E.ON Energy Solutions Limited

The Newcastle Heat Pump Ready Feasibility Report

Issued by
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1. Executive Summary

The aim of the Newcastle Heat Pump Ready feasibility study was to investigate E.ON's proposed innovative methodologies for coordinated, dense deployment of heat pumps whilst reducing cost and improving the customer experience at every stage of the heat pump journey. Furthermore, E.ON wished to develop a robust blueprint for large-scale urban deployment of heat pumps. Analysis was carried out across a range of work packages;

- understanding the target areas for deployment
- grid modelling
- carrying out consumer insights research
- community engagement strategy formulation and planning
- finance proposition review
- validating innovative scalable survey approaches

Overall, the results indicate many objectives of the project were met, and improvements could be made to the customer experience and customer journey timescales. Specifically, the delivery of innovations to the survey approach to improve scalability, accuracy and efficiency, supported by a validated strategy of community led engagement with the creation of an initial suite of marketing materials. Also, the formulation of a detailed approach to analysing deployment locations and subsequent deployment planning has proven replicable to other projects.

However certain barriers could not be overcome, most notably these were;

- an incomplete grid model of Newcastle City. This was due to;
  - the omission of critical property asset data to inform which addresses were connected to which substations and specific low voltage networks within the substation area and the property's location on the LV networks.
  - missing data on ~37% of secondary substations
- confidence in achieving the required 25% uptake of heat pumps at the secondary substation level based on the results of the grid modelling that was completed and subsequent comparison to customer and property data.
- the HaaS model requiring further development to achieve market readiness (TRL 9)
- the delay to E.ON aftercare service to be provided via the E.ON Home app.

The report concluded that the proposed coordinated methodology was not feasible to progress into deployment. However, it has identified that large-scale, community led deployment of heat pumps is possible within an urban location. It is recommended that increased detailed grid modelling is completed and further collaborative planning carried out with the DNO to ascertain the ability to overcome localised constraints.

2. Introduction

Building on our successful BEIS funded Electrification of Heat (EoH) Demonstration Project, E.ON and its stakeholders proposed to demonstrate the coordination of technically and commercially feasible solutions for high density heat pump deployment within the Newcastle region. The Newcastle Heat Pump Ready project aimed to explore a methodology suitable for an urban environment, deploying air source heat pumps to at least 25% of domestic buildings served by at least one single secondary sub-station. The objective was to build a deployment plan of 750 properties, significantly upscaling current and planned air source heat pump (ASHP) deployment in the region.

The project offered the ability to refine the service offer to customers, de-risking potential grid issues, whilst improving the targeting of offers to homes more suitable for air source heat pumps – a critical aspect of the City's Net Zero plans.

Our project structure facilitated a collaborative public & private partnership that had the potential to drive investment and significant delivery of heat pumps across the City of Newcastle. E.ON working with Newcastle City Council, Northern Powergrid (NPG), and Heatio (previously Clean Air Ventures) would provide the core consortium, with added targeted industry expertise included from our appointed marketing agency TwentySeven Design and our supply chain surveyors Nationwide Drones. The consortium structure is outlined below in Figure 1 along with each party's role within the project.

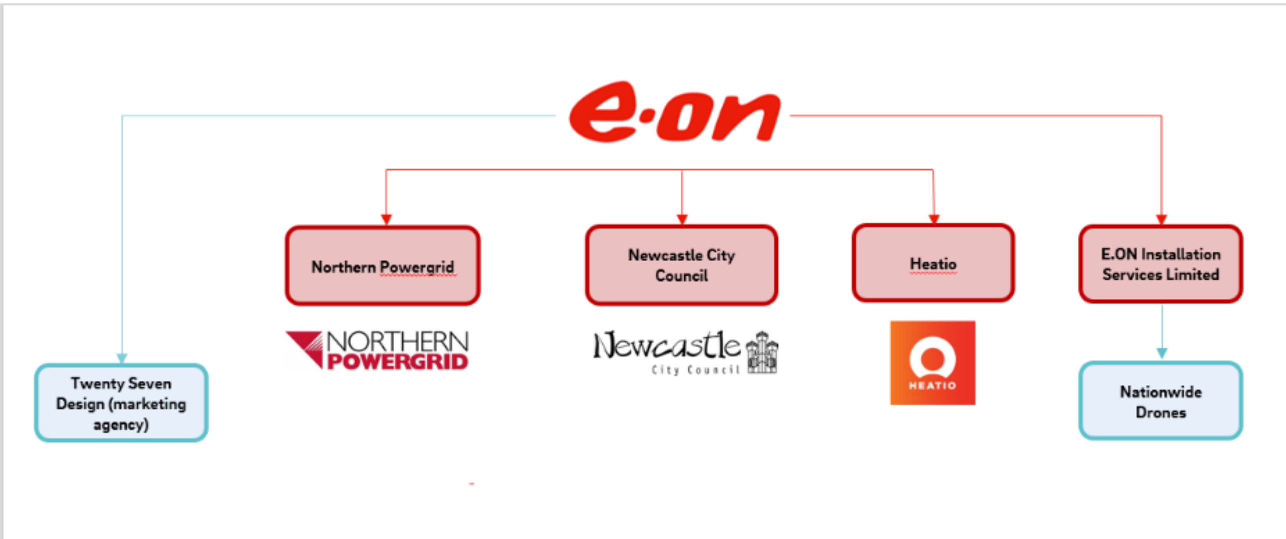


Figure 1: Consortium structure

Newcastle City Council (NCC): The council's key role was to provide strategic guidance to E.ON aligned to their private sector housing and climate change policy. Utilising a wealth of extensive experience in delivering multi-million-pound projects including Local Authority Delivery schemes, Renewable Heat Incentive schemes, Warm Homes Fund, along with input into citywide decarbonisation investment (CDDP) and the BEIS Heat Network Zoning pilot, the council team were members of the consortium steering group. Through discussion, debate and decision making they played an active role in exploring deployment plans that would be suitable for the city. Collaboration included aspects such as input into E.ON's analysis of the city and development of a targeting approach, grid analysis process and outcomes, community engagement plan and marketing approach.

Heatio: Heatio's role under contractual agreement with E.ON, was to provide industry consultancy based on their experience of design, specification, and installation of air source heat pumps in commercial and domestic buildings and their success in creating and deploying innovative methods of financing heat pumps e.g., Assignment of Rights (AoR) under the Renewable Heat Incentive (RHI). Heatio colleagues were part of the consortium steering group and collaboration activity spanned multiple work packages with a focus on;

- the feasibility of Heat as a Service (HaaS) and if this could support overcoming the barrier of the cost of ASHP's for consumers
- analysis on the integration of HaaS into a feasible deployment methodology
- exploring improvements to the technical specification and design of ASHP's
- any implications this could have on consumer uptake and guidance on effective engagement and marketing strategies.

Northern Powergrid (NPG): NPG are a non-contractual member of the consortium, who under a letter of support, agreed to collaborate with E.ON on this project. Their role was to provide grid specific guidance/knowledge, information and data sharing to allow a robust assessment of the grid in Newcastle, to facilitate informed decision making by E.ON on the feasibility of large-scale deployment and any associated geographical planning. They were not part of the consortium steering group.

Twentyseven Design: They were E.ON's contractually appointed marketing agency for the project, they hold an existing relationship with NCC, detailed knowledge of the NCC brand guidelines and successfully completed the marketing delivery on the Electrification of Heat Demonstration Project. Their role was to deliver marketing development workshops including market analysis, ideation, marketing proposals and consortium engagement on viability of the marketing proposals. They were not part of the consortium steering group.

Nationwide Drones: They were an existing surveying supply chain subcontractor for E.ON, who were engaged directly on service provision for this project. Their role was to provide innovative surveying insights based on their drone and digital twin technology to inform E.ON's decisions on the optimum surveying customer journey for consumers.

The total eligible project cost for feasibility was £200,000 and the funding requested by E.ON £188,546. The cost was developed on a bottom-up basis for each work package based on detailed cost plans from each partner and scrutinised against industry standards.

3. Aims, Expected Outcomes & Objectives

Aligned to the Heat Pump Ready Stream 1 project objectives Heat Pump Ready Programme - GOV.UK (www.gov.uk), E.ON's feasibility study methodology aimed to reduce cost and improve the customer experience at every stage of their heat pump journey and develop a robust blueprint for large-scale and high density deployment of air source heat pumps.

This was to be delivered by exploring the following;

1. **Joined up, coherent customer experience**
   a. Expand digitisation opportunities for simple, stress free journey
   b. Review our online pre-qualification tool, offering a single view of all customers' services and offers
   c. Consumer appetite for air source heat pumps (ASHP) transition via insights, analysis & engagement
   d. Finance proposition development - Heat as a Service (HaaS)

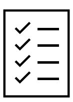
2. **Improve customer journey timescales and efficiency**
   a. Early property suitability assessments/triage
   b. Identifying the optimum survey approach
   c. Digitisation of heat pump designs & quotes
   d. Marketing approach & customer retention – cost to acquire and cost to serve

3. **Iterate and innovate**
   a. Collaboration between Northern Powergrid & E.ON, utilising E.ON's grid analysis approach
   b. Heat pump design methodology analysis – iterative refinements to explore optimum customer outcomes (product specification, sizing, upgrade scope & cost)
   c. Improving customer aftercare via E.ON Home customer app

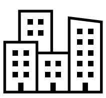
The expected outcomes from feasibility research and analysis were delivery of a robustly validated deployment plan for key areas of Newcastle City based upon;

Substation locations identified and mapped, multi-layer validation of grid capacity, property suitability, demographic suitability

Consumer acceptance and engagement; establish if widescale, dense low carbon heating adoption is possible.



ASHP product portfolio validated, successful alignment to Heat Pump Ready rules (cap on hybrid and high temperature heat pumps)



Surveying & install deployment approach understood (can efficiency of scale be achieved)

Also, the delivery of an optimum customer journey, tailored to dense large-scale deployment of ASHPs in an urban environment.

Coherent integration of innovative approaches & finance products

SLA reductions across the end-to-end journey; reduction in complex customer touchpoints + decrease timescales at key touchpoints

Cost reductions; improved conversion rates into the customer journey, improved retention once within the journey

Baseline customer journey vs new "optimum" journey mapped to identify improvements

While continuing to understand the best route to collaborating with a multitude of organisations and industry stakeholders.

It is key to note the reasoning behind the decision to focus on ASHPs and not to include GSHPs within our feasibility study. This was based on our baseline analysis and knowledge of the city, informed by the Electrification of Heat Demonstration Project, which carried out >900 home surveys to ascertain those most suitable for heat pumps against the prevalent housing stock. ASHPs and hybrids presented the best alignment and opportunity to achieve scale.

4. Work package summary

Outlined below in Figure 2 is the work package structure used within the Newcastle Heat Pump Ready project. This outlines each core workstream and the corresponding core objective. Each work package had a subset of expected deliverables which are further explored within Section 4.1 and 4.2 of this report.

	1 Workpackage 1	2 Workpackage 2	3 Workpackage 3
Work-stream	**PROJECT MANAGEMENT**	**TARGET AREA ANALYSIS**	**PROPERTY ARCHETYPE MODELLING**
Objective	Provide project management and coordination of work packages WP2-7. Contracting, procurement, risk management	Localised understanding of the network impacts of high-density heat pump deployment. Strategic decision making on proposed locations	Localised understanding of specific urban archetypes; ASHP solution suitability, opportunities for design & specification refinements, grid flexibility solutions.

	4 Workpackage 4	5 Workpackage 5	6 Workpackage 6
Work-stream	**CONSUMER INSIGHTS & PROPOSITIONS**	**COMMUNITY ENGAGEMENT**	**PHASE 2 FINAL DESIGN & APPLICATION**
Objective	Collate detailed consumer insights research. Understanding proposition alignment with consumer appetite, and variances across communities. Incorporate new insights from WP5 community engagement. Exploration of HaaS.	Raising awareness of the Heat Pump Ready project, establish an integrated plan for large scale deployment that puts the community and it's needs at the core of the programme.	Detailed Phase 2 plan completed. Tender application completed and submitted.

7 Workpackage 7
FEASIBILITY PROJECT REPORT
Collate and write final feasibility report.

Figure 2: Work package structure

	Lead	Contributors
1 Workpackage 1.	E.ON	
2 Workpackage 2.	E.ON	NCC, NPG, E.ON (group innovation)
3 Workpackage 3.	E.ON	Heatio, Nationwide Drones
4 Workpackage 4.	E.ON	Heatio, NCC
5 Workpackage 5.	E.ON	NCC, Heatio
6 Workpackage 6.	E.ON	All
7 Workpackage 7.	E.ON	All

Figure 3: Summary of involved parties for each work package

5. Methodology

5.1 Work Package 1. Project Management

E.ON as lead organisation, provided the overarching project management and discharged all duties under work package 1. ensuring robust principles of project management, stakeholder engagement and sub-contractor management were adhered too. An established routine of progress meetings for all consortium organisations, alongside work package specific workshops supported working successfully to the project plan and within established contingencies.

5.2 Work Package 2. Target Area Analysis

As preparation for entering the feasibility phase, E.ON, working with Newcastle City Council completed initial high-level analysis to identify 8 target wards across the city as most suitable for high dense deployment of ASHP to individual homes. These are shown in Figure 4 circled in green and are as follows;

- Castle
- Parklands
- Callerton and Throckley
- Chapel
- Dene and South Gosforth
- Manor Park
- Kingston Park South
- Denton and Westerhope

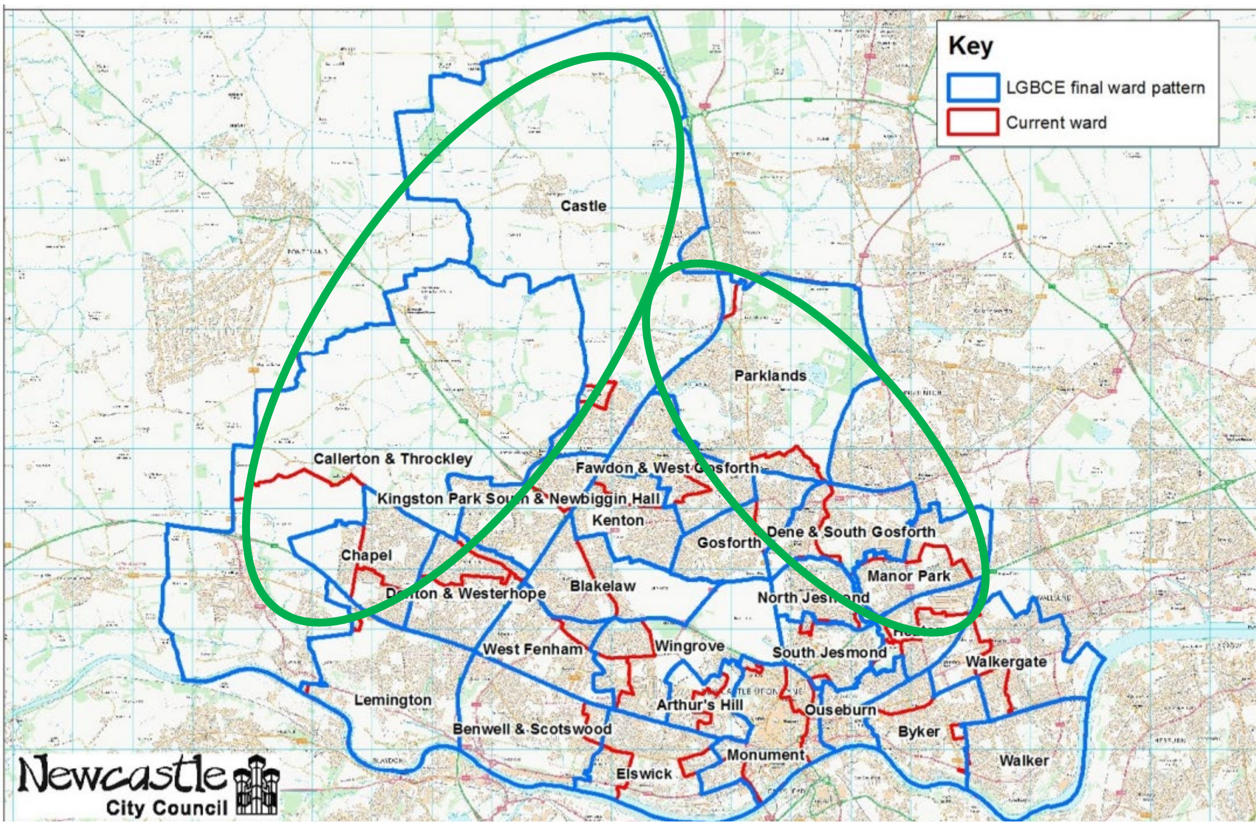


Figure 4: Ward map of Newcastle City with highlighted wards of interest

These areas were representative of typical urban and sub-urban communities across the UK with a variety of mixed tenure, mixed demographic, high density housing with all property archetypes and spanning a significant breadth of age bands from 1914 to post 2010. E.ON expected a significant proportion of deployment to be via retrofit, with very limited opportunities for the incorporation of new build delivery currently across the city. Thus, tackling the core challenge of large-scale deployment and a methodology analysis already completed by the council that would provide UK wide benefits and replicability. This approach excluded those wards potentially suitable for district heat networks based on pilot heat network zoning.

Our approach therefore was to build upon this already established local knowledge of communities within Newcastle Upon Tyne and carry out an in-depth area-based analysis of the 8 wards to inform our decision making on shortlisting proposed locations to take forward into our deployment plan. This was achieved by layering multiple sources of data and insights, to narrow our search to specific communities. To effectively visualise the results of our multi-faceted data analysis, and embed this at community level, a mapping exercise was completed overlaying key data points. This enabled identification of a subset of communities deemed most suitable for dense deployment opportunities, that were grouped into 6 priority zones.

The step-by-step process to achieve this is outlined below;

1 — **Baseline data set review of each of the 8 wards**
- -EPC data
- - Age band
- -Archetype
- - Tenure

2 — **Existing heat pump data (Electrification of Heat) incorporated;**
- - Consumer applications
- - Heat pump MCS designs
- - Technical surveys
- - Heat pump installs
- - Customer cancellation reasons

MAPPING EXERCISE TO SEE GEOGRAPHICAL TRENDS

3 — **Initial "priority zoning" hypotheses made** – identifying 6 multi-community areas of interest, within the original 8 Wards.

REFINEMENT & VALIDATION

4 — **Consumer Segmentation & Propensity Model developed** (see 4.1.4) to further steer "priority zoning" to specific communities of interest, ensuring consumer suitability is central to deployment decision making.

5 — **Street-by-street visual suitability analysis completed** further validated utilising existing archetype knowledge (as outlined in 4.1.3). RAG status used to qualitatively rate every street within each priority community based on suitability for dense deployment of ASHP.

PRIORITY ZONES FOR ONWARD GRID ANALYSIS...

The output of this process is shown in Figure 5. These colour coded zones are grouped based on the highest density of positive indicators for heat pump deployment linking to customer suitability (step 2 & 4) and property suitability (step 1, 2, 5) and the highest propensity for early adoption of heat pumps.

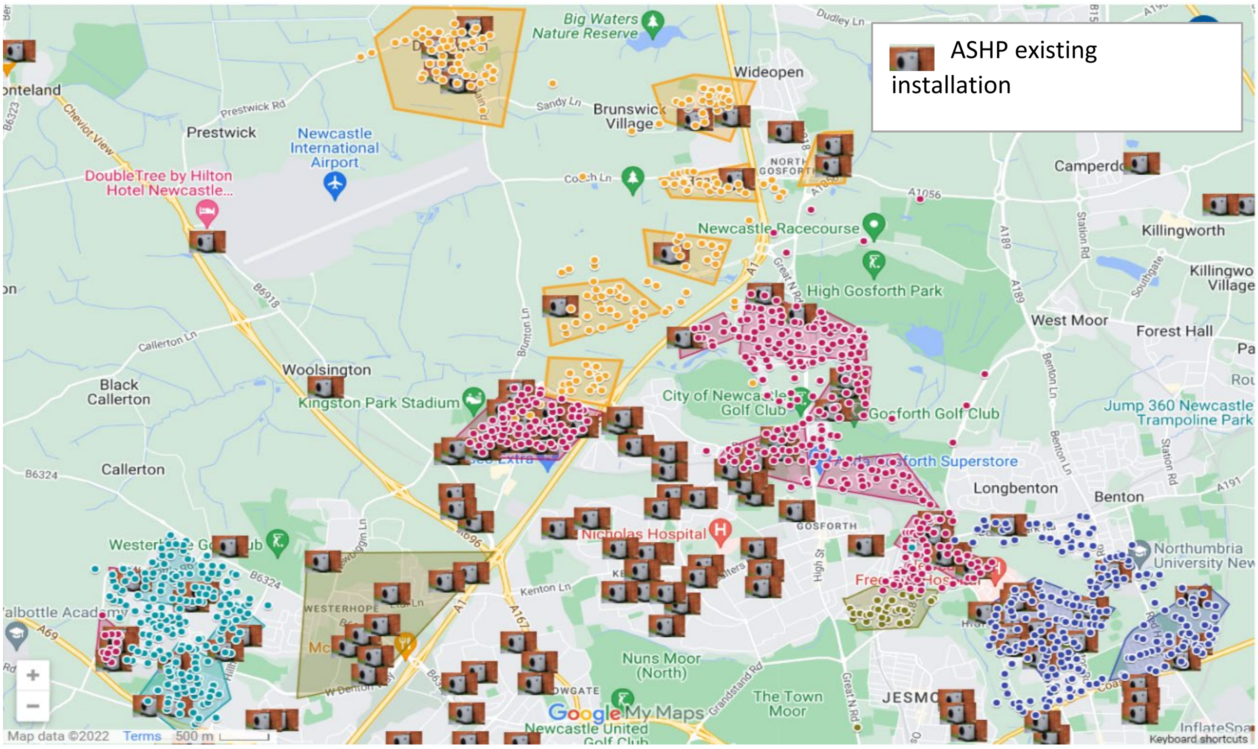


Figure 5: Map to show identified priority target zones for deployment

The zones also support the marketing strategy to engage with the communities most likely to secure high volume of early take up, advocacy and drive conversations by sharing experiences with other areas across the city. There are also clear identifiers shown for previous successful heat pump installations.

The target area analysis was paused following step 5 outlined above, dependent then on critical insights from the substation level grid analysis and completion of the community level consumer insights research. However, prior to receiving the secondary substation level data, we reviewed over 31k properties across our priority zones.

<u>Example activity undertaken at key Target Area Analysis steps</u>

Existing Heat Pump Data (step 2)

E.ON's existing portfolio of ASHP customer applications, in-home technical surveys, MCS designs, successful installations, and cancellation data - including c1,000 technical surveys, >300 successful heat pump designs and >200 installations, were mapped and cross referenced to support this assessment. This gave us opportunity to understand, at a community level consumer appetite (positive or the presence of any barriers to deployment), alongside a direct knowledge of properties suitable and unsuitable for deployment of ASHP. Mapping extracts of this data can be found in Appendix 3, figure 3.1 and 3.2, with a summary of cancellation data outputs summarised in figure 3.3 and 3.4.

Street by street visual suitability analysis (step 5)

Within these priority zones a street-by-street desktop ASHP suitability assessment was completed utilising freely available imagery e.g., google maps/street view etc. This was completed manually by E.ON's ASHP Energy Expert with support from a project administrator to record each outcome. Remote measuring tools within Google Maps Pro were used to accurately measure potential Heat Pump locations for proximity to habitable rooms in neighbouring properties and boundary lines. An example of this is shown in Figure 6. The digital measuring tool was also used to check the available space for outdoor units according to the manufacturer's specifications and MCS guidelines. Local planning regulations on permitted development state that heat pump outdoor units must not be within one meter of the property boundary line.

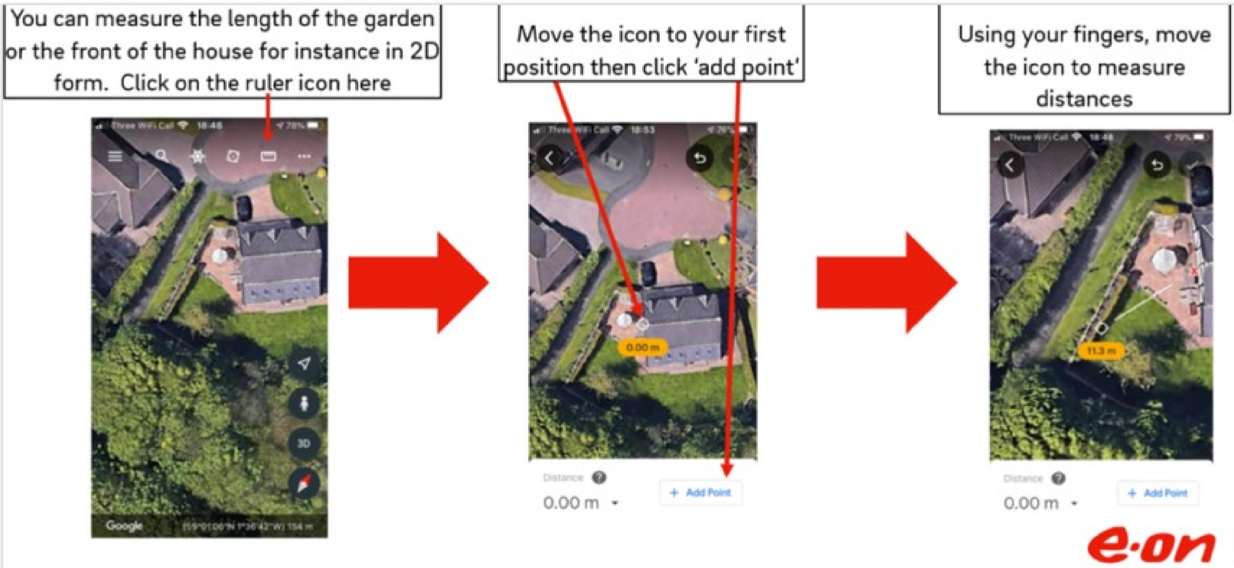


Figure 6: Indicative example of assessment tools used to ascertain suitability characteristics

In addition to this, summarised below in Figure 7 are the suite of suitability factors utilised to assess likelihood of technical suitability for an ASHP at this early stage of deployment planning.

1. **External space for ASHP outside unit**

   a. locations on the rear & side(s) of property
   b. presence of conservatories, extensions, outbuildings that could limit locations
   c. location of windows & doors that could limit locations
   d. general accessibility, particularly if rear sited unit

2. **Proximity to neighbouring properties**

   a. space to closest boundary vs possible heat pump locations
   b. proximity to closest habitable window vs possible heat pump locations
   c. presence of any barriers between possible heat pump locations & neighbouring property

3. **Archetype features that could impact suitability**

   a. L shaped terraces, very narrow terraces, terraces with extensions
   b. extra-large properties, particularly detached 5+ bedrooms (as an indicator for high heat loss)
   c. very high heat demand, with low thermal efficiency (e.g., solid brick walls)

Figure 7: Summary of suitability factors

A RAG status was then applied to each street within the community based on the characteristics in Figure 8; green attributed to streets with properties highly likely to be suitable for ASHP deployment to red with a low likelihood.

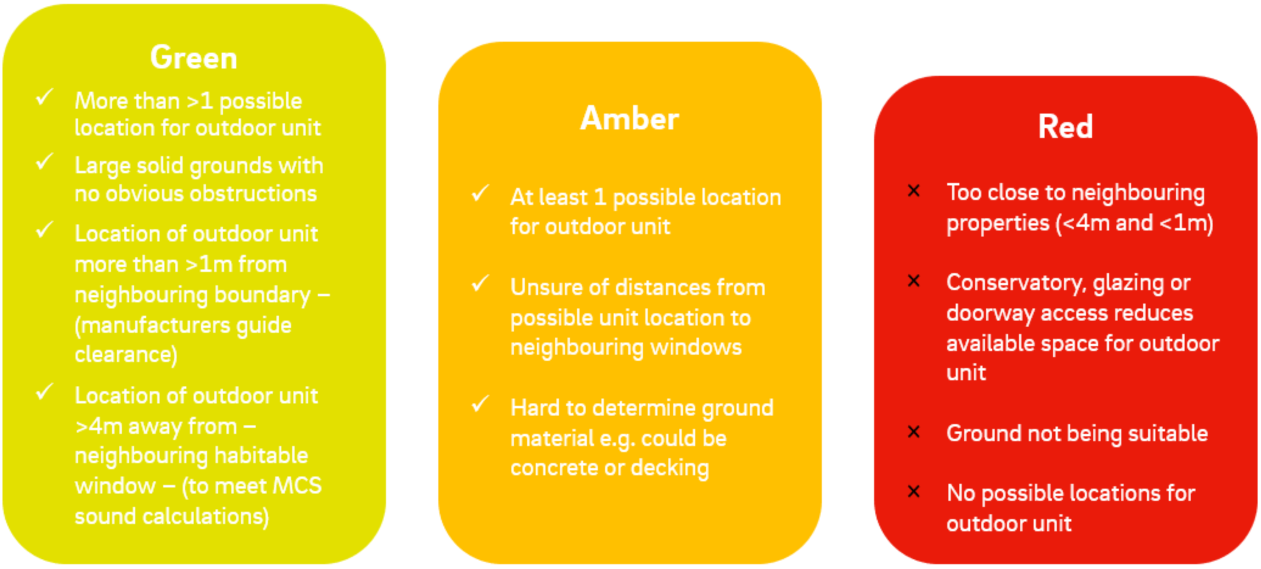


Figure 8: RAG status decision making factors

An extract from Appendix 5. Desktop suitability assessment results: a street-by-street overview, is shown below in Figure 9 with results consolidated to street level.

Count of MDTK1	Column Labels						
Row Labels	Council / housing association	Owner occupied	Privately rented	Grand Total		Street name	Soft survey RAG - houses on street
NE13 6BT	14.29%	85.71%	0.00%	100.00%	Zone 1	Brenkley Lane	1
NE13 6DL	0.00%	0.00%	100.00%	100.00%	Zone 1	Seaton Burn	1
NE13 6DN	0.00%	100.00%	0.00%	100.00%	Zone 1	Seaton Burn	2
NE13 6LQ	0.00%	100.00%	0.00%	100.00%	Zone 1	Cragside	9
NE13 6PA	0.00%	100.00%	0.00%	100.00%	Zone 1	Aintree street	15
NE13 6PB	0.00%	100.00%	0.00%	100.00%	Zone 1	Ascot Drive	45
NE13 6PH	0.00%	0.00%	100.00%	100.00%	Zone 1	Brunton Quarry	1
NE13 6PN	0.00%	100.00%	0.00%	100.00%	Zone 1	Ascot Drive	34
NE13 6QF	0.00%	100.00%	0.00%	100.00%	Zone 1	Cheltenham Close	35
NE13 6QG	0.00%	100.00%	0.00%	100.00%	Zone 1	Chepstowe Close	15
NE13 7AA	0.00%	75.00%	25.00%	100.00%	Zone 1	Horton Grange Road	6
NE13 7AB	0.00%	100.00%	0.00%	100.00%	Zone 1	Horton Grange Road	2
NE13 7AD	0.00%	100.00%	0.00%	100.00%	Zone 1	Prestwick Carr Road	4
NE13 7AF	0.00%	73.33%	26.67%	100.00%	Zone 1	March Terrace	14
NE13 7AG	0.00%	93.75%	6.25%	100.00%	Zone 1	Prestwick Road	18
NE13 7AH	0.00%	25.00%	75.00%	100.00%	Zone 1	South View	4
NE13 7AJ	0.00%	100.00%	0.00%	100.00%	Zone 1	Brunton Road	1
NE13 7AN	0.00%	80.00%	20.00%	100.00%	Zone 1	Brunton Lane	5
NE13 7AP	0.00%	100.00%	0.00%	100.00%	Zone 1	Coach Lane	4
NE13 7AQ	0.00%	100.00%	0.00%	100.00%	Zone 1	Prestwick Road	2
NE13 7AR	11.11%	77.78%	11.11%	100.00%	Zone 1	Strawberry Terrace	9
NE13 7AS	0.00%	70.27%	29.73%	100.00%	Zone 1	Coach Lane	45

Figure 9: Extract of suitability assessment results by street

To further validate our manual visual assessments, we used additional archetype data which collated suitability characteristics of varying property archetypes specific to those locations of interest. For example, this included internal characteristics such as boiler type (combi or standard), whether the property has an existing hot water tank and if not whether there was sufficient space to locate one, along with the level of disruption associated to the available locations. This was a key barrier to deployment we have experienced previously in Newcastle, recognising many customers now have a gas combi boiler and to transition back to an ASHP need to re-adopt a hot water tank within their property. An overview of this is shown in Appendix 3. Target area analysis: understanding existing insights.

Grid Analysis Methodology

To underpin the decision making on target areas and shaping deployment plans “grid centrically” with substations that could withstand 25% density of ASHP deployment, our project devised a staged approach to grid analysis to ensure an optimised and feasible deployment of heat pumps within Newcastle communities could be achieved. The intention was to establish visibility of all secondary substations, regardless of existing headroom initially, and use the analysis results to inform onward decision making and risk assessment. E.ON could then incorporate any investigation into areas with limited headroom if needed and viable within the project, while also reviewing those with sufficient headroom. A visualisation of the staged approach is presented in Figure 10 below, with early focus on agreement between NPG and E.ON as to the proposed grid analysis methodology E.ON would undertake and the associated data that NPG would need to provide to facilitate this successfully.

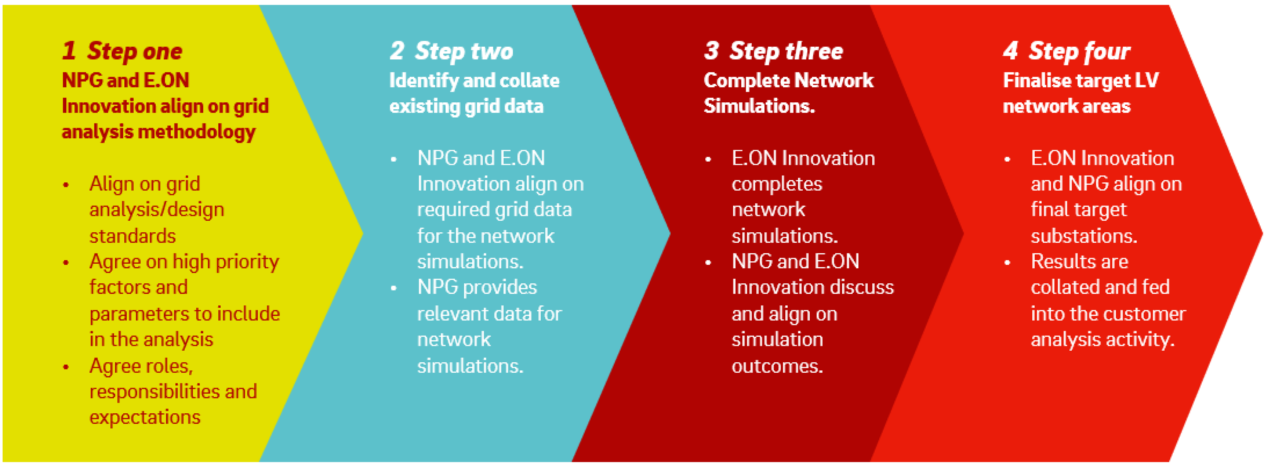


Figure 10: Step-by-step grid analysis methodology

E.ON Innovation and NPG agreed to the following through a series of meetings and workshops:

Step 1 – Northern Powergrid (NPG) and E.ON Alignment

- E.ON Innovation and NPG agreed on the grid constraint characteristics to be analysed in the high level grid analysis. These were:
  - Capacity constraints at the substation level (transformer max capacity)
  - Capacity constraints of cables on individual feeders
  - Voltage drop on individual feeders
- Assumptions agreed for the high-level model creation:
  - Customer Led Network Revolution (CLNR) Trials [Customer Trials - Customer-Led Network Revolution]and After Diversity Maximum Demand (ADMD) data to be used for estimating the residential electricity demand for heat pumps
  - A maximum voltage drop of 6% allowed on any one substation feeder, following guidance provided by NPG
  - A homogenous spread of customers and demand along each of the substation feeders e.g., assuming install of heat pumps equally distributed along the cable route linked to the substation

Step 2 – Identify and collate existing grid data:

In this stage relevant data was identified by E.ON innovation for the grid analysis. A series of meetings were carried out with NPG to align on what data was present in their system, what format it was in and the quality of the data. Newcastle substation and high-level feeder data was received from NPG. This allowed the capacity constraints at the substation level to be analysed and understood.

Step 3 – Complete network simulations:

E.ON Innovation utilised the following data sets to complete the grid analysis;

1. Substation name
2. Customer count
3. Number of feeders
4. Transformer rating
5. Current kW Max demand on the substation
6. Existing ADMD data for heat pumps from the NPG CLNR trials

Correlations were built from the ADMD data supplied from NPG. This allowed aggregated ADMD values (kW) to be calculated for different sized substations with varying numbers of customers. Three different heat pump deployment values were created for the feeders on the substations:

1. Assuming a minimum heat pump density of 25% on each feeder
2. Assuming an equal peak demand on each feeder with a minimum heat pump density of 25% under the secondary substation.
3. The maximum number of heat pumps that could be installed on a feeder before breaching the 100% capacity utilisation limit

Step 4. Finalise Low Voltage Network Target Areas:

The results from the initial grid analysis were overlaid on to a map of Newcastle city, with a particular focus on where the secondary substations intersected with priority zones / communities already identified. This allowed for;

1. Geographical visualization of all secondary substation locations and the associated capacity results e.g., whether achieving 25% density would breach the capacity utilisation limits or not. An extract is shown in Figure 11 , with all substations with breached capacity marked with a red cross icon and all with capacity a green tick icon for ease of reference. The secondary substation "CAROL" is highlighted for reference, showing the location postcode and number of properties attached to the substation.

2. Assumptions to be made on the streets / homes that would be connected to each secondary substation based on substation name, proximity to homes, volume of homes attached to the substation, potential overlap with other neighbouring substations. The preferred route was to use specific asset data from NPG which could identify addresses attached to each substation, however this wasn't made available during the project (this is further outlined in the Results section 4.2.1).

3. Decision making on the optimum target substations for dense deployment of ASHP's, when combined with existing propensity modelled target area analysis relating to suitability for ASHP.

Figure 11: Extract of substation locations, overlayed on target area analysis zones

5.3 Work Package 3. Property Archetype Modelling

Step 1. Archetype identification and ASHP product alignment

This work package activity had a key dependency on work package 2. whereby assessments of suitable target areas for large-scale dense deployment were underway. It was vital to understand the prevalent property archetypes in these priority areas to make informed decisions on ASHP product requirements and alignment to the HPR project requirements. This was to ensure we could continue to validate the suitability of the properties for ASHP install (and hybrid heat pumps if needed, keeping to under 20% of the total expected install volumes for this product type). As outlined manual visual desktop assessments were being undertaken, these were supplemented where appropriate with comparison to existing survey, design and install data: reviewing external and internal photos, floorplans, property dimensions, age band, build type, heat pump design outputs (heat loss, flow temperature modelling, radiator sizing). We considered carrying out additional sample surveys if needed to inform the analysis.

It was recognised this insight could also inform the propositions we have available for customers and an understanding of what the most suitable funding route could be e.g., a hybrid install aligned to a Heat as a Service proposition.

Step 2. ASHP survey process review

To identify ways in which the ASHP surveying journey could be improved for co-ordinated large-scale dense deployment of heat pumps, taking into consideration the following factors: customer, time, cost, logistical deployment, the accuracy of data collection and implications for the accuracy of the heat loss calculation.

This was completed through an in-depth case study of 3 existing ASHP customers with varied property archetypes and complexities of build (e.g., number of rooms, shape of property and floorplans, extensions/porches). The methodology would review and compare the existing survey approach E.ON employ vs more innovative approaches, investigating three different solutions to calculate heat loss for existing properties, accuracies of the outcomes and the impact on the customer journey.

The three solutions considered in this study are:-

1. E.ON's standard technical survey process and representative of typical industry approach - manual survey completed by a surveyor, typically utilising a laser measuring tool and manual completion of a survey form while on site, along with taking supporting photos. Key data points from the survey results then need to be manually identified and input into an online Heat Loss calculation and design tool (in this case the Daikin Stand by Me which can be accessed through the Daikin online portal Stand by Me (daikin.co.uk))

2. An innovative survey carried out by Nationwide Drones, utilising a 2-person team to carry out an external drone inspection and an internal mobile laser scan. Using state-of-the-art NavVis VLX Scanners, the operatives circulate the property to generate comprehensive digitised and fully annotated models, that complement and link up with aerial survey data from the drone to provide a complete model or 3D twin of the property. The heat loss calculations can be automated from the 3D model/digital twin of the property. Drone Specialists in the UK | Nationwide Drones

3. An innovative survey carried out by Veritherm measuring in-situ thermal performance of the building, measuring the actual amount of energy that is lost through the thermal envelope of a building:

"The Veritherm test takes place overnight and is activated by their software platform. A measured heating load is applied to the building during the first phase, before the building is left to passively cool during the second phase. These will give you a thermal performance rating, the amount of heat that is lost through the fabric (expressed in watts per kelvin), an understanding of the measured performance compared to the designed performance (i.e., the performance gap) and an average U-Value for the building. The system measures the internal and external temperatures every minute. Veritherm Testing Brochure V5

Alongside the three surveying solutions, air permeability tests and in-situ u-value measurements have been undertaken to provide benchmark data for overall result comparison.

The detailed scope and explanation of each survey solution is contained in Appendix 10. Nationwide Drones: survey approach review and case studies.

Step 3. ASHP design process review

The objective of this activity was to complement the surveying case studies carried out in Step 2 and provide recommendations on potential process improvements for accurate heat pump designs and subsequent product specifications. Part of this was to understand whether oversizing may be occurring when specifying a heat pump because of heat demand and/or hot water demand calculations and whether this can be mitigated.

Both factors are critical in providing customers with the most suitable and cost-effective solution and addressing barriers to deployment such as upfront capital cost, disruption, and confidence in the technology.

The approach taken was focussed on four core design elements to investigate what improvements, if any, can be considered during the design process. Each of these considerations had several factors which may affect the accuracy of the estimate within the current methodology. This examined each of these factors, their impact and the level of risk associated with the accuracy of each factor within the current design methods.

- **Energy (kWh)**
  Currently heat pump system performance estimates that include energy calculations are made available to customers, clearly showing the running costs of the proposed system. Any inaccuracy in the EPC assessment, especially when combined with factors that may affect the SCOP, may both reduce design accuracy to a significant degree and negatively impact customers' decision-making processes. Over-estimation may discourage customers from proceeding if they expect any return on investment to take longer. Equally, under-estimation may potentially result both in liability claims and reduced consumer confidence should running systems prove more costly than had been forecasted.

- **Heat Loss (W)**
  The kW capacity of the heat pump is determined by factoring in heat loss to the design methodology and relevant conditions. Heat loss from a property can be caused by key factors such as the U-Values of the building's fabric, internal and external air temperatures, air fluctuations per hour, and air change factors associated with each room. Inaccurate calculations of heat loss factors may result in poor performance of the heat pump system, either through its inability to achieve target temperatures or short cycling of the system causing increased energy costs.

- **Efficiency (SCOP)**
  Seasonal efficiency is the way of measuring the true energy efficiency of heat pumps over an entire year. This measurement aims to provide a more realistic indication of the energy efficiency and environmental impact of a system. The Seasonal Coefficient of Performance (SCOP) is the average Coefficient of Performance (CoP) of a heat pump over the full heating season. The CoP is the ratio of heat output (in kilowatts) over the electrical input (in kilowatts) at any given time. Many factors impact both the SCOP and COP as identified in this feasibility report.

- **Cost (£)**
  Installation and running costs play a critical role in customers' decision-making processes. They pay particular attention to likely return on investment (ROI) from savings made post-installation given a considerable variation in capital costs in comparison to fossil fuel heating systems and marketing messages that emphasise prospective energy savings. Potential ROI may be miscalculated as a result of factors such as over-estimation of the system (including specification of key components, pipework, and emitters) combined with over-estimation of energy consumption and output, and inaccuracies within the existing and proposed energy profiles.

Our research focused on the factors within the calculation methodology for heat loss and energy demand to understand what, if any, improvements could be made to accuracy and efficiency**.** The research included a review of 43 existing ASHP installations deployed within Newcastle, based on real-world performance data captured through the properties monitoring systems, the specification of which meets metering and monitoring service package (MMSP) requirements. Demand profiles across a range of housing and consumer types were also used to test the accuracy of the current method of design calculations and compared against real-world performance data.

The detailed scope and explanation of methodology is outlined within Appendix 11. Heatio Heat Pump Ready Report.

Step 4. Explore the Heatio Smart Home Energy Monitoring device

During feasibility we explored how the Heatio Smart Home Energy Monitoring device could be integrated into an innovative, optimum air source heat pump customer journey, building our understanding of what the device is, what barriers to deployment it might overcome, and how it could work alongside other surveying approaches. We reviewed whether the Heatio Smart Home Energy Monitoring device supports more accurate design calculations and thus the most appropriate heat pump solution outcomes for customers. And in doing so serve to accelerate the installation of heat pumps appropriate to the thermal profile of each property, enabling customers to access efficiencies and related cost savings in a timelier manner.

This was carried out via a desktop review of the proposed technology, within the context of supporting co-ordinated large-scale dense deployment of ASHP's. The detailed scope and explanation of the review methodology is explained further within the Appendix 11. Heatio Heat Pump Ready Report.

What is the Heatio Smart Home Energy Monitoring device and how does it work?

The Heatio Smart Home Energy Monitoring System combines machine learning, smart meter data, discreet sensors, and intelligent building information modelling technology to monitor the real impact of energy improvements and better inform future decision-making for customers.

The Heatio Smart Home Energy Monitoring System delivers an informed measurement of the properties' Heat Transfer Coefficient (HTC) while capturing their operating performance during seasonal weather fluctuations and occupancy usage. We then use a combination of machine learning, neural networks, and existing housing data to calculate sophisticated forecasting models which can support the PAS2035 assessment process, enabling informed decision-making when considering energy improvements in the drive towards Net Zero.

This solution represents a significant advance on current assessment processes, such as PAS2035 and Energy Performance Certificates, which rely on visual inspection procedures that are both time-consuming and invasive. Furthermore, they fail to take adequate account of important factors such as thermal bridging and airtightness as these cannot easily be seen by an inspector. The outcome of our process will be a unique evidence-based improvement strategy.

Two profiles are produced: an architecture type and an occupancy profile. The occupancy profile allows energy consumption and carbon emissions to be reliably predicted, providing the required data for bespoke forecasts of the financial savings that can potentially be realised. It also offers an accurate assessment of installation costs which, when offset against these savings, permit each household to arrive at an informed decision about the benefits of retrofitting with budgeted roadmaps to support this.

Once established and combined with architecture profiles, occupancy profiles offer a reliable tool for intelligent, evidence-based recommendations for retrofitting of similar properties. As the Heatio Smart Home Energy Monitoring Solution allows for measurement of improvements as they occur it is possible to assess accurately whether improvements realised closely correspond to assumptions made at the design stage. These in turn lead to more sophisticated and nuanced strategies informing future improvements of buildings of the same architecture profile.

The Heatio Smart Energy Monitoring Solution is designed to work in harmony with smart meter devices currently being installed across properties in the UK. Readings can be taken directly from these systems and by the deployment of a small number of discrete sensors placed throughout the property [Appendix 11. Heatio Heat Pump Ready Report].

Step 5. Stream 2 project alignment

Through the attendance of BEIS organised workshops with Stream 2 applicants, E.ON and our project consortium assessed the relevance of research and technological developments being deployed in Stream 2 and their alignment to E.ON's approach to co-ordinated large-scale deployment.

5.4 Work Package 4. Consumer insights and propositions

Step 1. Consumer segmentation analysis

Working with E.ON's internal consumer insights team, the following approach was taken to inform insights gathering and decision making on deployment planning and viability for Newcastle City. This aided the marketing approach by identifying the highest propensity customers, including the groups of highest affluence, appetite for new tech and environmental awareness.

a. **Segmentation Analysis;**

Figure 12 provides an overview of the underlying principles and basis of this analysis. Mosaic Segments are a way Experian group customer types based on a large array of characteristics and give us an opportunity to better understand customers, their drivers and needs.

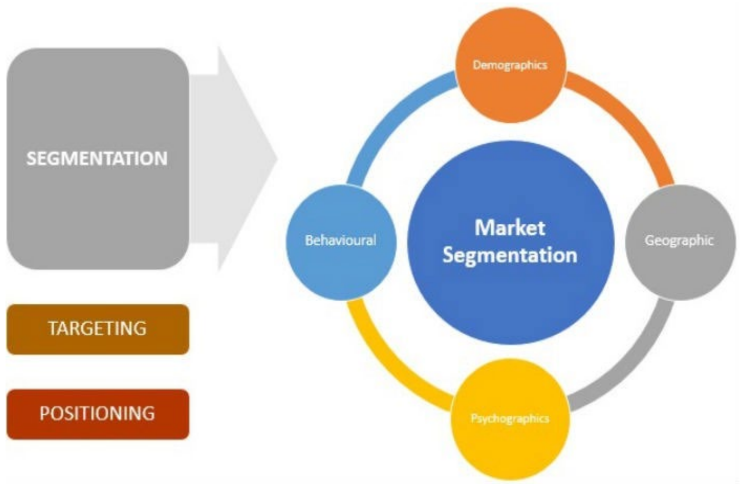


Figure 12: Principles to segmentation

What is Mosaic?
Mosaic uses variables from a combination of Experian proprietary, public, and trusted third-party sources - including research findings and behavioural data - to build a picture of the latest UK consumer and social trends. Mosaic | Consumer Classification Platform | Experian Business

Figure 13 shows the step-by-step methodology to understand the target areas, and then the application of the mosaic data and associated segmentation categories relevant to these specific target areas.

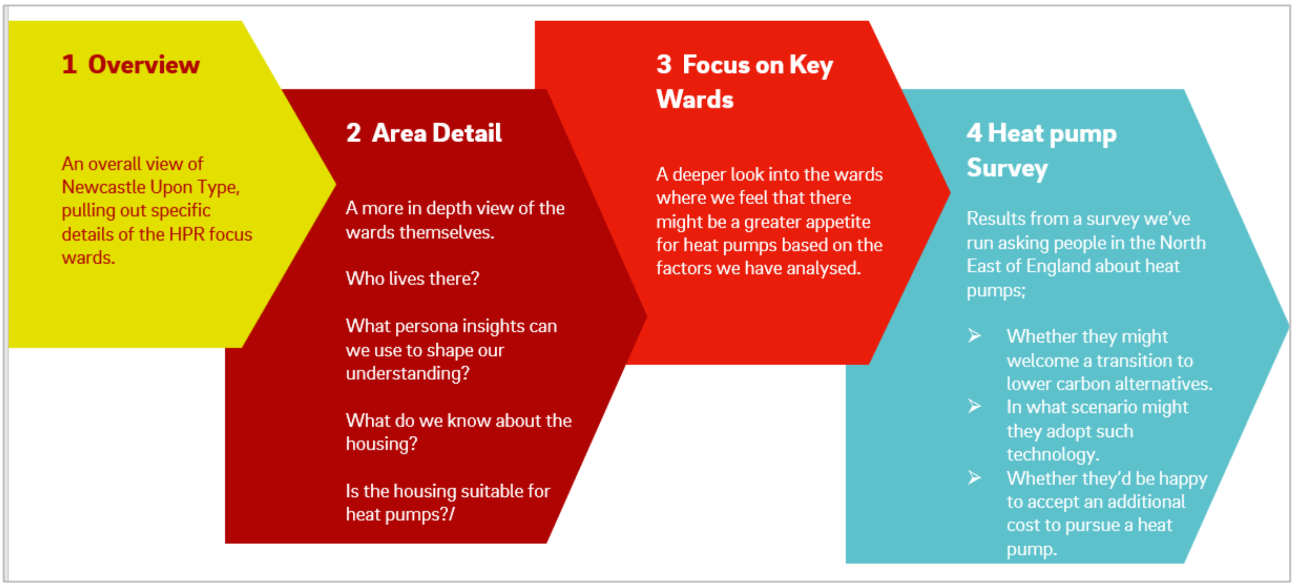


Figure 13: Customer insights gathering approach

b. Propensity modelling

To build upon the segmentation analysis approach, E.ON developed a propensity model, a method used within the E.ON business to assess specific markets and customers. These models are comprised from criteria based on customer characteristics that best fit our target audience. The model then shows the likelihood of customers to adopt products and services based on their criteria 'fit'. The propensity model is then used to inform consumer behaviour and is linked back to key Experian Mosaic data fields down to postcode level. The propensity approach interacts with WP2 target area analysis to underpin deployment decision making and support relevance of engagement activity and marketing strategy in WP5 dependent on the customer segment categories prevalent in each community.

In this model favourable factors will be scored, the logic/attributes used are outlined below:

- Household income: Over £100k = 5pts, Over £75k = 3pts
- Previous Install in postcode: 4pts
- Previous Lead in postcode: 2pts
- Over 75% of postcode is a suitable property: 5pts
- Over 75% of postcode is Owner occupied: 3pts
- Over 50% are in "settled/comfortable owner" segments: 3pts
- In highest affluence/engagement mosaic segments: 2pts
- Above average Solar interest: 1pt
- Above average Energy engagement: 1pt
- Likely to have £50k+ savings: 1pt
- Interested in reducing energy usage: 1pt
- Likely to have an EV: 1pt
- Likely to have solar: 1pt
- Likely to feed back to grid: 1pt

Age and lifestyle of the residents is also a key factor for consideration; the Electrification of Heat project taught that 'disruption' for the resident was the second most prevalent reason for cancellation, even with cost being removed as a barrier.

A database of scoring will be collated, and a review of propensity results completed, allowing for direct comparison between postcode areas.

c. Other market analysis

Other analysis e.g., Cost of Living review will be understood, to ascertain any potential implications on our customer insight positioning e.g., the changing income metrics associated with the assumptions about which customers fall within an "able-to-pay" status.

Step 2. Consumer proposition review

The feasibility project explored the Heat as a Service (HaaS) proposition as an alternative way to buy renewable warmth and if this is a beneficial addition to E.ON's current proposition portfolio, in support of large-scale dense deployment of air source heat pumps in Newcastle.

Heat as a Service helps customers to save money and stay in control of how and when they heat their home by removing the upfront cost, instead paying only for the heat they need. This solution works in a similar way to car finance or a streaming service. Rather than paying for your heat pump upfront, you'll make an affordable monthly payment that covers both the cost of the heat pump and the heat that has been used. At the end of the agreement, you can choose to either buy your heat pump by making a balloon payment or go onto another contract with a new heat pump installed free of charge.

A detailed modelling exercise was completed to better understand:

- What are the typical costs associated with the components that would typically be included within a HaaS Service Package?
- What would be the typical cost of a HaaS Service Package to these customers?
- What if any assumptions could be made to determine how a customer's energy requirements change post installation?
- What if any certainty could be obtained from the data to deliver confidence to the financial markets as to how much energy will be required & billable in warm hours?

We'll also initiate understanding of what types of customers would be likely to engage in this proposition vs currently available finance packages (e.g., low interest loans) and consider how this could be incorporated into E.ON's customer journey.

Step 3. E.ON Home and delivery high quality aftercare to customers

E.ON will assess the delivery of improved aftercare through the existing E.ON Home App which is already in use for E.ON customers with solar panels, battery storage, EV smart charging and Tado thermostat as part of their core solution offering, as shown in Figure 14. E.ON Home's role is to make it easy for all customers to manage and optimise their energy use, and benefit from low carbon propositions and services.

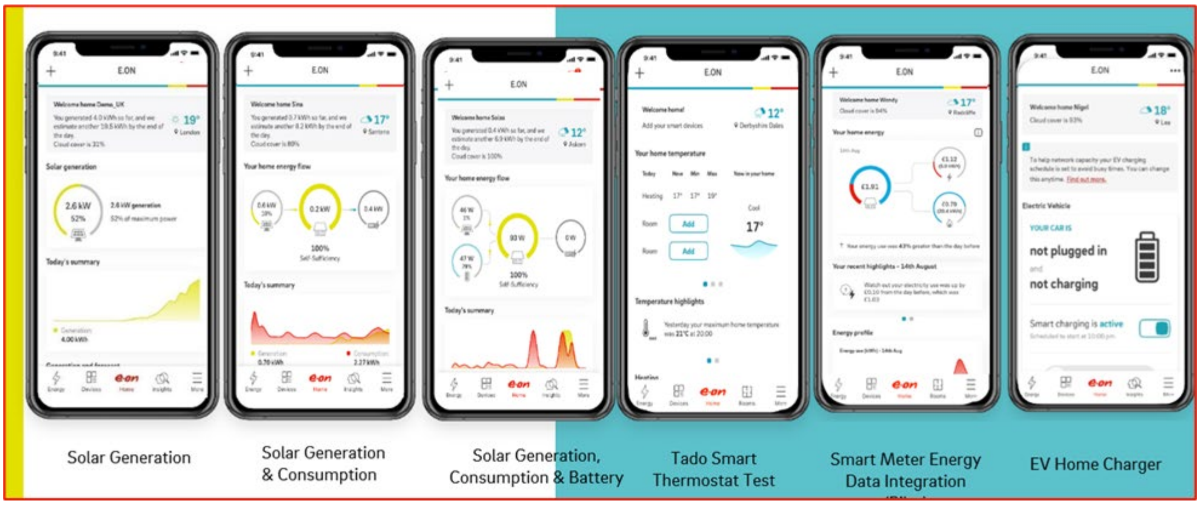


Figure 14: E.ON Home app

Completion of consumer use cases for an ASHP offering were considered to understand varying features and their importance to customers – for example control & scheduling, visualisation, optimisation, coaching, and maintenance & servicing notifications. Along with how this could be integrated into the ASHP customer journey and aligned to the proposed product portfolio. Insights were collated through a number of routes;

- Consortium expert input based on industry knowledge of aftercare pain points and previous customer experience feedback
- Direct consumer research and attitudes
- E.ON regional business unit input based on live ASHP offerings already viable (potentially differing use cases / commercial & strategic drivers to review)

Viability will be determined, along with the roadmap for readiness for deployment.

5.5 Work Package 5. Community Engagement

We expect to target green-minded, early technology adopters to create momentum, using our successful Electrification of Heat Newcastle case studies to then promote heat pumps to a broader subset of Newcastle residents with clear transparency on how this compares to gas central heating.

We recognise that we will need to ensure transparency, openness, and creation of opportunities for a diverse range of key representatives from across the city. During Phase 1 we will create a consultative forum with community energy organisations, community leaders and Newcastle residents to co-design the final consumer engagement, campaign and targeting.

Step 1. Community Engagement planning/design

a. Local authority community team – stakeholder engagement with Newcastle City Council's community team to collaboratively agree requirements of a co-ordinated and suitable plan.

b. Community leaders / organisations – identification of, and engagement with relevant stakeholders aligned to the target, priority communities. Determine prevalent community activity within each area, researching active community groups either local authority led or private groups.

c. In person events – to start to gather direct community input and appetite.

Step 2. Marketing and engagement co-design

a. High level market review / competitor analysis of how ASHP offerings are marketed to customers, to inform how our approach on Heat Pump Ready needed to stand out, and secure better cut through and to achieve successful dense deployment and high volume of engagement within each community.

b. Collaborative and iterative brand and marketing design workshops, informed by points a, involving the local authority, E.ON project team (and E.ON Go to Market team) and Heatio – led by our appointed marketing agency TwentySeven Design, based on their local knowledge, local authority branding experience and performance on the Electrification of Heat project.

c. Propensity Model insights to steer marketing strategy. *E.g., adaptations to the engagement messages dependent on customer segment, placing them at different points within the marketing strategy.*

Step 3. Online digital pre-qualification tool and integration of early customer journey triage.

We will explore the feasibility of extending our digital pre-qualification tool the Green homes grant finder | energy efficiency | E.ON (eonenergy.com). Currently the core purpose of the tool is in assessing customers for eligibility for grant funding support through E.ON, ensuring customers in fuel poverty receive the best energy efficiency offers available (for example Home Upgrade Grants, Local Authority Delivery schemes, Energy Company Obligation (ECO) funding). However, will we consider if it can successfully be applied to support able to pay focussed propositions, aligned to dense deployment of ASHPs.

We will review the features of the tool, current performance metrics and development roadmap to understand if and how this will add value to the ASHP customer journey. Does this alternative route better support co-ordinated dense deployment?

6. Findings

6.1 Work Package 1

Outlined below are the key findings from each of the work packages based on the methodology described in section 4.1.

6.2 Work Package 2

Significant volumes of properties within the shortlisted target wards in Newcastle city have a high likelihood of suitability for transition from gas boilers to ASHP.

- Based on the postcode-by-postcode review process of c.31k properties, across out target communities, we identified c.58% with a high likelihood for ASHP suitability and, and a further 22% with medium likelihood. Providing a significant volume of c.25k properties as the initial basis to build a deployment plan from and provide confidence in large-scale deployment being feasible.

Total	31,646
Green	18,446
Amber	6,918
Total potential	**25,364**
% Total	80%

Figure 15: Suitability review results (volume of properties)

- The detailed street-by-street results are included within Appendix 5. Desktop suitability assessment results: a street-by-street overview.
- The consolidated results have been incorporated into the Propensity Model, outlined in 4.2.3 and into the "priority zoning map" shown in Figure 5.

The grid analysis of the available Newcastle area network showed that 57% of substations would go over the 100% utilisation of capacity following a 25% density coverage of heat pumps.

Two example substations from the analysis are presented in Figure 16. It can be seen that Abberwick substation doesn't have enough capacity on an entire substation level (highlighted red) which is why the maximum heat pump coverage applied against all feeders is 0. The opposite is true for Abbey substation where a 25% heat pump deployment results in an overall substation capacity utilisation of only 91.5%.

Substation Name	Way No / Substation	Premises Count	Proportioned Transformer Rating (kW)	Customers with a heat pump (assuming a 25% spread on each feeder)	New Feeder Demand (kW)	Feeder Utilisation (%)	Entire Substation Utilisation (%)	Feeder Heat Pump Number (based on equal peak loads on all feeders)	Maximum Possible Heat Pump Coverage on Each Feeder
ABBERWICK	0101	4.0	12.5	1.0	17.2	137.9	137.9	N/A	0.0
ABBERWICK	Substation	4.0	12.5	1.0	17.2	137.9	137.9	N/A	0.0
ABBEY	0101	28.0	57.7	7.0	70.1	121.4	91.5	3.0	4.0
ABBEY	0103	53.0	109.2	13.0	124.2	113.8	91.5	8.0	9.0
ABBEY	0104	101.0	208.1	25.0	182.2	87.5	91.5	26.0	35.0
ABBEY	Substation	182.0	375.0	45.0	309.7	82.6	91.5	54.0	74.0

Figure 16: Extract from substation capacity analysis

The full detail of the grid modelling results can be found in Appendix 1. Grid analysis: substation capacity results.

It is important to note, since the completion of this project NCC have had a continued focus on developing and building upon the grid analysis completed and continue to work with NPG to review available datasets. They linked the NPG HPR data provided to NPG's spatial data and have found 37% of secondary substations in Newcastle weren't provided within the HPR dataset to E.ON. When subsequently flagged to NPG they confirmed they had sent a subset of specifically for the HPR project and excluded sites with single connections, but in doing so there are other substations with multiple customers that were excluded.

Very few substations with sufficient capacity for 25% ASHP deployment intersect with our priority target zones & communities of higher affluence, limiting scale of a dense deployment feasible within a Phase 2 project.

A substation-by-substation review was completed. Initially via inserting an overlay of data on to existing maps of our priority zones and understanding where the data intersected. An extract of this is shown in Figure 17.

Then by grouping streets/postcodes assumed to be connected to the substation – cross referencing with postcode level income data, propensity metrics, desktop suitability assessments and tenure. This was applied to all substations with potential to support 25% uptake of ASHP and remain within c.120% capacity (based on DNO feedback of indicative operating limits) within priority zones for deployment. The results and analysis approach are shown in Appendix 2. Substation mapping and comparative analysis against potential target areas, with only c.5-6 substations left for onwards consideration.

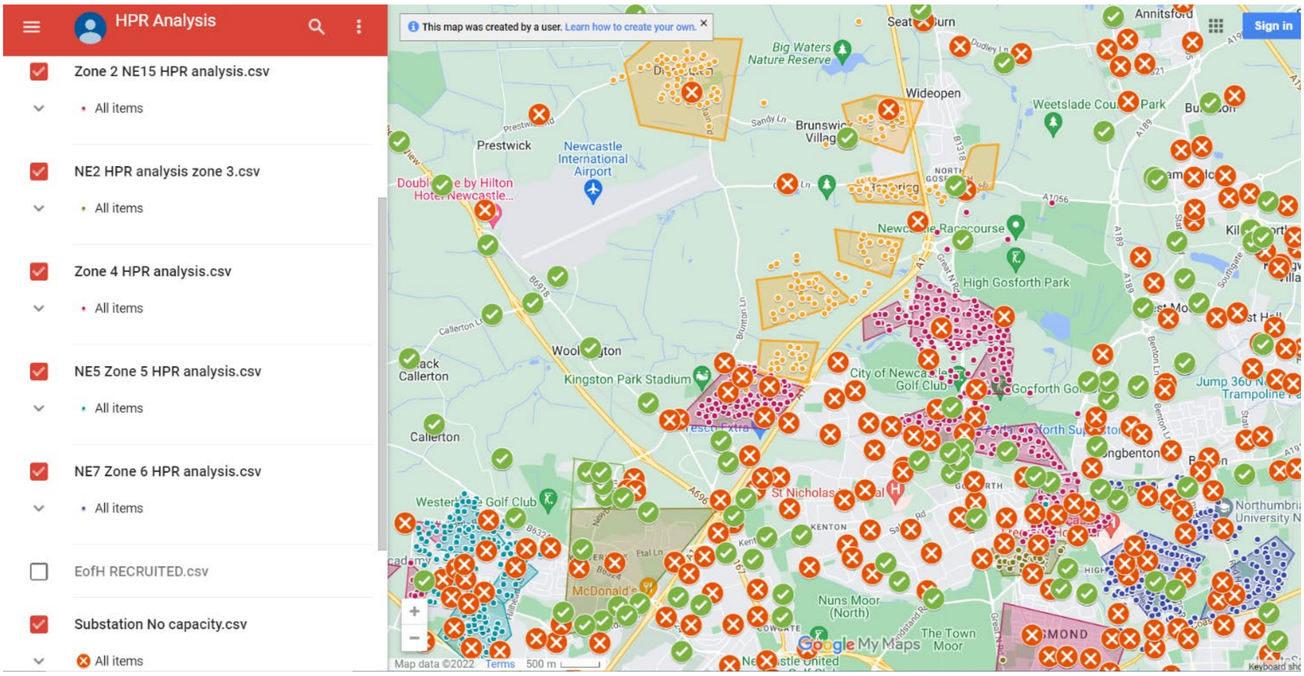


Figure 17: Substation capacity results in priority zones for deployment

Further detailed planning would be required with Northern Powergrid to understand roll-out of substation upgrades and associated lead times and prioritisation, potential substation monitoring requirements and consideration of other innovative grid tools to support localised capacity management. E.ON did consider its own innovation substation level management via Dynamix and the scope for inclusion in this project to support utilisation of a higher volume of substations i.e., ones with limited headroom. However, this was not an eligible cost that could be funded from within the project. Another alternative was to explore a Strategic Innovation Fund bid (SIF) to work concurrently alongside our Heat Pump Ready deployment plans, offering another source of funding and opportunity to explore grid innovations. However, a clear appetite and commitment from NPG to explore all routes to maximising grid availability and offering E.ON a level of certainty via a roadmap for this activity was not established within the timescales of this project. This was a significant factor in our onwards decision making on the feasibility of a large-scale, dense deployment plan for ASHPs for Newcastle.

Since the completion of the project, NPG working together with NCC, have used the target area analysis from this project to support decision making on secondary substations to prioritise for substation monitoring to continue to further localised learning in support of Low Carbon technology deployment across the city.

The complete grid analysis model was not achieved based on limitations in the collaboration from the DNO, increasing the level of risk attributed to viability of deployment locations.

It is key to note here that E.ON did not have access to asset data sets from NPG that could effectively and accurately link which property addresses were associated to each of the secondary substations, and each of the feeders off that substation. This, as outlined above, meant geographical assumptions had to be made reducing the robustness of our deployment planning and increasing the level of risk within our decision making.

As such it was anticipated that this could further reduce opportunities to convert properties to ASHP deployment and impact our ability to reach the required 25% density threshold.

NPG confirmed in our early discussions around scope and project requirements that this asset data could be made available however this point was revisited repeatedly, and it was subsequently outlined that it would not be made available without necessary NDA's being agreed and confirmation from the regulatory team that the data could in fact be shared, along with engagement with another team who hold the asset data. Significant time by both parties then went into negotiating mutually acceptable terms for the NDA during August, with E.ON issuing the final document at the end of August for execution. The NDA remained un-signed and E.ON continued to request from NPG updates pertaining to the provision of the asset data through to mid-October. This also included the provision of data to allow the completion of capacity and voltage drop calculations on a cable level. Both established as key to further ascertain spatial implications of ASHP deployment and how to best manage this within a co-ordinated deployment plan.

Upon completion of the Feasibility Study the asset data remained un-shared with no agreed route forward between E.ON and NPG to make this data available at a later date i.e., in support of deployment mobilisation should the feasibility project be successful. This meant a continued risk that would have to be carried forward into deployment, at a point when our confidence in this critical stakeholder was very low.

This outcome also impacted the council negatively. They recognised the significant value of E.ON's grid analysis and were hopeful this project and the focus on close collaboration with the DNOs (in this case NPG) could achieve a completed grid model of Newcastle (that included property asset data) which could be used to inform this project robustly and also other net zero deployment planning – a model they had not been able to achieve at scale themselves from manual analysis and limited data availability prior to the feasibility project. Unfortunately, this objective could not be delivered successfully.

6.3 Work Package 3

Step 1. Archetype identification and ASHP product alignment

The review of existing ASHP survey and design data across Newcastle offers confidence in alignment to the core product offering of low temperature ASHP, along with the use of hybrids to overcome specific barriers to deployment e.g., internal space constraints including hot water tank positioning.

The output of the mapping exercise was completed to show: the spread of successful surveys/designs, the location of successful installs, the location of instances of customer or technically led cancellations/non progression (used to indicate suitability barriers), as the basis for identification of representative suitable archetypes to take forward into deployment planning and product portfolio decisions. This data was collated from the Electrification of Heat Demonstration Project delivered across Newcastle.

An extract from the analysis is shown below in Figure 18 with results contained within Appendix 4. Typical archetype identification and suitability review, whereby we completed a review of 21 differing sub archetypes representative of the community, across the 6 priority regions for deployment. This included:

- all core property types bungalows, semi-detached, detached, end terrace (and a smaller volume of mid terraces).
- a range of age bands from 1930's through to modern homes built post-2010.
- 23% of the 21 sub archetypes had limited space for a hot water tank and thus assessment on a property-by-property basis would be needed to ascertain the most suitable solution i.e., ASHP or hybrid considering customer needs and acceptance of internal disruption.
- all had evidence of having suitable external locations for the heat pump unit.

- all could remain within planning permitted development rules for noise.
- there are no properties within this analysis that are of pre-1930's of solid wall or non-traditional build construction types as these are not prevalent within the target areas for deployment.

The use of this analysis can also support informed decision making about the specific heat pump manufacturers products to procure to ensure a robust and cost-effective product portfolio and a deployment model that meets the needs of varying housing stock (and customers).

We can also start to make informed assumptions on the likely size of units needed, associated capital costs of install and link to available finance propositions – collating this information for each community, further informing the bespoke engagement strategies, as outlined in work package 4.

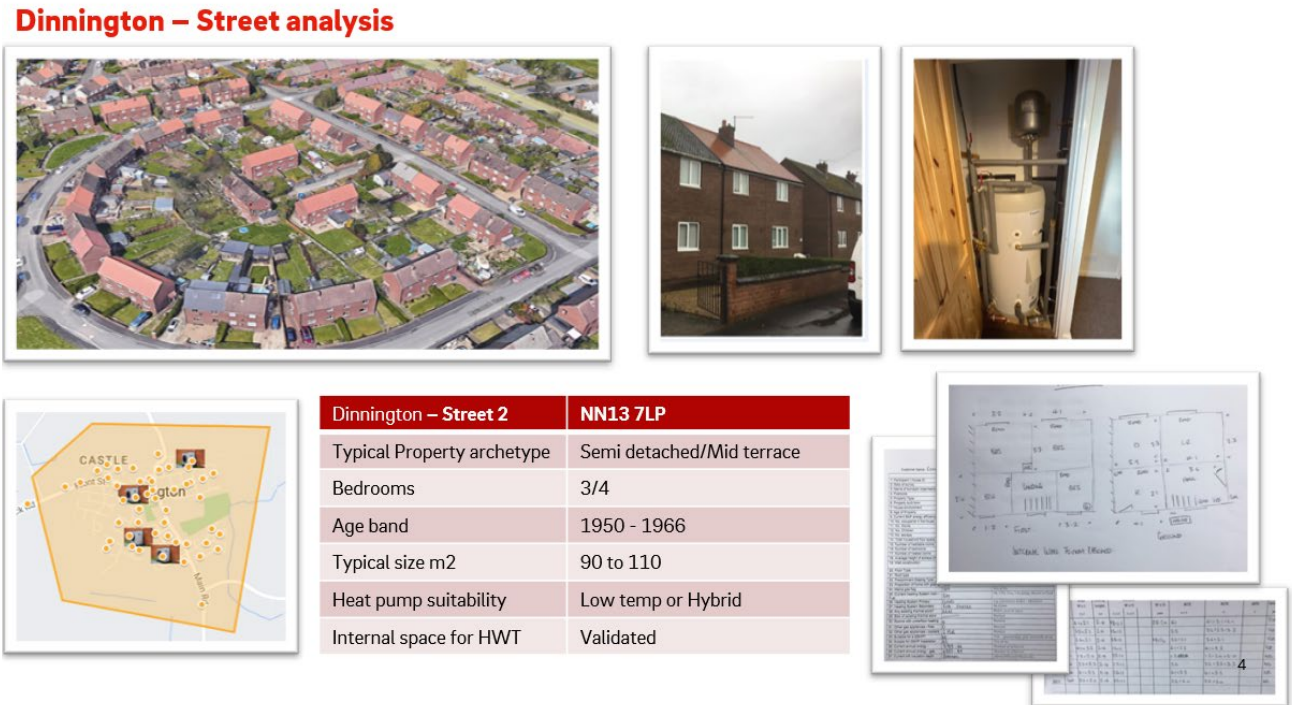


Figure 18: Showing a typical archetype and associated characteristics within Dinnington

Step 2. ASHP survey process review

An innovative survey approach could be applied to co-ordinated dense deployment with the potential to deliver measured customer journey efficiencies, customer benefits and improved data gathering accuracy.

Several qualitative factors were considered to comparatively assess the 3 surveying approaches to understand the benefits and challenges of each and considerations of how they could support an optimum customer journey for large-scale, dense deployment. This has been summarised in Figure 19 using a RAG status and then explored in more detail below:

Factors	Approach 1	Approach 2	Approach 3
	Standard Survey	Drone survey	Veritherm survey
Survey time (hrs)	2.5	0.5	12
Workforce scalability			
Accuracy of data collection			
Digitisation/automation of the design process			
Economies of scale			
Customer engagement			

Figure 19: Summary of the qualitative results of the comparative assessment of survey approaches

1. **Survey time and customer journey efficiency**

   Approach 1, the standard survey, takes on average 2 hours to complete (property size dependent) whereas Approach 2, the drone survey, offers a reduction in individual survey time to 0.5 hours because of the digital internal scanning being a much quicker route to gathering a large amount of data points / measurements and imagery. Comparatively the Veritherm survey takes c.12 hours through the overnight measurement period, plus the time needed to set up of the necessary equipment and removal of equipment the following morning approximately 1-1.5 hours.

   Considerations also then need to be made about the speed of survey results data collation and transfer onwards to the recipient (in this case to E.ON for review and ASHP design completion/approval). Typically for standard technical surveys it could take c.3-5 working days before the survey results are and supporting evidence documents are manually collated and uploaded from the supply chain to E.ON's CRM system.

   For Approach 2 the full suite of results is available within 2-3 working day post survey completion, to allow time to convert the laser scan point cloud into the full 3D model. However, fabric information, photos and additional specified information captured is received straight into the project once submitted on the iPad and the following morning, post survey, a 3D replica of the property is available online, which is interactive to navigate and measure from, giving the designer the opportunity to navigate the property remotely and start their design process promptly. [*Appendix 10. Nationwide Drones: survey approach review and case studies*]

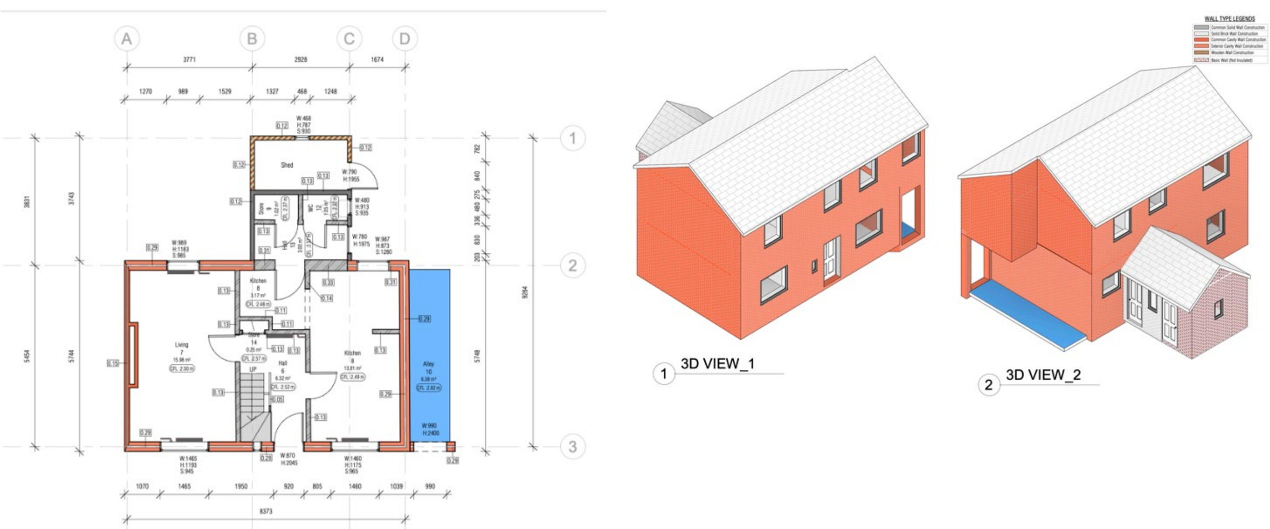


Figure 20: 3D replica based on data captured at survey

For Approach 3, the results are available within 1 working day: data is uploaded to the cloud and analysed automatically, with the proprietary algorithms returning a definitive answer as soon as the test is complete [Appendix 10. Nationwide Drones: survey approach review and case studies]. However, there are challenges of how these results are translated into the current MCS design process, outlined further in point 4 below.

Based on this we see clear benefits to Approach 2, particularly as this not only increases the volume of surveys that can be completed in a day (up to 8) it supports moving a higher volume of customers through the heat pump customer journey more quickly and in co-ordinated geographically specific batches, supporting onwards installation planning and downstream efficiency realisation.

2. **Workforce scalability**
   Current Approach 1 surveying methods are highly reliant on experienced and skilled technical surveyors to accurately measure and assess property suitability, therefore has limitations on increasing the workforce locally to service large-scale deployment volumes, without the commitment and cost of significant training programmes and quality oversight/audit mechanisms. Approach 2 has developed in such a way that it can be undertaken with only basic training and still offer accurate, consistent, dependable data sets. As such there would be little challenge in scaling a local workforce to tackle large-scale deployment. Approach 3 requires skilled set up of the necessary equipment to ensure accuracy of measurements but arguably less workforce training commitments than Approach 1. [Appendix 10. Nationwide Drones: survey approach review and case studies]

3. **Accuracy of data collection**
   Manual surveying practises are dependent on and open to human error, including but not limited to inaccuracies in the measurements themselves, the recording of the measurements or supporting data (e.g., positioning and size of radiators or the available space to position the outside fan unit for the ASHP) and the interpretation of the space/room configuration into a 2D floor plan. Approach 2 has shown consistent accurate dimensional information results, with 3D model output and detailed CAD floor plans. If the same property was surveyed by ten different surveyors as per Approach 1, the results could vary between each surveyor. However, if the property was scanned 10 times, there would be little to no variation in the dimensional results, providing accurate, replicable, and consistent results. [Appendix 10. Nationwide Drones: survey approach review and case studies]

   Equally, Approach 3 was proven to capture reliable, actual, measured data specifically reflecting the individual characteristics of each property and doing so very consistently, thus helping to overcome the "performance gap". [Appendix 10. Nationwide Drones: survey approach review and case studies]

   A suite of underlying factors impacting data accuracy were also reviewed as part of the case study including U-values and ventilation. Commentary on how each survey approach addressed these is outlined within the report, the key point being both have influenced the end heat loss output of each property within the case study. Measured data should be used where possible to remove assumption/interpretation and provide the most accurate heat loss of the property but this clearly needs to be balanced with customer impact, cost, and overall survey efficiency. [Appendix 10. Nationwide Drones: survey approach review and case studies]

4. **Digitisation/automation of the design process**

   Current manual methods of data collection at survey, result in manual data transfer and entry into a suitable design tool e.g., Daikin Stand by Me, as such there is a risk that data is misread and a risk of input error and implications again for a skilled, competent person to be completing this activity within the supply chain. It is also time consuming, with a typical design taking between 1 – 1.5 hours (+ the time to collate / submit all relevant documentation, potentially up to 3 hours in total).

   Whereas Approach 2 allows for geometric dimensions to be directly exported from the 3D Revit model and directly imported into the heat loss calculation tool, providing automated outputs and integration into the preferred CRM system. The digital replica/360 view of the building & navigable online platform then provide easier auditability and oversight, removing the requirement to query or clarify individual survey data points or decision making back with the individual surveyor – a process which can delay the design being validated and halt the customer progressing by days, if not weeks.

   For Approach 3, the output of the survey provides an accurate maximum space heating load in kilowatts. Due to Veritherm providing a whole house heat loss which is not broken down on a room-by-room basis as required by MCS, it makes it difficult for a designer to correctly specify a heat emitter. With rooms having different fabric make ups, such as floors, ceiling, and walls, it would be very difficult to accurately break this down on a room-by-room basis. [Appendix 10. Nationwide Drones: survey approach review and case studies]

5. **Customer engagement and acceptance**

   Our current surveying approach is widely accepted by customers; however, the surveying time is not insignificant in terms of disruption to their day. This route also offers some opportunity for discussion in the home with customers by a qualified expert surveyor who can answer any questions in person and offer some feedback on the likely suitable solution. However, the output is less engaging with a 2D survey form and design document for the customer to interrogate and can cause complexities in supporting a customer to understand the data included fully.

   Approach 2 offers less opportunity for this level of solution specific discussion with a customer in the home as the objective is efficient, speedy data collection. However, the digital replica/360 view of the building and navigable online platform can support proactive and interactive engagement with the customer post design/pre-install instead, to discuss and show the customer siting options for the unit and potential changes to radiator positions or sizing and explore any other disruption factors so the customers are fully informed about their solution, providing ample opportunity to ask any questions etc as needed. Arguably at this point in the journey, delivering a more informed discussion once design implications have been assessed fully. [Appendix 10. Nationwide Drones: survey approach review and case studies]

   For Approach 3, the key concern of using Veritherm versus the manual or laser scan approach is the not-insignificant disruption to the customer, requiring they vacate the property overnight while the test is being undertaken [Appendix 10. Nationwide Drones: survey approach review and case studies]. For the case study customers to accept this route we had to offer goodwill gesture payments to cover the cost of them staying in a hotel for the night, providing insights into the challenges of achieving large-scale consumer acceptance to incorporating this survey methodology into the customer journey. It also adds cost and administration complexity.

By reviewing these factors E.ON would favour the adoption of Approach 2, the digitised mobile laser scan / drone approach, to fulfil our core technical surveying requirements. This is based on strong performance across all considered factors and the potential to deliver accurate, timely and efficient surveys within an innovative customer journey.

However, it is key that we achieve economies of scale during deployment to fully realise a sustainable surveying model, due to the higher cost of this survey (c.£500 per survey vs standard survey at c.£350 per survey). Applying a localised community approach with "block" bookings planned across neighbouring properties and streets to maximise daily delivery of survey volumes and limit wasted travel time is critical, which a dense community led deployment approach unlocks. Further development of digital integration would be assessed to understand if we could continue to improve customer journey efficiencies and reduction of manual resource intervention, completing a cost benefit analysis.

The full surveying case study report is outlined within Appendix 10. Nationwide Drones: survey approach review and case studies.

It is important to note that multiple Stream 2 projects continue to explore improvements to surveying and data capture to support an accurate heat pump design and product specification, alongside advances in digitisation of data for efficiency of customer journey. E.ON will review these to understand application within our customer journey at the point they are commercially viable / market ready. Heatio have begun this process exploring some developments within this space and provided insights as to how this could be integrated and the positive implications for customers and the progression of large-scale deployment of heat pumps as part of their report in Appendix 11. Heatio Heat Pump Ready Report. High level findings are summarised within Step 3 & 4. Below.

Step 3 & 4. ASHP design process review and the "Heat Pump Ready" approach

The review completed highlights both inaccuracies inherent in the current methodology for approaching heat pump designs across the four key design considerations of energy demand, efficiency, cost and heat loss, and the potential detriment these have on the confidence of consumers considering switching to a heat pump system and inhibit conversion to install.

One example highlights this point particularly well;

- In 31 out of 43 examples the estimated energy demand was more than 30% higher than the actual, measured energy demand.
- In 29 out of 43 examples the estimated energy consumption was more than 30% higher than the actual energy demand.
- In 31 out of 43 examples the estimated space heating demand was more than 30% higher than the actual energy demand.
- In 41 out of 43 examples the estimated hot water demand was more than 30% higher than the actual hot water demand.

Over-estimation of demand can have a negative impact on the sales process. With a higher than actual energy demand predicted, customers are wrongly led to expect a longer return on investment than would be the case. When they compare the demand estimate and associated running cost estimate, with their current energy bill many customers will expect significantly lower savings because of these inaccuracies. This is compounded when actual customer usage cannot be considered; rather the process indicates likely performance based on standard methods which may show little resemblance to actual operating conditions.

This will potentially impact the decision to switch to a heat pump with a resultant higher cost for customer acquisition and very likely to have further price implications for those moving forward with an installation as they unfairly bear the costs associated with unconverted customers.

Lack of design accuracy also raises significant concerns when considering the possibility of financing installations, for example with propositions such as HaaS, where an accurate ability to model the system is fundamental to the offering/package.

Further detail can be found in the Appendix 11. Heatio Heat Pump Ready Report.

Existing design processes lack customer engagement, resulting in failure to align the system design and specification with customer budgets and requirements.

Current methods fail to take adequate account of longer-term approaches to improvements. They only offer the customer an ‘all or nothing’ solution: upgrading the entire system to achieve maximum efficiency without due consideration for the customer budget or invasiveness of installation. With both capital cost on installs and internal upgrade being known barriers to deployment, steps are needed to offer personalised recommendations for each customer, while balancing the need to specify a robust and suitable heat pump solution.

We propose a step to address this could be to incorporate a Heat Pump Ready report as shown in Figure 21, created by Heatio early in the customer journey. To promote continued incremental education of customers, guide customers on their options, promote discussion on how to achieve the outcome that’s best for them. This will also support a robust triage process; allowing opportunities for customers to make an informed choice not to proceed, ahead of the supply chain committing to downstream survey and design costs.

Figure 21: Example of a Heatio "Heat Pump Ready Report"

In the case study depicted above the heat pump ready model/report was created within 48 hours of receiving the original enquiry. It is expected that integrating this process step with the E.ON online pre-qualification tool would enable the service level (48-72 hours) to be maintained at scale*

**Dependent on customer availability for virtual energy assessor call and required data access provisions being completed.*

Data sharing routes are understood and can be explained to customers to access the half-hourly energy data that can be taken from a smart meter or, if this is not available, from standard meter readings at the start and end of the temperature monitoring period. However, it must be noted that we have not tested the consumer acceptance of this data sharing within the scope of this project and recognise further work is needed to robustly ascertain the viability of this and address any consumer concerns [Appendix 11. Heatio Heat Pump Ready Report].

Improvements to the accuracy of heat pump design could be achieved via the introduction of the Heatio Smart Energy Monitoring solution, designed to establish the Heat Transfer Coefficient (HTC) of a property.

In section 4.1.3 it is outlined what the Heatio Energy Monitoring solution is and how it works. Further explanation of this and the benefits of establishing the Heat Transfer Co-efficient (HTC) can be found in Appendix 11. Heatio Heat Pump Ready Report, along with details on the desktop review completed. Acknowledging the need to find methodologies of capturing real, measured data and balance with customer needs and cost-effective survey deployment was a key outcome as outlined in our survey case study review. The integration of this Heatio solution within offers an opportunity to strike that balance.

The required sensors/hardware in the home can be sited during the survey with limited training and minimal increase in surveying time, with no separate site visit needed. While this monitoring takes place, the building may still be occupied as normal so there is no additional impact on the customer. [Heatio – Newcastle Heat Pump Ready Report] Further assessment is needed for full customer journey integration, and to understand timescales for development of a market ready solution, however we hypothesise that we can combine outputs of the technical survey + the measured data from the Heatio Smart Energy Monitoring solution utilised effectively together to inform and improve the end solution for the customer, based on improved accuracy of sizing and specification of the heat pump. Heatio continue to work with Heat Pump Ready Stream 2 participants to progress this:

Hildebrand Technology Ltd – https://www.hildebrand.co.uk/

Build Test Solutions – https://www.buildtestsolutions.com/

6.4 Work Package 4

Step 1. Consumer segmentation analysis

To better understand how the public feel about gas heating alternatives we ran a survey to a panel of 40 members of the public through the User Zoom platform across the Northeast of England. The findings are highlighted below in Figure 22 and Figure 23.

A large percentage are keen to look into gas alternatives

The appetite from respondents in the North East was overall very positive.

- 45% of people said that they would definitely would switch to a heat pump or similar technology, with two thirds saying they'd even go ahead now rather than wait until their existing gas boiler failed.
- 50% said they'd need more information, and as such with the right supporting resources would potentially become more positive in their response.
- Only 2% completely ruled it out.

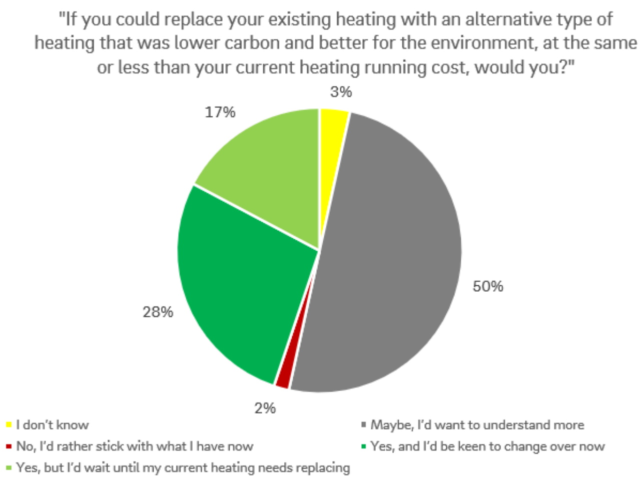


Figure 22: User zoom consumer insights survey

People would often be willing to pay more for a heat pump than a gas boiler

Respondents who responded positively to switching to a lower carbon heating solution were then asked about the cost they would be willing to incur in such a move.

62% of people said that they'd be happy to pay more, the highest proportion of this group saying they'd be happy to pay up to £2500 more, with 19% even saying they'd pay £5000 more for a low carbon option.

38% said that any alternative would have to be roughly the same cost as a traditional gas powered boiler.

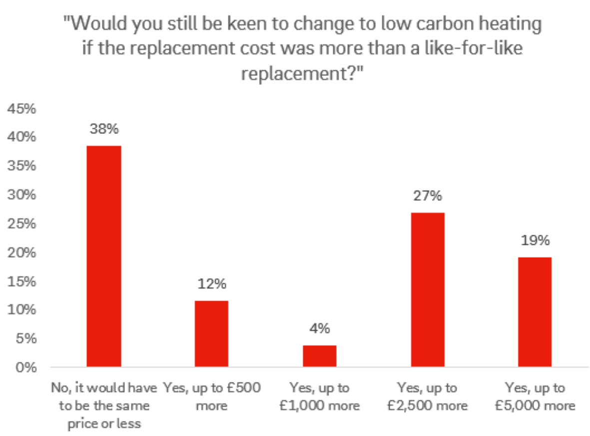


Figure 23: User zoom consumer insights survey

Although broadly positive appetite was exhibited, it confirms the price point of the solution to be an important consideration and thus critical to achieve capital cost reductions / price point efficiency and a package of suitable propositions, to incentivise transition away from their gas heating [Appendix 7. Consumer insights pack: People, property, and perception in Newcastle].

Segmentation analysis was successfully completed, with 4 core mosaic segments identified as having characteristics that were most aligned with owner occupier customers transitioning to a heat pump.

The detail of each of these segments is included below in Figure 24 along with a summary of the percentage of these types of households within each target ward.

Mosaic Segment G: Domestic Success

Wards that have a high match (% of households in ward):
Dene & South Gosforth (26%)
Parklands (23%)
Manor Park (14%)
Castle (11%)

Defining Features:

- Families with children
- Upmarket suburban homes
- Owned with a mortgage
- 3 or 4 bedrooms
- High Internet use
- Own new technology

Families are headed by couples typically aged in their late 30s and 40s, many have school age children. Parents in this group are likely to have a degree and may have delayed having children until their careers were established.

They now live in good-sized three or four bedroom detached properties, owned with a considerable mortgage outstanding. Their lives are now settled and they have very comfortable standards of living. These are homes they can expect to stay in while their children grow up.

Company car ownership is high, a benefit of working for well-known organisations or professional firms.

Domestic Success are frequent internet users. As well as being constantly connected for work, they enjoy the time-saving convenience of banking, shopping and managing bills online. They love owning the latest technology and, in addition to smartphones, they are the most likely group to own tablets.

Reason for inclusion:
High income, possibly with savings
Very keen on new technology
Will be looking for ways to reduce energy costs through technology.

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Mosaic Segment B: Prestige Positions

Wards that have a high match (% of households in ward):
Parklands (26%)
Chapel (13%)
Manor Park (10%)

Defining Features:

- High value detached homes
- Married couples
- Managerial and senior positions
- Supporting students and older children
- High assets and investments
- Online shopping and banking

Well-educated couples who have reached senior and managerial positions in companies, or have accomplished professional careers.

Live in large family homes even though some of them no longer have children living at home, frequently with five bedrooms and large mature gardens in easily commutable locations. Of those whose children have grown up many are still offering support. For this group the continued financial support of their children is not a problem.

Almost all own their own home, many outright and, in addition to sizeable salaries or large pensions, they have a substantial investment portfolio making their financial situation very comfortable.

With busy lives to manage many make good practical use of the internet without spending long hours online. In particular they manage bank accounts online, search for savings accounts with the best interest rates, and save time by shopping online.

Reason for inclusion:
Likely to have disposable income/savings
Keen on new technology
Will be looking towards reducing outgoings for a comfortable retirement.

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Mosaic Segment F: Suburban Security

Wards that have a high match
(% of households in ward):
Chapel (28%)
Lemington (13%)
Castle (12%)
Manor Park (11%)

Defining Features:

- Older families
- Some adult children at home
- Suburban mid-range homes
- 3 bedrooms
- Have lived at same address some years
- Research on Internet

Mostly headed by people aged between 45 and 65. Often still supporting adult children who may be studying, looking for work or enjoying their parents help while they save money for their own future.

Their typical home is a mid-range traditional three bedroom inter-war or post-war semi-detached house built for families in established suburbs. These are settled households and the average length of residency is 17 years.

Many years employment in a range of lower managerial, supervisory and technical occupations means they have been able to afford to buy their own homes. Many have paid off the mortgage altogether and others have a relatively small amount left outstanding.

Incomes within this group are respectable and lives are generally comfortable. Some families can feel stretched, particularly when the younger generation are not contributing to the household finances.

As a group they are reasonably tech-savvy, though they do not rush to buy the latest gadgets. They access the internet daily via broadband and will use it for researching products and services.

Reason for inclusion:
Lower outgoings
Looking ahead to retirement and may want to further reduce costs
Will be concerned about energy price rises, and will have houses that are HP suitable

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Mosaic Segment E: Senior Security

Wards that have a high match
(% of households in ward):
Chapel (33%)
Parklands (15%)
Dene & South Gosforth (12%)

Defining Features:

- Elderly singles and couples
- Homeowners
- Comfortable homes
- Additional pensions above state
- Don't like new technology
- Low mileage drivers

The most elderly group of all, their average age is 75, and almost all are retired. Some are living with their long-time spouse, but a larger number are now living alone, and women outnumber men.

During their working lives Senior Security were employed in a range of managerial and intermediate occupations. They had sufficient income to buy their own homes with a mortgage which they have now paid off, leaving them with considerable equity in their homes.

These homes are comfortable semi-detached three bedroom houses and bungalows in pleasant suburbs. They are generally very settled, long-standing residents of their local communities and have the longest length of residency of any group, having lived in their homes for nearly 25 years, on average.

Though few now have high incomes, most live in reasonable comfort, their state pensions being supplemented by occupational pensions, and they are content with their standard of living.

Reason for inclusion:
Although not keen on new technology, will be looking to minimise outgoings.
Likely to have the equity to be able to invest in heat pumps
Will have houses that match heat pump requirements

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Figure 24: Priority Mosaic Segments for heat pump uptake

The proportion of customers within the favourable segments has been compared with all available segments, across our favourable wards and shown below in Figure 25.

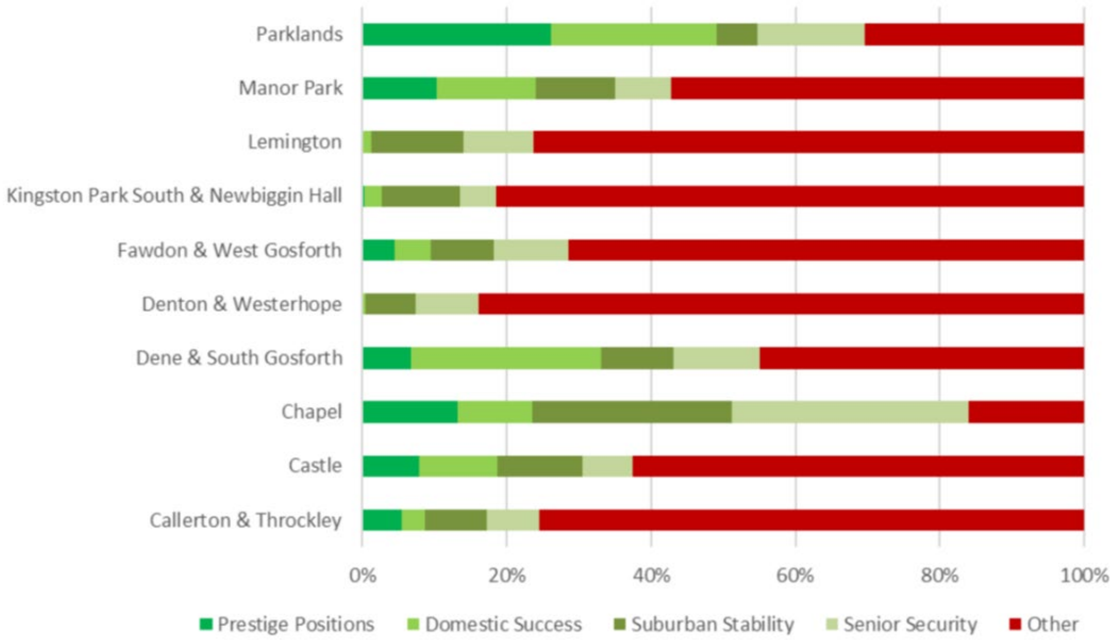


Figure 25: % of customers within favourable mosaic segments

Each segment has been explored with defining features for consideration and rationale as to the reason for inclusions within the analysis. This was fed into consumer insights workshops to guide target areas analysis (in WP2) and considerations for tailoring potential marketing approaches / community engagement strategies.

Higher Affluence and Tech Adoption in Four Wards

Parklands, Castle, Dene & South Gosforth, and Manor Park all have higher levels of household income and ownership and will be more aware of new technology. They will probably already have higher levels of heat pump knowledge, and similarly will be keen to reduce their energy costs in the face of rising prices.

Chapel could be an area of focus

Although heat pump knowledge is likely to be lower in this ward, there are high levels of home ownership and suitability. The population is older and may well be looking to use some of the large equity they have in their houses to reduce future outgoings.

The complete segmentation detail is included within Appendix 7. Consumer insights pack: People, property and perception in Newcastle.

A robust, multi data point propensity model was completed as outlined in section 4.1.4, reviewing more than 2k postcodes for suitability for high density heat pump deployment.

In addition to the attributes already outlined, consumer cancellation data from the Electrification of Heat Demonstration Project was included – this would drive a slightly lower score due to an indication of lower customer appetite. The maximum propensity score that could be achieved was 32; no postcode achieved this, with the highest reaching a score of 27.

An extract of the model is shown in Figure 26 with the full results available in Appendix 6. Consumer insights modelling: Newcastle Propensity model. Working with E.ON's customer insights team this steered the target areas analysis in WP2 to locate priority zones for dense deployment of heat pumps.

Postcode	Ward	No Leads	1+ Leads	Total properties	Avg HH Income	Consider Solar %	Energy Engagement %	Suitable Property %	Segment %	Cut Energy %	Likely Savings £50k+	Likely EV %	Have Solar %	B2G %	Favourable Seg %	Install %	Owner occupied	Propensity Score
NE3 5RG	Parklands	50	4	54	£115,925.93	94%	2%	96%	100%	0%	59%	96%	59%	94%	91%	7%	90.74%	27
NE3 5RB	Parklands	58	2	60	£84,333.33	88%	2%	82%	98%	7%	32%	87%	28%	92%	75%	3%	75.00%	22
NE7 7GB	Manor Park	55	4	59	£88,898.31	63%	5%	100%	100%	14%	80%	68%	80%	98%	98%	7%	98.31%	25
NE3 5RR	Parklands	18	3	21	£163,095.24	100%	0%	100%	100%	0%	100%	100%	100%	0%	95%	0%	95.24%	24
NE13 9AG	Castle	25	0	25	£119,000.00	100%	0%	100%	100%	0%	100%	100%	100%	100%	100%	0%	100.00%	23
NE13 9AP	Castle	47	0	47	£121,595.74	96%	2%	98%	100%	0%	98%	98%	98%	77%	100%	0%	100.00%	23
NE13 9AT	Castle	19	0	19	£117,631.58	100%	0%	100%	100%	0%	100%	100%	100%	79%	100%	0%	100.00%	23
NE13 9AY	Castle	19	0	19	£110,263.16	95%	5%	100%	100%	0%	100%	100%	100%	100%	100%	0%	100.00%	23
NE13 9BF	Castle	21	1	22	£126,818.18	91%	9%	91%	100%	0%	64%	100%	64%	91%	100%	0%	100.00%	23
NE13 9NQ	Castle	3	0	3	£125,000.00	100%	0%	100%	100%	0%	100%	100%	100%	100%	100%	0%	100.00%	23
NE3 5RE	Parklands	32	3	35	£120,714.29	100%	0%	91%	100%	0%	43%	100%	43%	77%	77%	0%	77.14%	23
NE3 5RT	Parklands	9	0	9	£126,111.11	89%	0%	100%	100%	0%	100%	89%	100%	100%	89%	0%	88.89%	23
NE7 7FL	Manor Park	41	1	42	£77,380.95	36%	0%	98%	98%	36%	74%	29%	71%	95%	98%	2%	100.00%	23
NE13 9AF	Castle	16	0	16	£110,625.00	100%	0%	100%	100%	0%	100%	100%	100%	38%	100%	0%	100.00%	22
NE13 9AN	Castle	14	0	14	£129,285.71	100%	0%	93%	100%	0%	100%	100%	100%	21%	100%	0%	100.00%	22
NE13 9AR	Castle	13	0	13	£130,384.62	92%	8%	100%	100%	0%	100%	100%	100%	46%	100%	0%	100.00%	22
NE13 9AZ	Castle	23	0	23	£113,695.65	74%	22%	100%	100%	0%	100%	96%	100%	100%	100%	0%	100.00%	22
NE3 1RQ	Dene & South G	37	2	39	£86,794.87	49%	36%	100%	100%	3%	100%	85%	100%	97%	92%	0%	92.31%	22
NE3 2DW	Parklands	11	0	11	£144,090.91	100%	0%	100%	100%	0%	100%	100%	100%	0%	100%	0%	100.00%	22
NE3 2EA	Parklands	12	0	12	£125,833.33	83%	17%	100%	100%	0%	100%	92%	92%	17%	100%	0%	100.00%	22
NE3 5HD	Parklands	14	1	15	£81,000.00	27%	73%	100%	100%	0%	100%	100%	100%	80%	100%	0%	100.00%	22
NE3 5JA	Parklands	36	2	38	£89,013.16	42%	42%	100%	95%	3%	100%	79%	100%	95%	89%	0%	94.74%	22
NE3 5JE	Parklands	20	1	21	£91,666.67	57%	33%	100%	100%	5%	100%	90%	100%	81%	71%	0%	71.43%	19
NE3 5JW	Parklands	20	1	21	£77,380.95	43%	48%	100%	100%	5%	100%	90%	100%	100%	95%	0%	100.00%	22
NE3 5LG	Parklands	11	1	12	£86,666.67	33%	50%	92%	100%	0%	100%	83%	100%	100%	100%	0%	100.00%	22

Figure 26: Propensity model extract

The rising cost of living has impacted the volume of customers with income sufficient to purchase high value investments such as ASHPs.

Taking guidance from E.ON's consumer insights team and recent cost of living research we profiled customers with a household income of >£70k as being the minimum for alignment to our core able to pay ASHP propositions. Previously this was around £50k as a guide.

In Newcastle there is a distinct divide in areas of affluence; geographically, the more affluent wards are slightly further north from the centre. The average household income in key wards across the city has been collated utilising our available mosaic data and in none of these does the average meet the £70k threshold. However, there are 4 key wards where 10 – 26% of households do reach and exceed this threshold. This directly influenced E.ON's target area analysis and guided the detailed propensity modelling at a postcode level to ascertain exactly where the higher income households were located.

Step 2. Consumer proposition review

A review of Heat as a Service (HaaS) was completed, as outlined in section 4.1.4. Appendix 11. Heatio Heat Pump Ready Report outlines the principles of the offering and how it works, why it is needed, what tariffs are available and proposes how the customer journey could work.

The proposed HaaS approach was taken to the Heatio Energy Challenge Group and as a result, the completion of the first indicative case study delivery of Heat as a Service has been achieved.

During feasibility, an indicative "test case" customer was recruited from Heatio' s Energy Challenge Group, a voluntary panel of customers who have agreed to work with Heatio, to provide feedback on emerging propositions, technology innovations and general heat pump insights. Although the full legal/commercial operating model for Heatio's HaaS was not yet market ready, it was an opportunity to provide indicative insights into the processes needed, interactions with the customer and validity of the ASHP solution specified – alongside a modelled HaaS package (tariff / servicing & maintenance etc).

The case study HaaS installation was able to offer the customer a reduced upfront installation capital cost of £1k, and a monthly package cost of £175 inclusive of maintenance and servicing fee.

Further market testing across a range of properties and heating profiles is needed to understand if this is competitive vs other standard finance packages.

The utilisation of case studies such as this are therefore key for robustly building a consumer proposition that meets customer needs and inform a viable underlying business case with the necessary support from financial institutes. It was recognised that repaying the capital costs of investing in decarbonised systems remains challenging for financial institutes, and a lack of commercially ready tested models remains a barrier to entry for many providers [Appendix 11. Heatio Heat Pump Ready Report].

To address this, Heatio completed a detailed modelling exercise reviewing existing performance data from heat pump installations to better understand the capital investment requirements and ongoing billing potential of the HaaS Service packages.

The full data modelling results can be found in Appendix 12. Heatio design modelling and HaaS proposition modelling.

The data reviewed during feasibility provided great insight into the customer energy profile and the system's performance. Unfortunately, the review also highlighted significant inaccuracies in the space and water heating at the design stage, as already outlined, impacting the accuracy of the modelled capital investment and billing. Heatio discussed these findings with their finance partners, who advised that greater certainty would be required before they could support the proposition to commercial scalability. E.ON and Heatio therefore decided on the need to further focus on the provision of innovative finance solutions outside of the Heat Pump Ready project and looked to other routes such as the Green Home Finance Accelerator for additional funding and support to develop this further.

Consumer research carried out during the HaaS feasibility study found the customer profile outlined below willing to engage and would consider the rental model and affordability; however, all who we engaged with had energy saving/energy security as a core requirement.

Consumer Research via the Heatio Energy Challenge Group customer panel was used to inform the types of customers who would engage with the HaaS Service model in the target region. These customer profiles include;

- Middle-income young families
- Comfortable with subscription services over ownership
- Some savings but not willing to tie them up in heating systems
- Medium to Low credit risk with No CCJs or record of bankruptcy
- A drive to reduce carbon and energy savings
- Willing to accept some "minor" disruption to become more sustainable
- Typically working from home with some office hours flexible for visits and installation schedules
- Keen to ensure continuity of service, i.e., not willing to accept long periods without hot water
- Willing to move forward on an energy-saving roadmap once the "big ticket" items, Heat Pump, Solar, and Storage, have been completed
- Previously less willing to engage with solutions due to the high capital cost and a lack of tailored support.

In addition to this HaaS was introduced to attendees at E.ON led community events in Newcastle during feasibility, for general qualitative discussion. During these sessions customers initial reactions, demonstrated a need to find out more to fully understand the proposition and the benefits vs a standard finance model they were more familiar with.

This has also informed the decision to continue to develop robust validation of the proposition aligned to customer needs i.e., through more detailed and formal consumer research. Another reason why E.ON and Heatio have sought out the Green Home Finance Accelerator as a potential route to progress this.

6.5 Work Package 5

Deliverable 1. Community Engagement planning/design

The basis for the engagement strategy is around inspiring change within a community. We know from past campaigns and projects such as the Electrification of Heat Demonstration Project people are more likely to take interest and see the process through to install given the right engagement throughout the journey. We know that residents are more receptive to messages when it's conveyed in terms that are familiar to them, we've previously built trust in the communities by engaging local people to speak about their related experiences.

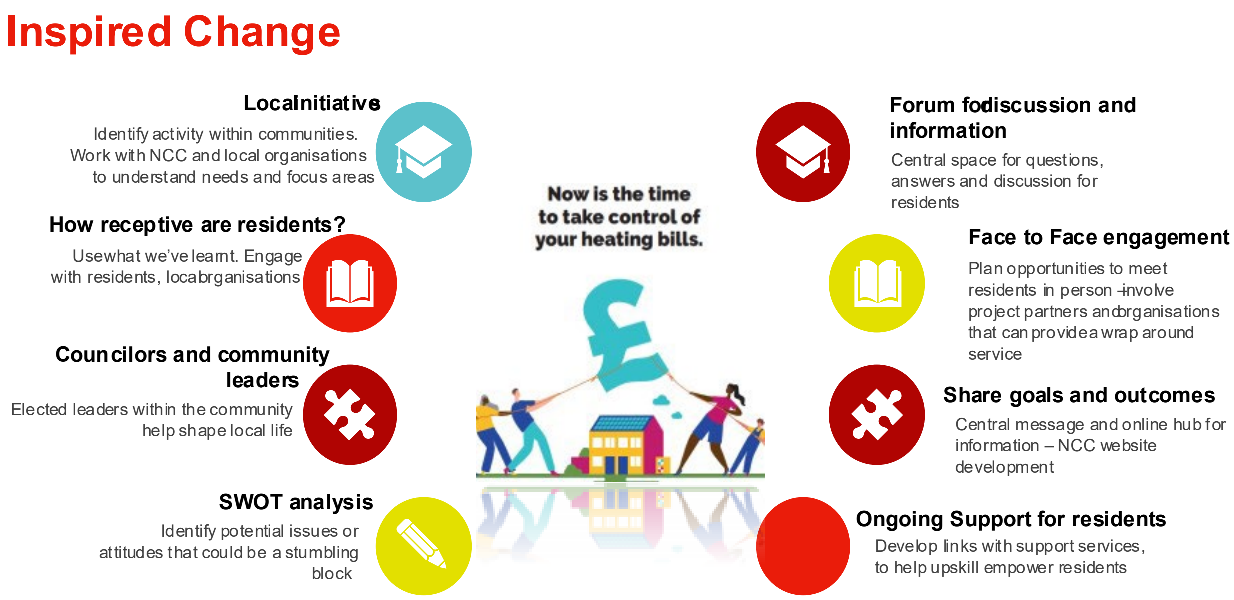


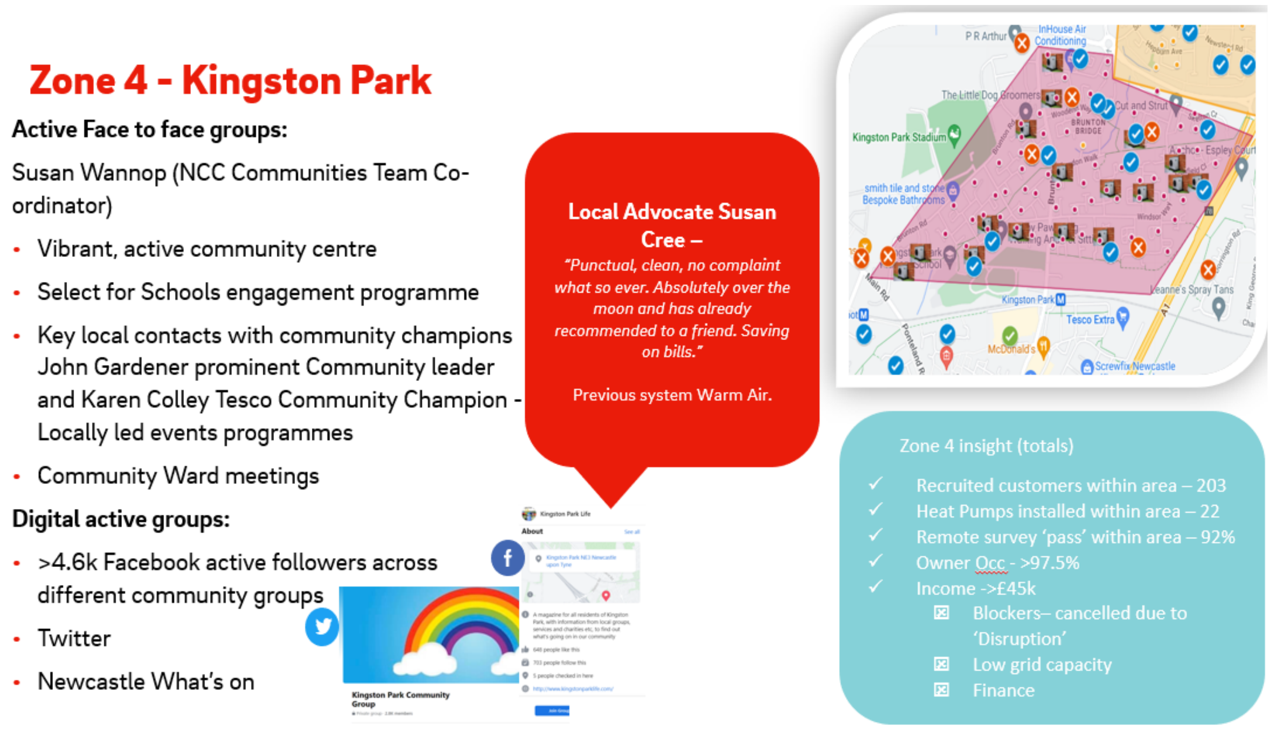
Figure 27: Approach to building successful engagement strategies

The Inspired Change concept shown in Figure 27 is critical for dense deployment as we're reliant on residents within proximity of each other to sign up and progress to install. Just as negative messages can spread throughout a community so can a positive one. Once a community adopts a concept and gets behind a message collectively that isn't imposed on them, the more lasting the effect of the change and the challenges are overcome from within the group.

Early work with Newcastle City Council's Communities team helped get a deeper understanding of what's at the heart of each localised community. We selected 6 sub zones from the target area analysis, 4 of which were the top areas highlighted by the propensity model and 2 further zones which were in lower income areas, with less data but had potential for successful engagement and the opportunity for more insight into how to overcome some of the financial barriers by exploring different ways to pay i.e., Heat as a Service. There were also decisions made to explore a school programme as another route to embed engagement within a community summarised in Figure 28.

Figure 28: School engagement ideation

The high-level output from the community team collaboration is summarised by area, with an extract included below in Figure 29.



Zone 2 - Chapel

Active Face to face groups:

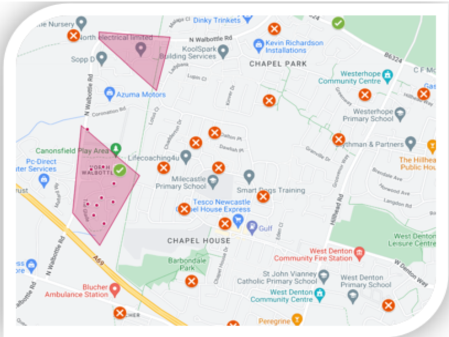
Susan Wannop (NCC Communities Team Co-ordinator)

- Potential for Busy community centre – after school clubs
- Select for Schools engagement programme - grandchildren
- Community Ward meetings

Digital active groups:

- Facebook/Twitter
- Newcastle Community Connect
- Denton Burn Fenham Community page

"I'd love to have a Heat Pump and I'd take advantage of any grant to help me take that step - I'm busy, I hear I'll have to change my pipework, I can't deal with the mess."
Local resident



Zone 2 insight (totals)

- ✓ Recruited customers within area – 155
- ✓ Heat Pumps installed within area – 12
- ✓ Remote survey 'pass' within area– 92%
- ✓ Owner Occ - >95%
- ✓ Income - <£50k
    - ☒ Blockers – Cancelled due to: Disruption, solution unsuitable

Figure 29: Community engagement strategies by ward

The full community engagement analysis is contained within Appendix 8. Newcastle City Council: Community team input into engagement planning.

In-person council ward meetings were attended by the E.ON team to talk to key local community leaders including Councillors, to gauge appetite for our suggested community led approach in support of the councils' net zero plans. This also included an opportunity to speak face to face with local residents in attendance, gathering some qualitative comments. The insight given through our propensity modelling also highlighted areas that required different funding methods for residents and potential adaptations to the engagement messages, placing them at different points within the marketing strategy. Placing the more affluent residents at the start of the campaigns would be the catalyst needed to positively affect our ability to meet the dense numbers within communities to fulfil the project brief and drive activity within other areas. The initial focus on the more affluent areas does not mean that sectors of the city were being ignored; by taking this customer focussed approach, time will be spent building trust and support networks within communities. The resulting holistic engagement strategy is outlined in Figure 30.

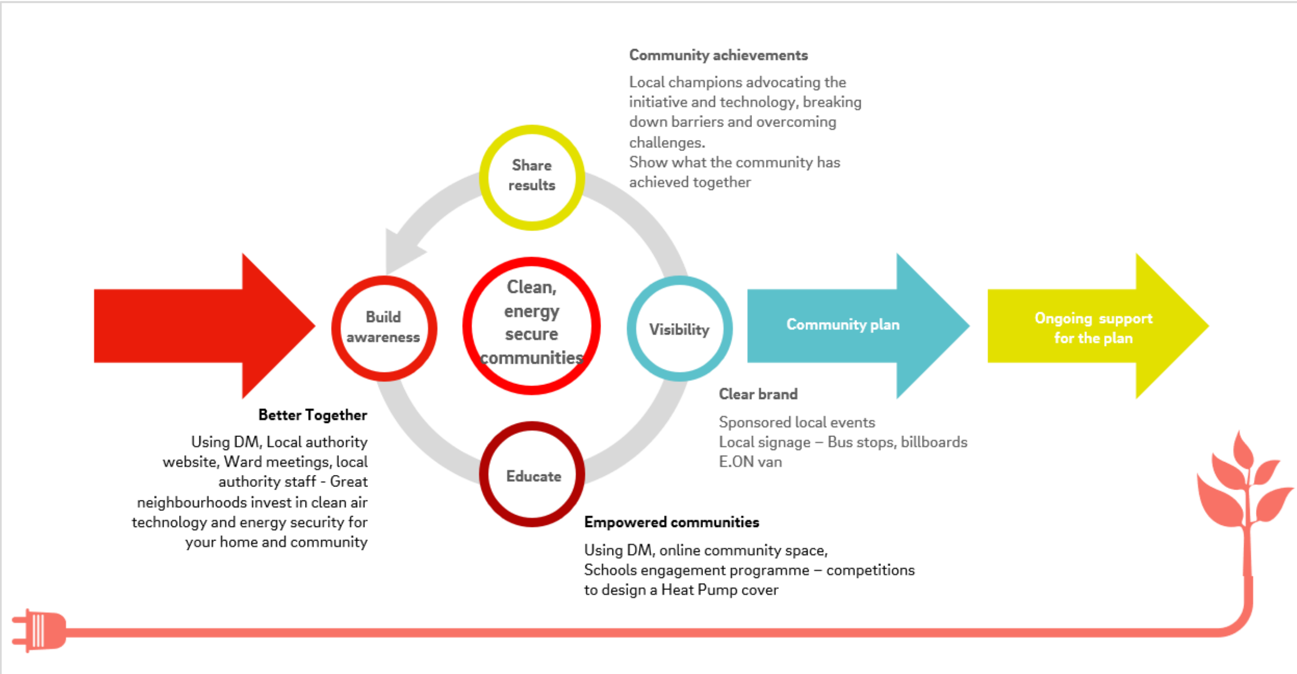


Figure 30: Overarching informed engagement strategy

Deliverable 2. Marketing and recruitment process

The Marketing approach was formed with communities in mind, a review of past local campaigns was completed, with focus on activity that featured residents advocating heat pumps that previously proved successful in attracting the required target group. For example, the 'Be Like Barry' customer heat pump video diary resulted in 25 customers prequalified for an ASHP install on a previous project, as a direct result of engaging with this social media activity, with "real" resident stories and experiences at its heart. As a result this would continue to form part of our core marketing approach, creating accessible case studies as part of our "Meet our Heat Pump Ambassadors" approach.

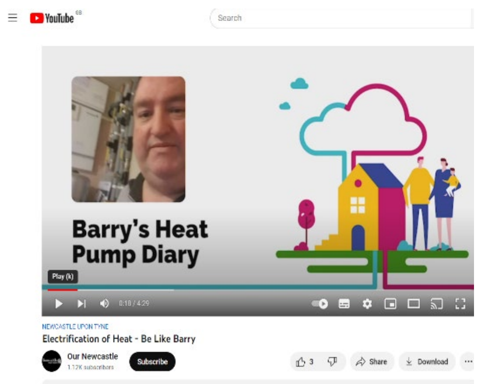


Figure 31: "Be like Barry" heat pump case study

Figure 32: Example promotion material

We developed a range of materials through the iterative co-design workshops to support and enable the effective communication of key messages.

Deliverables

- Using a familiar look and feel, building on the Electrification of Heat brand - an adaptation to the graphics have been made to incorporate a core community focus required for Heat Pump Ready – but recognisably linked to previous campaigns.

- One core image at the centre of the design, however tailored to reflect the prevalent housing archetype by area, so customers recognise their own property, and it has relevance to them.

- Newcastle-wide messaging maintained a strong focus on moving away from gas and taking control of energy bills.

- Tailored messages have been adapted to be "hyper-local" to the community types and subsections of residents. Further development to be explored in this area, recognising the need for market testing within the specific communities, ahead of deployment.

- Design of various digital content and graphics for use on social media and online channels, marketing materials including leaflets, flyers and posters, advertising collateral for print, broadcast, digital and face to face community events are shown in Figure 33.

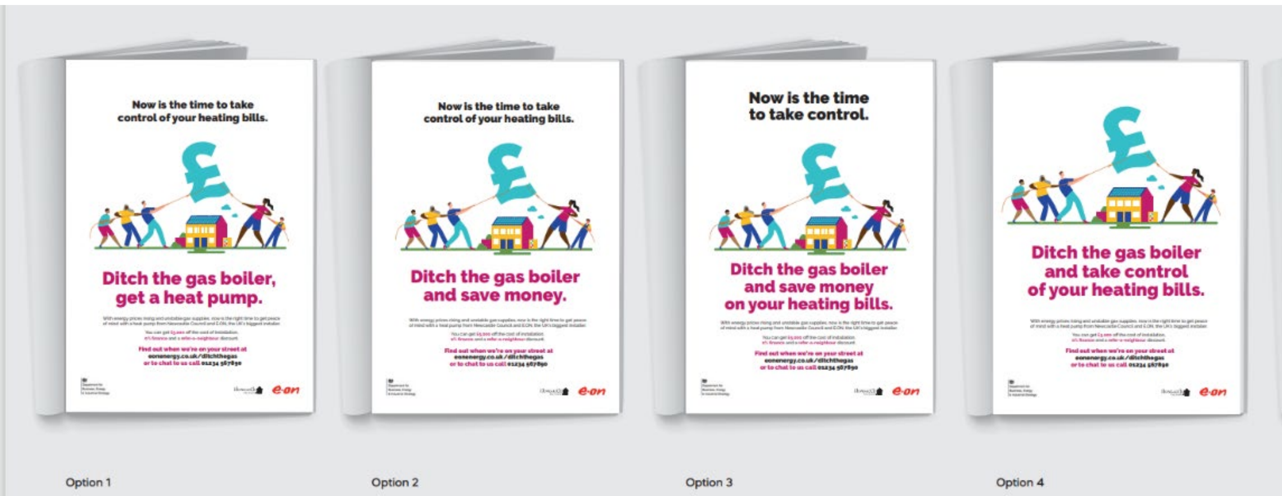


Figure 33: Example marketing materials and varying messaging options

- An easy to understand, customer journey graphic was produced – to provide customers an understanding of the steps they are likely to go through on their route to a heat pump installation. Considerations were made to the level of detail included dependent on the purpose of the graphic e.g., to support marketing and lead generation/high level engagement and understanding vs in-journey customer communication of their progress.

The full suite of deliverables are included within Appendix 9. Marketing Concepts.

An indication of the approach to deliver community-focussed campaigns, suitable to coordinated dense deployment is shown below in Figure 34.

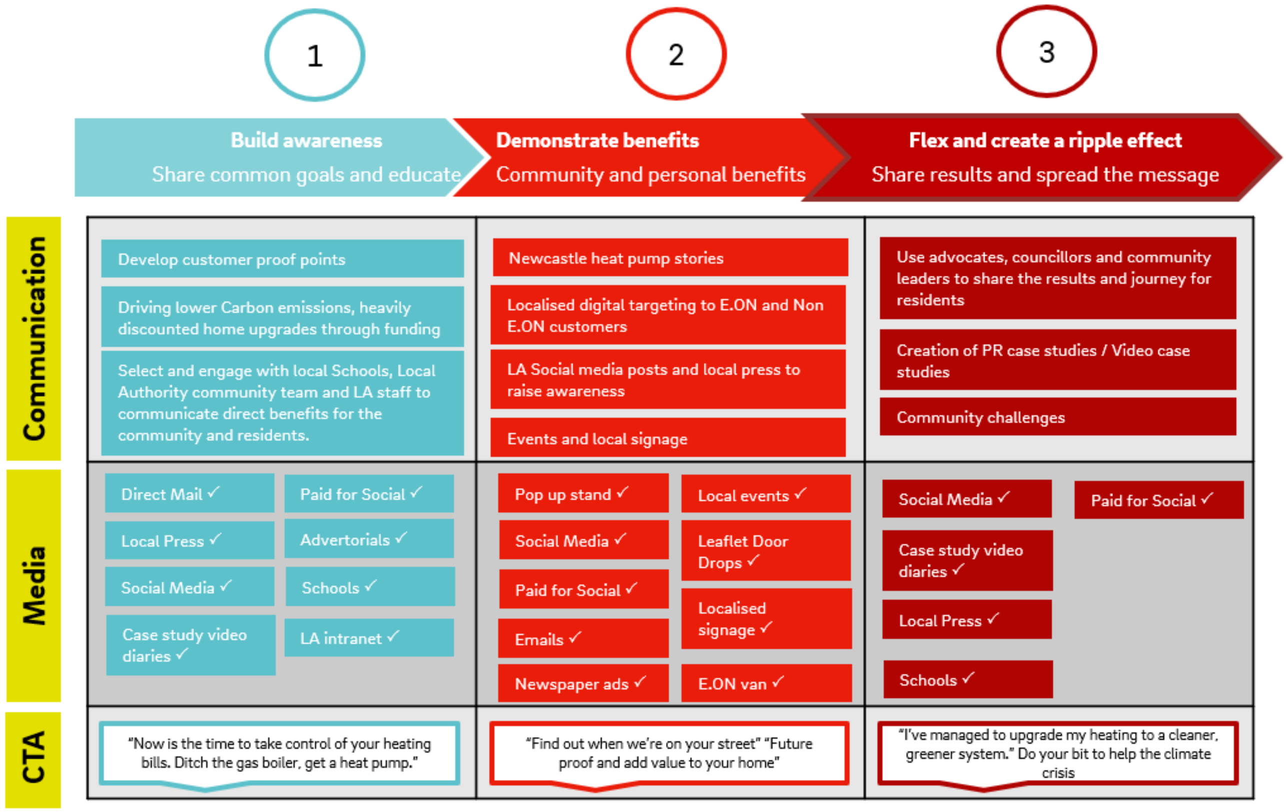


Figure 34: Marketing campaign planning

Deliverable 3. Online digital pre-qualification tool and integration of early customer journey triage.

An outline of the process steps within the tool and onwards delivery of customers into the customer journey is shown in Figure 35.

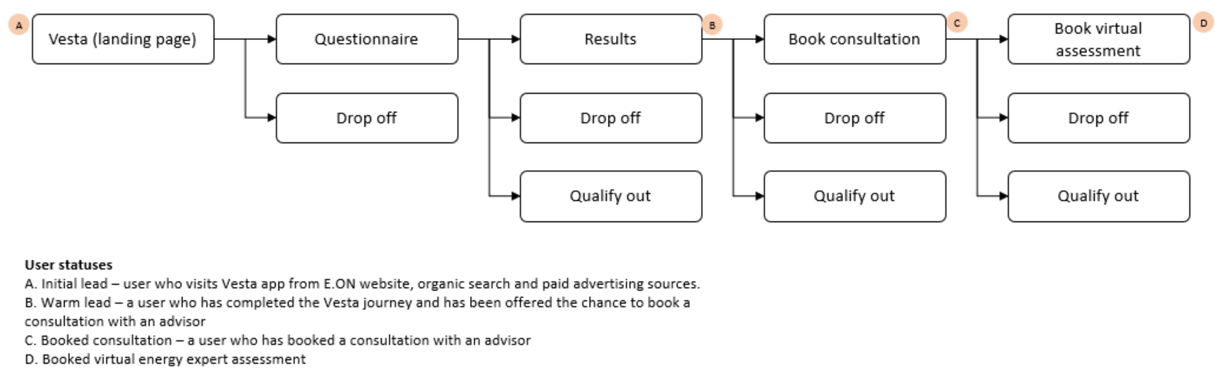


Figure 35: Online pre-qualification tool process steps

A review of the tool has shown it could successfully be applied and add value to a co-ordinated dense deployment of heat pumps within an "able to pay" market.

As part of the review, we considered several factors that support this outcome;

- The tool is performing positively based on its current internal performance metrics for our grant funded schemes. The tool is live [Green homes grant finder | energy efficiency | E.ON (eonenergy.com)] and has already undergone two phases of development based on internal business, customer and market insights. Significant benefits are already materializing driving increased conversion rates from customers landing on the application webpage, through to completing a detailed eligibility questionnaire – currently the highest performing completion rates of a lead generation funnel in E.ON's solutions business, operating consistently at over 70%. The tool delivers automated qualification against project or proposition requirements and allows for customers to proactively book an advice consultation upon completion of the questionnaire. Customers are typically completing the advice consultation within 24 hours of landing on the webpage supporting "warm leads" progressing into the customer journey and minimising early drop out from being unable to re-establish contact with customers.

- The hyper targeted community-based approach to engagement and marketing on this project closely aligns to our strategy in our grant-based programmes such as Local Authority Delivery (LAD) schemes, Home Upgrade Grant (HUG) schemes and ECO4, where we are dependent on locating specific consumer group, property types and energy efficiency measure suitability and encouraging them to apply via the digital tool. As such we hope to realise the same conversion benefits as outlined above for a large-scale, dense deployment of heat pumps.

- We can start to consider each priority deployment community with Newcastle as a "sub project" and manage with the same level of ringfenced care and support we do to each of our grant-based projects. This will increase visibility of each group of customers from a community within the application process, providing increased control and ability to tailor our communication accordingly. Rather than individual customers going through the current E.ON able to pay digital journey in isolation. Currently we have c.36 different regional communities/areas live in the tool showcasing the variety of scheme requirements being actively managed.

- With the "sub project" approach we can; define specific parameters within the decision engine of the tool relevant to the needs of each, for example pre-defining eligible geographic locations e.g., specific to a sub-station to support automated pre-qualification of a customer into or out of the process.

- Linked to those parameters we can tailor the tool's results messaging to be presented to customers, specific to the engagement strategy, products, and proposition we have available and have auto assessed the customer is most likely to be suitable for. This can also include the presentation of customer journey next steps, specific to the project. The tool allows us to start engaging with customers higher up the awareness / sales funnel with less friction.

- Other complex innovation schemes have successfully been integrated into the tool, providing confidence that the heat pump ready co-ordinated dense deployment requirements can also be met.

- There is a development roadmap in place to provide iterative improvements to the tool, based on continuous feedback from customers, the business and performance metrics, providing confidence of operational mobilisation of the tool to support the heat pump ready programme.

- This allows for a level of flexibility and agility in how we manage the front-end journey, with the ability to quickly test and learn and adapt the tool to the project requirements and minimises impact on the current, nationwide ASHP offering & operating model.

However, there are some foreseen challenges in this approach, most notably ensuring customers are directed via our marketing and engagement collateral effectively to the digital tool landing page, rather than E.ON's nationwide ASHP digital landing page. Re-direction routes will need to be considered, along with identification procedures for customers who may still proceed through to E.ON via alternative routes.

7. Conclusion

During the completion of the latter stages of the feasibility phase, E.ON and our consortium members made the decision not to proceed to Phase 2 of the Heat Pump Ready Programme.

It was determined that the following outcomes from the previously described work packages presented significant barriers to ensuring a co-ordinated, dense heat pump deployment plan for Newcastle;

1. Insufficient grid capacity to achieve the required 25% density of uptake at a secondary substation level within the target regions most suitable for heat pump deployment. It is important to note there are a limited volume of substations with capacity within areas of interest, but this presented limited scope to build a robust deployment plan and **achieve large-scale volumes of uptake**.

2. This was further impacted by the **non-completion of the full suite of grid analysis**, recognised as one of E.ON's key mitigations for effectively steering deployment plans. Nor had we managed to establish a clear agreement with the DNO to gaining the additional data required to complete this modelling. This increased the risk of proceeding to Phase 2 with a lack of certainty, particularly relating to identifying the exact homes attached to each secondary substation.

3. E.ON, with extensive consultation with Heatio and Newcastle City Council, agreed that the required **customer conversion rates to install, needed to achieve 25% density of uptake, were prohibitive and unlikely to be attainable**, especially during the context of a cost of living crisis. For example: by making informed assumptions on the removal of "unsuitable properties" from our detailed triage analysis, subsequently leaving a pool of suitable properties, this ranged from needing to convert 40% to 60% of those remaining suitable properties/customers attached to a substation to hit the 25% density requirement. It was decided that this was currently high risk, likely to be unachievable and not replicable at scale, even with innovations within our methodology to improve engagement, conversion rates and limit drop out.

4. **The recognition that our HaaS proposition**, although showing positive indicators of supporting heat pump uptake and integration into an E.ON customer journey, **requires further work and funding (out of scope of HPR) to bring to market robustly, and ensure it is commercially competitive with clear return on investment visible for customers.** The timeline for this was non-feasible within E.ON's expected mobilisation period within Phase 2 and will be explored through other government funded routes such as the Green Home Finance Accelerator.

5. The digital roadmap development timeline associated with bringing our E.ON Home platform to market for ASHP customers, **put at risk our ability to deliver the integrated, innovative aftercare package within E.ON's expected mobilisation timescales** for successful deployment. E.ON have built and validated user cases for robust aftercare packages following the management of a portfolio of >300 heat pump customers on the Electrification of Heat Demonstration Project, and via supporting hundreds of customers from our various grant funded schemes who transition to a heat pump. Currently our aftercare is delivered manually to customers through a variety of routes including provision of resources, sign posting and interactions with our renewables energy experts and project administrators. This ensures customers are confident in the use of their new system. However, to

successfully achieve large-scale dense deployment **that is cost effective and deliver an optimal customer journey**, we want to ensure our customers have visibility, control, optimisation, relevant insights and coaching easily accessible via our app.

6. Further innovation is still required to streamline the manual aspects of our detailed suitability analysis at a community level **and introduce an increased level of automation** for efficiency and a cost-effective operating model. E.ON's manual analysis of over 31k homes delivered significant value to the project and NCC, and it would also be interesting to explore how the outputs of this could be presented to customers within E.ON's own digital pre-qualification tool and via Newcastle's GREEN website, with headline suitability information for owners who could "self validate" their address to support informed decision making, education and mass take up of low carbon technologies.

7. The opportunity to **directly compare varying surveying techniques**, in the context of large-scale, dense air source heat pump deployment was incredibly insightful in terms of shaping key operational decision making on what an optimum and replicable survey approach could be. Along with the recognition of how this needs to continue to develop with the inclusion of additional innovations that support the increase in measured data to address "the performance gap" and deliver more accurate heat pump design and onwards solution specification for customers. There was an aspect not fully explored within scope of this project due to the core focus on air source heat pump deployment, which was how this technical survey approach might need to interact with PAS retrofit assessment requirements for homes that need a suite of energy efficiency improvements and any opportunities to achieve without increasing the number of site visits to the property. E.ON would continue to analyse this in line with our commitment to reducing the complexity within the customer journey for the consumer.

However, withstanding the factors above which could not be overcome in this instance, the feasibility project has offered valuable insights into aspects that could support co-ordinated dense deployment and would be applicable for others to consider, as detailed in Section 6.

It is also important to note that our analysis during feasibility has proven **that Newcastle City has the potential for large-scale deployment of ASHPs and at a significant increase beyond previous UK trials carried out in similar locations** and that a co-ordinated community driven approach has been collectively recognised as the most suitable way to achieve this, aligned with other proof-of-concept approaches like Newcastle's Low Carbon Neighbourhood project. **But further critical work is needed to complete the baseline model of the electrical network in Newcastle.** Specifically, by allowing local authorities to have greater insights into headroom in the LV networks and to use this to inform planned targeting of schemes, in a phased manner, to allow DNOs to gradually reinforce only ahead of planned need or to incorporate grid management tools / innovations. Net Zero capacity could then be focused much more effectively. This is even more important when integrating EV charging networks, planning heat pump schemes, and coordinating this with possible district heating schemes. Local Area Energy Planning is ineffective without this, unless it is able to plan from the bottom-up, reflecting the ideal transition pathways of individual homes, clustered around LV networks.

7.1 Reflections

As a whole, our consortium was well balanced with a mixture of public and private sector partners and relevant industry expertise, internally within E.ON and provided by our collaborators. This delivered a breadth of value throughout the feasibility project across multiple operational, technical, commercial and consumer topics. If we were to complete the feasibility project again, we would however consider including another industry expert such as Energy Systems Catapult (or other similar organisation) to provide consultancy to assist and provide guidance in the following areas:

- Formalising a multi-faceted consumer research plan, carried out to specific communities of interest to drive extremely relevant insights to shape deployment and engagement plans. Use opportunities to "market test" our recruitment campaigns via this route to drive refinements to our bespoke engagement strategies (also note both limitations of our delivery were impacted by shortened timescales of the project, not just due to consortium skillset).

- Better scoping what could be achievable from the analysis into HaaS and providing expert insights related to their knowledge on this innovative proposition. E.ON's initial work package ambitions were too high considering the complexity of bringing a new finance product to market and it being one of many items to investigate within the scope of the feasibility project. Although the principles and initial outcomes from this project have certainly shaped how this could play a role in a varied portfolio of customer propositions to support large-scale uptake of heat pumps and next steps in how to achieve this.

- Formal report writing to support with the robust dissemination of all insights collated during the project.

E.ON would re-consider the contractual arrangements for consortium members, and instead may have opted to formally contract with NPG via a collaboration agreement or services agreement to better support the desired outcomes of the project, commitment of NPG resource and considered provision for their associated resource cost requirements. This may have allowed for more robust planning by NPG following a formally negotiated scope and service provision and given us a clearer route forward to plan for deployment with NPG fully onboard. This contractual route was not explored so E.ON cannot comment on NPG's appetite for this mechanism.

8. Recommendations

Based on the findings of the Newcastle Heat Pump Ready project, recommendations can be made to stakeholders in other locations who may be looking to deploy at high density. The key points have been outlined below;

1. **Collaboration with local authorities** in target deployment locations to establish an understanding of their overarching net zero plans/policies and localised plans (e.g. heat network analysis) is key to facilitating the ability for coordinated decision making on suitable deployment of heat pump technology within a wider portfolio of low carbon technology deployment ambitions.

   Working with the local authorities; for example, their comms team, experienced project teams and community teams helps to ensure all elements of the deployment planning are co-designed. For E.ON this was critical across several work packages, incorporating local authority feedback into community engagement & marketing, target area analysis and grid analysis deliverables.

   Consideration must be given to how the local authorities can gain mutual benefit from insight gathering / dissemination of learnings, based on the effort, time and any public subsidy put in and it is helpful to have this pre-agreed.

2. **Collaboration with the relevant Distribution Network Operator (DNO) in target deployment locations to build a baseline model of the electrical network is critical, from which to accurately assess which properties are connected to which parts of the DNO network and capacity / load analysis.**

   This has been an activity under development by NCC for some years. However, without any statutory driver, it was always piecemeal, an add-on to BAU and only happened at the pace of the weakest link or limitations in available data, ongoing resource capacity issues and software challenges have also hampered progress. There is no standard methodology for DNOs to enable local authorities to build this baseline. Projects like HPR therefore enter a space with an increased focus in this area which was hugely welcomed by the local authority and recognised that developing more intelligent, automated assessment tools is needed. E.ON has the capability and tools to build the more intelligent model, however as outlined in the conclusions, the model remained incomplete due to a lack of data from the DNO.

   NPG have reflected on this outcome and the process experienced through feasibility and have made the following recommendations, applicable to themselves and potentially useful for other DNOs.

   - Commit resource to agree internally and with consultation with industry which data sets are the most useful, focus resource on these in terms of validating the contents and quality (prepared for release).
   - Create and publicise a glossary of available data sets and the specific processes for requesting them.
   - Outline details about each data set – what it includes, the value of the data, what is open-source data vs what needs specific data sharing agreements in place.
   - Have a defined process (with SLAs) in place for agreeing a relevant data sharing agreement, based on pre-agreed templates to limit implications on legal resource.
   - Ask for any modelling outcomes / results to be shared back with the DNO for mutual benefit and feeding into the continued design considerations of local networks.

3. **Consider innovative dynamic grid management solutions and the application of these on the low voltage network and whether this could alleviate short to medium terms constraints** thus allowing for deployment progress to continue at pace, ahead of network upgrades being required. Unfortunately, this was commercially out of scope for the Newcastle Heat Pump Ready project but recognised as having potential to overcome barriers to dense, large-scale deployment.

4. **To achieve attractive propositions that can convince customers to switch away from gas, there needs to be a key focus on the ability to provide strong Return on Investment (ROI) that has been robustly calculated.** This has links to improving accuracy of surveying and design practises for example to ensure we are presenting customers with accurate energy demand and running cost predictions. It also links to ongoing monitoring processes that ensure the ROI is being realised through system performance optimisation, and to controlling the upfront capital cost of install allowing customers to make informed decisions about their solution requirements.

5. **Fully explore a variety of finance products / propositions and look at integrating these service providers within the overarching operating model and customer journey.** Large-scale dense deployment requires high conversion rates of customers to install to be achieved, thus having a portfolio of financing mechanisms ensures choice, alignment with multiple customer segments. Ensure ROI is clear and visible for customers to make informed decisions between propositions and associated financing routes.

Appendix 1. Grid analysis: substation capacity results

Grid
analysis_substation fe

Appendix 2. Substation mapping and comparative analysis against potential target areas

Substation mapping
and analysis against t

Existing E.ON portfolio data review:

Summary outputs of the mapping exercise are shown below in Figure 3.1 and 3.2 to understand geographical spread of the following categories (leads, technical surveys, designs and installs) as indicators for ASHP appetite, property suitability and conversion to install. This has been used to support decision making on priority zones for deployment in HPR for example indicating areas with customer advocacy is already established etc

Figure 3.1 – map extract of heat pump leads (at postcode level) received during previous E.ON projects in Newcastle, as an indicator for customers willing to engage with and apply for a heat pump

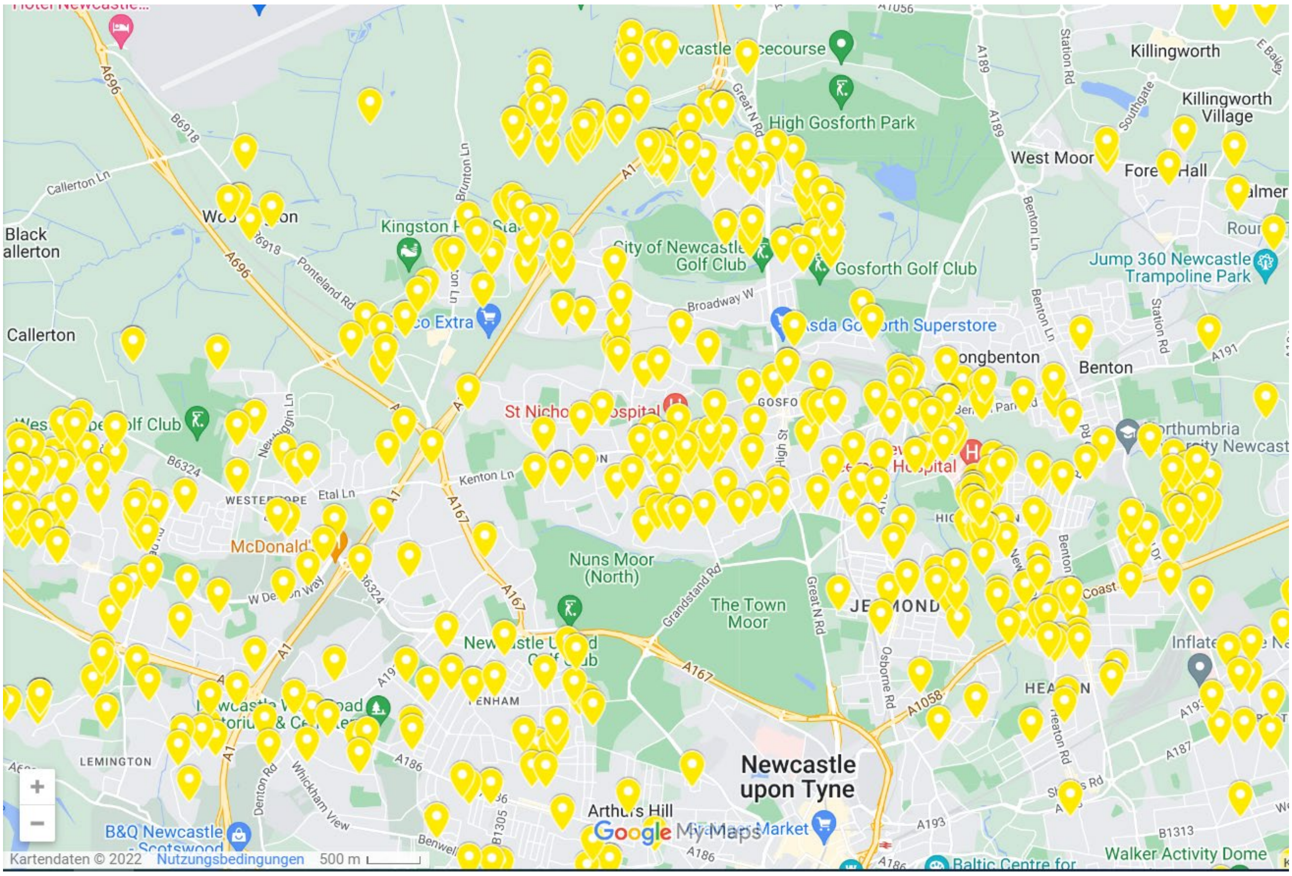
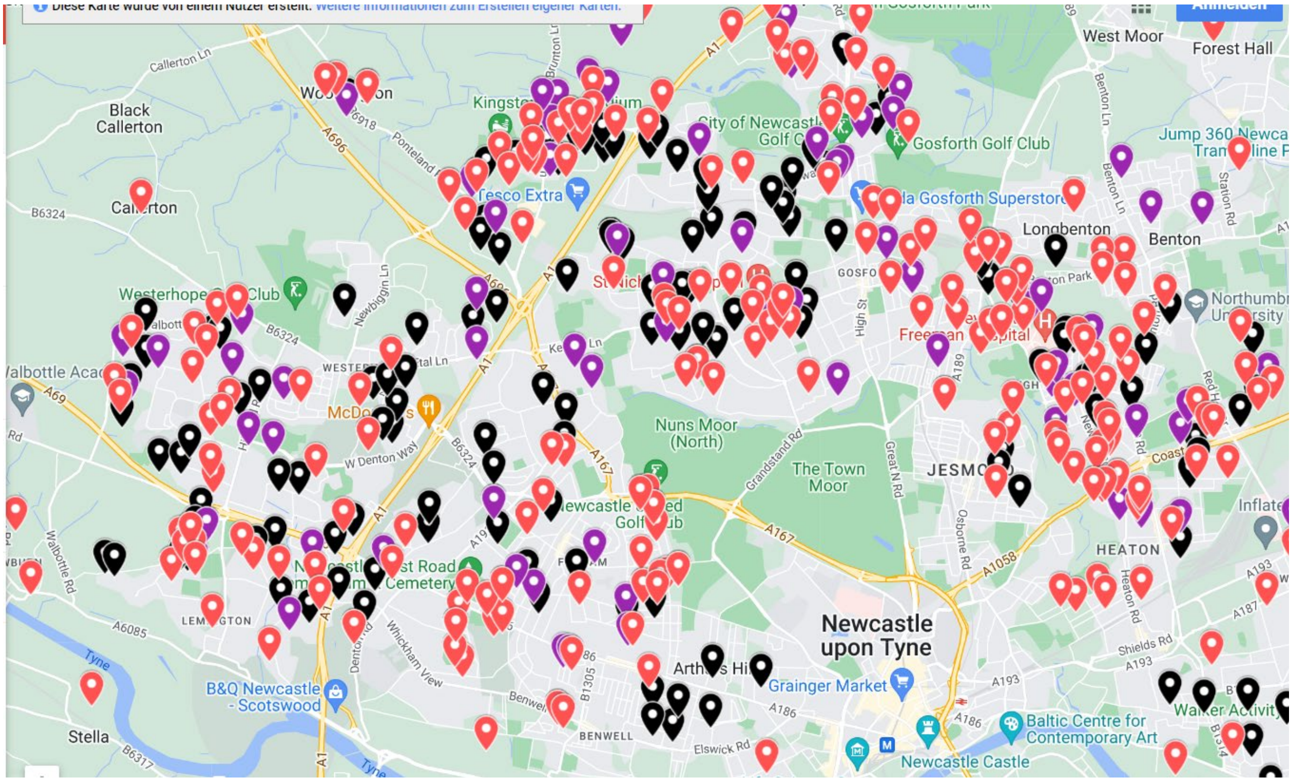


Figure 3.2 – map extract showing (at postcode level) successful heat pump technical surveys, designs, and installations, as an indicator of technical suitability for heat pumps.



Review of existing insights:

E.ON initially established a re-focus on known existing challenges to deployment in Newcastle from experience. This included review of project performance reports that tracked cancellation / drop out reasons at multiple stages in the journey to ensure these were considered as part of our approach to large-scale, dense deployment. Extracts are included in figure 3.3 to show insights for properties dropping out of the customer journey at early stages of their application and 3.4 showing a mix of cancellation reasons experienced at/after the technical survey stage.

Figure 3.3 – extract from E.ON analysis report into the triage process used to omit unsuitable properties prior to progressing customers to technical survey.

Some extracts from the assessment outcomes have been included below to offer additional context into the specific reasons identified for property unsuitability. There are clear reoccurring factors such

"Mid terrace with a conservatory in the middle of the back garden, no room for the heat pump unit"

"Patio doors and back door, no space on rear wall and no position on the side due to proximity to boundary"

"4m wide mid terrace - small garden - limited space for unit , any location would be too close to neighbours habitable windows for noise calcs"

"L-Shaped semi, will fail on noise due to boundary wall and courtyard, and neighbours habitable window"

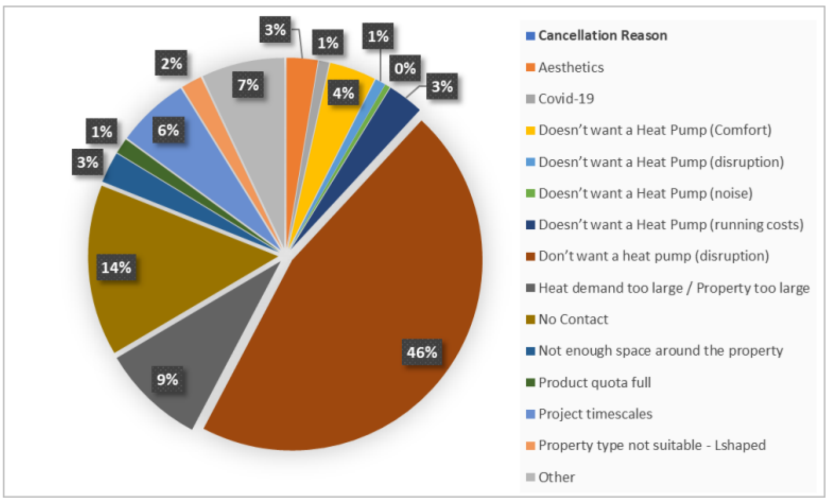
"2 lower rear extensions leaving no space for unit - side elevation too narrow"

as size of garden, presence of conservatories, extensions and patio doors that are limiting the available locations for the external unit on the rear elevation. The predominant urban & semi-urban location and resulting dense housing meant the side elevations were also difficult due to proximity to the neighbours boundary.

Figure 3.4 - cancellation reason snapshot based on data held within E.ON's CRM platform, for customers at or post technical survey, within the heat pump journey

The reasons for cancellation by participants (or E.ON) are summarised below in Figure 13. with the leading reason being customer led with c.46% of non-progressing participants quoting disruption as a significant concern.

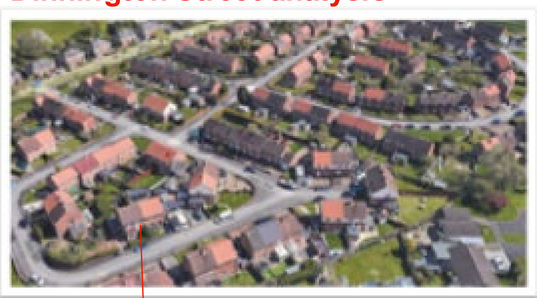
Figure 13. Cancellation Reason Summary

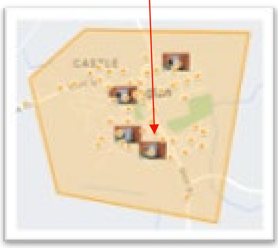


Appendix 4. Typical archetype identification and suitability review

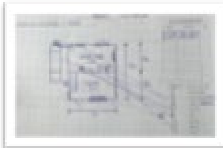
Zone 1 Property suitability analysis

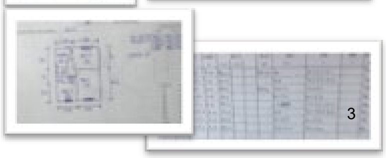
Dinnington Street analysis





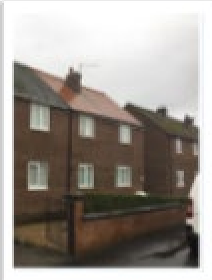
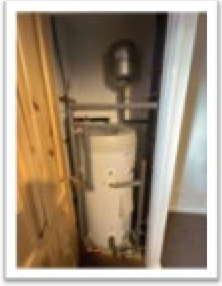
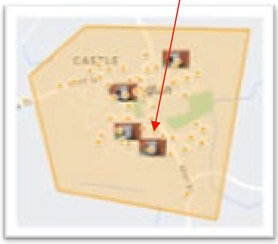
Dinnington– Street 1	NN13 7LF
Typical Property archetype	Semidetached/Endterrace
Bedrooms	3/4
Age band	1950 - 1966
Typical size m2	90 to 110
Heat pump suitability	Low temp or Hybrid
Internal space for HWT	Validated



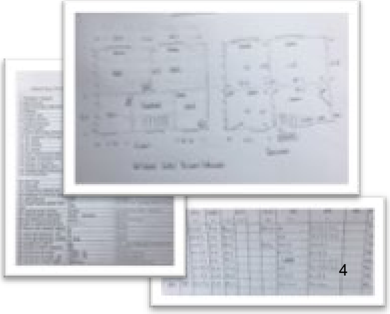


3

Dinnington Street analysis

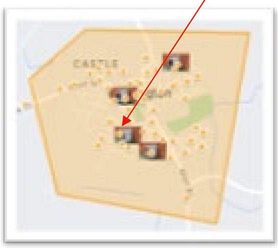
Dinnington– **Street 2**	**NN13 7LP**
Typical Property archetype	Semi detached/Mid terrace/End terrace
Bedrooms	3/4
Age band	1950 - 1966
Typical size m2	90 to 110
Heat pump suitability	Low temp or Hybrid
Internal space for HWT	Validated



Dinnington Street analysis

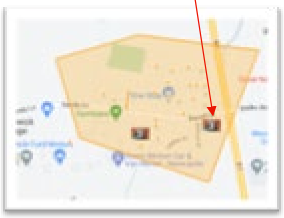




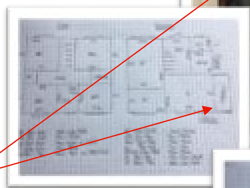


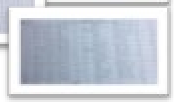
Dinnington– **Street 3**	**NN13 7LS**
Typical Property archetype	Semi detached/Semi Bungalows
Bedrooms	2/3
Age band	1967 - 1975
Typical size m2	60 to 90
Heat pump suitability	Low temp or Hybrid
Internal space for HWT	Validated (attached garages)

Brunswick Street analysis

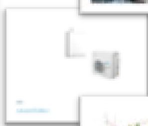


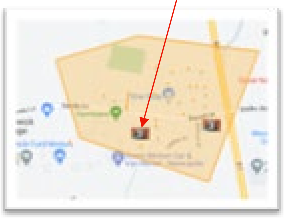
Brunswick – **Street 1**	**NN13 7LS**
Typical Property archetype	Detached Houses & Bungalows
Bedrooms	3/4
Age band	1967 - 1975
Typical size m2	90 to 120
Heat pump suitability	Low temp or High temp
Internal space for HWT	Validated (attached garages & cupboards)



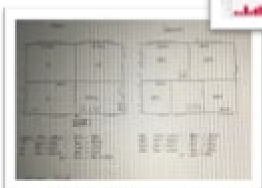


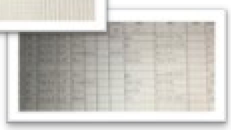
Brunswick Street analysis



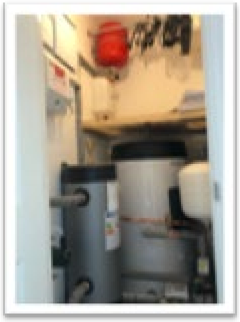


Brunswick – **Street 2**	**NN13 7DL**
Typical Property archetype	Semi-Detached Houses
Bedrooms	3
Age band	1950 - 1966
Typical size m2	85 to 105
Heat pump suitability	Low temp or Hybrid
Internal space for HWT	Limited





North Gosforth Street analysis



North Gosforth – **Street 1**	**NN13 6NN**
Typical Property archetype	Semi–Detached & detached Houses
Bedrooms	3/4/5
Age band	2012 onwards
Typical size m2	115 to 140
Heat pump suitability	Low temp
Internal space for HWT	Cylinder cupboards

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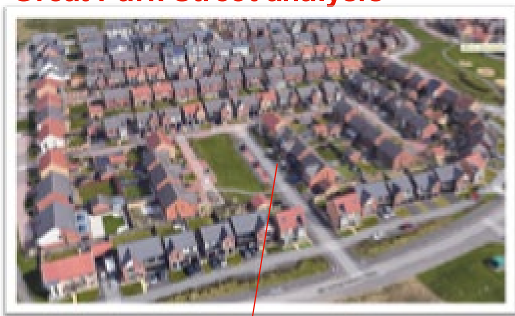
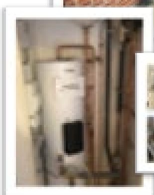
Hazlerigg Street analysis

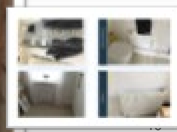
Hazlerigg – **Street 1**	**NN13 7ND**
Typical Property archetype	Mid Terrace & End Terrace
Bedrooms	3
Age band	1950 - 1966
Typical size m2	85 to 105
Heat pump suitability	Low temp or Hybrid
Internal space for HWT	Limited (cylinder cupboards)

Great Park Street analysis

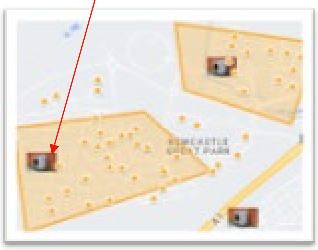


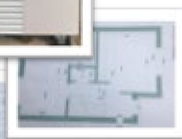
Great Park– **Street 1**	**NN13 9DH**
Typical Property archetype	Detached Houses
Bedrooms	4/5
Age band	2012 Onwards
Typical size m2	120 to 145
Heat pump suitability	Low temp
Internal space for HWT	Validated (cylinder cupboards)





Great Park Street analysis





Great Park– **Street 2**	**NN13 9EH**
Typical Property archetype	Detached & Semi-detached Houses.
Bedrooms	3/4/5
Age band	2012 Onwards
Typical size m2	90 to 145
Heat pump suitability	Low temp
Internal space for HWT	Validated (cylinder cupboards)

All properties have 10mm microbore copper & plastic pipework

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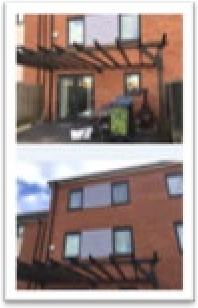
Great Park Street analysis



Great Park – **Street 3**	**NN13 9BN**
Typical Property archetype	Detached & Semi-detached Houses (3 story)
Bedrooms	3/4/5
Age band	2012 Onwards
Typical size m2	110 to 145
Heat pump suitability	Low temp
Internal space for HWT	Validated (cylinder cupboards)

All properties have 10mm microbore copper & plastic pipework

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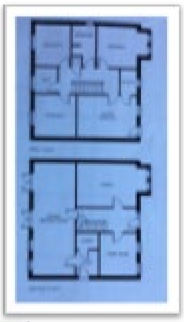
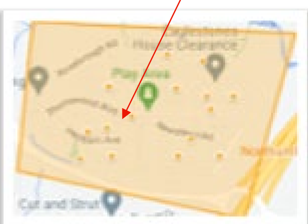
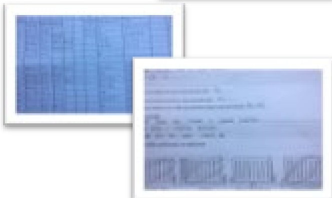
Brunton Bridge Street analysis





Brunton Bridge – **Street 1**	**NN13 9AP**
Typical Property archetype	Detached Houses
Bedrooms	4/5
Age band	2012 Onwards
Typical size m2	160 to 210
Heat pump suitability	Low temp
Internal space for HWT	Validated (cylinder cupboards)



All properties have 10mm microbore copper & plastic pipework

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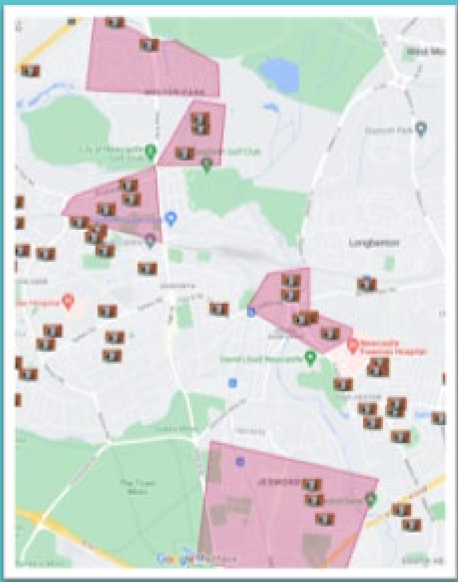
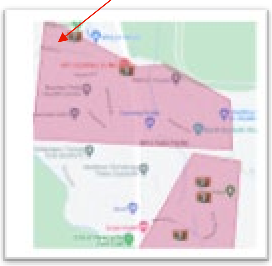
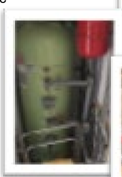
Zone 2 Property suitability analysis



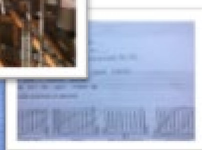
Melton Park Street analysis

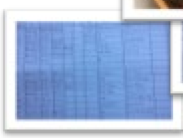
All properties have 10mm microbore copper & plastic pipework



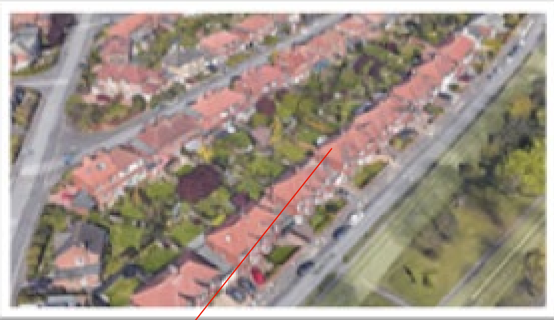


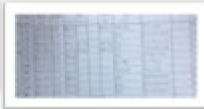
Melton Park – **Street 1**	**NN3 5RB**
Typical Property archetype	Detached Houses
Bedrooms	4/5
Age band	2012 Onwards
Typical size m2	145 to 160
Heat pump suitability	Low temp
Internal space for HWT	Validated



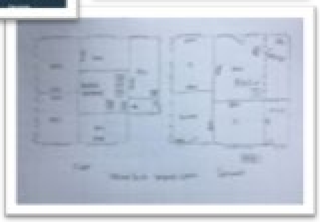


Melton Park- Street analysis



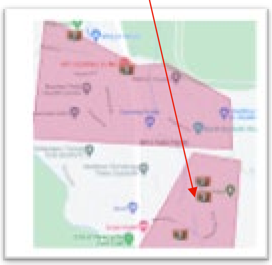

Melton Park – **Street 2**	**NN3 5LX**
Typical Property archetype	Semi-Detached Houses
Bedrooms	4/5
Age band	1930 to 1949
Typical size m2	125 to 160
Heat pump suitability	Hybrid or High temp
Internal space for HWT	Limited



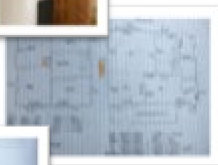
Melton Park- Street analysis





Melton Park – **Street 3**	**NN3 5LU**
Typical Property archetype	Detached Houses
Bedrooms	4/5
Age band	1983 to 1990
Typical size m2	90 to 160
Heat pump suitability	Hybrid or Low temp
Internal space for HWT	Validated (Garage & cylinder cupboard)

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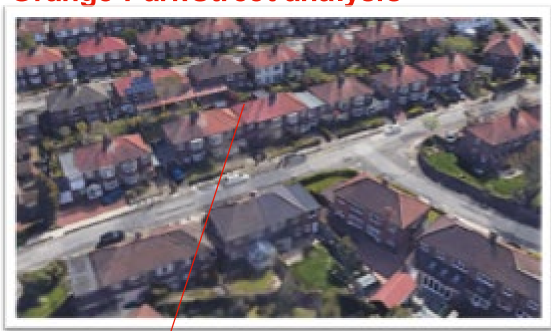
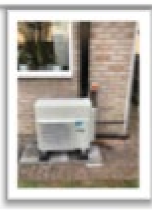
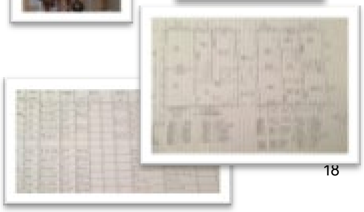
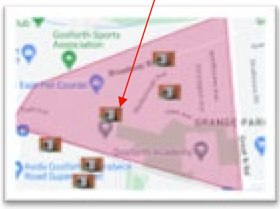
Grange Park Street analysis









Grange Park – **Street 1**	**NN3 2HQ**
Typical Property archetype	Detached Houses
Bedrooms	4/5
Age band	1950 to 1966
Typical size m2	85 to 120
Heat pump suitability	Hybrid or Low temp
Internal space for HWT	Validated (cylinder cupboard)

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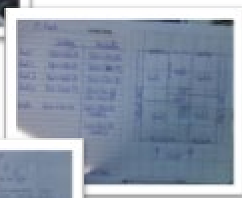
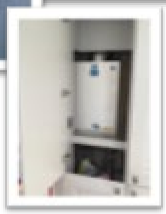
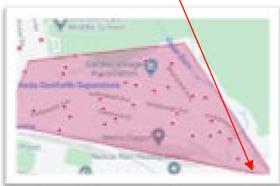
Zone 4 Property suitability analysis

Grange Park Street analysis



Grange Park– **Street 1**	**NN3 5BH**
Typical Property archetype	Semi- Detached Houses
Bedrooms	3/4
Age band	1976 to 1982
Typical size m2	85 to 110
Heat pump suitability	Hybrid or Low temp
Internal space for HWT	Validated

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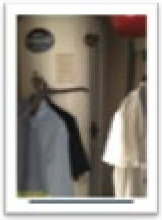
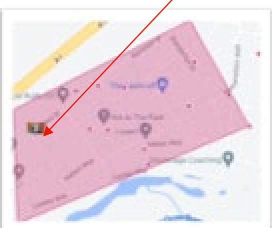
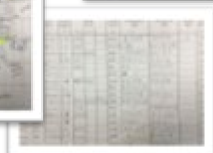
Grange Park Street analysis



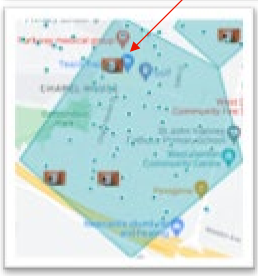






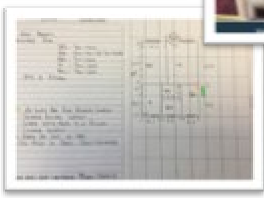
Kingston Park– **Street 1**	**NN3 5RG**
Typical Property archetype	Mid terrace /Semi & Detached Houses
Bedrooms	3/4/5
Age band	2003 to 2006
Typical size m2	115 to 235
Heat pump suitability	Low temp
Internal space for HWT	Validated

Zone 5 Property suitability analysis

Chapel House Street analysis



Chapel House Street 1	NN5 1XB
Typical Property archetype	Semi & Detached Bungalows
Bedrooms	2/3
Age band	1950 to 1966
Typical size m2	50 to 75
Heat pump suitability	Low temp & Hybrid
Internal space for HWT	Limited



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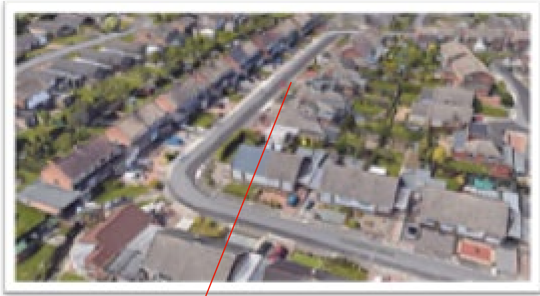
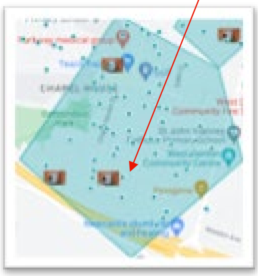
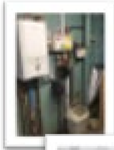
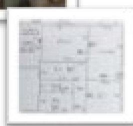
Chapel House Street analysis



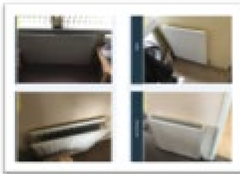


Chapel House Street 2	NE5 1BP
Typical Property archetype	Semi-Detached Houses & Bungalows
Bedrooms	2/3
Age band	1950 to 1966
Typical size m2	50 to 95
Heat pump suitability	Low temp & Hybrid
Internal space for HWT	Limited

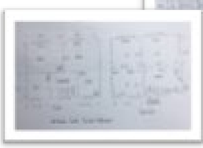




Chapel Park Street analysis



Chapel Park Street 1	NE5 1TU
Typical Property archetype	Semi-Detached Houses
Bedrooms	3
Age band	1950 to 1966
Typical size m2	80 to 95
Heat pump suitability	Low temp & Hybrid
Internal space for HWT	Validated



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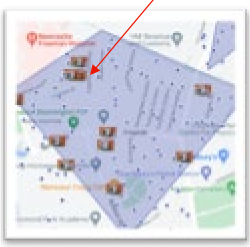
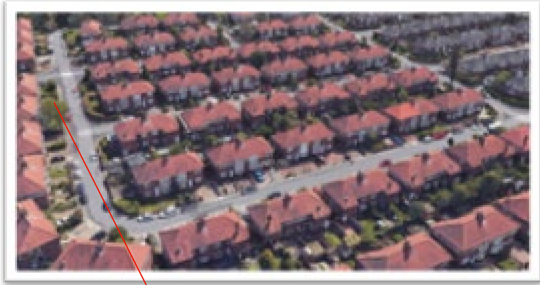
Zone 6 Property suitability analysis

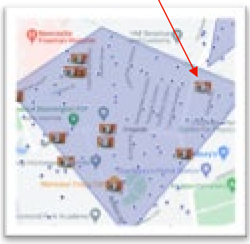
High Heaton Street analysis



High Heaton - Street 1	NE7 7AB
Typical Property archetype	Semi-Detached Houses
Bedrooms	3
Age band	1950 to 1966
Typical size m2	100 to 150
Heat pump suitability	Low temp & Hybrid
Internal space for HWT	Validated

High Heaton Street analysis





High Heaton – **Street 2**	**NE7 7PL**
Typical Property archetype	Semi-Detached Houses
Bedrooms	3
Age band	1967 to 1975
Typical size m2	100 to 150
Heat pump suitability	Low temp & Hybrid
Internal space for HWT	Validated

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Appendix 5. Desktop suitability assessment results: a street-by-street overview

WP2_Desktop
suitability assessment:

Appendix 6. Consumer insights modelling: Newcastle Propensity model

WP4_Counsmer
Insights_Newcastle Pr(

Appendix 7. Consumer insights pack: People, property, and perception in Newcastle

David Hardy

Heat Pump Ready

People, Property and Perception in Newcastle upon Ty

Contents

1 Overview

An overall view of Newcastle Upon Type, pulling out specific details of the HPR focus wards.

2 Area Detail

A more in depth view of the wards themselves.

Who lives there?

What persona insights can we use to shape our understanding?

What do we know about the housing?

Is the housing suitable for heat pumps?

3 Focus on Key Wards

A deeper look into the wards where we feel that there might be a greater appetite for heat pumps based on the factors we have analysed.

4 Heatpump Survey

Results from a survey we've run asking people in the North East of England about heat pumps.

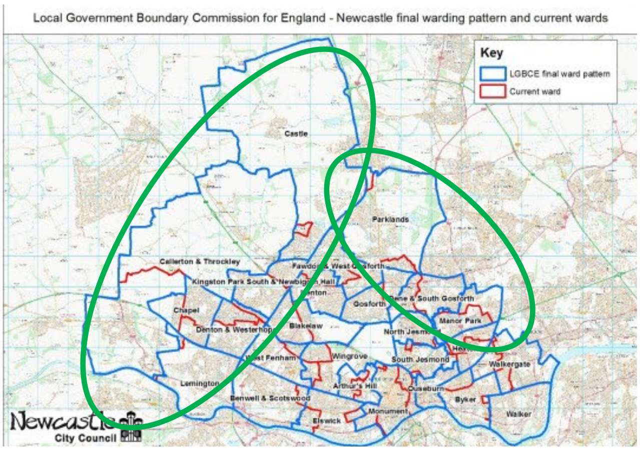
2

1 Overview

An overall view of Newcastle Upon Type overall, pulling out specific details of the HPR focus wards.

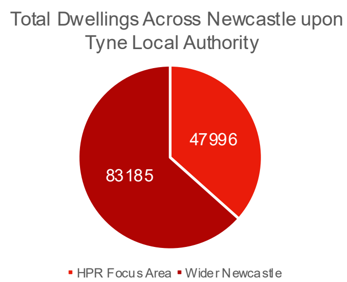
3

Areas of Focus



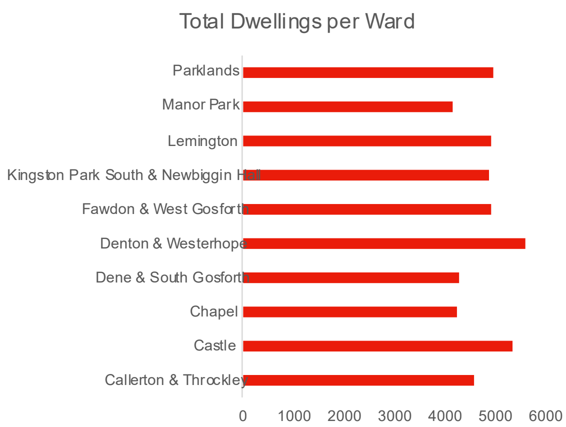
HPR focus wards

The Heat Pump Ready campaign in Newcastleupon Tyne covers largely the suburbanareasof the city. Of the 130k dwellingsin the wider local authority,our focusis on 36.6% or c.48k householdsin thoseareas



4

In Focus Wards



Focussing on the ten wards within Newcastle upon Tyne, we can see that they do not vary hugely in terms of volume.

However, to better understand the areas in isolation we will focus on several key aspects:

- Affluence
- Personas
- Age/lifestage
- Housing types
- Housing efficiency
- Potential for heat pump adoption

5

2 Area Detail

A more in depth view of the wards themselves.

Who lives there?

What persona insights can we use to shape our understanding?

Is the housing suitable for heat pumps?

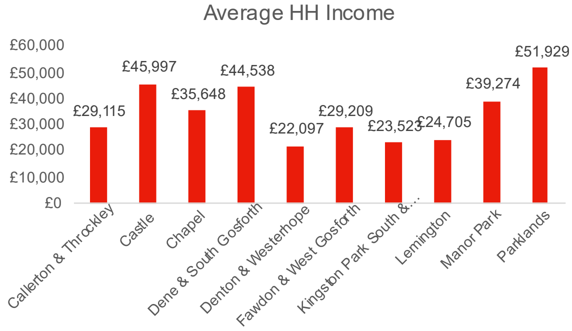
Is there an appetite for new energy solutions?

6

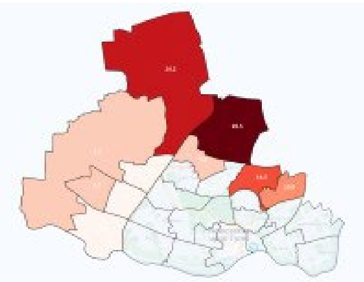
There is a distinct divide in areas' affluence

When looking at household incomes, we can see that the wards we're focussing on can be divided into two main groups:

Higher– Parklands, Castle, Dene & South Gosforth and Manor Park
Lower– Callerton& ThrockleyDenton &Westerhope, Fawdon& West Gosforth, Kingston Park South & Newbiggin Hall andLemington



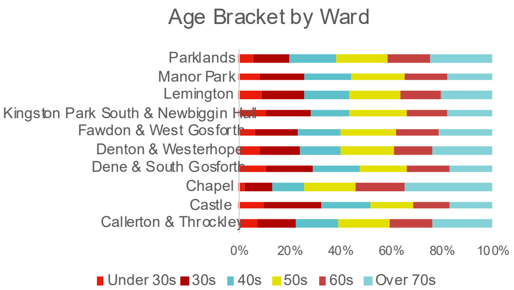
Ward	>£70k Income
Callerton& Throckley	5.1%
Castle	20.2%
Chapel	5.2%
Dene & South Gosfo	14.5%
Denton & Westerhope	0.1%
Fawdon& West Gosforth	5.3%
Kingston Park South Newbiggin Hall	0.3%
Lemington	0.3%
Manor Park	10.9%
Parklands	26.5%

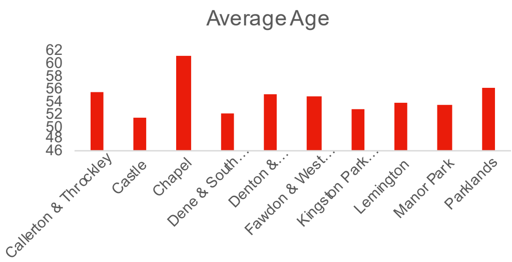


Geographically, the more affluent wards are slightly further north from the centre.

One ward not mentioned in these two income bracket group is Chapel, for a few reasons this ward stands separately fro the others, which we will see in other areas of insight. 7

Chapel stands out in terms of average age





Most wards are fairly consistent in terms of household age (based on the age of the dwelling's main decision maker).

However Parklands (56),Callerton& Throckley(56), and particularly Chapel (61) have more aging populations than the other areas.

This is a key factor that differentiates Chapel from the other regions, the likelihood of residents there being retired is much greater.

Dene & South Gosforth and Castle are areas of interest in terms of having higher representation from younger age groups.

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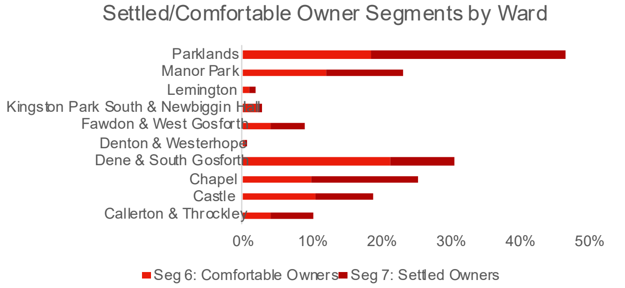
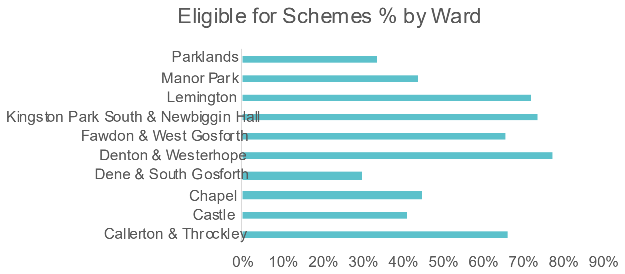
Who lives in these wards?





Echoing what we saw looking at household income, looking at the wards by sector also suggests that we can divide the wards by their characteristics.

- The four higher affluence wards have higher percentages of households in the comfortable/settled owner segments.
- Likewise we see far higher proportions of those eligible for schemes and support in the five lower income wards.

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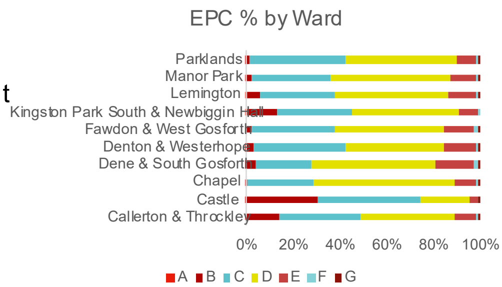
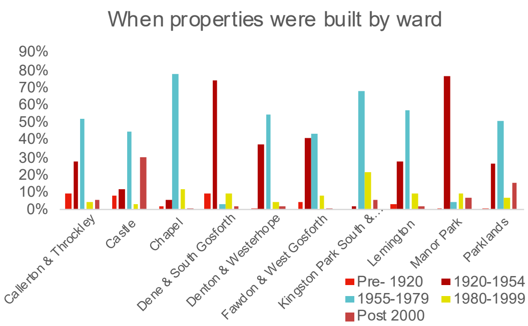
Housing is often older and only averagely energy efficient



Nearly half of all properties in our focus wards were built between 1955 and 1979, and as such will be mostly of solid wall construction. This is consistent with the EPC data (where available), as we mostly see properties falling into the D category.



Two particular exceptions to this convention are:

- Dene & S. Gosforth have much older houses, with little being built since 1955.
- Castle and Parklands have seen housing expansions since the turn of the century, with Castle seeing nearly 30% of its dwelling built in the past decade. This is reflected with Castle's higher average EPCs.

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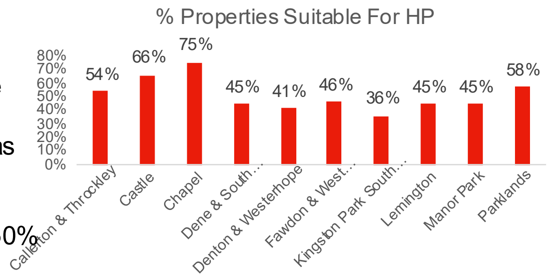
Heat pump specific housing metrics

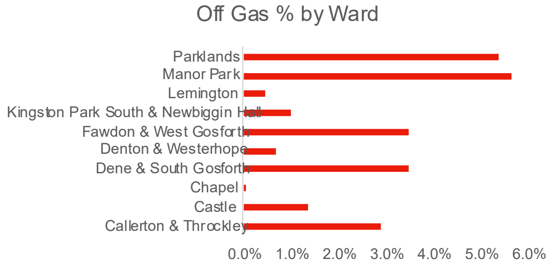


Two common issues with heat pump uptake are the suitability of the property, and the fact that many people have (and often prefer) a more traditional gas heating system.

Looking at property type, several areas have over 50% of their dwellings that fall into the suitable category (detached, semi detached, bungalow).

Again, Chapel fits with other metrics in terms of having an older population with nearly 1 in 10 properties being bungalows.

Parklands and Manor Park have the highest levels of properties with no gas supply, which are areas of opportunity as people might look to move away from expensive oil or electrical heating.



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3 Focus on Ke Wards

A deeper look into the wards where we feel that there might be a greater appetite for heat pumps based on the factors we have analysed and their Mosaic segments.

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Mosaic Segment B: Prestige Positions

Wards that have a high match (% of households in ward):
Parkland (26%)
Chapel (13%)
Manor Park (10%)

Well-educated couples who have reached senior and managerial positions in companies, or have accomplished professional careers.

Live in large family homes even though some of them no longer have children living at home, frequently with five bedrooms and large mature gardens in easily commutable locations. Of those whose children have grown up many are still offering support. For this group the continued financial support of their children is not a problem.

Almost all own their own home, many outright and, in addition to sizeable salaries or large pensions, they have a substantial investment portfolio making their financial situation very comfortable.

With busy lives to manage many make good practical use of the internet without spending long hours online. In particular they manage bank accounts online, search for savings accounts with the best interest rates, and save time by shopping online.

Defining Features:

- High value detached homes
- Married couples
- Managerial and senior positions
- Supporting students and older children
- High assets and investments
- Online shopping and banking

Reason for inclusion:
Likely to have disposable income/savings
Keen on new technology
Will be looking towards reducing outgoings for a comfortable retirement. 13

Mosaic Segment G: Domestic Success

Wards that have a high match (% of households in ward):
Dene & South Gosforth (26%)
Parklands (23%)
Manor Park (14%)
Castle (11%)

Families are headed by couples typically aged in their late 30s and 40s, many have school age children. Parents in this group are likely to have a degree and may have delayed having children until their careers were established.

They now live in good-sized three or four bedroom detached properties, owned with a considerable mortgage outstanding. Their lives are now settled and they have very comfortable standards of living. These are homes they can expect to stay in while their children grow up.

Company car ownership is high, a benefit of working for well-known organisations or professional firms.

Domestic Success are frequent internet users. As well as being constantly connected for work, they enjoy the time-saving convenience of banking, shopping and managing bills online. They love owning the latest technology and, in addition to smartphones, they are the most likely group to own tablets.

Defining Features:

- Families with children
- Upmarket suburban homes
- Owned with a mortgage
- 3 or 4 bedrooms
- High Internet use
- Own new technology

Reason for inclusion:
High income, possibly with savings
Very keen on new technology
Will be looking for ways to reduce energy costs through technology. 14

Mosaic Segment F: Suburban Security

Wards that have a high match (% of households in ward):
Chapel (28%)
Lemington(13%)
Castle (12%)
Manor Park (11%)

Mostly headed by people aged between 45 and 65. Often still supporting adult children who may be studying, looking for work or enjoying their parents help while they save money for their own future.

Their typical home is a mid-range traditional three bedroom inter-war or post-war semi-detached house built for families in established suburbs. These are settled households and the average length of residency is 17 years.

Many years employment in a range of lower managerial, supervisory and technical occupations means they have been able to afford to buy their own homes. Many have paid off the mortgage altogether and others have a relatively small amount left outstanding.

Incomes within this group are respectable and lives are generally comfortable. Some families can feel stretched, particularly when the younger generation are not contributing to the household finances.

As a group they are reasonably tech-savvy, though they do not rush to buy the latest gadgets. They access the internet daily via broadband and will use it for researching products and services.

Defining Features:

- Older families
- Some adult children at home
- Suburban mid-range homes
- 3 bedrooms
- Have lived at same address some years
- Research on Internet

Reason for inclusion:
Lower outgoings
Looking ahead to retirement and may want to further reduce costs
Will be concerned about energy price rises, and will have houses that are HP sui

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Mosaic Segment E: Senior Security

Wards that have a high match (% of households in ward):
Chapel (33%)
Parklands (15%)
Dene & South Gosforth (12%)

The most elderly group of all, their average age is 75, and almost all are retired. Some are living with their long-time spouse, but a larger number are now living alone, and women outnumber men.

During their working lives Senior Security were employed in a range of managerial and intermediate occupations. They had sufficient income to buy their own homes with a mortgage which they have now paid off, leaving them with considerable equity in their homes.

These homes are comfortable semi-detached three bedroom houses and bungalows in pleasant suburbs. They are generally very settled, long-standing residents of their local communities and have the longest length of residency of any group, having lived in their homes for nearly 25 years, on average.

Though few now have high incomes, most live in reasonable comfort, their state pensions being supplemented by occupational pensions, and they are content with their standard of living.

Defining Features:

- Elderly singles and couples
- Homeowners
- Comfortable homes
- Additional pensions above state
- Don't like new technology
- Low mileage drivers

Reason for inclusion:
Although not keen on new technology, will be looking to minimise outgoings.
Likely to have the equity to be able to invest in heat pumps
Will have houses that match heat pump requirements

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Mosaic Segment I: Family Basics

Wards that have a high match (% of households in ward):
Denton &Westerhope(19%)
Kingston Park South & Newbiggin Hall (21%)
Lemington(16%)
Callerton& Throckley(13%)

Defining Features:

- Families with children
- Aged 25 to 40
- Limited resources
- Some own low cost homes
- Some rent from social landlords
- Squeezed budgets

Families in their 30s and 40s usually with school age children, whose finances can be overstretched due to limited opportunities, low incomes and the costs of raising their children. In addition to younger children, some families also continue to support their adult offspring. While many households are headed by a couple providing two incomes, a small proportion are lone parent households.

Homes are typically low value and may be located on estates or in pockets of low cost housing in the suburbs of large cities and towns. They are usually three bedroom terraced or semi-detached houses, often dating from between the wars or from the 1950s and 1960s. Most people have lived in the area for many years.

Limited qualifications mean that people can struggle to compete in the jobs market, and rates of unemployment are above average. Employment is often in low wage routine and semi-routine jobs. As a result many families have the support of tax credits, but significant levels of financial stress still exist.

Reason for inclusion:
Likely eligible for any schemes or grants to support heat pump adoption
Will be extremely concerned about rising energy costs

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Summary of Segmentation Analysis

Higher Affluence and Tech Adoption in Four Wards

Parklands, Castle, Dene & South Gosforth and Manor Park all have higher levels of household income and ov and will be more aware of new technology. They will probably already have higher levels of heat pump knowle similarly will be keen to reduce their energy costs in the face of rising prices.

Chapel could be an area of focus

Although heat pump knowledge is likely to be lower in this ward, there are high levels of home ownership and suitability. The population is older, and may well be looking to use some of the large equity they have in their h reduce future outgoings.

Lower income wards may benefit from grants and schemes

Callerton& Throckley,Denton &Westerhope,Fawdon& West Gosforth, Kingston Park South & Newbiggin Hall and Lemingtonare often resided in by lower income groups that may already receive benefits/tax credits and be elig any green homes support that is available.

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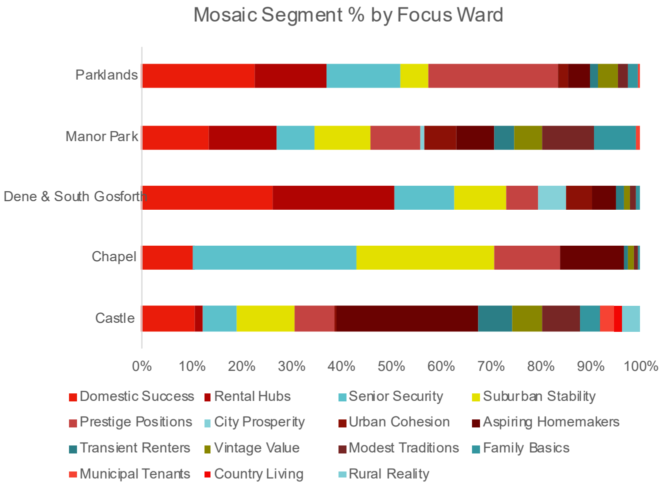
Mosaic Segments of Focus Wards



Top Three Segments by Ward

Parklands
Prestige Positions (26%)
Domestic Success (23%)
Senior Security (15%)

Manor Park
Domestic Success (14%)
Rental Hubs (13%)
Suburban Stability (11%)

Dene & South Gosforth
Domestic Success (26%)
Rental Hubs (25%)
Senior Security (12%)

Castle
Aspiring Homemakers (28%)
Suburban Stability (12%)
Domestic Success (11%)

Chapel
Senior Security (33%)
Suburban Stability (28%)
Prestige Positions (13%)

4 Heatpump Survey

Results from a survey we've run asking people in the North East of England about heat pumps.

UserZoom Heatpump appetite survey

To better understand how the public feel about gas heating alternatives we have run a survey to a panel of members of the public through the User Zoom platform.

Whilst asking more questions around their current housing and lifestage situation, we focused on the following:

- ➢ Whether they might welcome a transition to lower carbon alternatives.
- ➢ In what scenario might they adopt such technology.
- ➢ Whether they'd be happy to accept an additional cost to pursue a heat pump.

Note: These results are based solely on responses from customers based in the North East of England, in order to support our Newcastle campaign.

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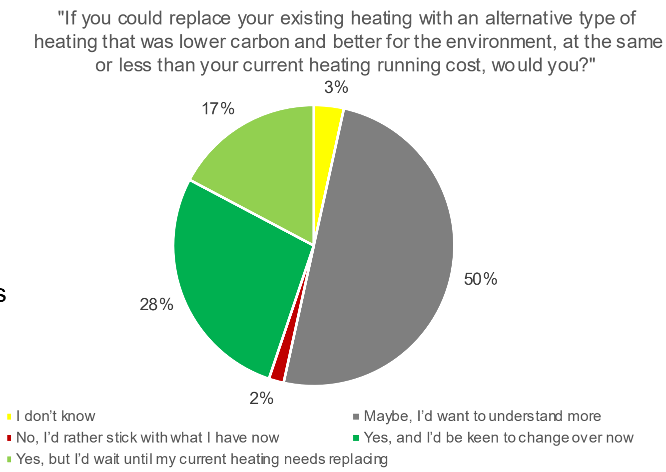
A large percentage are keen to look into gas alternatives

The appetite from respondents in the North East was overall very positive.

- ➢ 45% of people said that they would definitely would switch to a heat pump or similar technology, with two thirds saying they'd even go ahead now rather than wait until their existing gas boiler failed.
- ➢ 50% said they'd need more information, and as such with the right supporting resources would potentially become more positive in their response.
- ➢ Only 2% completely ruled it out.



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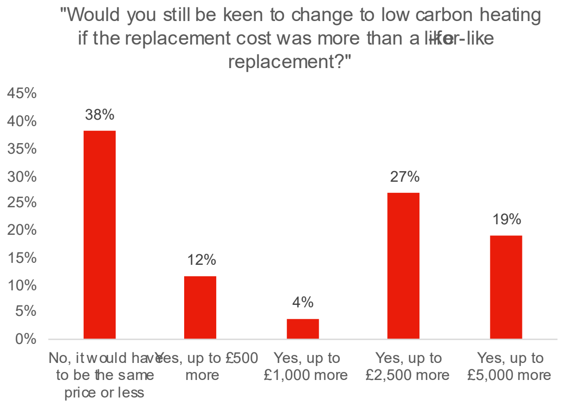
People would often be willing to pay more for a heat pump than a gas boiler

Respondents who responded positively to switching to a lower carbon heating solution were then asked about the cost they would be willing to incur in such a move.

62% of people said that they'd be happy to pay more, the highest proportion of this group saying they'd be happy to pay up to £2500 more, with 19% even saying they'd pay £5000 more for a low carbon option.

38% said that any alternative would have to be roughly the same cost as a traditional gas powered boiler.



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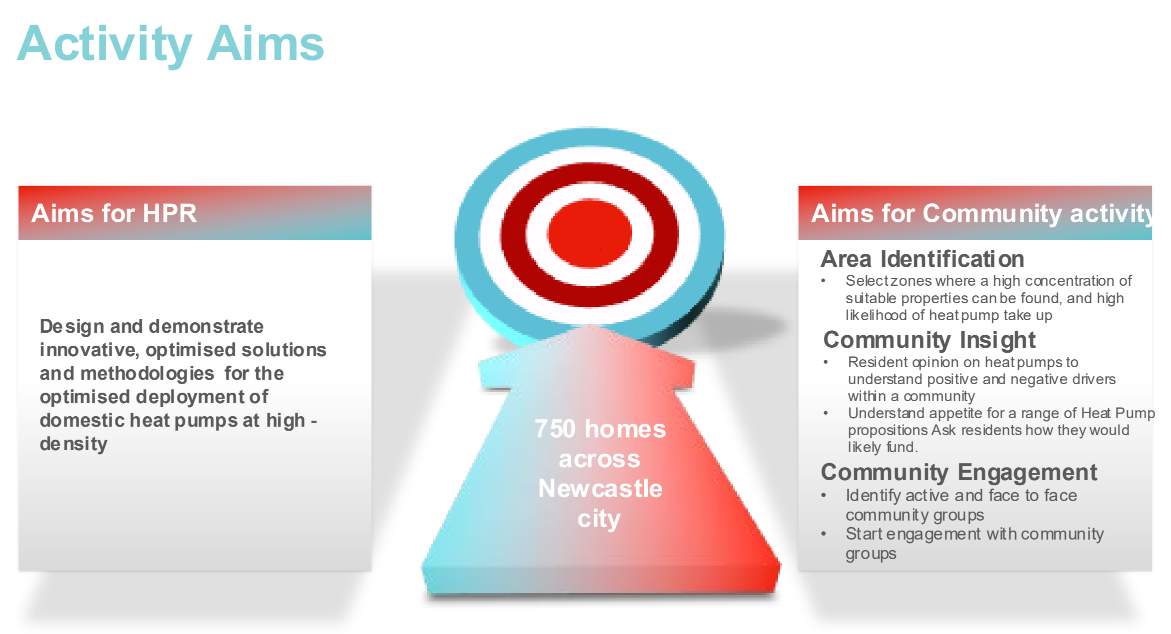
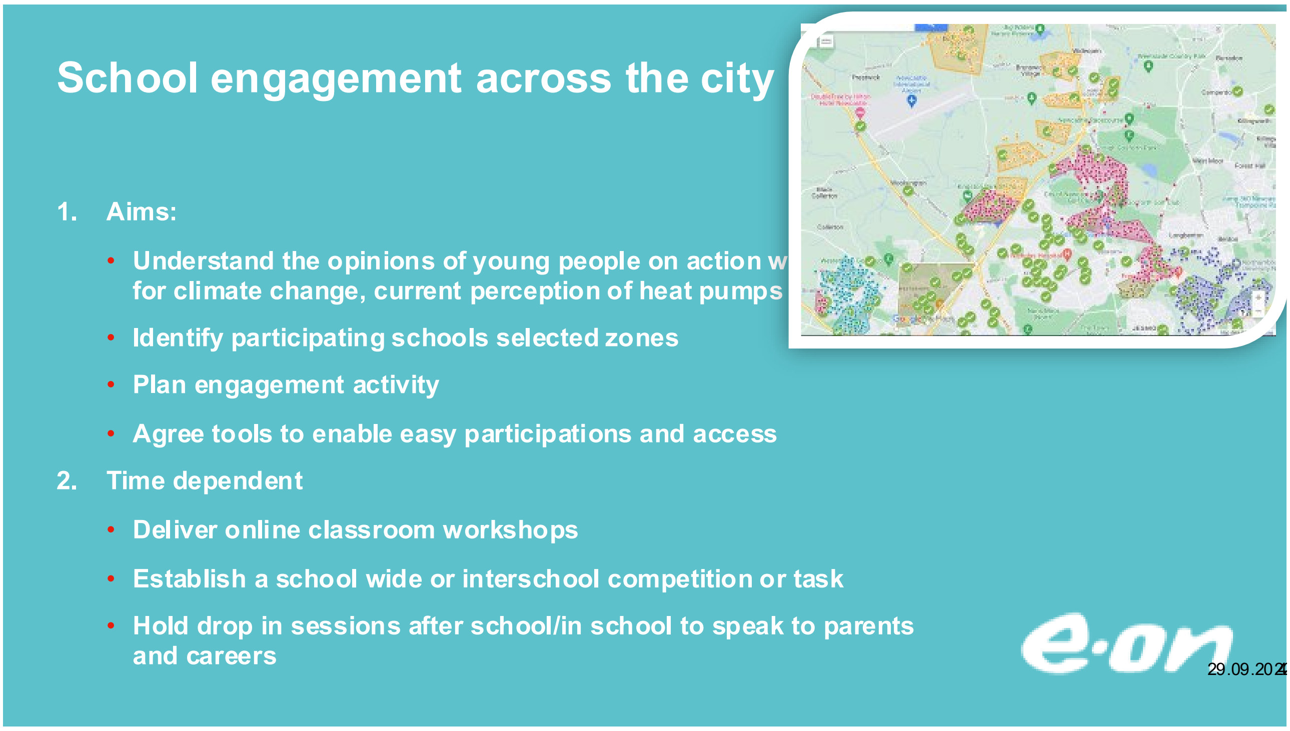
Appendix 8. Newcastle City Council: Community team input into engagement planning





Zone 1 - Great Park

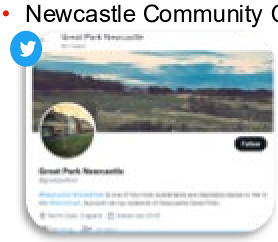
Active Face to face groups:

Susan Wannop (NCC Communities Team Co-ordinator)

- Busy community centre – after school clubs
- Select for Schools engagement programme
- Locally led events programme
- Community Ward meetings

Digital active groups:

- Facebook/Twitter
- Newcastle Community Conne



“I'd love to have a Heat Pump a
I'd take advantage of any grant t
help me take that step – I'm busy,
I hear I'll have to change my
pipework, I can't deal with the
mess. “
Local resident

Zone 1 insight (totals)

- ✓ Recruited customers within area – 249
- ✓ Heat Pumps installed within area – 19
- ✓ Remote survey 'pass' within area – 81%
- ✓ Owner Occ - >66%
- ✓ Income - >£50k
  - ☒ Blockers – Cancelled due to Disruption
  - ☒ IDNO, no data on grid capacity

Zone 2 - Chapel

Active Face to face groups:

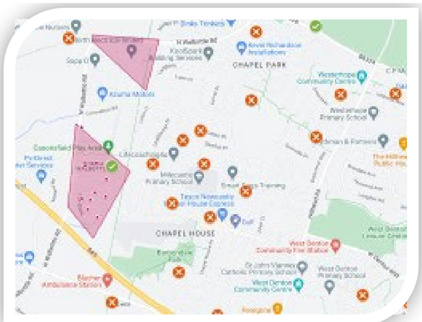
Susan Wannop (NCC Communities Team Co-ordinator)

- Potential for Busy community centre – after school clubs
- Select for Schools engagement programme – grandchildren
- Community Ward meetings

Digital active groups:

- Facebook/Twitter
- Newcastle Community Connect
- Denton Burn – Fenham Community pag

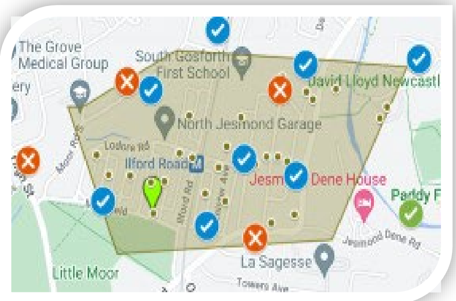
“I'd love to have a Heat Pump and
I'd take advantage of any grant to
help me take that step – I'm busy, I
hear I'll have to change my
pipework, I can't deal with the
mess. “
Local resident



Zone 2 insight (totals)

- ✓ Recruited customers within area – 155
- ✓ Heat Pumps installed within area – 12
- ✓ Remote survey 'pass' within area – 92%
- ✓ Owner Occ - >95%
- ✓ Income - <£50k
  - ☒ Blockers – Cancelled due to: Disruption, solution unsuitable

Zone 3 Jesmond



This area was not selected for Community engagement due to hi levels of cancellation due to property suitability.

There was a high level of engagement with residents initially, how large drop out due to significant fabric measures being required, l properties and internal upgrades needed to pipework.

There was no customer appetite to proceed with an install after surv due to the level of disruption.

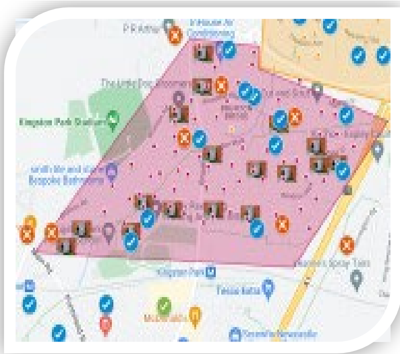
Digital active groups:

- Facebook/Twitter
- Denton Burn/Fenham community page

Zone 3 insight (totals)

- ✓ Recruited customers within area – 67
- ✓ Heat Pumps installed within area – 1
- ✓ Remote survey 'pass' within area – 92%
- ✓ Owner Occ - >25%
- ✓ Income - >£50k
  - ☒ Blockers – Cancelled due to Disruption
  - ☒ Low grid capacity

Zone 4 Kingston Park



Active Face to face groups:

Susan Wannop (NCC Communities Team Co-ordinator)

- Vibrant, active community centre
- Select for Schools engagement programm
- Key local contacts with community champi John Gardener prominent Community lead and Karen Colley Tesco Community Cham Locally led events programmes
- Community Ward meetings

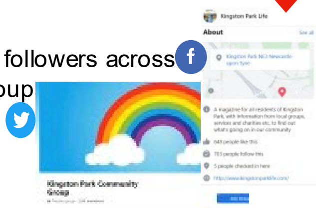
Local Advocate Susan Cree –

"Punctual, clean, no complaint what so ever. Absolutely over the moon and has already recommended to a friend. Saving on bills."

Previous system Warm Air

Digital active groups:

- >4.6k Facebook active followers across different community group
- Twitter
- Newcastle What's on



Zone 4 insight (totals)

- ✓ Recruited customers within area – 203
- ✓ Heat Pumps installed within area – 22
- ✓ Remote survey 'pass' within area – 92%
- ✓ Owner Occ - >97.5%
- ✓ Income ->£45k
  - ☒ Blockers– cancelled due to 'Disruption'
  - ☒ Low grid capacity
  - ☒ Finance

Zone 6 High Heaton

Active Face to face groups:

Louise Cameron (NCC Communities Team Co-ordinator)

- Local Cllr Folker active member of Climate Change Committee and keen advocate
- Select for Schools engagement programme
- Community Ward meetings

Digital active groups:

- Active Social Media following
- >4.6k Facebook active followe

across different community grou

- Twitter
- Newcastle Community Connec

Local Ward Meeting

"I'm still a little sceptical on whether the technology is there yet, I've heard negative things about heat pumps and just need more information and support when making the decision. I'd even consider including the upfront cost within a monthly plan combined with my energy"

Resident comments at ward meeting

Zone 6 insight (totals)

- ✓ Recruited customers within area – 300
- ✓ Heat Pumps installed within area – 16
- ✓ Remote survey 'pass' within area – 92%
- ✓ Owner Occ - >97.5%
- ✓ Income - <£50k
  - ☒ Blockers – Cancelled due to Disruption
  - ☒ Low grid capacity

Zone 7 Lemington

Labour Ward Active groups:

Active Face to face groups:

- Caroline Collinson (NCC Communities Team C ordinator)
- Community Centre, Health Works, Tyne View, Lemington, Newcastle upon Tyne NE15 8RZ
- Lunch session 11:30-13:30 2 hrs

Digital active groups:

- **Facebook**

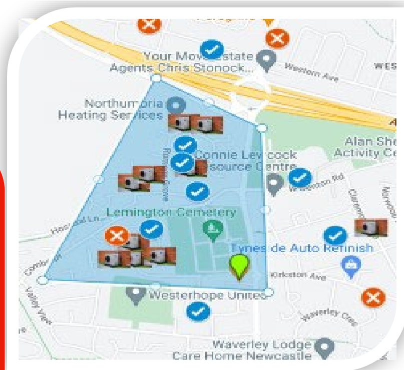
LemingtonShout Lemington residents past and presen

Lemington look out

- **Main supermarket: LIDL** (Might be an option for engagement vehicle as has large car park) see below for contacts
- [LIDL- Lemington, Newcastle upon Tyne Opening Times & Store Offers (openingtimesin.uk)]

Local resident

"I would have loved to be part of the past Heat Pump scheme in the area but just missed out - I want to get a new heating system and would welcome any help to do so



Zone 6 insight (totals)

- ✓ Recruited – 75
- ✓ Installed – 22
- ✓ Remote survey pass – 92%
- ✓ Owner Occ - >97.5%
- ✓ Income - >£50k
  - ☒ Blockers – cancelled 'Disruption'
  - ☒ Low grid capacity
  - ☒ Finance

Appendix 9. Marketing Concepts

HeatPumpReadyNew
castleConcepts Rt2 De

ASHP Study

by

Nationwide Drones Limited

Rev	Date	Author	Checked	Description of modifications
0	10/10/2022	DM	OJ	Original Issue

Table of Contents

1. Introduction

This report will investigate three different solutions to calculate heat loss for existing properties, accuracies of the outcomes and the impact on the customer journey. The three solutions considered in this study are:-

1. Traditional, manual survey by surveyor, with results input into online Heat Loss calculation tool (Daikin – Stand by Me)
2. Mobile Laser Scan utilising SLAM technology, with results being 3D Modelled in Revit then MCS heat loss calculations scheduled from the 3D model.
3. Veritherm, overnight whole house heat loss assessment, the output provides *total fabric Heat Loss,* measured in Watt per Kelvin (W/K), multiplied to give the total heat load.

1.

Alongside the three surveying solutions, air permeability tests and in-situ u-value measurements have been undertaken to provide benchmark data for overall result comparison.

2. Scope

Undertake three property surveys, utilising a wide range of data capture and processing tools, to provide comparisons of methodology, accuracy, disruption, and speed.

Carry out a manual survey, capturing all the data required onsite and transferring the data into Daikin Stand by Me.

Full Whole House Scan with NavVis VLX & Drone – external and internal walk-through property capturing laser scan and panoramic photography. Along with key fabric information this enables the creation of 3D Revit model, which allows for Heat Loss calculations to be produced, automatically.

Thermography (internal) – non-intrusive, hand-held camera. Images are captured internally to identify suitable locations for u value sensor to be installed.

In-situ u-value measurements - sensors – small (2cm x 2cm) pads stuck to internal walls using non-marking tape. Internal temp sensor attached using non-marking tape. External temperature sensor mounted externally, usually through a window (window will be closed and locked after install). Depending on location, a reflective cowl may be placed over the external sensor. This allows us to have a full understanding of how the wall is performing and removes the unknowns.

Air permeability testing – all windows, doors and vents are closed. One external door (usually front door) has a set of fans installed and sealed into aperture. Property is pressurised to provide an air pressure test value. This can be used to compare against assumed ventilation heat loss.

Veritherm – Sensors, fans and heaters are placed throughout the property to provide a mechanical airflow throughout the property, which is monitored overnight to provide a heat loss measurement for the property.

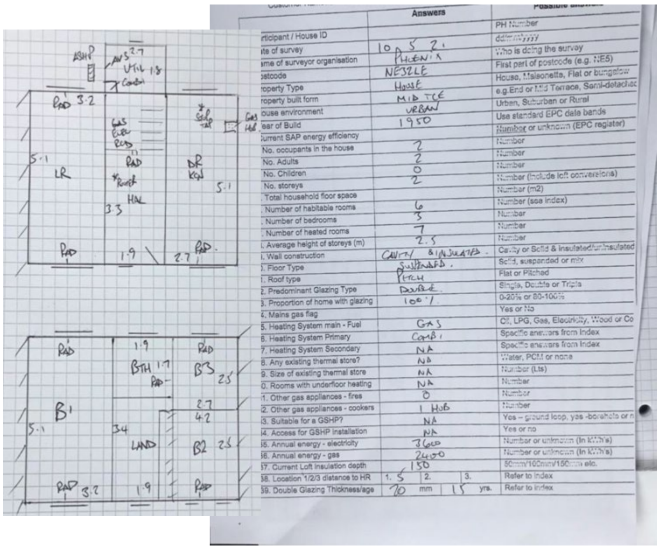
3. Purpose

Assess and make recommendations to E.ON on the optimum survey approach for large-scale, dense deployment – focusing on validating improvements to customer experience, customer journey and costs. Key theme will be accuracy of survey, implications for accurate design, timescale improvements, scalability/replicability, link into downstream install journey.

4. On-site Survey

Manual Survey

The traditional survey is formed of two parts. Firstly, a paper-based survey form collecting information about the property and a second part being a measured plan of the property. The survey investigates the fabric build-up of the property to ensure u-values can be calculated.



The onsite survey for a heat pump typically **takes 1.5 - 2 hours per property** and can vary depending on complexity, both in size/layout of the building and number of different property parts/construction types. On larger, complex buildings, the survey times can be expected to take up to half a day, per property.

Beside is an example of sample floor plans and site notes, along with this the surveyor will also provide photographic evidence to give the designer a visual representation of the property.

Mobile Laser Scan

Much like the manual approach (above) the Mobile Laser Scan is formed of two main parts, focusing on dimensional measurements and the fabric build-up of the property. However, the data is collected in different formats. All photo evidence and fabric information are collected on a web-based app, all the dimensional information is collected using a survey grade accurate mobile laser scanning device and converted into a 3D Revit model.

The app is typically used on an iPad, but can be used on different viewing tools, such as laptop web, iPhone, or android. The app allows all data to be collected in a clean, clear format, The app is designed to ensure all essential information is collected and that the survey cannot be progressed without completing all fields.

The app also prompts the user to take photos to support the data collection, benefitting later audit processes.

Dimensional information is collected using a mobile laser scanning device, producing an accurate point cloud which is then converted into a 3D Revit model. The device used is a NavVis VLX, which offers high levels of accuracy utilising SLAM technology. Mobile laser scanning is up to 10x faster than terrestrial laser scanning.

Combining both mobile laser scanning and data collection via the onsite app, offers significant time savings, with a typical property taking approximately 30min to survey.

Veritherm

The Veritherm system uses a network of data loggers and sensors, electric heaters and fans to determine a buildings Heat Transfer Coefficient (HTC). The Veritherm thermal validation process is designed to operate overnight, by applying a constant, measured heating power to the building for a period of time, using fans to ensure as even temperature as possible throughout the interior of the building. The test is run overnight to avoid the effects of solar heating/loading.

The measurement stage consists of measuring the temperature inside and outside the building while it is heated, and then when it is left to cool. During this process the building should be sealed against air ingress in a way consistent with the airtightness test to minimise the heat loss through air exchange. If an up-to-date airtightness result is available, the measured rate of air exchange at this level of sealing can be used by the Veritherm calculations.

The set-up of the equipment varies depending on the amount of equipment that is required to ensure a consistent stable heat can be achieved. The set-up time is approximately 1-1.5 hour, this allows for all equipment to be set up and set up test complete. The property needs to be unoccupied during the test, once the kit is set up the property is usually vacated till the following morning. On the following morning when the property is handed back to the client, data is reviewed, and the equipment is packed away.

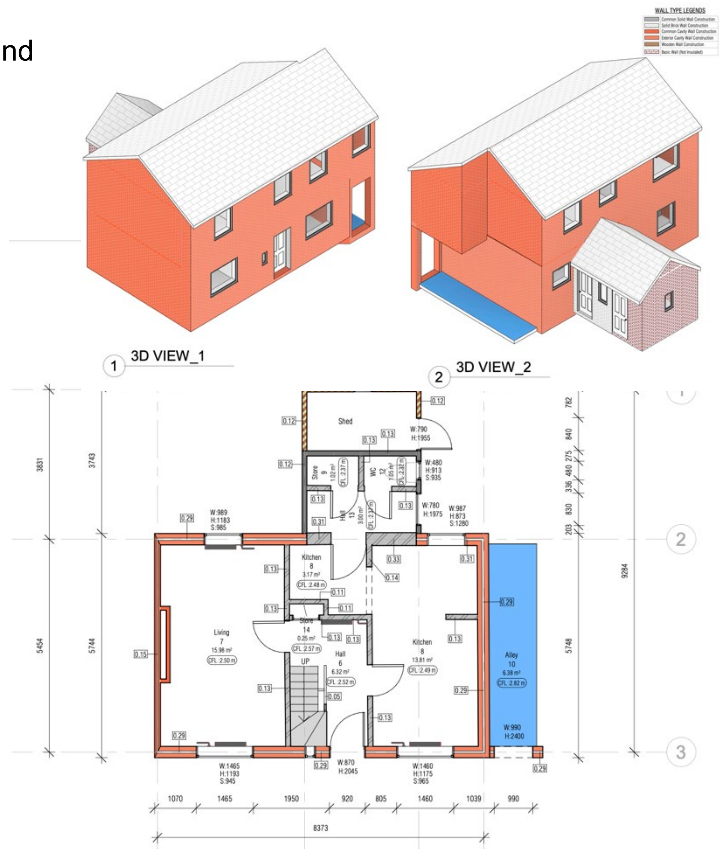
5. Design/Post survey processing

Manual Survey to Daikin - Stand by Me

Post survey the data is collated and submitted for the designers to start their process of transferring the information into online software (Daikin - Stand by Me). It typically takes three days to gather all the information required by the designer. Once the designer has received the onsite survey it takes the designer approximately three hours to run the information through the online platform. It is worth noting that if data is not clear or information is missing it can take two days to receive responses from Daikin to continue with the design.

Mobile Laser Scan to MCS heat loss calculation

Fabric information, photos and additional information is received straight into the project once submitted on the iPad. However, the laser scan information is processed into a 3D Revit model, post survey. The following morning, post survey, a 3D replica of the property is available online, which is interactive to navigate and measure from, giving the designer the opportunity to navigate the property remotely and start their design process promptly.



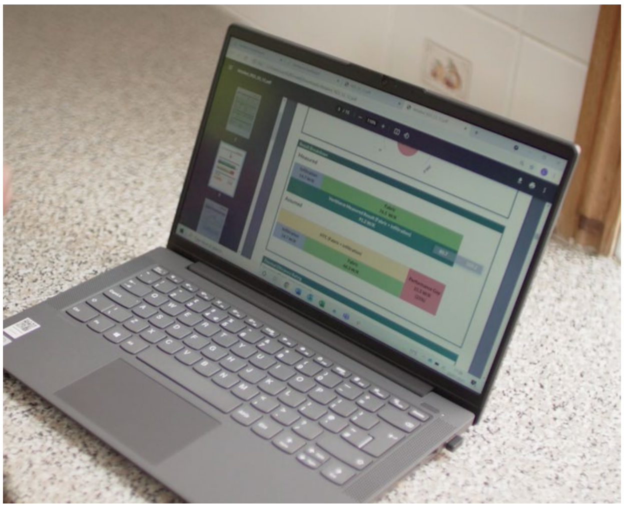
The laser scan point cloud takes 2-3 days to convert into a 3D model. Point clouds are datasets that represent objects or space. These points represent the X, Y, and Z geometric coordinates of a single point on an underlying sampled surface. Point clouds are a means of collating a large number of single spatial measurements into a dataset that can then represent a whole. A custom developed script is used to export all the required dimensional information from the model.

Dimensional information that is extracted from the model is room volume, floor area, below the floor relationship, external wall area, ceiling area, above the ceiling relationship, roof area, window area, door area, party wall area, internal wall area and adjoining. All the dimensional information is directly imported into the software and enables the data to be connected to the fabric information gathered on the iPad. Once this data is combined in the software a heat loss calculation is automatically generated. This then only requires the designer to review the calculations and spec the relevant heat emitters.

Veritherm survey to total fabric heat loss

Data is uploaded to the cloud and analysed automatically, with the proprietary algorithms returning a definitive answer as soon as the test is complete. The building's thermal response to both heating and subsequent cooling is measured and compared to the calculated response based on the design data.

The output from the system provides overall Heat Transfer Coefficient (HTC), the result can be broken down into fabric and infiltration loss, if an air test has been undertaken on the property. The HTC of a building is defined as the "heat flow rate divided by temperature difference between two environments" as in ISO13789. For example, if the required property is to be heated to 21ºC and the outdoor design temperature Is -3.4ºC the HTC is multiplied by 24.4 (the difference between the two) which provides the maximum space heating load in kilowatts.

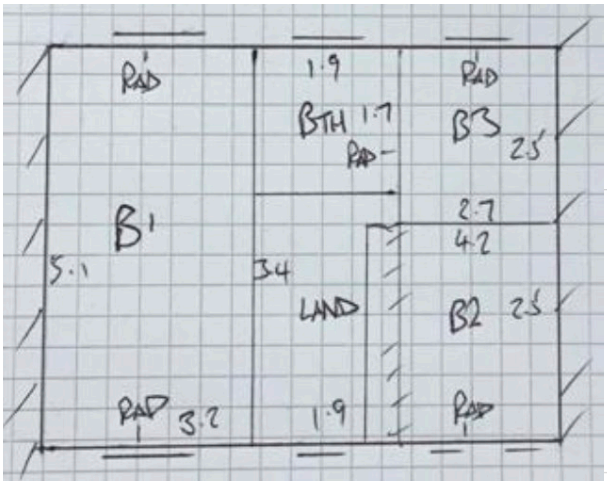


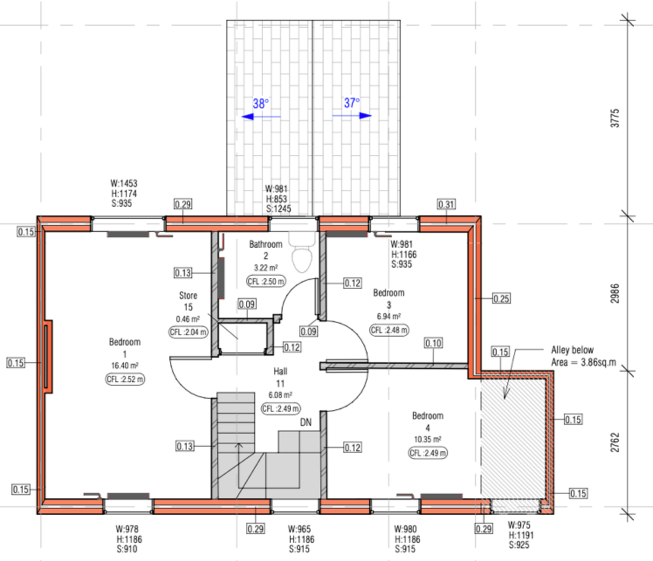
6. Heat loss review

Manual Survey

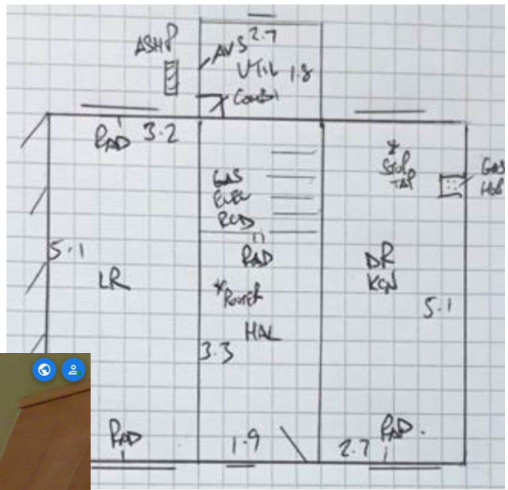
The software used for this approach was Daikin - Stand by Me. By manually capturing dimensional information and inputting into the online tool there is a risk that data is misread and a risk of input error. During manual survey it is common that complex rooms are mis-calculated and that some rooms are treated as square, this is also how rooms are treated in online tools. However, this is not how we experience rooms in the real world, with it being very common to have built in storerooms, indents into rooms, with different floor types and ceiling roof types.

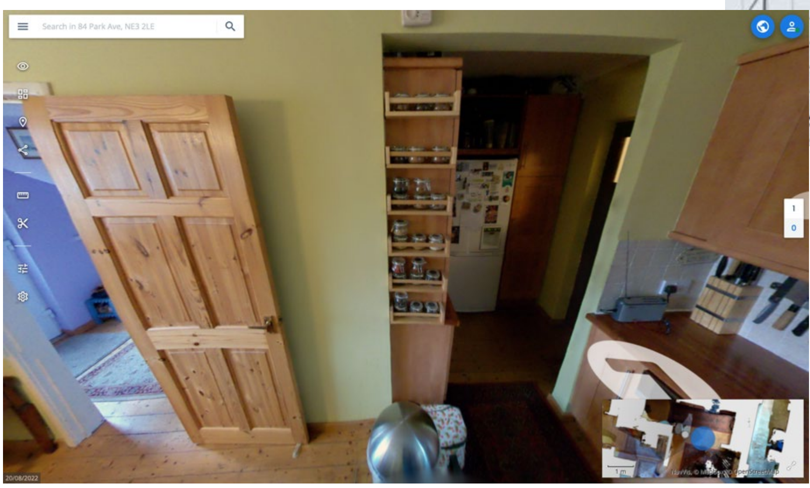
In the floor plans below, room B2 in the manual survey vs room 4 on the CAD plans differs, with part of the room being suspended over the alley, the properties interlock and are not split 50/50 over the alley. This will mean a greater party wall area has not been factored in, with the wall being calculated as an internal wall to another room the same, resulting in no loss. However, if treated correctly as a party wall it would result in a heat loss. The manual survey has also not factored in the exposed floor of the alley way, this would offer a large heat loss. However, it has been treated as a heat gain from the room below.

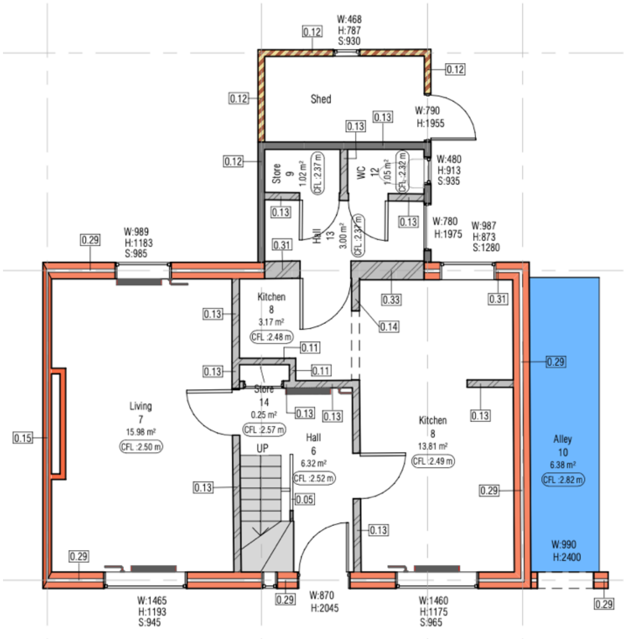




The floorplans from the manual survey have errors on the ground floor plan, with the hall being shown as being as much larger than it is, a section which is labelled as 'hall' belongs to the kitchen, as seen in the below image. The correct floorplan can be seen in the cad floor plan below. The utility and WC have also not been included within the calculations.







Further to the inaccuracies in the manual floor plan onsite capture and input, Daikin also adds 15% to all fabric calculations. The total heat loss per room is the fabric heat loss plus 15%, plus the ventilation heat loss, which can be seen on the below example.

The correct total fabric element should total 356.34. However, Daikin adds a factor of 15% to the fabric, which totals 409.79.

Bedroom 2

Measurement: internal

Fabric loss	Material	Heat transfer to	Thermal bridges insulated	Length (m)	Width (m)	Height (m)	Area (m²)	U-value (W/m²K)	ΔT (°C)	Heat loss (Watts)
Internal floor	Intermediate Floor Timber without insulation	Dining room	No	2.5	4.2		10.5	1.73	-3	-54.5
Roof	300mm Insulation	Directly to the exterior	No	2.5	4.2		10.5	0.12	21.4	26.96
External wall	Cavity wall, insulated, 50mm Mineral Wool, Brick 102mm, Plaster	Directly to the exterior	No	4.2		2.5	10.5	0.56	21.4	99.95
Window	Standard Double Glazing Wood/PVC frame						2.16	2.8	21.4	129.43
Internal wall	Brick 102.5mm	Through an unheated space	No	2.5		2.5	6.25	1.76	8	88
Internal wall	Brick 102.5mm	Bedroom 3	No	4.2		2.5	10.5	1.76	0	0
		To an								

Ventilation loss	Air changes per hour	Length (m)	Width (m)	Height (m)	Volume (m³)	Specific heat of air	ΔT (°C)	Heat loss (Watts)
	1	2.5	4.2	2.5	26.25	0.34	21.4	191
Sub total								191

Ventilation heat loss is estimated based on internal room dimension. If the room dimension input is external, then a factor 0.8 will be multiplied.

Result	Heat loss (Watts)
Fabric heat loss	409.79
ventilation heat loss	191
Reheat load	0
Exposed location	0
Total heat loss	600.79

Mobile Laser Scan

Geometric dimensions are directly exported from the 3D Revit model and **directly imported into the heat loss calculation tool, without the risk of human error in transferring the data, this results in increased accuracy of dimensional information.** By creating a 3D model, it enables the rooms to be broken down by adjacency, above/below and percentage of which rooms are adjacent/above/below. This offers increased accuracy of calculation by not only assuming one room above or below, as seen in the manual calculations.

This method does not rely on the surveyor to measure or identify what is above or below a room, this is undertaken directly on export from the 3D model. If the same property was surveyed by ten different surveyors, the results would vary between each surveyor. **However, if the property was scanned 10 times, there would be little to no variation in the dimensional results, providing accurate, replicable, and consistent results.**

The calculations from this approach are in line with MCS guidelines. Due to the buildings being existing dwellings, it is very difficult to have a full understanding of the fabric build up and what materials the properties are built from. Therefore, RdSAP has been used. RdSAP is designed to assess existing dwellings based on build type and age band. **RdSAP software gives the designer flexibility to overwrite with a calculated or measured value.**

Veritherm

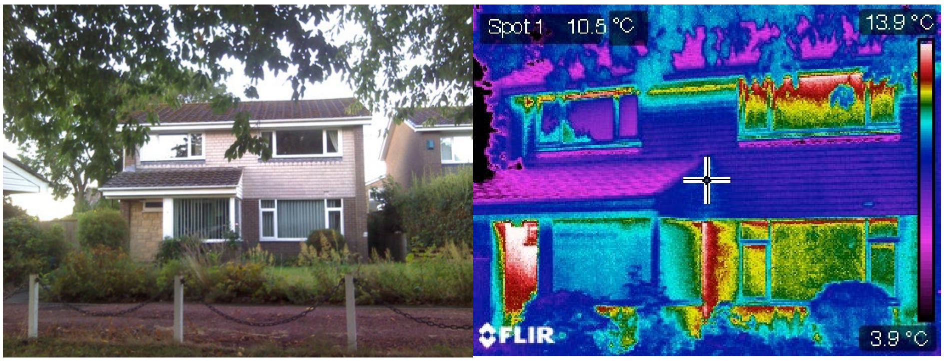
This solution offers a whole house calculation, which calculates *total fabric heat loss in* W/K, the unit of measurement for energy loss from a building as a function of temperature difference. The measured performance of the Veritherm approach shows it can detect deviations from the specified HTC of ±15%. This is only slightly less accurate than a good co-heating test yet requires only a single night's testing.

The main limitation to performance found is significant heat losses through party walls – these can be accounted for accurately if the thermal resistance of the walls is known and the temperature in the adjacent property is accurately measured. Without an air tightness test measuring air infiltration, Veritherm can only measure the HTC for fabric and air infiltration, and if it determines a lack of conformity to specification it cannot say if this is a fabric or air-tightness issue. If combined with an air tightness test, Veritherm can measure the HTC for fabric alone and can determine if a lack of conformity is a fabric or air-tightness issue.

In summary, the Veritherm approach has shown good repeatability and robustness across a range of conditions and, from the trial data, agreement with measured values obtained using the more extensive co-heating test. It is shown to be a system that can verify the thermal specification of housing.

Due to Veritherm providing a whole house heat loss which is not broken down on a room-by-room basis as required by MCS, it makes it difficult for a designer to correctly specify a heat emitter. With rooms having different fabric make ups, such as floors, ceiling, and walls, it would be very difficult to accurately break this down on a room-by-room basis.

Property 1



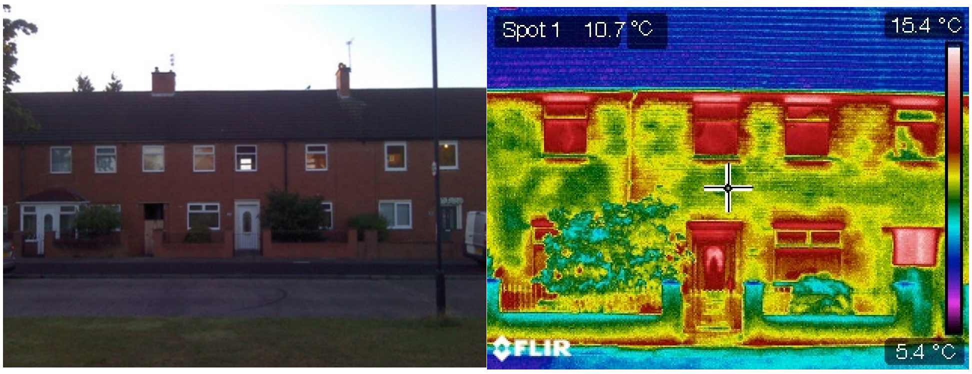
NE13 7LN is a detached cavity-built property with no insulation to the cavity walls.

Manual survey to Daikin Stand by Me = 9356.31 W

Mobile Laser Scan to MCS heat loss calculation = 8184.05 W

Veritherm = 6108.18 W

Property 2



NE3 2LE is a Mid-terrace cavity-filled property, which has a section to the front of the building, located over an alley way, with the neighbouring property over the rear part of the alley. The property has a rear extension which houses a utility, W/C and a store.

Manual survey to Daikin Stand by Me = 5684.94 W (Note W/C and Utility/hall not included)

Mobile Laser Scan to MCS heat loss calculation = 5425.01 W

Veritherm = 5082.64 W

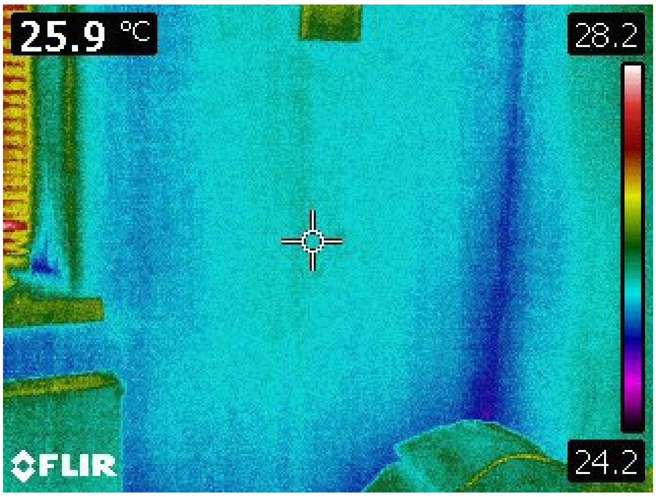
7. U-Values

There are multiple approaches to obtain u-values, such as calculated based on design values, based on property age band and construction, or measured. For calculated u-values, a full understanding of the building materials is required. This can be very difficult to obtain on existing housing stock.

The RdSAP method utilising assumed u-values based on several set criteria, such as build type/fabric type and age band, gives a good indication of existing houses where a full breakdown of the construction is not available/possible. Other elements, such as windows, are based on type and age.

It is also well known that there is a significant difference between 'as designed' and 'actual' as-built performance, known as the "Performance Gap". There are many impacts that can affect the performance gap such as build quality, material selection and environment. Veritherm does not utilise u-values in its calculation method, therefore overcoming the issue of assumption and the performance gap.

During this study we undertook measured u-values to highlight the difference in both calculated u-values and RdSAP u-values. The measured as-built u-values are obtained using an in-situ measuring device which consists of a heat flux sensor, external and internal temperature loggers. This approach is standardised in ISO 9869, ASTM C1046 and ASTM C1155 which is a method of calculating as built u-values. This method delivers reliable quantitative in-situ information about a building envelope. Thermal imaging is used to place the sensor in the most stable location on a wall to ensure it not situated on a cold bridge or stud, and represents an example of the whole wall, as seen in the below thermal image.



An example of the differences in wall u-values are highlighted below:-

<u>Property 1</u>

Designed = 1.37 W/(m2K)

RdSAP = 1 W/(m2K)

Measured = 1.16 W/(m2K) Gable wall, Lower construction front and rear 0.79 W/(m2K) and upper tiled part to the rear of the property 0.55 W/(m2K)

Both the Manual survey and 3D model have used one wall construction. However, both should, and can, be broken down to highlight the different wall types. The designed value of 1.37 is the highest u-value, which is much higher than the measured and RdSAP u-values. Alternative wall sections of the building are performing much better (lower u-value).

Property 2

Designed = 0.56 W/(m2K)

RdSAP = 0.7 W/(m2K)

Measured = 0.41 W/(m2K) Rear 0.75 alley way W/(m2K)

RdSAP is showing in line with the measured u value of the alleyway, whereas the designed is more closely aligned with the rear upper of the building.

8. Ventilation

Daikin and MCS follow the same process to calculate Heat loss from air changes per hour, the key difference is in the volume measurements resulting in a difference in heat loss. Both systems use design air change per hour rates per room type. Veritherm utilises a blow door test, which was undertaken to give a more accurate measurement of the heat demand, **based on actual ventilation loss**. **This further highlights the performance gap, as discussed in the previous section.** Workmanship and design will vary significantly from property to property, which will have a significant impact on the required heat demand. All the subject properties have been improved over their lifespan, with new windows, doors, insulation etc. However, the workmanship and materials used will vary, **and similar house types can have very different air loss characteristics.**

Property 1

Daikin = 2703.41 W

MCS = 2866.38 W

Veritherm = 1982.58 W

Property 2

Daikin = 1950.6 W

MCS = 2371.69 W

Veritherm = 944.30 W

9. Summary

Onsite survey

Manual survey has highlighted the risk of input error and reliance on skilled resource to accurately measure properties to ensure a reliable heat loss can be calculated. Accuracy of measurements and the surveyor's assumptions/interpretations will affect the result, giving the designer little opportunity to sense check the results and audit the plans.

Mobile laser scan

Mobile laser scanning has developed significantly in recent years, resulting in the reduction of scan time, and becoming more commercially viable, especially in housing. Laser scanning has developed in such a way that it can be undertaken **with only basic training and still offer accurate, consistent, dependable data sets.** The mobile laser scan has shown consistent accurate dimensional information results whilst offering significant time saving when compared to the other surveying approaches and **removes the risk of human interpretation when transferred to heat loss calculation.** Also, the added benefit of offering the designer a digital replica/360 view of the building, navigable online platform and aerial imagery to sense check and audit their own designs.

Veritherm

This approach offers a consistent **method of measuring total heat loss**. However, Veritherm cannot be used to break down the heat loss into a room-by-room basis. Therefore, the correct heat emitters can't be specified off the back of the results. The key concern of using Veritherm versus the manual or laser scan approach is the not-insignificant disruption to the customer, requiring they vacate the property overnight while the test is being undertaken.

Performance gap

This exercise has highlighted that both u-values and heat loss from background ventilation have influenced the end heat loss output of each property. Measured data should be used where possible to remove assumption/interpretation and provide the most accurate heat loss of the property.

10. Supporting documents

- [Veritherm – validation report]
- [NavVis VLX Accuracy report]
- [In-situ measurement of thermal resistance and thermal transmittance]
- Property 1 Manual Survey to Daikin Heat loss report
- Property 1 Laser Scan to Heat loss report
- Property 1 Veritherm Heat Transfer Coefficient report
- Property 1 Air test result
- Property 1 in-situ u-value
- Property 2 Manual Survey to Daikin Heat loss report
- Property 2 Laser Scan to Heat loss report
- Property 2 Veritherm Heat Transfer Coefficient report
- Property 2 Air test result
- Property 2 in-situ u-value

Appendix 11. Heatio Heat Pump Ready Report

Introduction

The Heat Pump Ready Newcastle project is focused on those areas of Newcastle-Upon-Tyne with existing capacity for large-scale heat pump roll-out. It aims to support Northern Powergrid in identifying areas of the city in which grid upgrades may be necessary. Eight areas will be analysed to determine the most feasible locations for heat pump deployment at scale.

In the medium term, surveys utilising drone and laser scanner technology will be undertaken to create a digital twin of a customer's home and garden. This will dramatically reduce surveying time and disruption to the customer, whilst producing accurate first-time data capture and improving the accuracy of heat pump design and specification. This will remove significant consumer barriers to the installation of heat pump systems.

Our research identifies 1) potential process improvements that will facilitate the optimisation of accurate heat pump design & product specification and 2) clarification of where oversizing may be occurring and processes by which this may be mitigated.

Outcomes from our research will form the basis for the development of a portfolio of consumer propositions. These will ensure that consumers receive accurate heat pump system designs and specifications, whilst addressing capital cost barriers through innovative finance solutions, including Heat as a Service (HaaS) .

Author of this report

Simon Roberts
Managing Director
Heatio Limited

Research Objectives

1. Design Process Improvements

Objectives: 1) To provide recommendations on potential process improvements for optimising accurate heat pump designs & product specifications; 2) To Understand whether oversizing may be occurring and whether this can be mitigated.

- Summary of Analysis
- Approach & Methodology
- Findings Report
- Project Review
- Recommendations

2. Heatio Smart Home Energy Monitoring

Objective: 1) To provide recommendations on integration into the E.ON customer journey, validating alignment with specific consumer requirements.

- Proposition Summary, including potential benefits to the consumer
- Customer Journey Integration Recommendations

2) To create desktop case studies which utilise available data relating to customers who chose not to proceed with a Heat Pump installation on account of perceived negative factors. Ways in which the device could have been applied to support incremental "heat pump ready" activities and overcome barriers to deployment are identified.

3. Heat as a Service

Objective: To integrate HaaS proposition within the E.ON customer journey, validating proposition alignment with consumer requirements.

- Consumer Research Report
- Proposition Summary, including modelling examples for various HaaS packages

4. Next Steps

1. Design Process Improvements

Objectives: 1) To provide recommendations on potential process improvements for optimising accurate heat pump designs & product specifications; 2) To Understand whether oversizing may be occurring and whether this can be mitigated.

Summary of Analysis

We have identified four core design considerations to investigate what improvements, if any, can be considered during the design process. Each of these considerations has several factors which may affect the accuracy of the estimate, whilst each of these factors then shows varying levels of accuracy within the current methodology.

Our research included a review of 43 projects based on real-world performance data for heat pumps. Demand profiles across a range of housing and consumer types were also used to test the accuracy of the current method of calculation against real-world performance data.

The demonstration project funded by the Department for Business, Energy, and Industrial Strategy (BEIS) sought to evaluate the feasibility of a large-scale roll-out of heat pumps in UK homes. Its stated intention was to prove that heat pumps can be installed in a wide variety of homes whilst delivering high customer satisfaction across a broad range of consumer groups.

Core Design Considerations

Energy (kWh)
Currently heat pump system performance estimates that include energy calculations are made available to customers, clearly showing the running costs of the proposed system. Any inaccuracy in the EPC assessment, especially when combined with factors that may affect the SCOP, may both reduce design accuracy to a significant degree and negatively impact customers' decision-making processes. Over-estimation may discourage customers from proceeding if they expect any return on investment to take longer. Equally, under-estimation may potentially result both in liability claims and reduced consumer confidence should running systems prove more costly than had been forecasted.

Heat Loss (W)
The kW capacity of the heat pump is determined by factoring in heat loss to the design methodology and relevant conditions. Heat loss from a property can be caused by key factors such as the U Values of the building's fabric, internal and external air temperatures, air fluctuations per hour, and air change factors associated with each room. Inaccurate calculations of heat loss factors may result in poor performance of the heat pump system, either through its inability to achieve target temperatures or short cycling of the system causing increased energy costs.

Efficiency (SCOP)
Seasonal efficiency is the way of measuring the true energy efficiency of heat pumps over an entire year. This measurement aims to provide a more realistic indication of the energy efficiency and environmental impact of a system.

The Seasonal Coefficient of Performance (SCOP) is the average Coefficient of Performance (CoP) of a heat pump over the full heating season. The CoP is the ratio of heat output (in kilowatts) over the electrical input (in kilowatts) at any given time. Many factors impact both the SCOP and COP as identified in this report.

Cost (£)
Installation and running costs play a critical role in customers' decision-making processes. They pay particular attention to likely ROI from savings made post-installation given a considerable variation in capital costs in comparison to fossil fuel heating systems and marketing messages that emphasise prospective energy savings.

Potential ROI may be miscalculated because of factors such as over-estimation of the system (including specification of key components, pipework, and emitters) combined with over-estimation of energy consumption and output, and inaccuracies within the existing and proposed energy profiles.

Our research focused on the factors within the calculation methodology for heat loss and energy demand to understand what, if any, improvements could be made to accuracy and efficiency.

- **Current Estimated Space Heating Energy (kWH/yr) Calculation**
  Energy Performance Certificate (Space Heating) RDSAP
- **Current Estimated Water Heating Energy (kWH/yr) Calculation**
  Energy Performance Certificate (Water Heating) RDSAP
- **Current Estimated Heat Loss (W) Calculation**
  Design Temperature difference (Design Room Temp (°C) - Outside Design Temp (°C)) x Air Changes per hour x Air Change Factor (W/m^3K) x Total Volume (m^3)

Summary of Findings

Energy Demand (kWh)

To establish a domestic property's heat demand in the form of space and water heating (kWh), the Microgeneration Certification Scheme (MCS) Standard for heat pump system design (MIS 3005 D) states the following, within the pre-sale information (Section 4.1.1).

"For domestic installations a valid Energy Performance Certificate (EPC) should be used to produce an estimate of the annual energy performance of the system using MCS 031: Heat Pump System Performance Estimate Template."

Energy Performance Certificates may only be issued by approved Domestic Energy Assessors certified to use a reduced data version of the standard assessment procedure (RD SAP). This methodology is used by government to assess and compare the energy and environmental performance of dwellings. Its purpose is to provide accurate and reliable assessments of a dwelling's energy performance needed to underpin energy and environmental policy initiatives.

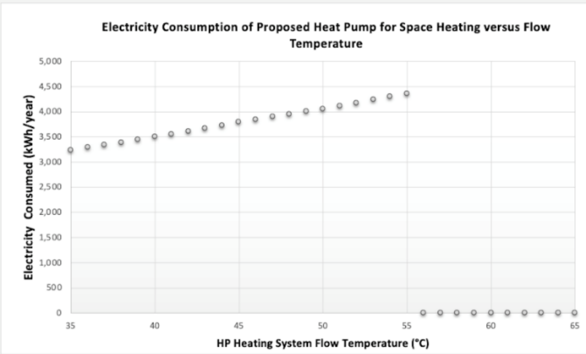
Working with the current calculation method a system designer extracts the home's space and water heating demand from the EPC and then enters this information into MCS 031, alongside the SCOP of the proposed system. This will predict system performance - see figure 1 below:

*Figure 1**

Estimated System Performance / Comparison

	Heating	Hot water	Total	
Energy Requirement for the building				
Net Energy required to heat property	14,101	2,057	16,158	kWh
Existing System Consumption	15,327	2,484	17,811	kWh
New HP System Estimated Consumption				
Full Heat Pump System (if selected above)				
HP System Electricity Consumption	4,352	1,175	5,528	kWh
Hybrid System (if selected above)				
HP System Electricity Consumption	0	0	0	kWh
Hybrid system other consumption	0	0	0	kWh
Hybrid Total Consumption			0	kWh

Note: There are different types of hybrid system. This calculation presumes a hybrid where both sources of heat supply the same hydraulic circuits (heating and hot water) according to the proportion selected above.



Disclaimers

MCS 031 includes several disclaimers (below) that must be shared with the customer in advance of an order being placed for installation of a heat pump system. These appear to suggest a tolerance of + 25-30% in predicted performance is deemed acceptable. The disclaimer also refers to running cost assumptions. These appear to have been removed with only forecasted energy output and consumption now shown:-

Predicting the heat demand of a building, and therefore the performance and running costs of heating systems, is difficult to predict with certainty due to the variables discussed here. These variables apply to all types of heating systems, although the efficiency of heat pumps is more sensitive to good system design and installation. For these reasons your estimate is given as guidance only and should not be considered as a guarantee.

MCS Seasonal Coefficient of Performance (SCoP) is derived from the EU ErP labelling requirements and is a theoretical indication of the anticipated efficiency of a heat pump over *a whole year using standard (i.e., not local) climate data for 3 locations in Europe. It is used to compare the relative performance of heat pumps under fixed conditions and indicates the units of total heat energy generated (output) for each unit of electricity consumed (input). As a guide, a heat pump with a MCS SCoP of 3 indicates that 3 kWh of heat energy would be generated for every 1 kWh of electrical energy it consumes over a 'standard' annual cycle.*

An Energy Performance Certificate (EPC) is produced in accordance with a methodology approved by the government. As with all such calculations, it relies on the accuracy of the information input. Some of this information, such as the insulating and air tightness properties of the building may have to be assumed and this can affect the final figures significantly leading to uncertainty especially with irregular or unusual buildings.

We have identified 3 key types of factors that can affect how much energy a heating system will consume and how much energy it will deliver into a home. These are 'Fixed', 'Variable' and 'Random'. Most factors are common to ALL heating systems regardless of the type (e.g., oil, gas, solid fuel, heat pump etc.) although the degree of effect varies between different types of heating system as given in the following table.

The combined effect of these factors on energy consumption and the running costs makes overall predictions difficult however an accuracy ***+ 25-30%*** *would not be unreasonable in many instances. Under some conditions even this could be exceeded (e.g., considerable opening of windows). Therefore, it is advised that when making choices based on mainly financial criteria (e.g., payback based on capital cost versus net benefits such as fuel savings and financial incentives) this variability is considered as it could extend paybacks well beyond the period of any incentives received, intended occupancy period, finance agreement period etc.*

The outputs derived from this report aim to establish the accuracy of this method including the tolerances in the design for each of the below:

- Energy requirement for the building
- Energy requirement for space and water heating
- Energy consumed for space and water heating

Table 1 below shows the actual heat pump energy consumption and output compared with the original EPC estimation completed during the design process.

This table also shows differences between the estimated and actual outputs as a value and a percentage against the design to determine current tolerance levels.

This table can also be viewed in the supporting documents provided, namely: "Heat Pump Ready Design Review- Supporting Evidence Design Comparison"

Table 1 - Energy Demand and Consumption Comparison.

House_ID	Floor Area (m2)	Heat Pump Energy Consumed (kWh)			Heat Pump Energy Output (kWh)			
		Actual	Differential		Design	Actual	Differential	
HIO001	200	4,880	5,551	53%	32,640	15,714	16,926	52%
HIO002	78	4,526	3,225	42%	22,360	10,207	12,153	54%
HIO003	91	3,501	2,453	41%	16,682	10,786	5,896	35%
HIO004	109	2,445	3,323	58%	14,879	6,257	8,622	58%
HIO005	70	2,583	2,794	52%	15,084	7,523	7,561	50%
HIO006	99	2,583	2,647	51%	14,291	7,523	6,769	47%
HIO007	90	3,036	2,934	49%	16,657	7,961	8,696	52%
HIO008	90	4,027	1,164	22%	14,244	10,432	3,811	27%
HIO009	100	4,753	1,288	21%	16,470	9,075	7,396	45%
HIO010	91	4,174	1,122	21%	14,355	12,352	2,003	14%
HIO011	87	2,718	3,317	55%	16,781	7,123	9,658	58%
HIO012	85	2,700	2,899	52%	14,616	6,849	7,767	53%
HIO013	57	3,266	2,325	42%	16,139	10,036	6,103	38%
HIO014	86	4,276	819	16%	13,904	12,250	1,654	12%
HIO015	87	5,295	572	10%	15,111	14,184	927	6%
HIO016	80	5,295	1,197	18%	17,814	14,184	3,630	20%
HIO017	94	2,387	3,151	57%	15,419	8,000	7,419	48%
HIO018	62	3,113	2,687	46%	16,051	8,115	7,936	49%
HIO019	90	2,994	2,727	48%	15,247	9,095	6,152	40%
HIO020	106	3,600	3,724	51%	19,822	11,290	8,532	43%
HIO021	128	5,324	514	9%	16,148	14,570	1,578	10%
HIO022	68	2,439	3,039	55%	16,755	5,035	11,720	70%
HIO023	90	3,507	2,775	44%	17,287	9,169	8,117	47%
HIO024	76	3,306	1,673	34%	14,906	8,921	5,984	40%
HIO025	100	4,032	3,223	44%	20,215	10,265	9,950	49%
HIO026	102	3,057	3,677	55%	19,877	9,130	10,747	54%
HIO027	112	3,654	3,756	51%	21,349	10,066	11,283	53%
HIO028	90	5,378	1,438	21%	18,464	14,559	3,905	21%
HIO029	99	5,569	1,870	25%	19,536	11,971	7,565	39%
HIO030	120	7,970	-561	-8%	21,520	16,237	5,283	25%
HIO032	92	3,953	3,575	47%	20,672	12,886	7,786	38%
HIO033	131	6,422	3,002	32%	25,826	14,318	11,509	45%
HIO034	128	5,051	3,653	42%	23,655	15,013	8,642	37%
HIO035	73	2,866	3,289	53%	18,180	8,720	9,460	52%
HIO036	97	3,846	365	9%	13,999	11,524	2,475	18%
HIO037	109	4,367	1,744	29%	18,098	13,925	4,173	23%
HIO038	83	5,511	2,189	28%	20,404	14,917	5,486	27%
HIO039	101	4,414	3,078	41%	23,359	12,296	11,063	47%
HIO040	94	4,075	2,335	36%	20,210	8,259	11,951	59%
HIO041	120	2,418	4,420	65%	21,809	9,190	12,619	58%
HIO042	80	2,833	4,583	62%	22,400	8,527	13,873	62%
HIO043	127	6,211	-2,128	-52%	10,505	20,452	-9,947	-95%

In summary, the following variations within the estimated and actual energy output of the heat pump were identified. This highlights both inaccuracies inherent in current methodology and the potential detriment these have on the confidence of consumers considering switching to a heat pump system.

1	Project where the estimated energy demand of the property was lower than the actual increasing the running costs for the customer.
0	Project where the estimated and actual energy demand matched
2	Project where the estimated energy demand was no more than 10% higher than the actual.
9	Project where the estimated energy demand was between 10 - 30% higher than the actual.
31	Project where the estimated energy demand was more than 30% higher than the actual.

Taken in isolation, the single project which resulted in a higher energy demand could be considered an outlier. However, over-estimation of energy demand can also have a negative impact on the sales process. With a higher than actual energy demand predicted, customers are wrongly led to expect a longer return on investment than would be the case, thereby negatively impacting the sales process. When they compare the estimate with their current energy bill many customers will expect significantly lower savings because of these inaccuracies.

2	Project where the estimated energy consumption of the property was lower than the actual causing an estimated running cost to be lower than the actual.
0	Project where the estimated and actual energy consumption matched
3	Project where the estimated energy consumption was no more than 10% higher than the actual.
9	Project where the estimated energy consumption was between 10 - 30% higher than the actual.
29	Project where the estimated energy consumption was more than 30% higher than the actual.

We identified two projects which had higher energy consumption than originally estimated. These will result in higher running costs for the customer than they had been led to expect.

To clarify the source of these inaccuracies the allocation of space and water heating needs to be fully understood.

Table 2 (below) displays differences between estimated and actual energy demand for space and water heating.

Table 2

Table 2 - Energy Demand and Consumption Comparison (Space & Water Demand)

House_ID	Floor Area (m2)	Average Internal Temp (°C)	Space Heating Energy Consumed (kWh)				Space Heating Demand (KWH)				Water Heating Energy Consumed (KWH)				Water Heating Demand (KWH)			
			Design	Actual	Differential		Design	Actual	Differential		Design	Actual	Differential		Design	Actual	Differential	
HIO001	200	21.6	7,992	4,162	3,829	48%	28,370	13,668	14,702	52%	2,440	706	1,734	71%	4270	1,943	2,327	54%
HIO002	78	19.3	5,396	3,761	1,635	30%	18,238	7,789	10,449	57%	2,355	1,022	1,334	57%	4122	2,365	1,757	43%
HIO003	91	20.7	3,819	2,704	1,116	29%	12,948	8,848	4,100	32%	2,134	947	1,186	56%	3734	1,878	1,856	50%
HIO004	109	18.9	2,765	1,838	928	34%	9,624	4,781	4,843	50%	3,003	670	2,333	78%	5255	1,442	3,813	73%
HIO005	70	20.5	3,460	2,162	1,298	38%	11,728	6,260	5,468	47%	1,918	552	1,365	71%	3356	1,224	2,132	64%
HIO006	99	20.5	2,823	2,162	662	23%	10,079	6,260	3,820	38%	2,407	552	1,855	77%	4212	1,224	2,988	71%
HIO007	90	19.4	3,412	1,732	1,680	49%	12,182	5,102	7,080	58%	2,557	979	1,578	62%	4475	2,812	1,663	37%
HIO008	90	20.6	2,835	3,078	-243	-9%	10,122	8,673	1,448	14%	2,355	708	1,647	70%	4122	1,691	2,431	59%
HIO009	100	19.3	3,686	3,387	299	8%	12,348	7,348	5,000	40%	2,355	697	1,659	70%	4122	1,661	2,461	60%
HIO010	91	19.5	3,010	2,203	807	27%	10,353	7,306	3,047	29%	2,287	1,479	808	35%	4002	4,972	-970	-24%
HIO011	87	19.2	3,680	2,068	1,612	44%	12,659	5,691	6,967	55%	2,355	729	1,626	69%	4122	1,398	2,724	66%
HIO012	85	20.8	3,278	1,913	1,365	42%	10,554	4,910	5,644	53%	2,321	748	1,573	68%	4062	1,899	2,163	53%
HIO013	57	20.1	3,673	2,326	1,348	37%	12,783	7,161	5,621	44%	1,918	1,163	755	39%	3356	2,817	539	16%
HIO014	86	20.8	2,740	3,880	-1,140	-42%	9,782	11,088	-1,306	-13%	2,355	491	1,865	79%	4122	1,096	3,026	73%
HIO015	87	19.5	3,511	4,383	-872	-25%	10,989	13,035	-2,045	-19%	2,355	489	1,866	79%	4122	1,070	3,052	74%
HIO016	80	19.5	3,935	4,383	-448	-11%	13,339	13,035	304	2%	2,557	489	2,068	81%	4475	1,070	3,405	76%
HIO017	94	17.7	3,148	1,722	1,426	45%	11,237	5,901	5,336	47%	2,390	931	1,459	61%	4182	2,045	2,137	51%
HIO018	62	19.6	3,243	2,995	247	8%	11,576	7,495	4,081	35%	2,557	455	2,102	82%	4475	567	3,908	87%
HIO019	90	19.6	3,794	2,942	852	22%	11,875	8,525	3,350	28%	1,927	261	1,666	86%	3372	514	2,858	85%
HIO020	106	19.5	4,379	2,932	1,447	33%	14,669	9,256	5,413	37%	2,945	813	2,132	72%	5153	1,963	3,190	62%
HIO021	128	20.4	3,617	3,371	246	7%	12,262	10,587	1,675	14%	2,221	1,402	819	37%	3886	3,906	-20	-1%
HIO022	68	20.8	3,939	2,199	1,740	44%	14,063	4,292	9,771	69%	1,538	495	1,044	68%	2692	708	1,984	74%
HIO023	90	17.7	3,724	1,983	1,741	47%	12,812	5,744	7,067	55%	2,557	1,234	1,323	52%	4475	3,362	1,113	25%
HIO024	76	20.0	3,776	2,849	927	25%	12,801	8,650	4,151	32%	1,203	686	517	43%	2105	218	1,887	90%
HIO025	100	21.0	4,698	3,040	1,659	35%	15,740	8,707	7,033	45%	2,557	700	1,858	73%	4475	1,504	2,971	66%
HIO026	102	21.5	4,447	1,841	2,606	59%	15,875	5,823	10,052	63%	2,287	1,063	1,223	54%	4002	3,241	761	19%
HIO027	112	19.8	5,020	2,974	2,046	41%	17,167	8,591	8,576	50%	2,390	757	1,632	68%	4182	1,417	2,765	66%
HIO028	90	19.5	4,508	3,952	556	12%	14,426	12,063	2,363	16%	2,307	1,097	1,211	52%	4038	2,411	1,627	40%
HIO029	99	19.5	4,495	3,537	957	21%	14,383	8,648	5,734	40%	2,945	1,268	1,676	57%	5153	3,260	1,893	37%
HIO030	120	20.7	5,122	6,884	-1,761	-34%	17,518	15,078	2,440	14%	2,287	778	1,509	66%	4002	1,064	2,938	73%
HIO032	92	20.5	5,172	3,859	1,313	25%	16,550	11,496	5,054	31%	2,355	723	1,633	69%	4122	1,308	2,814	68%
HIO033	131	19.1	6,438	4,828	1,609	25%	20,601	11,822	8,779	43%	2,986	1,188	1,798	60%	5225	2,413	2,812	54%
HIO034	128	20.6	5,850	3,767	2,083	36%	18,662	11,106	7,556	40%	2,853	1,526	1,327	47%	4993	3,821	1,172	23%
HIO035	73	20.9	4,117	2,509	1,608	39%	14,614	7,778	6,836	47%	2,038	349	1,689	83%	3566	890	2,676	75%
HIO036	97	20.9	3,099	3,253	-155	-5%	12,054	10,474	1,580	13%	1,111	300	811	73%	1945	981	964	50%
HIO037	109	19.6	4,113	4,416	-302	-7%	14,602	12,502	2,100	14%	1,998	522	1,476	74%	3496	1,353	2,143	61%
HIO038	83	21.6	4,846	2,990	1,856	38%	15,410	8,991	6,419	42%	2,854	3,421	-567	-20%	4994	5,835	-841	-17%
HIO039	101	17.8	5,694	3,631	2,063	36%	20,213	9,995	10,218	51%	1,798	739	1,059	59%	3146	2,220	926	29%
HIO040	94	16.9	4,163	2,811	1,352	32%	16,277	6,315	9,962	61%	2,247	722	1,526	68%	3933	1,895	2,038	52%
HIO041	120	20.7	5,468	1,809	3,659	67%	19,412	7,761	11,651	60%	1,370	382	988	72%	2397	1,379	1,018	42%
HIO042	80	19.8	5,234	1,941	3,293	63%	18,580	7,582	10,998	59%	2,183	438	1,745	80%	3820	899	2,921	76%
HIO043	127	16.8	2,086	5,144	-3,058	-147%	7,009	17,374	-10,365	-148%	1,998	1,430	568	28%	3496	2,945	551	16%

Space & Water Heating Demand (kWh)

- Actual values of heating demand ranged from 148% higher to 69% lower than estimates produced for the space.
- We identified three projects where actual space heating demand was higher than that estimated. However, one project benefitted from reduced water heating demand compared to the estimated resulting in the total energy consumption being lower than predicted.
- In cases where the estimation of space heating demand was higher than actual use this fell within 8% & 152% of the overall inaccuracy of the estimated demand of the property.
- No clear pattern was apparent as to the percentage of inaccuracy within the current methodology: actual results ranged from 221% below the actual to 69% above it.
- In 84% of projects, the Space Heating Estimate contributed more than the Hot Water estimated to the overall difference when compared to the actual.
- We identified significant over-estimation within Water Heating Demand with 41 or 43 customers receiving an estimate more than 30% higher than actual use.

3	Project where the estimated space heating demand of the property was lower than the actual increasing the running costs for the customer.
0	Project where the estimated and actual space heating demand matched
1	Project where the estimated space heating demand was no more than 10% higher than the actual.
8	Project where the estimated space heating demand was between 10 - 30% higher than the actual.
31	Project where the estimated space heating demand was more than 30% higher than the actual.

1	Project where the estimated water heating demand of the property was lower than the actual increasing the running costs for the customer.
0	Project where the estimated and actual water heating demand matched
0	Project where the estimated water heating demand was no more than 10% higher than the actual.
1	Project where the estimated water heating demand was between 10 - 30% higher than the actual.
41	Project where the estimated water heating demand was more than 30% higher than the actual.

Efficiency (SCOP)

The *COP* is a performance metric that can be produced in a controlled test environment and then used to compare the performance of different heat pumps under specific test conditions. The *COP* tested at 7 ◦C ambient temperature is sometimes declared on product labels as an indicator of performance. However, individual *COP*s are not designed to capture the performance of heat pumps over seasonal periods or changes in air temperature.

To predict performance over a seasonal period Seasonal Coefficient of Performance (*SCOP*) is employed. This is a metric used to obtain a more reliable indication of how a heat pump will perform in practice for space heating across a range of air temperatures and flow rates.

To calculate the *SCOP*, several dependent parameters must be first established:

A **reference climate zone** is first selected based on where the heat pump will be installed. Three climate zones are broadly categorised: Cold (C), Average (A) and Warmer (W) in EN 14825. Each of these is given an associated number of hours when the outdoor temperature reaches a particular level. The zones for the cold, average and warmer climates are based on the temperature characteristics of the cities of Helsinki, Strasbourg, and Athens, respectively. The design temperature (the coldest operating temperature for a given climate), *Tdesign*, is 22 ◦C for cold climates, 10 ◦C for average and 2 ◦C for warmer climates.

An **application temperature** is then specified based on an assumed distribution heating system. This is broadly categorised as low (35 ◦C - e.g., underfloor heating), intermediate (45 ◦C - e.g., large radiators), medium (55 ◦C - e.g., small radiators) and high (65 ◦C - e.g., domestic hot water). These temperatures are the test requirement outlet temperatures specified in EN 14511–2 and EN 14825.

The **design heating load**, (kW), for the building in which the heat pump will be installed is then established by estimating the total heat loss for that building at the design temperature. A heat pump which will either fully or partially meet that heat demand is then selected based on its rated output (like any heating system design). For the heat pump to meet the heating demand at the design temperature, the capacity of the selected heat pump must be greater or equal to *design heating load, (kW).*

The part-load conditions are the partial heat capacity to which the heat pump is expected to perform in relation to *design heating load, (kW)* at a given temperature where the constant 16 comes from. This is an assumption of the threshold temperature in ◦C, above which no additional heat is required.

The two critical parameters required to measure the performance of heat pumps and thereby deliver an accurate SCOP are heat provided and electrical energy consumed. To accurately calculate the heat provided, the mass flow rate and the flow and return temperature must be established.

Our research uncovered significant variations in the flow rate of the system. Achieving the optimum flow rate may prove a challenge even in new-build properties. However, it is particularly difficult to achieve in retrofit installations with existing pipework having a significant impact on flow rate, resulting in the actual SCOP compared to the one given to the customer during the initial design stage have been seen.

Several physical phenomena must be taken account of to monitor the performance of heat pumps: fluid temperature (◦C), air temperature (◦C), relative humidity (%), electrical current (W) and flow rate (m3/s).

Our research found that the average *SCOP* was 2.73 compared with an average SCOP at the design stage of 3.4 across the 40 projects.

This should come as no surprise. Two Energy Savings Trust (EST) reports produced almost a decade apart highlighted significant differences in the actual SCOP's achieved in the field in comparison with those at design and under test conditions.

Owing to overestimation in the space and water heating design (kWH) only two of the projects have a higher running cost than that which was presented at the design stage.

However, when looking at ways to improve the accuracy of predicted energy demand and consumption, the reduced SCOP's being achieved in the field must be considered.

Our recommendation is a correction factor be applied to the SCOP, driven by the level of confidence the system designer has in the system's ability to achieve the design conditions, specifically the flow rate, should be considered. The level of retrofit work the customer will tolerate and the accessibility of existing pipework for upgrading must also be taken into consideration.

The application of a correction factor could also be used when considering small bore pipework (microbore) given that this will have an impact on the SCOP of the system but may still be considered suitable once a correction factor has been applied to the performance.

Cost (£)

Heat Loss (W)

When we assessed the current methodology, we found no determining factor(s) to establish a target position of a property from a heat loss perspective for it to be considered "Heat Pump Ready".

The sole focus of the assessment is to determine the heat loss of the building without considering possible next steps to improve energy efficiency. As such it relies, we presume, on the minimum requirements from incentive programmes such as RHI (pre-April 2022) and the Boiler Upgrade Scheme at the present time.

Our research brings to light significant concerns about the accuracy of the sizing and specification of heat pump systems, in addition to the impact this can have on core design considerations and consumer expectations relating to performance and ongoing costs.

We have used the methodology below to calculate the exact heat output required from the heat pump and thereby determine what, if any, oversizing has occurred and how this may be addressed.

W = c_p * (T_out-T_ret) * F * rho
Where:

W :	heat output rate (Watts)
c_p :	heat capacity of water = 4184 J kg^−1 K^−1
T_out:	Flow Temperature HP Out (°C);
T_ret:	Return temperature HP In (°C);
F:	water flow (m^3 s^-1)
rho:	water density = about 984 Kg m^-3 at 35 °C

Please note this method takes into consideration real world conditions to deliver a heat output rate reduced by heat generation, such as the number of occupants, extent and duration of heating, use of appliances and cooking. The purpose of this calculator is not to serve as an alternative method allowing for real-world conditions. It is rather to establish the accuracy of the method used to predict heat loss in comparison with actual heat loss based on data available to us.

- Within the assessment of the projects, one was identified which returned an actual heat loss lower than that predicted at design.
- The same project also showed the highest differential in the SCOP. We make the working assumption that this can be attributed to the under sizing of the unit. The SCOP at design for this project was 3.39 compared to the 1.85 delivered.
- Because of an overestimation in the space and water heating load the customer will not see an increase in running costs in comparison with the estimate.
- In three cases actual heat loss was found to fall within the 10-30% range although 39 projects showed actual heat loss with a differential greater than 30% when compared to the design.

Oversizing may have significant impact across the whole system including increased running costs due to short cycling, reduced SCOPs, increased capital costs due to oversizing over the emitter system. The impacts of this are discussed in greater detail below in the summary of our research.

Summary of the Research

The table below sets out the key factors identified with the current design process and their impact on core design considerations. This report examines each of these factors, their impact and the level of risk associated with the accuracy of each factor within the current design methods.

Design Factors	Energy (kWh)	Efficiency (SCOP)	Heat Loss (W)	Cost (£)
U Value (W/m²K)	YES	YES	YES	YES
Room / Building Dimensions	YES	YES	YES	YES
Radiator Sizing and Selection	YES	YES	NO	YES
Heat Pump Selection (kVA & kW)	YES	YES	YES	YES
Internal Design temperature(°C)	YES	YES	YES	YES
Outside Design Temp (°C)	YES	YES	YES	YES
Air Changes	YES	YES	YES	YES
Occupancy	YES	YES	YES	YES
Hot water usage per day (l/Day)	YES	YES	NO	YES
Seasonal Coefficient of Performance	YES	YES	NO	YES
Flow Rate (l/m)	YES	YES	NO	YES
Design Flow Temp (°C)	YES	YES	YES	YES

U Value (W/m²K)

The U Value of building fabrics is included within the current calculation method to establish the heat loss (W) of the property as part of a room-by-room heat loss calculator.

The current calculation method requires a room-by-room heat loss calculation to be completed given the importance of accurate sizing and heat pump selection and potential concerns relating to the performance of a heat pump were it later found to be over- or undersized.

For retrofit applications, the current methodology relies on a visual inspection of the property with U Values established primarily by reference to the construction age and the building regulations in force at that time.

Designers have the authority to overwrite the assumed U values, although their individual levels of experience, competence, and ability to determine the actual U value accurately, compounded by potential for human error during data entry, presents a high risk.

Room / Building Dimensions

On average, the current method takes two hours in the customer's home to capture all the necessary information to complete the room-by-room heat loss calculations. Given the sporadic nature of customers being "in the market" for a heating system upgrade, carrying out multiple assessments in a single geographic location is often not feasible. This results in considerable costs being incurred by the installer, further aggravated by the drop-out rate of prospective customers who choose not to progress to installation. The outcome of this factor is a high cost for customer acquisition, increasing operational overheads which are ultimately passed on to those customers who do move forward to installation.

Energy predictions are driven directly from the Space and Water Heating from the EPC, which is based on the external measurements of the property. Although comparisons can be made against the floor area within the heat loss calculations, the significant risk of inaccurate data entry during the RD SAP assessment combined with a lack of data visibility behind the EPC, raises real concerns about the reliability of this method.

Radiator Sizing and Selection

The current method for radiator sizing and selection relies on an accurate heat loss calculation to establish heat loss from each room. Fear of under sizing the heat pump and not achieving the design room temperatures may lead to overestimating heat loss from a room and the size of the radiators thought necessary to achieve the design temperature.

No factors were identified within the current design method relating to the flow rate of the system. The result appears to be that all systems will achieve the flow rate required to achieve the SCOP which is often not the case.

The current design methodology appears to assume a mean temperature loss across each of the radiators of 4 degrees which, when compared to the project which appears to be excessive.

Both insufficient flow rates and mean flow temperatures across the system have a significant impact on the SCOP and therefore the consumption of the heat pump during operation.

We compared the design and actual SCOP and found the actual values to be lower than the original design across all projects. Because of overestimation of the energy output and consumption, customers will in most cases not be affected in terms of assumed running costs.

If estimations of energy output and consumption are to be improved, we must also consider the accuracy of the SCOP. This would be dependent on a better understanding of the hydraulic systems, including improved assumptions over the mean flow temperatures & flow rates.

Heat Pump Selection (kVA & kW)

To correctly size the heat pump for a property, the heat loss (W) which, as we have outlined, relies significantly on both the U Values of the property and accurate data entry during the design process, must first be established.

Actual performance may vary from the estimates provided to the customer during the design phase quite dramatically if the heat pump system is under- or oversized. This means that inaccuracy in the early designs generates a high risk on consumption and therefore the costs incurred by the customer.

Underestimation of the heat loss (and therefore under sizing of the heat pump) results in the heat pump not achieving the internal design temperatures during the winter months. We have found that designers will often oversize both the heat loss factors and heat pump selection with this in mind.

This results in additional pressure on the grid, with increased KVA at start-up from the heat pump, with heat pumps that have larger outputs naturally costing the customer more than those with smaller outputs.

It is essential that any improvement strategy accurately takes account of heat loss and occupants of the property. This will ensure that the impact on the energy network and cost to the customer are both minimised.

Internal Air Temperature (°C)

The internal design temperature of each room of the property is selected based on the room type and may vary considerably from the actual customers' requirements. This will have an impact on the overall sizing of the heat pump as part of the heat loss calculation (Design Temperature Difference). Although we agree a customer's preference here should not be considered, as this will impact on the kW output of the heat pump, which ultimately must be sized accurately for the property at the time of installation.

The customer's actual internal design temperatures do however play a considerable role in the actual energy output & consumption of the heat pump system. However, they are not considered within the current calculation methodology, instead "degree days" are utilised.

The internal design temperature also plays a role in establishing the Delta T during radiator sizing. We believe the customer preference should not be considered here as a heat pump system must be designed for the property not the current occupants. We should however take note that the customers purchase decision will include the running costs of the system, which are currently overestimated due to the design not taking into consideration the customers preferred design temperatures. The impact of this, and the ROI to the customer, may result in a greater number of customers opting to not progress with the installation.

We believe the method for calculating energy consumption, needs to be altered to include the customer user profile, and their desired internal air temperatures to deliver an accurate energy forecast

Outside Design Temperature (°C)

Outside Design Temperatures are used in calculations for both energy and heat loss. However, the accuracy of those temperatures used and their relevance to the actual property location may impact the accuracy of both calculations.

The current method allows for just five locations within the UK, whereas we contend that an accurate result should be based on measurements taken at points at least 2km apart to obtain a significant difference in values.

Volume of air to be heated (m^3)

The volume of air to be heated in a property forms part of the heat loss calculations in two parts:

> **Air Changes per hour** – these are driven from a predetermined list of air changes based on the room type & usage. Our concerns about these primarily relate to the possibility of change of room use from one owner to another. This does not align with the objective of designing the system for the property rather than the user.
>
> **Air Change Factor (W/m^3K) -** In most cases a default value of 0.33 appears to be used without a great deal of consideration for the actual ventilation of the property or its current performance.

These factors have a significant impact on the heat loss of the property and require careful consideration with, where possible, mitigating measures to improve accuracy and ensure that heat pump systems are designed to match a building's requirements.

Occupancy

Generally, in SAP calculations, the energy use, and outputs from the calculations (such as ratings, running costs and emissions) are based on standard values for parameters (including the number of occupants, extent and duration of heating, use of appliances, and cooking). These parameters are defined in the SAP specification and include full-house heating for a specified number of hours and other parameters typical of a household that would occupy a dwelling of its size.

In practice these parameters vary considerably between households. When the assessment relates to a specific household the calculation should be adjusted accordingly. However, this would not currently be included within the remit of a domestic energy assessor completing an assessment to deliver an EPC. Consequently, the property planning to install a heat pump is not able to adjust the actual occupancy parameters. Therefore, the energy output does not take into consideration the extent and duration of heating, use of appliances, cooking, and so on. These factors may also have an impact on the heat loss calculation with the size of the heat pump required. Not including these factors within the heat loss calculations may mean that calculated heat loss could be higher than the actual power requirement of the heat pump, resulting in oversizing.

Hot water usage per day (l/Day)

As with the occupancy assessment in many cases assessors do not seek to establish an exact requirement for hot water, leading to inaccurate assumptions of energy consumption for water heating (kWH)

Assessors should therefore attempt to establish the number of showers and baths typically taken each day by that specific household.

Vd,shower (litres/day) = Showers per day × hot water per shower from Table V1
Vd,bath (litres/day) = Baths per day × 50.8
Vd,other (litres/day) = 9.8 N + 14
N is the actual number of occupants

As the number of showers and baths is not taken into consideration during the assessment, default values are used to drive the values included within the performance estimate.

Seasonal Coefficient of Performance (SCOP)

The SCOP is widely recognised within the industry as one of the key drivers determining the efficiency of a heat pump system, with customers and system designers often pushing for the maximum SCOP to deliver high levels of efficiency and performance. Flow temperatures and SCOP are listed side by side on the MCS product listing, although many other factors can affect actual performance, primarily the flow rate (l/m) and the mean temperature difference across the heating system.

These factors are difficult to predict and often result in systems underperforming. A lower than forecasted SCOP will lead to an increase in energy consumption. As the accuracy of the forecasts improves, we must take into consideration correction factors for SCOPs to prevent underestimation of the running costs.

Flow Rate (l/m)

Heat Pump system design often assumes both flow rate (l/m) and the mean temperature difference meet the manufacturers requirements, this can however prove difficult to establish within a retrofit application unless the existing distribution system is completely removed at significant inconvenience to the customer. Even in new-build properties in which a complete heating system will be installed, it is difficult to accurately design, and can be a costly process for the customer.

Once the system has been installed many factors may affect the flow rate, including build-up of debris, thermostatic radiator valves, heating system controls, incorrect balancing, and upgrades to the system post-installation.

These factors make it difficult to predict the performance of a system without an understanding of the existing flow rate and establishing a correction factor based on the actual. Failure to address this will lead to customer expectations not being properly managed with the risk that customer confidence in the heat pump market may be negatively affected.

Design Flow Temp (°C)

The system design temperature is a key consideration during the design process. Designers will often attempt to optimise efficiency in the form of the SCOP through reductions in flow temperature. As we decrease the design temperature the pipe diameter of the distribution system must be increased accordingly to achieve the energy output required in the rooms. We must also pay close attention to the size and specification of the radiators to ensure they have sufficient surface area to distribute the energy, whilst achieving the desired mean temperature difference. The direct result of this is that the consumer is faced with significant increases in the capital cost of installation (in the form of both materials and labour). Disruption to life in the property with the removal of an old system to be replaced by one which can achieve improved performance will also occur.

To minimise inconvenience to the customer, designers could simply increase the flow temperature, although the performance estimate would not look appealing as the SCOP reduces as the flow temperature increases.

The consideration here is that even with optimised system design and significant upgrades to the system customer may not achieve the target SCOP when considering the factors which may impact the performance of a heat pump system

Recommendations

The Problem

- In summary, our research findings show that the current method lacks accuracy
- In many cases we believe over-estimation at the design stage depresses the number of conversions with a resultant higher cost for customer acquisition
- This is very likely to have further price implications for those moving forward with an installation as they unfairly bear the costs associated with unconverted customers
- Existing design processes lack customer engagement, resulting in failure to align the system design and specification with customer budgets and requirements
- Current methods also fail to take adequate account of longer-term approaches to improvements. They only offer the customer and 'all or nothing' solution: upgrading the entire system to achieve maximum efficiency without due consideration for the customer budget or invasiveness of installation
- Current methods rely on visual inspections, even though many salient factors such as insulation and airtightness do not lend themselves to ready visualisation
- When calculating performance, the current methods rely on Space and Water Heating KWH calculated from the Energy Performance Certificate, despite the fact these are widely acknowledged to be inaccurate
- Failures at the design stage mean actual customer usage cannot be considered; rather they indicate likely performance based on standard methods which may show little resemblance to actual operating conditions
- Inaccurately captured regional weather data relating to the regions currently used within the design may not adequately correspond to those of the property location
- This problem then has a direct link to the overestimation at the design stage of running costs incurred by customers resulting in a longer projected ROI than actual
- Improvements in the estimation of demand and consumption must also be aligned with correction of factors applied to the Seasonal Coefficient of Performance (SCOP) with systems often not meeting the SCOP at design
- We advise that the actual output of radiators and capacity of existing pipework are examined more carefully as considerable cost and inconvenience are being placed upon those customers who move forward, with many systems being oversized and over-specified
- This also impacts conversion rates, as customers facing considerable cost and a lengthy ROI will find the proposition less attractive than it should be
- Our research clearly shows a lack of accuracy across the four key design considerations of energy demand, efficiency, cost, and heat loss. This degree of inaccuracy raises significant concerns when considering the possibility of financing installations with efficiency and cost being clear drivers for consumers
- We have no doubt that the current method will continue to have a negative impact on the speed of heat pump deployment within the UK. We therefore propose an alternative method of sizing and specifications be applied within Heat Pump Ready Phase 2
- Our recommendation is to utilise an energy monitoring solution designed to establish the Heat Transfer Coefficient (HTC) of a property while improving the accuracy of the design considerations and customer engagement during the design phase.
- The HTC of a dwelling describes the total rate of heat transfer through the building fabric and by ventilation, utilising units of Watts per degrees of temperature difference between inside and out. In winter, the HTC defines the rate of heat loss from the building: it is therefore critical to defining the energy requirement for maintaining a comfortable internal temperature difference
- The predicted HTC of a dwelling is calculated in energy models that define the heat demand for a dwelling. This means that the measured HTC can be directly compared

with the predicted HTC. The difference between the predicted and measured HTC is commonly referred to as the performance gap. The HTC prediction in an energy model can be replaced with the measured value to calculate more accurate predictions of energy demand, cost, and carbon equivalent emissions pre and post HP installation

- Heat Transfer Coefficient (HTC) is an informed calculation driven by real world data captured in a very basic building survey, with internal / external temperature and energy consumption monitoring over a period of 28 consecutive days in winter (October-March inclusive, in the UK)
- While this monitoring takes place the building may still be occupied as normal. Half-hourly energy data can be taken from a smart meter or, if this is not available, from standard meter readings at the start and end of the temperature monitoring period
- The output is a measurement of the overall thermal performance of the building, defined as its rate of heat loss per degree temperature difference between inside and out. All models of thermal performance or energy consumption in buildings are based upon this measure of thermal performance
- We believe this method will provide customers with far greater accuracy and reliable personalised recommendations than the current method. They will become the benchmark for future performance of systems.


Home Energy Assessment & Monitoring
Heat Pump Ready Energy Model
HEAT PUMPS DESIGNS
by HEATIQ

2. Heatio Smart Home Energy Monitoring

Introduction

Over 20% of total UK emissions come from the heating of buildings, but the energy performance of individual buildings is rarely measured and poorly understood. Existing assessments, such as Energy Performance Certificates and PAS2035, rely on visual inspections, yet many important factors such as insulation and airtightness are resistant to visualisation. The problem is that homes have been shown to routinely perform worse than predicted, often by significant amounts: by an average of 60% underperformance in the largest study undertaken.

The Heatio Smart Home Energy Monitoring System combines machine learning, smart meter data, discreet sensors, and intelligent building information modelling technology to monitor the real impact of energy improvements and better inform future decision-making for customers.

The Heatio Smart Home Energy Monitoring System delivers an informed measurement of the properties' Heat Transfer Coefficient (HTC) while capturing their operating performance during seasonal weather fluctuations and occupancy usage. We then use a combination of machine learning, neural networks, and existing housing data to calculate sophisticated forecasting models which can support the PAS2035 assessment process, enabling informed decision-making when considering energy improvements in the drive towards Net Zero

This solution represents a significant advance on current assessment processes, such as PAS2035 and Energy Performance Certificates, which rely on cumbersome and outmoded visual inspection procedures that are both time-consuming and invasive. Furthermore, they fail to take adequate account of important factors such as thermal bridging and airtightness as these cannot easily be seen by an inspector. The outcome of our process will be a unique evidence-based improvement strategy.

Two profiles are produced: an architecture type and an occupancy profile. The occupancy profile allows energy consumption and carbon emissions to be reliably predicted, providing the required data for bespoke forecasts of the financial savings that can potentially be realised. It also offers an accurate assessment of installation costs which, when offset against these savings, permit each household to arrive at an informed decision about the benefits of retrofitting with budgeted roadmaps to support this.

Once established and combined with architecture profiles, occupancy profiles offer a reliable tool for intelligent, evidence-based recommendations for retrofitting of similar properties. As the Heatio Smart Home Energy Monitoring Solution allows for measurement of improvements as they occur it is possible to assess accurately whether improvements realised closely correspond to assumptions made at the design stage. These in turn lead to more sophisticated and nuanced strategies informing future improvements of buildings of the same architecture profile.

The Heatio Smart Energy Monitoring Solution is designed to work in harmony with smart meter devices currently being installed across properties in the UK. Readings can be taken directly from these systems and by the deployment of a small number of discrete sensors placed throughout the property.

Heat Pump Ready

Currently public take-up of heat pumps as domestic heating solutions is lagging. This is largely on account of outdated and inefficient methods used to assess the feasibility of a heat pump installation, involving low-tech procedures such as home visits to take measurements in situ. The data produced is neither wholly accurate nor reliable.

Our innovative solution is to offer a Heat Pump Ready model which utilises machine learning, smart meter data, discreet sensors, and intelligent building information modelling technology to assess the thermal profile of a property and propose the most appropriate heat pump solution more accurately. This will dramatically speed up the transition process for the consumer in a non-intrusive way and reduce the end cost of installation to the customer.

Heat pump technologies are vital to the attainment of UK Net Zero targets, yet installations of these are at present very depressed with only 42,000 being fitted each year. This should be set against an annual target of 600,000 per year by 2028. The time it takes currently for inefficient assessments to take place is one major reason why consumers are failing to convert, coupled with lack of confidence in the data driving their potential heat pump use. This in turn has ensured that the heat pump sector in the UK has failed to maximise its commercial potential and reach true economies of scale in product distribution at home and abroad.

The efficiency with which our model operates will serve to accelerate the installation of heat pumps appropriate to the thermal profile of each property, enabling customers to access fuel efficiencies and related cost savings in a timelier manner. This will have a highly positive effect on both the UK energy sector and the environment alike.

The current heat pump assessment process is outdated and inaccurate, relying on excel models, visual inspections of property and neglecting occupancy factors. We aim to replace this with an innovative heat pump modelling solution employing machine learning, AI, smart meter data and discrete sensors to establish the thermal profile of a property and generate accurate and reliable data from which a clear road map to increased energy efficiency and cost savings can be secured.

Our “Heat Pump Ready” Energy Model has designed to significantly decrease the assessment time of a property to support high-density deployment of heat pump systems. This model will deliver accurate sizing and specification of the heat pump and system upgrades required while providing real visibility of performance and operating costs at a fraction of the time and cost of current methods.

It will play a significant role in achieving the UK’s Net Zero targets by directly reducing carbon emissions. As a means of encouraging the uptake of heat pumps and realising consumer cost savings it is commercialisable not just in the UK: we are already working with European manufacturers like Samsung Electronics Europe. Increased UK installation will furthermore increase UK-based distributors’ buying power in comparison with overseas competitors.

Within two years of project completion our business plan envisages 26,000 Heat Pump Ready models being commercially deployed, which will represent 12% of market share for heat pump installations.

The main risks to our product will be failure to capture smart meter data which is integral to our model’s purpose of driving behavioural changes in energy consumption. This may be due to the intended consumer not being willing to share the data or not having a smart meter installed. To mitigate this risk, we will have a robust consent and disconnect approval to build confidence with those who are concerned about data security and a clear process for those without smart meters to have an installation.

Current customer acquisition costs £1,000+. Our solution offers increased accuracy and the ability to engage with the customer early in the decision-making process. This will reduce the cost of acquisition for installers costs and capital cost of installation which will encourage more consumer uptake of heat pumps and profitability of installers.

Customer Journey - Heat Pump Ready Feasibility

To address the lack of accuracy within the current assessment model we propose to incorporate our innovative Heat Pump Ready modelling solution under Phase 2 of BEIS Funded Heat Pump Ready Newcastle Project.

Within the project we would identify ten architecture types from the locations selected during the grid capacity research. Enquiries which match the target architecture types would move into the below customer journey to assess the effectiveness of this approach alongside the current design / assessment methods.

We propose that the target of the Heat Pump Ready Model should be aligned to the objective of the Heat as a Service Proposition which is to provide energy security and confidence to the customer through the integration of a heat pump alongside an existing combination boiler, solar and energy storage solution. The purpose of this approach is to give On Gas Customer confidence in the ability for a heat pump to deliver a comparable solution to an existing boiler taking a staged approach to the decarbonisation with the space heating load switching from the heat pump to the boiler at a target set point driven by either cost or carbon.

Customers would also be required to have a smart meter installed at the property with a minimum of 12 months of data available.

1. Customers who meet the architecture and system requirements would be offered the Heat Pump Ready Energy model and existing heat pump assessment to maintain compliance with the relevant certification and regulatory requirements.
2. Heatio would complete a virtual assessment using Hostcom or similar to capture the necessary information required to identify a matching architecture type within our database. If we deem the property to be suitable following the virtual visit, we will send the customer a link to download the Bright Smart Meter Data App giving them visibility of their daily, monthly, and annual energy consumption.
3. The customer would consent to the data being shared with Heatio via the application. This will activate the data being shared with Heatio and fed into the database for the purpose of completing the heat pump ready energy model.
4. Heatio will discuss the results of the model with the customer giving them the ability to select varying flow temperatures to see the impact this has on running costs efficiency and installation budgets.
5. Customers will be presented with two funding options:
    a. Heat as a Service
    b. Able to Pay Installation
6. Customers who decide to proceed would then be offered a heat pump assessment as per the current scheme requirements to complete the necessary heat loss and design requirements.

7. During the visit the assessor would install a temperature sensor within the property with the objective of achieving a Heat Transfer Coefficient to confirm the Heat Pump Ready level of the property. This approach has been identified as part of a HPR stream 2 project in partnership with Build Test Solutions as an alternative to the current Heat Loss Assessment Approach.
8. Following the Assessment, we would establish the HTC and the installation requirements to deliver the customer a fixed-price quotation for the relevant funding option they have selected.
9. If the customer proceeds, we will require our metering and monitoring equipment to be installed to ensure we capture the post-installation operational data of the heat pump, thereby identifying the accuracy of the heat pump ready model compared with the existing design methods and actual system performance and to support robust and effective customer aftercare and optimisation.

Heat Pump Ready Stream 2 Delivery Partners

To deliver on our recommendations for an alternative calculation method we have partnered with two stream 2 competition winners.

Hildebrand Technology Ltd - https://www.hildebrand.co.uk/
Hildebrand are a Stream 2 winner and Smart DCC-approved user offering connected device and monitor consumption in real-time and deliver that data back to our digital services. When combined with the Heatio Energy Monitoring platform this will aid in the delivery of predictive analytics using consumption history offering personalised heat pump performance

Build Test Solutions - https://www.buildtestsolutions.com/
Build Test Solutions are one of the 24 projects within Stream 2 and have a system built on 10 years of academic research and data and has been tested and validated by 3rd parties and in hundreds of buildings. Build Test Solutions will receive the required data Heatio Energy Monitoring platform via an API in where they will then return a Heat Transfer Coefficient.

This aligns with the objective of the BTS Stream 2 project which aims to create a new method to optimise heat pump specification, design, and management by using on-site measurement of building performance parameters as design inputs. Through using smart meters, low-cost sensors, and newly established techniques to directly measure key performance parameters on a property basis, this project aims to determine:

Open Weather - https://openweathermap.org/
OpenWeather is a team of IT experts and data scientists that has been practising deep weather data science. For each point on the globe, OpenWeather provides historical, current, and forecasted weather data via light-speed APIs. Headquarters in London, UK. We will call on regional weather data within the aim of establishing real world weather data from within 2KM of the property to improve the accuracy of the external air calculations within the modelling.


Heat as a service
HEATIQ

3. Heat as a Service

Introduction

An affordable and sustainable solution delivering energy security to our customers.

In the UK there is growing concern around rising energy prices. A major factor in this is our reliance on imported energy from other countries and the impact the global energy market has on the price we pay for energy in our homes.

In April 2022 UK households felt the impact for the first time with energy bills increasing by 54% with increases of a further 80% due in October 2022. The new Energy Price Guarantee will limit the October increase to 27% for now but prices are set to rise. The UK government has committed to challenging the electricity pricing in the UK to incentives the switch away from fossil fuels and increase the uptake of electrified energy resources.

Heat pumps use electricity for domestic heating which can be generated through renewable sources such as wind, hydro and solar. This means potential access to unlimited amounts, and we have far greater control over how and when this energy is generated and used.

Significant energy savings can be gained by incorporating a heat pump with solar energy allowing customer to produce their own electricity to heat their home and hot water

What Are the Benefits?

Save Money

There is a finite amount of gas in the world and prices can dramatically fluctuate , being impacted by factors outside of our control. Therefore, it is difficult to predict with any certainty what will happen to prices in the future. Electricity can be generated from renewable energy resources such that if one generates one's own solar energy some electricity supply will be free. Therefore, heating homes using electricity offers a cheaper alternative to burning gas and other fossil fuels.

Stay In Control

Gas comes from locations around the world, and we rely on other countries to supply us with enough to heat our homes and hot water. The UK Government is keen to improve the UK's energy security, meaning it wishes to reduce reliance on other countries and generate more energy within the UK.

Electricity can be easily generated within the UK, using both renewable and non-renewable sources. Heat as a Service offers peace of mind that you'll continue to enjoy a warm and comfortable home, regardless of global events.

How Does It Work?

This innovative green homes finance solution will accelerate the deployment of heat pumps across the UK overcoming the largest barriers to entry for many homeowners.

Heat as a Service helps customers to save money and stay in control of how and when they heat their home by removing the upfront cost, instead paying only for the heat they need. This solution works in a similar way to car finance or a streaming service. Rather than paying for your heat pump upfront, you'll make an affordable monthly payment that covers both the cost of the heat pump and the heat that has been used. At the end of the agreement, you can choose to either buy your heat pump by making a balloon payment or go onto another contract with a new heat pump installed free of charge.

With approval from the relevant regulatory bodies, we propose the following customer journey which has been tested with our case study completed during Heat Pump Ready Phase 2.

Why is Heat as a Service Needed?

When you think of homes with heat pumps, you might think of large, detached properties in the countryside. However, while historically this has been the type of property most likely to use heat pump technology, this has nothing to do with these homes being the most suitable.

Heat pumps can reduce both the energy bills and carbon footprint of all types of properties across the UK, from small terraces to larger homes in the countryside. Let's look at the most common myths surrounding heat pump installation and usage, where they've come from, and whether they are correct.

Heat Pumps Are Expensive

Before 1st April 2022, the only financial incentive available for installing a heat pump was the Renewable Heat Incentive (RHI). The RHI calculated the amount of funding a homeowner would receive from the space and water heating requirements shown on the Energy Performance Certificate (EPC) and then calculated how much of this energy would be classed as renewable following the installation of a heat pump.

The higher the energy usage, the more money the homeowner would receive. This incentivised the owners of larger, older and less energy-efficient properties to sign up for RHI, as they had more to gain compared to the owners of smaller, newer, and well-insulated homes. Heat Pumps also appealed to the owners of older, poorly insulated properties who previously relied on oil or LPG central heating, as this costs approximately 30% more than gas, and therefore switching to a heat pump could represent a significant cost saving.

Due to the RHI payments being made quarterly over seven years, the customer still had to pay for the heat pump and all the associated costs upfront. These factors led to more heat pumps being purchased by wealthy homeowners who lived in large, old properties in rural locations. This has created the impression that heat pump technology is only for the affluent, which is far from being the case.

The Boiler Upgrade Scheme was launched on 1st April 2022 and, alongside Heat Pump Ready, aims to make heat pump technology accessible to everyone. The £5,000 upfront payment towards costs and installation means that everyone receives the same incentive regardless of the size of their home. This presents an exciting opportunity for those in smaller, more energy-efficient homes who will incur lower purchase and installation costs. These homeowners could be left with only £2,000 - £3,000 to pay, comparable to the cost of a new gas boiler.

Having A Heat Pump Installed Will Be Inconvenient

Under the old RHI scheme, higher incentives were paid to those who opted for a heat pump with a higher Seasonal Coefficient of Performance (SCOP) value. The SCOP value measures a heat pump's efficiency while considering the changes in the temperature outside over the course of a year. For example, a heat pump that uses 5,000kWh of electricity to generate 20,000kWh of heat over a year would have a SCOP of 4. (20,000 / 5,000 = 4)

This led to homeowners favouring high-efficiency heat pumps with lower operating (flow) temperatures, which weren't always the best choice for their property.

Larger, older and less energy-efficient properties often had very old heating systems, which required significant upgrades to operate at these lower flow temperatures.

This work often involved raising floorboards, installing new pipework, and fitting larger radiators. Customers who may have been able to afford the installation and receive significant savings often decided against a heat pump due to the inconvenience that the installation would involve. This led to the technology's reputation for needing costly and inconvenient installation work.

Newer, more energy-efficient properties are likely to require minimal upgrade work to get them 'heat pump ready', meaning that the installation can be carried out with minimal inconvenience to the homeowner and at a much lower cost.

Heat Pumps Don't Work in Winter
Heat pumps work in temperatures as low as -20°C and are popular in countries such as Norway, Sweden, and Finland, where winters much colder than the UK are typical. With this being the case, why do we often hear of people in the UK having heat pump installations that do not work in winter?

Did you know the colder it is outside, the bigger your boiler needs to be to keep your home warm and cosy? The term "bigger" refers to the kilowatt (kW) capacity of the boiler or heat pump, just like a car engine the bigger the engine, the more powerful the car. The bigger the heat pump's kilowatt capacity, the more powerful it is.

When we hear about a heat pump "Not Working" in winter, what this means in many cases is that the heat pump is not big enough to meet the heating demand of the property in the winter months.

Larger, older and less energy-efficient properties proved more difficult to accurately design the heat pump size as it was more difficult to assess their energy efficiency and insulation levels. This often led to installers fitting undersized heat pumps that weren't powerful enough to provide the required heat level in the colder months.

With the Heatio Smart Energy Monitoring System, it is now possible to precisely calculate the size of the heat pump you need and how much you will save.

Heat Pumps Cost a Fortune to Run
Larger, older and less energy-efficient properties proved more difficult to design accurately. This often resulted in the heat pump using more electricity than expected. This is because the heat pump had to work harder to heat the home to the required temperature increasing the running costs to the homeowner.

We often hear the answer: "Why don't we just fit a larger heat pump". This can also have a negative impact on the running costs of a system as an oversized heat pump can result in more power being needed to power it, increasing the running costs. Oversizing a heat pump would be the equivalent of driving a lorry to pick up a loaf of bread from your local supermarket, while under sizing would be the equivalent of crawling on your hands and knees to the shop. One uses far too much energy to get going, and the other requires a huge amount of energy over a longer period to achieve the same result.

The only way to avoid high running costs is to accurately design the heat pump size, resulting in accurate energy usage predictions and happy customers and more confidence in the technology.

Getting an in-depth home energy assessment from Heatio or installing one of our Smart Energy Monitoring Systems will ensure that your heat pump accurately meets your home's needs. You can find out more by joining our free Heatio Energy Challenge Group.

Heat Pumps Place Extra Pressure on The National Grid
The introduction of the Boiler Upgrade Scheme, Heat Pump Ready, and Heat as a Service have made heat pumps a viable option for most UK households. They are expected to become especially popular with those in newer houses, usually close together in built-up urban areas.

High-density heat pump installations combined with more people having electric vehicles, solar and battery storage will put extra pressure on the National Grid. This pressure can be reduced by running heat pumps at off-peak times, allowing homeowners on smart tariffs to benefit from lower energy costs.

Work is underway to improve the National Grid, ensuring plenty of electricity will be available for everyone as we reach the target of Net Zero by 2050.

Heat as a Service Customer Journey

So, what does this mean for heat pumps in the future?

In summary, it is fair to say that how the Renewable Heat Incentive funding worked led to larger, older and less energy-efficient properties being its main market. The properties required significant upgrade works to become heat pump ready, resulting in high-cost installations. Due to the age of the properties, it was difficult in many cases to predict the insulation and energy efficiency resulting in incorrectly sized heat pumps being installed and systems not meeting the heating demands of the property in winter and higher than forecasted running costs for the customer.

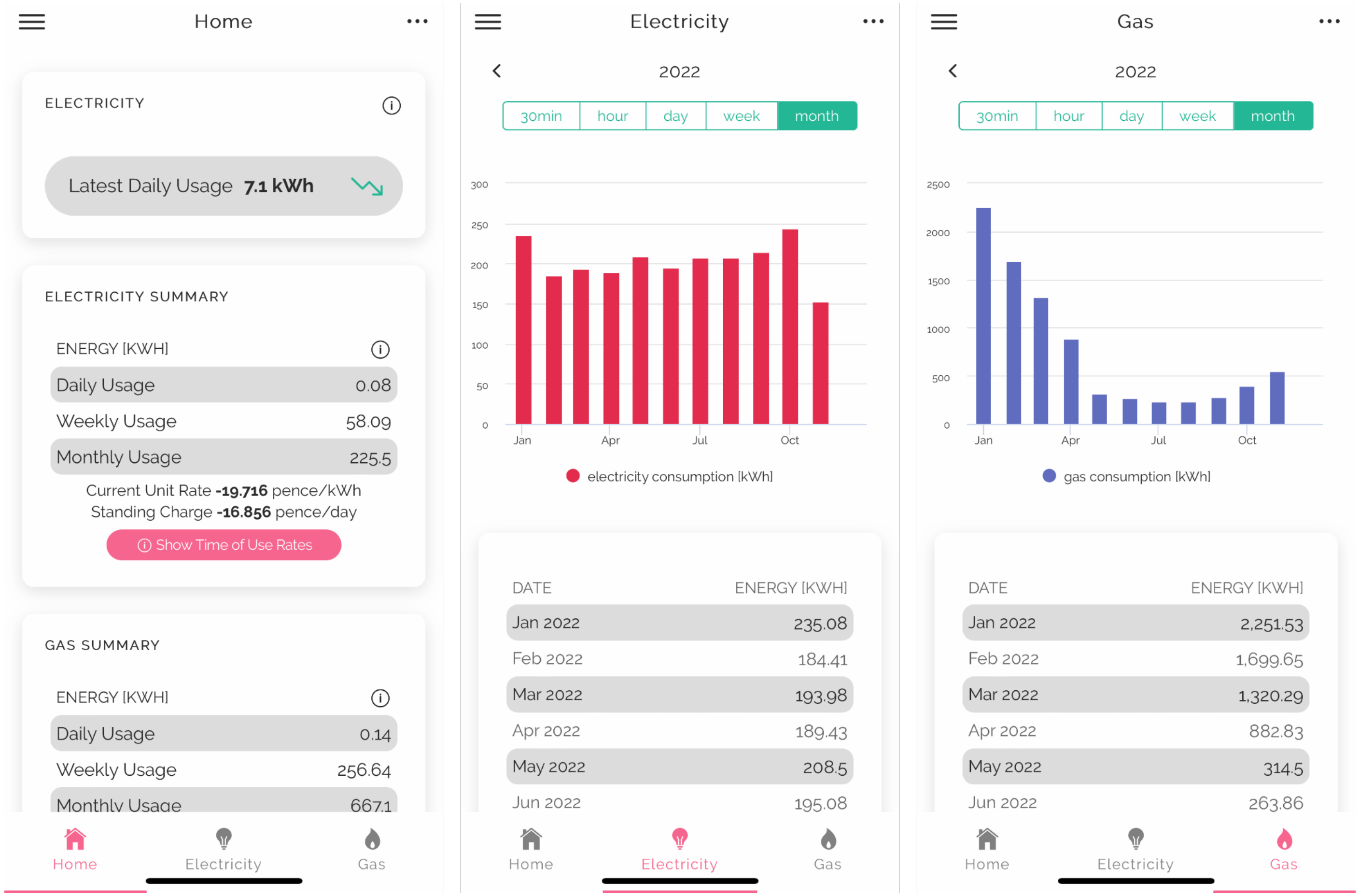
Going forward under the new schemes and innovative heat pump funding methods, newer, more energy-efficient properties will receive greater incentives than ever. They will require significantly fewer upgrades to the heating system, and with advances in technology and awareness, we are better than ever at sizing and specifying heat pump systems. The result will be more successful heat pump installations in more homes with greater confidence in the technology across installers and homeowners.

With this in mind we have taken our proposed approach to the **Heatio Energy Challenge Group and completed the first commercial delivery of Heat as a Service to the domestic market in the UK.**

We have outlined below the journey the customer went on with Heatio and propose we move forward with similar installation under phase 2 of the Heat Pump Ready programme.

1. We received an enquiry through our website from a customer who was considering a heat pump but the quotes they had received ranged from £5,000 - £9,000 once the £5000 grant from the Boiler Upgrade Scheme (BUS) has been applied. The customer has been quoted for a complete system upgrade which required 70% of the radiators within the property to be upgraded increasing the size and an area within the property to be converted to accommodate a 210 ltr hot water cylinder.
2. The inconvenience of the installation coupled with cost left the customer feeling the only option was to remain with the gas combination boiler.
3. We completed a Virtual Assessment with the customer during which we discussed the option of a high temperature hybrid installation under our heat as a service plan. The benefit of this approach would be no upgrades to the existing radiator system and no requirement for hot water cylinder with the customer continuing to utilise the existing boiler for all domestic hot water requirements.

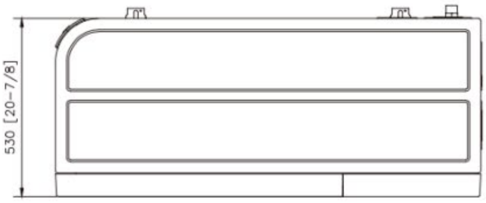
4. Following the virtual visit the customer agreed with the above approach and downloaded the Hildebrand Bright Smart Meter App to be able to see their current and historical energy consumption and spend and share this data with Heatio to deliver an accurate Heat Pump Ready model. Hildebrand are involved in Heat Pump Ready Stream 2 aiming to deliver greater accuracy in Heat pump System performance.



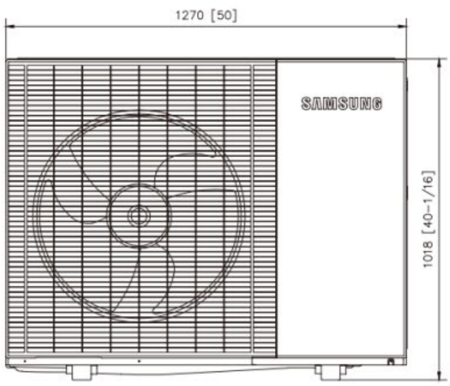
5. Within 48 hours of receiving the original enquiry we were able to combine the customer Smart Meter with regional weather and solar irradiance data to produce a heat pump ready model for the customer. During the discussions with the customer, we agreed on a design flow temperature of 65 Degrees C and that we would switch space heating load from the heat pump to the boiler when the ambient air temperature dropped below 3 degrees C.

6. The customer at this stage made the initial rental deposit of £1000 to secure the installation date and we moved to the installation assessment. During the assessment we identified and agreed on the location of the heat pump, proposed route for the pipework and the location of the pump and metering equipment. All components were to be located within a standard 600 x 600 cupboard space below the boiler. During the visit the customer raised concerns relating to how the heat pump may look in the proposed location. To address these concerns, we created the below in position renders to ensure the customer was comfortable with the location.

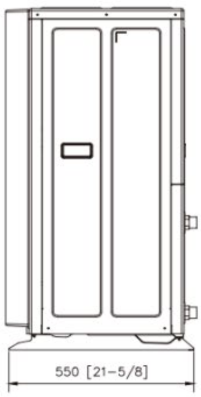
Top View



Front View



Side View



7. During the installation assessment we also completed the necessary room by room heat loss assessment to obtain the optimum flow temperature of the system to understand which, if any, radiators would need to be upgraded. At a Design Flow Temperature of 65 Degrees C and an outside air temperature of -2.2 Degrees C it was established that no radiators would need to be upgraded at this time. Combined with the Heat Pump Ready report we were able to identify the priority order of radiator upgrades for the customer to reduce the flow temperature over time through periodic upgrades as and when the funds become available. The customer was made aware of the benefits this can bring and understood how this will improve efficiency and reduce energy costs.

Room	Room Temp (°C)	Heat Loss for room (Watts)	Mean Rad temp (°C)	Delta T (°C)	Radiator Height	Radiator Size (HxW)	Radiator Panel/Convector	No. of Rads in room	Output of Rad @ delta t 50°C (Watts)	Output of Rad at required delta t (Watts)	Heat Loss for room (Watts)	Difference (Watts)	Min Rad Size Required @ Delta t 50°C
Dining	21	1175.59	65	44	600	600x1000	K2	1	1732.00	1510.30	1175.59	334.71	1175.59
Kitchen	18	498.48	65	47	600	600x0800	K2	1	1386.00	1208.59	498.48	710.11	498.48
Cloaks/WC	18	340.32	65	47	600	600x0500	K2	1	866.00	755.15	340.32	414.83	340.32
Utility	18	279.88	65	47					0.00	0.00	279.88	-279.88	279.88
Lounge	21	1656.38	65	44	600	600x0800	K2	2	2772.00	2417.18	1656.38	760.80	1656.38
Hall	18	583.69	65	47	600	600x0500	K2	1	866.00	755.15	583.69	171.46	583.69
Bedroom 1	18	582.24	65	47	600	600x0800	K2	1	1386.00	1208.59	582.24	626.36	582.24
Bedroom 2	18	339.34	65	47	600	600x1000	K2	1	1732.00	1510.30	339.34	1170.97	339.34
Bedroom 3	18	352.21	65	47	600	600x0800	K2	1	1386.00	1208.59	352.21	856.39	352.21
Bath	22	372.68	65	43	600	600x1200	P1	1	743.00	555.76	372.68	183.09	372.68
Landing	18	379.59	65	47	600	600x0500	K2	1	866.00	755.15	379.59	375.56	379.59
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
	0	0.00	65	65					0.00	0.00	0.00	0.00	0.00
									Total:	11884.79	6560.39	5324.40	Radiator sizing good

8. During the installation assessment we also installed a temporary temperature sensor within the property to obtain the necessary information to complete Heat Transfer Coefficient (HTC) calculations in association with Build Test Solutions. This method is being trialled as an alternative method to provide a greater accuracy of sizing and specifying heat pump systems under Stream 2 of Heat Pump Ready Programme

Calculation | Building | Charts | Measurements

Calculation Details

MY REFERENCE
1SUNCH4

CALCULATION DATE
14 Sep 2022 11:00

CALCULATOR VERSION
2.2.1

LOCATION
CH4 8EE

CALCULATION TYPE
Smart Meter Data

API VERSION
4.0.0

MEASUREMENT START
15 September 2021 - 01:00

MEASUREMENT END
11 September 2022 - 01:00

Thermal Performance

HEAT TRANSFER COEFFICIENT (HTC)
188 W/K

CONFIDENCE INTERVAL
[-35, +36] W/K

HEAT LOSS PARAMETER (HLP)
1.9 W/m²K

HLP RATING
Good

Heat Loss Parameter Scale (Lower value equals less heat loss)		HLP (W/m²K)
0-1	Excellent	
1-2	Good	1.9
2-3	Average	
3+	Poor	

Temperature Metrics

MEAN INTERNAL TEMPERATURE
21 °C

MEAN EXTERNAL TEMPERATURE
8.8 °C

MEAN TEMPERATURE DIFFERENCE
12.2 °C

9. Once the position was confirmed and the installation costs gathered the customer was presented with three Heat as a Service options. A full breakdown of the project costs can be found within the Heat Pump Ready Design Review Supporting Evidence Document.

What Tariffs Are Available?

There are 3 Heat as a Service Tariffs for you to choose from:

Flexi Warmth

- Benefit from cheaper energy during off-peak periods
- Your heating will be turned on at the cheapest time that meets the requirements of your household

Fixed Warmth

- You pay a fixed monthly payment for an agreed number of warm hours*
- You can increase your number of warm hours for an additional cost. This works in a similar way to adding extra data to your phone contract

Unlimited Warmth

- You pay for the amount of warm hours* used every month
- Your monthly payment will vary depending on how much you've used your heat pump

Description	Cost Price	Sale Price	Gross Margin
Heat Pump Installation Kit - Description	£ 3,895.99	£ 4,363.51	£ 467.52
Heat as a Service Metering and Billing System	£ 742.04	£ 831.08	£ 89.04
Installation	£ 4,650.00	£ 5,208.00	£ 558.00
Compliance & Notification Fees	£ 190.00	£ 212.80	£ 22.80
Sub Total	**£ 9,478.03**	**£ 10,615.39**	**£ 1,137.36**
Initial Rental Deposit (10%)		£ 1,061.54	
Option to Purchase Fee (10%) payable with Final Rental		£ 1,061.54	
Total Heat as a Service Finance Amount		**£ 8,492.31**	

		HaaS Tariff Options		
Capital Finance		**Fixed**	**Flexi**	**Unlimited**
Term	Years	7	7	7
Term	Months	84	84	84
Interest Rate	%	12%	10%	14%
Monthly Capital Finance Repayment	£	£ 149.91	£140.98	£159.15
Total Capital Finance Repayment Over The Term		**£ 12,592.66**	**£ 11,842.53**	**£ 13,368.27**
Annual Space Heating Requirement	kWh	10589	10590	10591
Total Space Heating Requirement	kWh	74123	74130	74137
Pence Per Warm Hour	£	£ 0.17	£ 0.16	£ 0.18
Monthly Service & Maintenance Fee (Inc VAT)	£	£ 25.00	£ 25.00	£ 25.00
Monthly HaaS Direct Debit	**£**	**£ 174.91**	**£ 165.98**	**£ 184.15**

10. The customer was keen to understand more about the Flexi Heat Plan which allows Heatio to connect heat pumps funded under this innovative package to our energy optimisation portfolio, giving customers the potential to earn up to £6 per kwh for 'turning down' in Flexible Demand trials. We explained to the customer that energy networks are highly complex, and incredibly delicate.

    For the grid to achieve optimum performance it must remain balanced. This requires supply (generation entering the grid) and demand (power being taken out) to align with each other. The challenges around this vary dramatically due to the way in which people heat their homes and the seasonal variations in external air temperatures and large-scale renewable energy. For example, large amounts of solar generation in summer and during the middle of the day when many homeowners are out of the house and have little need for this electricity.

    To avoid this, the grid needs consumers to be flexible with their energy consumption allowing for technology and devices within the home to turn energy generation up and down in line with demand. This solution has been active in the commercial energy markets for years, although typically linked to fossil fuel generating stations being turned on when the country is using more energy.

    The cost of balancing the grid can be expensive. In 2021 the cost of balancing reached £2.7bn, and is set to exceed that figure in 2022. These costs are one of the contributing factors to the standing charges homeowners pay, and in 2021 contributed roughly £30 to each household's bill.

    We explained to the customer that as we grow and more distributed energy resources such as heat pumps and energy storage (such as heat and solar batteries) are added to our network we will have the ability to shift larger demands and generate regular income for our customer through grid service.

    The customer chose to move forward with our flexi heat tariff benefiting initially from the lower pence per kWh of heat and future opportunities to receive income from grid service.

11. From enquiry to installation this journey took 28 days (4 Weeks) reduced from the industry average of 6-8 weeks. The main reduction came from the lack of DNO approval required with Heatio selecting an ENA Connect & Notify approved Heat Pump. We have listed below further process improvements which we would look to bring forward under Phase 2 of Heat Pump Ready to service the distressed boiler market with a replacement Hybrid System within 48 hours.
    a. Increased roll out of our Smart Home Energy Monitoring Solution to capture customer earlier in the process to identify heat loss and HTC calculation under the banner of energy saving advice
    b. Early-stage discussions around getting the home heat pump ready
    c. Hold Stock of HT Heat Pumps and ancillary components in the Target Locations
    d. Implement a retainer solution to have installation engineers on standby in target locations to enable quick reaction to breakdowns during likely seasonal breakdown periods.

4. Next Steps

- Development of our Smart Home Energy Modelling Platform to offer consumer free tailored energy saving advice engaging with customers earlier in the decision-making process.
- Using the Smart Home Energy Modelling with a wider energy saving message begin to identify targeted and interested homeowners at a regional level offering in home energy assessment capturing the required information for an installation assessment and drone surveys reducing the cost through economies of scale in regional areas.
- Utilising the assessment and data to deliver targeted installation campaigns in regions over a specific time frame to reduce capital cost through a high-density delivery programme.
    - Complete Market Research to identify the demographic of customers who are likely to engage with the heat as a service proposition. This demographic is likely to be different to that of the current heat pump customer profiles with HaaS customer being more open to a usership model and having fewer financial resources to invest in the technology. From the current market research, we have found that HaaS customer are often young families, concerned about rising energy costs and the impact on the climate with some disposable income but lacking or not willing to tie up savings in renewable heat technologies.
    - Identify regions within the target locations with the highest density of target HaaS customer demographics.
    - Engage with customer within these regions to offer a no obligation energy saving advice service aimed delivering a tailored approach to energy saving improvements and the journey to their homes becoming heat pump ready.

Appendix 12. Heatio design modelling and HaaS proposition modelling

Heatio modelling
data_design review ar