a local library, for example
- Examples of heat pumps being used more widely will help increase uptake (or minimise journey drop off), not just in homes but more widely across society (e.g. in commercial properties, government buildings, schools etc)
- Respondents welcome the idea of an online suitability assessment but some would be wary of sharing personally identifiable information at this stage
- There was a spilt opinion on whether the detailed home plan should require payment and, if so, how much. Some argued until they knew heat pumps were viable, expecting them to pay was too much. Others would pay but expect reimbursement if they went ahead.
- Several respondents suggested as well as a plan, they would appreciate an independent consultation with an expert to talk the plan through and address any questions they have.
- Overall, paying for and installing a heat pump is attractive to many but feels like it carries a high risk for the relatively early adopters. Normalising heat pump use and providing safety nets if things go wrong will be important to escalate uptake, both for fuel-poor and able-to-pay customers.

Objective

To test the proposed customer journeys and understand which factors would be most likely to minimise drop-off at each potential stage or decision point up to the decision to go ahead and commit to a heat pump installation.

Approach

5x one-hour one-to-one interviews conducted over Zoom by Tony Harbron and Holly Whitehead between 31st October 2022 and 2nd November 2022.

3 of the respondents were from the target location (the intention was 4 but one cancelled at the last minute). However, because we had no demographic information ahead of the interviews and the need for a rapid turnaround, we also arranged two additional sessions - one with a known fuel-poor respondent and one with a known able-to-pay respondent (these were not from the target location).

Respondent profiles

Using our best estimate of able-to-pay (ATB) or fuel-poor (FP) from the discussions held and occupational information, the respond profiles were:

Sex	Age group	Able-to-Pay/Fuel-Poor
1x Female	25-34	FP
1x Male	35-44	ATP
1x Female	45-54	FP
1x Female	55-64	ATP
1x Male	65+	FP

Key findings

We have broken the findings down by the stage of the customer journey, up to the point of giving the installation the go ahead.

Stage 1 - Awareness & interest

Awareness is low and even where present, there is a feeling that the lack of profile of heat pumps undermines their credibility as a viable option

Suggested drop-off mitigations based on respondent feedback

- A sustained mixed-media campaign to build awareness of heat pumps and their potential benefits ideally including editorial coverage (PR) as well as just direct promotional activity
- Many channels are likely to have a positive impact, e.g. social media, but those with more authority will be important to establish credibility, e.g. a letter or email from the local authority or advertising in the local/parish newspaper were seen as higher value
- Caution should be employed when using channels that are not necessarily environmentally friendly as this could be seen as hypocritical, so emails would be better than letters in that sense, for example
- On its own, a money-saving pitch or headline would be most likely to capture interest in the current situation, but the environment is important to many so a message relevant to this will gain their attention too.
- In addition to the environmental impact, it was suggested a heat pump might help future-proof a property and make someone less reliant on any type of fuel (electricity can come from multiple sources), which was attractive
- The local authority and relevant charities or environmental groups were seen as the key to any communication about heat pumps being taken seriously (with PECT being mentioned spontaneously by one respondent as a trusted and relevant source)
- Government backing was seen as important to some but others are extremely distrusting of the government and it might be counter-productive in those cases
- One respondent had looked into a heat pump but was quoted £14k and expected to pay in full in 5 days. There was no survey. He saw an ad in the paper and enquired. He is still interested but wants proper information
- Most would be keen to click through to a recommended website to learn more (especially if it was independent and it made clear what they would find there)

Selected respondent comments:

"I'm surprised there isn't a wider kind of initiative to raise awareness. You know, like we did with asbestos or solar, all those other things which got a lot of media attention"

“I probably wouldn't click on a social media post but something through the letterbox or the post like leaflets, letters, or something in the local paper or parish newsletter I probably would be interested in”

“Sending a glossy leaflet is not environmentally beneficial - it's a bit counterproductive but maybe an email from the local council?”

“If there was an article in the newspaper about it, saying that there are initiatives or we should think about them. Or if there was something on the radio, that would be of interest.”

“Any one of those [channels] I can easily ignore but a combination - say you send me a leaflet one week, and it's followed up with something the following week - that's more likely to get my attention”

“I’d suggest appealing to people thinking of upgrading or changing their heating and making clear heat pumps are the future”

“I do get a lot of good social media adverts and I have clicked them before but I'm always worried about scams”

“If we had unlimited money, we’d do it regardless of the cost to reduce the carbon but the reality of today's world is that it's got to be cost efficient as well. I'm willing to pay the same price or slightly more for more environmentally friendly products, but with young children and everything, I can't justify spending £1000s more.”

“I saw an ad in the local paper and a mate down the road had a heat pump and it was working well, so I called them and they quoted me £14k and expected me to pay in full in 5 days. That was much more than I expected and I thought they would organise financing. I didn’t go ahead but would still be interested. I would want to save money and have less fossil fuels going through the system”

“I'd rather have something that is going to be more environmental in the long term. So kind of future-proofing my home for heating.”

“I'm relying on gas and with the current situation, that makes me feel vulnerable. But if you've got a heat pump, it needs electricity, but that electricity can come from so many different sources. I don't feel so held over a barrel by it.”

“The government's an interesting one. I don't know if that would make me feel secure about anything. I would like it to be endorsed by a relevant environmental group, I think”

“If the council say we're in on it, or endorsing it, then I would think that's a good thing. They've looked into it I trust they would do the right thing.”

“If it came from one of those charities like PECT - they are already very knowledgeable in energy-saving situations and I would trust them”

Stage 2 - Active Consideration

Respondents suggested they would be likely to take action to find out more about heat pumps. All respondents thought a website would be the most likely place they would expect to go to do this.

Suggested drop-off mitigations based on respondent feedback

- Additional activity beyond the website - such as drop-in centres at the local library - would be desirable for some consumers
- The website would need to look professional and modern, be easy to use and easy to understand. Failure on these counts would make them suspicious.
- Examples of use that made heat pumps seem more common and 'normal' were recommended. And it was suggested this shouldn't just be domestic - they would be encouraged to learn that businesses, government buildings, schools etc were using them
- The opportunity to see a heat pump working in a property was suggested by several as being potentially helpful but failing this, case studies from 'happy users' would be useful
- It will be important to convey what it is like to live with a heat pump with reassurance that it is, for example, easy to adjust the temperature, get it up to the desired temperature quickly and cope with cold weather
- Similarly, explaining what they are like to have installed, how big or intrusive they are and so on will be important so they can make an informed decision
- Input from trusted local suppliers was also welcomed as they would be expected to be able to provide more practical expertise
- Ultimately, some indication of cost and benefits would be essential but they would also expect to see explanations of how heat pumps work, information why they are better for the environment, case studies, and an outline of grant and financing options
- It was also suggested any potential downsides should be made clear and it should help people understand when a heat pump might not be suitable and what would be required in terms of insulation etc

Selected respondent comments:

"Professionalism is important. As long as the website looks well done, like there's nothing unfunctional. I know it sounds silly, but if they're just a pain to use and navigate and not super simple then they can really be off-putting"

"A website's good. I do like reading on websites but it's not always that easy to ask or find the answer you need. An event, maybe at the library or one property where it's already been installed, would be good to get more information"

"A website would be really good to get all the details and I'd also like a monthly thing at the village hall or library where you could go and meet all the people behind it and ask them your questions"

“My first thought is I need more information. Where can I get information from an independent source?”

“What I don't understand is their efficiency compared to say gas and average bills over the course of an annual year, an annual cycle, and whether it'd be more cost-efficient over x many years and you know, that sort of stuff”

“On our property it would be fine because we've got plenty of space… but I guess for people in like more confined properties, especially limited garden space, they probably have a bit of an interest in understanding how much space they take up and things like that”.

“I'd be interested to see it working in a house that's not got 30 centimetres of insulation because we can’t do that in ours”

“An indication of costs and benefits is probably one of the higher importance to me. And case studies, so I know it actually works”

“I would want to see what it's costing in an equivalent house. I would want to also see how happy the occupiers were with it. Like, how easy is it to adjust the temperature? Can you achieve the temperatures in a reasonable timeframe? Are they happy with it? Yeah, you know, how is it performing in cold weather? Because one of my concerns is what happens in the cold.”

“I'd want to know what other industries are using heat pumps. Government buildings, council buildings, large businesses, schools, places like that, so it’s not just falling on homeowners to do this and it would make me trust heat pumps more”

“You want a whole page of cons. I don't like things always portrayed as a rosy picture”

Stage 3 - Online Suitability Assessment

An online suitability tool to give a ballpark indication of costs/benefits was seen as desirable and likely to be used.

Suggested drop-off mitigations based on respondent feedback

- It should be free to use (respondents were unanimous on this)
- An assurance of confidentiality over their data should be provided, along with a commitment they wouldn't be hassled just for having filled it out
- Asking them to provide personal information at this stage is likely to be off putting for some (respondents were mixed on this)
- Clear instructions up front over what information would be needed, how to get it, how long the process would take and what the output would be
- If their property was clearly unsuitable, this should be made clear quickly so as not to waste too much time, even if more info was then asked for to go deeper where relevant

Selected respondent comments:

"I would definitely want to do this"

"We were given quote but no figures on what it would cost to run or anything so this would be really useful"

"I'd be happy to give information about the house - the area, size, and so on, and how much we pay now, but not my name or email or phone number at this stage - it's too much too early"

"Normally when you go onto a website, that's probably the first thing that you do. And then it would say yes, or no. So I've done some before saying, am I eligible for roof Installation or something? And there are government grants available and you'd go through a tick list. They would say, yes, you are eligible for this or no, you're not. And that's really useful"

Stage 4 - Detailed Home Plan

All respondents appreciated that a survey of their home would be required to get accurate figures and reassurance over performance, environmental benefits and so on

Suggested drop-off mitigations based on respondent feedback

- It may be beneficial to provide a free survey to the homeowner because they are not in a position to know if there home is suitable without it, but some said they would expect to pay (up to a few £hundreds) but that they would want this to be reimbursed if they went ahead
- Some kind of screening based on their online assessment or follow-up questions would be expected and acceptable
- The data in the plan would need to come with some kind of verification because of the decisions they would be making on the back of it
- It will be important to provide recommendations on the most suitable equipment etc that is trustworthy. If there are obvious choices, the pros and cons should be detailed
- In addition it should give information about the process, the timings, the levels of disruption and as many issues as possible to avoid subsequent uncertainty and drop-off
- A consultation alongside the detailed plan would be helpful, so customers can talk all the recommendations through and ask any questions they have. This human aspect seems important, regardless of whether they are fuel-poor or able-to-pay

Selected respondent comments:

"For me, any figures would have to be kind of verified by someone. Not the ONS but someone like that"

"I'd be worried about how realistic cost savings were and if we will make a financial mistake because we don't really have money to make mistakes with."

"I get that it would be expensive to get an expert and go to a home and do this. I would be prepared to pay (up to a few hundred £) but I would expect to get that back if I went ahead"

"I'd happily pay up to £100 for this but if it was much more, then I'd have to think hard"

"This would be important - especially if it was independent of the person selling the heat pump. I'd like to know what to expect from the equipment, running costs and so on. And are they like gas boilers with an annual check-up and so on?"

"It would be nice for somebody to say okay, actually, this solution is realistically going to be best for your house. Or if you go for the cheaper system, these are the pros and cons for both, I guess then you can make an informed decision."

"I'd want to know what it would involve in the house, during the fitting or how it's going to fit in the house, how it's going to work, do things have to move about and you have to sort of change things internally. How long it would take to put in, so timings and how it works. What will it involve running it? Is it straightforward? Is it difficult?"

"I'd like to be able to talk it through with someone once they've done the survey. Get their take on things. Human contact is important and I'd want to hear what they really thought"

Stage 5 - Procurement

Ultimately, if respondents imagined they were still on the journey at this stage, they tended to focus on the following key issues as make or break in terms of whether they could see themselves going ahead:

- They would have to be at least no significant amount worse off over the lifetime of the heat pump and the upfront costs would have to be affordable.
- For fuel-poor respondents, this latter issue is obviously a considerably higher bar but they are prepared to consider paying a bit more ('up to £1k more') than the cost of a replacement boiler or even higher upfront costs, if financing is available and affordable, as long as there is a payback over time (realistically within 10 years)
- They would need significant reassurance over performance. This would mean the heat produced, the convenience of using them, and their likely length of life
- The potential to add value to a property was seen as helpful - any risk of it lowering the value would be seen as a major issue
- Recommended suppliers would need to have a track record and be likely to be around for the future, reputable and with reassurance that the equipment would meet all relevant standards and had been installed properly. Some suggested a government guarantee or safety net in case they go out of business would be important
- They would be very worried and therefore need considerable reassurance over the likely disruption of installation. This would cover potential damage to the fabric of their property (including the costs of making these good) and the length of time they might be left without heat (which would influence when/if a switchover would be viable)
- Overall, there is a sense that installing a heat pump is still a risk because not many people have them and that would make many feel nervous until it changes. The more that can be done to establish a perception that heat pumps are the future and the natural choice, along with guarantees or safety nets if things go wrong, the easier the challenge of getting people to install them will be

Selected respondent comments:

"I don't think you'd need to save money. I think we'd have to work out cost neutral, for the same heating effects and a quantifiable environmental benefit"

"I wouldn't want to be able to pay more than the cost of a replacement boiler. Or like slightly more. I think the replacement boilers are about £1,500. And I'd probably be willing to pay up to £2,500 for something that was better environmentally"

"With our solar panels, the energy will offset the cost within seven years. If the same thing is the case for heat pumps, if it would offset the price within 10 years, I think that would be the limit for me, then it's something I'd be willing to invest in"

“The disruption factor would be important - what's it going to do to my drive or my garden or whatever you're going to have to pull up to install these things. How is it going to get all get made good again? What's the recourse route on the installation side if it’s done badly?”

“It would be nice to know that it added value to your property. You wouldn't want it to lose money”

“When the payback is more than 10 years, that's quite a big investment. Low-interest loans are a really good idea. I would like to future-proof this house so I would consider something like that”.

“I would want to know the companies recommended had a track record and were going to still be there in ten years’ time”

“I’d want to know if they were guaranteed and what would happen if the company went bust - would I be left without any help? The government should provide a safety net”

“It would be important to know the company behind them were local and could get out to me quickly if there was a problem”

“Having somebody who's got the knowledge come in and say actually, for your situation, we suggest this, that would be really good. And explain why and what it would all really be like. That would be reassuring”

Post procurement stages

- The main focus of the research was on stages 1-5 of the customer journey (i.e. up to the point of a decision to go ahead and fit them). However, in the course of the discussion, some useful insights were obtained on expectations (and concerns) post-installation, which are summarised here:
    - Respondents have no experience with having a heat pump so it will be important that there is available reassurance that, for example, their system has been installed properly and they are able to receive guidance on how to use it properly
    - Likewise, respondents expressed concern whether the suppliers are likely to be around to ensure spare parts/upgrades etc will be available. Some kind of guarantee or assurance plan might be useful to reassure them while this uncertainty persists (it will likely diminish as heat pumps become more common)

Next steps

The findings from this research will be incorporated into revised customer journey profiles for able-to-pay and fuel-poor customers.

Further information

For more information on this report, please contact:

Tony Harbron

Email: tony@growthguides.co.uk

Tel: 07550 012076

Holly Whitehead

Email: holly@growthguides.co.uk

Tel: 07719 747509