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Local delivery of global value

Project Gaia

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EDF		
Project Sponsor	Rebecca Rosling	16/11/2022
EDF Customers	Keith Watson	16/11/2022
EDF Customers	Katharine Baker	16/11/2022
EDF Customers	Andrew Lawrence	16/11/2022
EDF Customers	Dan Hopcroft	16/11/2022
Technical reviewer	Christopher Webster	16/11/2022
Policy and Regulation	Denise Willis	16/11/2022
EDF R&D TREE	Paul Garret	16/11/2022
Consortium		
Kensa	Lisa Treseder	16/11/2022
UCL	Dominic Humphrey	16/11/2022
Sheffield	Solomon Brown	16/11/2022
Urbanomy	Benjamin Mousseau	16/11/2022
Programme management		
BEIS	Nicola Lazenby	22/12/2022
Frazer-Nash Consultancy	Steph Jones	22/12/2022
BEIS	S Fenton	22/12/2022
Frazer-Nash Consultancy	Ian Thel	22/12/2022

Project Stakeholders

Role	Name	Company
Report author	Julie Jolly	EDF R&D UK Centre
Technical lead	Jack Jarvis	EDF R&D UK Centre
Milestone deliverable author	Fiona Townsend	Enzen Global Limited
Milestone deliverable author	Matthew Richardson	Urbanomy
Milestone deliverable author	Michelle Quinn	EDF Customers
Milestone deliverable author	Katharine Baker	EDF Customers
Milestone deliverable author	Gopalakrishnan Sivakumar	EDF R&D UK Centre
Milestone deliverable author	Roberto Moreira	EDF R&D UK Centre
Milestone deliverable author	Emily Proud	Genius Energy Lab
Milestone deliverable author	Ben Hamilton	Kensa Contracting
Milestone deliverable author	Lisa Treseder	Kensa Utilities
Milestone deliverable author	Solomon Brown	University of Sheffield

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1. Executive Summary

1.1 Introduction

Project Gaia led by EDF R&D UKC is part of the Heat Pump Ready Programme which falls under BEIS's £1 billion Net Zero Innovation Portfolio. Project Gaia's main aim is to demonstrate how cross sector collaboration can achieve high density deployment of ground source heat pumps (GSHP) to a target market of domestic properties in a rural location who are connected to the gas network. Project Gaia delivers a feasibility study that takes a data led approach for the viability of a ground loop array solution for retrofitting home heating in a rural setting. For this project, the area of Teignbridge was selected to develop and trial a new innovative methodology and solution. The proposed solution explores the potential of a "split ownership" heating system consisting of three core components, a shared ground loop array, the heat pump, and the tertiary system & building fabrics. The project used the existing gas supply business model, which consumers are already familiar with, where the underground infrastructure is to be owned and maintained by a utility company or an investment firm, with consumers paying an annual connection fee. Project Gaia has been costed at £199k shared between the project consortium, and is funded by BEIS.

Proposed Technical Solution for Customers

Technology:

- Individual ground source heat pumps (GSHP) with a ground loop array located in the street and shared with neighbours.

Three components:

- Shared ground loop (SGL) - owned by a third party (either a private company or community lead, 40-year lease).
- Heat pump and controls - paid by the customer either with an upfront payment or a referral to one of our finance partners.
- Tertiary system and building fabric - paid by the customer either with an upfront payment or a referral to one of our finance partners.

Consumer experience:

- Enhanced customer journey with reduced time to install from the current average installation time.

Proposed Innovative Methodology

Target Area Selection:

- Build a housing stock model to fill missing data and provide detailed information on each individual premises.
- Conduct a full network analysis to identify potential network constraints which would prevent large-scale deployment of heat pumps. Classification of substations according to their available headroom.
- Build a set of criteria to identify the best suited areas and then the best suited streets.
- Energy demand simulation to identify target streets, future energy demand and flexibility potential.

Deployment Plan Creation:

- Identify housing stock's most represented archetypes.
- Sizing and costing of the technical solution installation per archetype.
- Create Resident Liaison Officer recruitment and formation plan and material.

Customer Offer Creation:

- Create a business model with split ownership of the technical solution components.
- Create a customer offer with surveys, monthly cost, and promotion scheme.
- Create a customer journey for a 17 week install period.
- Refine and confirm interest toward the offer through local customer focus groups.

Marketing Plan Creation:

- Understand customers sentiment and understanding of the technical solution through local customer focus groups.
- Create marketing campaigns mixing traditional methods, targeted digital operations and face to face interactions.

Long Term Impact Assessment:

- Conduct a life cycle analysis compared to a full gas boiler scenario.
- Assess the replicability of the deployment methodology.

1.2 Key Findings

Consumer focus groups identified that **customer awareness** of ground source heat pumps is low, and that the biggest barrier for the technology adoption is the **investment** into the technology. The apparent complex install process is also a barrier to customer uptake for customers. However, customers react positively to the **sustainable** aspect of the proposition and once informed, the principle of the technology is easy to understand.

Working with **resident liaison officers**, tasked with guiding customers through the customer journey, can elevate the level of community acceptance.

The marketing strategy identified by the consortium is a mix of **traditional print-based marketing** methods combined with local events, poster awareness and local radio advertising, as well as the use of **digital channels**. However, based on information gathered through consumer focus groups, **door knocking** and face to face interactions will be required to ensure the density is achieved to make the project viable.

A suitable business model was identified where the **ground loop array** itself would be owned by a third party (either a private company or community lead), and each property connected would pay a **connection fee** the agreement length would be 40 years. **Heat pump controls and tertiary systems** would be paid for by the customer either as an upfront payment or as a referral to one of EDF's finance partners.

Good quality **data** is key in the methodology developed during this project, and a good **engagement with relevant stakeholders** can help fill a potential data gap. The data collected helped identify target areas and carry out energy demand simulation.

Three target areas of 4,623 homes in total meeting the required criteria were successfully identified, however, it was not possible to extend the search radius outside of the chosen locations due to network capacity. Indeed, these **technical barriers** can limit the proposition, as can **network stability** and **housing density**. Another barrier is the length of trenching required (notably due to large gardens), driving the cost up which subsequently presents as a barrier for adoption. Using this technology for new build or a denser urban area would lift some blocking points.

The simulation carried out during this study demonstrated **efficiencies of ground loop arrays** above single ground source installations and gas boilers. However, this study couldn't demonstrate a high gain from **flexibility.**

The life cycle assessment conducted deemed the proposed solution **less damaging to the environment than gas boiler** 'business as usual' scenarios. The explored technology emits between 47% and 85.5% less GHG emissions than gas boilers. Moreover, this study demonstrated its **replicability** and identified areas of opportunity.

Finally, the most impactful actions identified to **unlock the mass adoption** of the technology in Teignbridge are:

- Access to lower cost finance
- Heat zoning (designated area in which heat networks are the lowest cost)
- Reduction in capital costs
- Rebalancing of energy costs (closing of the spark gap)

1.3 Consideration for Next Steps

The project offered opportunities to develop industry contacts, understanding new technology and installation processes and practising innovative community led recruitment.

The constraints for density of 1 in 4 homes, recruited in a 6-month window was the most challenging aspect of the project.

Although the concept was well received by focus group participants for the Ground Source Loop Array, there were serious concerns raised, including:

- Disruption to individuals' gardens or impact to communities from street works.
- Cost and impact of home upgrades for very low return on bill savings with long commitment periods doesn't encourage the switch.
- Ongoing connection fee isn't comparable with current gas connection fees.
- Reluctant to invest in current home or until more established technology or made compulsory.

Feedback from prospective customers and consensus is that this may not be the right technology for retrofit communities in the current financial climate. However, customers recognise the environmental benefits of the technology, and the consensus is that it should be compulsory for new builds.

Based upon the key learnings gathered during this feasibility, mass take up could still be achieved through developing a commercial offering into the local authority, housing association and new build landscape through partnership with Kensa.

1.4 Conclusion

Completing this Feasibility study has led to a number of conclusions which include the following:

What has worked well

- Successful collaboration between multi-disciplined partners.
- Greater insight into what the shared ground loop array technology requires to be deployed at a large scale.
- Data led approach which enabled us to easily identify suitable properties and locations.
- Study can be reused for digital twin assessment for an urban area.
- Flexibility potential reduction up to 6% during peak.

Challenges

- The focus groups conducted all provided similar findings that the current energy crisis makes it difficult for customers to invest the large amount needed for the proposed technology. This observation would not only apply to the shared ground loop technology but also to all the other heat pump technologies as they have a similar price point.
- Challenges on the customer proposition and business model, significant upfront customer contribution required.
- Recruiting 1 in 4 customers for Phase 2 in the required timeframes was identified by the consortium as a challenge to obtaining the required uptake.
- Subsidies and Grants are insufficient and require more support for greater adoption.

After careful consideration the consortium has decided that with the current energy climate it is not the right time for customers to progress Project Gaia to a Phase 2 application due to the amount of investment required by the customer. This study has helped identify the factors of failure and success for a large-scale deployment. This insight would not have been able to be obtained otherwise due to the low maturity of the market.

2. Introduction

2.1 The Project

This feasibility report presents the findings of the first phase of Project Gaia. This part of the work, Project Gaia Phase 1, seeks to conclude on the feasibility of an innovative methodology for high-density heat pump deployment with the technological solution of a shared loop array ground source heat pumps deployment in the district of Teignbridge.

Project Gaia is part of the Heat Pump Ready Programme which sits under BEIS's £1 billion Net Zero Innovation Portfolio. With this project the focus is on finding solutions for high-density heat pump deployment, also known as Stream 1. This project received a £199k funding from BEIS shared between the members of the consortium.

With its Net Zero Innovation Portfolio, BEIS wishes to accelerate the commercialisation of innovative clean energy technologies and processes through the 2020s and 2030s. This Heap Pump Ready Programme is set to support the government goal to build the heat pump market to 600,000 installations per year by 2028. Indeed, heat pumps are a critical low-carbon technology to remain on a credible path to net zero and meet the UK's Carbon Budgets. More information on the Heat Pump Ready Stream 1 is accessible on the dedicated webpage.

The consortium has selected Teignbridge as the location to develop and trial its methodology and solution. Teignbridge was recommended by Devon County Council (DCC) due to its sociodemographic population. Teignbridge, located within DCC, is classified as a Rural Location, according to 2011 Rural Urban Classification of Local Authority Districts and other higher-level geographies. Teignbridge has 54,003 households, which represent 16.74% of Devon's 322,644 households (1).

The shared ground loop array technology was identified at the point of which the consortium formed due to Kensa Utilities key expertise in understanding the potential of this technology. Kensa Utilities primary focus on ground source heat pumps positions them as experts in the heat pump market.

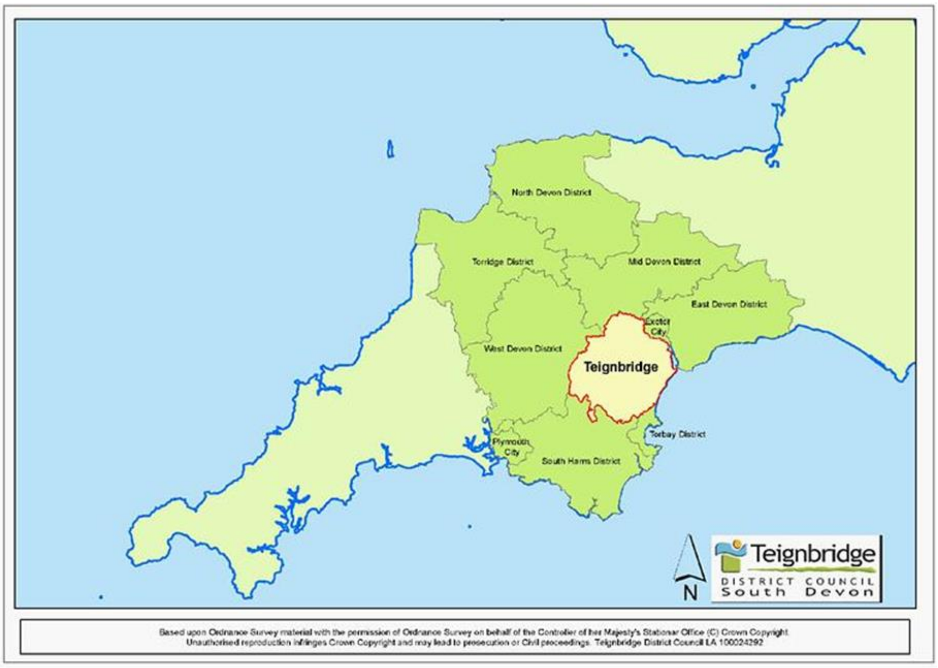


Figure 1: Location Map of Teignbridge

2.2 The Consortium

Project Gaia is the result of a joint effort from a diversity of players across the energy sector. The consortium is composed of six partners and two supporting partners bringing expertise and experience along all elements of the supply chain. EDF R&D UK centre is the leading partner, and Devon County Council (DCC), Kensa Utilities, the University of Sheffield (UoS), EDF customers and Urbanomy form the rest of the consortium. Some partners worked with subcontractors to complete their knowledge. In total five subcontractors have been involved.

For consortium members, Kensa is a technology provider, EDF Energy an energy supplier, Urbanomy an energy and carbon consultancy practice of the EDF Group, University of Sheffield is leading on housing stock analysis and sustainability and Devon County Council is leading on engagement work with local communities.

For sub-contractors, ENZEN is an expert on energy flexibility topics and UCL is an academic partner. Finally, WPD is a DNO and a supporting partner.

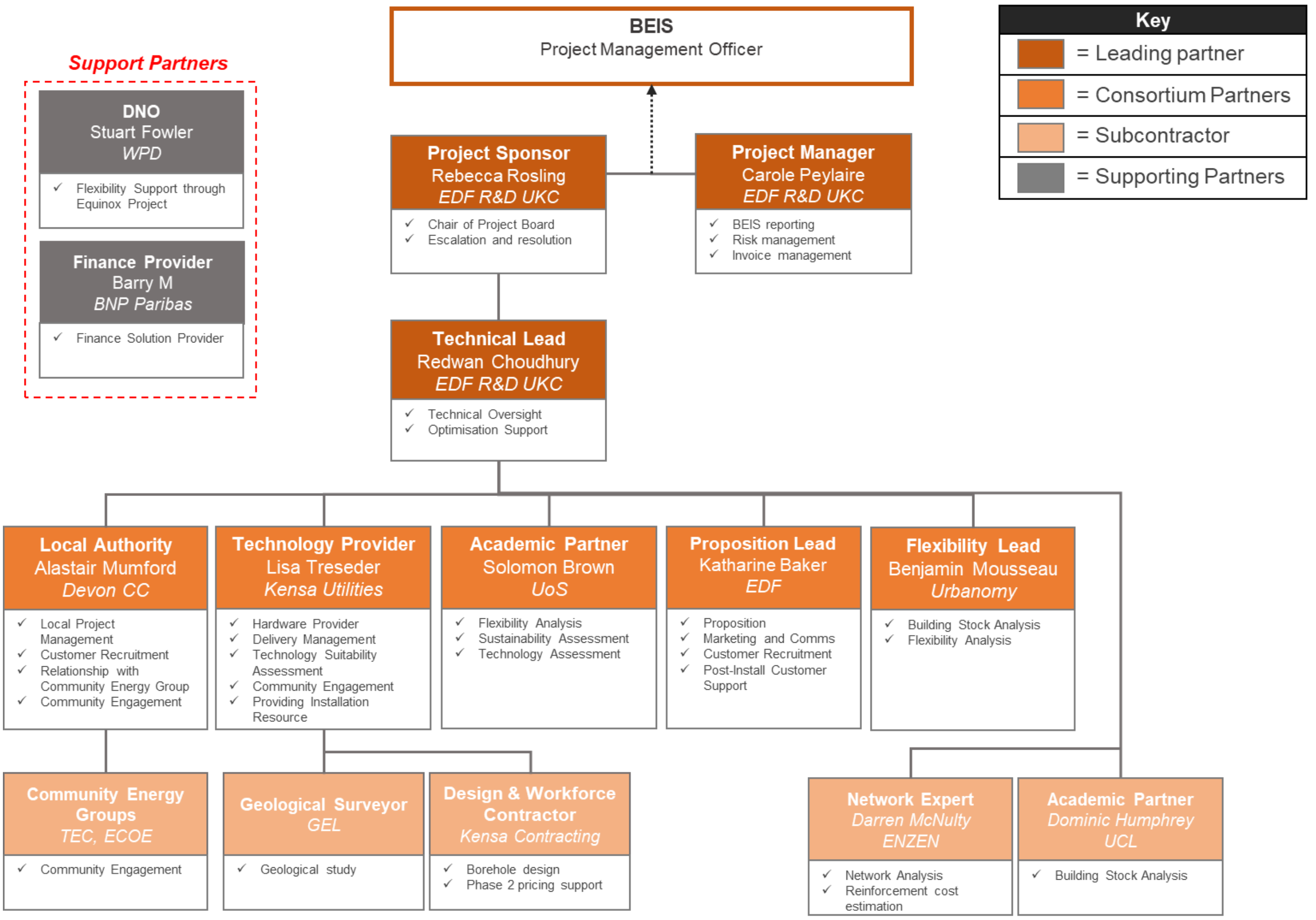


Figure 2: Organigram of the Consortium

- EDF R&D UK centre

EDF is the UK's largest supplier of zero carbon electricity, leading research in Local Energy Systems, Energy Storage & Efficiency and Smart Digital Technology. EDF Energy R&D UK Centre is a centre of technical excellence whose main purpose is helping to build a brighter energy future for the UK. Its vision is: "Accelerating the transition to a sustainable, low carbon society through the development and testing of new technologies and business models." EDF Energy R&D UK centre is currently advancing research in the fields of Low Carbon Generation (supporting existing nuclear, nuclear new build and renewables), Modelling and Simulation, Environment and Natural Hazards, Energy System Design, Smart Cities, Local Energy Systems, Energy Storage & Efficiency and Smart Digital Technology.

EDF R&D UK centre is the lead partner of this project providing program management and main point of contact between BEIS and the consortium.

- EDF Customers

EDF Customers is committed to contributing to local and regional communities and economies and in supporting the next generation of energy innovators. With their size and power, EDF Customers recognise that they hold a great responsibility – for the local economies, the people they work with, and the places in which they are based. And as they focus their activities on their mission to help Britain achieve Net Zero, they are making sure every decision and action has an overall positive impact on these local communities and would welcome the opportunity to understand how they can work with other industry partners to help customers face the individual challenges they have in transitioning to a low carbon future.

EDF Customers is responsible for delivering the customer proposition, marketing and the engagement plan.

- Devon County Council (DCC)

DCC has a statutory role in Teignbridge and also works in partnership with a number of key stakeholders including supporting partner, Teignbridge District Council (TDC). DCC has declared a climate emergency and have committed to facilitating the reduction of Devon's carbon emissions to net-zero by 2050 at the latest, as well as, improving the environment's and the communities' resilience to climate change. DCC plays an active role in supporting community energy projects.

DCC primary role within the project is creating engagement, dealing with local project management and providing local area insight.

- Kensa Utilities and Contracting

Kensa Utilities was established in 2018 as a funding mechanism to support the delivery of shared ground loop array projects through Kensa Contracting. The overarching objective of Kensa Utilities is to reduce the upfront cost of the technology to enable mass adoption of networked heat pumps. They will achieve this through street-by-street installation of split ownership ground source heating systems.

Kensa Contracting have been working closely with both private and public sector organisations to support decarbonisation of heat across various developments and housing estates. Kensa's core philosophy is to put the end user of low carbon heating at the forefront of everything they do.

Kensa is responsible for providing the technology expertise, as well as delivery and installation, customer recruitment, geological surveys and assisting in community engagement.

- University of Sheffield (UoS)

The University of Sheffield is a Russell Group University located in the North of England. Its Energy Institute is dedicated to using transformational research, innovation and collaboration to address the world's biggest energy challenges.

UoS is responsible for assessing the suitability, the flexibility potential, and the long-term impact of the technology.

- Urbanomy

Urbanomy is a consultancy of EDF Group, specialising in integrated energy and carbon planning. We advise medium and large-size corporates on decarbonisation strategies, providing carbon accounting and low carbon pathways and action plans. We also work closely with players from the built environment—including developers, local authorities, asset owners and managers—advising on how to decarbonise real estate portfolios and create net-zero blocks, districts, and communities using low and zero-carbon energy technologies. We develop our recommendations using a suite of in-house modelling tools, created and refined over the past decade by EDF's international Research & Development teams.

Urbanomy is responsible for the building stock analysis, assessing flexibility potential and providing street suitability for the solution.

3. Aims, Expected Outcomes & Objectives

3.1 General Objectives

Project Gaia demonstrates how cross sector collaboration can achieve high density deployment of ground source heat pump (GSHP) to a target market of on gas, domestic properties in a rural setting. Shared loop array ground source heat pumps have high capital investments, but good running performances and low running cost compared to other existing technologies – including against air source heat pumps (ASHPs)[1] – which suggests the potential to develop a sustainable business model in the long term. The proposed solution explores the potential of a "split ownership" heating system consisting of three core components:

- Shared ground loop array.
- Heat pump and controls.
- Tertiary system & building fabrics.

This project has opted for a business model similar to the existing gas network, as end customers are already familiar with it. In this model the underground infrastructure would be owned and maintained by a utility company or an investment firm, with consumers paying an annual connection fee. Other components are owned and managed by the end consumers themselves. Mitigating upfront costs to the customer via point of sale finance or asset lease options have also been explored.

The consortium has worked to provide a streamlined process that reduces upfront and lifetime cost, improves the customer journey, provides quality assurance and reduces system costs. Use of hyper local marketing and campaigns through a range of media will generate awareness and interest in the targeted areas. The consortium proposes adopting a community led approach to target groups of consumers to connect to the shared loop array and ensure that the community is both represented and prioritised.

The consortium's existing skills and knowledge have been utilized to conduct the following activities in this part of the work:

- Complete housing stock analysis allowing to:
    - Identify target areas.
- Carry out geological feasibility and pricing study allowing to:
    - Sense check stock analysis and complete pricing of all properties.
- Engage with community and test business model and marketing plan.
- Ensuring sufficient national coverage of local installers.

This report establishes the feasibility of the solution proposed by the Gaia project and sets out the approach for a potential trial deployment of the project. This Phase 1 lasted for 5 months and its completion allows a better understanding to enable the consortium to determine if there is potential to bid for Phase 2's 18 months trial.

[1] Table 41 in the annexes section 15.1 provides a comparison of running performances between ASHPs and GSHPs.

Project Gaia is a novel arrangement of tried and tested technology, finance and delivery methods using existing tools and techniques collaboratively to achieve a positive outcome for all partners, customers and stakeholders.

The consortium worked on streamlining the process, rather than using a standard consumer driven marketing model in order to reduce upfront and lifetime cost, improve the customer journey, provide quality assurance and reduce system costs. The proposed deployment strategy is therefore community focussed, scalable and replicable. The processes designed by the consortium are agnostic and can be utilized to other areas within the UK with little or no adaptation effort. The public can use those findings as a methodology for achieving net zero, and the industry as a business model to drive growth. The potential to reapply the “street by street” approach to other parts of the UK, as well as the potential of the modularity of the system to expand the existing structure as the number of connected customers grows, have been assessed.

3.2 Feasibility Assessment Milestones

The project objectives were developed into fifteen milestones used to provide a framework to assess the feasibility of the proposed solution. The objective of the project is to improve the consumer journey, reduce the cost for the consumer and understand the impact of the high-density deployment on the network. The solution was assessed in this report against these criteria according to the outcome of the different work packages. The outcome of this assessment can be found in the section Evaluation Against Criteria.

Table 1: Feasibility assessment criteria

Project Gaia Objectives	Feasibility Assessment Milestones
WP2.0: Street Suitability Assessment	1. Development of a nationally scalable methodology for shortlisting heat pump eligible stock using stock models driven by existing datasets. 2. Confirmation of the infrastructure benefit of the deployment. 3. Identification of 2 suitable areas of 3200 homes for trial.
WP3.0: Customer Proposition	4. Business model feasibility validated. 5. Customer offer approved. (includes finance) 6. Customer journey approved.
WP4.0: Customer Engagement Plan	7. Customer insight 8. Engagement and marketing plan.
WP5.0: Deployment Plan	9. Technical feasibility of Teignbridge shown. 10. Creation of a pricing schedule. 11. Identification of local surveyors and installers. 12. Creation of training modules. 13. Creation of a resource plan for deployment.
WP6.0: Long Term Impact	14. Environment impact assessment and risk/ benefit report deem the project as sustainable 15. Confirmation of methodology replicability

4. Structure of the Project / Summary of work packages

4.1 Work Packages Detail

In order to conduct Project Gaia's work and to produce the expected deliverables with the highest quality possible, the project has been divided in six work packages (WPs). A member of the consortium has been assigned to lead each WP while EDF R&D supervised the overall work. The first work package focuses on the project management and the last one on delivering this report. Two WPs look into the feasibility of a shared loop array ground source heat pump installation from a technical perspective, whereas two others investigate consumer adoption of the solution. Finally, one WP has been assigned to evaluate the social and environmental impact of the solution, once fully constructed. This report has been built by describing the technical WPs first, then the consumer focussed WPs and finally the sustainability of the proposed solution.

Project Gaia's work packages are the following:

- WP1.0: Project Management
- WP2.0: Street Suitability Assessment
- WP3.0: Customer Proposition
- WP4.0: Customer Engagement Plan
- WP5.0: Deployment Plan
- WP6.0: Long Term Impact
- WP7.0: Reporting and Disseminations

The flow chart below (Figure 3) describes the content of each work packages and the relation between them.

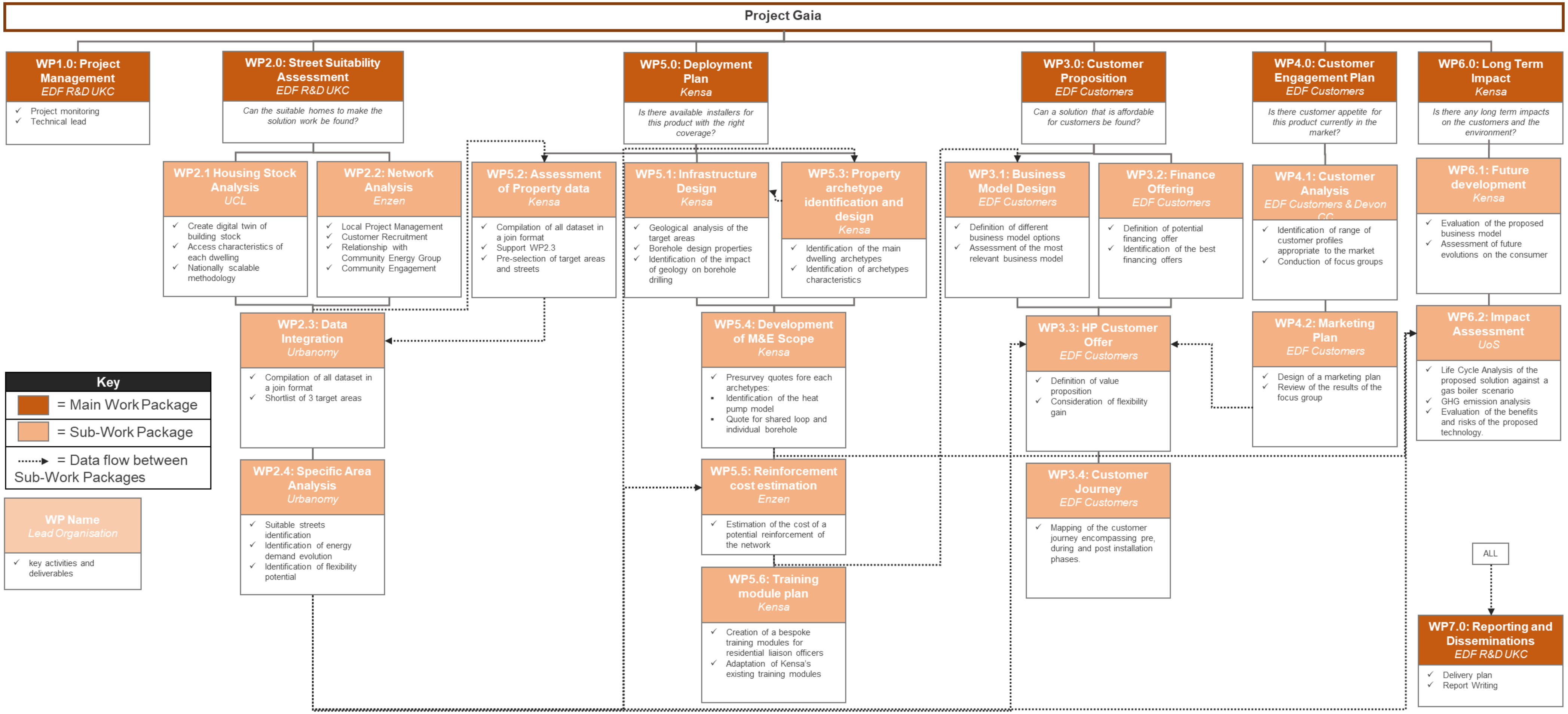


Figure 3: Project Gaia Work Packages Overview

4.2 Technological Assessment for A High-Density Deployment in Teignbridge, Devon (WP2 and WP5)

This section describes Work Package 2 and 5, which answer the question: How is the solution going to be deployed in the eventuality of mass rollout?

Three target areas were first identified within Teignbridge by investigating the technical and socio-economic feasibility for each household of the county. Based on these results and with further research on property archetypes and their influence on cost and installation a deployment plan has been put together.

4.2.1 Identifying Target Areas Objectives (WP2)

This section of the work has been conducted by Devon County Council (DCC), University College London (UCL), University of Sheffield (UoS), Kensa Utilities and ENZEN to identify specific streets based on the geographical, social and technical suitability of the households for the solution deployment.

This section aims to identify the suitable houses for retrofit ground loop array within the chosen area. The outcome is to:

- Understand the number of homes that qualify using the housing stock analysis.
- Conduct a network study to excluded areas where substation has no headroom.
- Use customer demographics and identifying suitable streets for a solution deployment.

This section is looking to answer the question:

Can the suitable homes for shared ground loop array be identified?

This data-led approach is divided in five different sub-work packages:

- Housing Stock Analysis (WP2.1)

Kensa and UCL worked on tailoring UCL's 3DStock model to Teignbridge to provide data on each dwelling's properties. This data was central in the work of the rest of the sections aiming to identify target areas. This part of the project helped to understand how mass appraisal data can be used to increase overall understanding and what is the potential for this insight to reduce survey and design costs.

- Assessment of Property Data (WP5.2)

This work package, conducted by Kensa, is here to assist in the completion of WP2 – Street Suitability Assessment, in establishing a list of 3,200 target properties which are deemed suitable based on the eligibility criteria for Stream 1.

- Network Analysis (WP2.2)

This work package, delivered by Enzen, aims to identify potential network constraints after a large-scale deployment of heat pumps. Indeed, taking customer off gas and having them adopt heat pumps would lead to a significant increase of electricity demand. This work identifies likelihood of reinforcement of the network being required to accommodate a high density of heat pumps being connected in the supply areas of the substations supplying Teignbridge with electricity.

- Data integration (WP2.3)

This work package, led by Urbanomy, integrates the data received as outputs from the housing stock analysis (WP2.1) and the network analysis (WP2.2) as well as the assessment of property data (WP5.2) into a joint format, to begin to shortlist areas for high-density heat pump deployment in the area of Teignbridge, Devon.

The shortlisting process involves a KPI flowchart to filter through the data at the building level, to identify the areas that best fit both the criteria in the brief and that defined by Urbanomy and the WP2 consortium.

- Specific Area Analysis (WP2.4)

In this work package, Urbanomy, ran a detailed simulation of the energy demand and available flexibility for the areas selected and identify streets where this solution could be installed (see 5.1.1.5 Specific Areas Analysis Methodology (WP2.4)). The goal of this work was to not only identify the suitable streets but to understand the modification of the demand and to identify flexibility potential. Three different work packages have been conducted:

- Load curves at the dwelling level have been simulated and aggregated at the area level to understand the potential impact or benefit on the grid (see 6.1.1.5 Specific Areas Analysis Results (WP2.4)).
- Calculation of After Diversity Maximum Demand (ADMD) that would result following installation of heat pumps to feed into business model.[2]
- Flexibility potential has been quantified using Urbanomy's EnergyLogic model, taking into account the innovation brought by Kensa's technology in increasing the thermal storage available within each system.

4.2.2 Deployment Plan Objectives (WP5)

Building on the findings of the previous section, this part of the work is looking to establish a deployment plan for the proposed large scale GSHP deployment solution. This work allowed a close approximation of the cost of this project's deployment and a precise idea of how to proceed if the solution were to be deployed.

This section has been conducted by Kensa Utilities, Genius Energy Lab for Kensa Utilities, Kensa Contracting and Enzen. Planning the large-scale deployment of the solution during the feasibility study ensures the project is adequately resourced to support design, logistics and project management capacity throughout the duration of the project in the eventuality of the project going to Phase 2.

By identifying the main architectural types of the housing stock of the areas selected in WP2, it was possible for Kensa to generate presurvey quotes for all target households. Enzen was also able to identify the reinforcement cost link the large-

[2] **ADMD** aggregates the demand of a large number of customers to account for the coincident peak load a network is likely to experience over its lifetime. It is an overestimation of typical demand. (36)

scale electrification of heat in the selected areas. Finally, the data gathered in all the previous sections helped Kensa create a training strategy plan, see 0

Training Module Plan Development Methodology (WP5.6).

In order to complete a detailed and appropriate deployment plan for the pre-selected areas, the actions below were taken:

- Completing the infrastructure design - Lead by Kensa Contracting.
- Agreeing sub-contractor pricing - Completed by Kensa Contracting.
- Ensuring training modules are in place - Carried out by Kensa Utilities.
- Completing a geological study of chosen area - Executed by Genius Energy Lab (GEL).
- Exploring if any structure changes required for the low voltage network - Completed by Enzen.

This section is looking to answer the question:

Are there available installers for this product with the right coverage?

This approach is divided in six different sub-work packages. WP5.2 has not been included as the output is covered in the previous section.

- WP5.1: Infrastructure Design

In this work package Genius Energy Lab has undertaken for Kensa Utilities a high-level geological analysis in order to understand better the local geological condition and how they may impact the borehole design and their pricing. The studies defined the required design properties for boreholes by looking at the heat demand and ground properties. Doing this work helped Kensa estimate the pricing of arrays in the next work packages. Having previously selected limited target areas helped focus these studies to the right places and therefore optimised the time and efforts spent.

- WP5.3: Property archetype identification and design

In this section Kensa utilised the data generated in WP2 by UCL and Urbanomy to identify the main dwelling archetypes present in the target areas and their characteristics. Indeed, all the useful characteristics of these archetypes were extracted, for instance the heat demand and the floor area. This work has then been used in WP5.4.

- WP5.4: Local development of M&E scopes and Pricing Schedule

In this work package Kensa generated presurvey quotes for eight previously identified archetypes using the work of the two previous work packages. Thanks to the technical elements identified for each archetype Kensa were able to identify the right model of heat pump for each household and to quote the price of a shared loop and individual borehole.

- WP5.5: Reinforcement cost estimation

Enzen was here able to estimate the cost of the reinforcement works potentially triggered by the connection of heat pumps in the target areas. The cost estimates presented in this part of the work might be subject to fluctuation but are intended as indicative costs to aid in the comparison of the three short listed areas.

This evaluation has been made possible thanks to the work of Urbanomy in WP2.4 looking at the peak demand, and external data from the National Grid Electricity Distribution (NGED)'s long term development statement (LTDS) and online heat maps.

- WP5.6: Training module plan

The goal of this final work package is to create bespoke training modules for residential liaison officers, and to adapt Kensa's existing training modules to conform to this project. Due to the need for multiple customers required within the same location a community led approach was vital to be added to the training. Indeed, to ensure a good response from the customers it is pivotal that the staff in direct contact with them is competent, able to address their worries and capable of providing a high-level service.

4.3 The Customer Offer, Journey and Engagement (WP3 and WP4)

This section describes Work Package 3 and 4, which answer the question: How can customers be recruited, and with which offer? While the previous section focused on the technical aspect of the deployment, this section investigates customers and their willingness to adopt the proposed solution.

A customer offer has been put together thanks to the consortium knowledge and information on the area collected during the first part of the work and put to the test during focus groups. This helped identify barriers to the adoption of ground source heat pumps and build a marketing plan in consequence.

4.3.1 Customer Offer Objectives (WP3)

This section of the work is looking to create a customer offer comprised of different financing solutions for the customer, information on the potential gain of the flexibility unlocked by the acquisition of a heat pump and a clear customer journey. This work, conducted by EDF Customers, Devon County Council and Kensa, allowed to develop a customer proposition that would be easy to understand, affordable and adopted by many at a street level approach.

Where heat pumps are often sold at an individual household level and tend to incorporate the heat pump, installation and tertiary household improvements as a single proposition, the proposed solution and its need for a ground loop might bring a greater physical disruption to the home. This would make the proposed solution a more tangible proposition for new build or for a homeowner that is conducting extensive home renovations. The challenge is therefore to find a customer offer that mitigates the disruption for retrofit, reduce the barriers of cost and ease of retrofitting to semi-rural homes. The solution found was to explore splitting the proposition into three core components, each with unique characteristics that lend themselves to separate and distinct ownership models: the shared ground array, the heat pump unit, and the tertiary system and building fabric.

The outcome of this section is to:

- Secure the right financing offer for customers.
- Explore the available heat pump offers for customer.
- Identify any HP tariffs and if any flexibility value can be obtained.
- Design the customer journey and aftercare.
- Agree on the business model.

This part of the work is looking to answer the question:

Can a solution that is affordable for customers be found?

This approach is divided in four different sub-work packages:

- WP3.1: Business Model Design

The goal of this work package was to define different business model options and to assess their feasibility using the 3 core components split principle. It ensured the proposed business model is commercially feasible for each business stakeholder and that the split ownership models are sustainable. The business models were developed in conjunction with WP5 pricing activity.

- WP3.2: Finance Offering

Here the consortium worked with a selected group of finance partners to assess potential financing options for households and identify the best financing offers. The high upfront cost of the solution requires to develop innovative financing options and to work with institutions able to take the burden of the investment away from the customers.

- WP3.3: Heat Pump Customer Offer

By applying learnings from WP2, WP3 and WP4, a value proposition that addresses existing capital and operational cost barriers and supports customers beyond the project lifetime was developed. In this work package the consortium looked into the provision of EDF services & offers including maintenance and support, flexibility services, and heat pump tariff. It also quantified value of asset flexibility and revenue opportunities, to feed into business model and customer proposition.

This work package has two main objectives: developing the value proposition and quantifying the value of asset flexibility and of the revenue opportunities.

- WP3.4: Customer Journey

The proposition includes a map of an innovative customer journey encompassing pre, during and post installation phases. Making sure the customer can have a superior experience from beginning to end is essential to ensure their adoption of the technology and to lift the barriers preventing them from shifting to the proposed solution. The proposed customer journey has to find the right timing to engage customer, educate them on the technology, and adapt to their needs and purchasing power.

4.3.2 Customer Analysis Objectives (WP4.1)

This part of the work aims to determine a range of customer profiles appropriate to the market with detailed information on drivers and triggers for making purchases. For this focus groups were conducted to gather intelligence on drivers and ambitions for change as well feedback on proposed benefits. Understanding in depth the consumers is primordial to build an effective marketing plan.

To support the feasibility study between Devon County Council, EDF & Kensa Heat Pumps, research was conducted to understand customer knowledge and appeal of the Shared Ground Source Heat Pump proposition and to help inform marketing campaigns for future phases of Project Gaia.

Specifically, this research aims to:

- Understand customer knowledge of the proposition.
- Understand drivers and barriers to uptake.
- Inform proposition development and understand key messages.
- Understand levels of financial investment and payment options.
- Understand community outreach proposition.

A qualitative research approach was taken to conduct two 2-hour focus groups via Zoom with participants recruited from the wider Devon area. It was agreed that participants could be recruited from both Teignbridge and Exeter areas to meet project timings and recruitment challenges.

This section and the next aim to answer the question:

Is there customer appetite for this product currently in the market?

4.3.1 Marketing Plan Proposition Objectives (WP4.2)

This section's goal is to design a marketing plan capable to answer all the challenges posed by the proposed solution. Indeed, as the goal of the project is a large-scale deployment of GHSP, it is necessary to recruit a large number of customers. A well thought out marketing will effectively recruit the targeted number of households. The results of the focus group conducted in the previous section were reviewed in order to determine an engagement plans for each of the customer profiles and to address every barrier identified.

Throughout the feasibility study, it was a requirement to consider engagement and marketing suitable to meet the volume and timescales of the Heat Pump Ready programme objectives. Consideration for the best methods to successfully engage and recruit to a "register your interest" level to proceed to Gate 2b for funding means that the initial engagement and recruitment is heavily upfronted in the first 6 months of the project.

This section and the previous one aim to answer the question:

Is there customer appetite for this product currently in the market?

5. Methodology for Feasibility Study

5.1 Technological Assessment for A High-Density Deployment in Teignbridge, Devon (WP2 and WP5)

5.1.1 Identifying Target Areas Methodology (WP2)

This section details the methodologies followed to obtain the results presented in the “Identifying Target Areas Results (WP2)” paragraph.

5.1.1.1 Housing Stock Analysis Methodology (WP2.1)

UCL’s 3D Stock Model has been upgraded and harnessed with the help of Kensa to provide the necessary insight on Teignbridge housing stock. Figure 4 below summarizes the different steps undertook for this part of the work:

Step	Action	Goal
UCL Stock Modelling Upgrade	Enhance the model with estimates of energy demand	Understand clusters at a high level
	Comparison to other GIS based data	Intersect where the stock selection criteria overlap with network capacity and spatial proximity to sites for ground source heat
	Generate highly specific local archetypes	Identify suitable properties with appropriate property fabric

Figure 4: WP2.1 "Housing Stock Analysis" methodology

- UCL stock modelling for selection

UCL built a model giving more granular detail of the building stock in order to support the selection of stock that would be targeted for a heat pump in a mass deployment for local authorities. This was using their 3DStock method. This model can be understood as a digital twin of the existing domestic stock at the moment in time the model was built. The component datasets are available nationally and updated annually allowing the same approach to be deployed across the UK and re-run as required.

The 3DStock model identifies all domestic stock using the authoritative register from the council (LLPG). For each domestic premises on the register a 3D digital twin is then built allowing a full 3D virtual replica of each household to be created incorporating a range of contextual data. This digital twin includes characteristics from three broad groupings:

- Physical stock characteristics; i.e., floor and exposed/party wall areas.
- Stock occupant characteristics; i.e., tenure estimate, premises heating system.
- Contextual characteristics (including geolocation of the stock); i.e., overlap with statutory restrictions and protections such as conservation area.

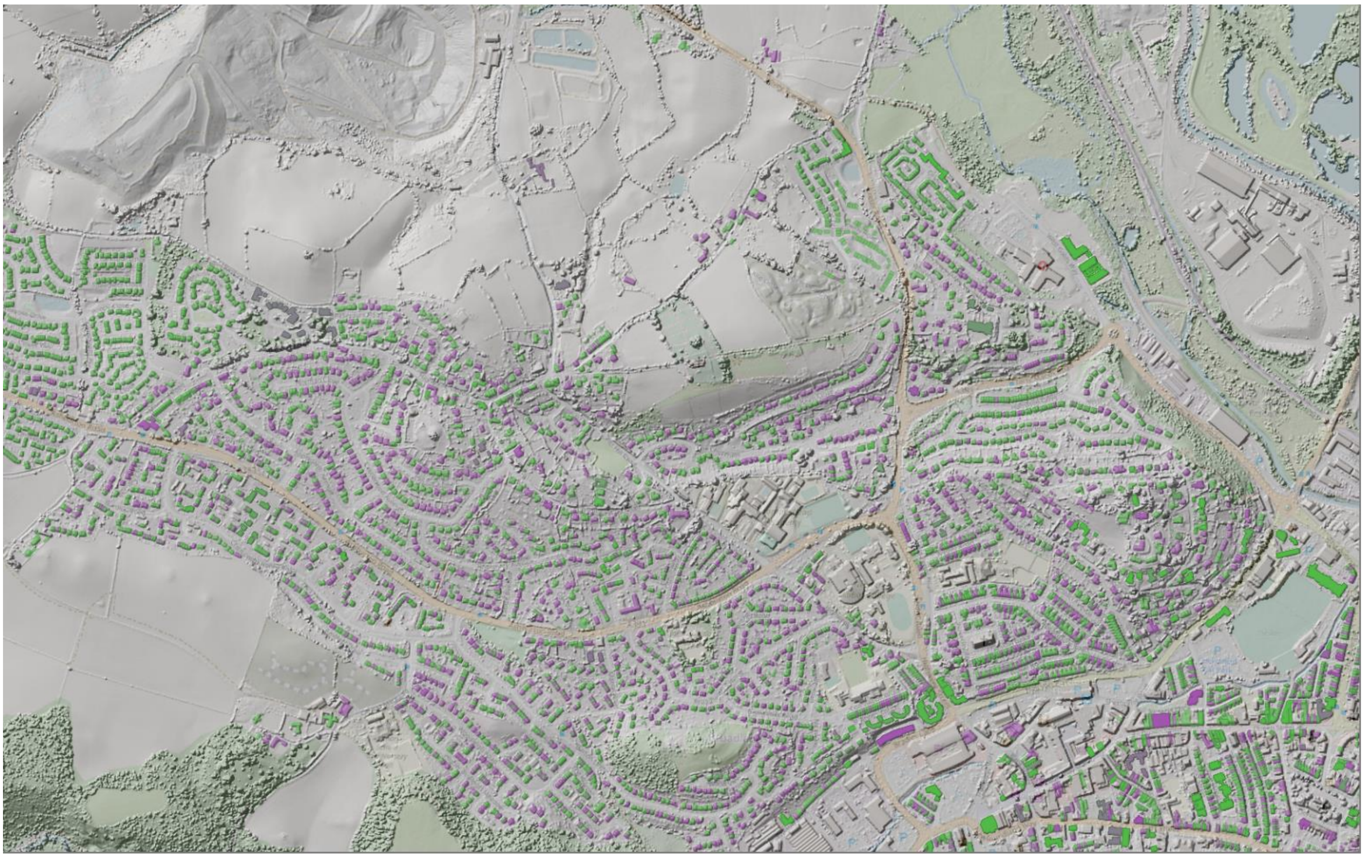


Figure 5: Digital Twin Presentation in Software

Figure 25 above uses GIS as a 2D representations with a 3D geometry underneath. The green buildings have an EPC, the purple ones are assigned a virtual EPC, the buildings without fill are non-domestic.

For this project, the digital twin was enhanced with estimates of energy demand. Those estimates were made using the BEIS National Energy Efficiency Data-Framework (NEED) sample data and BEIS postcode small area consumption statistics with estimates then compared to EUI benchmarks previously developed by UCL.

The stock model data enables a first pass of the target areas to understand clusters at a high level (aggregating to Lower Layer Super Output Area (LSOA), postcode or street). These can then be compared to other Geographical Information System (GIS) based data to intersect where the stock selection criteria overlap with network capacity and spatial proximity to sites for ground source heat. As part of this approach, the stock model can be used to generate highly specific local archetypes. An example of this is identifying clusters of similar sized, “street accessible front door”, owner occupied properties with building envelope characteristics that would make a ground loop array heat pump feasible. These archetypes can be further developed with all interested stakeholders to provide a whole system solution to understand the building stock and to further help tackle the electrification of heat challenge.

In summary, the UCL 3DStock tool has modelled every domestic premises in Teignbridge providing physical stock characteristics, stock occupant characteristics, and contextual characteristics. It also enables the generation of 25k virtual EPCs to supplement the 40k actual EPCs, using a machine learning algorithm developed by UCL.

The model achieved a mean absolute error (MAE) of 4.4 on the predicted numeric EPC grade. The focus for this project was to make predictions on some of the categories found in the EPC (fabric, age....) as they were of greater relevance to the decision process around heat pumps. The model appears to be better at predicting B to G grades. As EPC rated A properties are typically found in new builds, it can explain that there were a fewer A grades found.

Two methods were taken to understand the space heat and hot water demand:

- The energy use intensity (EUI) can be generated using small area aggregate data from grid (for gas) and floor area from model. The EUI is then compared to prior work by UCL where actual meter data were provided to QA the output.
- The NEED database (National Energy Efficiency Database, 135k premises in southwest region – 2020 data) can be used to generate an upper and median estimate for each premise along with the categorisation of demand (high, low, average).

5.1.1.2 Assessment of Property Data Methodology (WP5.2)

The Stream 1 methodologies are intended to be focused on domestic, on-gas-grid homeowners who are retrofitting heat pumps. In order to find the required number of properties the below filters were used[3]:

- Non-domestic – maximum 5% of trial buildings.
- Social housing – maximum 20% of trial households.
- New build (before occupation) – maximum 5% of trial households.
- Off-gas grid properties – maximum 15% of trial buildings

[3] No more than 30% across these four categories would be included in the final data set to comply with the competition guidance.

Step	Action	Goal
Target areas (round 1): UCL data	Application of the following filters: • Exclusion of caravans, chalets and park homes • Exclusion of listed and conservation areas • Exclusion non-gas properties • Owner occupied preferred but private and social rent included	Meeting Stream 1 consumer segmentation prerequisites
Target areas (round 2): combining the network capacity analysis with the non-gas map	Use of the analysis carried out by ENZEN on the network capacity to apply the following filtering: • properties within the green and orange RAG network capacity zones • LSOAs with higher than 60% mains gas connection	Determining primary substation supply areas overlapping with areas of higher gas-grid connectivity
Target areas (round 3): high-priority areas	Filtering out streets that have less than 20 properties.	determined which properties sit within 'reasonably large' sized clusters to ensure lower per property mobilisation and infrastructure installation costs
Target areas (further considerations): household attitudes and lifestage circumstances	Establishing the social grade distribution in the locality. Filtering the following social classes: • Social Grade: AB • Social Grade: C1 • Household Lifestage: Age 55- 64 2-person household with no dependent children.	Finding households willing and able to switch their heating system
Complements	Sense check using Streetcheck	Identification of streets as likely candidates for the trial
	• Check Teignbridge Local Plan • Check two commercial/industrial areas	Identification of suitable new build and commercial buildings

Figure 6: WP5.2 "Assessment of Property Data" methodology

- Target areas (round 1): UCL data

With the Stream 1 consumer segmentation clearly defined as domestic on-gas-grid homeowners who are retrofitting heat pumps, the stock model has been filtered down for certain conditions, as shown in Figure 6. To meet these prerequisites as far as possible, the following filters were applied:

- Excluded caravans, chalets and park homes.
- Only non-listed and non-conservation areas selected.
- Excluded non-gas properties entirely.
- Owner occupied preferred but private and social rent included.

In the Stock Model data set, there were **originally 64,303 properties**. The properties selected on the first filter are all on main gas. In terms of making an efficient first step for exclusion, this was seen as the most obvious starting point. The reason for this is because mains gas properties (which need to represent a minimum of 85%) tend to be in the areas of high-density housing which is one of the trial scope requirements - at least 25% of the domestic buildings on at least one low-voltage network. This was seen as the most efficient way of narrowing down the property selection to cover both of these parameters.

- Target areas (round 2): combining the network capacity analysis with the non-gas map

Using the analysis carried out by ENZEN on the network capacity in the Teignbridge area (Network Analysis Methodology (WP2.2)), it is possible to determine those primary substation supply areas which overlap with areas of higher gas-grid connectivity. This can only be done at an approximate level as this stage; however, this allows a method to further narrow down target areas adhering to the eligibility criteria of 85% of trial buildings on mains gas.

The non-gas map is an online map of GB showing the distribution of properties without a gas grid connection and the central heating type across LA and LSOA level. The areas have been selected as approximately having gas connected properties at 60% or higher (red outline in Figure 7 below). This tends to be in the built-up areas around the Teign Estuary whilst homes in the surrounding countryside are provisioned with oil in the most part. Although there are individual pockets of LSOAs in the locality on mains gas areas of 60% or higher, these communities would be less likely to suit the requirements of at least 25% of the domestic buildings on at least one low voltage network (connected to the same secondary sub-station), given those properties tend to be more spread out over a larger area. This would also incur higher infrastructure costs to reach the distance between dwellings spread out over a larger area.

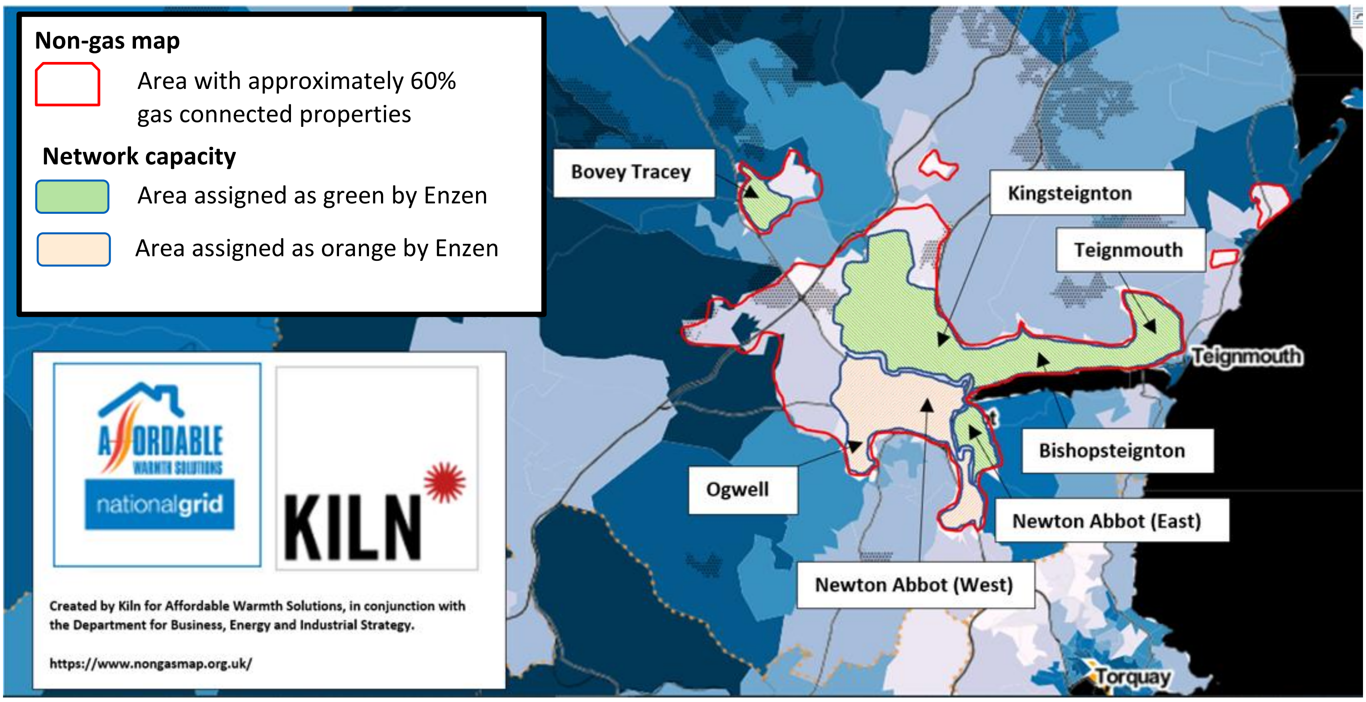


Figure 7: Non-gas map overlaid with ENZEN network capacity RAG ratings areas

ENZEN summarises the capacities of the network zones by assigning a **Red-Amber-Green (RAG)** based on the demand headroom available in MVA. The methodology for this assessment can be found in the next paragraph: Network Analysis Methodology (WP2.2).

The areas of higher gas connections that overlap with the Red-Amber-Green (RAG) ratings are shown. The red outline shows the approximate boundary of the 60% or higher gas grid connections.

Within that space, areas identified from the RAG mapped areas from the ENZEN Network Analysis report are shown with their respective RAG rating. Red areas were completely excluded. The green and orange areas selected were:

- Newton Abbot Primary
- Teignmouth Gasworks
- Bovey Tracy
- Higher Woodway
- Bradley Lane

- Target areas (round 3): high-priority areas

Within the 6 high/medium density housing areas identified in the previous round – properties within the green and orange RAG network capacity zones and LSOAs with higher than 60% mains gas connection – it must then be determined which properties sit within 'reasonably large' sized clusters to ensure lower per property mobilisation and infrastructure installation costs.

This is determined using the USRN (Unique Street Reference Number) by filtering out streets that have less than 20 properties. This number is generally used by Kensa Contracting as a threshold for a viable project.

The areas that are more sparsely populated would be suited to ASHP or individual GSHP solutions.

- Target areas (further considerations): household attitudes and lifestage circumstances

Offering a reduction in upfront and running costs to customers taking part is part of the key deliverables, however, we're also selling a low carbon lifestyle. This means that the target market has to be on those who are willing to make a financial contribution for the building upgrade costs, as well as those who are more likely to take the issue of climate change as an immediate and pressing matter. The issues are well known since the first COP meeting in 1995[4]. Although considerable effort will be made to increase uptake, attitudes are unlikely to change substantially[5] in the short delivery period of the project and customers in higher social grades are considered more likely to take interest. Age is not seen as a major factor in terms of attitudes to climate change; however, younger generations generally lack the capital to make the individual cost contribution. Datashine has been used to establish the social grade distribution in the locality. Social Grade is the socio-economic classification used by the Market Research and Marketing Industries, most often in the analysis of spending habits and consumer attitudes. Figure 8 shows 3 criteria that were selected.

[4] Although no reliable data going back to 1995 on people's attitudes to climate change is available, a consistent upward trend in concern or awareness when people are asked to give their opinions on climate related issues in the last decade can be observed. BEIS possesses reliable data on the topic, polling has shown that concern about climate in the UK between 2012 and 2020 increased from 65% to 76%. Currently, 90% of people in the UK have some awareness of the concept of Net Zero. (43) (44)

[5] Data from the Office for National Statistics (ONS) (October 2021) shows that reasons given for not being worried about climate change are not in the main to do with a lack of understanding. In the ONS data, of people who show little concern (25%), only 35% of that cohort said "I do not know much about climate change", whereas the rest stated it was more to do with other concerns being more important, no sense of urgency or exaggerated claims. This suggests that there is only a small proportion of people who don't have level of understanding to come to a more informed conclusion, with the rest of people aware but not wholly concerned.
Although not conclusive, it can be reasonably assumed that those people showing either concern or interest in issues to do with the climate will have more incentive to make lifestyle changes or investments when it comes to decarbonising their lifestyle. Those in higher social grades are more likely to see climate change as a concern and have awareness of Net Zero targets in the UK. On those two questions respectively, it was 8% and 23% higher when comparing AB and DE classifications. (45) (46) (47)

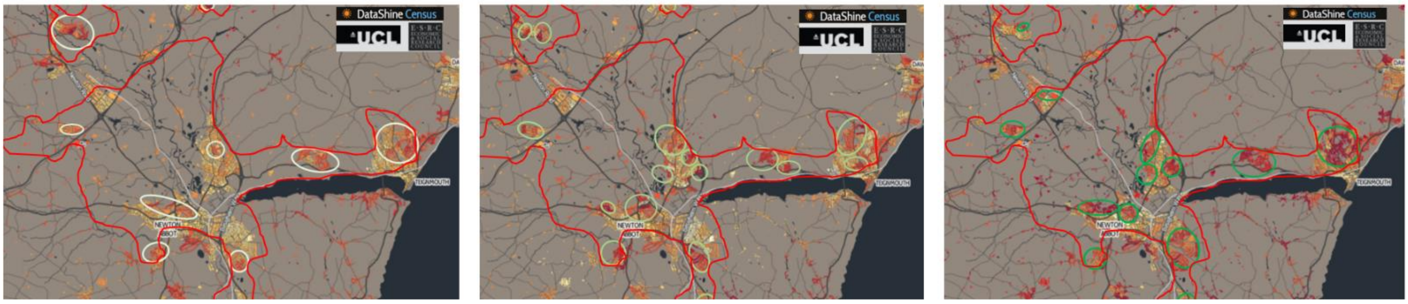


Figure 8: Social grade distribution in the locality (2)

Social Grade: AB	**Social Grade: C1**	**Household Lifestage: Age 55-64 2-person household with no dependent children.**
Those in higher social grades are more likely to say they are concerned about climate change (83% in AB, compared with 75% in DE). Awareness of 'Net Zero' is also higher among those in AB (74%, compared with 51% of those in DE). (3)	Of those in social grade C1, 41% said they were very concerned about climate change compared with 29% of those in social grade C2 and 24% in social grades DE. Just over half (52%) of those with annual household incomes of £50,000 or more said they were very concerned with climate change. (4)	Households are selected in the 55-64 age bracket and filter out those with dependent children. This is due to these workers being the most experienced (generating higher incomes) and having lower expenditure (mortgages paid off, no dependent children, etc).

- Shortlist of potential streets

Within the selected streets, the Stock Model reports a **total of 372 properties**. To gauge the wider neighbourhood size, a sense check has been carried using Streetcheck. This provides a number representative of the local area, not a specific street address or row of houses.

Therefore the Streetcheck figures will exceed the number of properties when compared to those streets with the USRN reference, however there is still opportunity to incorporate smaller side roads and avenues into the heat network if conditions allow.

- New build developments and commercial premises

Over 100 sites across the Teignbridge district have been identified as places where future housing provision could be provided as part of the Teignbridge Local Plan that will run until 2040. Identifying some of those developments (see Figure 9) that sit within the target areas would be feasible. The housing requirement for the Teignbridge Local Plan is 15,020 homes – at an average of 751 a year for the next 20 years. Of the 600 final properties chosen, the number of new builds would only need to number around 30, so a single site could potentially suffice.

Within the final selection, there is scope for inclusion of non-domestic sites. There are two commercial/industrial areas that are of interest: the Pottery Road and Rydons Industrial Estate in

Kingsteignton and the Brunel Industrial Estate in Newton Abbot. Any additional opportunities for heat recovery identified during the feasibility study, including industrial cooling or sewage works, will be incorporated into a final design and used to support a reduction in capital costs.

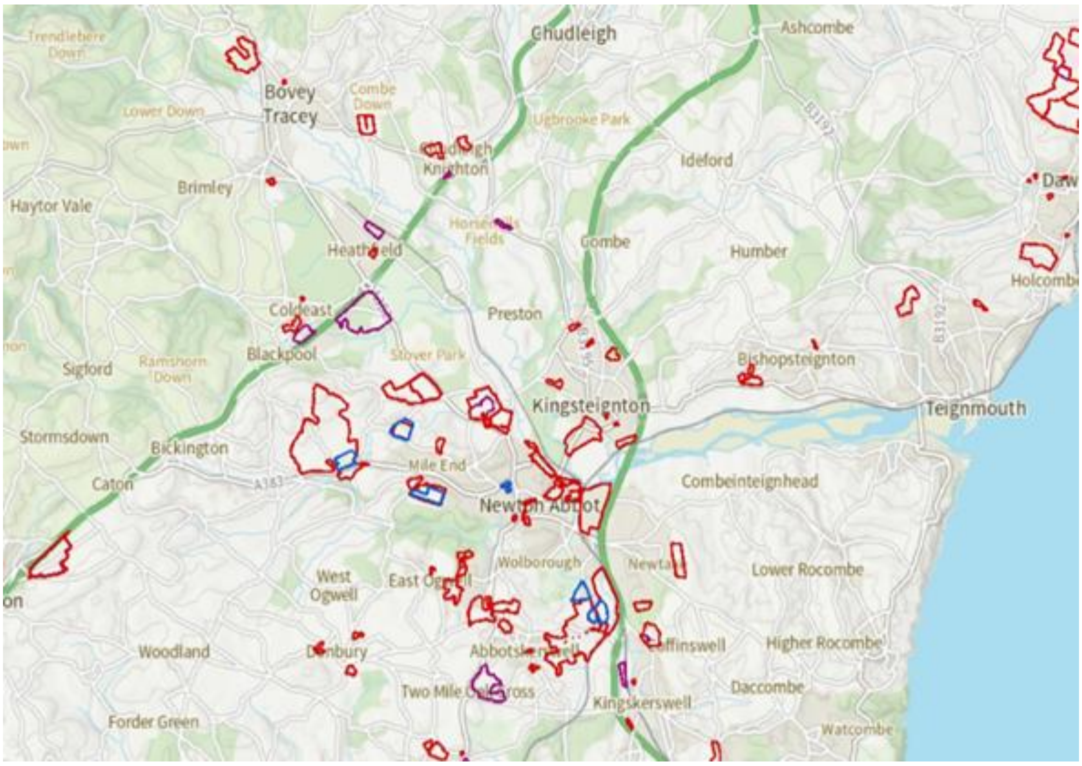


Figure 9: Sites identified as places where future housing provision (5)

- Secondary substations

Further analysis is required to determine specific areas which take into account the LV secondary substation networks. This will be made possible once the target properties have been decided, at which point ENZEN will inspect the network zones to make sure the 25% threshold is reached on at least one site. Then the required screenshots and the LV connections for the chosen trial sites can be traced from these based on the maps of the WPD's LV network on the dataportal2.

5.1.1.3 Network Analysis Methodology (WP2.2)

The following primary substations have been identified within Teignbridge local authority area:

- Newton Abbot Main
- Dawlish
- Teignmouth Gasworks
- Bovey Tracy
- Higher Woodway
- Bradley Lane
- Buckfastleigh
- Ashburton
- Chudleigh Knighton
- Exminster
- Mortonhampstead

***Red-Amber-Green (RAG) rating**: This outcome of this section has ranked each of these substations with a Red-Amber-Green (RAG) rating. It illustrates the likelihood of reinforcement of the network being required to accommodate a high density of heat pumps being connected in the supply areas of these substations, with red indicating there is a high likelihood and green indicating a low likelihood.*

Figure 10: Location of Substations Under Consideration

The colour of the marker corresponds to the RAG status of the connection point. Red indicating there is a high likelihood of need for reinforcement and green indicating a low likelihood.

Other maps illustrating this section can be found in the annexes section: Network Analysis (WP2.2).

Additionally, the smaller substations of **Rydon Farm** and **Heathfield Landfill** generator have been identified. These are likely to be purpose-built substations for the developments and unlikely to be near to residential areas. Rydon Farm connects into Bradley Lane primary substation and Heathfield Landfill Generator is tied into the connection between Chudleigh Knighton and Newton Abbot BSP.

A review of network constraints has been conducted using **data from Western Power Distribution (WPD)**, accessed in August 2022. A detailed overview of the capacity available at each primary substation and their supply areas is provided in the following sections. Additionally, information on potential future connections at the budget estimate (for demand and generation) or connection offer stages (only for generation; demand connections at this stage have been accounted for in calculations of demand headroom) is provided. This gives insight into potential future reductions or increases in capacity at the substations, although potential timelines, whether these connections would be firm or non-firm and the possible impact on the capacities of specific overhead lines, underground cables and transformers is not known.

Table 2: Demand capacity data for all primary substations

Primary substations	**Capacity (MVA)**			
	Firm Demand Capacity	**Peak Demand**	**Demand Headroom**	**Upstream Demand Headroom**
Newton Abbot Primary	28.86	22.08	6.78	17.61
Teignmouth Gasworks	14	6.16	7.84	17.61
Chudleigh Knighton	10.5	7.83	2.67	17.61
Dawlish	17.25	11.67	5.58	17.61
Bovey Tracy	7.98	5.75	2.23	17.61
Higher Woodway	17.25	6.09	11.16	17.61
Bradley Lane	17.25	14.75	2.5	17.61
Buckfastleigh	12.57	5.3	7.27	10.92
Ashburton	9.78	6.21	3.57	10.92
Exminster	5	3.44	1.56	-
Mortonhampstead	2.46	2.46	-	33.93

Table 3: Maximum demand and demand forecasts for all primary substations

Primary substations	Current Max Demand	Forecast Year 1	Forecast Year 2	Forecast Year 3	Forecast Year 4	Forecast Year 5	Firm Capacity
Newton Abbot Primary	21.57 MVA	22.35 MVA	22.45 MVA	23.08 MVA	23.32 MVA	23.85 MVA	28.86 MVA
Teignmouth Gasworks	6.29 MVA	6.60 MVA	6.70 MVA	6.83 MVA	6.97 MVA	7.24 MVA	14 MVA
Chudleigh Knighton	8.15 MVA	8.61 MVA	8.85 MVA	9.39 MVA	9.73 MVA	10.20 MVA	14.00 MVA
Dawlish	11.34 MVA	12.51 MVA	12.73 MVA	13.94 MVA	14.48 MVA	15.11 MVA	22.7 MVA
Bovey Tracy	5.79 MVA	5.93 MVA	6.08 MVA	6.38 MVA	6.60 MVA	6.95 MVA	7.98 MVA
Higher Woodway	6.63 MVA	6.84 MVA	6.95 MVA	7.13 MVA	7.27 MVA	7.58 MVA	22.9 MVA
Bradley Lane	14.88 MVA	15.64 MVA	16.45 MVA	17.85 MVA	18.72 MVA	19.89 MVA	22.9 MVA
Buckfastleigh	5.26 MVA	5.45 MVA	5.57 MVA	5.71 MVA	5.89 MVA	6.17 MVA	15.4 MVA
Ashburton	6.00 MVA	6.18 MVA	6.27 MVA	6.92 MVA	7.17 MVA	7.58 MVA	9.78 MVA
Exminster	3.65 MVA	4.20 MVA	4.45 MVA	5.43 MVA	5.62 MVA	6.35 MVA	5 MVA
Mortonhampstead	2.90 MVA	3.23 MVA	3.39 MVA	3.57 MVA	3.76 MVA	4.00 MVA	6.50 MVA

- Newton Abbot Primary

Newton Abbot 11kV primary substation is fed by two 33kV lines from Newton Abbot BSP. WPD record that budget estimates have been provided for two 11kV generation connections totalling 4.5MW. The two generation connections will increase the demand headroom, although this may be on a non-firm basis if the generation is intermittent.

- Teignmouth Gasworks

Teignmouth Gasworks 11kV primary substation is fed by two 33kV lines from Newton Abbot BSP.

- Chudleigh Knighton

Chudleigh Knighton 11kV primary substation is fed by two 33kV lines from Newton Abbot BSP. WPD has recorded two generators connected to Chudleigh Knighton substation at 11kV, with capacities of 2.6MVA and 3.5MVA respectively. Budget estimates have been provided for six 11kV generation connections totalling 22MW at Chudleigh Knighton and two 11kV demand connections totalling 4MW. The connected and prospective generation may increase the demand headroom at Chudleigh Knighton, although this is likely to be on a non-firm basis. The demand developments will reduce the demand headroom if connected.

- Dawlish

Dawlish 11kV primary substation is fed by two 33kV lines from Newton Abbot BSP and is also connected to Chudleigh Knighton and Teignmouth Gasworks. Budget estimates have been provided for a demand connection of 3.048MW at 11kV at Dawlish substation; if this is successfully connected It will reduce the demand headroom.

- Bovey Tracy

Bovey Tracy 11kV primary substation is teed into one of the 33kV lines connecting Chudleigh Knighton to Newton Abbot BSP.

- Higher Woodway

Higher Woodway 11kV primary substation is teed into one of the 33kV lines connecting Teignmouth Gasworks to Newton Abbot BSP.

- Bradley Lane

Bradley Lane 11kV primary substation is fed by two 33kV lines from Newton Abbot BSP.

- Buckfastleigh

Buckfastleigh 11kV primary substation is connected by two 33kV lines to Totnes BSP. WPD have provided budget estimates for two 11kV generation connections at Buckfastleigh, totalling 2.6MW. This could increase the non-firm demand capacity at Buckfastleigh substation if connected.

- Ashburton

Ashburton 11kV primary substation is connected by a 33kV line to Totnes BSP.

- Exminster

Exminster 11kV primary substation is fed from Exeter City BSP by one 33kV line. WPD have provided budget estimates for a 1MW demand connection at Exminster substation; if connected this would likely further reduce the demand headroom at this substation.

- Mortonhampstead

Mortonhampstead 11kV primary substation is fed by a 33kV line from North Tawton BSP and a 33kV line from Exeter City BSP.

In light of the results above Exminster and Mortonhampstead have been put in the Red category of the RAG rating. The distinction between an Amber substation and a Green is the demand: if the demand is between 2 and 5 MVA it has been ranked as Amber and if the demand is above 5 MVA it has been ranked as Green.

5.1.1.4 Data integration Methodology (WP2.3)

The aim of this work package is to integrate the data received as outputs from the housing stock analysis (WP2.1) and the network analysis (WP2.2) into a common format, to begin to shortlist areas for high-density heat pump deployment in the area of Teignbridge, Devon. This section has been conducted by Urbanomy and fed into by the previous work packages and WP5.2 conducted by Kensa thanks to numerous exchanges. This collaboration helped setting up some of the criteria described below (Figure 11) and to provide data for Kensa's work package. These two sections overlap lightly but also allow to verify the results.

The shortlisting process involves a KPI flowchart to filter through the data at the building level, to identify the areas that best fit both the criteria in the brief and that defined by Urbanomy and the WP2 consortium. This is shown in Figure 11. Two types of criteria were applied, the eligibility criteria and the additional criteria. The eligibility criteria were mentioned in the tender document, they are mandatory criteria that had to be taken into account. The additional criteria are the ones Urbanomy and the consortium judge necessary to add on top of the previous ones to identify the target areas.

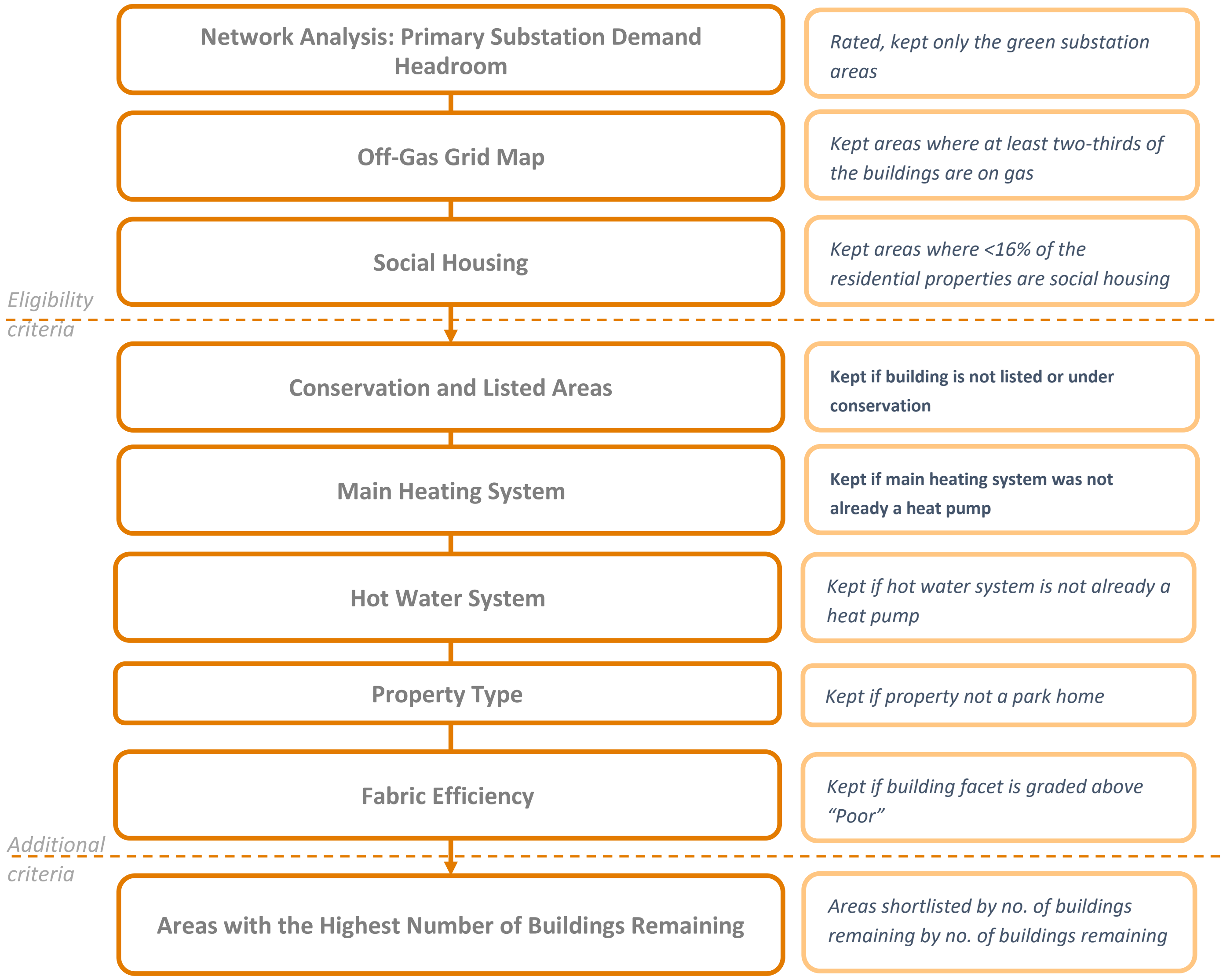


Figure 11: Filtering process at the building level to identify best fit areas

5.1.1.5 Specific Areas Analysis Methodology (WP2.4)

This work package builds on the previous one to provide a more detailed analysis of the energy demand and available flexibility of the previously shortlisted areas as well as selected the most appropriate buildings for the deployment.

- Energy Simulation: Scenarios

For the analysis of the building stock in the chosen area, energy simulations as outlined below have been conducted to assess the energy consumption of the current situation and compare it with a hypothetical scenario where all the gas boilers systems would be replaced by heat pumps.

For the scenarios, the following assumptions have been made:

Table 4: Specific Areas Analysis Energy Simulation Assumptions

Assumption	Value
Heating system (each scenario)	Boiler/Heat pump
Heating setpoint (°C)	21
HVAC service	Central heating radiators
Heating profile	06:00 – 08:00 & 17:00 – 06:00
Occupancy (m^2 per person)	20

Concerning the efficiency of the systems, we based our analysis on the fact that the vast majority (97%) of the heating systems were boilers, given the selection made on the chosen area. We have then developed scenarios simulating a BAU situation and a scenario with 100% of heat pump deployment. For the BAU situation, we classified the boiler efficiency in the following classes: 0.6 for the oldest boilers / 0.75 for the average boiler / 0.95 for the most recently replaced.

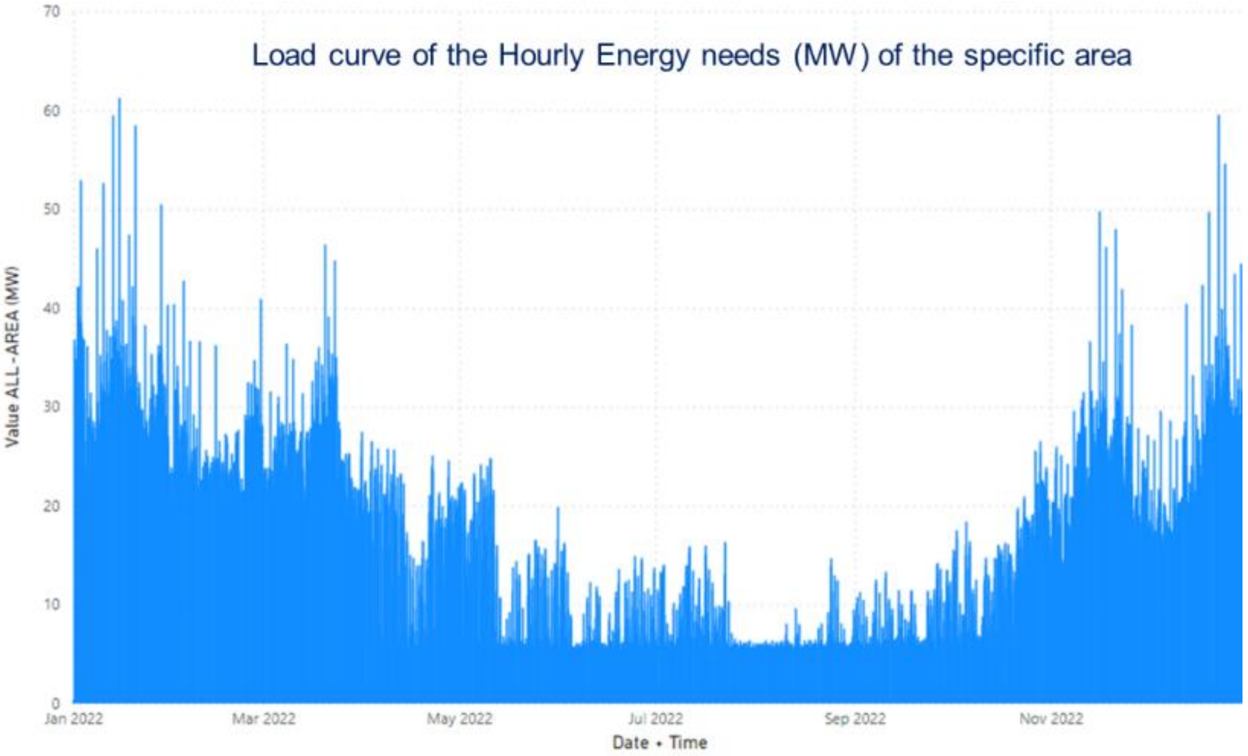
The energy needs were then calculated and the consumption estimated for the 2 scenarios, with and without heat pumps.

Heat pumps were sized considering the standard of the current fabric at a power density of $50W/m^2$ and the thermal storage was sized to enable the provision of 2.25 hours of max heat pump load (without turning the heat pump on).

An additional analysis has been conducted to assess the flexibility available in the full heat pump scenario and evaluate the theoretical reduction in peak demand.

- Scenario business as usual: analysis of the current situation.
- Scenario Heat pump: theoretical scenarios with full heat pump deployment.
- Flexibility assessment: analysis of the theoretical flexibility through thermal storage.

- Peak demand simulation



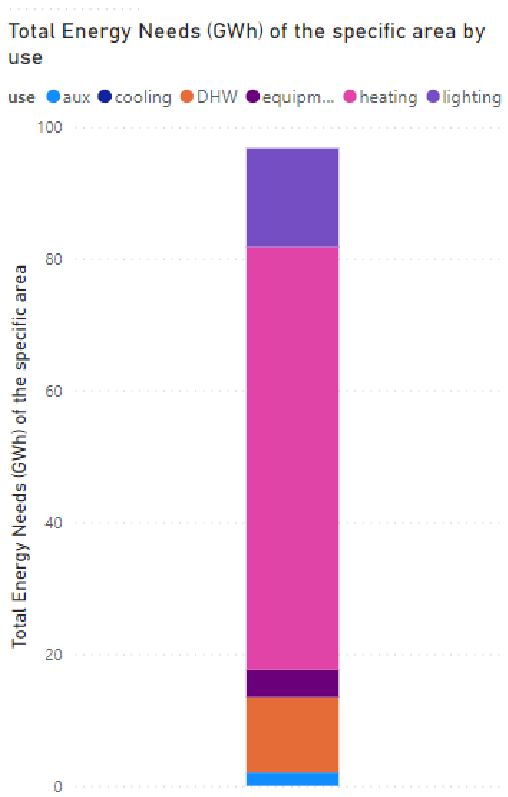


Figure 12: Energy Needs - Scenario Business as usual

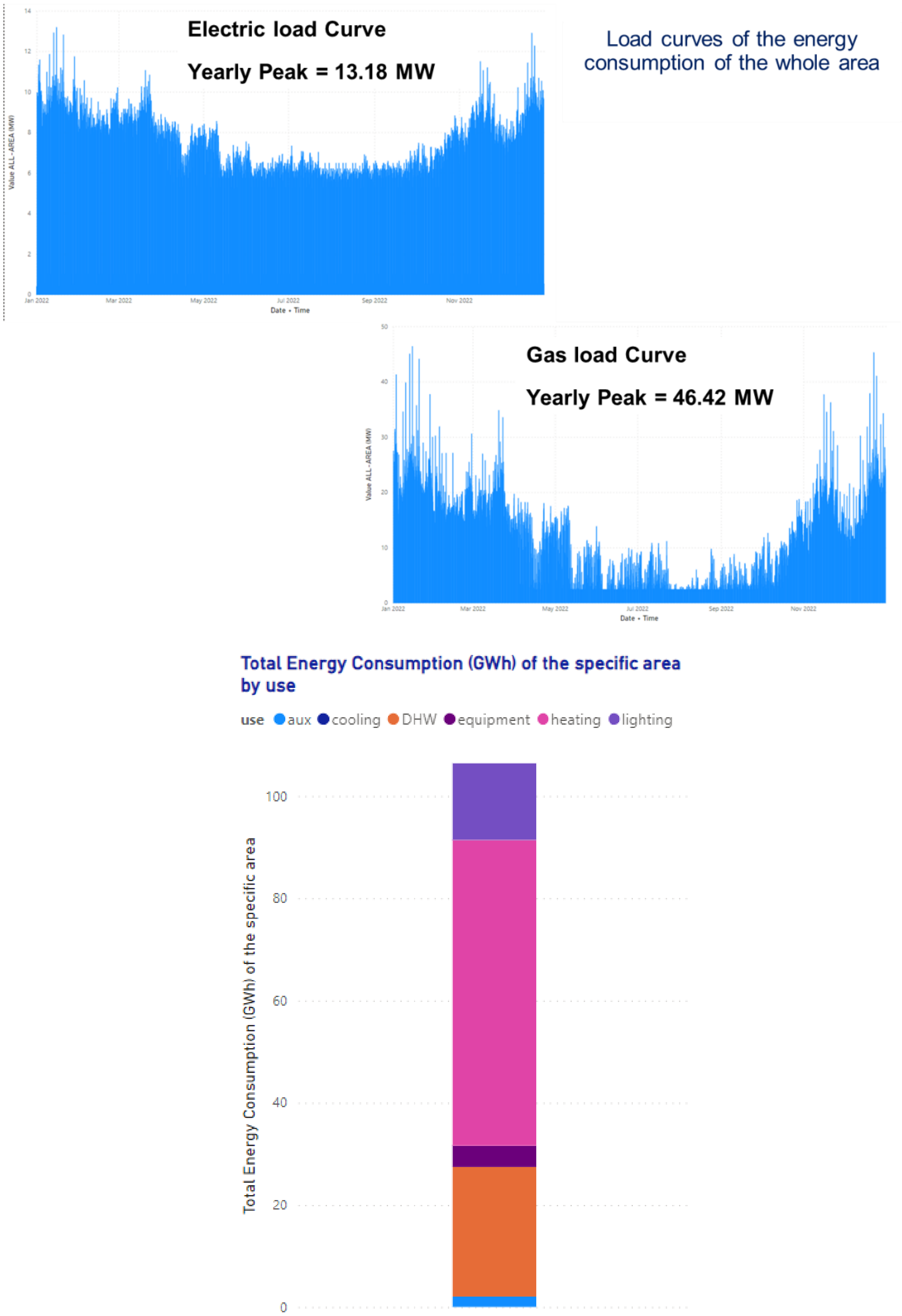
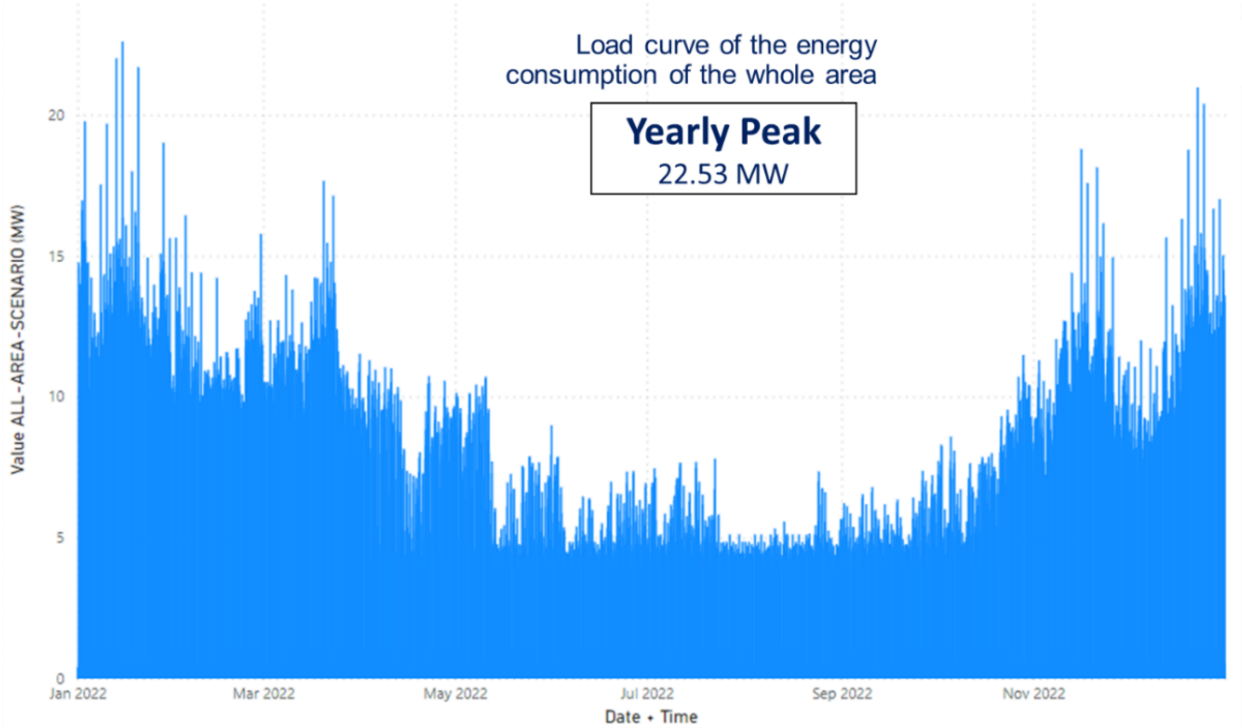


Figure 13: Energy Consumption - Scenario Business as usual



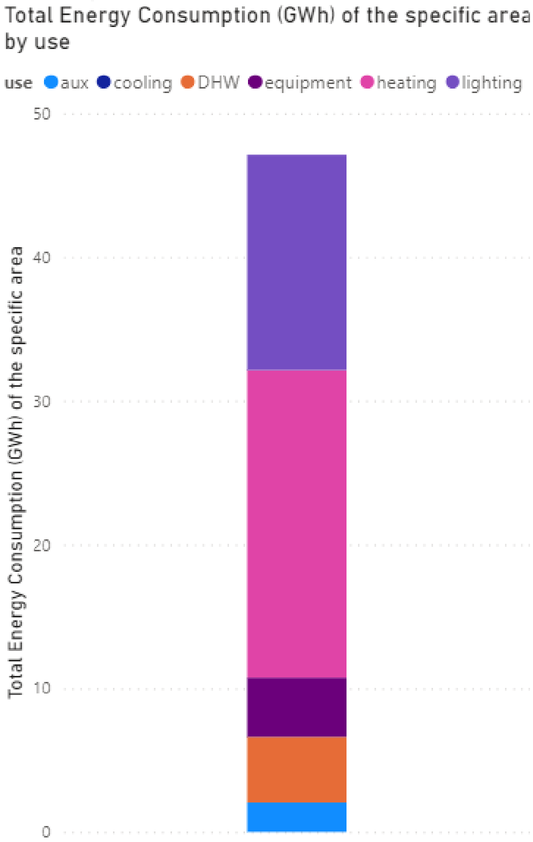


Figure 14: Energy Consumption - Scenario Full Heat Pump

- ADMD Calculation

To estimate the **peak demand** in the area the ADMD method has been used. For the area selected, the following ADMD range have been estimated. It is therefore possible to use this diversity to estimate the potential real peak in the area, after deployment of heat pumps.

After Diversity Maximum Demand (ADMD): Can be used to determine the sizing of any energy supplier or conversion system, including electrical wires or district heating pipes and substations.

ADMD = Diversity factor x Maximum demand

Diversity factor (df)

$$df_{min} = 1.32$$

$$df_{max} = 1.63$$

Figure 15: Diversity Factors Used

Various types of **flexibility** can be estimated and simulated.

1. In total power (absolute potential): Power that could be momentarily activated without any constraints (storage state, demand not considered).

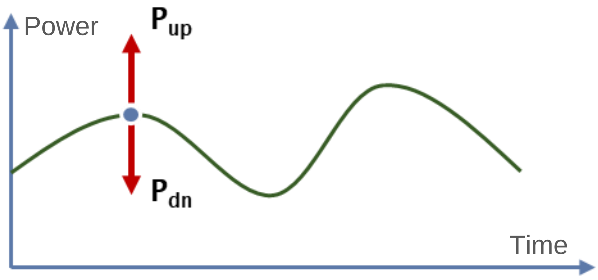


Figure 16: Total Power

2. In guaranteed power (usable potential for EVs): Power potential that can be held during a predefined time duration (input). In this case, the duration of an average daily EV charging process (68min, results of the EV charging hypothesis), considers prediction of demand.

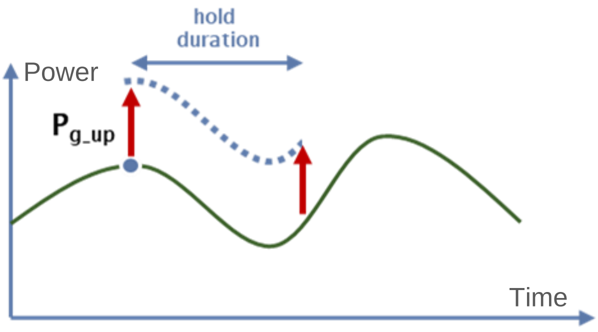


Figure 17: Guaranteed Power

3. In flexible energy (absolute potential): Total energy that can be shifted, without considering any power or time limits. Is calculated based on the current SOC and the prediction of the demand.

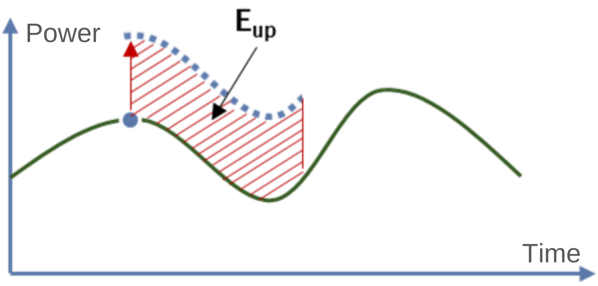


Figure 18: Flexible Energy

In this study the flexibility has been simulated with these two principles:

- **Upward Flexibility –** Increase of consumption (e.g. heat pumps could be turned on)
- **Downward Flexibility –** Decrease of generation (e.g. heat pumps can be turned off)

Thermal storage with **water tanks** represents the main flexibility potential for heat pump residential dwellings. The upward flexibility potential can be observed when the heat pump is used to charge the water tank before the need for hot water or space heating occurs, when the downward flexibility can be used to shut down or reduce the use of the heat pump and cover the heat and hot water needs thanks to the water tank.

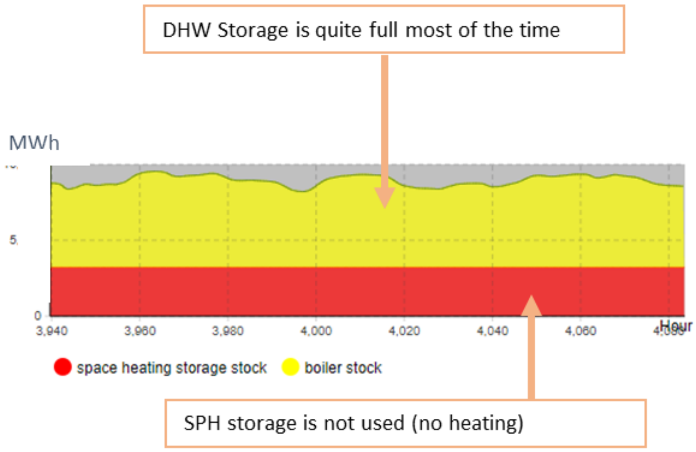


Figure 19: Water Tank Utilisation for a Typical Summer Day (example from previous UK projects)

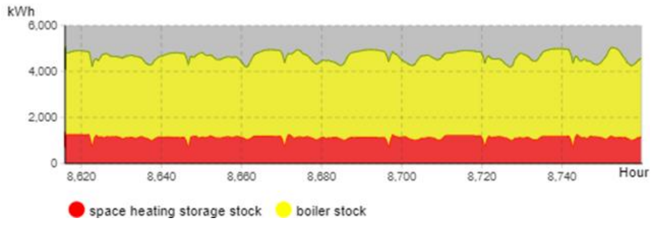


Figure 20: Water Tank Utilisation for a Typical Winter Day (example from previous UK projects)

5.1.2 Deployment Plan Methodology (WP5)

This section details the methodologies followed to obtain the results presented in the “Deployment Plan Results (WP5)” paragraph.

5.1.2.1 Infrastructure Design Methodology (WP5.1)

A Geology & Feasibility study was conducted by a Certified Geoexchange designer, Genius Energy Lab, for Kensa Utilities in the 3 identified target areas: Bishopsteignton, Kingsteignton and Newton Abbott.

Genius Energy Lab is an industry leading design and consultancy company with over 20 years of experience in the low and zero carbon sector. Well over 450MW of installed energy systems utilised their designs. The initial geology studies outline the geological conditions at the selected sites and take a profile for drilling boreholes at specified locations when considering a closed loop system. Kensa requested the following be considered in the desktop assessment:

- underlying geology
- underlying hydrogeology
- assessment of drilling conditions and likely drilling depths
- assessment of ground thermal properties

The purpose of the assessment was to investigate the anticipated geological conditions, classifications, permissions, risks, and estimated ground thermal properties in the 3 final selection areas:

- Newton Abbott (TQ12) Site centred on NGR: SX 87088 73158
- Kingsteignton (TQ12) Site centred on NGR: SX 87638 70416
- Bishopsteignton (TQ14) Site centred on NGR: SX 90650 73605

These three studies are looking to conclude on economic ground loop requirement for each archetypes:

- the economic ground loop requirement – per archetype,
- the economic ground loop requirement – averaged across 30 properties.

They base their investigations on eight different household archetypes identified in the following section (WP5.3) and their peak heating load, annual heating load, and annual domestic hot water (DHW) load. These different archetypes can be seen in Figure 21 below.

The studies conclude on the number of boreholes required, the required depth, spacing, U-Tube sizing, and U-Tube pressure drop for each type of properties. Finally, they give the same findings for an average across 30 properties.

Choose an item.				
Project Address	Kingsteignton			
Building Type & Number	Residential			
Provisional Loads by archetype	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Peak Heating Load	4.42 kW	4.85 kW	3.85 kW	5.0 kW
Annual Heating Load	8,032 kWh	9,041 kWh	6,955 kWh	9,453 kWh
Annual DHW Load	2,234 kWh	2,225 kW	1,982 kWh	2,158 kWh
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Peak Heating Load	5.82 kW	5.09 kW	6.0 kW	7.52 kW
Annual Heating Load	11,257 kWh	9,578 kWh	11,727 kWh	15,112 kWh
Annual DHW Load	2,255 kWh	2,238 kWh	2,216 kWh	2,348 kWh

Figure 21: Example of input data for the geology study

5.1.2.2 Property Archetype Identification and Design Methodology (WP5.3)

Data from UCL, Urbanomy and EPC Opendata has been combined and interrogated to identify a set of housing archetypes that are representative of the properties in the area. This data has then been used to estimate installation costs based on the distribution of each property type in the shortlisted areas.

- Property Type Count

To start compiling a list of archetypes, the merged *built_form* (detached, semi-detached, mid-terrace, etc) and *property_t* (house, bungalow, flat, etc) data columns were combined for the selected addresses to provide a list of property type (see Property Archetype Identification and Design Results (WP5.3)).

When flats were given their built form, they were assigned descriptions which don't fit their traditional build type i.e. detached flat, end-terrace flat, mid terrace-flat. It was decided that the flats and maisonettes make up a small enough proportion of the total properties that they can be excluded. This is a reasonable elimination as there are so few number of these property types (241 properties) they do not merit their own archetype. A full data set exists for the built-form, however, for the data that did not exist for property types, the following assumptions were made:

- Storey count 1 = "Bungalow"
- Storey counts 2 or 3 = "House"

- Number of Habitable Rooms Identification

EPC data provides the number of **habitable rooms**. A habitable room is defined as bellow in the EPC guidance (6).

Habitable rooms include any living room, sitting room, dining room, bedroom, study and similar; and also a non-separated conservatory. A kitchen/diner having a discrete seating area (with space for a table and four chairs) also counts as a habitable room. A non-separated conservatory adds to the habitable room count if it has an internal quality door between it and the dwelling. Excluded from the room count are any room used solely as a kitchen, utility room, bathroom, cloakroom, en-suite accommodation and similar and any hallway, stairs or landing; and also, any room not having a window.

Habitable rooms count provides an indication of property radiator count. Estimation of bedroom number supports domestic hot water cylinder sizing. Both support **costing of capital works**.

Upon inspecting the merged data, it was found there were **duplicates** in the shortlisted property data set. There were found to be 521 duplicated properties (of those that had the available EPC data showing habitable rooms). These duplicates were removed.

- Archetype selection

The properties with 0, 1 & 2 and above 7 habitable rooms have been excluded. End-terrace bungalows (107) and mid-terrace bungalows (102) make a small enough proportion to exclude them from the final archetype selection.

This selection allows to identify suitable archetypes to support fast and simple system pricing for feasibility and delivery for GSHP installation.

- Archetype characteristics

Finally, it is possible to conclude on each identify archetype’s characteristics. The average floor area by habitable rooms and property type, the average heating load by habitable rooms and property type, and the number of bedrooms by property type have been defined.

5.1.2.3 Cost Estimate - Development of M&E Scope Methodology (WP5.4)

Kensa Contracting has carried out an initial review into the feasibility of installing a shared ground loop GSHP systems in the area of Teignbridge. This study is based upon removal of the current heating system and replacement with a ground source heat pump solution to meet the full heating and hot water load required.

- Geological Assessment

Physical access, geology and general suitability for ground source heat pumps has been assessed.

A desktop study of the geological conditions at the sites has been carried out by a ‘Certified Geoexchange Designer’ (certification provided by the Association of Energy Engineers). Their assessment of the anticipated geological conditions is included in the section Infrastructure Design Methodology (WP5.1).

- Budget Cost Estimate

The economic ground loop requirements for the installation include:

- Core component supply: Heat Pumps, antifreeze, manifolds, expansion vessels.
- External contracting services: Boreholes installation, trenching excavation and headering installation.
- Internal contracting services: Internal plumbing installation, ground side connections / riser supply & install, Heat Pump Installation.
- Other equipment supply: Cylinders, electricity meters, smart controls.

The costs do not include:

- Design: Heat Losses, property surveys, Mech Design, Borehole Design.
- Mobilisation: Site establishment.
- Welfare: Compound and facilities for onsite staff.
- Site surveys and permissions: Topography, UXO, Coal authority, highways section 50 licence, etc.

The estimates presented in the “Cost Estimate - Development of M&E Scope Methodology (WP5.4)” section take into account the elements related to the **retrofit** of the property and the **infrastructure required to provide the required heating** to the properties based on the findings in the geological assessment by Genius Energy Lab.

The solution that is proposed is that each property is fitted with a Kensa **ground source heat pump** connected to **radiators** and **hot water tank**. It has been assumed that **circulation pipework** will need to be upgraded in areas and that pipework to radiators will be surface mounted and able to be routed directly for the GSHP installation. Costs assume radiators will be upgraded to suit. As each property will benefit from an individual GSHP, the resident will be responsible for paying their own energy bill associated with the operation of the heat pump.

The **shared ground loop** (SGL) is a series of deep boreholes connected in sequence and infinitely scalable, which form an ultra-low temperature heat network that provides ambient temperature to individual heat pumps. This heat is then upgraded inside the dwelling. Similar to the gas mains infrastructure, the SGL has an estimated life 100 years. Increasingly, Kensa’s customers treat SGLs as asset infrastructure which they own and operate over a long term. Due to the long life of the asset infrastructure, SGL owners are able to recover their capital expenditure associated with the shared ground loop over many years by operating various commercial agreements with connected properties. In this model, the Internal Rate of Return (IRR) is projected to be 6%.

- Commercial Income and Avoided Cost

With 1.6 million gas boilers sold every year, the majority of heating systems are now powered by gas. It is a legal requirement for landlords to have all **gas appliances checked annually** to ensure they are safe for their tenants. Once this check is completed a CP12 certificate is issued. Landlords often contract this work out to Gas Safe registered engineers or employ an in-house team to arrange and carry out these inspections. On average £120 a year is budgeted for this process. This cost is not just for the inspection, it also covers the cost of multiple phone calls to tenants to arrange an inspection and in some cases taking enforcement action to enter a property for the landlord to dispense its obligation.

There is **no requirement for an annual safety inspection or service of the GSHP** itself. However, it is usually good practice to carry out periodic checks on the internal central heating system itself, as would be recommended with any heating system. This can often provide landlords with saving in comparison with traditional heating systems that have more moving parts and involve internal combustion.

5.1.2.4 Cost Estimate - Network Reinforcement Cost Estimation Methodology (WP5.5)

Cost estimates for equipment that could be utilised to reinforce the primary and secondary substations that supply the shortlisted areas under consideration have been derived from a proprietary database of asset costs. Costs have been volatile over the past few years as material and labour costs have risen in response to a number of factors, so the cost estimates presented here are intended as **indicative costs to aid in the comparison of the three short listed areas**.

As part of the specific area analysis conducted by Urbanomy in Work Package 2 of Project GAIA, the estimated **yearly electrical demand peak** in the Business as Usual (BAU) scenario was 13.18MW, compared to peak demand of 22.53MW under a scenario where gas boilers are replaced by the networked heat pump arrangement. This gives an estimated increase in electrical peak demand of 9.35MW following the installation of heat pumps at the required number of properties.

Data is not available[6] from National Grid Electricity Distribution (NGED, formerly Western Power Distribution) on the capacity and equipment at the secondary substations. However, due to the size and voltage levels (11kV/0.4kV) of secondary substations, it is assumed that the estimated increase in peak electricity demand would **necessitate an upgrade in the capacity of one or more transformers**, or the installation of an additional transformer if possible. Actual reinforcement costs could vary due to the capacity at secondary substations (which is not known unless project specific monitoring is carried out) and depending on which properties are targeted and how many supply areas they fall under.

If the properties chosen for heat pump installation fall under more than one secondary substation supply area, transformers at multiple substations could need upgrading, or, conversely the need for reinforcements may be mitigated as the demand increase will be shared across different substations. As the final shortlist of properties known at the time of the work, the price of an additional transformer at one secondary substation has been included in the reinforcement cost estimate for the three areas considered, but the actual costs encountered in the future may represent the price of reinforcement at multiple substations.

Data from NGED's long term development statement (LTDS) and online heat maps has been used to determine whether the installation of the networked heat pump arrangement would require reinforcement

[6] Following Enzen asset information request, NGED provided access to their dataportal2. This system contains substation number, location and conductor details. However, information such as transformer ratings, age etc is not present but is shown in the Common Information Model (CIM). Access to the CIM for the South West was requested but not granted in enough time to utilise the data within the project.

at the primary substations that feed each of the three areas and what the required reinforcement may be. Additionally, data available from NGED's website was used to ascertain whether any current or planned reinforcement work may affect the capacity available on the networks in these areas. There are no relevant reinforcement works that affect the areas under consideration.

Following the next stages of shortlisting of the properties, it is recommended that further engagement with NGED is carried out to confirm the likely impacts of the installation of the networked heat pump arrangement and to understand their view on the likely costs and timelines involved in ensuring the network is able to accommodate the increase in demand.

- Kingsteignton

The shortlisted Kingsteignton area falls under the Newton Abbot Main primary substation supply area. Figure 22 below shows the shortlisted properties in this area and the secondary substations that supply these properties.

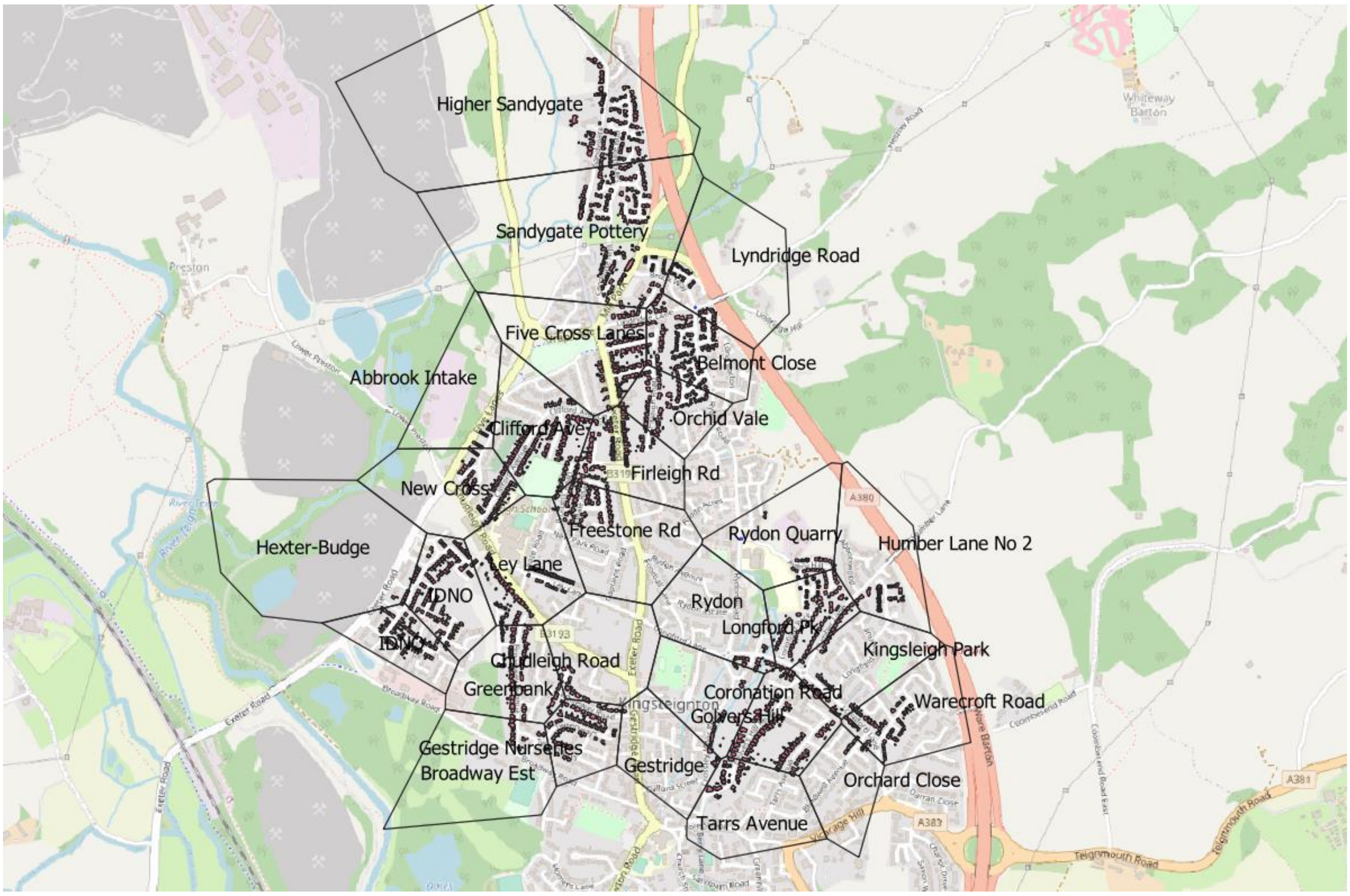


Figure 22: Map showing the shortlisted properties under consideration in Kingsteignton and the secondary substations that supply these areas. Base map from ©OpenStreetMap contributors and Supply areas provided by National Grid Electricity Distribution, dataset pro

Newton Abbot Main primary substation has a demand headroom of 6.78 MVA and upstream demand headroom of 17.61MVA. Using the estimated increase in peak demand calculated in the specific area analysis, it has been determined that a transformer at Newton Abbot Main primary substation would likely need to be reinforced to accommodate the additional demand. The upstream demand headroom available suggests that no reinforcement works would be needed above 33kV.

According to NGED's LTDS Table 2 (7), Newton Abbot Main has two 33/11kV transformers rated at 18MVA. Accounting for the demand increases NGED has forecasted for Newton Abbot Main primary substation, it is assumed that replacing one of the 18MVA transformers with a 24MVA transformer would provide adequate capacity.

Additionally, it is assumed that at least one secondary substation will require a transformer upgrade. Depending on the properties that are selected, multiple secondary substations may be impacted and require reinforcement, increasing the reinforcement costs (See table Table 26 in the Results section).

The NGED South West planning teams provided 3 examples of local works, with costs:

1. 11kV line refurbishment in Oakhampton (£400k).
2. Tower and Line replacement, Plymouth (£1.5M).
3. Substation replacement - Torridge (£61k).

Where these works are identified by the DNO as necessary, they are usually planned as part of the LTDS and paid for by the DNO. Where such works would be triggered by a project such as project Gaia, the costs would be borne by the developer requesting the connection.

- Bishopsteignton

The shortlisted Bishopsteignton area falls under the Teignmouth Gasworks primary substation supply area. Figure 23 below shows the shortlisted properties in this area and the secondary substations that supply these properties.

Figure 23: Map showing the shortlisted properties under consideration in Bishopsteignton and the secondary substations that supply these areas. Base map from ©OpenStreetMap contributors and Supply areas provided by National Grid Electricity Distribution, dataset

Teignmouth Gasworks primary substation has a demand headroom of 7.84 MVA and upstream demand headroom of 17.61MVA. Considering the estimated increase in peak demand calculated in the specific area analysis, it is likely a transformer at Teignmouth Gasworks primary substation would need to be upgraded. The level of upstream demand headroom that is available suggests that no reinforcement works would need to be carried out above 33kV.

NGED's LTDS Table 2 shows that Teignmouth Gasworks primary substation has two 33/11kV transformers with a rating of 14MVA. Considering the demand increases NGED has forecasted for Teignmouth Gasworks primary substation, it is assumed that replacing one of the 14MVA transformers with a 20MVA transformer would provide adequate capacity to accommodate the increase in demand following heat pump installation in the area. As described above, it is assumed that at least one secondary substation will require a transformer upgrade.

- Buckland and Milber

The shortlisted Buckland and Milber area falls under the Newton Abbot Main primary substation and Lawes Bridge primary substation supply areas. The Newton Abbot Main primary supply area covers the North section of the shortlisted area, to just below St Marychurch Road. The Lawes Bridge primary substation supply area covers the section South of this road. Figure 24 below shows the properties in this area and the secondary substations that supply these properties.

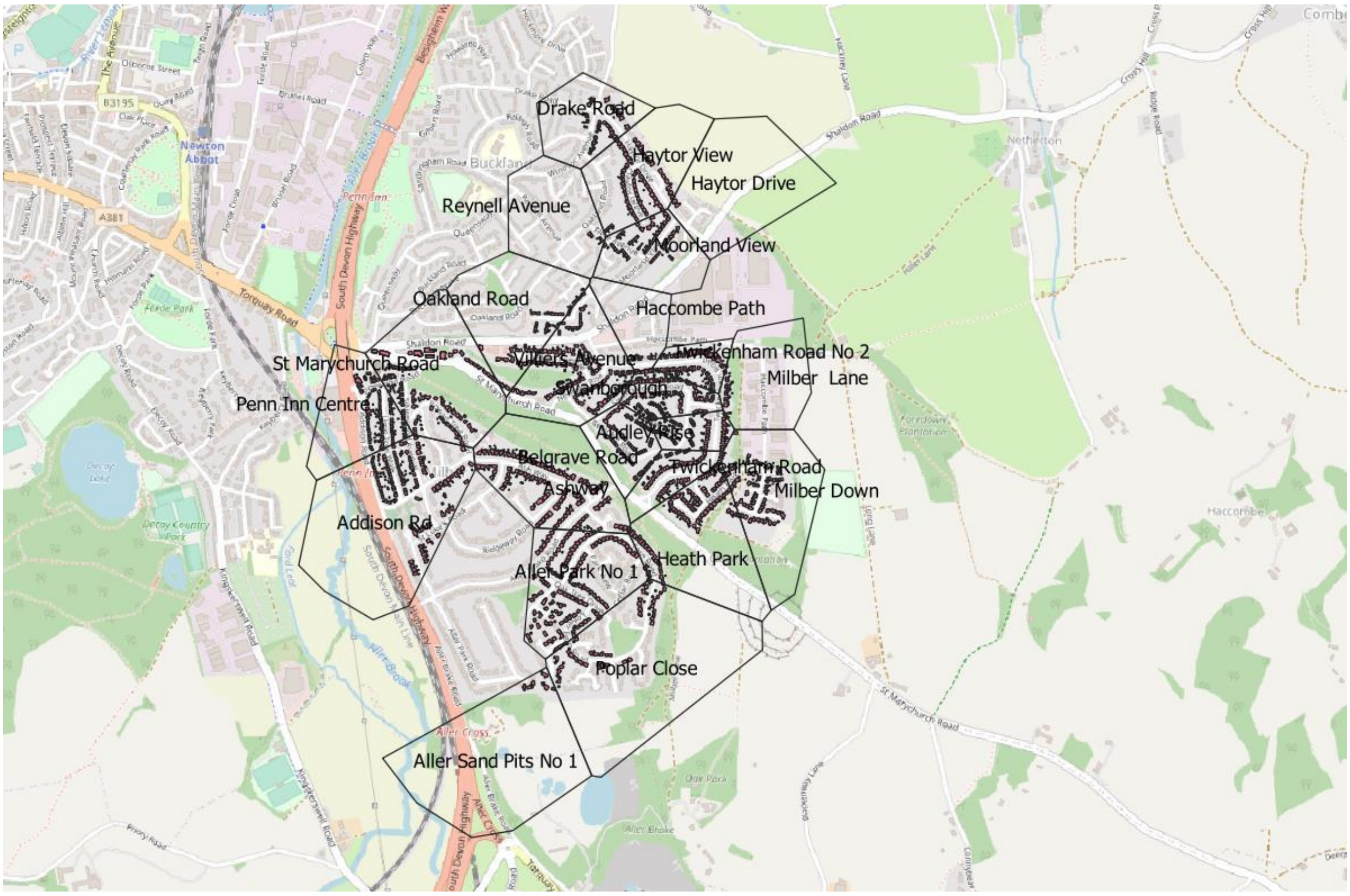


Figure 24: Map showing the shortlisted properties under consideration in Buckland and Milber and the secondary substations that supply these areas. Base map from ©OpenStreetMap contributors and Supply areas provided by National Grid Electricity Distribution, data

Newton Abbot Main primary substation has a demand headroom of 6.78 MVA and upstream demand headroom of 17.61MVA. Lawes Bridge primary substation has a demand headroom of 8.38 MVA and upstream demand headroom of 44.96MVA. If the properties that are selected for the networked heat pump are split across these two primary supply areas, this could alleviate the need for reinforcement at the primary level, as the increase in electricity demand at each primary substation could easily fall within the demand headroom.

However, if all properties fall under only one of the primaries, the resulting increase in peak electrical demand, as estimated in the specific areas analysis, would mean that a transformer would likely need to be reinforced. The upstream demand headroom available suggests that no reinforcement works would need to be carried out above 33kV.

According to NGED's LTDS Table 2[7], both Newton Abbot Main and Lawes Bridge substations have two 33/11kV transformers rated at 18MVA. Taking into account the demand forecasts for these primary substations, is assumed that replacing one of the 18MVA transformers with a 24MVA transformer would provide adequate capacity to accommodate the increase in demand at either substation. Additionally, it is assumed that at least one secondary substation will require a transformer upgrade. Depending on the properties that are shortlisted, multiple secondary substations may be impacted and require reinforcement, increasing the reinforcement costs. See Table 28 in the Results section.

During the project Enzen engaged with Local Network Planners, Distribution Managers and the DSO Engagement Officer from NGED. Data and information were provided by the NGED Innovations team and other departments. Enzen also coordinated with the NGED Local Investment teams. Had the project progressed to a deployment phase, Enzen would have been able to use the CIM and the Enzen embedded network planners within NGED to determine accurate network development costs. Embedded capacity data, Network data (at all voltage levels), as well as, associated datasets such as dataportal2 and the CIM is all data produced and owned by NGED. These data are provided under various terms of use.

[7] Nominal transformer ratings are shown in Tables 2A and 2B which are available to registered partners of NGED through an online registration process. Table 2A lists transformers with a single lower voltage winding. Table 2B lists transformers with two lower voltage windings. Only assets above 11kV are listed. The nominal transformer ratings are normally enhanced to reflect the cyclic nature of the load except for Continuous Emergency Rated (CER) units. Factors including transformer design, hotspot temperatures, shape of load curve and the ratings of ancillary equipment will dictate the extent of enhanced rating. The transformers are listed in alphabetical order of the substations where they are located; showing their nameplate rating, tap changer details, impedance and other parameters.

5.1.2.5 Training Module Plan Development Methodology (WP5.6)

As Kensa have led numerous retrofit projects they were in the best position to develop a robust training plan for local Installers. They incorporated key milestone deliverables including the customer journey proposition, as well as their own experience as ground source heat pump manufactures.

The training plan description can be found in the results section (6.1.2.5 Training Module Plan Proposition (WP5.6)) and in the annexes (15.10 Training Module Plan Development (WP5.6)).

During large scale retrofit projects lead by Kensa, Resident Liaison Officers (RLOs) are employed locally on a temporary basis and receive basic GSHP training to enable them to explain the technology and installation process at a very basic level to tenants. The primary role of RLOs in large scale retrofit is to act as the go-between for tenants, social housing landlords and the delivery team.

A sub-contractor upskilling training programme is also put in place for qualified installers, as well as some training for call centre staff in housing associations. These trainings help reduce the delay between tenants raising an issue and fault identification.

Project Gaia requires a very different approach due to the spread of responsibilities across the consortium and the responsibilities of the inhabitant of the building (as customer as well as end-user). Extensive staff training is therefore required, as well as very clear guidance documents and practical shared policies to ensure a smooth customer journey that will result in successful sales. Moreover, the RLO staff is not expected to have prior heat pump experience and, as the deployment activities are led by different consortium partners, Kensa staff will not be available to support outside of training.

The training plan incorporates lessons learned from delivery of Kensa first mass private retrofit project, Heat the Streets, as well as the ongoing work of Kensa Contracting in heat pump sales, installer training, and resident liaison for large social housing retrofit projects.

6. Findings from Work Packages

6.1 Technological Assessment for A High-Density Deployment in Teignbridge, Devon (WP2 and WP5)

6.1.1 Identifying Target Areas Results (WP2)

This section highlights the results of each part of the work aiming to find target areas for the solution deployment. The methodology is described in the previous section: Identifying Target Areas Methodology (WP2).

6.1.1.1 Housing Stock Analysis Results (WP2.1)

The physical and contextual data generated for every premises in Teignbridge were communicated to Kensa and Urbanomy to support them in finding the best fitted target area.

As seen in the methodology section the first output, an excel and geoJSON database, contains information on:

- Physical stock characteristics; i.e., floor and exposed/party wall areas.
- Stock occupant characteristics; i.e., tenure estimate, premises heating system.
- Contextual characteristics (including geolocation of the stock); i.e., overlap with statutory restrictions and protections such as conservation area.

The second output is a database of the energy demand of each premises.

prem_key	uprn	official_use_state	virtual	ucl_attachment_source	ucl_best_estimated_attachment_type	ucl_domestic_stock_type_source
1130L000000001	1E+11	In use	TRUE	epc_or_v_epc	end-terrace	ucl_stock_model
1130L000000002	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000003	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000004	1E+11	In use	TRUE	epc_or_v_epc	semi-detached	ucl_stock_model
1130L000000005	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000006	1E+11	In use	TRUE	epc_or_v_epc	end-terrace	ucl_stock_model
1130L000000007	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000008	1E+11	In use	FALSE	epc_or_v_epc	mid-terrace	epc_or_v_epc
1130L000000009	1E+11	In use	TRUE	epc_or_v_epc	semi-detached	ucl_stock_model
1130L000000010	1E+11	In use	FALSE	epc_or_v_epc	mid-terrace	epc_or_v_epc
1130L000000011	1E+11	In use	TRUE	epc_or_v_epc	end-terrace	ucl_stock_model
1130L000000012	1E+11	In use	TRUE	epc_or_v_epc	end-terrace	ucl_stock_model
1130L000000013	1E+11	In use	FALSE	epc_or_v_epc	mid-terrace	epc_or_v_epc
1130L000000014	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000015	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000016	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000017	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000018	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc
1130L000000019	1E+11	In use	FALSE	epc_or_v_epc	semi-detached	epc_or_v_epc

ucl_best_estimated_stock_type	takeoff_f2f_ht	takeoff_floor_level	floor_area_sq_m	storey_count	party_wall_area_sq_m
default_house	3.15		141.23601	2	48.29049
house	2.35		75	2	38.597008
house	2.3		103	2	36.160027
default_house	2.35		92.8905	2	40.94693
house	2.3		76	2	33.86014
default_house	2.29		70.792984	3	42.66789
house	2.32		67	2	30.770527
house	2.45		68	2	77.38044
default_house	2.7		123.81376	2	39.47102
house	2.45		71	2	77.400856
bungalow	3.6		60.185787	1	0
default_house	2.65		64.126656	2	40.519688
house	2.15		75	2	22.474815
bungalow	4.09		38	1	28.217302
bungalow	2.2		38	1	15.178728
bungalow	2.26		38	1	15.573626
bungalow	4.32		38	1	29.770075
bungalow	4.45		38	1	27.420513
bungalow	2.8		38	1	18.234377

Figure 25: Extract of UCL 3DStock Model[8]

column name	notes
prem_key	this is ucl unique key
uprn	the official open os id: UPRN, can be used with ONS statistical lookups
official_use_state	is the building registered as in use / occupied etc. We've not used this historically and is dependent on how up to date the council keep their registers
virtual	is this record from a real epc or a machine learning generated virtual one, for all virtual records data is inferred or dervied from the physical geometry in the digital twin
ucl_attachment_source	source used for building attachment
ucl_best_estimated_attachment_type	
ucl_domestic_stock_type_source	source used for stock type
ucl_best_estimated_stock_type	
takeoff_f2f_ht	floor to floor height
takeoff_floor_level	which floor level
floor_area_sq_m	party wall area in square meters
storey_count	
party_wall_area_sq_m	

Figure 26: Column List of the UCL 3DStock Model

[8] All the column and lines are not included

master_key	calc_eui_from_need_sample_meter	postcode_median_gas	postcode_mean_gas	upper_need_est_demand
1130L000000001	100	11188.195	10563.848	14600
1130L000000002	155	8831.627	9763.434	13400
1130L000000003	103	11507.543	11187.527	12100
1130L000000004	144	8831.627	9763.434	15600
1130L000000005	145	11507.543	11187.527	12800
1130L000000006	134	8831.627	9763.434	11000
1130L000000007	149	11507.543	11187.527	11400
1130L000000008	125	8831.627	9763.434	9700
1130L000000009	102	11507.543	11187.527	14600
1130L000000010	95	8831.627	9763.434	7800
1130L000000011	153	8988.798	9768.748	10500
1130L000000012	136	8831.627	9763.434	9900
1130L000000013	96	8988.798	9768.748	8300
1130L000000014		6162.217	6297.0146	
1130L000000015		6162.217	6297.0146	

avg_need_est_demand	energy_demand_source	energy_demand_estimate_annual_kwh	eui_benchmark_compare
14100	need_2020_estimated_demand_calc	14100	low_demand
11636.56098	need_2020_estimated_demand_calc	11637	demand_in_range
10584.9642	need_2020_estimated_demand_calc	10585	low_demand
13337.01299	need_2020_estimated_demand_calc	13337	demand_in_range
11016.41414	need_2020_estimated_demand_calc	11016	demand_in_range
9516.049383	need_2020_estimated_demand_calc	9516	demand_in_range
9961.654135	need_2020_estimated_demand_calc	9962	demand_in_range
8523.310023	need_2020_estimated_demand_calc	8523	demand_in_range
12576.8559	need_2020_estimated_demand_calc	12577	low_demand
6774.476987	need_2020_estimated_demand_calc	6774	low_demand
9197.955707	need_2020_estimated_demand_calc	9198	demand_in_range
8716.666667	need_2020_estimated_demand_calc	8717	demand_in_range
7185.772358	need_2020_estimated_demand_calc	7186	low_demand
	postcode_gas_data_median	6162	no_match_made
	postcode_gas_data_median	6162	no_match_made

Figure 27: Extract of Energy Demand Export from the 3DStock Model[9]

master_key	link to model data
calc_eui_from_need_sample_meter	estimated energy use intensity using model floor area and matched need property from need sample (~300k prems in southwest)
postcode_median_gas	BEIS official statistics for domestic gas use
postcode_mean_gas	BEIS official statistics for domestic gas use
upper_need_est_demand	upper estimated demand from need matched property
avg_need_est_demand	average estiamted demand using need matched method
energy_demand_source	source of data for energy_demand_estimate_annual_kwh
energy_demand_estimate_annual_kwh	best estimate from available data sets
eui_benchmark_compare	comparison of energy use intesity to previous models, if high / low there's option to use upper estimate or postcode median

Figure 28: Column List of the Energy Demand Export from the 3DStock Model

[9] All the lines are not included

6.1.1.2 Assessment of Property Data Results (WP5.2)

6.1.1.2.1 Results

This work package provided alternative methodologies for selecting target areas using a different set of requirements. It fed into the Data integration Methodology (WP2.3) and Specific Areas Analysis Methodology (WP2.4) sections.

Step	Results
UCL Stock Modelling Upgrade	64,303 properties
Target areas (round 1): UCL data	16,665 properties
Target areas (round 2): combining the network capacity analysis with the non-gas map	10,032 properties 6 areas likely to provide 'street-by-street' deployment.
Target areas (round 3): high-priority areas	5,120 properties 6 areas and 20+ clusters
Target areas (further considerations): household attitudes and lifestage circumstances	372 properties
Shortlist of potential streets	1,421 properties in the wider neighbourhoods

Figure 29: WP5.2 results breakdown by steps

- Target areas (round 1): UCL data

As described in the section Assessment of Property Data Methodology (WP5.2), the first set of filters applied is:

- Exclusion of caravans, chalets and park homes,
- Only non-listed and non-conservation areas are selected,
- Exclusion of non-gas properties entirely,
- Owner occupied are preferred but private and social rent are included

After this first set of filters is applied, 16,665 properties remain from the 64,303 properties contained in the Stock Model data set.

- Target areas (round 2): combining the network capacity analysis with the non-gas map

This second round of filtering selects areas that:

- Have gas connected properties at 60% or higher,
- Are within the primary network supply zones listed by Enzen as green and orange,

There are 6 areas of medium-high density housing that are likely to provide 'street-by-street' deployment:

- Bovey Tracey
- Kingsteignton
- Teignmouth
- Ogwell
- Bishopsteignton
- Newton Abbot (east and west)

After this round there are 10,032 properties.

- Target areas (round 3): high-priority areas

The larger towns (Newton Abbot, Kingsteignton and Teignmouth) were found to have more streets with 20+ properties than those in the smaller towns (Bishopsteignton, Bovey Tracey and Ogwell).

This further confirms the justification for excluding the smaller villages and settlements in the remote parts of the locality. However, it should be noted that given the focus on the medium/high density housing areas, this has meant a drop in home ownership rates as these tend to be more common on the less densely populated areas.

The selection of properties after round 3 is shown in Figure 30 below with the statistics on homeownership and 20+ cluster sizes observed in Table 5 below.

After this round there are 5,120 properties.

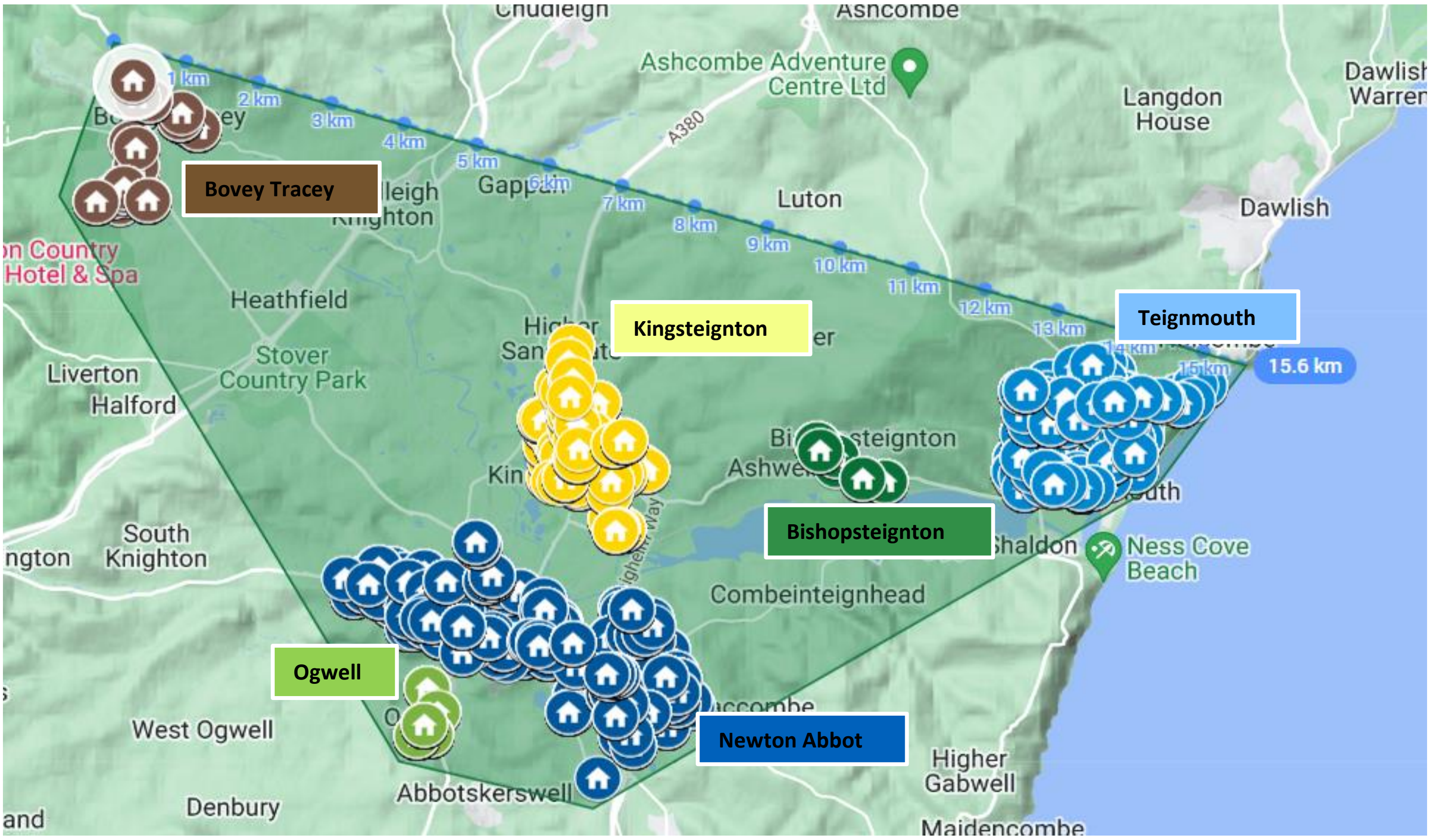


Figure 30: Distribution of selected properties across Teignbridge locality (Google map)

Table 5: property data – owner occupation and 20 plus property clusters on USRN

Town L- Large S - Small	No. of properties after round 2	Owner Occupied % for round 2	USRNs with 20 or more properties %	No. of properties after round 3	Owner Occupied % for round 3
Bishopsteignton (S)	328	88%	16%	52	90%
Bovey Tracey (S)	767	83%	34%	259	82%
Kingsteignton (L)	1,769	79%	51%	910	77%
Newton Abbot (L)	4,296	71%	57%	2,449	69%
Ogwell (S)	340	81%	30%	103	68%
Teignmouth (L)	2,532	80%	53%	1,347	75%
Total / %	10,032	77%	51%	5,120	73%

- Further considerations and shortlist of potential streets

Based on the further analysis, looking at social traits of the areas for further consideration, there are 11 streets that could see the largest voluntary uptake in the scheme from local residents (see Table 6 below). The sites picked are those that had at least 2 overlapping areas from the “further considerations” figure (Figure 8) in the previous round. This is not to be treated as a final selection, rather they should be seen as a potential shortlist based on the analysis that has been carried out thus far.

Within the selected streets, the Stock Model reports a **total of 372 properties**.

Streetcheck identifies 1,421 properties in the wider neighbourhoods. Figure 31 below shows the locations of the streets that have been identified as likely candidates for the trial.

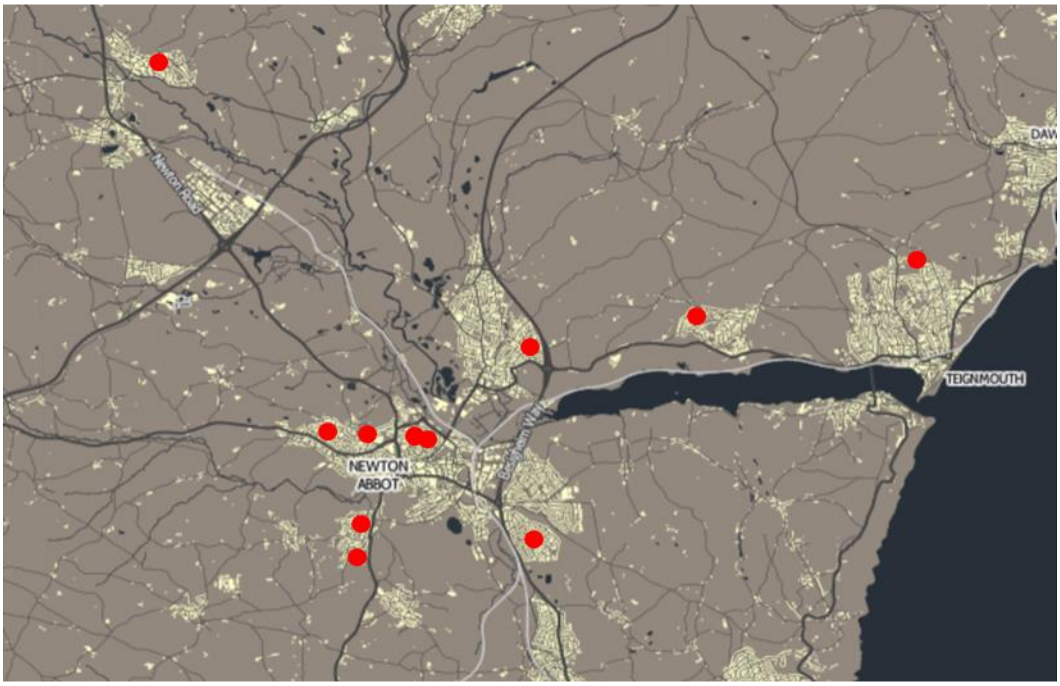


Figure 31: potential shortlist streets locations

Table 6: The 11 streets that could see the largest voluntary uptake in the scheme from local residents

Shortlist of potential streets	**Stock Model property numbers**	**Streetcheck reported neighbourhood size ***	**Majority property types**	**Links**
The Churchills, Newton Abbot	28	131	70% detached	Google maps link
Hamilton Dr, Newton Abbot	41	136	30% detached, 30% semi-detached, 40% terraced	Google maps link
Sandford View, Newton Abbot	48	136	30% detached, 30% semi-detached, 40% terraced	Google maps link
Castlewood Ave, Newton Abbot	28	132	60% detached, 30% semi-detached	Google maps link
Aller Brake Rd, Newton Abbot	41	135	95% detached	Google maps link
Larksmead Way, Ogwell	26	143	70% detached, 30% semi-detached	Google maps link
Buttercombe Cl, Ogwell	20	79	90% detached	Google maps link
Longford Ln, Kingsteignton	56	128	40% detached / semi-detached, 50% terraced, 10% flats	Google maps link
Hazeldown Rd, Teignmouth	26	133	90% detached	Google maps link
Grange Park, Bishopsteignton	26	150	60% detached, 25% semi-detached, 20% terraced	Google maps link
De Tracey Park, Bovey Tracey	32	118	60% detached, 25% semi-detached, 20% terraced	Google maps link
Totals	372	1,421		

* Streetcheck has been used to provide further inspection of neighbourhood size. Note that the Streetcheck figures may include adjacent streets.

6.1.1.2.2 Recommendations

It should be noted that all of the areas evaluated are likely to be suitable for networked heat pumps, demonstrating the likelihood of replicability of this solution across the locality (and indeed the country). After round 3, there were found to be 5,120 properties considered high priority, with the number brought down to the final work package target of 3,200 once the analysis from Urbanomy has been completed. The shortlisted streets (372 properties) are provided as an example only with the added parameter of socio-demographic circumstances.

Although off-gas properties have been excluded in this analysis, they could be considered if they were found to be in close proximity to selected on-gas properties chosen for the heat networks, as they can constitute 15% (e.g., Oil, solid fuel, LPG) of the final selection.

Once the target properties (3,200) have been identified (Specific Areas Analysis Results (WP2.4)), Kensa have been able to establish the heat pumps required for those properties based on the heat demand figures provided in the Stock Model, which in turn will provide the required borehole depths. This again will filter out certain sites as the required space for the boreholes and infrastructure may exceed that available on the streets identified.

6.1.1.3 Network Analysis Results (WP2.2)

Table 7 below summarises the demand headroom at the primary substations in Teignbridge local authority area, as well as the upstream demand headroom available at the bulk supply point (BSP) that feeds the substations. A Red-Amber-Green (RAG) rating has been assigned to each to illustrate the likelihood of reinforcement of the network being required to accommodate a high density of heat pumps being connected in the supply areas of these substations, with red indicating there is a high likelihood and green indicating a low likelihood.

Table 7: Need for reinforcement of the network to accommodate a high-density deployment of heat pumps for each primary substation

Primary Substation	Substation Demand Headroom (MVA)	Upstream Demand Headroom (MVA)	RAG rating
Newton Abbot Main	6.78	17.61	
Dawlish	5.58	17.61	
Teignmouth Gasworks	7.84	17.61	
Bovey Tracy	2.23	17.61	
Higher Woodway	11.16	17.61	
Bradley Lane	2.50	17.61	
Buckfastleigh	7.27	10.92	
Ashburton	3.57	10.92	
Chudleigh Knighton	2.67	17.61	
Exminster	1.56	-	
Mortonhampstead	0	33.93	

Red-Amber-Green (RAG) rating: likelihood of reinforcement of the network being required to accommodate a high density of heat pumps being connected in the supply areas of these substations	low likelihood	
	medium likelihood	
	high likelihood	

6.1.1.4 Data Integration Results (WP2.3)

In this section Urbanomy produced a set of maps compiling the findings of the previous WPs to extract the best fitted areas for deployment.

- Eligibility criteria
    - Network Analysis: Primary Substation Demand Headroom

The map below (Figure 32) summarises the findings of WP2.2 (Network Analysis) on the substations' need for reinforcement. Indeed, the first eligibility criteria to be considered is the primary substation demand headroom. This criterion gives the indication of the headroom available in the various substations in the area of Teignbridge. Only the **substations rated green** have been shortlisted. Those are the area with the highest headroom. The rest of the work will focus on these green areas.

It can be noted that for the same step WP5.2 kept the areas rated green and orange.

After running this criterion, the building count is **64,397**.

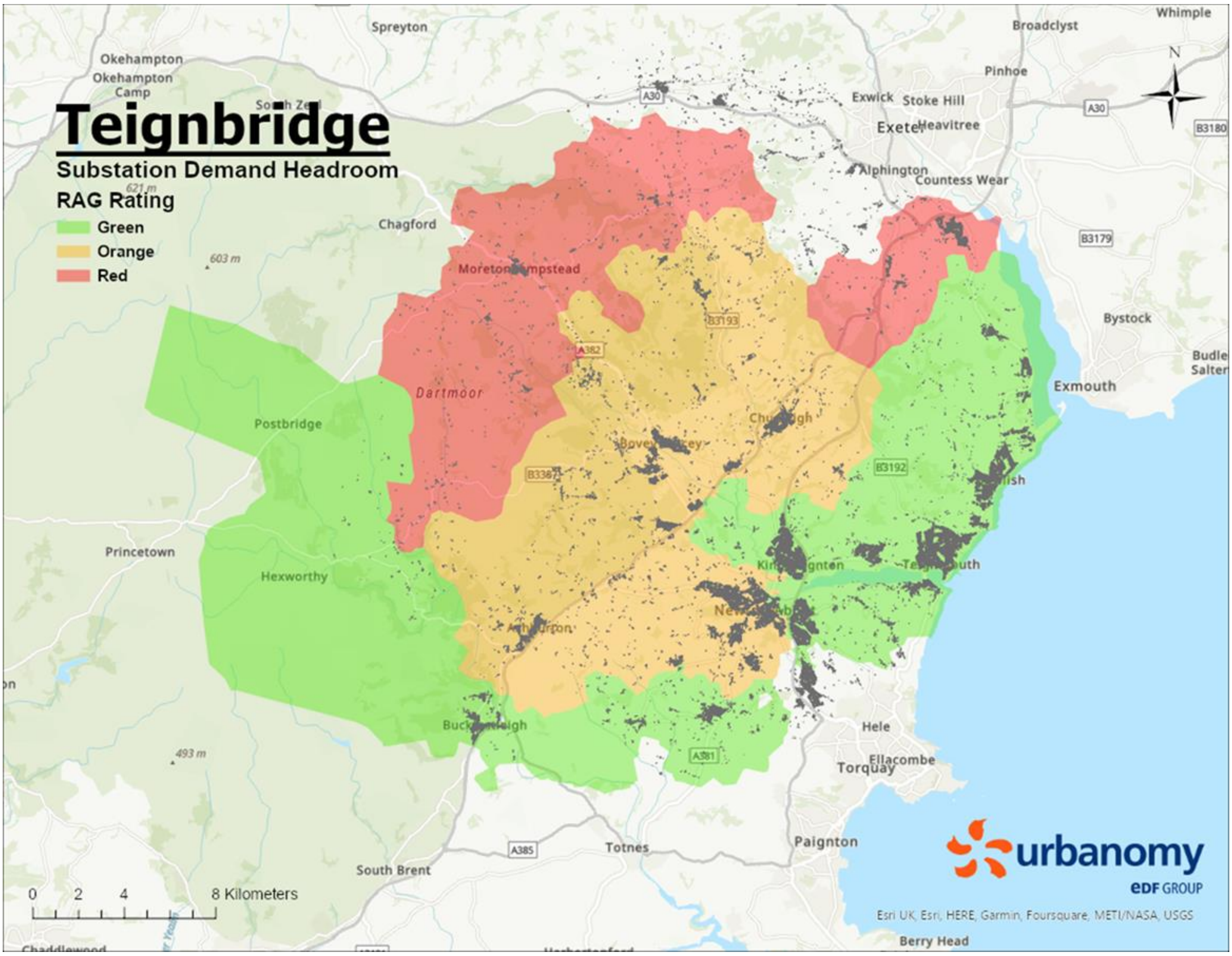


Figure 32: Substation demand headroom in Teignbridge

- Off-Gas Grid Map

As the second eligibility criterion focus on the off-gas grid map, Figure 33 below was produced to assess the amount of off gas properties in Teignbridge. This criterion **filters out the off gas areas** of Teignbridge.

Only the areas where at least two-thirds of the buildings are on gas are kept. Those areas appear as yellow on the map (0-33%). The areas with **less than 33% of off gas properties** have been shortlisted

For the same step WP5.2 considered areas having 60% or higher of gas connected properties.

After running this criterion, the building count is **33,338**.

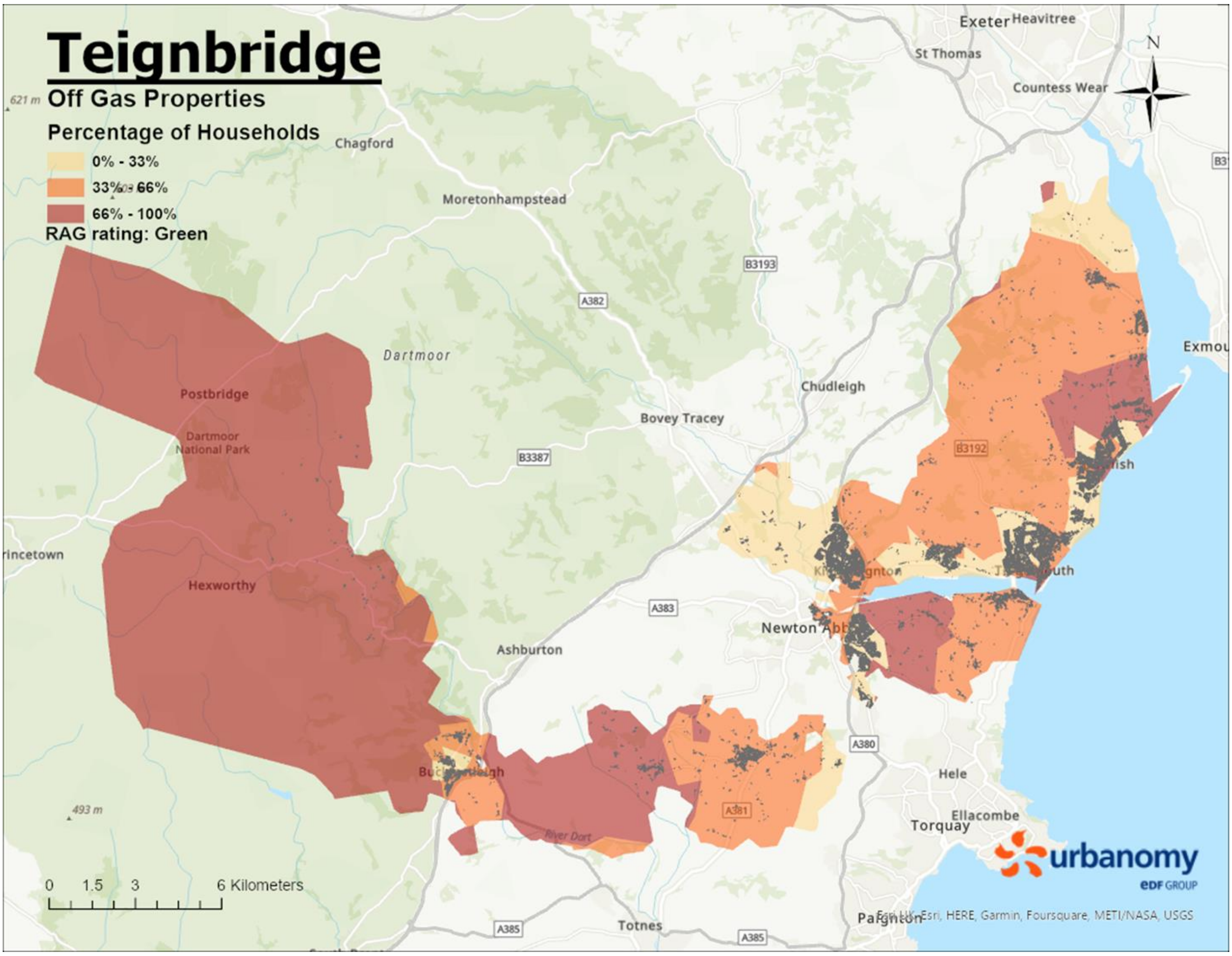


Figure 33: Off gas properties in Teignbridge

- Social Housing

The third eligibility criterion allows to keep only the areas with a low percentage of social housing estates. The areas with less than 15% of social housing properties in the housing stock have been shortlisted. Those areas appear as yellow on the map in Figure 34.

For this step, WP5.2 kept a maximum of 20% of social housing for the trial households.

After running this criterion, the building count is **13,914**.

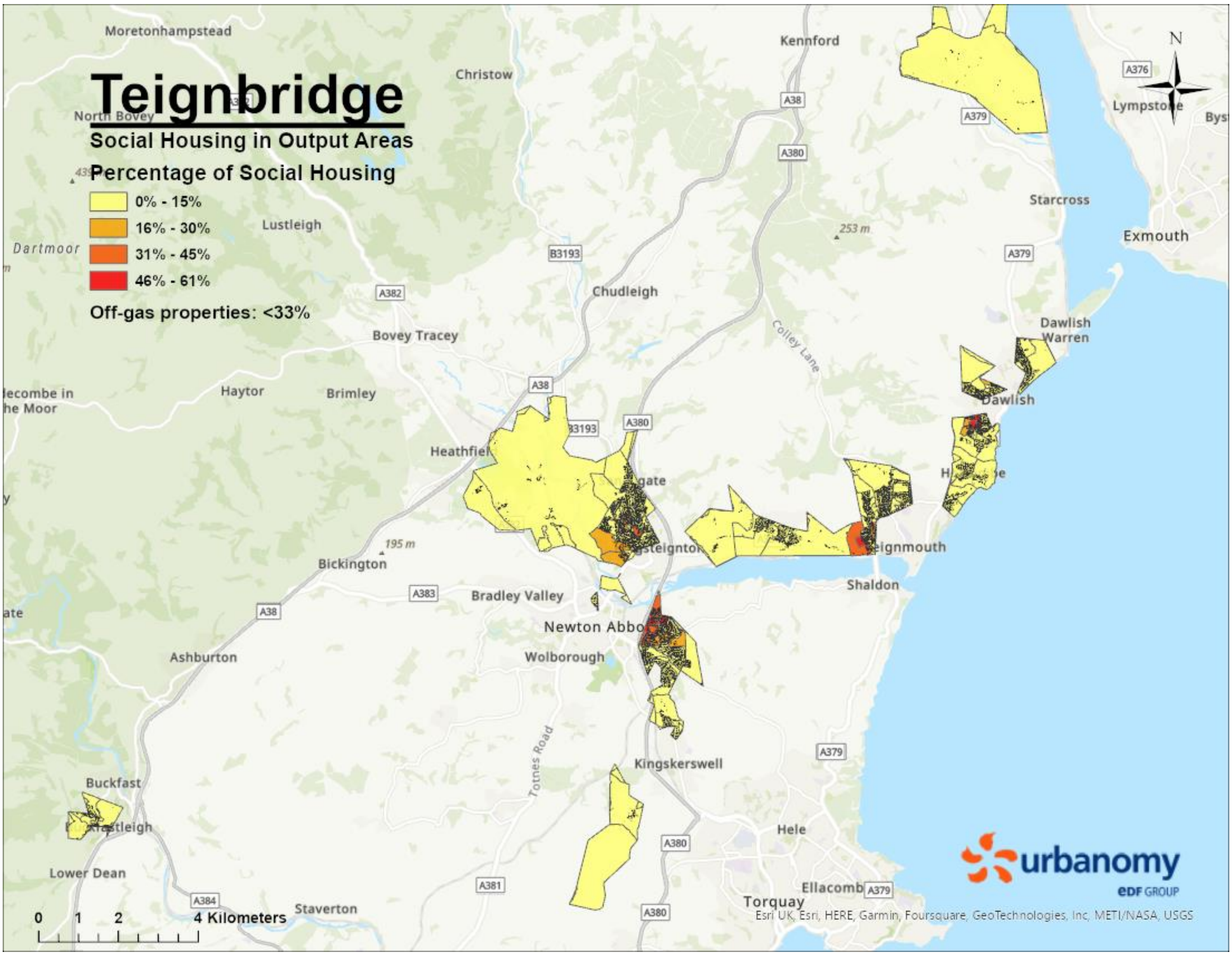


Figure 34: Social housing in output areas

- Additional criteria

After this first round of filtering all the other five criteria listed in Data integration Methodology (WP2.3) were applied (Conservation and Listed Areas, Main Heating System, Hot Water System, Property Type, Fabric Efficiency). As part of the shortlisted areas, a further discussion took place with the consortium and an analysis of socio-economic data have allowed to shortlist 3 areas providing a total of **3133 units**.

The map below (Figure 35) shows the amount of buildings in each area fitting the requirements established in the previously mentioned section. The amount of suitable building in each area varies between 10 and 2750. The best areas to deploy the proposed solution would be the ones with the largest amount of suitable buildings.

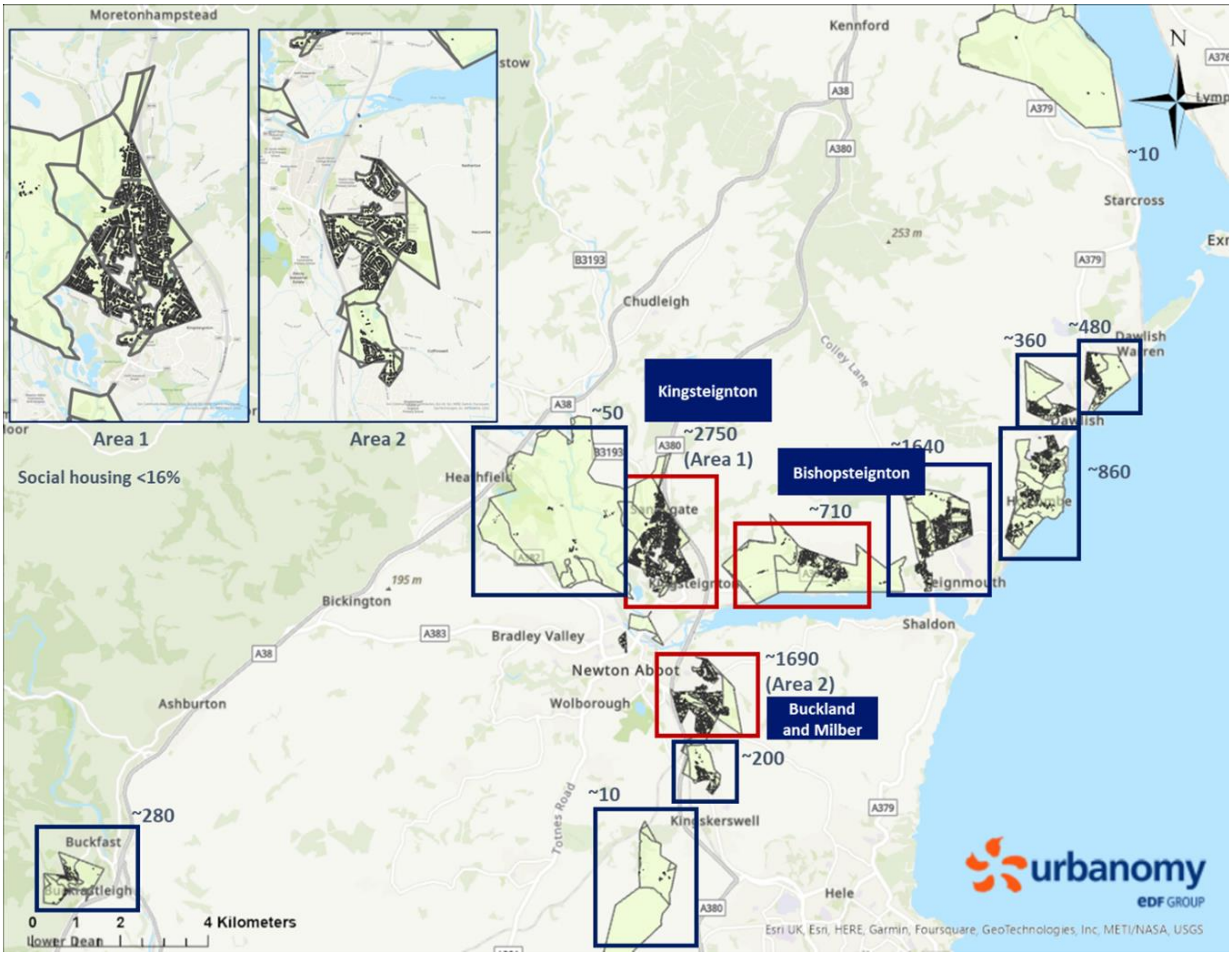


Figure 35: Remaining Areas After Filtering

- Final selection

The three most populated area have each 2750, 1690 and 710 suitable buildings. These three areas are therefore shortlisted as best suited areas to deploy the proposed solution. In the map above (Figure 35), these areas are circle in red.

The 3 shortlisted areas are:

- Kingsteignton
- Bishopsteignton
- Buckland and Milber, Newton Abbot

- Conclusion

The areas shortlisted are those that fall within the primary substation areas with the most adequate demand headroom, whilst also fulfilling the eligibility criteria given in the brief. The areas have also been further specified with the criteria defined by Urbanomy and the WP2 consortium. The next step in the study is to clearly define the streets for the high-density heat pump deployment, in the specific areas' analysis (WP2.4).

As seen in the methodology, section WP5.2 led by Kensa conducted a similar assessment, both area analysis identified equivalent findings. Thanks to this observation the results of this section can be verified, and it is possible to conclude that the target areas have been rightfully selected.

Following this analysis, additional maps were plotted to highlight the specificities of the three chosen areas. These maps represent the below:

- Age of the units
- Main heating system fuel type: biomass, electricity, natural gas, oil, unknown
- Floor area

The figures representing these outputs can be found in the annexe section: Data Integration (WP2.3).

6.1.1.5 Specific Areas Analysis Results (WP2.4)

- Buildings Selection

The maps below (Figure 36, Figure 37,Figure 38) highlight the specific buildings selected by Urbanomy as preferred buildings for the ground source heat pumps deployment. The number of buildings identified is the following:

Table 8: Number of Preferred Buildings

Target Area	Number of Preferred Buildings
Buckland and Milber	1,589
Kingsteignton	1,517
Bishopsteignton	1,517

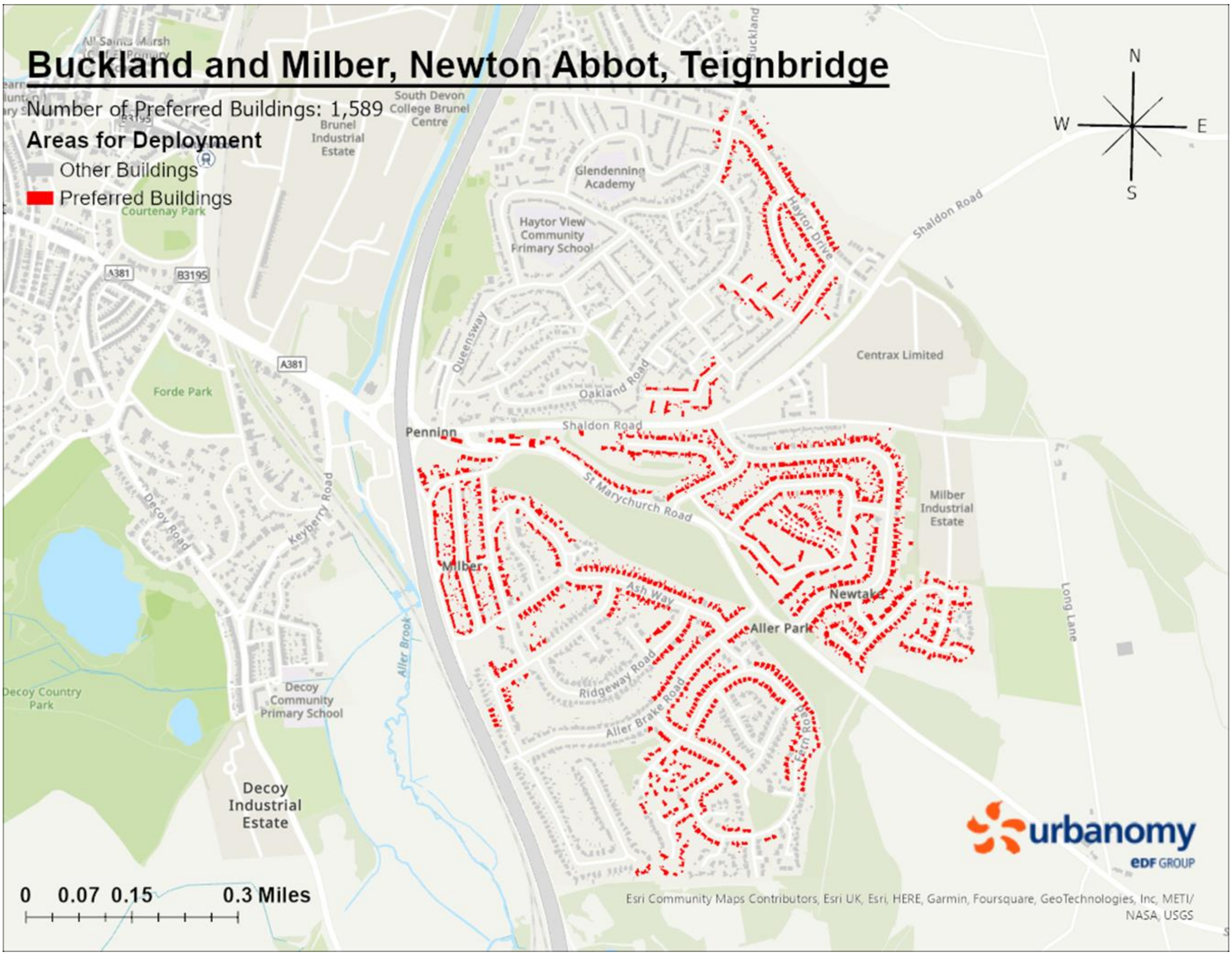


Figure 36: Buckland and Milber Buildings Selection

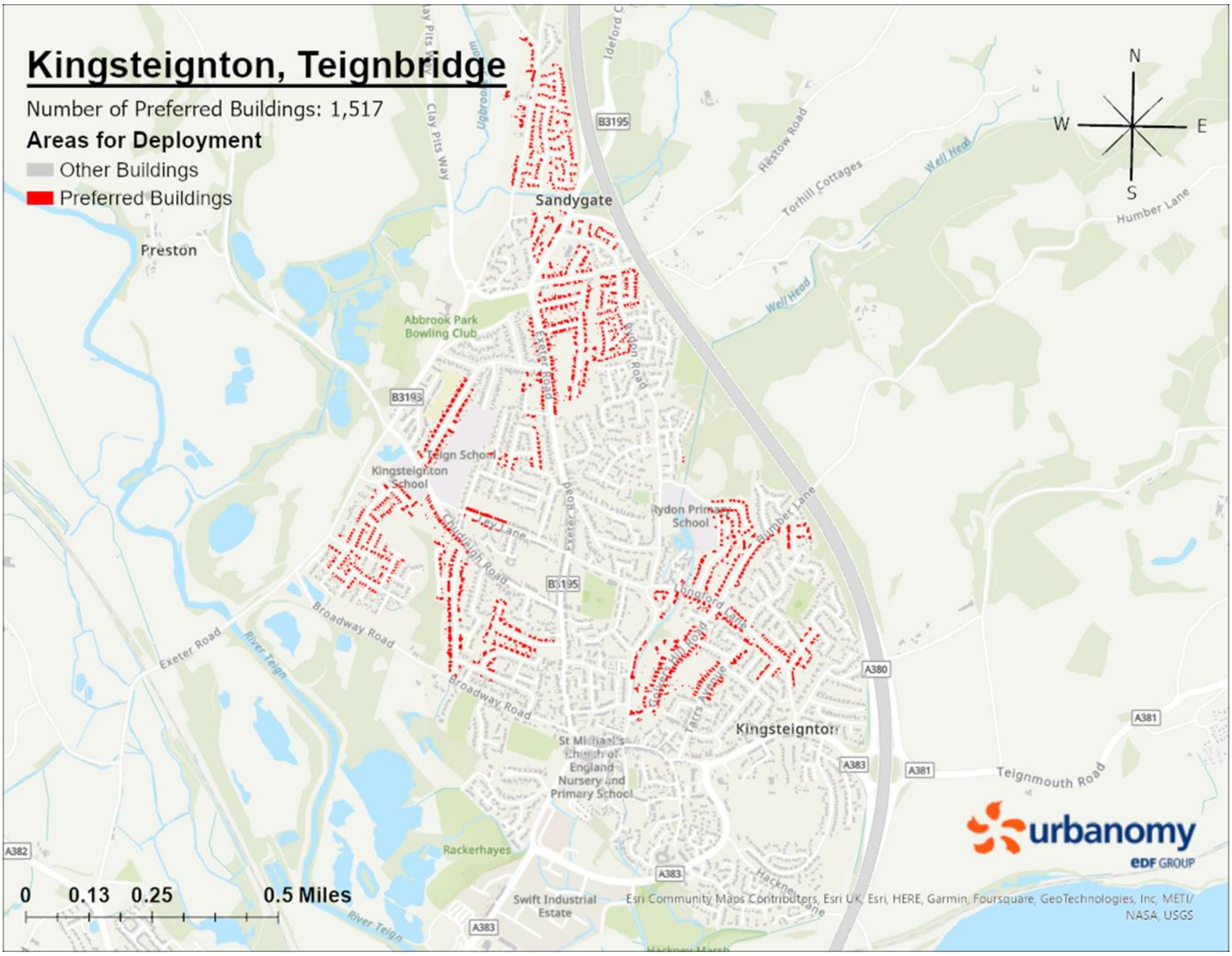


Figure 37: Kingsteignton Buildings Selection

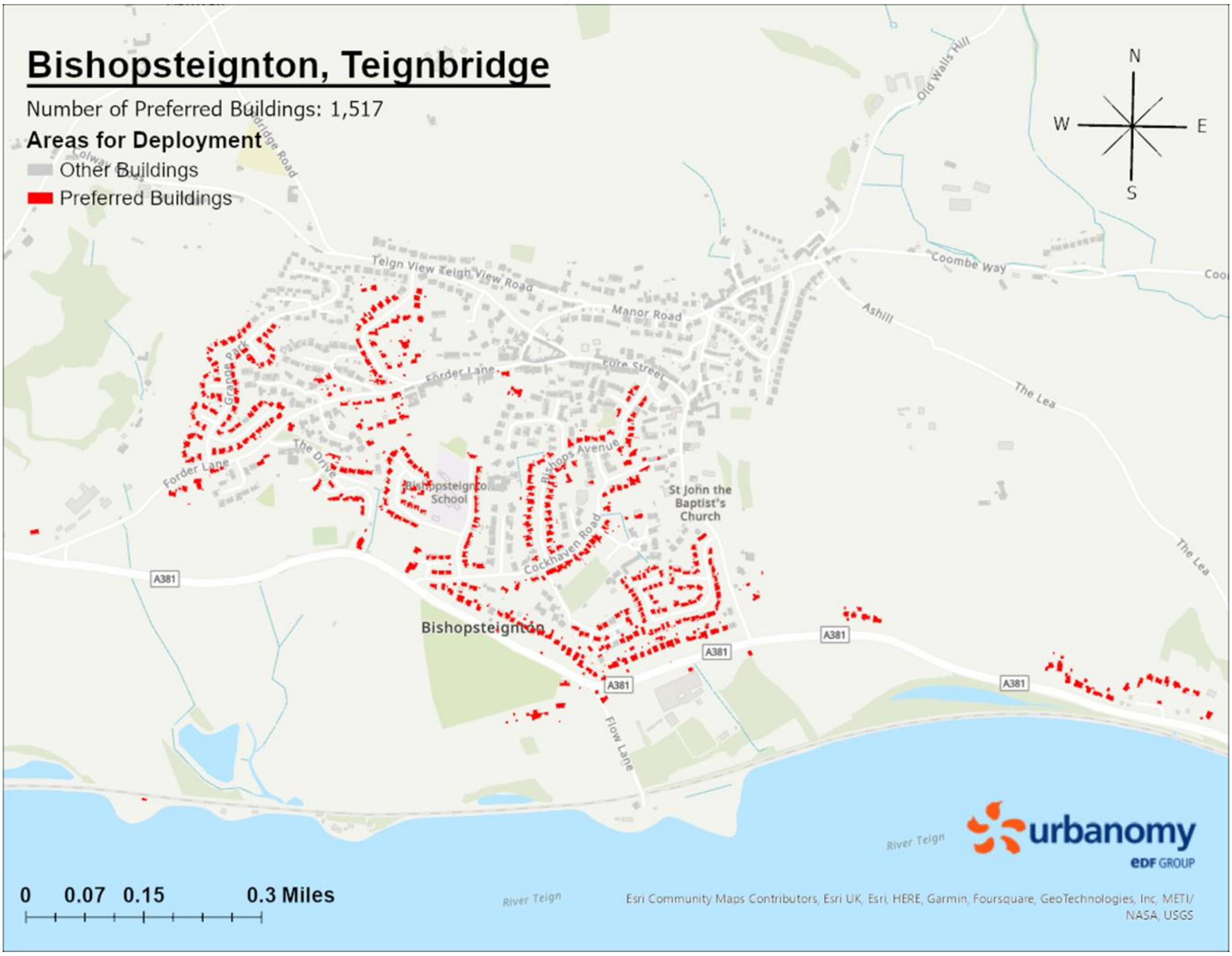


Figure 38: Bishopsteignton Buildings Selection

- Patterns of upwards and downwards flexibility with high volumes of thermal storage

The downwards potential defines the ability to turn off assets (only heat pumps in the scenario case). This means that heat pumps need to be running for a flex potential to exist in downward direction. The remaining energy in the hot water storage determines the energy potential, through the maximum possible shedding time.

- The potential is low during the night: low use of domestic hot water leads to most of the heat pumps not operating
- A clear pattern can be observed for week and weekend days
- Most of the potential is available when the heat pumps are most in use, in the morning, noon and evening
- The potential is larger in winter due to the higher use of heat pumps in this period
- The monthly pattern of the demand inputs can be clearly recognised

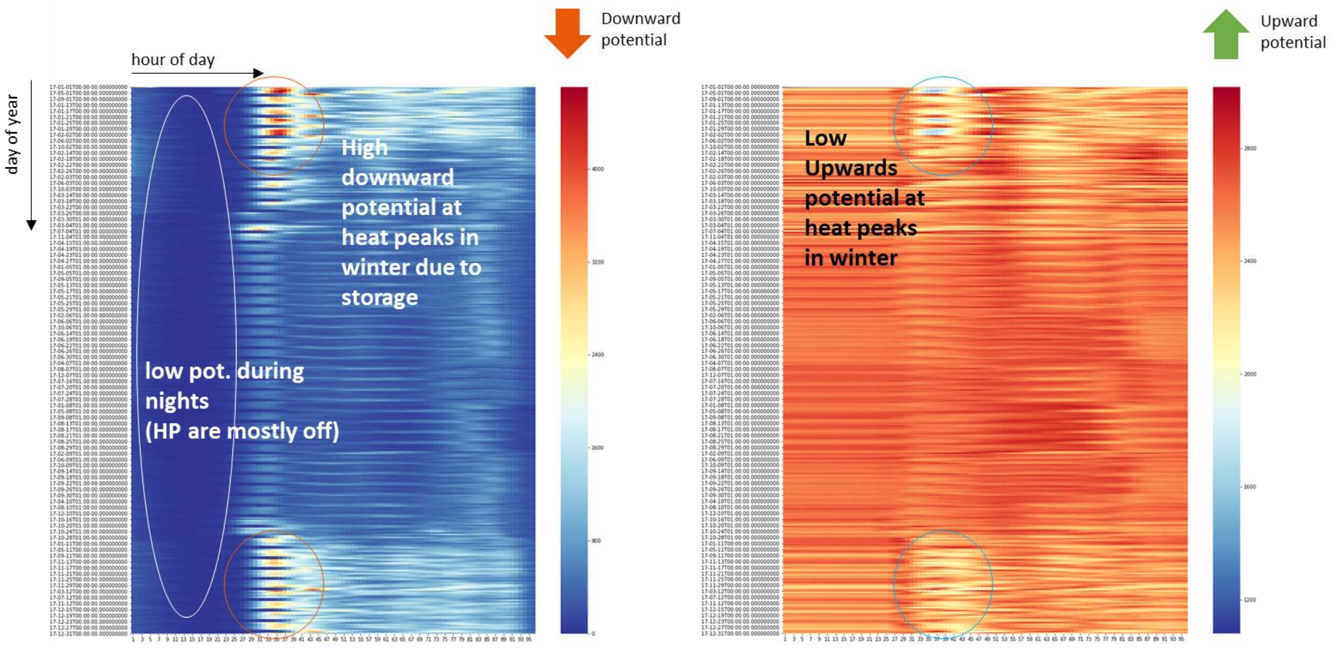


Figure 39: Flexibility mapping of the absolute energy potential

- Flexibility Potential of the Heat Pump Retrofit

Cumulated flexibility available through thermal flexibility in the scenario of a complete retrofit of all heating system with a heat pump in the selected areas (3133 units).

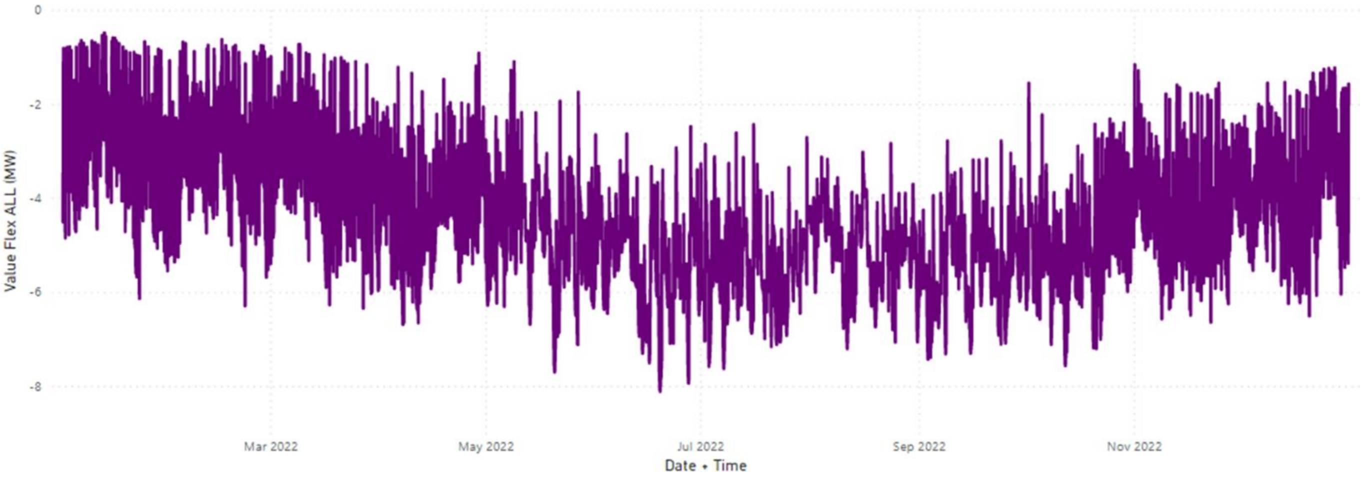


Figure 40: Cumulated flexibility available through thermal flexibility - Scenario Flexibility (with HP scenario)

- Potential of peak reduction with Flexibility

The flexibility through thermal storage coupled with heat pump can provide a significant benefit for the grid infrastructure. In this case, the instant flexibility available during the highest peak can reduce it by 6.3%.

Additional benefit along the year can be provided and depend from the types of constraints on the grid, the potential for grid services provision to the distribution and transport infrastructure.

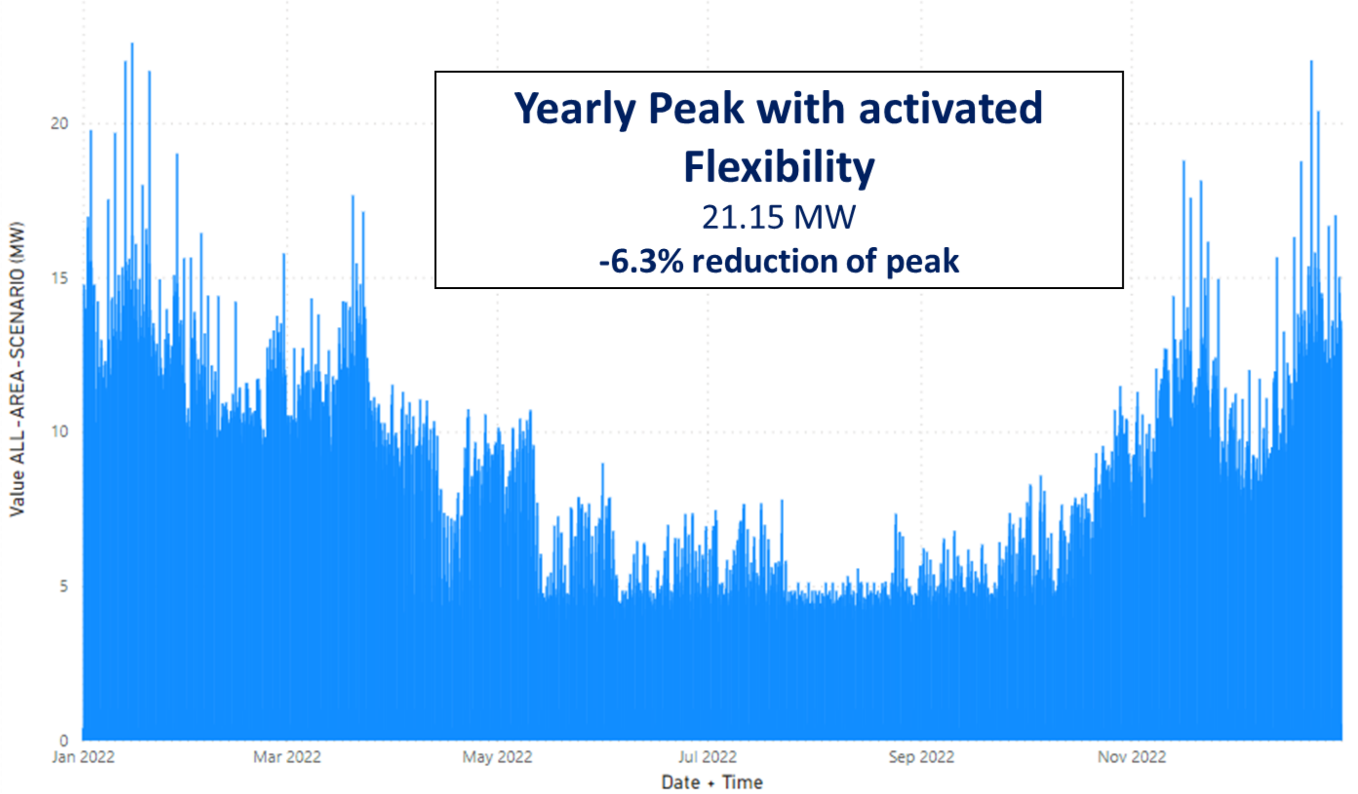


Figure 41: Potential of peak reduction with Flexibility - Scenario Flexibility (with HP scenario)

6.1.2 Deployment Plan Results (WP5)

This section highlights the results of each part of the work aiming to create a large-scale deployment plan for the GSHP solution. The methodology is described in the previous section: Deployment Plan Results (WP5).

6.1.2.1 Infrastructure Design Proposition (WP5.1)

The three studies conducted by Genius Energy Lab allowed Kensa to understand the required properties of the boreholes design in each area. The information given in the studies are for economic purposes only and are not intended for use as final design.

- Geological conditions

Based on the thermal properties, the three geological reports carried out for project Gaia provide estimates on the anticipated ground loop requirements, both on an individual archetype level, and on a selection of 30 properties which was a pro rata of the shortlist archetypes required for each of the three areas. The confidence in the geological assessments is on the whole considered to be high, based on the quantity and quality of borehole records in the vicinity of the areas. These records are available through the British Geological Survey (8). The bedrock and superficial layer formation informs for the technique required e.g. rotary speed, drill bit type, pressure applied. These results can also provide plans for drilling operation and gives the team knowledge of what to expect. Although the drilling rate does not vary greatly, extra over costs such as casings, can be factored into the drilling costs.

- Classifications, permissions, risks

The classification of aquifer designation dataset (9), created by the Environment Agency (EA), Natural Resources Wales (NRW) and the BGS, identifies the different aquifers and when groundwater protection policy in England and Wales come into effect. It is found that the aquifer vulnerability is high in all cases, meaning the likelihood of a pollutant reaching the groundwater through penetration is high and the risk of transmission of pollution to groundwater is high.

Artesian conditions were found to be present on 2 of the 3 sites, with Newton Abbott expected to have a high risk of occurrence. Bishopsteignton is expected to have the lowest risk of the 3 sites. Unexploded Ordnance is found to be moderate in all areas and none of the areas sit within the Coal Authority reporting area.

Artesian conditions referrers to a geological condition where water is confined under pressure below layers of impermeable rock. Drilling in the concerned areas would potentially release the pressurised water.

Bishopsteignton and Kingsteignton require similar number of boreholes and borehole depths as each other, whereas in Buckland Milber, and Newton Abbott the conditions are better and shallower drilling is required. The spacing and size and pressure drop of the U-tube are about the same in the three areas.

Looking at the design requirements averaged across 30 properties, Bishopsteignton and Kingsteignton would need 35 boreholes, while Buckland Milber would only need 30. Kingsteignton has the deepest borehole with 200m, then comes Bishopsteignton with 187m and finally Buckland Milber with 153m.

Given that there are a range of geological conditions for the area, applying an archetype rate only provides a base cost and ideally there would be a mechanism to account for varied ground thermal properties. We can say that the geological conditions in the Teignbridge area are not ideal for drilling on a large scale, however, with the risks identified early, mitigation measures can be factored in for provisional costings and this can also help to build a more accurate programme of works, for example, accounting for possible contingency periods for delays. The initial desktop geological study indicates the potential for artesian conditions. A detailed risk assessment will need to be conducted and factored in for each area. A Thermal Response Test (TRT) would be undertaken on the first completed hole with the test and processing of the results confirmed in approximately 1 week. The bore hole drilling would continue during this time and any impact on drilling depths will be applied to the remaining bore holes due to be drilled after the TRT has been completed.

Table 9: Budgetary Ground Loop Requirement – Per Archetype - Bishopsteignton

Quantity	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Number of Boreholes	1	1	1	1
Depth	116.0 m	134.0 m	105.0 m	137.0 m
Total Borehole Requirement	116.0 m	134.0 m	105.0 m	137.0 m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	40mm Single
U-Tube Pressure Drop	15.6 kPa	21.1 kPa	11.2 kPa	22.7 kPa
	Detached Bungalow - 3 bed	**Semi-detached House - 3 bed**	**Detached House - 3 bed**	**Detached House - 4 bed**
Number of Boreholes	1	1	1	2
Depth	162.0 m	139.0 m	185.0 m	126.0 m
Total Borehole Requirement	162.0 m	139.0 m	185.0 m	252.0m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	45mm Single	40mm Single
U-Tube Pressure Drop	34.5 kPa	23.7 kPa	25.0 kPa	13.0 kPa

Table 10: Budgetary Ground Loop Requirement – Per Archetype - Kingsteignton

Quantity	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Number of Boreholes	1	1	1	1
Depth	115.0 m	133.0 m	104.0 m	136.0 m
Total Borehole Requirement	115.0 m	133.0 m	104.0 m	136.0 m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	40mm Single
U-Tube Pressure Drop	15.5 kPa	20.9 kPa	11.1 kPa	22.5 kPa
	Detached Bungalow - 3 bed	**Semi-detached House - 3 bed**	**Detached House - 3 bed**	**Detached House - 4 bed**
Number of Boreholes	1	1	1	2
Depth	161.0 m	138.0 m	184.0 m	127.0 m
Total Borehole Requirement	161.0 m	138.0 m	184.0 m	254m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	45mm Single	40mm Single
U-Tube Pressure Drop	34.3 kPa	23.5 kPa	24.9 kPa	13.1 kPa

Table 11: Budgetary Ground Loop Requirement – Per Archetype - Buckland Milber

Quantity	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Number of Boreholes	1	1	1	1
Depth	84m	96m	76m	99m
Total Borehole Requirement	84m	96m	76m	99m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	40mm Single
U-Tube Pressure Drop	11.3 kPa	14.8 kPa	8.1 kPa	16.4 kPa
	Detached Bungalow - 3 bed	**Semi-detached House - 3 bed**	**Detached House - 3 bed**	**Detached House - 4 bed**
Number of Boreholes	1	1	1	1
Depth	118m	101m	135m	172m
Total Borehole Requirement	118m	101m	135m	172m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	45mm Single
U-Tube Pressure Drop	25.2 kPa	17.2 kPa	30.3 kPa	33.9 kPa

Table 12: Budgetary Ground Loop Requirement – Averaged across 30 Properties - Bishopsteignton

Quantity	Initial Estimate
Number of Boreholes	35
Depth	187m
Total Borehole Requirement	6,545m
Spacing	12m
U-Tube	40mm Single
U-Tube Pressure Drop	30.3 kPa

Table 13: Budgetary Ground Loop Requirement – Averaged across 30 Properties - Kingsteignton

Quantity	Initial Estimate
Number of Boreholes	35
Depth	200m
Total Borehole Requirement	7,000m
Spacing	12m
U-Tube	40mm Single
U-Tube Pressure Drop	32.4 kPa

Table 14: Budgetary Ground Loop Requirement – Averaged across 30 Properties - Buckland Milber[10]

Quantity	Initial Estimate
Number of Boreholes	30
Depth	153m
Total Borehole Requirement	4,590m
Spacing	12m
U-Tube	40mm Single
U-Tube Pressure Drop	30.0 kPa

The complete studies can be found in the annexe section: Infrastructure Design (WP5.1)

6.1.2.2 Property Archetype Identification and Design Results (WP5.3)

- Property Type Count

The final shortlist from Urbanomy has 3,702 properties. After this first round of selection and the exclusion of flats and maisonettes, a total of **3,461 properties remain**.

The compiled list of built form and dwelling properties is shown in Table 15 below.

[10] This information is for budgetary purposes ONLY and is not intended for used as final design.

Table 15: Property Type Count

Property Type	Count
Detached House	901
Detached Bungalow	773
Semi-Detached House	536
Mid-Terrace House	420
End-Terrace House	316
Semi-Detached Bungalow	306
End-Terrace Bungalow	107
Mid-Terrace Bungalow	102
Total	**3461**

- Number of Habitable Rooms Identification

The total number of **EPCs which provided data on habitable rooms** is 2,489. After the duplicates were removed, this number went down to **1,968.**

Table 16 below shows the number of habitable rooms per household in the selected properties identified in the Table 15.

Table 16: Number of Habitable Rooms Identification

Habitable Rooms	Count
5	594
4	494
3	314
6	299
7	164
8	58
9	27
2	8
10	6
11	2
14	1
12	1

- Archetype selection

The **habitable rooms count total is 1,865** after the exclusion of properties with 0, 1 & 2 or above 7 habitable rooms. The final selection of property archetypes totals is 1,741.

The suitable archetypes to support a fast and simple system pricing for feasibility and delivery for GSHP installation is identified within these totals 924 (highlighted in dark green in Table 17 below).

Table 17: Count Property Type by habitable rooms

Property Type	3	4	5	6	7
Detached House	9	30	74	109	106
Detached Bungalow	93	189	137	67	23
Semi-Detached House	21	61	121	52	25
Mid-Terrace House	45	81	116	28	4
End-Terrace House	24	49	80	16	0
Semi-Detached Bungalow	66	49	44	16	6

- Archetype characteristics

All the previous steps led to conclude on the archetype characteristics represented in the tables below (Table 18, Table 19,Table 20).

Table 18: Average floor area by habitable rooms & property type (m^2)

Property Type	3	4	5	6	7
Detached House	89	89	99	123	146
Detached Bungalow	69	81	92	112	151
Semi-Detached House	64	77	91	108	133
Mid-Terrace House	56	73	85	95	109
End-Terrace House	60	76	85	100	No data
Semi-Detached Bungalow	63	72	84	97	116

Table 19: Average heating load by habitable rooms & property type (kWh)

Property Type	3	4	5	6	7
Detached House	12,229	12,872	12,855	13,979	15,311
Detached Bungalow	10,372	11,706	12,900	14,575	16,277
Semi-Detached House	8,411	9,877	11,445	12,112	13,017
Mid-Terrace House	6,004	8,080	9,899	10,743	9,826
End-Terrace House	7,166	9,400	11,024	11,798	No data
Semi-Detached Bungalow	9,742	10,727	12,198	13,587	15,209

Table 20: No. of bedrooms by property type

Archetypes	**Habitable Rooms**	**Floor area (sqm)**	**Heat demand (kWh)**	**Bedrooms**	**Heat Pump Selection**	**Rated current (max) amps**
Detached House	6	123	13,979	3	9kW EVO	21
Detached House	7	146	15,311	4	9kW EVO	21
Detached Bungalow	4	81	11,706	2	Shoebox6	14
Detached Bungalow	5	92	12,900	3	7kW EVO	19
Semi-Detached House	5	91	9,877	3	Shoebox6	14
Mid-Terrace House	5	85	9,899	3	Shoebox6	14
End-Terrace House	5	85	11,024	3	Shoebox6	14
Semi-Detached Bungalow	3	63	9,742	1	Shoebox6	14

- Final results

The two tables below (Table 21, Table 22) summarise the findings of this section.

Table 21: Count Property Type by Habitable Rooms

Property Type	**3**	**4**	**5**	**6**	**7**
Detached House	9	30	74	109	106
Detached Bungalow	93	189	137	67	23
Semi-Detached House	21	61	121	52	25
Mid-Terrace House	45	81	116	28	4
End-Terrace House	24	49	80	16	0
Semi-Detached Bungalow	66	49	44	16	6

Table 22: Archetypes Properties

Archetypes	**Habitable Rooms**	**Floor area (sqm)**	**Heat demand (kWh)**	**Estimated bedroom count**
Detached House	6	123	13,979	3
Detached House	7	146	15,311	4
Detached Bungalow	4	81	11,706	2
Detached Bungalow	5	92	12,900	3
Semi-Detached House	5	91	9,877	3
Mid-Terrace House	5	85	9,899	3
End-Terrace House	5	85	11,024	3
Semi-Detached Bungalow	3	63	9,742	1

6.1.2.3 Cost Estimate - Development of M&E Scope Results (WP5.4)

- Budget Cost Estimate

Based on providing each dwelling with an individual Kensa GSHP, domestic hot water cylinder and new heating system connected to the SGL network, **the economic investment per household is found to be higher for this scenario, when compared to individual boreholes in the front gardens**. This is due the nature of Teignbridge being a rural area with large property frontages. It is estimated that that with boreholes in the road, the required distance to provide headering from the SGL network, installed in the street, would be approximately 10-14m of trenching to connect to each property.

Although the SGL solution is a highly flexible system, which also provides scalability and replicability, the upfront investment required to transition typical UK streets requires that on a scale which was similar to when the original gas infrastructure that is taken for granted was installed. Residential buildings did not begin to be supplied with gas until the 1840s because the cost of laying pipes to small buildings with low demand proved prohibitive, particularly when there were often many companies in the same area, each with their own pipeline network. The ground source industry finds itself in a similar situation at present. It is anticipated that only a small proportion of the residents of the target streets will be willing to commit to the proposed solution during the Phase 2 trial.

The SGL approach is optimised when designed to accommodate future changes in its configuration, where deployment could be easily replicated in other streets across the UK. The design of the underground structure should allow for expansion as interest amongst households grows, however, this entails higher upfront per property costs.

In Table 23 the economic ground loop requirements for the installation include:

- Core component supply: Heat Pumps, antifreeze, manifolds, expansion vessels
- External contracting services: Boreholes installation, trenching excavation and headering installation
- Internal contracting services: Internal plumbing installation, ground side connections / riser supply & install, Heat Pump Installation
- Other equipment supply: Cylinders, electricity meters, smart controls

The costs do not include[11]:

- Design: Heat Losses, property surveys, Mech Design, Borehole Design
- Mobilisation: site establishment
- Welfare: compound and facilities for onsite staff
- Site surveys and permissions: topography, UXO, Coal authority, highways section 50 licence, etc.

[11] The listed costs were excluded following BEIS guidance on which cost to consumer to consider.

Table 23: Budget Cost Estimate

Type of ground installation	**Archetypes**	**Qty**	**Price per property**	**Total investment**
Individual arrays	Detached House - 3 bed	109	£33,154	£26,980,206
	Detached House - 4 bed	106	£37,270	
	Detached Bungalow - 2 bed	189	£27,203	
	Detached Bungalow - 3 bed	137	£31,310	
	Semi-detached House - 3 bed	121	£28,027	
	Mid-terrace House - 3 bed	116	£25,205	
	End-terrace House - 3 bed	80	£26,399	
	Semi-detached Bungalow - 1 bed	66	£23,606	
Shared-loop arrays	Detached House - 3 bed	109	£38,086	£32,793,153
	Detached House - 4 bed	106	£38,683	
	Detached Bungalow - 2 bed	189	£34,854	
	Detached Bungalow - 3 bed	137	£37,519	
	Semi-detached House - 3 bed	121	£35,548	
	Mid-terrace House - 3 bed	116	£32,884	
	End-terrace House - 3 bed	80	£33,109	
	Semi-detached Bungalow - 1 bed	66	£31,050	

- Commercial Income and Avoided Cost

The comparison between the mandatory yearly check for gas boilers and the absence of such requirement for heat pump allows to estimate a **compliance cost saving**. Over the life of a GSHP, 20 years, this does add up to a considerable saving of £2,400 in real terms. This is a tangible saving that should be considered as part of life cycle cost analysis.

On average Kensa's clients benefit from a 50% saving in annual **maintenance cost** by comparison with gas boiler owners. This will need to be assessed on a project-by-project basis.

- Final estimates

The archetypes have been identified with the quantities shown in Table 24 below.

Table 24: Property Number per Archetypes

Archetypes	Quantity
Detached House - 3 bed	109
Detached House - 4 bed	106
Detached Bungalow - 2 bed	189
Detached Bungalow - 3 bed	137
Semi-detached House - 3 bed	121
Mid-terrace House - 3 bed	116
End-terrace House - 3 bed	80
Semi-detached bungalow - 1 bed	66

Table 25 below shows the final pricing for each dwelling archetype.

Table 25: Archetypes Pricing

Archetypes	**Heat demand (kWh)**	**Heat Pump Selection**	**Price (shared loop)**	**Price (individual boreholes)**
Detached House – 3 bed	13,979	9kW EVO	£38,086	£33,154
Detached House – 4 bed	15,311	9kW EVO	£38,683	£37,270
Detached Bungalow – 2 bed	11,706	Shoebox6	£34,854	£27,203
Detached Bungalow - 3 bed	12,900	7kW EVO	£37,519	£31,310
Semi-Detached House – 3 bed	9,877	Shoebox6	£35,548	£28,027
Mid-Terrace House – 3 bed	9,899	Shoebox6	£32,884	£25,205
End-Terrace House – 3 bed	11,024	Shoebox6	£33,109	£26,399
Semi-Detached Bungalow - 1 bed	9,742	Shoebox6	£31,050	£23,606

6.1.2.4 Cost Estimate - Reinforcement Cost Estimation Results (WP5.5)

- Kingsteignton

Table 26 below sets out the estimated costs for the equipment that may be required to reinforce the primary and secondary substations to accommodate the connection of the heat pumps. Installation costs include transportation cost, the cost of civil works, and erection and commissioning costs associated with the upgrade of a transformer at the primary and secondary substations. These costs may evolve after April 2023 when a greater proportion of reinforcement costs will be socialised due to Ofgem charging reforms.[12]

Table 26: Summary of estimated reinforcement costs at primary and secondary substations that could apply in Kingsteignton.

Reinforcement Work	**Equipment Specification**	**Asset Cost**	**Installation Costs**	**Total Cost**
Reinforcement of transformer at secondary substation	11/0.4kV 2000kVA Transformer, oil filled	£25,000	£7,000	£32,000
Reinforcement of transformer at primary substation	33/11kV 24MVA Transformer	£320,000	£150,000	£470,000

- Bishopsteignton

Table 27 below sets out the estimated costs for the equipment that may be required to reinforce the primary and secondary substations to accommodate the connection of the networked heat pumps in Bishopsteignton. Installation costs include transportation costs, the cost of civil works, and erection and commissioning costs associated with the upgrade of a transformer at the primary and secondary substations.

Table 27: Summary of estimated reinforcement costs at primary and secondary substations that could apply in Bishopsteignton.

Reinforcement Work	**Equipment Specification**	**Asset Cost**	**Installation Costs**	**Total Cost**
Reinforcement of transformer at secondary substation	11/0.4kV 2000kVA Transformer, oil filled	£25,000	£7,000	£32,000
Reinforcement of transformer at primary substation	33/11kV 20MVA Transformer	£285,000	£150,000	£335,000

- Buckland and Milber

Table 28 below sets out the estimated costs for the equipment that may be required to reinforce the primary and secondary substations to accommodate the connection of the heat pumps. Installation costs include

[12] https://www.ofgem.gov.uk/publications/access-and-forward-looking-charges-significant-code-review-decision-and-direction

transportation costs, the cost of civil works, and erection and commissioning costs associated with the upgrade of a transformer at the primary and secondary substations.

Table 28: Summary of estimated reinforcement costs at primary and secondary substations that could apply in Buckland and Milber.

Reinforcement Work	Equipment Specification	Asset Cost	Installation Costs	Total Cost
Reinforcement of transformer at secondary substation	11/0.4kV 2000kVA Transformer, oil filled	£25,000	£7,000	£32,000
Reinforcement of transformer at primary substation	33/11kV 24MVA Transformer	£320,000	£150,000	£470,000

6.1.2.5 Training Module Plan Proposition (WP5.6)

- Training plan

Project Gaia is dependent on high community acceptance and positive feedback from customers throughout the customer journey. This can only be done with the support of skilled and knowledgeable resident liaison officers (RLOs) that can guide customers through the customer journey, explain the complex technology and customer offer to provide a single point of contact throughout the process.

Resident liaison officers will be recruited in the area on a fixed term basis to deliver Project Gaia.

Due to the relatively low public awareness of heat pump technology and the novel customer proposition to be used in Project Gaia, it is not expected that candidates will be recruited with sufficient prior knowledge to deliver positive customer outcomes. Instead, recruiters will seek candidates with relevant interpersonal skills that will be trained by experienced staff in the required, project specific, areas.

- Heat pump technology

Resident liaison officers will require a basic understanding of the technology to be deployed and the installation process so that they can support households through this process, answering technical questions, referring to more knowledgeable staff when appropriate, and explaining the basics of potential counterfactuals.

Material will be adapted from Kensa Heat Pumps and Kensa Contracting's standard Continuing Professional Development (CPD) and installer training programmes.

Resident liaison officers will be taken on site visits to see in-use Kensa heat pumps and discuss the installation experience with existing customers.

Resident liaison officers will be taken to a live site to experience the noise levels associated with drilling, see the internal disruption to a property, and understand the measures employed to minimise risk to vulnerable households and what can be done to lower impact on quality of life during installation (sequencing of works, temporary heaters etc.).

- Customer offer

Resident liaison officers will be taken through the customer offer in depth.

Project staff will justify all costs to consumer including capital spend, finance options, and finance costs.

CPI, RPI, interest rates, payment terms, capital costs and maintenance costs will all be discussed to enable RLOs to answer the majority of questions without delay for the consumer.

- Service agreement

The service agreement is in line with current heat pumps offerings which are typically 6 pages in length. The agreement has a 40 year term and must be passed on to the next resident on the sale of a property.

This document is complex and a potential barrier to some households in acceptance of the scheme. RLOs will learn this document inside out.

Using FAQs from existing projects using the same terms, the trainer will prime RLOs to be able to answer common questions with confidence and less common questions with ease.

- Consumer protection

As the primary point of contact for all households, RLOs are in a position to learn the needs of their customers and provide appropriate support where needed.

RLOs will be trained in GDPR to ensure all personal and sensitive information is handled correctly and in line with the law.

Vulnerable customers will be identified in a sensitive manner in the CRM. Particular care will be taken to enable these customers to have the same opportunities as other project beneficiaries.

- The Heat Trust

The Heat Trust is an independent, non-profit accreditation body setting regulatory standards to be followed by signed up heat network providers. It holds suppliers to account, for the benefit of all stakeholders and specifically customers, to ensure fair treatments and high-quality customer services. Customers can be ensured that the technology chosen will be of high quality and at a fair price.

All Project Gaia installations will be registered with the Heat Trust. RLOs will be trained in the basic principles of this customer protection scheme to provide them with the information required to reassure households and secure sign-up.

The RLO training programme will be a 5 day course delivered at the start of Phase 2a, immediately following recruitment.

This training plan is also available in the annexes section: 15.10 Training Module Plan Development (WP5.6)

6.2 Project Management

- Project administration

The project was managed by EDF R&D UKC to ensure deliverables were completed on time and the project hit the required milestones.

- Project tools

Project Gaia was managed in the Microsoft application, Teamwork. All consortium partners were given access to the full project so they could manage tasks and milestone and track the project progress in real time. The tool has the ability to notify (automatically) any assigned partner when a milestone was due or if any change had been made. When a task is completed or a date changed the inbuilt GANTT chart is automatically regenerated ensuring the most up to date view is communicated. By using Microsoft teamwork the consortium was also able to overcome any security issues which often arise from different company policy's view in regards to filesharing applications. The tool provided the consortium a secure file repository so all evidence could be uploaded allowing it to be reviewed by each partner before it was submitted as evidence.

- Project communication plan

Table 29: Project Communication Plan

Communication	Frequency	Channel	Purpose	Owner	Audience
Kick-Off Meeting	One-time event	Microsoft Teams	Project set up, project plan review, project team introductions	Technical Lead	Project Team
WP Team Meeting	Weekly	Microsoft Teams	Share weekly progress made on sub-WP tasks, share upcoming activity	WP Lead	WP Team members
Work Group Meeting	Fortnightly	Microsoft Teams	Collaboration between WP's, organise tasks, report on progress, share upcoming activity	Technical Lead	WP Leads
Project Board Meeting	Monthly/ Every Two Months	Microsoft Teams	Monitor delivery of the work packages, sharing conclusions and learnings, ensuring there is a balance of collaboration, delivering against the critical path of the plan	Project Sponsor	WP Leads, Technical Lead
Lessons Learnt	One-time event	Microsoft Teams	Document successes and what could have been improved	Technical Lead	Project Team

- Project GANTT

Table 30: Project Gantt

WP ID	Work packages and tasks	Lead Partner & Contributors	Sub - WP Lead
WP1	**Project Management**	EDF Energy R&D	
WP1.1	**Project set up**		EDF R&D
WP1.2	**Project management and communications**		EDF R&D
WP1.3	**Project finance management**		EDF R&D
WP1.4	**Risk management**		EDF R&D
WP1.5	**Phase 2 Application Submission**		EDF R&D
WP1.6	**Net Zero Innovation Portfolio KPI tracking**		EDF R&D
WP2	**Street Suitability Assessment**	UCL	
WP2.1	**Housing Stock Analysis**		UCL
WP2.1.1	*Energy Efficiency Analysis*		UCL
WP2.1.2	*Housing archetype Analysis*		Kensa / UCL
WP2.1.3	*GSHP Suitability*		Kensa
WP2.2	**Network Analysis**		Enzen
WP2.2.1	*LV Network Review*		Enzen
WP2.2.2	*Network Constraints*		Enzen
WP2.2.3	*After diversity heat demand*		Enzen
WP2.3	**Data intergration**		Urbanomy
WP2.4	**Specific areas analysis**		Urbanomy
WP2.4.1	*Simulation of load curves for 2 areas*		Urbanomy
WP2.4.2	*Simulation of Flexibility potential for 2 areas*		Urbanomy /UoS
	MILESTONE: 3200 target homes idenitfied		
WP3	**Customer Proposition**	EDF Customers	
WP3.1	**Business Model Design**		EDF Customers
WP3.2	**Financing Offering**		EDF Customers
WP3.3	**HP Customer Offer**		EDF Customers
WP3.3.1	*HP Tariff*		EDF R&D
WP3.3.2	*Flexibility Value*		EDF R&D
WP3.3.3	*Customer Aftercare and Support*		EDF Customers
WP3.4	**Customer Journey**		EDF Customers
	MILESTONE: Customer journey approved		
WP4	**Customer Engagement Plan**	EDF Customers/ Devon CC	
WP4.1	**Customer Analysis**		Devon CC
WP4.1.1	*Customer Profiles*		EDF Customers
WP4.1.2	*Focus Groups*		Devon CC
WP4.2	**Marketing Plan**		EDF Customers
	MILESTONE: 3 focus group session complete		
WP5	**Deployment Plan**	Kensa	
WP5.1	**Infrastructure Design**		Kensa
WP5.1.1	*Feasibility*		Kensa
WP5.1.2	*Design*		Kensa
WP5.2	**Assessment of property data**		Kensa
WP5.3	**Property archetype identification and design to support fast and simple system pricing for feasibility and delivery**		Kensa
WP5.5	**Reinforcement Cost Estimate**		Enzen
WP5.4	**Local development of M&E scopes and sub-contractor pricing returns**		Kensa
WP5.6	**Training module plan**		Kensa
	MILESTONE: Training modules developed for subcontractors and project staff		
WP6	**Long Term Impact**	Kensa	
WP6.1	**Future proofing of business model**		Kensa
WP6.2	**Impact Assessment**		UoS
	Environmental Analysis		UoS
	Risk/ Benefit Report		UoS
	MILESTONE: Business model review complete		
WP7	**Report**	EDF R&D	
WP7.1	**Phase 2 Delivery Plan**		EDF R&D
WP7.2	**Phase 2 Project Costs Confirmation**		EDF R&D
WP7.3	**Feasibility Report**		EDF R&D
	MILESTONE: Feasibility Report submitted		

7. Recommended Methodology for Coordinating High-Density Heat Pump Deployment

Using the numerous findings brought by this work it is possible to conclude on the feasibility of the proposed solution and to assess whether it is suitable to proceed to the next phase, the trial. The feasibility criteria defined at the beginning (Table 1) of this report can help shedding light on the positive outcomes and barriers met throughout this study.

7.1 Evaluation Against Criteria

Project Gaia Objectives	Feasibility Assessment Criteria	Outcome	Link to the relevant section
WP2.0: Street Suitability Assessment	1. Development of a nationally scalable methodology for shortlisting heat pump eligible stock using stock models driven by existing datasets.	✓ The consortium successfully created a methodology to identify the most suitable areas for the proposed solution deployment.	Identifying Target Areas Methodology (WP2)
	2. Confirmation of the infrastructure benefit of the deployment.	✓ The ground loop array demonstrates efficiencies above single ground source installations.	Specific Areas Analysis Results (WP2.4)
	3. Identification of 2 suitable areas of 3200 homes for trial.	✗ Even though three target areas of 4,623 homes total meeting the required criteria were successfully identified, the stability of the network would not allow a potentially needed extension of the search radius in Phase 2.	Data Integration Results (WP2.3)
WP3.0: Customer Proposition	4. Business model feasibility validated.	✓ A suitable business model was successfully identified.	Business Model Proposition (WP3.1)
	5. Customer offer approved. (includes finance).	✓ A suitable customer offer was successfully identified.	HP Customer Offer Proposition (WP3.3)

	6. Customer journey approved.	✔ A suitable customer journey was successfully identified.	Customer Journey Proposition (WP3.4)
WP4.0: Customer Engagement Plan	7. Customer insight.	✘ Focus groups found that the current energy crises would not allow customers to invest in the technology.	Customer analysis (WP4.1)
	8. Engagement and marketing plan.	✔ A suitable engagement and marketing plan were successfully identified.	Marketing plan proposition (WP4.2)
WP5.0: Deployment Plan	9. Technical feasibility of Teignbridge shown.	✔ No blocking technical barriers were identified for the target areas.	Property archetype identification and design Results (WP5.3)
	10. Creation of a pricing schedule.	✘ Even though the pricing schedule was successfully created, housing density makes it difficult to be cost-effective.	Cost Estimate - Development of M&E Scope Methodology (WP5.4)
	11. Identification of local surveyors and installers.	✔ A training module capable of engaging with local installers has successfully been created.	Training module plan Proposition (WP5.6)
	12. Creation of training modules.		
	13. Creation of a resource plan for deployment.		
WP6.0: Long Term Impact	14. Environment impact assessment and risk/ benefit report deem the project as sustainable.	✔ The life cycle assessment conducted deemed the proposed solution less damaging to the environment that gas boiler business as usual scenario: 47-85.5% less GHG emissions.	Impact Assessment (WP6.2)
	15. Confirmation of methodology replicability.	✔ Even if the proposed offer has not proven to be attractive enough for Teignbridge, it is still replicable and could be more attractive in urban areas, new build developments and social housing retrofit.	Future Proofing of Business Model (WP6.1)

7.2 Achievement Against Project Objectives

7.2.1 Objective 1 - Development of a Nationally Scalable Methodology for Shortlisting Heat Pump Eligible Stock

The consortium created a replicable methodology to identify the most suitable areas for the technology deployment (ground source heat pump with a shared loop array). This methodology uses technical constraints to target areas with the required number of properties.

The target area selection methodology can be described as follows.

- A housing stock model used as a digital twin, was first built to fill missing data and provide detailed information on each individual premises. This tool modelled every domestic premises in Teignbridge and generated 25,000 virtual EPCs to fill the gap made by the missing ones.
- A full network analysis was conducted to identify potential network constraints which would prevent large-scale deployment of heat pumps. The substations providing electricity to Teignbridge were classified according to their available headroom. This section allowed for a greater understanding of the low voltage network landscape and for a discount of areas where the network had no available capacity.
- To select the areas, Urbanomy and Kensa used the criteria given in the Heat Pump Ready Program's brief (the first three criteria below) and built a set of new relevant criteria to identify the best suited areas and then the best suited streets. A selection of 3 target areas were then made using the following criteria.
    - Keep only the substations with the most headroom[13]
    - Keep areas where at least two-thirds of the buildings are on gas
    - Keep areas where less than 16% of the residential properties are social housing (the percentage was chosen by the consortium in order to meet the required number of properties)
    - Keep building if not listed or under conservation
    - Keep building if main heating system is not already a heat pump
    - Keep building if hot water system is not already a heat pump
    - Keep property if not a park home (static home on a holiday park)
    - Keep building if facet is graded above "Poor"
    - The areas are shortlisted by number of buildings remaining to keep the most populated areas.

The amount of suitable buildings for selection would be increased without the consideration of criteria defined by the programme's requirements (on-gas and social housing).

[13] When considering demand headroom, the latter was seen as one element contributing to selection of the target area and not as the prevailing limiting factor. As the area classification came later, the option to increasing headroom with the DNO was not explored in WP2.2.

Table 31: Amount of Buildings Selected for Each Criteria

Criteria	Number of Buildings	Suitability Rate
Teignbridge	64,397	
Keep only the substations with the most headroom	33,338	52%
Keep areas where at least two-thirds of the buildings are on gas	13,914	22%
Keep areas where less than 16% of the residential properties are social housing	11,134	17%
Final 3 areas	3,133	5%

This methodology is replicable to the rest of the UK as the data used is publicly available at a national level. As this study found, suitable houses were found in most areas of Teignbridge and by extension it can be assumed that this methodology would identify suitable properties in the rest of the country. For instance, the UCL housing stock model - used in the first step of the methodology - uses a national dataset, and, while shortlisting the most appropriate areas for deployment, Kensa found a large proportion of Teignbridge areas to be likely to be suitable for networked heat pumps. Moreover, even though Kensa and Urbanomy developed a set of filtering criteria in parallel, the same three areas selected by Urbanomy were also selected by Kensa, and the number of buildings in both selection was significantly close. This gives confidence in the results and in the robustness of the set of criteria.

7.2.2 Objective 2 - Identification of Suitable Areas of 3,200 Homes for Trial

Three target areas of 4,623 homes in total meeting the required criteria were successfully identified using the methodology described in the previous paragraph. However, it would not be possible to extend the search radius outside of the chosen locations due to network capacity.

Enzen found that 5 out of 10 substations have enough capacity for a large-scale deployment of heat pumps. No planned upgrades are due for substations without available headroom. Therefore, all the areas with the highest suitability in terms of network in Teignbridge have been utilised in this section of the work.

Urbanomy analysis identified three suitable areas for deployment: Buckland and Milber, Kingsteignton, Bishopsteignton with 11,134 buildings overall and 3,133 suitable buildings (28% suitability rate) with 4,623 homes overall. The initial requirements of selecting 3,200 homes was therefore successfully completed.

The following maps present in red the selected buildings for technology deployment in the target areas.

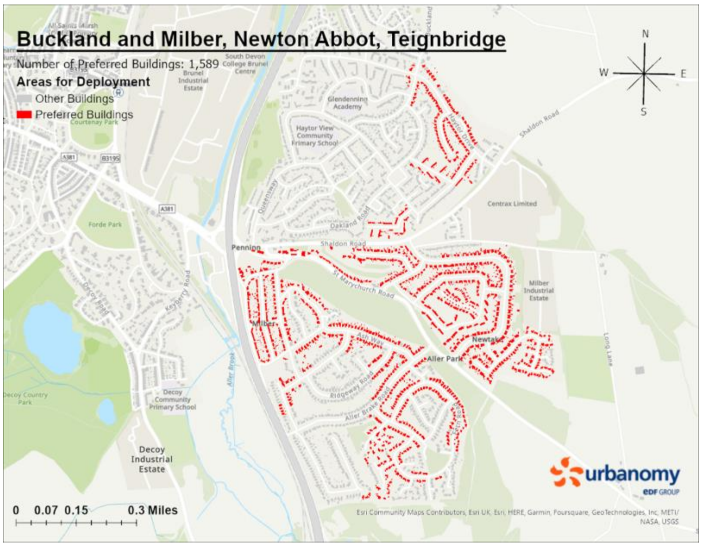


Figure 42: Buckland and Milber Buildings Selection

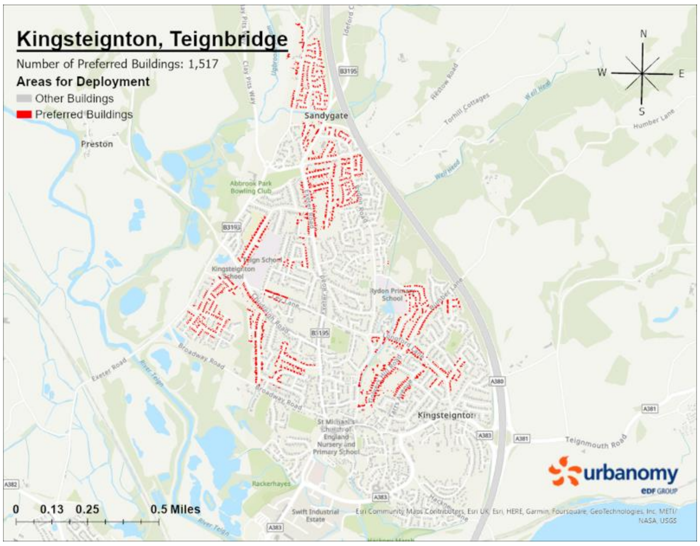


Figure 43: Kingsteignton Buildings Selection

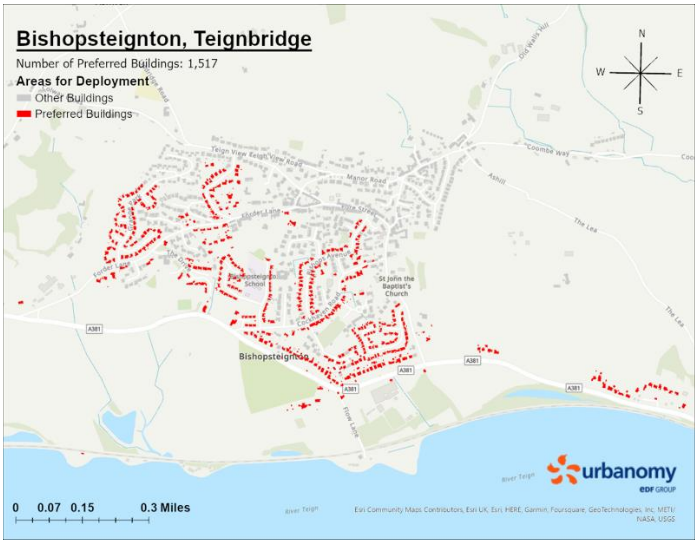


Figure 44: Bishopsteignton Buildings Selection

These figures can also be seen in the section Specific Areas Analysis Results (WP2.4)*".*

7.2.3 Objective 3 - Confirmation of the Infrastructure Benefit of the Deployment

The ground loop array demonstrates efficiencies above single ground source installations and gas boilers.

Even if switching to heat pumps increases the electricity demand and the pressure on the grid, it has very positive outcomes on the energy consumption reduction. This study showed that a business as usual scenario (current situation) yearly peak consumption is of 13.18MW for electricity and 46.42MW for gas for the three target areas. For a full heat pump deployment scenario, the yearly peak is of 22.53MW for electricity. Overall, the consumption falls from 106 GWh per year to 47 GWh per year for the whole area by switching to heat pumps (52% reduction).

Finally, this study concluded that flexibility potential is higher when the heat pumps are the most used, during the morning, at noon and during the evening, as well as in winter. The flexibility associated with heat pumps and thermal storage would benefit the grid as it could represent a reduction of 6.3% of the energy consumption during the highest peak. The yearly peak would go from 22.53MW to 21.5MW with activated flexibility.

Flexibility can ensure stability of the network in the long term, and if heat tariffs were to be put in place, customers could make savings on running cost. As no tariffs are currently offered this study did not evaluate the monetary gain for customers. Moreover, as the observed gains from flexibility are quite moderate (-6.3% reduction of peak demand), further work would be needed to understand the benefits of it against its cost which is mainly driven by the cost of thermal storage.

Table 32: Targets Areas Consumption According to Different Scenarios

	Business as Usual	**Full Heat Pump Deployment**	**Heat Pump and Flexibility**
Yearly peak consumption - electricity	13.18 MW	22.53 MW	21.15 MW
Yearly peak consumption - gas	46.42 MW	-	-
Yearly consumption	106 GWh	47 GWh	-

7.2.4 Objective 4 - Technical Feasibility of Teignbridge Shown

No technical barriers were identified for the target areas. Even if desktop geological investigations found that the drilling conditions in the area were not ideal (aquifer vulnerably high, artesian conditions in 2 out of 3 areas), these risks can be managed on a case by case basis when anticipated. A need to carry out more precise studies during the trial has been expressed, however, these investigations would not affect the drilling schedule.

7.2.5 Objective 5 - Creation of a Pricing Schedule

Even though a pricing schedule was successfully created, the housing insufficient density has proven difficult to make the proposition cost-effective.

In order to generate a pre-survey quote, the 8 most represented archetypes in the target areas have been identified. These 8 archetypes represent 1,865 buildings out of the 3,133 originally identified (60% of the properties are represented by these 8 archetypes). The most represented archetype are detached houses with 6 and 7 habitable rooms and detached bungalows with 4 and 5 habitable rooms. The heat demand of these 8 archetypes varies from 9,742 to 15,311 kWh per property per year.

Shared ground loops are highly flexible, scalable and replicable. They are therefore well equipped to accommodate future changes, but a key barrier to their deployment is their higher upfront cost than most heating solution (boilers, air source heat pumps…). It has been found that the density of the housing has an impact on the cost of the shared ground loop. The cost for an individual array in the selected areas of

Teignbridge is lower than the cost for shared arrays. On average this pricing difference is of 18%. For instance, for a detached house with 3 beds, an individual array would cost £33,154 upfront where a shared loop array would be £38,086.

Indeed, based on these inputs, this study found that the investment for a property installing a Kensa GSHP, radiators, a hot water tank and upgrading circulation pipework, is higher for shared ground loops than for individual ground loops (individual boreholes in the front gardens). Due to the nature of Teignbridge, a rural area with large property front gardens, the distance from the property to the ground loop array would be approximately 10-14m of trenching to connect to each property. The cost of this large trenching distance acts to the disadvantage of the shared ground loop.

7.2.6 Objective 6 - Creation of Training Modules and Deployment Plan

To ensure the right level of community acceptance is achieved, a team of skilled and knowledgeable resident liaison officers will need to be recruited and trained to support the adoption of this ground loop array technology. The following training module capable of engaging with local installers has been developed:

- Resident Liaison Officer:
  - The customers will have a single point of contact in the Resident Liaison Officer. The latter is the key player in this plan and will therefore require proper, well designed training.
  - The recruitment of an Officer will be focussed on finding individuals with relevant interpersonal skills and then providing them with training thanks to experienced staff, rather than finding individual with previous knowledge on technology.
  - The Liaison Officers will be given enough knowledge to answer basic questions and to know who to turn to in order to answer the more complex ones.
- Materials and Training: 5-day training course for all resident liaison officers
  - Officers will be provided with material adapted from Kensa's Continuing Professional Development (CPD) and installer training programs.
  - Officers will visit installation sites.
  - Officers will be taken through the technology proposition in detail. They will know how to justify every cost of the proposal and explain the complex 6-page long service agreement.
  - Officers will undergo full GDPR training, and vulnerable customer care will be ensured thanks to the registration with the Heat Trust and training in the basic principles for the customer protection scheme.

7.2.7 Objective 7 - Business Model Feasibility Validated

A suitable business model was identified where the ground loop array itself would be owned by a third party (either a private company or community lead), and each property connected would pay a connection fee, the agreement length would be 40 years. Heat pump controls and tertiary systems would be paid for by the customer either as an upfront payment or as a referral to one of EDF's finance partners.

7.2.8 Objective 8 - Customer Offer Approved (Includes Finance)

A customer proposition has been identified to suit the technology. The customer would receive:

- A no obligation survey
- Fixed cost, pay monthly towards the shared ground source system with the customer's neighbours
- Smart controls allow the customer to control their home's heating and maximise their savings
- Up to £6,000 discount if the customer signs up their neighbours (Kensa's promotion scheme)

With optional extras

- Zero carbon tariff with EDF
- Future grid balancing services – rewarded for times when the grid needs your energy
- Annual servicing and maintenance of your system
- Financing options to spread the cost

7.2.9 Objective 9 - Customer Journey Approved

The customer journey for this technology has been mapped and optimised, the estimated time to install has been calculated to be around 17 weeks. To help ensure the customer journey is a smooth as possible some key elements have been identified. Advanced work on targeted regions, housing suitability, street selection, local permissions and network connection discovery are all areas which can be pre-worked ahead of time to help the customers throughout the journey.

7.2.10 Objective 10 - Customer Insight

The following key points summarise the EDF/Devon led Focus groups on the take up of this proposition. The outcomes highlighted closely align with independent research conducted on behalf of BEIS by Ipsos, specifically, research into consumer attitudes.

- Awareness of Ground Source Heat Pumps is low and therefore needs a focus on education for consumers to raise knowledge.
- Once informed, the principle of the technology is easy to understand, and an alternative renewable source is welcomed.
- Install process feels complex to customers.
- The biggest barrier is the investment required, particularly in the current economic climate. There is an expectation of a more immediate ROI for upfront payments.

Financing and grants are expected by customers for a proposition like this, but they need to be delivered in a tactical way and work hard to stand out. Financial support is a requirement given the overall costs of the system.

7.2.11 Objective 11 - Engagement and Marketing Plan

The marketing and engagement plans produced as part of this study are reliant on subsidies being available to the end consumer which can be innovatively used to secure clustering of neighbours, like referral schemes.

A traditional print-based marketing method combined with local events, poster awareness and local radio advertising would help drive awareness and word-of-mouth engagement. Use of digital channels would be overlaid through use of targeted email, where customers details are known, and paid social media campaigns aimed at postcode and Facebook group levels would be expected to attract the right customers. But door knocking and face to face interactions will be required to ensure the density is achieved for the project based on information gathered during focus groups.

7.2.12 Objective 12 - Environment Impact Assessment and Risk/ Benefit Report Deem the Project as Sustainable

The life cycle assessment conducted deemed the proposed solution less damaging to the environment than gas boiler 'business as usual' scenario. The explored technology emits between 47% and 85.5% less GHG emissions than gas boiler (see 11.2.2 Results).

The University of Sheffield conducted a life cycle analysis, focusing on greenhouse gas emissions. A scenario implementing the proposed technology was compared with a business-as-usual (BAU) scenario keeping natural gas (NG) boilers as heat sources.

The total embodied emissions for the GSHP system are calculated as 5.3 tCO_2e per dwelling. When the GHG emissions for the 40-year lifetime of the GSHP project are estimated at 30.8 tCO_2e per dwelling. In comparison the lifetime emissions for BAU scenario are 213 tCO_2e. The largest emission sources are the installation of the borehole heat exchanger (42.4%) for the embodied emissions and electricity use (54.8%) for the lifetime emissions.

The highest embodied emissions of GSHP are offset by the saving in operational emissions. After 40 years of use, the GSHP system can save 85.5% of GHG emissions when compared with the natural gas boiler; in absolute terms, the saving is approximately 180 tCO_2e per dwelling.

Finally, taking into account the uncertainties due to the grid carbon intensity, the emissions savings with GSHP are of 47% in the worst-case scenario. The environmental advantages of the technology are very dependent on the evolution of the electrical mix in the UK.

7.2.13 Objective 13 - Confirmation of Methodology Replicability

Even though the offer was not deemed attractive enough for Teignbridge, it is however best suited for urban areas, new build developments and social housing retrofit.

This study has demonstrated its replicability and identified areas of opportunity.

- The development of a nationally scalable methodology for shortlisting heat pump eligible stock using stock models driven by existing datasets and is available for any location within the UK.
- Detailed network analysis has been conducted within the Teignbridge area using agreed methodology which can be applied to any area within the UK.
- A comprehensive detailed demand and flexibility study has been built so it can accept any location for analysis and suitability for the technology.
- Identification of a list of archetypes which represent all suitable housing across the UK for this technology.
- Creation of a training model which is not areas specific and covers all areas of the UK.
- Business model established for technology with finance and ownership leasing not specific to any area.
- Customer journey for technology has been mapped, optimised, and can be applied to any area across the UK.
- Customer focus groups and engagement plan established which can be used to gain greater understanding of the area and refine offering in the above bullets.
- Life cycle analysis framework has been established to better understand the long-term impacts of the technology for a given area.
- A comprehensive programme management methodology has been created for the identification for suitable properties and installation of the ground loop array technology.

Given the current economic situation and the low grant funding available for capital works, it was important that Project Gaia focussed on areas with higher numbers of able-to-pay customers. This had a knock-on effect as it included a high number of larger detached and semi-detached homes which have higher associated running costs. Despite this, during Phase 1 Project Gaia, identified suitable heat pump offers.

The most impactful actions identified to unlock the mass adoption of the technology in Teignbridge are:

- Access to lower cost finance
- Heat zoning (designated area in which heat networks are the lowest cost)
- Reduction in capital costs
- Rebalancing of energy costs (closing of the spark gap)

Finally, it can be noted that the greatest barrier to adoption of heat pumps is the low cost of gas compared to electricity, which is a factor dependent on policies. Adjusting this variable would drive the market growth and reduce reliance on subsidies.

7.3 Stakeholder Management

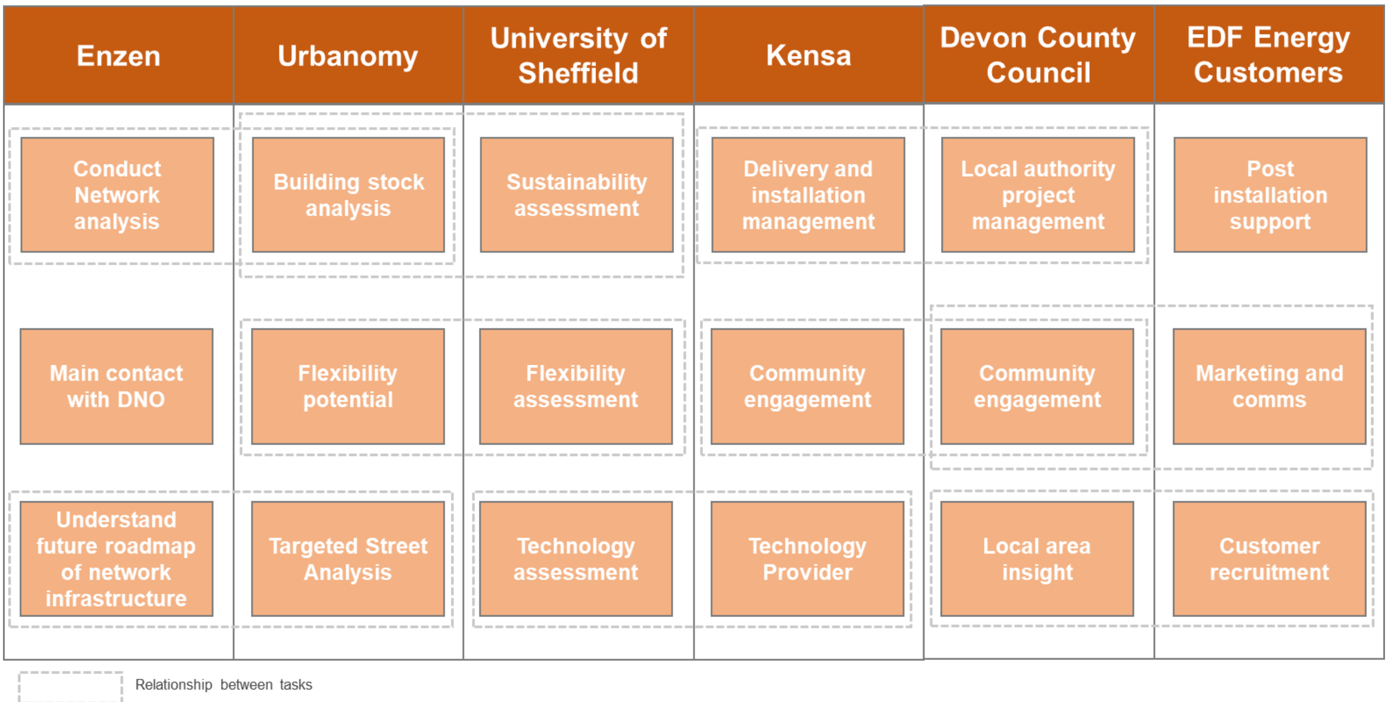


Figure 45: Stakeholder Management

8. Areas for Innovation

The purpose of the Heat Pump Ready Programme is to drive innovation; therefore, Project Gaia tested the feasibility of an innovative solution for a large-sale deployment of ground source heat pumps.

While developing a methodology for customer engagement, this project was innovative in its work in **collaborating with community organisation** and by taking the customers' spirit into account. The customer journey and engagement plan have been built so that it overcomes barriers and fulfils expectation identified in the targeted population. The close interaction between stakeholders in the field and the members of the consortium helped develop a best fitted solution.

The customer engagement goes further than the interaction during the installation phase, keeping them engaged until the end of their heat pump journey can be challenging. Using heat pumps is a good opportunity for **flexibility**. This project innovated by looking at its potential, its gain for the energy systems and the customer, but also the opportunity for customer engagement. Offering flexibility is a way of keeping an interaction with the customer and keeping them engaged throughout the lifetime of the heat pump.

During the construction of the business model, a **collaboration with financiers** took place allowing to try different financing options. Even though this approach can be seen as innovative, there is here place for further investigation. More solutions can still be tested for this deployment model.

The **technology** proposed also had its share of innovation, the concept of using a ground source array is still a niche market that hasn't been widely spread. This study helped identify the factors of failure and success for their large-scale deployment, data which the maturity of the market would not have been able to provide otherwise.

The potential for a future **asset aggregation** has also been explored. A big opportunity for innovation could come from the aggregation of heat pumps for flexibility.

9. Approach for Mobilisation and Deployment following Recommended Methodology

9.1 The Customer Offer, Journey and Engagement Methodology (WP3 and WP4)

9.1.1 Customer Offer Methodology (WP3)

This section details the methodologies followed to obtain the results presented in the Results paragraph.

9.1.1.1 Business Model Design Methodology (WP3.1)

The proposed business model has been created, as described in this section, by looking at the product as the total of three products: the shared ground array, the heat pump unit, and the tertiary system and building fabric.

Even though it was identified that an individual borehole would be more efficient than an SGL due to the large distance between the properties, the business model analysis was conducted in parallel to the previous work package. Therefore, SGL is still explored in this work package.

EDF Customers and the consortium members compared the market for how heat pumps are currently offered both internationally and in the UK. Typically, the quote for a heat pump includes all three components making them seem at face value like a large investment.

By splitting the proposition into 3 components it was possible to explore innovative options for reducing the costs and providing options for financing to reduce the barrier of the total upfront cost.

Consideration to how the proposition could be split in terms of ownership to reduce the upfront cost burden and to overcome identified barriers, with clear key messages led to a 3-component approach.

The system is, therefore, separated in 3 core components each with unique characteristics that lend themselves to separate and distinct ownership models (see Figure 46: Business Model Options above):

- Shared ground array
- Heat pump and controls
- Tertiary system and building fabric

This approach provided an opportunity to **relate the heat pump upgrades to customers** in relatable terms with like for like comparisons. The easiest way to describe the shared **ground loop array** to customers is a comparison with current gas infrastructure where they pay an annual standing charge to receive gas to the home and for ongoing maintenance and replacement costs as part of their gas standing charge. The ground loop array provides the neighbourly group access to residual heat. Each property would have an individual agreement for the duration of their use at the property, and the flexibility for this to transfer to new homeowners was well received. Optimum length of time to allow for sufficient spread of the infrastructure costs was deemed to be **40 years**.

We were able to break down the costs of heat pumps and their component parts to be able to directly compare to that of other heating forms, such as gas boilers and to put this to potential customers in focus groups. Although the initial cost of the heat pump is higher, the attendees at our group understood the energy efficiency benefits and the potential for the relative cost of the heating forms to balance out over the longer term. A customer typically pays £3,000 for a new boiler. Boilers tend to last around 10 years, our focus group participants could see the benefit in paying more for a piece of kit that lasts longer and requires less maintenance. [14]

By splitting the solution into three components allows the possibility of exploring the option of a Heat as a Service, leasing heating equipment to reduce these upfront costs. Participants also felt that there was opportunity to earn back from the kit through smart heat pump tariffs and grid balancing options – they want to feel that they are generating their own heat and have control over how they use it. Together with time of use tariffs there could be opportunity to reduce running costs and to create system flexibility.

The third component was the most innovative in that explaining to customers that the **home upgrades** they require could add value to their properties and improve their running costs for heating, regardless of the installation of a heat pump. This direct comparison of home improvements opens opportunities for homeowners to start to modify and upgrade their properties in advance of a heat pump installation. Although logistically the time constraints of this project do not offer the opportunity to explore this further, the likelihood is that the upgrades would be conducted at the same time as the heat pump installation. As this is the most variable cost of the installation, putting the onus back on the customer helps reduce the barrier of cost shock if they can source their own plumbing and installers to modify radiators, water cylinders, insulation, and pipework.

Two business model options were considered to best fit the split ownership approach and offered opportunities to further explore finance options for each component. The difference between the two business models resides in the management of the component “Heat pump and Controls.” The first relies on a Heat pump tariff and the second on the principle of Heat as a Service:

- Shared ground array: Business model 1&2

In both business models the shared ground array is **owned by a third party**. An entity, such as a large investment company, pension provider, local energy group or even local council, could benefit by investing in the infrastructure and receiving an ongoing income to recoup the investment cost. Once the investment partner was identified they would invest in the ground works provided and supplied by Kensa, and then could either have a contractual agreement with Kensa or even directly with each property. The schemes already developed and used by Kensa, *Heat the streets* and other projects can be taken as an example. The agreement length that does not overly burden the customer with the annual connection charge could be 20 – 100 years. It was felt that 40 years would provide the optimum duration to recoup investment by

[14] The commercial comparison between different heating technologies can be found in the annexes section: 15.4 Business Model Design (WP3.1).

investor and provide enough time to spread the cost to the customer. The initial investment is paid back by the user to the investing entity through a yearly fee. This is consistent across both models.

- Tertiary systems & building fabric: Business model 1&2

Two possibilities exist to finance this component, and both are offered in both business models. If the **customer can or would prefer to pay in full** for the house updates, then no finance scheme is needed. If not, then **personal loan arrangement through customer point of sale finance** can help spread the costs. Options were explored with BNP Paribas, a community lending scheme and large investment firms who could also potentially provide personal finance. The options to plug-and-play providers keeps this flexible during the current climate of rising interest rates. The consortium would contract with the provider who could offer the customer the best rates.

- Heat Pump and Controls
    - Business model 1

If the customer can pay for this component, then they will fully finance it. Otherwise like above, a finance option to spread the costs would be made available to the customer through a finance partner.

The appeal of this offer for the customer resides in the possibility to have access to heat pump tariffs. They can realise cost savings thanks to **multi-rate or time of use (TOU) tariff**. Operating their system during cheaper period will allow them to make savings.

It is also possible to have a separate agreement with customers for **flexibility control** (DSR – demand side response), where the supplier can enrol the customer into flexibility programmes, retain control over the heat pump and control the amount of energy the equipment is using. They could be compensated either through ad hoc payments or as part of a flexible tariff. There could be an option to have a separate maintenance agreement, or the customer can source this themselves.

    - Business model 2

The customer receives this component through an **asset lease agreement**. Heat becomes a service that the operator provides to the consumer. The customer does not own the heat pump and controls but pays an annual subscription fee to the leasing company for the use of the equipment or for an agreed level of annual heat provision for a fixed fee.

The revenue generated through DSR will go to the operator and shared with the customer.

Bundled Monthly Direct Debit (MDD) provides certainty to the customer for a fixed monthly value, incorporating the flexibility, removing complexity of rebates or adjustments and has less financial risk while still sharing in the benefit from flexibility.

System Component	Life Span	Approximate Cost per Household	Business Model 1	Business Model 2
Shared Ground Array	100 years	£6,000-£10,000	**Split Ownership Model – Owned by third party** **Ownership model – private entity or community owned asset** Review of finance providers who would want to invest in this size of asset Connection agreement with each property Agreement Length: c40 years (ref Kensa schemes) Cost per year subject to cost of finance and ground array cost	**Split Ownership Model – Owned by third party** **Ownership model – private entity or community owned asset** Review of finance providers who would want to invest in this size of asset Connection agreement with each property Agreement Length: c40 years (ref Kensa schemes) Cost per year subject to cost of finance and ground array cost
Heat Pump and Controls	20 years	£6,000-£8,000 Funded/Part funded by BEIS funding	**Customer Able to Pay** OR **Customer Finance (Own Asset)** **Heat Pump Tariff** Opportunity for customer to realise cost savings v standard flat rate tariff via a multi-rate / TOU tariff, operating during cheaper periods Separate agreement with customer for flexibility control (DSR) worth £88 p.a. with option for maintenance agreement	**Asset lease arrangement** **Heat as a service – Outcome based – Provide a warm environment** Flexibility revenue (DSR) realised by asset operator, shared with customer Bundled MDD – customer has less risks and shared benefit from flexibility
Tertiary System & Building Fabric HW Cylinder, Radiators, Pipework, Insulation, Home Survey (potential abortive cost)		£1,000-£7,000 *Property Specific	**Customer Able to Pay** OR **Customer point of sale finance option**	**Customer Able to Pay** OR **Customer point of sale finance option**

Removal of Gas connection

Figure 46: Business Model Options

9.1.1.2 Financing Offering Methodology (WP3.2)

System Component	Life Span	Approximate Cost per Household	Business Model 1	Business Model 2
Shared Ground Array	100 years	£6,000-£10,000	Propose financing (either via Kensa or direct with customer)	Similar approach to Smart Meter Asset Provision Long term investment with little risk and servicing in the ground loop array
Heat Pump and Controls	20 years	£6,000-£8,000 Funded/Part funded by BEIS funding	Propose financing	Customer appetite to own the heat pump component will be tested
Tertiary System & Building Fabric HW Cylinder, Radiators, Pipework, Insulation, Home Survey (potential abortive cost)		£1,000-£7,000 *Property Specific	Propose financing by BNP Paribas or other provider	Classic hire purchase or 0% financing

Removal of Gas connection

Figure 47: Financing options for the two proposed business models

EDF is exploring current relationships with large investment companies, like smart meter asset providers around the opportunity to expand their relationship into renewable heat solutions.

This project aligns closely to the asset providers business models as there is a long-term investment with insignificant risk and servicing in the ground loop array. 100-year lifespan with no moving parts that is recoverable through an annual connection fee for the customer. These energy aware investors share similar values, already have a history of working together with suppliers and could be mutually beneficial to become consortium partners for this project.

Different options are available to include Investment Partner (IP) in the project:

- **Option 1:** IP provide the financing arrangement directly to Kensa **only** for the ground loop array – customer retains their contractual relationship with Kensa.
- **Option 2:** IP own and maintain the ground loop array and have the contractual relationship with the customer – this could also be a local community group.
- **Option 3:** IP are also registered to provide consumer hire arrangements for the heat pumps to customers.
  At this point, the customer appetite to not own their heat pump is not known - however they would also not be responsible for service and maintaining the system – this will be tested in later work, during the customer focus groups.

- **Option 4**: Customer has a traditional consumer credit arrangement with BNP Paribas and retains ownership of the heat pump – they remain responsible for service and maintenance of the system.

Customer may also be able to add **home upgrades** to their consumer credit agreement to help spread the costs. Investment partner may not be registered to provide consumer credit facility currently and this moves away from their business models. There could be multiple solutions available to the customer made through existing relationships.

9.1.1.3 HP Customer Offer Methodology (WP3.3)

- **Development of the value proposition**

In determining the value proposition for the customer, **key barriers to heat pump uptake** were identified through the analysis and write up of the focus group outcomes. The focus group organisers talked through the different components of the proposition and asked open questions to participants on their thoughts and feelings around the different attributes. These key barriers can be summarized as:

- The upfront costs of equipment.
- Reluctance to transition to modern technology. This point was an unknown before the focus groups.
- The running costs of gas compared to electricity. Indeed, gas is currently cheaper per kWh than electricity, although it is worth noting that the gap is reducing as gas prices are rising.
- The impact of upgrading the home and the associated costs.

In addition to the above, and aiming to achieve density heat pump take up the following element were also identified:

- Timeline for gas replacements do not align by street.
- Consensus amongst neighbours is not uniform.
- Attitudes to need to upgrade is not consistent.
- Price is still king over environmental benefits.
- Reluctance to be early adopter.
- Subsidies for early adoption not significant enough.

To overcome these barriers, the proposition was developed to be **easy to understand**, **attractive to a range of customers** within the target areas, **affordable** and aims to help customers understand and compare their heating in terms of maintenance and running costs rather than just the upfront investment costs. Targeting customers to upgrade to a renewable heating source for environmental reasons rather than just replacing a boiler is essential, but value needs to be easy to identify.

To be attractive to largest reach of customers, there is a **plug-and-play concept** on the finance partners, so that customers who can afford and choose to, can fully fund themselves, whilst those who are unable to have the option to spread the costs. The additional extras allow for **flexibility and choice** without locking the customer into a single supplier.

Incentives that encourage the consumer to engage with their neighbours were also explored and well received and helped drive the intention of large-scale upgrades by street.

- **Quantification of the value of asset flexibility and of the revenue opportunities**

EDF R&D evaluated the potential of heat tariffs for this proposition. As there are no heat tariffs currently in place in the UK, the following previous tariffs have been investigated.

Table 33: Tariffs Considered in the Flexibility Analysis

Tariff Name	Description	Import price (£/MWh)	Export Price (£/MWh)
Flat	Typical flat tariff from 2022	0.24	0
E7	A typical Economy-7 tariff from 2020. E7 is a ToU tariff which encourages night-time consumption.	0.08 (off-peak 23:30-06:30) 0.121 (peak 06:30-23:30)	0
Agile	Octopus Agile dynamic ToU[15] tariff. This tariff exposes customers to wholesale market fluctuations.	Variable on half-hourly basis, capped at 0.78, typically 0.12 at night and 0.78 at evening peak	0
E10	A similar tariff to E7, but with 3 additional hours of off-peak during the day.	As an example: 0.1 (00:00-05:00) 0.2 (13:00-16:00 & 20:00-22:00)	0

These four steps can be used to calculate the cost of the heat generated with a heat pump:

- Considering electricity price. Electricity price = 0.13£/kWh_{el}
- Hypothesis on the efficiency. Here the COP of heat pump is assumed to be 3.
- Conclusion on the price of generated heat. Here the price of the electricity used to generate 1kWh of heat is 0.13÷3 = 0.043£.
- The final cost is therefore, (0.043£+Tariffs) £/kWh_{heat}

EDF R&D also investigated the possibility of heat as a service as it is a service that is expected to be developed in the near future and as it was one of the options explored in the construction of the business model in WP3.1. A deck of slides presenting what heat as a service is and different business model backing this type of offer can be found in the annexe section: 15.5 HP Customer Offer (WP3.3).

[15] ToU: Time of use tariff

9.1.1.4 Customer Journey Methodology (WP3.4)

EDF in conjunction with DCC and Kensa intend to deliver a **superior customer experience** throughout the project delivery. This requires enough engagement to educate customers but not harass them. The following elements are needed:

- Sufficient time to contemplate, educate and embrace the new technology, without committing before ready.
- Consideration for withdrawal from project if funding not secured or not enough homeowners to proceed with project.
- Re-engagement and signatures of contracts with access to experts and local liaison officers.
- Hassle free and co-ordinated installation and commissioning.
- Best in class after care and support services with flexibility for customers to decide on their own supplier and servicing partners.
- Opportunity to gather feedback and learnings for continuous improvement.

The customer journey was reviewed and constructed to allow an element of flexibility in customer choice for options to pay upfront or to allow for financing to be made available to help **overcome affordability**, and to allow customer choice in terms of tariff provider and ongoing maintenance providers.

From research conducted heat pump **awareness** is low, but ground source and shared loop arrays is even lower. The customer journey needs to allow for a period to raise awareness with soft launch and non-targeted messaging before targeted marketing to gain commitment from customers.

When designing the optimum customer journey, each of the key touchpoints with customers were considered, as well as the length of time between interactions and the key channel used to communicate with the customer.

The intended goal was for the most time efficiency within the project timescales and volumes required to meet the objectives of the project for high density uptake. The additional constraints of cluster requirements by neighbours for this proposition, contribute to the additional need for face-to-face engagement and re-engagement. The period between project gates and milestone decisions for funding have also been factored into the customer journey and duration.

9.1.2 Customer Analysis Methodology (WP4.1)

Devon county council provided some statistical information about their residents to help form the selection criteria of the focus group recruitment. This aligned closely with what EDF and Kensa know about their existing heat pump customers.

The focus group audience was selected from Teignmouth and surrounds as far as Exeter to be representative of the Teignmouth residents and to meet the feasibility timescales.

The **selection criteria** were the following.

For the different groups:

- Group 1 – Retired & Older Families
- Group 2 – Pre & Younger Family

For both groups:

- Live in semi-detached, detached, or terraced housing, with at least 2 bedrooms
- X3-4 males & X3-4 females per group
- ABC1C2 (spread)
- £35k+ annual income
- Open to idea of having a heat pump, do not currently have one; able to afford a heat pump
- Environmentally engaged
- Mix of energy providers, all to be energy bill payers

Participants were pre-tasked to begin initial reading into GSHPs and start forming an opinion based on this research.

The topic guidance used for the focus groups can be found in the annexes (15.7.1 Focus Groups Topic Guidance).

9.1.1 Marketing Plan Proposition Methodology (WP4.2)

The **initial assumption** taken is that the consortium would be required to recruit around 4000 interested parties in a 6-month timeframe, to ultimate secure 300 successful installations.

A 6-month recruitment window was chosen to give time for the other stages of the recruitment phase. Sufficient time needs to be reserved to educate the neighbourhood and for Questions & Answers sessions to reassure customers entering into this innovative technology.

Focus group studies were undertaken to gauge the current awareness levels of consumers around heat pumps and share ground loop array systems. The appetite for consumers to lead community engagement programmes where they educated and enrolled their neighbours into the project and as a result received subsidies towards the cost of their heat pump or home upgrades was tested.

Using EDF's knowledge on the importance of local community engagement and the reliance on word-of-mouth success to create awareness and engagement, the consortium was able to **identify which channels of engagement and marketing** would be most successful. Previous experience in engaging communities around the acceptance of nuclear projects and Net Zero Leiston, Eco projects and innovative school programmes helped identify the most effective campaign structures.

Kensa also already had experience and success in embarking on community engagement strategies at local root level with the use of community liaison officers, to firstly engage with community, but also to help co-ordinate street level installation and local education events.

A **traditional print-based marketing** method combined with **local events, poster awareness and local radio advertising** would help drive awareness and word-of-mouth engagement. Use of **digital channels** would be overlaid through use of targeted email, where customers details are known and paid social media campaigns aimed at postcode and Facebook group levels to attract the right customers. But **door knocking and face to face interactions** will be required to ensure the density is achieved for the project.

The consortium also aims to provide sufficient **training and materials** to engaged parties to help recruit their neighbours. This involves significant access to online and paper-based materials for the resident liaison officer and for community groups to help promote the project.

9.2 The Customer Offer, Journey and Engagement Results (WP3 and WP4)

9.2.1 Customer Offer Results (WP3)

This section highlights the results of each part of the work aiming to create a customer interaction plan for the GSHP solution. The methodology is described in the previous section: Customer Offer Methodology (WP3).

9.2.1.1 Business Model Proposition (WP3.1)

Business model 1 was chosen as the best suitable fit for this project. Heat as a Service was not in scope for this work stream, and it was felt that the new business model would need additional educational time as it is not a recognisable or adopted way of heating your home with the bulk of energy customers. This additional barrier was deemed to impact on the success of the project, given the timescales to recruit a considerable number of low awareness customers.

Business model 1 also provided the most opportunity for a plug-and-play solution that created enough flexibility to discover suitable partners and offer customers choice.

System Component	Life Span	Approximate Cost per Household	Business Model 1
Shared Ground Array	100 years	£6,000-£10,000	**Split Ownership Model – Owned by third party** **Ownership model – private entity or community owned asset** Review of finance providers who would want to invest in this size of asset Connection agreement with each property Agreement Length: c40 years (ref Kensa schemes) Cost per year subject to cost of finance and ground array cost
Heat Pump and Controls	20 years	£6,000-£8,000 Funded/Part funded by BEIS funding	**Customer Able to Pay** OR **Customer Finance (Own Asset)** **Heat Pump Tariff** Opportunity for customer to realise cost savings v standard flat rate tariff via a multi-rate / TOU tariff, operating during cheaper periods Separate agreement with customer for flexibility control (DSR) worth £88 p.a. with option for maintenance agreement
Tertiary System & Building Fabric HW Cylinder, Radiators, Pipework, Insulation, Home Survey (potential abortive cost)		£1,000-£7,000 *Property Specific	**Customer Able to Pay** OR **Customer point of sale finance option**

Removal of Gas connection

Figure 48: Chosen Business Model

9.2.1.2 Financing Offering Proposition (WP3.2)

Investment partners and BNP Paribas have indicated that they are open to exploring opportunities to support heat projects where EDF is the recognisable brand recruiting customers. BNP Paribas has already provided EDF with a signed note of interest. It would also be possible to bring Investment partners into the consortium as a partner for Phase 2.

The **customer's attitude** to who they contract with, ownership versus hire status of heat pumps and optimal lengths of financing to help spread the costs can all be flexible within the proposition developed. Focus group commentary and reactions to financing were interesting amongst the two age groups – those with disposable income preferring to own the equipment outright rather than being locked into personal finance agreements. While the younger group with less disposable income and savings were keen to explore finance options in general but would not want to over commit themselves in the current climate.

Options to work with **community financing** companies has also been explored considering the financial turmoil seen during the feasibility study – discussions with the likes of community lending schemes could help homeowners with the upfront costs of renewable heating options but at lower interest and repayment rates.

The consortium conclusion is that options to spread the costs need to be made available for the cost barriers to upgrading to renewable heating solutions, but a stable financial rate needs to be secured to help support the proposition.

9.2.1.3 HP Customer Offer Proposition (WP3.3)

- **Development of the value proposition**

Proposition

- An opportunity for the customer to reduce their gas heating bill and carbon footprint, without the outlay of a traditional heat pump.
- An innovative system that uses natural ground heat to create the optimal efficiency of a ground source heat pump with the chance to share the cost with neighbours.
- The ground infrastructure lasts 100 years, but you only pay an annual connection fee for the time you use it.
- Requires less maintenance than a gas boiler or other types of electric heating.

What's included:

- No obligation survey.
- Super reduced heat pump.
- Fixed cost, pay monthly towards the shared ground source system with your neighbours.
- Smart controls allow you to control your homes heating and maximise your savings.
- Backed by [Devon County Council / Local council].
- Up to £6,000 discount if you sign up your neighbours.

Optional extras:

- Zero carbon tariff with EDF.
- Opt into grid balancing services – rewarded for times when the grid needs your energy.
- Annual servicing and maintenance of your system.
- Financing options to spread the cost.

The efficiency and environmental benefits were easily recognisable, with comments like "why is this not compulsory for new build properties?" and consensus was that the proposition was a great offer, but the current financial climate and turmoil do not lend themselves to large long-term investments right now.

- **Quantification of the value of asset flexibility and of the revenue opportunities**

The studies looking at the potential of flexibility with heat pumps highlight the great saving potential of such system both for customers and the grid. The energy provider Octopus found that their customers using a heat pump with a smart tariff can save up to 30% on their final bill by running their heat pump during low hours. (10) An Austrian study evaluated that at least 50% of heat loads can be moved to off peak hours. (11)

Looking at the overall demand, the current associated with heating in the UK is 100 GW with a peak at 200GW. The electrification of the sector could reduce this demand to just 16-35GW.

As seen before there is an opportunity for individual users to participate in demand flexibility through smart tariff however other mechanism such as frequency response (FR), balancing market (BM) and capacity market (CM) bid would be more difficult to reach as their limit is set to 1MW to 100MW. Unlike large scale heat pumps, the small-scale ones would have to be coordinated to work as one system to be able to participate in these bids. This solution would add the challenge of system control. Moreover, participating in Demand Side Management (DSM) on electrical load without a thermal storage solution exposes the customer to a loss of comfort.

Finally, it is worth noting that in the current state of the electricity and gas market, running a heat pump is as costly as running a gas boiler. Indeed, the carbon tax applied on electricity do not find its match for gas making electricity four time more expensive than gas. Reducing the carbon tax on electricity or adding it on gas would make heat pumps more profitable to run and help push toward their adoption. (10)

9.2.1.4 Customer Journey Proposition (WP3.4)

The constraints of the project add to an already lengthy journey. Time to install is estimated to be around 17 weeks.

The benefits of pre-work on the targeted region, housing suitability, street selection, local permissions, advance network connections and the introduction of resident liaison officers are intended to reduce wasted effort in trying to recruit the optimum number of customers. These benefits are offset through the protracted gate decision process. It would be unwise to get final and contractual commitment from the customer prior to having the approvals to continue to the delivery phase of the project.

Phase 2a Jan 23 - Jun 23								
	Launch/Awareness		Engage & Recruit		Design			
Stage	Project Soft Launch / National Awareness	Local Launch / Local PR /Street and property leaflet drops	Express interest	1:1 with resident liaison	Home Survey	Design	Contracts/ Ball Park Quote	Phone call to discuss
Timings	-3weeks	-1week	0	+1 week	+1 week	+1 week	+3 days	+2 days
Channel	Social Media	Print/ Press	Web	Face 2 Face	Face 2 Face	Email	Email	Phone

Phase 2b Jul 23 - Dec 24									
	Launch/Awareness	Engage & Recru	Design	Engagement	Delivery				Evaluation
Stage	Phase 2 Gate updates	Final Contracts Signed (inc 14 days cooling off)	Finance Arrangements	Installation - external works (5 days)	Installation - internal commissioning	Aftercare	Value Products	Customer Survey	Ongoing support
Timings	+6 weeks	+2 weeks		+4 weeks	+5 days	+10 days	+1 week		ongoing
Channel	Email / Print/ Face 2 Face	Electronic	Electronic	Face 2 Face	Face 2 Face	Phone / Email	Email		Phone/Web/Email

Figure 49: Customer Journey Proposition split view

The overall view of Figure 49 above can be found in the annexes section: Customer Journey Proposition (WP3.4).

There is a period of "hold" while the gate decisions are made between Gate 2a and 2b for funding and then to secure and order equipment requires the project to re-engage customers prior to installation for final commitment and contract signatures.

There is a risk that committed customers will change their opinion, financial position or have personal circumstances that prevent them from being able to proceed. The consortium anticipates that the numbers are likely to decrease during this period, and the project will need to re-evaluate overall commitment from the community. Re-engagement and additional communication are therefore required to ensure the success of the project, but these will add to the engagement costs and efforts in the marketing plan.

The requirement to engage and secure the bulk of customers upfront in a 6-month window, with a lengthy installation period also adds to the risk of customers dropping out throughout the 18-month duration of the delivery phase. Very few homeowners will be willing to agree contracts and then wait an elongated period for their installation. Home moves over a 2-year period are likely, and the current financial climate makes it a high probability that customers circumstances will lead to a change of heart with a risk on project targets.

Area specific targeted recruitment phases followed by rapid installations in clusters could reduce this risk, but the project would not be able to guarantee that the full recruitment objectives at the time of the Phase 2 Gate application. Ongoing monitoring throughout the delivery stage would allow the project to ascertain likelihood of success to achieve the overall targets.

Customer aftercare and support

EDF, KENSA and the investment partner responsible for the ground loop array all agree that the customer journey does not just stop at installation. All three parties have a duty and ongoing relationship with the consumer throughout their lifetime with the product and proposition.

The customer will continue to have contact with the infrastructure group as annual servicing visits will need to be conducted to ensure top condition of the boreholes and ground loop array.

Kensa will provide the option for maintenance and servicing contracts to the customer, although customer choice is available to opt for another provider.

Ongoing after sales support and bedding in with the technology with also be provided through Kensa and the 5-year warranty product on the equipment gives piece of mind and recourse for any technical faults. EDF provide a touchpoint for feedback and call centre for any additional customer complaints or stalemate with Kensa.

The consortium envisages the community energy group or initial promoter maintaining contact with the consumer to gain feedback for case studies and word of mouth advocacy of the system.

9.2.2 Customer Analysis Results (WP4.1)

The following figures show the outcomes of the focus groups. The full report is available in the annexes (15.7.2 Focus Groups Master Report).

Awareness of Ground Source Heat Pumps is low and therefore there is a job to be done to raise knowledge.

Once informed, **the principle of the technology is easy to understand** and an alternative renewable source is welcomed.

However, the **install process feels complex**.

There are lots of barriers to be overcome because people **lack in-depth knowledge of the process**.

Namely, **people need to understand the impact that it has on their property** and **how the shared relationship works**, as there are fears for both.

The biggest barrier is the investment required, particularly in the current economic climate.

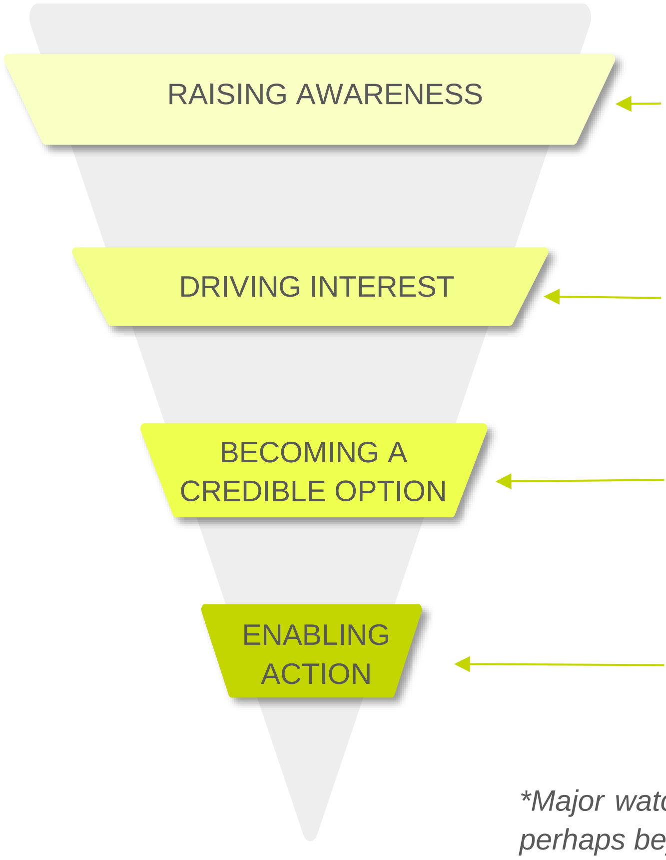
People are **expecting a more immediate ROI for upfront payments.**

Financing and grants are expected for a proposition like this, but they need to be delivered in a tactile way and work hard to stand out.

Because of the lower than expected saving, **it is important to play to the Environmental benefits in terms of the higher-order positioning to generate interest.**

This **still needs supporting by some sense of financial benefit**, as very few would initiate this process based on the environment alone.

Figure 50: Focus Groups Outcomes Executive Summary



Knowledge of GSHPs is lower than other renewables and therefore there is a wider job to be done to ensure that it is recognised as a viable option

The best way to drive interest in current circumstances would be to demonstrate cost savings. As these are not significant, **an angle promoting the environmental impact drives more engagement than price certainty** and taps into a macro motivator.*

A need to overcome the barriers that exist, namely impact on personal property and alleviating any fears over any partnerships with neighbours

Finally, **showcasing cost savings in a tactile manner** (e.g. positioning grants as ‘free’ elements, no servicing, opt-in to cost saving) help to convince that the system is achievable

**Major watch out that energy sourcing still feels like a bigger issue, perhaps beyond personal control*

Figure 51: Recommendation: there are 4 tasks to be done in order to generate interest in the Teignbridge GSHP scheme

Table 34: Opportunities and barriers to overcome with current proposition

	Upfront (primary)	Ongoing (secondary)	Gaps	Actions:
Shared infrastructure ground loop	• No upfront payment	• No servicing or maintenance • No dependency on neighbours – own contractual commitments	• Needs to be **gas comparable** • Disruption • Reluctance to long term contract	• Look at alternative financing and ownership models: Local Energy group • **Council led funding** • Other funding streams – Not for profit with lower fixed interest rates
Heat Pump	• ***Free Heat pump** • 80% less CO2 emissions • 4X more efficient	• No servicing or maintenance • Longer lifespan than gas boiler (justify higher spend)	• ToU tariff or options to eam back – grid balancing services • **Much lower running costs** • Disruptions • Space	• Alternative funding options – less constraints on install targets • Local authority tenders • ToU tariff options • **Pricing policy** to shift between gas and electricity
Home upgrade	• *Free Home upgrades *either or align to grant funding	• Add value to your property (personalised) • Financing options to spread the cost • Ongoing efficiencies & using less energy	• Reduce the install costs – fixed costs • Disruption • Reluctance to finance over long periods or invest as **likely to move (current climate)**	• Free EPC after installation • Options to add to mortgage/green mortgage rates – improved EPC • **Higher subsidies available for readiness programmes**
Community Scheme	• Awareness – indirect • Awareness – direct • Expert available in the area	• Support and community lead • Local Events • Social campaigns • Register your interest forms	• Education/case studies for the area and technology • **Financial support and incentives for community lead** • Reluctance to be community lead/engage with neighbours	• Investigate discounts available on connection fee/energy bills/upfront costs for recruitment • Education centres/training packs and support materials • Community Energy Scheme engagement

More work is required to break down the barriers to the proposition that also reduce anxiety over the current financial climate. Further work is also required to:

- Raise awareness and to create a culture of adoption to the technology.
- Higher subsidies are required for the early adoption curve to be worth the perceived risk to many customers.
- A shift in the dis-proportionate running costs between gas and electricity also needs to be addressed to generate higher density adoption.

9.2.1 Marketing Plan Proposition Results (WP4.2)

The outcome of this work showed that the **awareness is extremely low,** which is reflected by customer appetite**.**

Significant cost is required to attract the number of consumers to guarantee success of this project. Circa £1m in marketing and recruitment costs are required to achieve the large recruitment number and to provide buffer as high-level fall out due to the duration to still observed is expected.

The costs to acquire customers are inflated due to the **hyper local** nature of the targeting and in the **tight timescales**. There is an intense requirement for on the ground local support and staffing and for face-to-face engagement. Use of visitor centres and pop-up shops alongside radio and bus stop advertising add significant costs to the project.

A **factorisation in seasonal events** has been done to help keep awareness high and engagement strong within the community. Use of printed materials that can be distributed to specific neighbours is also a costly means for engagement, as opposed to a blanket mailer approach.

Digital campaigns would require a significant budget to generate the audience penetration required to achieve 1 in 4 street density targets.

The cost to install is higher than what could be seen with a regional targeting campaign to achieve similar numbers without the constraints of the project.

The marketing and engagement plans are reliant on **subsidies** being available to the end consumer which can be innovatively used to secure clustering of neighbours, like referral schemes. This subsidy is not included in these engagement plan costs.

The roadmap and channel plan developed for the marketing plan proposition can be found in the annexe section: Marketing plan proposition (WP4.2).

10. Costs to Consumers

10.1.1 The Customer Offer

Two customer propositions were developed for Project Gaia in Teignbridge, a rural area. Due to the relatively low density of housing in the area, the costs illustrated below are for individual borehole installations, street-by-street, rather than shared ground arrays. For an area like Teignbridge with predominantly detached and semi-detached housing, the increased cost of trenching to connect boreholes results in a per-property cost that is currently very high due to the stage of the heat pump market, particularly in the current economic climate and with rising electricity costs.

Option 1: Upfront Contribution

- You pay £6,800 upfront, which is ~£3,800 more than you'd pay for a boiler replacement, but you should see a small (~£40 per year) saving on your heating bills and maintenance at current price caps.
- Given a recent study showing the increase in your home equity value by up to £8,000 in doing so, the payoff is in essence immediate.
- You can further save by switching to a Heat Pump Tariff or a Time of Use Tariff (ToUT). You should then see a total saving of ~£326 per year.

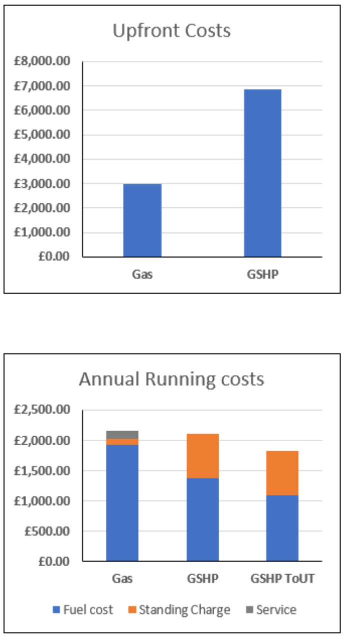


Figure 52: Overview of customer proposition for Project Gaia, based on 3-bed house

As can be seen here, the high efficiency of the heat pump offers a running cost saving compared to gas however this benefit is almost entirely lost through the inclusion of the standing charge.

Although this product offers ~82% carbon saving compared to gas central heating (see 11.2 Impact Assessment (WP6.2)) and is effectively cost neutral after the initial £6,800 investment, feedback from the consumer engagement suggests this is not a compelling enough offer at present. Interestingly the EV market also took a hit this year when the increase to the energy price cap reduced per mile cost savings. (12)

10.1.2 Market Levers

The consumer savings must, therefore, be increased to improve the appeal of the product and re-introduce the potential for shared arrays in rural and semi-rural areas to deliver greater system flexibility. This can be achieved by addressing the following variables within the customer proposition:

- Cost of finance
- Running cost
- Installation cost

10.1.2.1 Cost of Finance

Kensa Utilities' funded ground array offer is new to the market. At the current scale of deployment and current level of interest rates, costs of finance range from 6-10%. Once the market reaches a scale such that Kensa can draw down £50+ million at a time, we will unlock costs of finance closer to 4% which reduces the standing charge in this scenario by ~25% per month (£150 per year).

Access to lower cost finance can be accelerated in two ways: focus on existing closer-to-market offers to new build and social housing, access to state finance offerings. The latter would bring forward deployment of networked heat pumps in detached and semi-detached homes by several years.

10.1.2.2 The Spark Gap

To make heat pumps viable and produce savings compared to gas, the ratio of electricity to gas prices (sometimes called the spark gap) needs to be lower than 3.5 (13). In the UK, the ratio is currently 3.3 after application of the recent price cap. In the Dutch market, the spark gap is only 1.3 which is mostly due to taxation and energy policy. If the UK had a similar spark gap then installation of heat pumps would be mostly self-financing through energy bill savings.

For instance, if the spark gap is decreased to 2.3, with 30p/kWh for electricity and 13p/kWh for gas, households in Project Gaia would have seen a saving of up to £600 a year, even after the monthly connection fee.

	Gas	GSHP
Service	£120.00	
Standing Charge	£102.00	£702.71
Fuel cost	£2,388.75	£1,260.00
Saving		**£648.04**

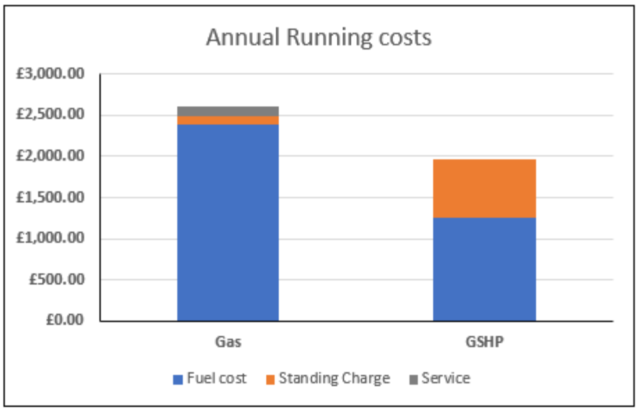


Figure 53: Impact of spark gap of 2.3 on Project Gaia customer proposition

10.1.2.3 Reduction in Capital Cost

The installation costs of ground source heating will come down as the market grows. In the meantime, the Kensa Group companies are investing in research into new technologies such as the Highly Flexible Storage Heat Pump which combines heat storage for space heating and hot water, removing the need for installation of a hot water cylinder and thereby reducing labour costs. Kensa is also in discussions with an entrepreneur with a solution to reduce drilling costs by ~40%. This cost reduction would provide an annual saving of ~£160 compared to gas.

	Gas	GSHP
Service	£120.00	
Standing Charge	£102.00	£524.97
Fuel cost	£1,892.63	£1,428.00
Saving		**£161.66**

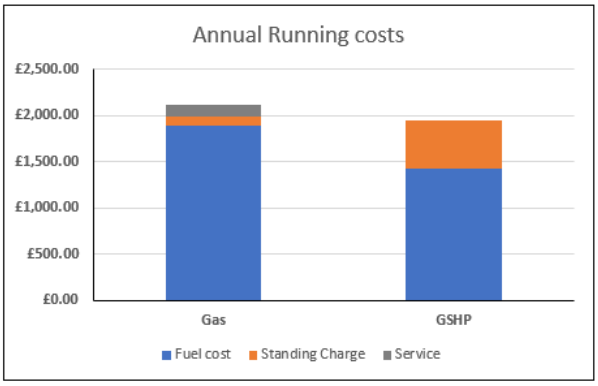


Figure 54: Impact of 40% saving on drilling cost on Project Gaia customer proposition

10.1.2.4 Impact

Combining the impact of these three levers (spark gap of 2.3, interest rate of 4%, reduced borehole costs) can make the annual savings very attractive to on-gas consumers, even in lower density, hard to retrofit housing. When combined with mortgage incentives such as those recently announced by both Halifax (14) and Barclays (15) there is the potential for networked heat pumps to become the most desirable heating to the majority of the UK's able-to-pay market.

	Gas	GSHP	GSHP after 5 years
Service	£120.00		
Standing Charge	£102.00	£389.24	£389.24
Fuel cost	£1,649.24	£1,260.00	£1,260.00
Loan	£651.52	£1,488.12	
difference		**£614.60**	**-£961.52**

Loan amount GSHP	£6,852.20
Interest rate	3.29%
Loan years	5

Loan amount Gas	£3,000.00
Interest rate	3.29%
Loan years	5

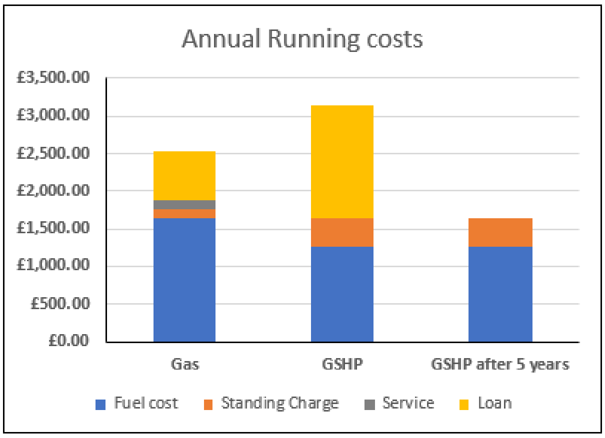


Figure 55: Cumulative impact of market levers to incentivise networked heat pump uptake

A study by the Eco Experts in 2022 (16) found that the single biggest factor in decision making over renewable technologies was the price. With annual running cost savings of over £600 per year, this would suggest that, should all of these market levers be successfully applied, the business model could be offered subsidy free by 2028.

10.1.2.5 Further Levers to Accelerate Market Readiness

Heat network zoning offers a great opportunity for government to incentivise deployment of low carbon heating across the UK in a way that can benefit all technologies. Current state subsidies allow a level of choice that has the potential to reduce the profitability of all area-based technologies. For instance, scatter gun deployment of heat pumps in an area suitable for a district heat network would reduce the number of short-medium term connections in that area. Through simple heat zoning, investment opportunities can be protected:

- High heat density - over 7,000 kWh/m/annum but potentially down to 4,000kWh/m/annum. Central Plant district heating.
- Medium heat density. Under 8,000 kWh/m/annum down to 500 kWh/m/annum. Networked heat pumps.

- Low heat density. Detached or semi-detached houses and bungalows. Individual ASHP/GSHP or biogas.
- H2 near heavy industry where this is already required.

10.1.2.6 Not All Heating Is Equal

With lower energy efficiency on the coldest days, when people are using them most, mass deployment of air source heat pumps would require greater investment in energy generation and grid reinforcement than networked ground source heat pumps. According to a 2021 study by Aurora Energy Research (17), a future scenario with an equal number of ground source heat pumps (predominantly networked) to ASHP would result in average system cost savings to the UK of £1bn per year. This would suggest that there should be consideration of alternative methods to rewarding and incentivising flexibility.

10.1.1 Market Growth

Kensa is the long-term leader of the ground source heat pump market in the UK (BSRIA 2019), however with ASHP having a lower upfront cost, ASHP installations currently take around 84% of heat pump sales in the UK (MCS Data Dashboard, 2020-2021).

Assuming the government target of 600,000 heat pumps installed per year by 2028 is achieved but no significant uptake in split ownership networked heat pumps as described in this consumer offer has been achieved, the market share of GSHP is anticipated to be reduced to around 12% by 2028, with Kensa's share of the GSHP market decreasing to around 32% (from 44% in 2022). This would in fact still represent a nine-fold increase in the organisation in a 7-year period, enormous achievement for a British manufacturer that is currently classified as an SME.

Widescale adoption of split ownership networked heat pumps would see a markedly different future for the Kensa group. High density deployment of this solution in the UK's largest heat pump market, private retrofit, could see the GSHP share of the heat pump market increase to 23%. If a similar portion of the GSHP market is retained, 31%, Kensa factories would be producing >40,000 heat pumps per year, 17 times as many heat pumps by 2028 as they achieved in 2022.

Currently, just 26% of Kensa GSHP sales are for individual installations in private retrofit, the vast majority of our heat pumps go to large-scale, high-density deployment projects in new build and social retrofit. Since late 2022, feasibility reports for all large new build and social retrofit projects have included a similar funding model to that adopted for project Gaia. Our modelling of the market below suggests an additional 40,000 heat pumps could be sold in the private retrofit market over the next 6 years using this business model.

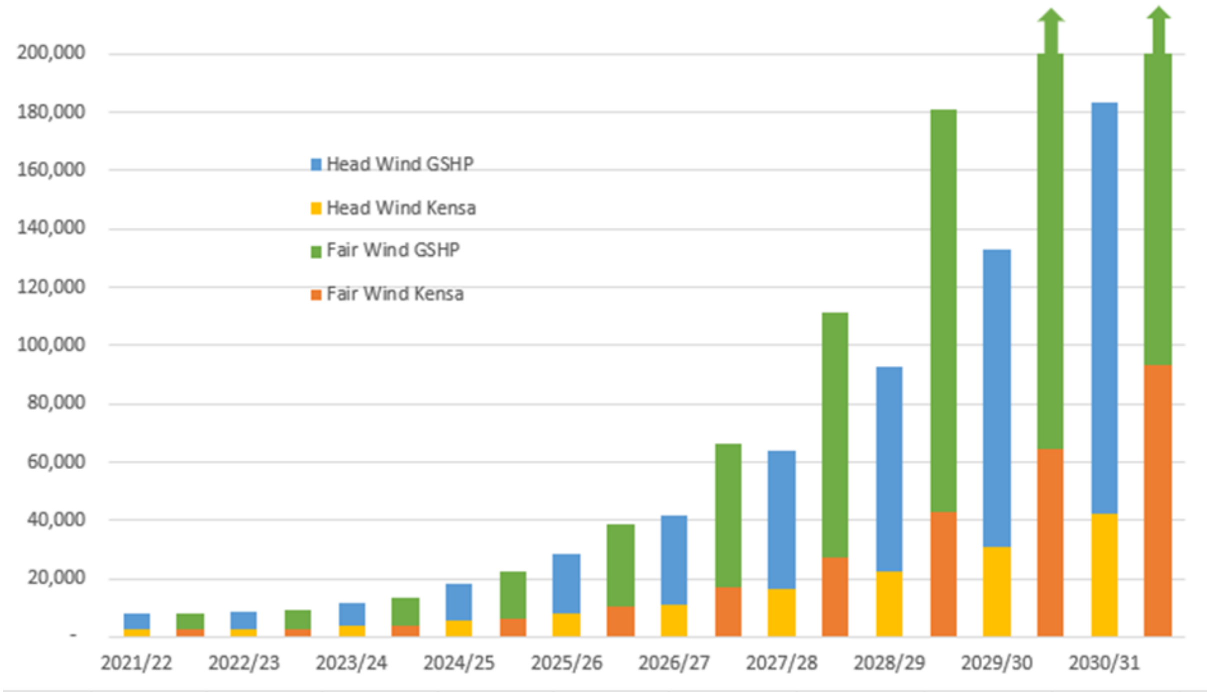


Figure 56: Market Growth Projection

11. Long Term Sustainability (WP6)

As this piece of work is part of a larger programme aiming to drive the decarbonisation of the UK economy, it is necessary to ensure the proposed solution is sustainable both from the perspective of the business model and from the perspective of climate change. The consortium ensured that the solution is scalable and replicable, and that will participate to reduce the UK greenhouse gases (GHG) emissions.

This section is looking to answer the question:

Is there any long term impacts on the customers and the environment?

For this, it has been divided into two work packages:

- WP6.1: Future Proofing of Business Model

The goal of this section is to evaluate the proposed business model in the event of a Phase 2, and to create a blueprint of how this proposal can be applied to similar areas.

- WP6.2: Impact Assessment

This section carried out a Life Cycle Analysis (LCA) to understand environmental impact, from the point of view of the greenhouse gases (GHG), of the proposed methodology. The results can be used to assess and improve the sustainability of the business model. Conducting this technical assessment helped determining the benefits and risks of the proposed technology.

11.1 Future Proofing of Business Model (WP6.1)

11.1.1 Challenge

Low carbon heating is one of the greatest challenges remaining to the UK's to net zero ambition. To date, government incentives for private retrofit have failed to incentivise adoption of low carbon heating at the scale required (18), what's more, the application of grant funding at the level of the homeowner encourages a scatter gun deployment of individual systems which will have a negative impact on area-based approaches such as district heating, hydrogen, and shared ground arrays.

In order to provide a business model capable of delivering a solution at the scale required, and in the time required in the UK, there must be a significant shift in the market.

11.1.2 Solution

Ground source heat pumps (GSHP) are the lowest carbon, lowest grid impact, lowest running cost and most flexible form of heating currently available. (19) (20) Whilst providing higher efficiency and longer life than air source heat pumps (ASHP), the ground array infrastructure required increases the capital cost compared to ASHP by ~40%.

With no moving parts and a life expectancy of ~100 years, ground array infrastructure is well suited to long-term private investment. Securing private investment in the infrastructure enables a shift away from reliance on government subsidies which provides a more stable base for business planning.

The proposed split ownership business model divorces the homeowner from the long-term investment in the shared asset, linking the cost to the house rather than the individual and spreading the cost over a period of 40 years.

Kensa will secure private investment to install the infrastructure, retaining ownership and therefore all asset management responsibilities. Homeowners will pay for and own the small heat pump in their home as well as the whole wet system and pay a standing charge for access to the ground array. In this way Kensa replicates the arrangements seen in the gas network.

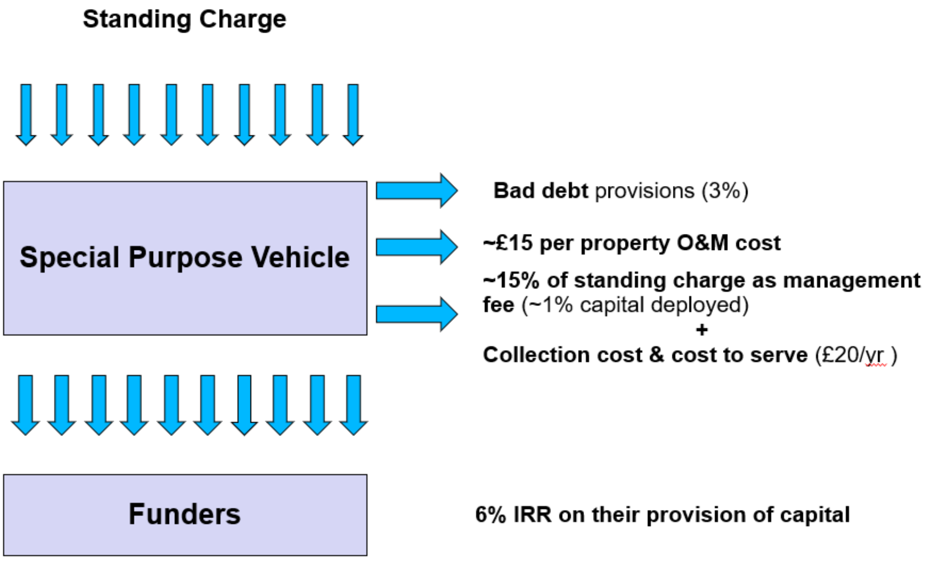


Figure 57: Project Gaia Business Model

Kensa already has funding offers in place for split ownership installations, these have come from:

- Banks
- Crowd funding platforms
- Energy infrastructure investors

There are three domestic markets for this offer that are at varying stages of development:

- New build developments
- Social retrofit
- Private retrofit

The new build split ownership offer is already commercially viable in most instances, even ahead of the Future Homes standards coming into force. Kensa Utilities has already secured sales of split-ownership networked heat pumps without any government subsidy.

The social housing retrofit business model benefits from 'anchor' customers, large numbers of households making network connections simultaneously, as well as some borrowing power to fund the residual capital costs of home upgrade and heat pump purchase, and the environmentally policy drivers within housing associations. The split ownership for social retrofit is close to market for off-gas homes, Kensa has not yet achieved sales of this business model in this sector without funding.

The private housing retrofit market is much further behind, even for off-gas homes. With low fossil fuel prices, low subsidies, high electricity costs, a cost-of-living crisis (21) and low level of public understanding (22), generating sales at a high enough density to unlock private investment or achieve economies of scale (>£50m) is incredibly challenging.

11.1.3 The State of Play

Electric vehicles sales have had resounding success in the UK in recent years, with almost a million being registered in the UK in the last ten years, over 300,000 last year alone (23). This is in stark contrast to the sale of heat pumps over the same period, with just a tenth of this number installed last year (24), despite comparatively low cost and high grants, as well as a longer time on the market.

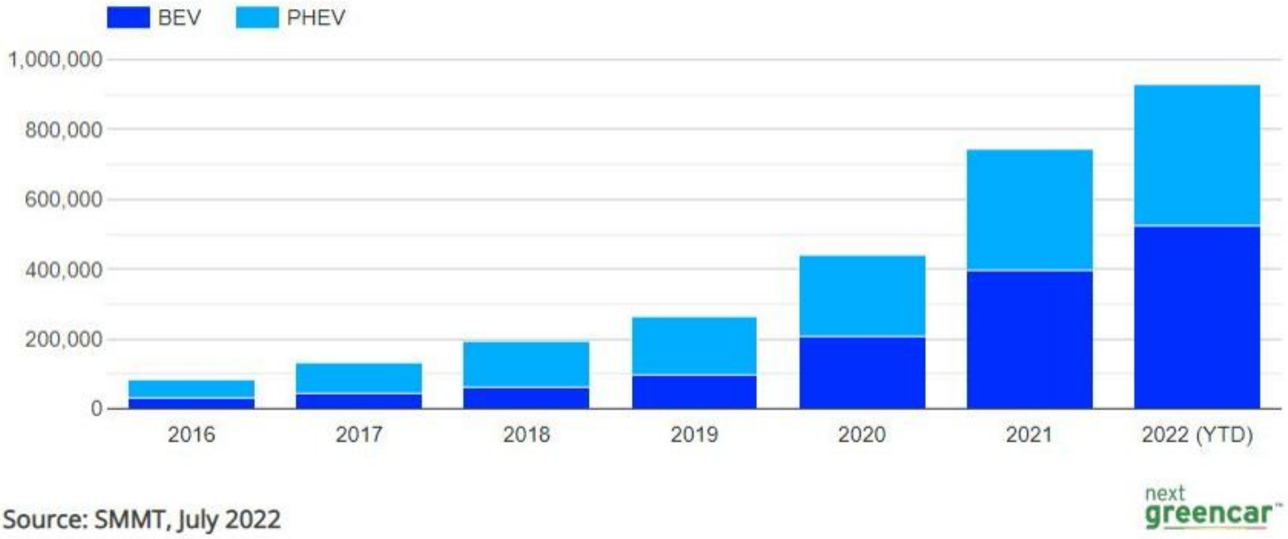


Figure 58: Cumulative number of plug-in cars registered in the UK (2016 to date) (25)

There are several key differences between the EV and heat pump markets:

- the way the ownership cost of vehicles is experienced by consumers
- the public perception of emissions from cars
- great cars are socially valued, whereas great heat pumps are invisible

At this project's scale the last barrier can hardly be acted upon, a good heating system, once established, isn't something people tend to think much about and we can't show it off in public, but, with the British public showing an increasing concern over the environment (26), the appeal of heat pumps will increase, which brings us to the second point.

Education on the emissions from private transport has been very successful over the years and the public is rightly sensitive to the impact of their transport choices on the environment and local air quality (27) however, a study by Nesta has shown that the public greatly underestimates emissions related to heating with gas (28).

"A representative poll of 2,000 UK adults, conducted by Opinium for Nesta, asked respondents to estimate the carbon emissions associated with a range of activities. 50% of respondents accurately estimated that taking 6 transatlantic return flights would emit 'very high' annual emissions (more than 1.5 tonnes of CO_2), whereas only 12% correctly put heating their home with a gas boiler in this category."

This goes some way to explain why there is such disparity in the appetite for heat pumps in comparison to EVs and will have to be addressed as part of the education and awareness aspect of heat pump sales.

Finally, in the UK over 90% (29) of private car sales are financed, with advances worth over £17.5 billion in 2021. The established private finance market means that, despite being on average 35% more expensive, EVs are still an accessible option.

Figure 59:Average upfront cost of an electric, petrol and diesel car (30)

Moreover, government has delivered on some bold strategies to incentivise EV uptake, including grants, tax breaks and very high tax on petrol and diesel. (31) After hovering around 60% for the last 10 years, the percentage of UK fuel price which is tax reached a low of 43% in early 2022. With low electricity prices (up until October 2022) offering ~65% saving per mile compared to heavily taxed fossil fuels and readily available finance spreading the capital cost, EVs have been an attractive commodity.

This is in stark contrast to domestic natural gas supply with tax and levies making up less than 6% of the cost to consumer. Despite a clear commitment to increasing heat pump sales, the market has not benefited from a 'carbon tax' equal to that of the transportation sector.

Ground source heat pumps cost, on average, 100% more than a gas boiler and require ground infrastructure that can cost an additional £10,000 per home. For the ground source heat pump market to achieve a similar growth as the EV market, the capital cost of installation must be reduced, compelling finance offers must be provided, and running cost disparity must be tackled.

The ground array infrastructure required by a heat pump has no moving parts, an anticipated life of 100 years and requires very little maintenance. This makes it ideal for private investment. By installing the infrastructure street-by-street there are economies of scale, greater opportunities for system flexibility-incorporation of waste heat, accommodation of increases to property size, and scope for extension of the asset.

With homeowners spending an average of just 12 years in a property (32), there is no great desire to invest in infrastructure that will serve inhabitants for generations to come. Through long-term finance arrangements, Kensa can provide access to ground source heat for around a fifth of the cost of EV finance. This cost is attached to the home rather than the individual and will be passed onto the next homeowner.

Home upgrade measures such as new pipework, radiators, hot water cylinder, as well as the heat pump itself can be financed through mortgage borrowing, with some lenders now offering cash back incentives for heat pump installations (33).

11.1.4 Local Stakeholders

The scale and scope of the work required to deliver this solution is best supported by a range of stakeholders. The specific organisations involved may vary but the activities will remain very similar.

It has been acknowledged that the electrification of heat will require significant investment in the national grid. Whilst Ofgem is working on the Access and Forward Looking Charges Significant Code Review, the timescales for extensive work can be a significant barrier (34). Consultants such as Enzen will provide future projects with information on capacity to enable planning of projects that are currently viable, as well as those that would take longer to be technically feasible.

It is expected that this work would be less in-depth than was shown in Project Gaia and therefore have lower impact on the costs that would be passed to the consumer.

Support of the local authority in any future deployment is required for successful delivery, from a local energy planning perspective and from a community engagement perspective, through impartial, educated assessment of the customer offer and a local drive on awareness of the impact of heating on an individual's carbon footprint. This will support us to overcome the barriers around perception identified in the previous section.

Of equal importance is the local supply chain. Mass decarbonisation of existing housing stock will require upskilling of existing heating contractors as well as an increase in the workforce due to the increase in workload required to upgrade central heating systems to accommodate heat pumps rather than for maintenance and replacement of existing gas heating. A large numbers of staff will also be required to secure contracts with private households as well as conduct home surveys. An increase in the number of drillers as well as investment in equipment to carry out borehole drilling is also needed.

Kensa has spent considerable resource already on training programmes and on an MCS umbrella scheme for installers to enable market growth. There will remain a requirement for further development work by the consortium for growth of local supply chains for future deployment of this business model during the mobilisation period for some time to come.

11.1.5 Cost to consumers

The costs developed for Project Gaia reflects the rural nature of the area. Due to low density housing costs were based on individual boreholes on a street-by-street basis, rather than a shared ground loop. For detailed explanation of costs to consumers see section 10 Costs to Consumers.

11.1.6 Summary

Kensa and the consortium recommends a street-by-street approach using networked heat pumps, shared ground arrays, split ownership and financing as the lowest overall system cost to transition to zero carbon heating. This vision is unlocked via a series of actions from various stakeholders including central government; local government; the finance industry and the heat pump industry itself.

Through application of the market levers described in this report, it is entirely possible that heat pumps could be deployed at scale, in on-gas areas, without a need for continued government subsidies by 2028.

Although the customer proposition for Project Gaia does not appear to be desirable enough in the specified area, in the current climate and within the confines of Heat Pump Ready, Kensa is continuing investment in activities that reduce the barriers to uptake with the view to offering a long-term, sustainable business model. This is through Kensa daily work as well multiple high-profile research and demonstration projects such as Heat the Streets and Heat Pump Ready Stream 1 & 2.

11.2 Impact Assessment (WP6.2)

This section presents a life cycle analysis, focusing on greenhouse gas emissions, for the shared loop ground source heat pump system proposed by Kensa (35). Natural gas (NG) boilers are considered as the business-as-usual (BAU) alternative to the GSHP system.

The nomenclature below (Table 36) is used throughout this section.

Table 35: Impact Assessment Nomenclature

Acronyms

BAU	Business as usual
CCGT	Combined cycle gas turbine
GSHP	Ground source heat pump
GWP	Global warming potential
HHV	Higher heating value
HP	Heat pump
LCA	Life cycle analysis
NG	Natural gas

- Case study

The proposed retrofit of the GSHP system for 3133 houses in the Newton Abbot area of Devon forms the specific case study for this work. Assessment of the various sites was carried out by Urbanomy; their work, which provides important inputs for the LCA analysis, included:

- sizing of the heat pump for each dwelling (6 kW, 7 kW or 9 kW)
- sizing of the hot water cylinder for each dwelling (150 – 300 litres)
- simulation of gas demand for the business-as-usual scenario
- simulation of electricity demand for the HP scenario

Additionally, for this project, the average depth of borehole per property is estimated to be 129m. It is expected that electrical grid reinforcement would not be required for the GSHP installations, as grid headroom was the first priority in site selection.

The time horizon for the LCA is 40 years; it is predicted that the borehole heat exchangers will have a lifetime of at least this duration. The heat pump itself is assumed to be replaced halfway through this period. (36) (37)

11.2.1 Methodology

The life cycle analysis (LCA) presented here has been carried out using SimaPro (38), with data drawn from the Ecoinvent database version 3.8 (39), unless otherwise specified. ReCiPe 2016 v1.1 midpoint method (40) has been used to compute environmental impacts.

11.2.1.1 Boreholes

Previous comparable studies (41) (42) found that use of diesel for the drilling of boreholes comprises a large proportion of embodied emissions for a GSHP system. The actual diesel consumption will be site-dependent and is also affected by the method of drilling, with hydraulic circulation drilling more efficient than hammer drilling. Greening (43) and Saner (44) suggest diesel consumption of 1.5 litres/m for boreholes in the depth range considered here; Ecoinvent has a higher range of 2.5 – 3.5 litres/m, with 3.1 as the mean. Drilling contractors AWSynergy and Aquasource have been contacted with a request for any data on their diesel consumption. Meanwhile 3.1 litres/m is adopted as the baseline assumption.

Here, all inputs are assumed to scale directly with depth of borehole, provided the depth is in the range relevant range (i.e. 100 – 300m). An average of 129m borehole depth per dwelling is assumed. Note that bentonite consumption is low as most can be recycled.

Table 36: Inputs for construction of 150m borehole heat exchanger. Sources: (39) (45) (46)

Input	Unit	Amount	Amount per metre
Diesel burned in drilling rig	litre	225 - 525	1.5 – 3.5
Polyethylene	kg	180	1.2
Ethylene glycol	kg	102	0.68
Reinforcing steel	kg	33	0.22
Cement	kg	33	0.22
Activated bentonite	kg	8	8.22
Water	litre	10200	68

11.2.1.2 GSHP

Three heat pumps manufactured by Kensa have been considered. These are the 6 kW Shoebox, the 7 kW Evo and the 9 kW Evo. Embodied carbon calculations for these have already been carried out by CIBSE on behalf of Kensa. Table 37 contains the results from this work, which are adopted for use in this analysis.

Table 37: Embodied emissions for Kensa GSHP models (kgCO2e) (47) (48)

Category	**Heat pump model**		
	6 kW Shoebox	7 kW Evo	9 kW Evo
Material extraction	570.8	508.2	514.7
Transport to factory	89.5	110.1	110.9
Manufacturing	16.5	16.5	16.5
Transport to site	4.5	5.5	5.5
Transport to waste processing	1.5	1.8	1.8
Waste processing	4.1	4.1	4.1
Disposal	0.3	0.4	0.4
Replacement components	68.7	64.7	65.4
Total embodied carbon excluding refrigerant leakage	**982.6**	**924.6**	**935.1**

- Refrigerant

It will be seen that the likely escape of refrigerant to the atmosphere is the dominant part of emissions related to the GSHP itself, other than electricity consumption. The refrigerant for the 6 kW heat pumps is r134a, with a GWP (over 100 years) of 1430 $kgCO_2e$ / kg; for the larger heat pumps the refrigerant is r407c with GWP of 1774 $kgCO_2e$ / kg. The mass of refrigerant is respectively 1.6kg, 1.8kg and 1.9kg for the three capacities of heat pump.

In the CIBSE calculation of embodied emissions, leakage of refrigerant is assumed to be 1% of fill mass during manufacture, 0.5% annually, and 30% at end of life. (49) (50) (51) It is possible that this assumption for annual leakage is too optimistic. Ecoinvent suggests an average of 6%/a; Elementa have 2%/a (39) (52). Accordingly, 6% per annum will be taken as the baseline assumption in this work.

11.2.1.3 Emitters

Assuming that the GSHP will operate with 35°C flow temperature, it is possible that dwellings will require larger radiators. The extent to which this is the case depends on whether the existing radiators are already oversized.

Radiators are assumed to be double panel and made of mild steel or aluminium. Steel is preferred in order to minimise embodied emissions (52). Only steel / aluminium are considered as raw material inputs. The ‘average’ metal-working process (for each metal) in Ecoinvent is used to represent emissions associated with manufacture. Total embodied emissions for radiators are computed as 340 $kgCO_2e/kW$ for steel, and 603 $kgCO_2e/kW$ for aluminium.

Table 38: Assumed characteristics of radiators operating at 35°C flow temperature.

Measurement	Steel radiator	Aluminium radiator	Sources
m^2 / kW	1.75	1.5	(53) (54) (55)
kg / m^2	53	29	(53) (54) (55)
kg / kW	93	44	-
Embodied emissions: raw material $kgCO_2e/kW$	181	434	(39)
Embodied emissions: manufacture $kgCO_2e/kW$	159	169	(39)

It is worth comparing these numbers to those in (52), where the embodied emissions for radiators were in the range 330 – 490 $kgCO_2e/kW$ (although a slightly higher flow temperature of 45°C was assumed in this work).

Generally steel radiators will be preferred to aluminium in order to minimise embodied carbon emissions. Whether the claimed superior performance of aluminium radiators could offset their embodied emissions is an interesting question, but out of scope. The baseline assumption for this work is that dwellings will need to have an additional 4.3 m^2 of radiators, representing ca. 2.5 kWth at 35°C flow temperature. These represent embodied carbon of 0.85 tCO2e per dwelling, comparable to the heat pump itself.

11.2.1.4 Thermal Stores

Hot water cylinders of size 150, 200, 250 or 300 litres are assumed to be installed in the houses, where the size of cylinder for each house has been specified in work by Urbanomy. The embodied emissions of these are interpolated from (52). The average embodied emissions for a tank in the case study are 386$kgCO_2e$, represented by a tank of volume 196 litres (1.97 $kgCO_2e$ / litre).

Table 39: Sources for embodied emissions of hot water tanks.

Capacity (litres)	Embodied emissions ($kgCO_2e$ / litre)	Source
600	1.36	(39)
300	1.4	(52)
170	2.2	(52)
130	2.75	(52)

Table 40: Specifications for hot water tanks.

Capacity (litres)	Number	Embodied emissions ($kgCO_2e$)	Dry mass (kg)
150	1195	367	30
200	1154	388	45
250	311	405	50
300	473	420	50

11.2.1.5 Gas Boiler

The BAU scenario assumes the use of a 10 kWth natural gas boiler in all dwellings. This has efficiency of 90% on a HHV basis. (56) Allowing for this efficiency, the operational emissions of the gas boiler are assumed to be 0.204 $kgCO_2e/kWh_{th}$ (57). Embodied emissions of the gas boiler, as specified in Ecoinvent, are 523 $kgCO_2e$. Note that under the BAU scenario, neither a hot water cylinder nor additional heat emitters are installed.

11.2.1.6 Transport

Heat pumps, boilers, radiators and components of the borehole heat exchanger are assumed to be transported by 44-tonne lorry over a representative distance of 100km.

11.2.1.7 Operations

Electricity demand for the heat pumps in the case study has been estimated by Urbanomy as 6.8 MWh per dwelling per year. This is based on a seasonal performance factor (SPF) of 3, and compares to 20.4 MWh of gas demand. SPF of 3 is considered reasonable on the basis of measured data from the RHPP trial (19) and OFGEM (58).

Figure 60 below shows the marginal and average grid carbon factors, forecast by BEIS for the next decades. For the LCA, the marginal carbon factors are used to assess the GHG emissions associated with operation of the GSHP. The average carbon factor over the project lifetime of 40 years will be 0.062 $kgCO_2e/kWh$. Note that these carbon factors allow for transmission and distribution losses.

It is important to note that these long-run marginal carbon factors are only forecast at a yearly resolution; neither diurnal nor seasonal variations in carbon intensity are captured. An assessment of operational emissions taking account of these variations would be of interest in the future.

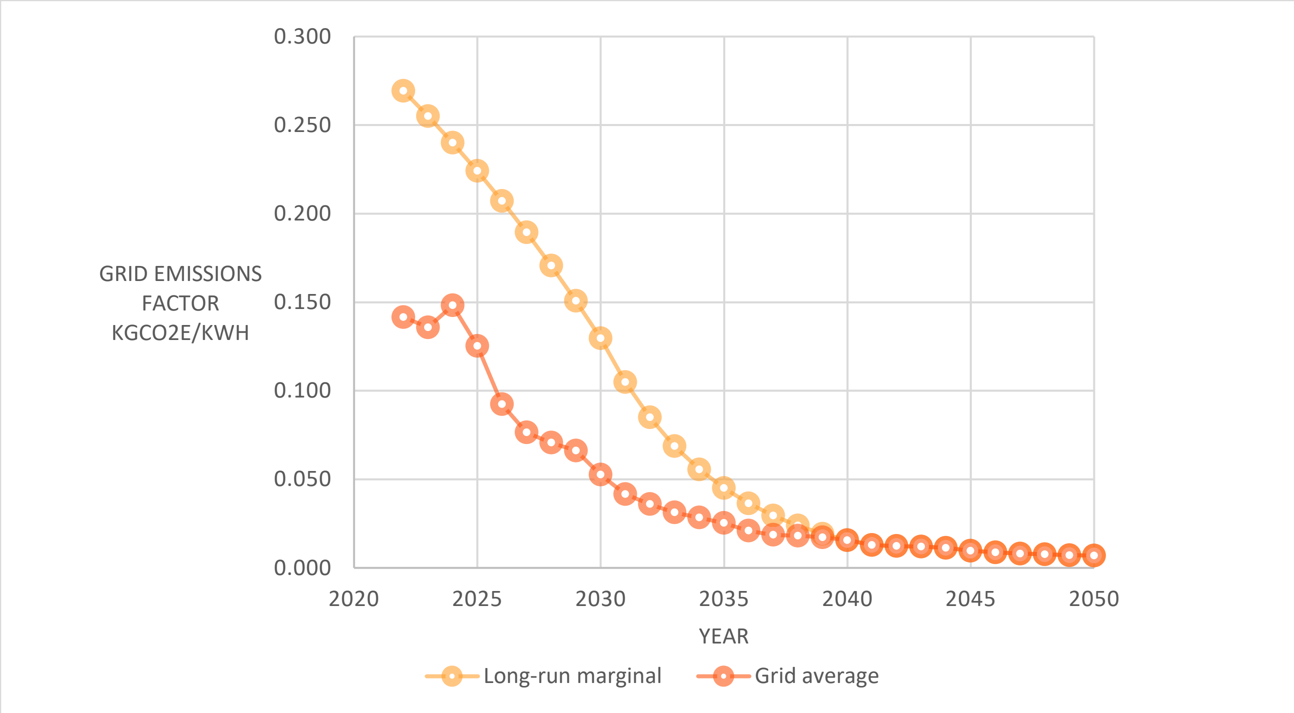


Figure 60: Marginal and grid average carbon factors forecast by BEIS (57)

11.2.2 Results

11.2.2.1 Embodied Emissions

The total embodied emissions for the GSHP system are calculated as **5.3 tCO_2e per dwelling**, as shown in Figure 61 below. The single biggest contributor to embodied emissions is the installation of the borehole heat exchanger (42.4%).

(Note that these embodied emissions include refrigerant leakage during manufacture and end-of-life, but not during the operational phase.)

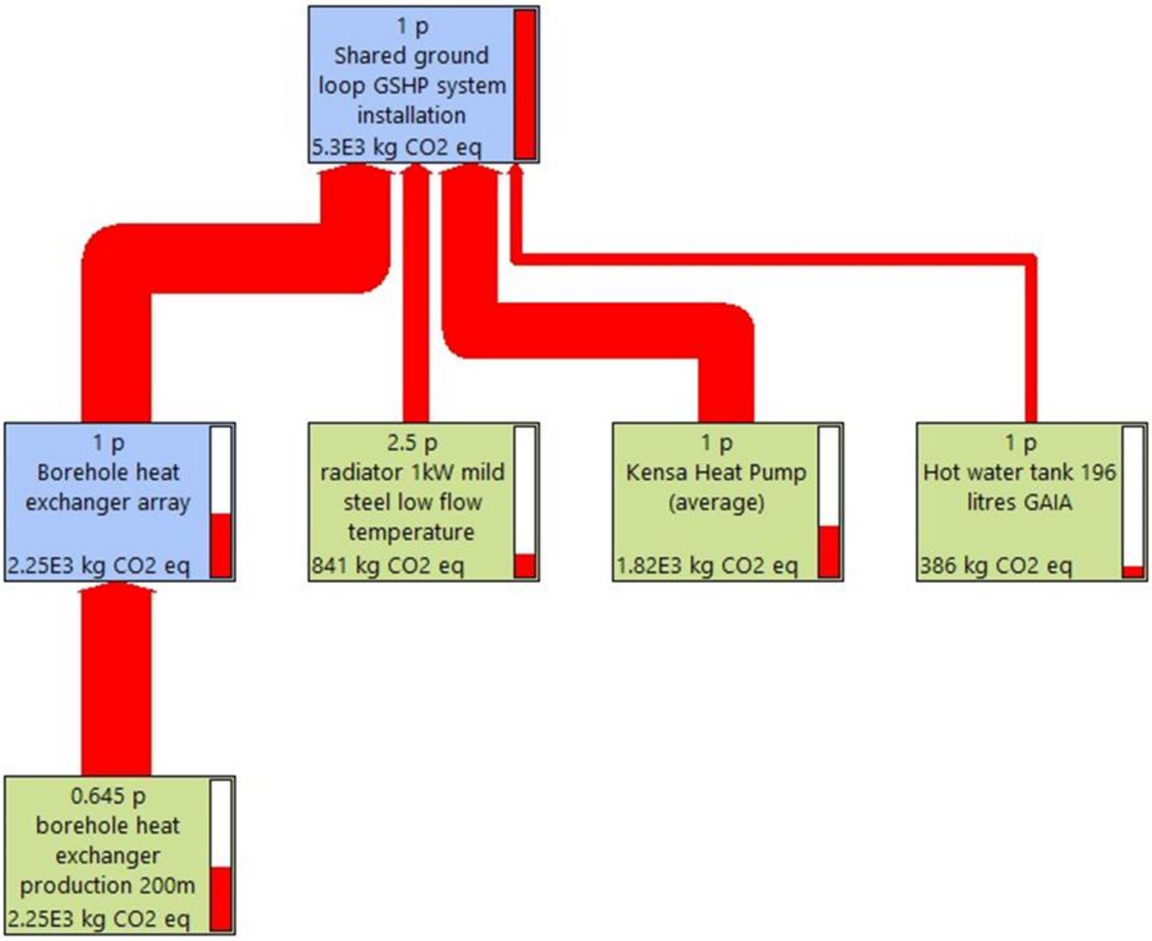


Figure 61: Network of the system's embodied emissions, showing top-processes only. Emissions are scaled to represent one average dwelling from the 3133 in the case study.

11.2.2.2 Lifetime Emissions

GHG emissions for the 40 year lifetime of the **GSHP** project are estimated at **30.8 tCO_2e per dwelling**, as shown in Figure 62 below. The largest contributors are electricity use (54.8%); refrigerant leakage (27.5%);

and heat pump production (11.8% including 20-year replacement). By comparison, the lifetime emissions for BAU scenario with **natural gas boiler** are **213 tCO_2e**, as shown in Figure 63 below, where the overwhelming majority of emissions are due to burning of gas in the operational phase.

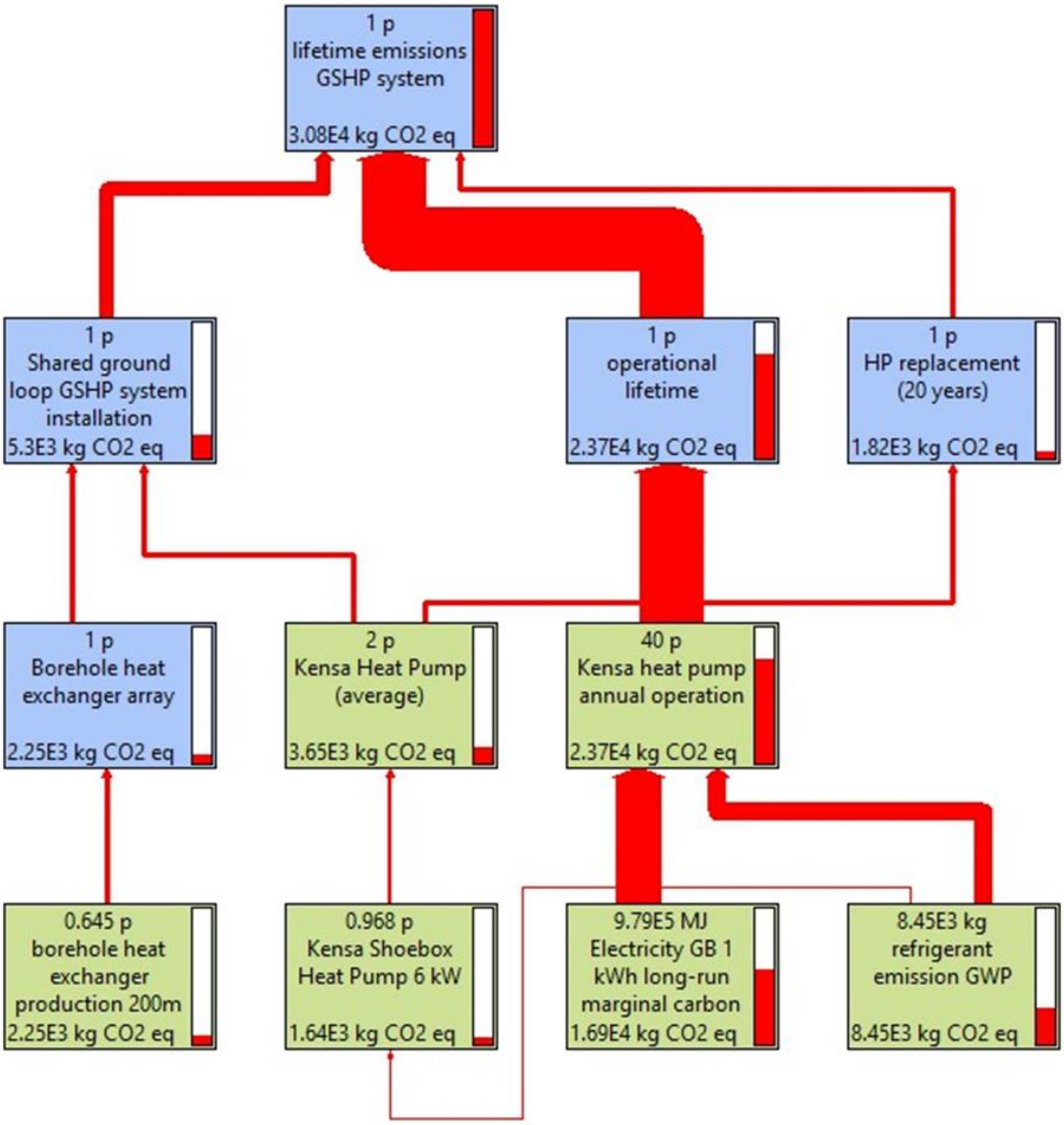


Figure 62: Network showing whole lifetime GHG emissions for the GSHP system. (Figures are on a 'per dwelling' basis.)

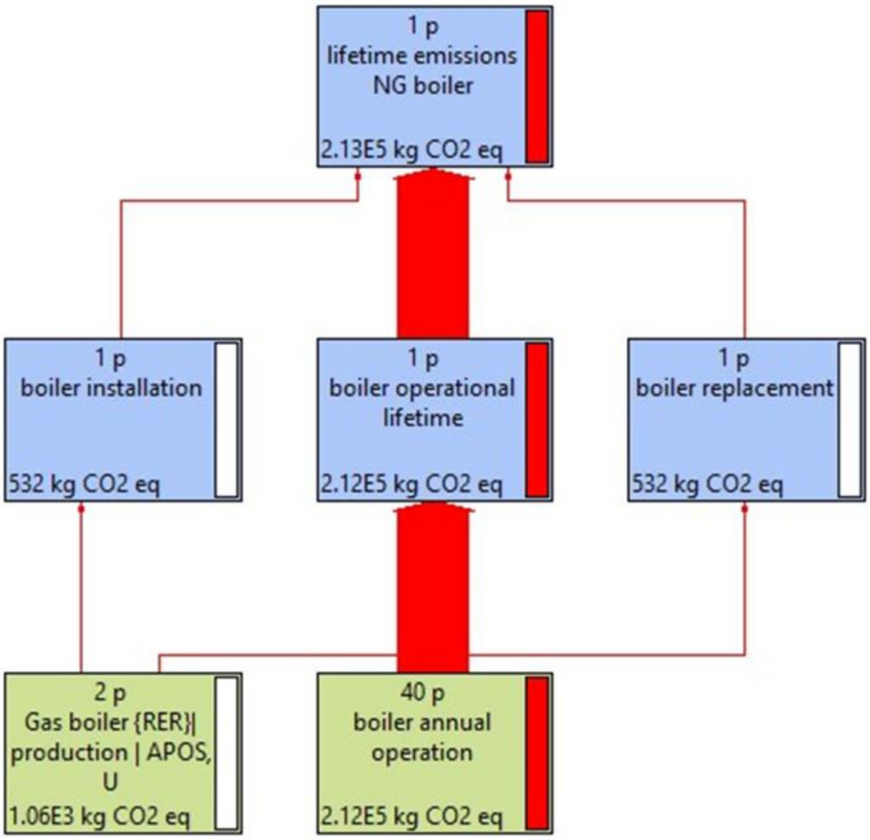


Figure 63: Network showing whole lifetime GHG emissions for the GSHP system. (Figures are on a 'per dwelling' basis.)

11.2.2.3 Discussion

Although embodied emissions for the GSHP system are around an order of magnitude higher than for the NG boiler, ultimately these embodied emissions are eclipsed by the saving in operational emissions. Results of the LCA suggest that over 40 years, the GSHP system can save 85.5% of GHG emissions when compared with the natural gas boiler; in absolute terms, the saving is approximately 180 tCO_2e per dwelling, or 570 $ktCO_2e$ for the aggregation of all dwellings. The greatest uncertainty in this result stems from the use of marginal grid carbon factors forecast by BEIS; both because of the inherent uncertainty in forecasting future changes to the electrical grid, and because of the inability to allow for diurnal or seasonal profiles in heat pump use.

It is worth considering a **worst-case scenario** where the marginal electricity generation is always provided by CCGT. For this generation the carbon factor is approximately 0.36 $kgCO_2e/kWh$. Under this assumption the operational emissions (per dwelling) increase from 23.7 tCO_2 to 105 tCO_2, and the whole lifetime emissions from 30.8 tCO_2 to 112 tCO_2. Even in this case, the GSHP still saves 47% of GHG emissions relative to BAU.

12. Recommendations

The consortium would like to advise the following for future deployment of ground source heat pumps with shared loop array:

- As the **customer awareness** of ground source heat pumps is low, focus should be made on raising their knowledge.
- The biggest barrier identified is the **investment** into the technology. The solution proposed should address it in priority, with financial support for instance. The focus could also be made on reducing the capital cost. Capital cost can vary based upon location for example housing that have a closer proximity to one another would benefit from lower trenching costs. Geological factors would also affect the capital costs due to time and difficulty in drilling boreholes through more complex ground.
- It is possible to leverage the **sustainable** aspect of the proposition, as customers react positively to it and it has been established as more sustainable than gas boilers.
- **Deployment areas** should be selected with attention as technical barriers can limit the proposition. Network stability and housing density were identified here as the two main barriers. The length of trenching (notably because of large front gardens) has also been identified as a driver of cost.
- The **home filtering criteria** should be updated to reflect the new barriers identified above.
- Using this technology for new build or a denser urban area would lift some blocking points.
- Some of the criteria can be extended, namely the technology which could also be used to retrofit **off-gas properties**. These properties would represent in Teignbridge 15% of the final selection.
- As good quality **data** is key in the methodology developed during this project, focus should be made on finding the right data and processing it with attention.
- When the data is missing or not available, as here with data from National Grid Electricity Distribution (NGED) on the capacity and equipment at the secondary substations, a good **engagement with relevant stakeholders** can help fill this gap.
- Given the complexity of the project, of the assessment to be made and of the diversity of the required knowledge, good **collaboration** between multi-disciplined partners is key.
- As this study couldn't demonstrate a high gain from **flexibility**, future work should try to assess further the benefits of flexibility against the cost of thermal storage to conclude on relevance of adopting it.
- Knowledge of GSHPs is lower than other renewables and therefore there is more to be done to ensure that it is recognised as a viable option. Due to the complexities and the large investment the need for a **community led approach** is key to ensuring the consumer has maximum level of trust and comfort throughout the journey.

13. Conclusion

13.1 The Future of Project Gaia

After careful consideration it has been decided that Project Gaia will not be progressing to a deployment phase. Even though the current climate does not allow to consider going further development, it should be highlighted that this project has been a great example of a successful collaboration between multi-disciplined partners. The findings of this feasibility report still allowed each partner to obtain further insight into what the shared loop array ground source heat pump technology requires to be deployed at a large scale. The consortium communicated effectively delivering all work packages on time and in budget. Any issues were escalated quickly and resolves through the effective project management programme.

The feasibility identified three main factors that proved to be obstacles in the present situation. As all the focus groups conducted provided similar findings, it can be concluded with confidence that the current **energy crisis** makes it difficult for customers to invest the large amount needed for the proposed technology. Moreover, the nature of the chosen area made it challenging to meet the installation targets within the **cluster densities** required to make the proposition viable. Finally, the network stability might have limited Phase 2. **Network constraints** would have hampered the project if the original search radius had to be extended.

Overall, this work showed confidence in the proposed concept and technology, but due to the current conditions it has been assessed that going forward would not be rightful to the customers.

In hindsight, the consortium suggests that future projects using similar technology should focus on urban areas with higher population density. One of the highest cost factors of shared ground loop array is the trenching distances. A higher density area would increase the proximity of property, reducing the connection distance to the ground loop array, which would make the installation easier and more cost effective.

13.2 Key Findings

The Heat Pump Ready Programme has allowed the partners within Project Gaia to investigate an innovative solution for large scale deployment of ground source heat pumps. The solution developed here responded to the technical and socio-economic challenges of the adoption of heat pumps with a shared ground loop array. The proposed solution explored the potential of a "split ownership" heating system consisting of three core components, a shared ground loop array, the heat pump controls, and the tertiary system & building fabrics.

Through this project, successful collaboration between multi-disciplined partners has been demonstrated giving confidence in the ability of the consortium members to work together on future projects. EDF Energy will be active in future opportunities to keep collaborating on heat decarbonisation projects with the project partners.

Project Gaia looked at the feasibility of large complex datasets to identify best fitted areas for deployment and reduce survey and design costs. It also looked to develop a customer proposition addressing the majority of the barriers to the adoption of the solution. Finally, the scalability, replicability, and sustainability of the solution has been investigated to make sure of the positive impact a large-scale deployment would have.

This feasibility study found that it was possible to identify three areas of 3,200 homes suitable for a large-scale deployment by using public data. It was then possible to estimate their energy demand and to classify them in different archetypes to estimate the deployment price in total and for the customer. An appropriate training module could also be developed. However, the stability of the network has been found to be too weak to allow a potential extension of the search radius during a trial. The study also found that the house density of the target area reduces the cost-effectiveness of the solution.

Moreover, Project Gaia demonstrated the possibility to develop a customer journey capable of creating customer engagement even though the awareness toward the technology is low. However, it found that even with a business model tailored to reduce the customers upfront costs, these are still too high in the current energy crises climate to have confidence in a large adoption of the solution by customers. Feedback from prospective customers and general consensus is that this technology may not be the right one for retrofit communities in the current financial climate.

Future development of the technology should focus on addressing the challenges faced during the project and listed above. Working with financiers to develop competitive financing solutions and looking at different types of areas, for instance urban areas, are the two main recommendations coming out of this feasibility study. Another way of creating an appealing customer proposition could be coupling heat pumps with other technologies in the house such as solar panels or batteries.

Overall, even with a majority of positive outcomes both on the technical and commercial aspects, the findings of this study do not allow the consortium to confidently progress to a Phase 2 application.

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15. Annexes

15.1 ASHP and GSHP comparison

- Are GSHP the most efficient heating systems?

Measured data and manufacturer/installer values both agree that GSHP outperforms ASHP in terms of COP, although the difference is slight. Values from Table 41 suggest that GSHPs on average consume 10% less electricity to generate a given amount of heat.

Table 41: Values for Seasonal performance factor (SPF)

ASHP	GSHP	Source
2.41	2.77	Mean from RHPP data (SPFH4). (19)
2.67	3.02	Upper quartile from RHPP data (SPFH4). (19)
2.64	2.93	Mean from RHPP data (SPFH2). (19)
2.95	3.14	Upper quartile from RHPP data (SPFH2). (19)
2.71	3.07	OFGEM field data. (20)
2.5	2.5	Min to qualify for RHI.4 (59)
2.8	3.1	Min ‘design’ SPF for latest RHI installations. (59)
3.5	3.8	Median ‘design’ SPF for latest RHI installations. (59)
4.1	4.6	Max ‘design’ SPF for latest RHI installations. (59)

- Are GSHP the lower-carbon heating system?

Ground source heat pumps have higher efficiency, therefore use less electricity. They have therefore a lower running cost, they emit less carbon and have a lower impact on the grid. This has been evidenced by every in-use performance study found. (19) (20)

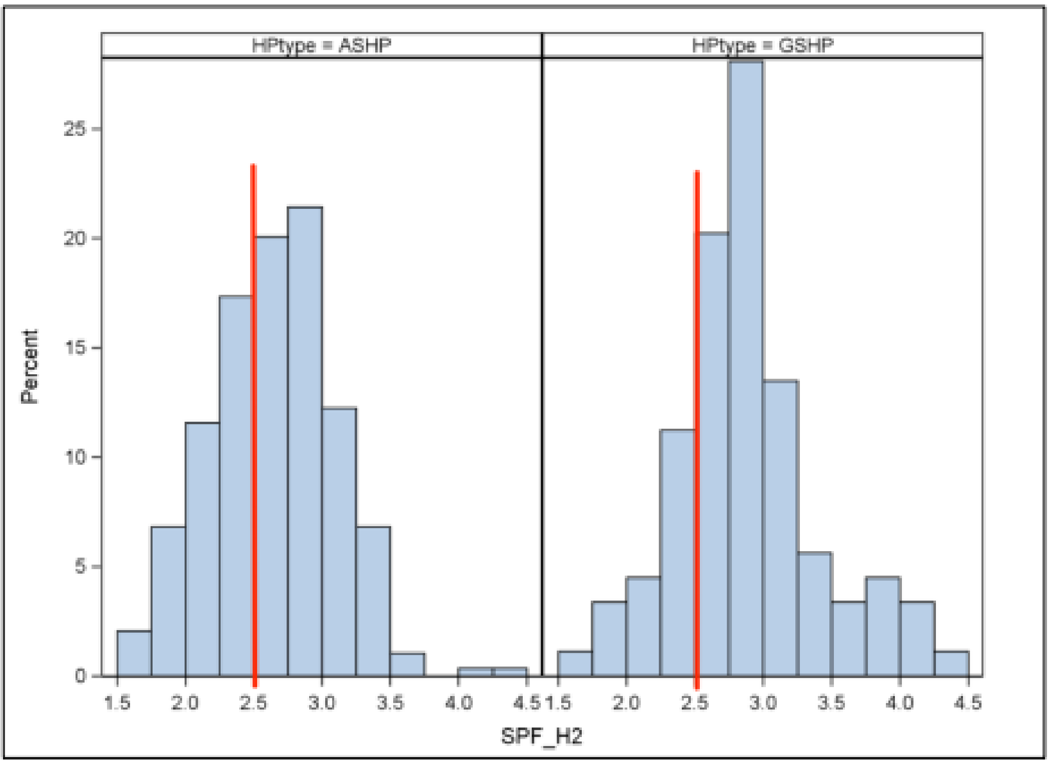


Figure 64: Histogram showing % failing to atchieve SPFH2 of at least 2.5. ASHP, left. GSHP, right. (19)

15.2 Network Analysis (WP2.2)

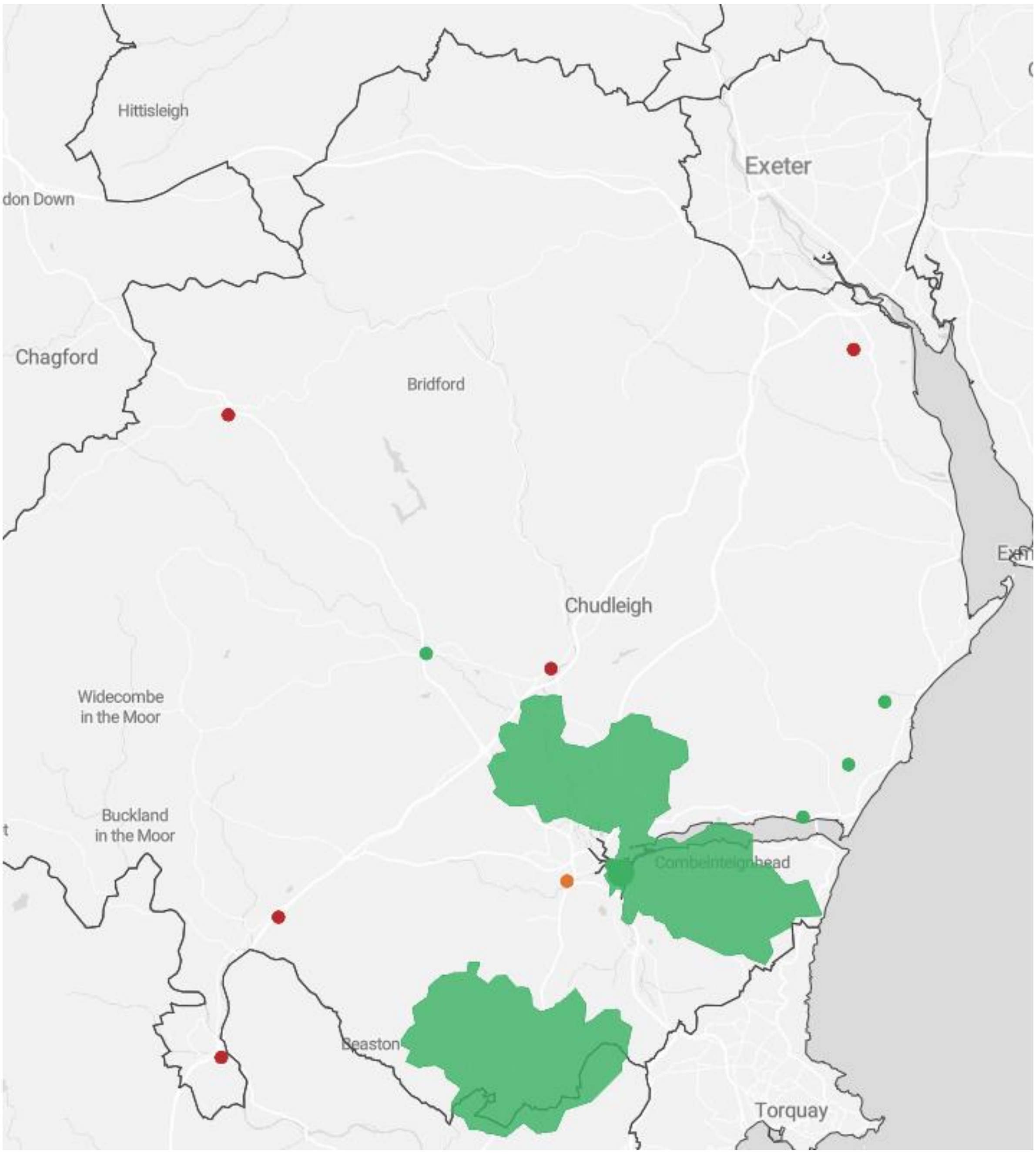


Figure 65: Map showing the supply area of Newton Abbot primary substation.

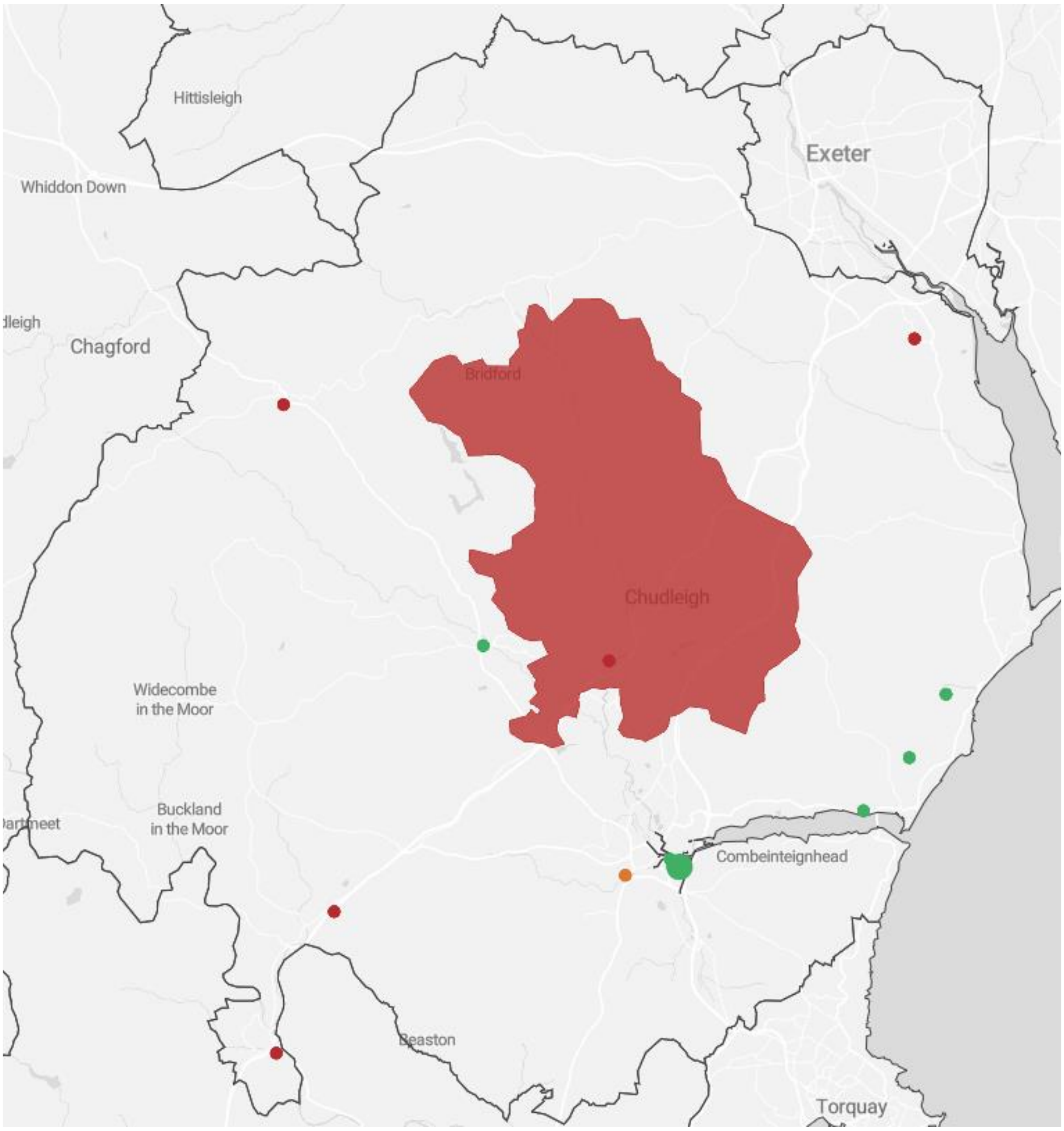


Figure 66: Map showing the supply area of Chudleigh Knighton primary substation.

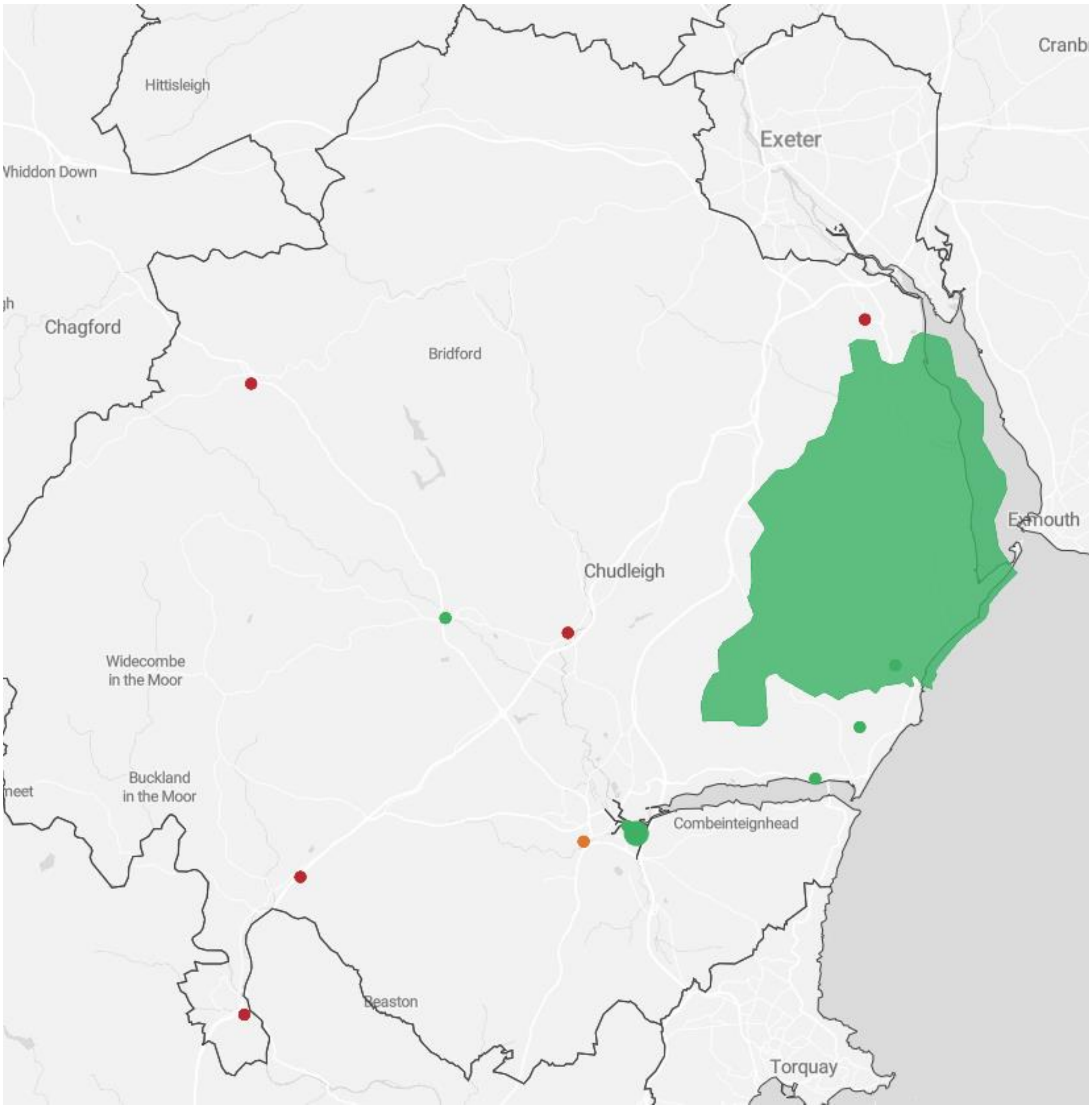


Figure 67: Map showing the supply area of Dawlish primary substation.

Figure 68: Map showing the supply area of Bovey Tracy primary substation.

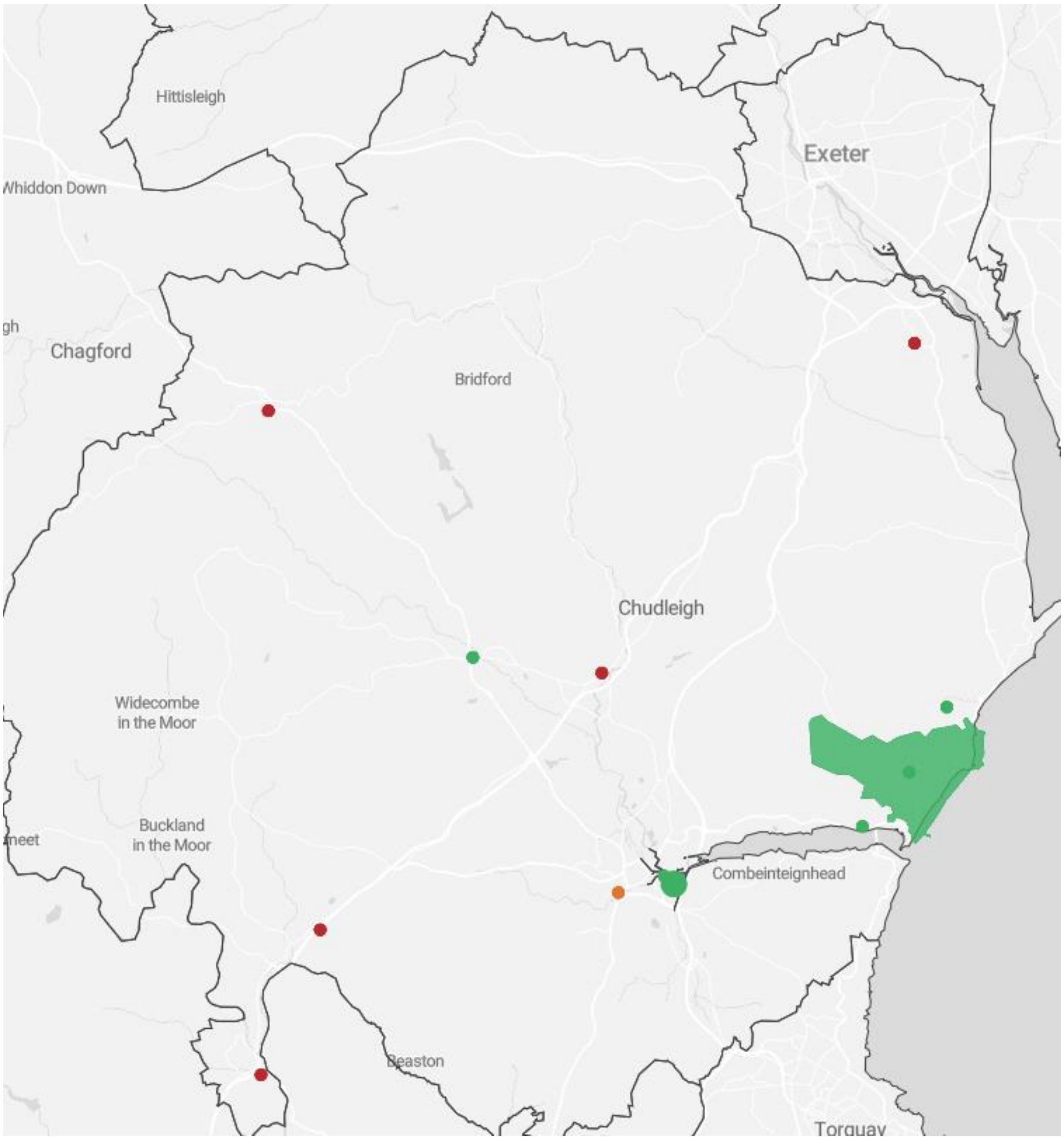


Figure 69: Map showing the supply area of Higher Woodway primary substation.

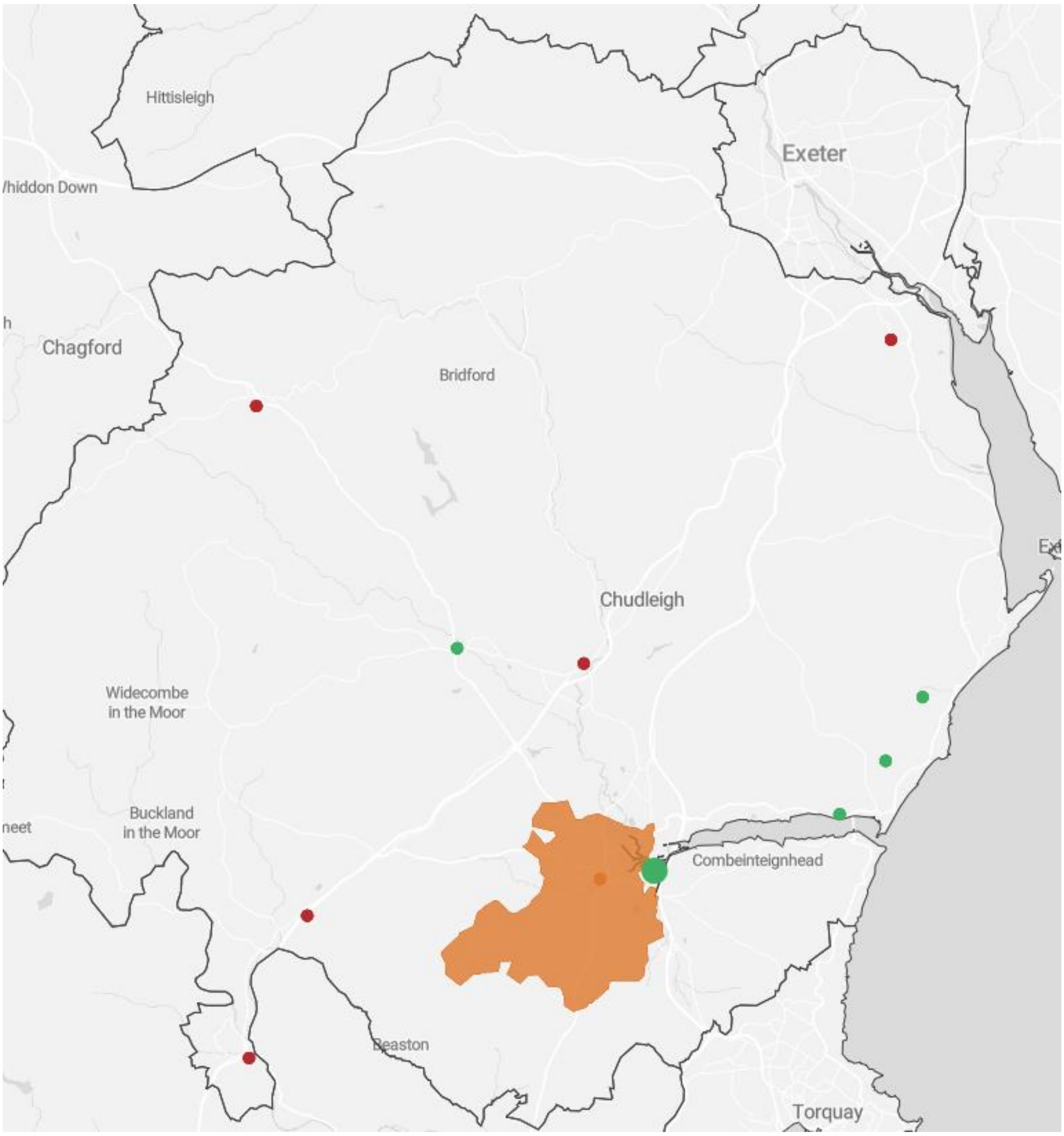


Figure 70: Map showing the supply area of Bradley Lane primary substation.

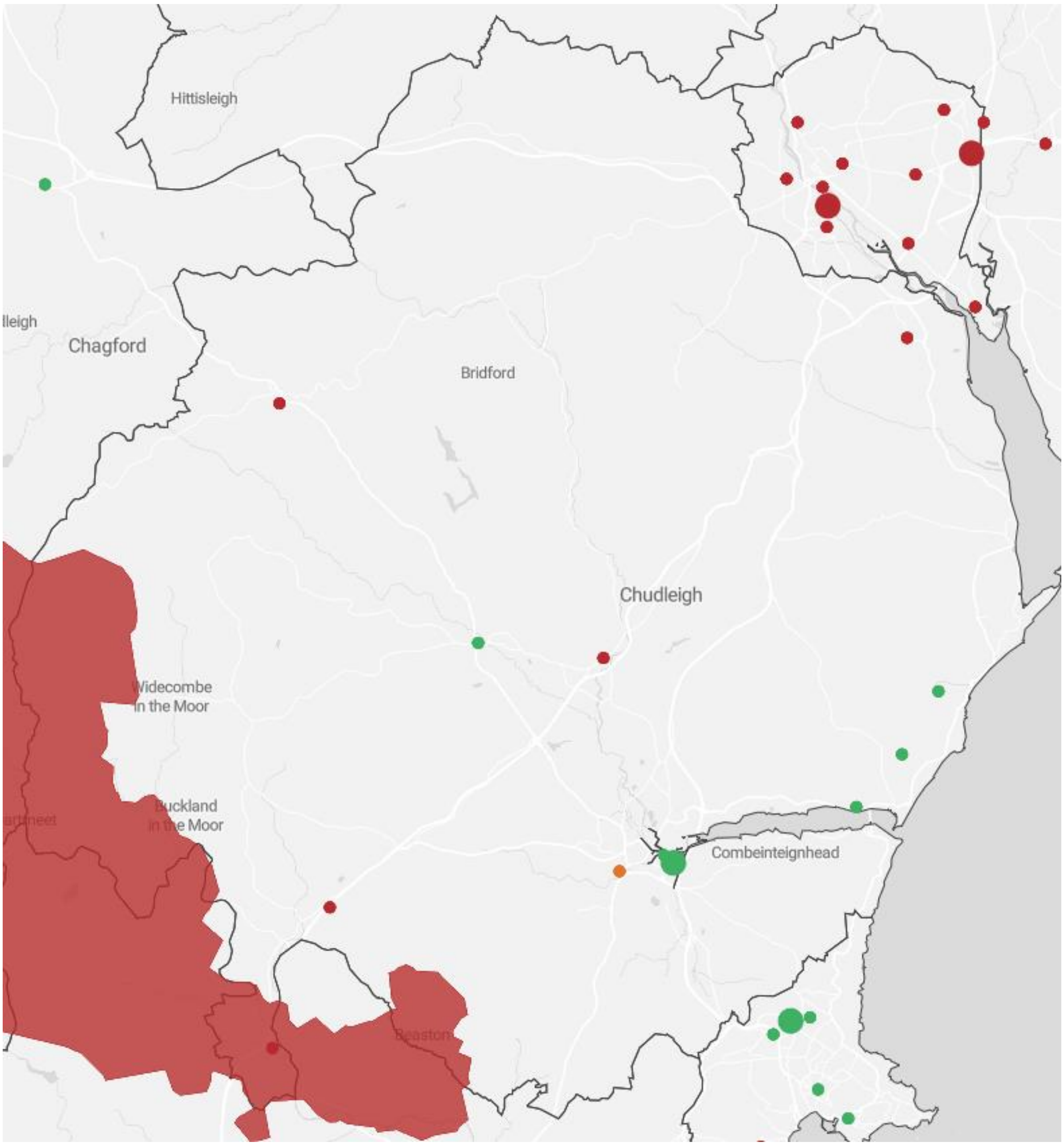


Figure 71: Map showing the supply area of Buckfastleigh primary substation.

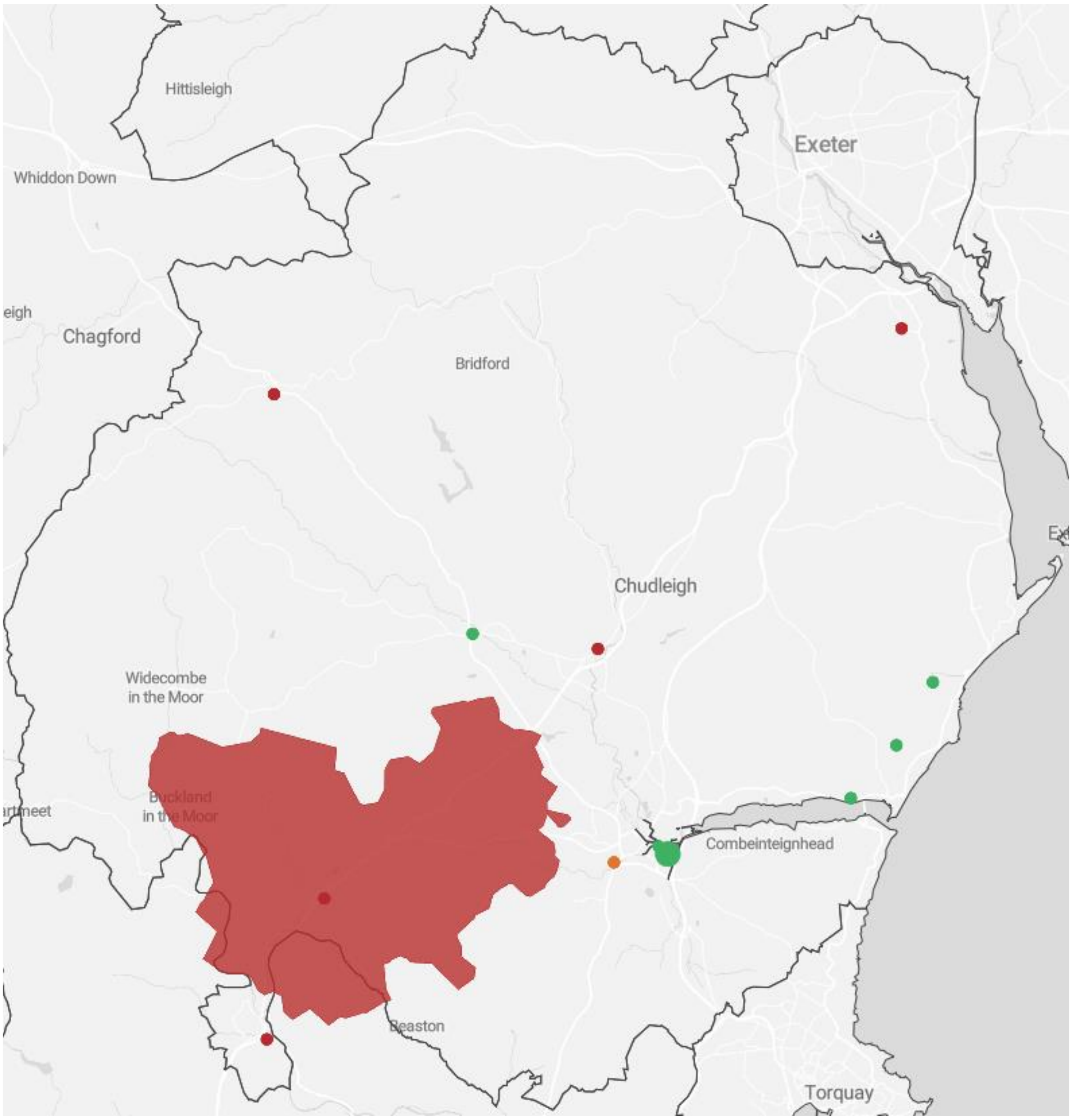


Figure 72: Map showing the supply area of Ashburton primary substation.

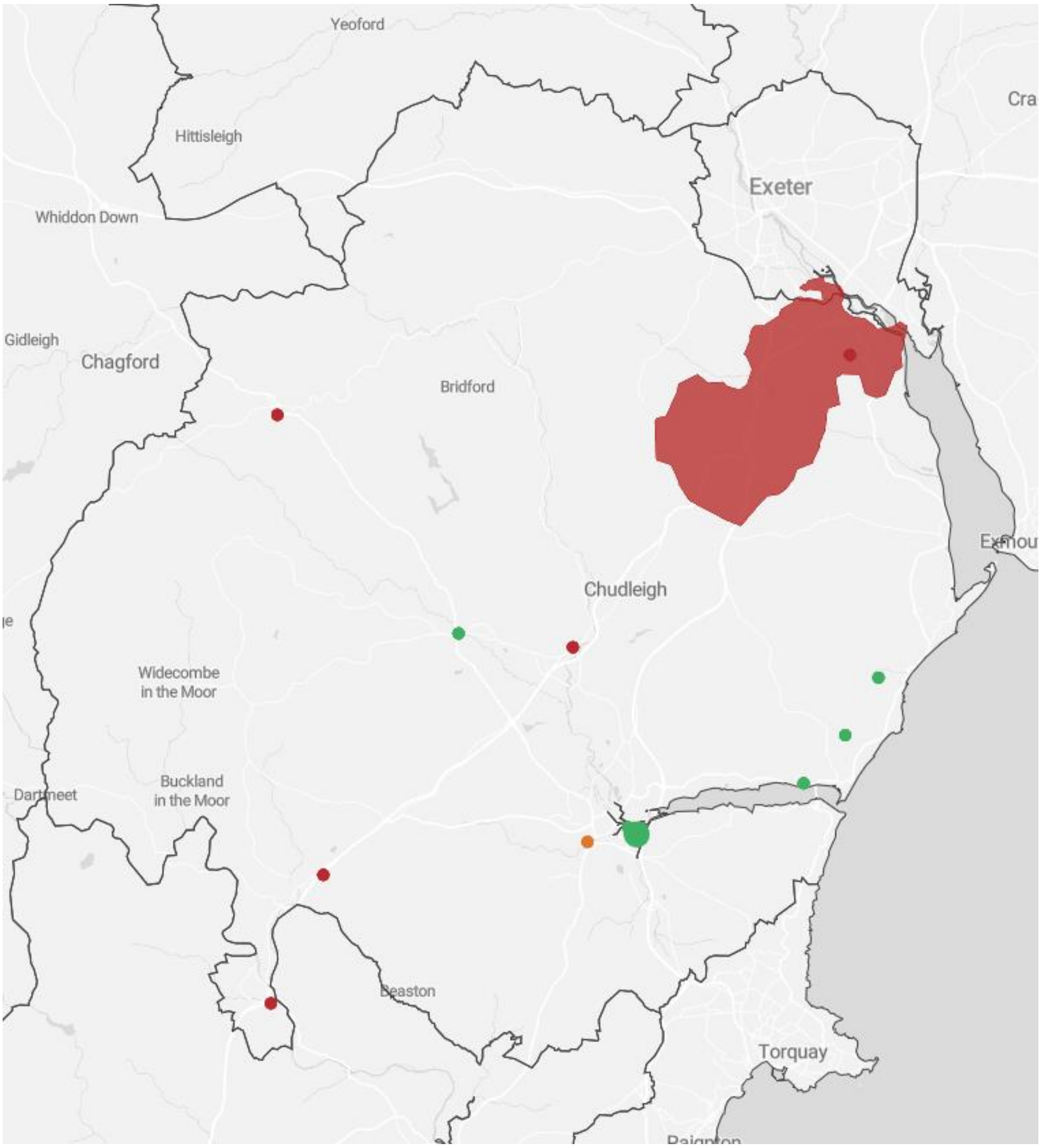


Figure 73: Map showing the supply area of Exminster primary substation.

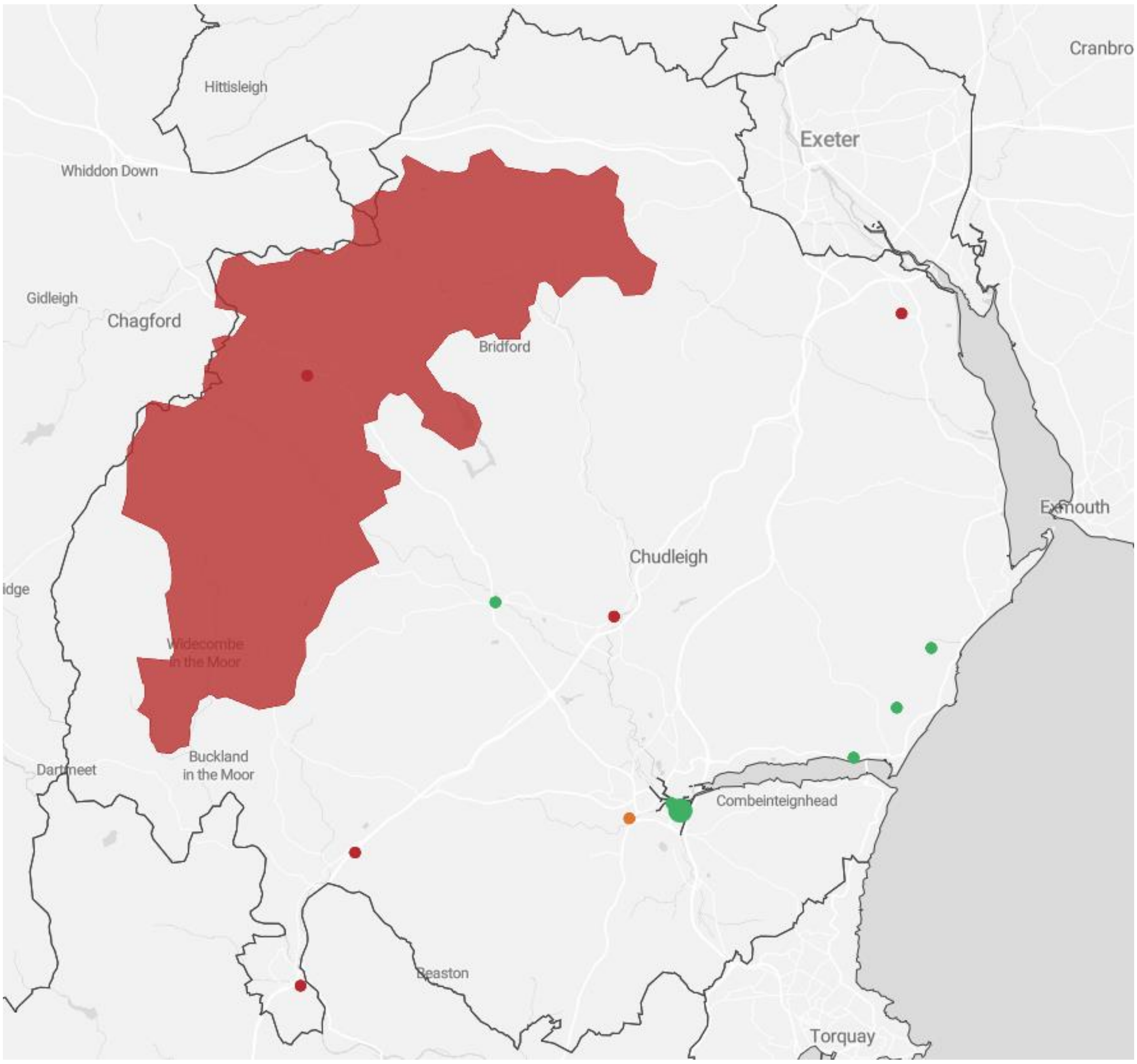


Figure 74: Map showing the supply area of Mortonhampstead primary substation.

15.3 Data Integration (WP2.3)

- Building stock analysis

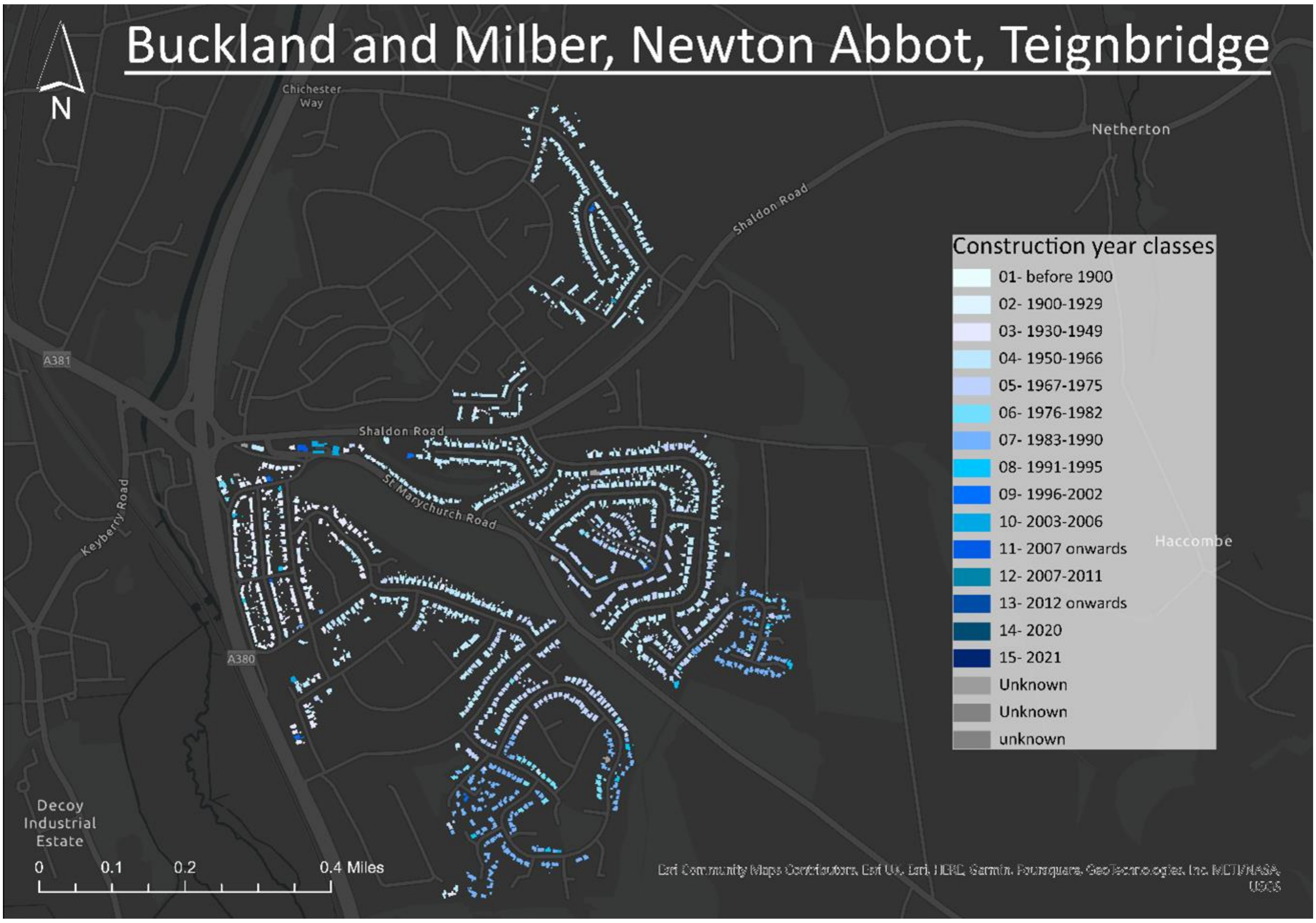


Figure 75: Buckland and Milber Construction year classes

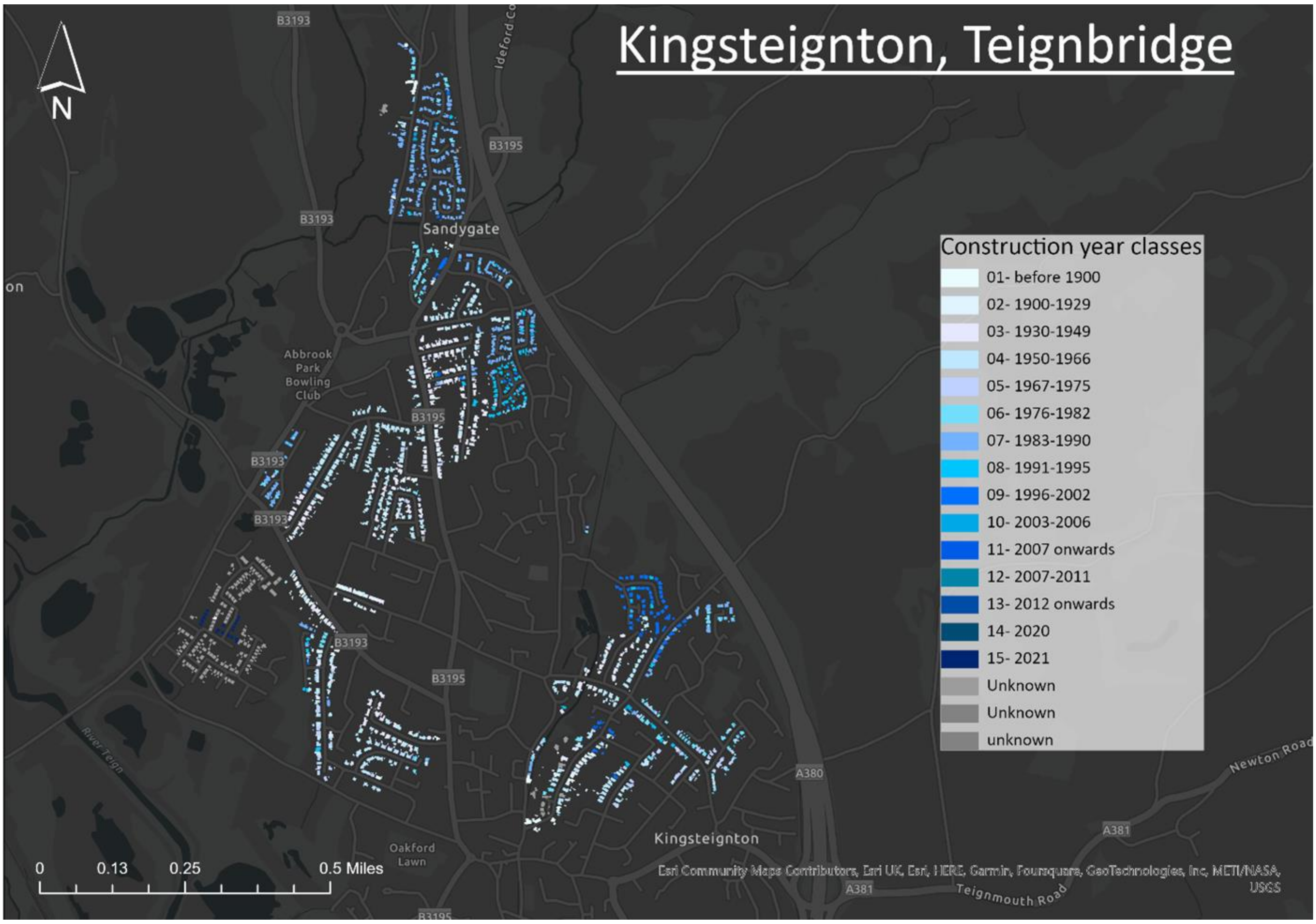


Figure 76: Kingsteignton Construction year classes

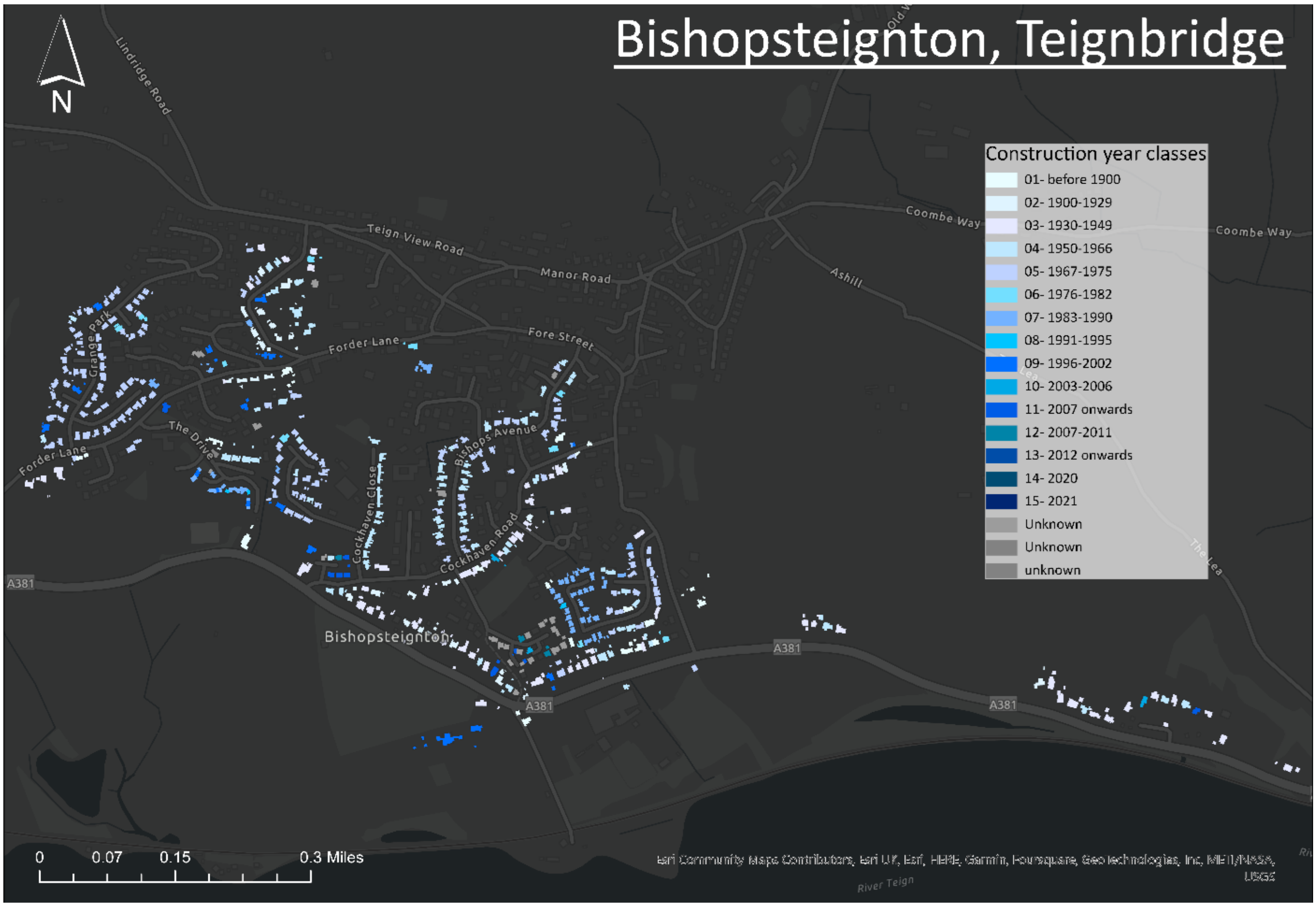


Figure 77: Bishopsteignton Construction year classes

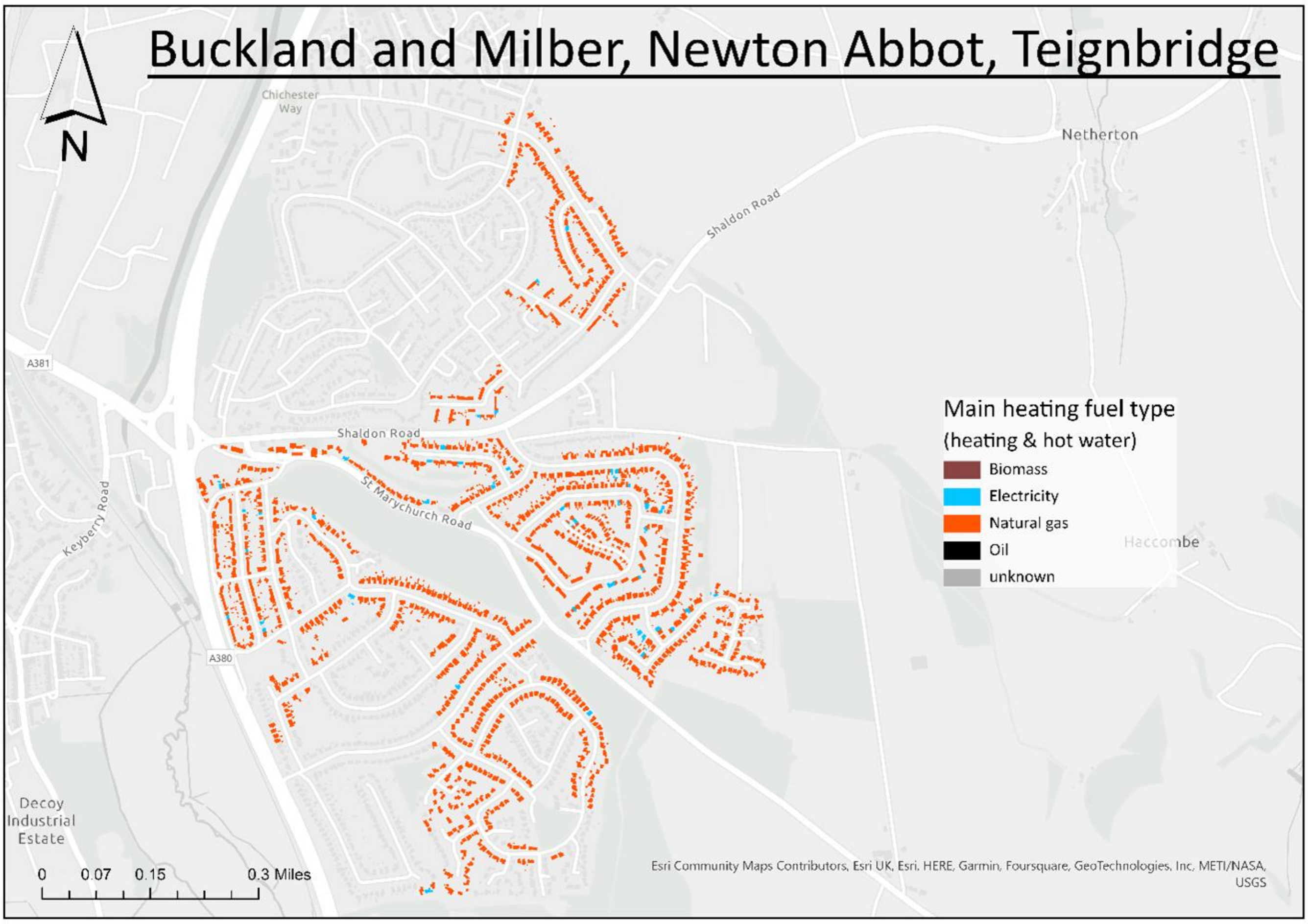


Figure 78: Buckland and Milber Main heating fuel type

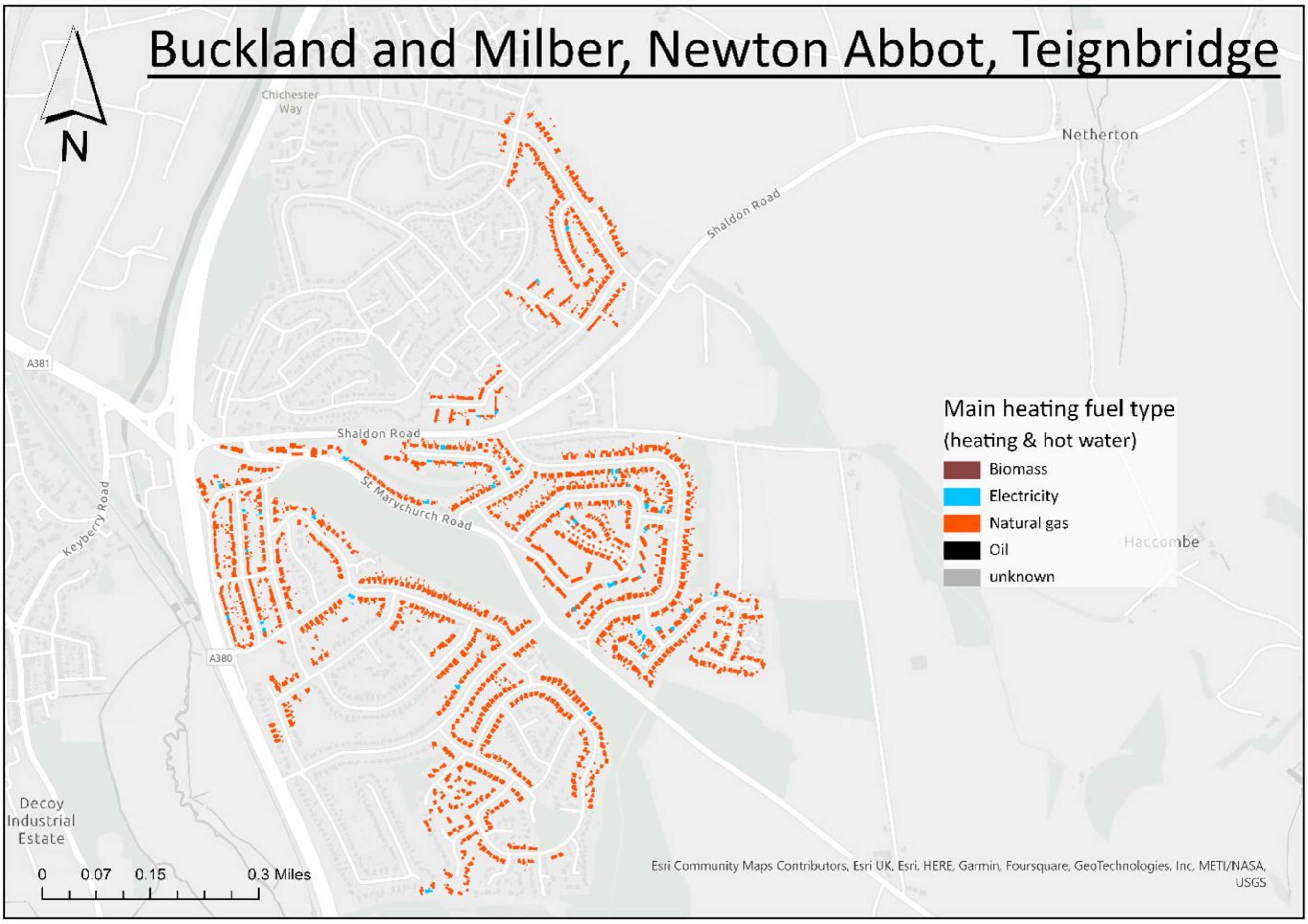


Figure 79: Kingsteignton Main heating fuel type

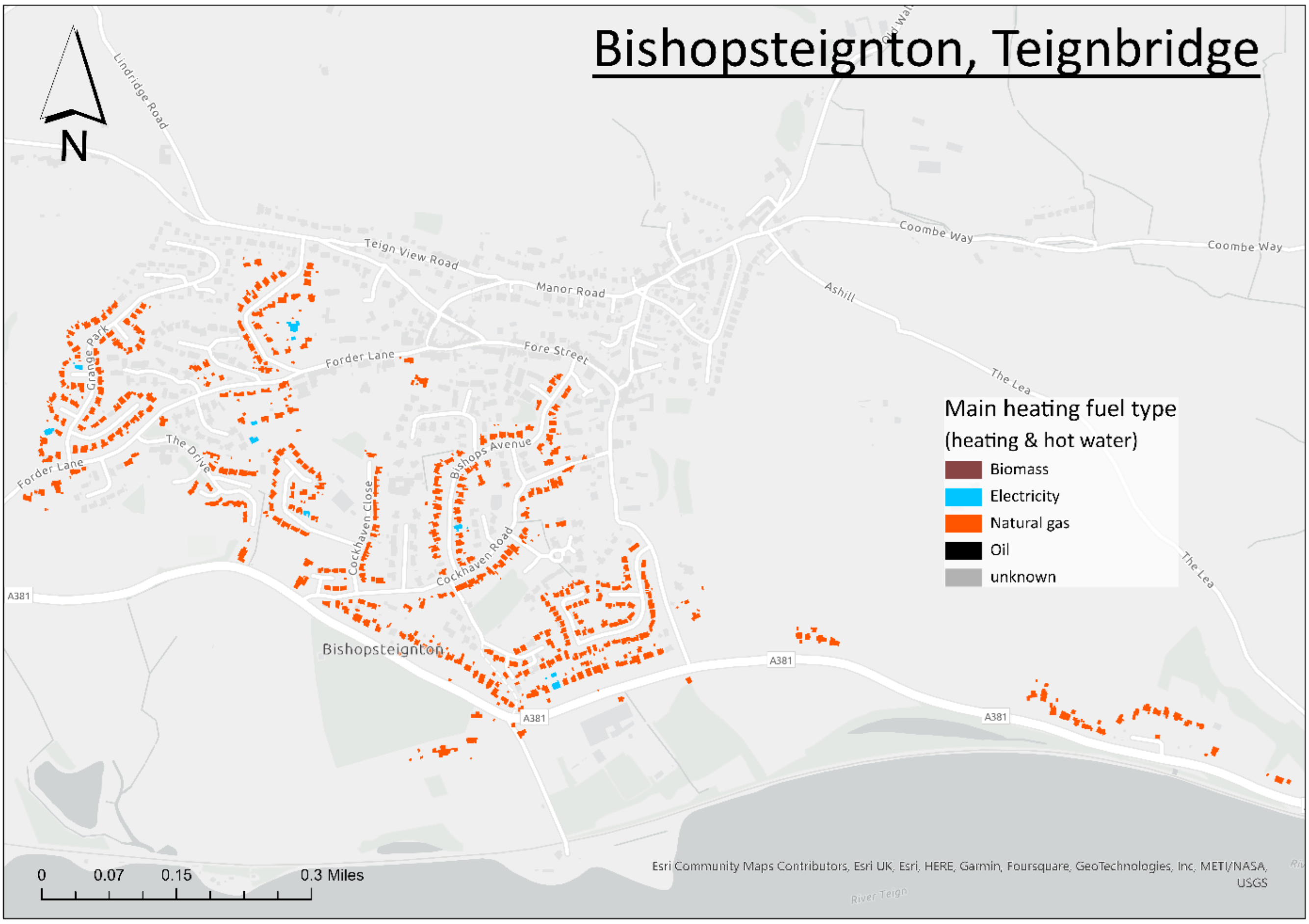
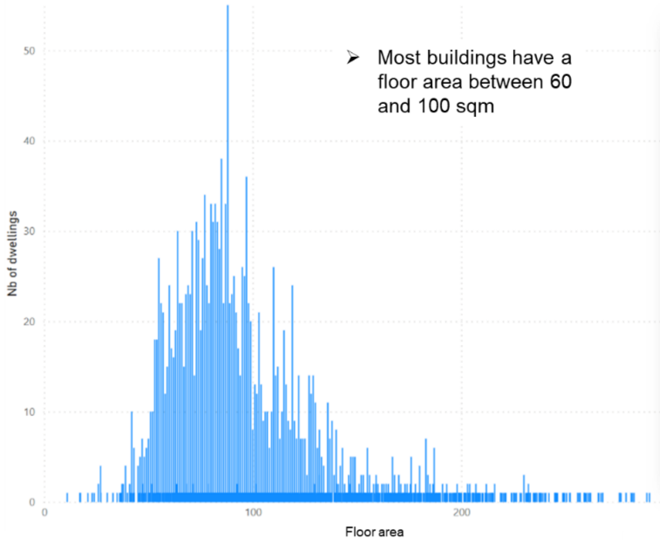


Figure 80: Bishopsteignton Main heating fuel type

- Building stock analysis Results

Number of dwellings by floor area



Share of the Fuel Type (heating & hot water) in the building stock
Most of the electric heating systems have been ruled out during the selection process

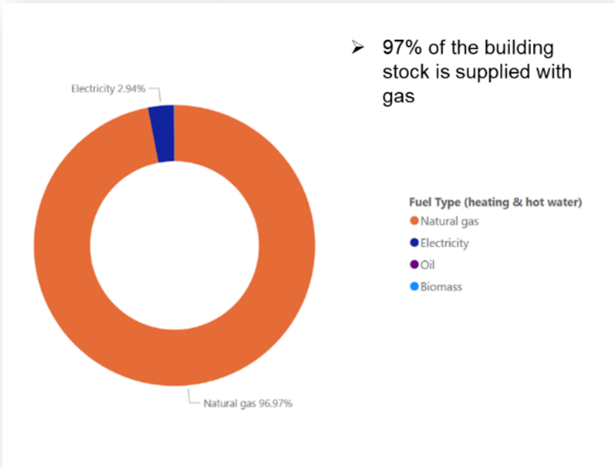


Figure 81: Building stock analysis – Heating systems

Number of buildings by Construction year

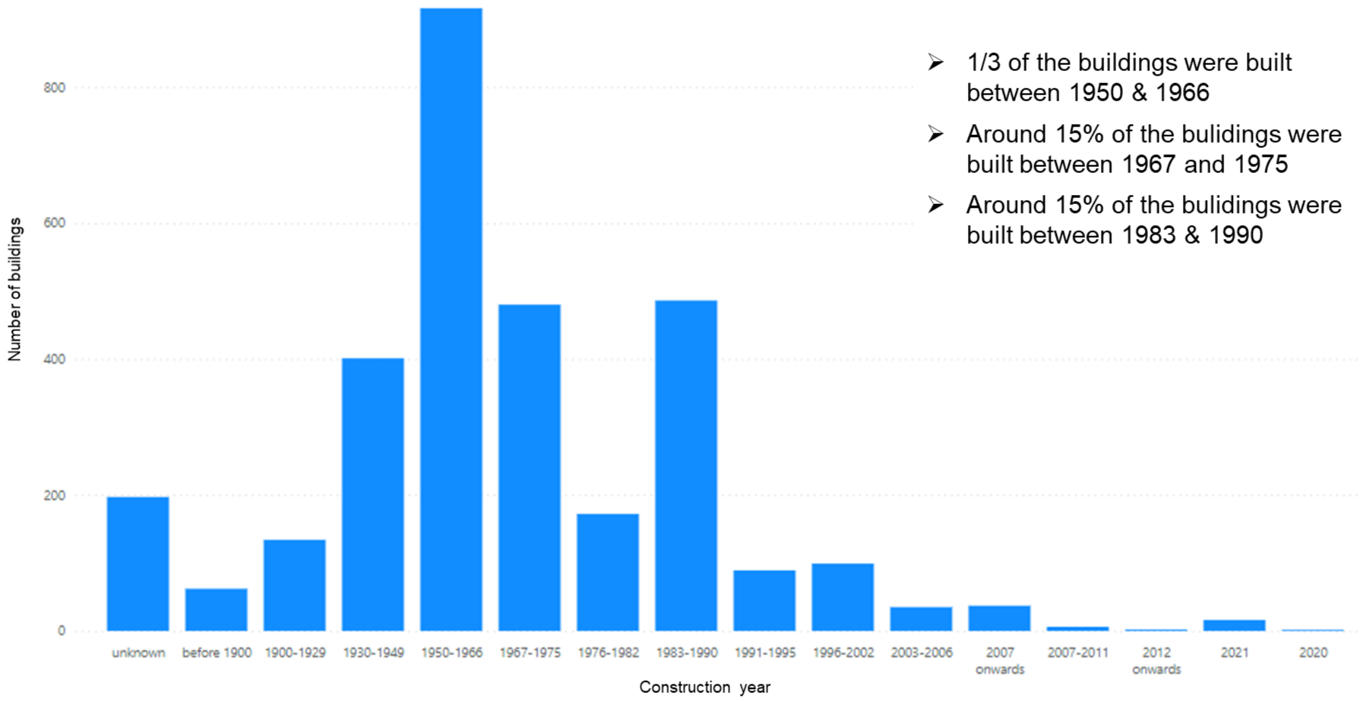


Figure 82: Building stock analysis – Construction years

15.4 Business Model Design (WP3.1)

Heating Source	Gas Boiler	Electric	Air Source Heat Pump	Ground Source Heat Pump	Shared Ground Loop Array
Efficiency (the more usage you'll get from a unit of power)	93%	100%	300%	350%	**400%**
Investment costs	£3,000	£3,000 - £6,000	£12,000 - £17,000	£18,000 - £24,000	**£12,600**
Annual connection/ standing charge	£103.98	£169.21	-	-	**£756**
Maintenance costs per year	£80	£80	£160 - £180	£80	**£80**
Replacement time	5 - 10 yrs	5 – 10 yrs	12 – 15 yrs	15 – 20yrs	**15 – 20yrs**

15.5 HP Customer Offer (WP3.3)

Heat as a Service (Future expected service)

What is heat?

Fuel input

kWh of fuel used by the heating appliances

Heat output

kWh of heat generated by the appliances – depends on the efficiency.

Warmth outcome

The temperature of the space being heated – depends on the property size thermal efficiency and behaviour of inhabitants.

Ref: https://www.delta-ee.com/blog/defining-heat-as-a-service/

Heat as a Service (Future expected service)

What is a service?

For the heating appliance

Service provider charges a recurring fee to lease and maintain the heating appliances rather than selling the product as a one-off

For heat use

Instead of charging for units of fuel consumed, service provider charges for the heat and warmth generated. The monthly fee might be fixed or usage dependent

Ref: https://www.delta-ee.com/blog/defining-heat-as-a-service/

Heat as a Service (Future expected service)

What is heat as a service?

Heat as a service is defined as a business model where the service provider takes on the following five risks, all of which (other than energy price risk) have historically been borne by the customer.

Financial risk
The credit risk for providing a heating appliance for a little or no upfront payment

Technical risk
Routine maintenance and repairs for the heating appliances

Performance risk
The efficiency of the heating appliances, heat distribution system and the customer's property

Behaviour risk
The impact of customer behaviour on quantity and timing of heating demand

Energy price risk
Fluctuations in wholesale energy prices

Ref: https://www.delta-ee.com/blog/defining-heat-as-a-service/

Heat as a Service (Future expected service)

What is heat as a service?

Other variants

Energy as a service
Service includes the supply of both heat and electricity, for uses other than heating such as lighting and electric vehicle charging.

Comfort as a service
Service includes both heating and cooling in order to maintain a customer's home within a set temperature range e.g. 20±2°C

Ref: https://www.delta-ee.com/blog/defining-heat-as-a-service/

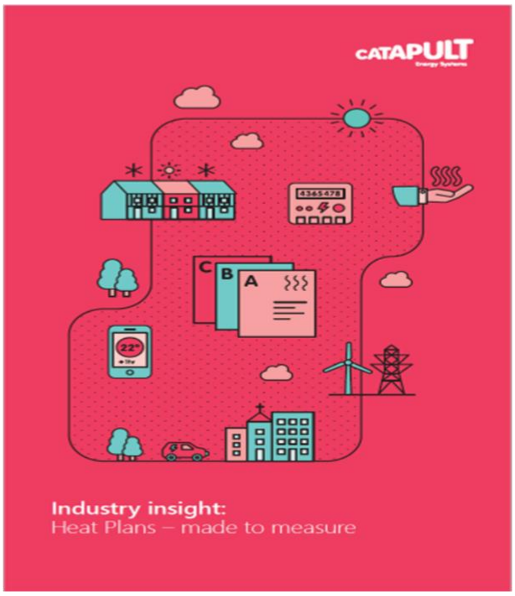
Heat as a Service (Future expected service)

What's on the market today?

Business model	How it works
Asset leasing	Service provider charges a fixed monthly fee to lease the heating appliance. The fee includes routine maintenance and repairs. For example: Feenstra offer boiler rentals in the Netherlands and OK offers heat pump leasing in Denmark.
Efficient asset leasing	Like asset leasing, except with some kind of performance guarantee. For example: Danish service provider Best Green reimburses customers for electricity used by its heat pumps.
Energy payment plan	An alternative way of paying for energy which does not include the heating appliances. For example: Spanish energy supplier Naturgy bundles together energy supply and maintenance services for a fixed monthly fee and the energy systems Catapult is trailing a "warm hours" model in the UK.
Heat (output) as a service	Service provider leases heating appliance and also supplies the fuel consumed. Customers are charged per unit of heat generated. Several German energy suppliers offer this kind of service with gas boilers, as do Thermondo and Viessmann.
Heat (outcome) as a service	Similar to heat (output) as a service, except customers are charged for warmth rather than heat generated. For example: Energy supplier Eneco is trialling offering 20°C for a fixed monthly fee with heat pumps in the Netherlands.

Ref: https://www.delta-ee.com/blog/defining-heat-as-a-service/

Heat as a Service (Catapult model)



Heat as service was proposed by **Catapult** and it was trailed by several energy suppliers in UK. (**Bristol energy and Baxi**).

Customers will pay based on warm hours instead of paying price for kWh of electricity.

This plan was brought for customers easy understanding but customers pay more than they were paying in previous system

Ref: https://es.catapult.org.uk/project/heat-the-streets/

Heat as a Service (Catapult model)

Baxi Heating UK trial bundling a heating system into a Heat Plan

- Fixed price, no upfront cost
- Fixed monthly price that includes everything (service, maintenance, installation, etc.)

Bristol Energy trial fixed price and Pay-As-You-Go Heat Plans

- Pay upfront cost which covers installation cost
- Then a monthly plan for hot water and warm hours
- Advantage is improved control and comfort, certainty of price.

Trialling hybrid heating systems

- Both HP and existing gas boilers are used.
- This method was trialled to understand how systems worked with smart controls as a part of heat plan and whether consumers could achieve the same comfort level.
- Customers didn't hear the HP running so it was noiseless. With HP they reduced the usage of gas boilers. With HP they were able to attain the same comfort as it is with gas boiler. After the trail 80% of the customers wished to remove gas boilers and entirely rely on HP.

BAXI Innovative Heating & Cooling Systems

BRISTOL energy

Ref: https://es.catapult.org.uk/report/the-potential-of-heat-as-a-service-as-a-route-to-decarbonisation-for-scotland/

Challenges for Heat as a Service

Data Communication
Understanding the customer requirements and their behaviour.

Coordination between stakeholders and engagement of end users.

Lack of proven market

Lack of proven skills and capacity

Lack of finance for transition to enabling technology

Lack of strong policy

Ref: https://ukerc.ac.uk/news/heat-as-a-service-understanding-evidence-needs-and-research-gaps/#:~:text=Some%20of%20these%20challenges%20include,finally%20lack%20of%20strong%20policy.

15.6 Customer Journey Proposition (WP3.4)

	Phase 2a Jan 23 - Jun 23							
	Launch/Awareness		Engage & Recruit		Design			
Stage	Project Soft Launch / National Awareness	Local Launch / Local PR /Street and property leaflet drops	Express interest	1:1 with resident liaison	Home Survey	Design	Contracts/ Ball Park Quote	Phone call to discuss
Timings	-3weeks	-1week	0	+1 week	+1 week	+1 week	+3 days	+2 days
Channel	Social Media	Print/ Press	Web	Face 2 Face	Face 2 Face	Email	Email	Phone

	Phase 2b Jul 23 - Dec 24								
	Engagement		Delivery					Evaluation	
Stage	Phase 2 Gate updates	Final Contracts Signed (inc 14 days cooling off)	Finance Arrangements	Installation - external works (5 days)	Installation - internal commissioning	Aftercare	Value Products	Customer Survey	Ongoing support
Timings	+6 weeks	+2 weeks		+4 weeks	+5 days	+10 days	+1 week		ongoing
Channel	Email / Print/ Face 2 Face	Electronic	Electronic	Face 2 Face	Face 2 Face	Phone / Email	Email		Phone/Web/Email

Figure 83: Customer Journey Proposition Overall View

15.7 Customer Analysis (WP4.1)

15.7.1 Focus Groups Topic Guidance

RELISH
INSIGHTS WITH FLAVOUR

PROJECT GAIA - GROUND SOURCE HEAT PUMP LOOP ARRAY

Group Discussions – 2 hours
Oct 2022
Version 1

REMINDER OF KEY RESEARCH OBJECTIVES AND NOTES:

1. Understand knowledge, interest, drivers and barriers of proposition
2. Inform development of marketing strategy of the arrays in Teignbridge
3. Understand willingness and needs for community outreach programme

SAMPLE AND KEY INFO:

G	Segment	Quotas	Date	Time	Location
1	**Retired and Older Families**	Live in semi-detached, detached or terraced housing, with at least 2 bedrooms X3-4 males & X3-4 females per group ABC1C2 (spread) £35k+ annual income Open to idea of having a heat pump (and not to currently have one); able to afford a heat pump Environmentally engaged Mix of energy providers, all to be energy bill payers	Monday 3rd October	5.00pm – 7.00pm	Online Zoom Groups **Conducted using a laptop or tablet**
2	**Singles, Couples and Younger Families**			7.30pm – 9.30pm	

Introductions (5 Mins)

Objective: Allowing people to join the Zoom, introducing them to the session and each other

Key points to cover:

- Thank everyone for coming to the session and remind them group/depth with last 2 hours
- Explain topic for discussion is about energy sources and building on your pre-task
- Explain we work for an independent research agency
- No judgements or right / wrong answers
- Encourage people to share views openly, but respect each other's opinions and try not to talk over each other
- May have to move them on as lots to cover
- Everything confidential and shared only with those present and end-client
- Explain recording and viewing (if applicable)
- Have a pen and paper to hand to make some notes

Any questions?

- Participant introductions – who is at home, what type of property do you own, and how long for?

1. CURRENT ENERGRY ATTITUDES (10 Mins; Total 15 mins)

Objective: A brief and very broad intro into the current climate to understand the context in which people might consider GSHPs and the extent to which current costs, uncertainty, climate issues, government targets are impacting their thoughts

- How do you **feel about energy** at the moment?

- To what extent are your thoughts/feelings driven by...
    - Costs?
    - Uncertainty / world events?
    - The environment?
    - Government targets / energy agendas?

- Today, as you know, we're going to be looking at different ways of sourcing our energy – **what do you know about other energy sources?**
    - Which ones have you looked at, or considered, in the past?
    - What has prevented you from moving to an alternative source?
        - Costs? Value? Knowledge? Time?

___

2. PROPOSITION KNOWLEDGE (15 Mins; Total 30 mins)

Objective: Building on the pre-task work to understand current knowledge & perception of GSHPs, particularly shared arrays to uncover immediate knowledge gaps, drivers and barriers

We asked you to look into Ground Source Heat Pumps as part of your pre-task and are keen to discuss these in detail now. I'll put some information up on screen as a refresher too. As a reminder, we're focussing on the shared aspect here...

MODERATOR TO SHARE INFO ON GSHPs SLIDE (S2)

MODERATOR NOTE: Ensure conversation is guided towards 'shared' proposition

- How **easy or difficult** did you find it to **understand** the premise of the idea?
  - What did you find most difficult to understand, or consider?
  - *If not covered;* Specifically, how much did you understand about the shared ground source?

- How **appealing** did you find this idea?
  - What did you like most about it?
  - Why is this appealing?

- What do you perceive to be the **key benefits** of a system like this?
  - How **motivating** are these benefits?

- What do you feel are the **main barriers** to a system like this?
  - What, if anything could **reassure/overcome** this?

- **What else** do you need to know at this stage?
  - How would this **help** you?

MODERATOR TO SHARE INFO ON PROCESS (S3)

- Without looking at specific costs at this stage, **how do you feel about the overall process of upfront and ongoing engagements**?
  - Anything here unexpected / interesting?

3. POSITIONING & MESSAGING (40 Mins; Total 1 hr 10 mins)

Objective: Explore the key positioning of the proposition, as well as supporting value propositions to understand motivating messages and inform campaign development

MODERATOR TO SCREEN SHARE PROPOSITION 1 (S4 or S5, rotated)

I'm going to share with you 2 slightly different ways of talking about this system. They're both talking about the same thing, but we're interested to know which angle is most appealing. Don't worry too much about the specific language

- *Positioning 1:*
  - How do **feel about this way of talking** about GSHPs?
    - Which element is most **interesting**?
    - How/why is price certainty **motivating**?
      - **What else** would you need to know to make this more interesting?
  - Looking at that top statement, how closely does this align with **how you're feeling**?

MODERATOR TO SCREEN SHARE PROPOSITION 2 (S4 or S5, rotated)

- *Positioning 2:*
  - How do **feel about this way of talking** about GSHPs?
    - Which element is most **interesting**?
    - How/why is saving carbon **motivating**?
      - **What else** would you need to know to make this more interesting?
  - Looking at that top statement, how closely does this align with **how you're feeling**?

- *Compare:*
  - **Which way** of talking about Shared GSHPs is **most interesting** to you? **Why**?
    - Which would make you **more likely to consider the next steps**?
    - Which do you think would be most motivating for your neighbours?
    - **What else** would you need to know at this point?

MODERATOR TO SCREEN SHARE PROPOSITION ATTRIBUTES (S6)

Let's now look at some different benefits of the system. I'd like for you to take a moment to read them all and write down your top 3 and bottom 3. Your top 3 should be the messages that make this system most appealing, and your bottom 3 should be the messages that have the least impact on you

- I'd like each of you to **share your top and bottom 3** – *Moderator to record each person's ranking*
  - What is motivating about [highest ranked statements]?
  - Why are [lowest ranked statements] not as interesting?

MODERATOR TO SCREEN SHARE ADDITIONAL BENEFITS (S7)

Let's now look at some other details about the shared GSHP system. Again, take time to read and write down which 1 or 2 statements grab your attention and increase your interest, and 1 or 2 which have little impact

- Which of the statements are **most appealing?** Why?
- Which of the statements are **least appealing?** Why?

CURRENT LEVEL OF APPEAL

- Now that we've looked at a bit more detail, **how appealing are you finding this idea**?
  - What have been the things that have **drawn your attention the most**? What is driving your desire to explore more?
  - What has **failed to capture your imagination**?
  - What **barriers** exist for you to consider this idea?
  - **What else** do you need to know at this point?

Depending on time & group energy, offer participants a 2-3 min break

---

4. COST INTRODUCTION (20 Mins; Total 1hr 30 mins)

Objective: Introducing possible cost models to the conversation to see what, if any, impact it has on the overall appeal of the proposition and understand reactions

MODERATOR TO SCREEN SHARE PROCESS OF INSTALL AS A REFRESH (S3)

- Looking back at this process, **what level / type of costs are you expecting** to encounter should you take this up?
  - Where do you **expect the most cost** to come from?
  - How do you think **ongoing costs** would compare to what you're paying now?
  - Why do you say that?

MODERATOR TO SCREEN SHARE COSTS (S8)

- How do you **feel** about the possible costs here?
  - To what extent does this feel **like good value for money** based on what you know about shared GSHPs?
- How does this **compare with your expectations**?

- How do you feel about the **upfront costs** for the Heat Pump and the in-home upgrades?
  - What impact does this cost have on your likelihood to investigate further?
  - *If cost is a barrier* - What kind of incentives / discounts would you be expecting to make this more appealing?
  - To what extent would you be expecting ways to spread upfront payments?

- How **likely** would you be personally to drum up this support?
  - What **additional information** would you need to support this?
  - What might **prevent you** from doing this?
    - Probe if needed – time, knowledge, disruption caused by set up, costs, relationship with neighbours?

- What **support** would you need if you were to be the one leading on your street?
  - What levels of information provided could encourage you to do this?
    - Provide you with materials?
    - Sign up for an event to learn more?

- What **financial** support, if any, would encourage you?
  - If you were to get money off some of your upfront commitments, **what level of discount would you expect?**
    - To what extent would a £6k subsidy help? *i.e. the heat pump paid for?*
  - To what extent would you prefer **individual discount vs group discounts?**
    - E.g. each person gets a discount depending on the number of neighbours you recruit vs you're the sole earner of the discount? (Use S10 if needed)
  - What else would you consider financially to be the driver of this effort?
    - Up front vs recurring discount?

- How would you feel about...
  - Zero interest for 3 years?
  - Spread over 3, 5, 10 year periods (with interest)?
  - Flexible upfront and finance deals?
- Which would be most interesting?

- How do you feel about the **ongoing costs** for connection, maintenance and tariff?
  - *If cost a barrier* – What would be an acceptable monthly cost? How do you come to that decision?
  - To what extent would you like to see combined costs – for example, tariffs and maintenance?

MODERATOR TO SCREEN SHARE COST COMPARISONS (S9). Note: covered briefly only

- Here's how these costs **compare** vs other sources of power
  - What impact, if any does this on your perception of the costs we have explored?

5. COMMUNITY ENGAGEMENT (25 Mins; Total 1hr 55 mins)

Objective: Deep dive into the shared aspect of the proposition, including understanding different mechanics and needs to galvanise local buy in

This system that we've been looking at is dependant on buy in from multiple properties, as we have discussed...

- How do you **feel** about this?
- How would you feel **if a neighbour approached** you to join their system?
- How **easy or difficult** would you find it with your neighbours?

- What sort of **people/organisations would you expect to hear information from** to help with this decision?
  - EDF? (Or other energy companies)
  - The Heat Pump supplier (Kensa)?
  - The local council?
  - Individual neighbours?
  - Local community groups?
  - Other?
- **Why is it important** to come from this source? *Moderator note: try to cover each possible source*

- **How would you expect them to contact** / share this information?
  - Local events?
  - Door knocking?
  - Leaflet drops?
  - Direct email/call?
- **What makes this your preferred source** of contact?

6. WRAP UP (5 Mins; Total 2hr)

Objective: Bringing the conversation to a close by understanding appeal and propensity to explore further based on all the information shared through the session

Thanks for your time this evening – I understand that there has been a lot to get through.

There is a possibility that a trial scheme like this could be taking place in the South West (TBC if your particular area).

Given all the information we've looked at this evening with regards to the Shared GSHP systems…

- How **appealing** do you find this idea?
    - If you were to give a score out of 5 how would you mark your level of interest? (5 being extremely interested)
- What have been the things that have **drawn your attention** the most? What is driving your desire to explore more?
- What **barriers** exist for you to consider this idea? Why are these important?
- To what extent do you feel you could be the **person driving recruitment** in your area?
    - Why/ why not?
- **What else** do you feel you still need to know at this point?

IF CLIENTS VIEWING: Check to see if any further questions

Thank and Close

15.7.2 Focus Groups Master Report

Project Gaia - Teignbridge Ground Source Heat Pumps District Arrays

Customer Understanding - Able to Pay Market

October 2022

Project Background

To support the feasibility study between Devon County Council, EDF & Kensa Heat Pumps, research was required to **understand knowledge and appeal of the Shared Ground Source Heat Pump proposition** & **inform marketing campaigns for future phases** of Project Gaia

Specifically, this research aimed to:

- Understand customer knowledge of the proposition
- Understand drivers and barriers to uptake
- Inform proposition development and understand key messages
- Understand levels of financial investment and payment options
- Understand community outreach proposition

2

Approach & Sample

A qualitative research approach was taken to conduct **2x 2 hour focus groups** (via Zoom) with participants recruited from the wider Devon area*.

Groups took place on Monday 3rd October, 2022.

Participants were pre-tasked to begin initial reading into GSHPs and start forming an opinion based on this research.

Group 1 – Retired & Older Families	Group 2 – Pre & Younger Family

- *Live in semi-detached, detached or terraced housing, with at least 2 bedrooms*
- *X3-4 males & X3-4 females per group*
- *ABC1C2 (spread)*
- *£35k+ annual income*
- *Open to idea of having a heat pump (and not to currently have one); able to afford a heat pump*
- *Environmentally engaged*
- *Mix of energy providers, all to be energy bill payers*

**It was agreed that participants could be recruited from both Teignbridge and Exeter areas in order to meet project timings and recruitment challenges*

Executive Summary – Proposition

Awareness of Ground Source Heat Pumps is low and therefore there is a job to be done to raise knowledge.

Once informed, **the principle of the technology is easy to understand** and an alternative renewable source is welcomed.

However, **the install process feels complex.**

There are lots of barriers to be overcome because **people lack in-depth knowledge of the process**.

Namely, **people need to understand the impact that it has on their property** and **how the shared relationship works**, as there are fears for both.

The biggest barrier is the investment required, particularly in the current economic climate.

People are **expecting a more immediate ROI for upfront payments**.

Financing and grants are expected for a proposition like this, but they need to be delivered in a tactile way and work hard to stand out.

Because of the lower than expected saving, **it is important to play to the Environmental benefits in terms of the higher-order positioning to generate interest**.

This **still needs supporting by some sense of financial benefit**, as very few would initiate this process based on the environment alone.

Executive Summary - Community

There is a **need to overcome existing barriers in order to support people to becoming the community lead**.

Local residents will need **supporting with lots of information about the system**, as well as **reassurances over the support they will get** so that it does not feel like a time & effort burden.

Individuals are best placed to help promote the system, backed by reputable, not-for-profit groups like the Local Council & associated schemes.

Together, these **feel like a more trusted source of informative** vs commercial enterprises where skepticism exists about their interests.

Residents will need supporting throughout.

Initial outreach to raise awareness and drive interest through a comms mix of information leaflets, social media posts etc.

Organisations will also need to **set up events to answer personal questions of those interested** – something which the promoter will struggle to do

Financial support is a requirement given the overall costs of the system.

Grant schemes which reward neighbours equally are seen as the most fair, and these should start at a reasonable amount and without the need to recruit to be fairly rewarded

Any additional small incentive for the main promoter would be welcomed

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Proposition Understanding & Appeal

What is driving possible uptake & what are the barriers?

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Macro events impacting everyday lives frame consideration of alternative energy sources, particularly costs

RISE IN COSTS	CLIMATE CONSIDERATIONS
PRIMARY CONCERN – WILL DRIVE DECISIONS People experiencing a **real impact on their monthly outgoings** & aware of some of the drivers of these increases.	**STILL RELATIVELY LATENT BY COMPARISON** Heatwaves, changes in temperature & ongoing dialogue about climate targets **increases personal need to be more proactive.**

HAS A **DIRECT IMPACT ON CONSIDERATION OF ALTERNATIVE SOURCES** – TO BE MINDFUL OF IN ANY PROPOSITION DEVELOPMENT

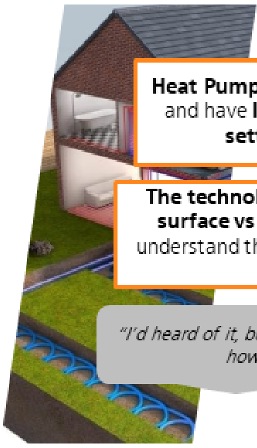
	RISE IN COSTS	CLIMATE CONSIDERATIONS
POSITIVELY	***Driven by ways of cutting personal energy usage** & **costs**; plus more aware of energy sourcing*	***More aware of the need to change to greener solutions in the long term** & how renewables can achieve this*
NEGATIVELY	*Extreme **caution with any new major upfront or ongoing expenditure** due to uncertainty*	***Energy sourcing still feels like a larger issue** – personal role in upstream initiatives less clear*

Knowledge of Ground Source Heat Pumps (GSHPs) is relatively low as they are less commonplace than other renewable sources

Solar & **Wind** have greater awareness – **more visible** in the environment, and **solar widely known as a domestic solution**

Solar in particular is also **more likely to have been explored** (even if briefly)

"My partner's dad works for a government scheme for solar energy and it's a conversation I've had quite a lot with him" Male, 26



Heat Pumps (Air & GS) are **less commonly seen** and have **lower true awareness in domestic settings**, despite recent publicity

The technology feels more complex on the surface vs solar & wind (simple enough to understand the basics of it, but feels complex for installation)

"I'd heard of it, but I didn't really know what it was, or how it worked" Female, 49

Therefore there is an immediate overarching knowledge & understanding barrier that needs to be overcome for GSHPs to be part of the same conversation as other renewable sources

Once aware of the proposition, it has the potential to drive behaviour in line with the macro influencers in life

POTENTIAL TO SAVE MONEY – PRIMARY MOTIVATION

There is a **perception that the GSHP system can save money & energy usage** in the long run – **believe that any upfront investments would deliver *significant* ROI in the long-term**

"Potentially saving money. Ultimately, by the time you've installed it, would it be something that would save you money in the long run" Female, 49

POTENTIAL TO HELP ENVIRONMENT – SECONDARY MOTIVATION

GSHPs **provide an alternative domestic solution** that they had not considered. Although there are still many complexities, it **feels relatively achievable** (though felt to be more achievable in new build houses as opposed to retrofitting)

"It is fairly evident from how high profile it's become worldwide, that our current energy resources are not going to last forever. I think it started out feeling like it's going to be a long time in the future, but it's seems to be getting closer and closer." Male, 53

*Given the current economic climate, realistically, the **environmental benefits have to be matched up with some form of financial payback** for the majority.*

Attention quickly turns to personal impact & there are clear knowledge barriers to be addressed when communicating the proposition

Barriers to be addressed exist around the three main components of the system:

GROUND ARRAY

- **Impact on property deeds & resale of house** (e.g. *heard negative stories about impact of solar)*
- Unsure **where it is installed / damage** to grounds / the **need for space** on property
- What are **ongoing maintenance** needs

IN-HOME EQUIPMENT

- **Unaware of need to upgrade internal systems** – wary of **time/cost** of this
- Concerned about **aesthetic damage** (style of radiators, need to re-decorate)
- Need to **change gas kitchen appliances**

HEAT PUMP

- What the **maintenance needs / schedule and costs are**
- **Where it is stored** in the property

More likely to be a deal-breaker and therefore most important to address

A shared system also creates a fear of ongoing politics and further barriers that people will need help addressing

NOW → FUTURE

LACK A PERSONAL RELATIONSHIP
A feeling that a personal relationship would be needed to initiate; doubts if experienced previous conflict

LACK AWARENESS OF CIRCUMSTANCE
Not all are aware of individual finances of each neighbour, or their home ownership

UNSURE WHERE TO BUILD
Unclear about the implications of installation in public vs private space

ROLES & RESPONSIBILITIES
Unclear as to how the shared elements are managed and who is responsible

IMPLICATION OF NEW NEIGHBOURS
Biggest risk if somebody else joins the system and how that will be managed; worse case if they want to change supply

EVENT OF DAMAGE & MAINTENANCE
How is unforseen damage and maintenance covered?

These shared barriers would need to be overcome with solid and unambiguous advice which demonstrates the lack of ongoing involvement and risks of joining a shared system

However, costs are ultimately the biggest dealbreaker and any longer term benefits are lesser seen, particularly in times of financial hardship

UPFRONT COSTS

EXPECTATION:
Renewable solutions will come with a higher upfront cost given the nature of changing energy source

REALITY:
- ✓ **Pleasant surprise** that there are **no costs for installing the ground array**
- ➢ £6-8k for the **Heat Pump does not feel unreasonable** **but** still **high cost vs gas boiler** and **not an insignificant sum**
- X Unexpected & unattractive **costs to upgrade internal systems are more damaging to initial interest** than Heat Pump cost

NEED: Dialling up the 'free' ground array install & exploring ways to mitigate shock of the unexpected need for in-home upgrades

ONGOING CHARGES

EXPECTATION:
The bigger the upfront cost, the bigger the pay off on an ongoing basis

REALITY:
- ✓ **No/low additional maintenance costs are welcomed** & somewhat unexpected. Coupled with lifespan, this represents a genuine saving
- X **Connection fee is off-putting**, but more understandable…
- X **Biggest turn off is high fuel costs** – expectation that these would be much lower with own source of energy
- X **Lack of real overall saving** is not motivating and contradicts expectations

NEED: Communicate the 'why' behind ongoing costs. Demonstrating small savings (i.e. £40 per year) could actually be more damaging than not as it highlights what is not being achieved. More positively, dial up the maintenance benefits

Inability to be certain about the future puts up a further barrier against a significant financial investment

Fear that something new (& cheaper) will come along

"I would like to see it run a bit longer before I committed myself….if you lock yourself into it now, in five years time, you might regret it." Female, 74

Change in personal finance situations and being locked in, especially in a shared facility

"I'm scared of shared because what happens if I lose my job? What happens to the other people? Male, 49

Money invested reduces possibility of moving house in the future – have to be sure of planned tenure

"Are you going to stay in your own house or that property for 10 years? I don't know. I certainly don't see myself still being here in 10 years time" Male, 53

Taking the proposition to market

How to position to drive the greatest level of interest

A striking message about the environment is more motivating than price certainty

REDUCE CARBON AND SAVE ENERGY

I would like to do more with my own energy usage to help reduce my personal carbon footprint and help the planet

- Reduce your carbon footprint by heating your home using the earth's natural warmth
- Sharing this warmth with your neighbours provides maximum efficiency
- Reduce CO2 by 82% vs gas*

*Using the Carbon Grid Factor for 2020 of 136 gCO_2/kWh published by BEIS on 11 April 2019

- **People buy into this positioning because they are aware of the need to be better for the environment and this system provides a tool to achieve this**
- **'Reduce CO_2 by 82% vs gas'** is the most motivating aspect of the positioning
- **'4x more efficient vs gas'** should be incorporated here as it is highly motivating (links to saving cost) & using less = better for the planet
- 'Earth's natural warmth' is the reason why this is achieved
- 'Sharing with neighbours' is an additional bonus

GAIN MORE PRICE CERTAINTY

My energy bills are changing more frequently than I would like and I would prefer more price certainty

- Shared Ground Source heat pumps puts less reliance on increasing gas & oil prices, providing you with greater price certainty through a more efficient energy source
- The system is 4x more efficient vs a gas boiler and therefore you use less energy to heat your home
- A shared infrastructure system with your neighbours allows you to share installation and running costs vs individual systems

- **Price certainty is appealing**, and people more aware that worldwide fluctuations cause price increases
- However talking about 'price' means people often shortcut to desire for cheaper – **people want to pay less, not just a consistent amount**
- Sharing energy costs with neighbours is a new concept, and therefore raises more questions than driving action

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Cost still plays a crucial role, and while overall savings are not as large as expected, there are still tactile ways to help with financial buy-in

	UPFRONT	ONGOING
MESSAGES TO PROMOTE	- **No initial payment for necessary ground works** - Consider positioning upfront grants in a way that mitigate unexpected in-home upgrades (e.g. 'Free home upgrades' or 'Free Heat Pump') rather than a lump sum	- **No servicing or maintenance required** on the Heat Pump - Drive measures from which people earn back – i.e. Opt-in to grid balancing services – rewarded for times when the grid needs your energy
MESSAGES TO REASSURE	- Consider driving messages about lifespan of Heat Pump vs Gas Boiler to help provide personal justification for larger investment - Financing options to spread the cost - Add value to your property *(although this message needs to be personalised, as people look past a topline figure)*	- While it would be possible to talk about more stable electricity prices, it rarely comes into consideration and more likely to confuse - Ongoing efficiencies & using less energy would be better supporting messages

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There is an expectation that finance options are made available as part of any proposition, particularly to cover upfront costs

GRANTS	FINANCING OPTIONS	PAYBACK
➢ c.**£6k grant is welcomed, but is expected** (very unlikely to act without it) & **therefore not significant enough to really pique interest** ✓ **More appeal when this is packaged up** – for example, 'Get free radiator upgrades', or 'Free Heat Pump' rather than a grant in the form of a financial sum *(exact packages untested)*	➢ Given size of investment, **financing is an expectation** ✓ Appeal varies on individual circumstances, but **boundaries / rules include:** ✓ 0% financing for as long as possible ✓ Flexibility welcomed (deposit vs monthly payment) ✓ 5+ years begins to feel too much of a tie-in & therefore any suggested agreements over 120 months lack motivation	➢ Measures of **earning back from the system** would also be welcomed ➢ Desire here is **framed by awareness of feed in tariffs** that existed for solar panels ✓ 'Opt-in to grid balancing services – rewarded for times when the grid needs your energy' message is particularly motivating

There are a number of expected messages which do not necessarily add anything to the proposition and should be parked for now

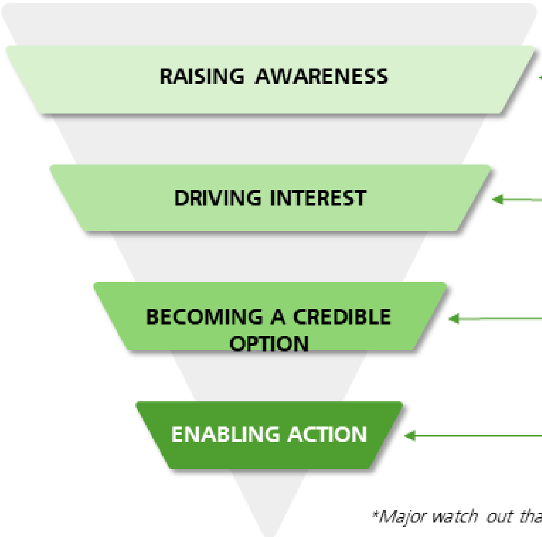
Project background and supplier choice do not motivate uptake – these are reassurances after engagement

- *EDF vetted and endorsed*
- *Backed by your local council*
- *Locally manufactured*
- *Trusted and quality installers*
- *5 year warranty on heat pump and controls*
- *No obligation survey up front*

Discussing costs that do not equate to a solid saving add very little (and can confuse)

- *You pay an annual connection fee to your shared neighbourhood system if you move home the new home owner will become responsible for their connection*
- *Spread the cost with your neighbours*
- *Low carbon tariff with EDF – lower evening rates for pre-heating your water*
- *Smart controls to control your heating and maximise savings*

Recommendation: there are 4 jobs to be done in order to generate interest in the Teignbridge GSHP scheme



Knowledge of GSHPs is lower than other renewables and therefore there is **a wider job to be done to ensure that it is recognised as a viable option**

The best way to drive interest in current circumstances would be to demonstrate cost savings. As these are not significant, **an angle promoting the environmental impact drives more engagement than price certainty** and taps into a macro motivator.*

A need to overcome the barriers that exist, namely **impact on personal property** and **alleviating any fears over any partnerships with neighbours**

Finally, **showcasing cost savings in a tactile manner** (e.g. positioning grants as 'free' elements, no servicing, opt-in to cost saving) help to convince that the system is achievable

**Major watch out that energy sourcing still feels like a bigger issue, perhaps beyond personal control*

Community Engagement

How to support those embarking on recruitment of neighbours

Local residents believe that Teignbridge does have the potential to lead on initiatives like this

Proximity to Dartmoor National Park means that the local community are felt to be more mindful of environment preservation initiatives

Some awareness of the initiatives taking place at the Eden Project in the drilling for geothermal heat – helps to reassure about the possibilities of the technology

Some awareness too of local domestic GSHP projects in Cornwall from local news – helps to reassure about the possibilities of domestic application

Comms would benefit from highlighting localised initiatives in order to help to drive a more personal interest

Note: Participants were mainly from Exeter area, with only a handful from Newton Abbot

It will be challenging to engage willing volunteers to step forward and drive local engagement; they will need real support

BARRIERS TO BEING THE PROMOTER

FEAR OF RESPONSIBILITY	TIME/EFFORT INVESTMENT	ENGAGEMENT WITH NEIGHBOURS
- Technology is new to people and therefore **feels to be a risk** about performance in a domestic setting - Innate **fear of being the one to make a recommendation and it go wrong** (e.g. it becomes too expensive)	- Perception that this is **going to take up a lot of time & effort** across all stages – **learning about the process**, **recruiting neighbours**, **legalities & paperwork**, **installation** - As the promotor, it is anticipated that there would be **more work to do than others**	- **Not everyone has a close relationship with their neighbours**, particularly a large number of them - There is **a risk of opening up a conversation about personal finances & circumstance** that is unnerving
WAY TO OVERCOME: - Promotors would need to be **supplied with lots of information and reassurances** before embarking on a recruitment drive	**WAY TO OVERCOME:** - **Reward** for the extra commitment - **Reassurances over ease & speed**, particularly with the legalities	**WAY TO OVERCOME:** - Difficult to directly overcome this barrier, but the **more confidence** instilled overcoming others, the easier this will be

Despite difficulties, there is a need to enable individuals to drive the effort because they are seen as the most trustworthy source

Most trustworthy ← *Least trustworthy*

Informed Individual	Public Services (Community Interest Groups, Local Council)	Commercial Enterprise (EDF, Kensa)
Most trusted because they are **perceived to be doing this for selfless reasons**, i.e. the good of the environment However, may also be perceived to be the **least knowledgeable**, and so **need support**	**Trusted** as **expected to be well informed**, & **not expected to be making a direct profit**. Some slight doubts as **there could be ulterior motive** (e.g. additional funding)	**Least trusted** because these are **profit driven businesses**. Coupled with high costs, it is assumed that **these organisations are trying to make money from this scheme**

A **combination of these groups is required**.

Prospects **need the knowledge and technical aspects from organisations**, but **need reassurance from others also taking part** in the scheme

Background groups only. Being at the forefront of a recruitment drive would raise doubts amongst prospective audiences. Will need to help public groups support individuals

Support will have to be delivered from the organisations backing the scheme, in order to help both the promoter and local residents

INITIAL OUTREACH INDIRECT → **FURTHER INFORMATION DIRECT**

JOBS TO BE DONE TO SUPPORT

Initial outreach (indirect)	Further information (direct)
RAISING AWARENESS Of the GSHP technology and local scheme	DRIVING INTEREST Reaffirming the reason 'why'
DRIVING INTEREST Highlighted the higher order benefits (environment)	BECOMING A CREDIBLE OPTION Greater detail on the processes
BECOMING A CREDIBLE OPTION By beginning to address some of the knowledge barriers	ENABLING ACTION Raising cost implications that are personalised to the individual

WAYS TO DELIVER

At this stage, the **form of comms has to be indirect** to share generalised information and enable prospects to make an initial decision based on interest (e.g. social media outreach, leaflet drop)

Essential for **comms to be direct and personalised** at this stage. Because of a lack of knowledge, events and the opportunity to ask questions are vital – this is something an individual promoter will struggle to do

Financial support is an absolute must and is most beneficial in the form of equal group incentives rather than rewarding the individual

Higher appeal

£6k grant for the promoter only

Single grant available to the main promoter of the neighbourhood scheme is **not likely to be sufficient.** The promotor may feel uneasy about getting buy in when they are the only one benefitting

£6k grant shared between all

Only one c.£6k grant across multiple neighbours **would significantly increase initial costs**, and therefore **not appealing**

£6k grant per neighbour (but depending on number of sign ups)

An interesting idea in principle, but **having to work to a maximum of £6k is less appealing**. It **would need to be a minimum amount** (e.g. £5k each for 2x households) **and each extra person means all households get more**

£6k grant per neighbour

A straight grant for each person **feels most fair as everyone is rewarded equally** for their buy-in

£6k grant per neighbour plus promoter reward

People would not begrudge the promoter receiving a small reward, but only when all others are covered fairly. This would also increase likelihood of people starting the initiative

> *I think there **needs to be incentive for everybody** because otherwise, it just feels a little bit like a pyramid scheme, if you're the one going to somebody with this idea where you're benefiting from it, and it trickles down. **Obviously, if you're the one putting in more admin, and you benefit more, I hope neighbours would understand it.***
>
> ***But I think there needs to be a benefit for the people that you're introducing into it as well.** And maybe in terms of volume, as well. So **the more people you get on it, the better it is for all of you.***
>
> Male, 26

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Recommendation: break down the barriers that exist around the system and provide promoters with information and financial support

1. All people, but particularly the promoter, **need reassurances that the shared elements are issue free**
2. **Individuals, when supported by not-for-profit organisations are the most trusted source of information**. It is important for **EDF and Kensa to support these in the background**
3. **Promotors will need to be supplied with technical information that helps them to break through knowledge barriers** that prospective customers have *(full detail in Proposition Understanding Report)*
4. **There will be a need for all prospect customers to be able to engage with organisations at the heart of this scheme** to **understand the personal impact** of enrolment
5. **Financial support is a must** and it is recommended that this is a **shared grant, rather than rewarding just the promotor**, or having them work hard towards achieving what is currently available

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15.8 Marketing plan proposition (WP4.2)

Table 42: Project Gaia Roadmap

		PHASE 2 - AWARENESS			PHASE 2a - CUSTOMER RECRUITMENT					PHASE 2b - DEPLOYMENT					
		Nov-22	Dec-22	Jan-23	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23
							Consideration						Conversion		
Channels	Awareness		Present to CEG/Parish Council							Re-engage Parish / CEG					
				Staff - invitation for local community advisor	Staff offer - Exeter Friends and Family	Staff training and advocate programme				Staff announcement					
			Social announcements		Organic social 3 posts			Organic social 3 posts			Organic social 3 posts			Organic social 3 posts	
	PR		Announcement for Phase 2 bid success	Newspaper articles - local x3	Local Events x3	Bus advertising				Charity partners announced	Street parties/Summer BBQ	Local shop/ visitor centre opening	School visits	Xmas sponsorship	
	Partners		Approach CEG / Parish	CEG/Parish newsletter	CEG/Parish facebook groups			CEG / Parish newsletter		CEG/Parish announcement					
	Social			Paid advertising - invite/register interest			Paid advertising								
	Leaflet				3 regions										
	Doordrop / Newsletter					3 regions									
	Email					3 regions				Contracts next steps		Installation next steps/Case study		Congrats - install dates	Project updates
	Events						3 local events			Charity partner events	Summer BBQ events		Customer Home visit - open house		Xmas events
	Webex FAQ							Follow up FAQ		Contracts next steps					
	Visitor Centre / Shop							Invite to visitor centre					Home visit		
Engagement	Content		Content Development		Content design	Content Audit	SEO content review	Consideration and advice Content review		Content refresh	Content design	Content Audit	SEO content review		
	Video Content		Content Development		Content design	Content Live	SEO content review			Content refresh	Content design	Content Live			
	Digital			Jan - Cust webform & email confirmation approved Feb - Web content live Feb - Webform tracking GA Feb - Web form live		March - Customer survey live March - Event registration live April -UX redesign - Basic content updates		May - CRO review May - Delivery of Web content updates Jun - Delivery of holding messages to webform June - remove holding messages June - Delivery of Successful implementation message		Jul - removal of register interest form Jul - update content to delivery and implementation next step messages Jul - Update to charity partner information Aug - Update local event information			Oct- removal of local event info Nov - xmas sponsorship messages Dec - update with Xmas event information Dec - update with case studies		
Logistics	Recruit and train		Job descriptions finalised	Job descriptions published / interviews	Training		Attend Events	Canvassing			Attend Events				Attend Events
	Draft, Design, Print			Identify suppliers and secure slots; leaflets, doordrop, banners, event handouts	Leaflets, Product Guides, Sales Brochures, Training materials	Business cards, posters,									
	Deliver			Identify suppliers and secure slots	Leafelts, Doordrop Banners Event Handouts	Product Guides, Sales Brochures									
	Source and Book			Experts, customers, venues, refreshments	Visitor centres	Heat pump for visitor centres				Identify social impacts					
Key Project Dates	Project Milestones	Awared Ph2							Gate B - Phase 2b submission						

Table 43: Project Gaia Channel Plan

Project Phase	Activity	Unit Rate	Items	Total Budget
Awareness Campaign	PR and marketing staff secured	£45,000.00	1.00	**£45,000.00**
	News paper article - highlight project	£500.00	3.00	**£1,500.00**
	Parish letter - printing costs	£100.00	3.00	**£300.00**
	Source local facebook groups	£0.00	24.00	**£0.00**
	Social announcements	£0.00	3.00	**£0.00**
	Organic social x 4	£0.00	3.00	**£0.00**
Customer Recruitment	Local Liason officer recruited	£45,000.00	1.00	**£45,000.00**
	Bus advertising	£30,000.00	1.00	**£30,000.00**
	Local radio advertising / interviews	£20,000.00	6.00	**£120,000.00**
	Staff engagement materials - web and advocacy programme	£10,000.00	1.00	**£10,000.00**
	Recommend a friend/family staff offer	£500.00	20.00	**£10,000.00**
	Social campaign x 3 posts - copy writter/agency costs	£10,000.00	4.00	**£40,000.00**
	Information packs printed	£5,000.00	3.00	**£15,000.00**
	Video draft, edit, publish	£12,000.00	2.00	**£24,000.00**
	Email design and HTML creation	£10,000.00	3.00	**£30,000.00**
	Email design and HTML creation	£10,000.00	3.00	**£30,000.00**
	Web form created	£10,000.00	1.00	**£10,000.00**
	Survey form created	£5,000.00	1.00	**£5,000.00**
	Local venues hired	£100.00	3.00	**£300.00**
	Pop up shops venue and hire charges - visitor centres	£10,000.00	6.00	**£60,000.00**
	Staff costs for visitor centres	£30,000.00	3.00	**£90,000.00**
	Posters printing	£500.00	3.00	**£1,500.00**
	Posters delivery	£30.00	3.00	**£90.00**
	Business cards printed	£500.00	1.00	**£500.00**
	Event Banners	£500.00	9.00	**£4,500.00**
	Press advert	£2,000.00	3.00	**£6,000.00**
	Press social campaign	£5,000.00	3.00	**£15,000.00**
	Guest speaker expenses	£500.00	3.00	**£1,500.00**
	Paid social campaign	£35,000.00	2.00	**£70,000.00**
	Leaflets printed	£500.00	3.00	**£1,500.00**
	Leaflets delivery	£500.00	3.00	**£1,500.00**
	Doordrop - targetted (print and data)	£5,000.00	3.00	**£15,000.00**
	Doordrop delivery	£500.00	3.00	**£1,500.00**
	Community event leaflets printed	£500.00	3.00	**£1,500.00**
	Community event leaflets delivered	£500.00	3.00	**£1,500.00**
	Email campaign to local residents (EDF/ ECOE data)	£5,000.00	3.00	**£15,000.00**
	Community facebook group set up	£0.00	12.00	**£0.00**
	Telesales campaign	£5,000.00	3.00	**£15,000.00**
	Incentives - free school laptops / charity sponsorship	£20,000.00	3.00	**£60,000.00**
	Event refreshments	£2,500.00	3.00	**£7,500.00**
	Training materials	£10,000.00	1.00	**£10,000.00**
	Training expenses	£500.00	7.00	**£3,500.00**
	Product leaflets creatied - copywritter	£10,000.00	1.00	**£10,000.00**
	Product leaflets creatied - printing	£5,000.00	1.00	**£5,000.00**
	Product guide online content created	£5,000.00	1.00	**£5,000.00**
	Case study commissioned	£5,000.00	1.00	**£5,000.00**
	Case study photographs	£5,000.00	1.00	**£5,000.00**
	Paid social campaign x 4	£20,000.00	4.00	**£80,000.00**
Deployment	Community events - Summer BBQ / Street closures	£15,000.00	3.00	£45,000.00
	Re-engagment email campaign	£10,000.00	3.00	£30,000.00
	Local event meetings - next steps	£100.00	3.00	£300.00
	Re-leaflet parties who have not responded	£500.00	3.00	£1,500.00
	Leaflets delivery	£500.00	3.00	£1,500.00
	Door knocking for neighbours withdrawn from project / housemoves (agency staff and	£4,680.00	3.00	£14,040.00
	Press release for deployment updates	£500.00	3.00	£1,500.00
	Social media campaign for updates on deployment success and local charity benefits	£10,000.00	3.00	£30,000.00
	Community xmas event leaflets printed	£500.00	3.00	£1,500.00
	Community xmas event leaflets delivered	£500.00	3.00	£1,500.00
	Community events - Summer BBQ / Street closures	£15,000.00	3.00	£45,000.00
	Feedback survey	£5,000.00	1.00	£5,000.00
	Community success video	£10,000.00	1.00	£10,000.00
	Local community event - open house	£10,000.00	1.00	£10,000.00
Cost per acquisition (4000 interested customers)	£264.68			**£1,058,730.00**
Cost per install (300 customers)	£3,529.10			

15.9 Infrastructure Design (WP5.1)

GeniusEnergyLab

Project Gaia

Ground Source Heat Pump

Geology & Feasibility

Bishopsteignton, TQ14.

Site centred on NGR SX 90650 73605

For

Kensa Utilities

Private & Confidential

Version 1.1

24 October 2022

Author:
Emily Proud
Design Engineer
ep@geniusenergylab.com

Reviewed by:
Chris Davidson
Chairman & Technical Director
cd@geniusenergylab.com

Contents

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1. Introduction

Choose an item.				
Project Address	Bishopsteignton			
Building Type & Number	Residential			
Provisional Loads by archetype	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Peak Heating Load	4.42 kW	4.85 kW	3.85 kW	5.0 kW
Annual Heating Load	8,032 kWh	9,041 kWh	6,955 kWh	9,453 kWh
Annual DHW Load	2,234 kWh	2,225 kW	1,982 kWh	2,158 kWh
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Peak Heating Load	5.82 kW	5.09 kW	6.0 kW	7.52 kW
Annual Heating Load	11,257 kWh	9,578 kWh	11,727 kWh	15,112 kWh
Annual DHW Load	2,255 kWh	2,238 kWh	2,216 kWh	2,348 kWh

2. Anticipated Geological Conditions

Formation	Classification	Conductivity W/mK	Thickness m	Depth bgl m
Whiteway Mudstone Formation	MUDSTONE with subordinate locally laminated mudstone (slatey)	1.7	6	6
Exeter Group	Predominantly BRECCIA with subordinate sandstone	1.6	>39 c.700	>45

Notes & Comments	
Local Borehole Records to Depth	45 m
Anticipated Groundwater Depth	1 m
Expected Rest Water Level	1 m
Likelihood of Artesian Conditions	Moderate
Confidence in Geological Assessment	Good
Notes on artesian likelihood	No artesian conditions noted to local borehole depth. However, there are noted as being few borehole records in the vicinity of the site.

3. Classifications, Permissions & Risks

Environment Agency / Scottish Environmental Protection Agency	
Source Protection Zone	None
Surface Aquifer Classification	Secondary
Bedrock Aquifer Classification	Principal
Aquifer Vulnerability	High
Coal Authority	
Reporting Area	No
Undermining Status	Not Undermined
Development High Risk Area	No
Risks	
Unexploded Ordinance Risk	Moderate

4. Estimated Ground Thermal Properties

Quantity	Estimated Value
Expected Drilling Depth	200m
Thermal Conductivity	1.6 $W \cdot mK^{-1}$
Diffusivity	0.100 $m^2 \cdot day^{-1}$
Undisturbed Ground Temperature	11 °C
Recommended Grout Conductivity	1.78 $W \cdot mK^{-1}$
Conductivity Test	Required

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5. Budgetary Ground Loop Requirement – Per Archetype

Quantity	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Number of Boreholes	1	1	1	1
Depth	116.0 m	134.0 m	105.0 m	137.0 m
Total Borehole Requirement	116.0 m	134.0 m	105.0 m	137.0 m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	40mm Single
U-Tube Pressure Drop	15.6 kPa	21.1 kPa	11.2 kPa	22.7 kPa
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Number of Boreholes	1	1	1	2
Depth	162.0 m	139.0 m	185.0 m	126.0 m
Total Borehole Requirement	162.0 m	139.0 m	185.0 m	252.0m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	45mm Single	40mm Single
U-Tube Pressure Drop	34.5 kPa	23.7 kPa	25.0 kPa	13.0 kPa
N.B. This information is for budgetary purposes ONLY and is not intended for used as final design.				

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6. Budgetary Ground Loop Requirement – Averaged across 30 Properties

Quantity	Initial Estimate
Number of Boreholes	35
Depth	187m
Total Borehole Requirement	6,545m
Spacing	12m
U-Tube	40mm Single
U-Tube Pressure Drop	30.3 kPa
N.B. This information is for budgetary purposes ONLY and is not intended for used as final design.	

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Project Gaia

Ground Source Heat Pump

Geology & Feasibility

Kingsteignton, TQ12.

Site centred on NGR SX 87088 73158

For

Kensa Utilities

Private & Confidential

Version 1.0

24 October 2022

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Engineer
ep@geniusenergylab.com

Reviewed by:
Chris Davidson
Chairman & Technical Director
cd@geniusenergylab.com

GeniusEnergy*Lab*

Contents

1. Introduction

Choose an item.				
Project Address	Kingsteignton			
Building Type & Number	Residential			
Provisional Loads by archetype	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Peak Heating Load	4.42 kW	4.85 kW	3.85 kW	5.0 kW
Annual Heating Load	8,032 kWh	9,041 kWh	6,955 kWh	9,453 kWh
Annual DHW Load	2,234 kWh	2,225 kW	1,982 kWh	2,158 kWh
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Peak Heating Load	5.82 kW	5.09 kW	6.0 kW	7.52 kW
Annual Heating Load	11,257 kWh	9,578 kWh	11,727 kWh	15,112 kWh
Annual DHW Load	2,255 kWh	2,238 kWh	2,216 kWh	2,348 kWh

2. Anticipated Geological Conditions

Formation	Classification	Conductivity W/mK	Thickness m	Depth bgl m
Abbrook Clay and Sand Member	Non-carbonaceous, high silica CLAY and SAND, sometimes silty. Clay breccias occur locally. Lignite bands.	2.4	Up to 40 on western side. Zero on eastern side	0 to 40
Aller Gravel Formation	Flint and chert GRAVEL with subordinate silt and clay. Coarse, angular, flinty gravelly clayey SAND with lenticles of clayey sand to coarse sand	1.9	Up to 20 on western side. Zero on eastern side	0 to 20
Upper Greensand Formation	SAND and SANDSTONE	2.6	<5	0 to c.60
Chercombe Bridge Limestone Formation	Fossiliferous LIMESTONE	1.7	c.250	c.300

Notes & Comments	
Local Borehole Records to Depth	60 m
Anticipated Groundwater Depth	20 m on western side to 30 on eastern side
Expected Rest Water Level	c.20 m
Likelihood of Artesian Conditions	Moderate
Confidence in Geological Assessment	Very Good
Notes on artesian likelihood	Water under pressure noted in Aller Gravel formation on western side of the area. This is potentially weakly artesian. Groundwater is deeper and less likely to be artesian on the eastern side of the area.

3. Classifications, Permissions & Risks

Environment Agency / Scottish Environmental Protection Agency		
Source Protection Zone	None	
Surface Aquifer Classification	Secondary	Confined to valleys areas
Bedrock Aquifer Classification	Principal	Variable Principal to secondary
Aquifer Vulnerability	High	
Coal Authority		
Reporting Area	No	
Undermining Status	Undermined	Potentially small area on western edge of the area.
Development High Risk Area	No	
Risks		
Unexploded Ordinance Risk	Moderate	

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4. Estimated Ground Thermal Properties

Quantity	Estimated Value
Expected Drilling Depth	200 m
Thermal Conductivity	1.7 W·mK^{-1}
Diffusivity	0.130 m^{2}·day^{-1}
Undisturbed Ground Temperature	11 °C
Recommended Grout Conductivity	1.78 W·mK^{-1}
Conductivity Test	Required

5. Budgetary Ground Loop Requirement – Per Archetype

Quantity	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Number of Boreholes	1	1	1	1
Depth	115.0 m	133.0 m	104.0 m	136.0 m
Total Borehole Requirement	115.0 m	133.0 m	104.0 m	136.0 m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	40mm Single
U-Tube Pressure Drop	15.5 kPa	20.9 kPa	11.1 kPa	22.5 kPa
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Number of Boreholes	1	1	1	2
Depth	161.0 m	138.0 m	184.0 m	127.0 m
Total Borehole Requirement	161.0 m	138.0 m	184.0 m	254m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	45mm Single	40mm Single
U-Tube Pressure Drop	34.3 kPa	23.5 kPa	24.9 kPa	13.1 kPa
N.B. This information is for budgetary purposes ONLY and is not intended for used as final design.				

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6. Budgetary Ground Loop Requirement – Averaged across 30 Properties

Quantity	Initial Estimate
Number of Boreholes	35
Depth	200m
Total Borehole Requirement	7,000m
Spacing	12m
U-Tube	40mm Single
U-Tube Pressure Drop	32.4 kPa
N.B. This information is for budgetary purposes ONLY and is not intended for used as final design.	

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Project Gaia

Ground Source Heat Pump

Geology & Feasibility

Kerwell-with-Combe & Buckland Milber,

Newton Abbott, TQ12

Site centred on NGR: SX 87638 70416

For

Kensa Utilities

Private & Confidential

Version 1.0

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Author:
Emily Proud
Engineer
ep@geniusenergylab.com

Reviewed by:
Chris Davidson
Chairman & Technical Director
cd@geniusenergylab.com

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1. Introduction

Choose an item.				
Project Address	Newton Abbott			
Building Type & Number	Residential			
Provisional Loads by archetype	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Peak Heating Load	4.42 kW	4.85 kW	3.85 kW	5.0 kW
Annual Heating Load	8,032 kWh	9,041 kWh	6,955 kWh	9,453 kWh
Annual DHW Load	2,234 kWh	2,225 kW	1,982 kWh	2,158 kWh
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Peak Heating Load	5.82 kW	5.09 kW	6.0 kW	7.52 kW
Annual Heating Load	11,257 kWh	9,578 kWh	11,727 kWh	15,112 kWh
Annual DHW Load	2,255 kWh	2,238 kWh	2,216 kWh	2,348 kWh

2. Anticipated Geological Conditions

Formation	Classification	Conductivity W/mK	Thickness m	Depth bgl m
Aller Gravel Formation	Flint and chert GRAVEL with subordinate silt and clay. Lenticles of white clayey sand and reddish brown coarse sand.	1.2	Up to 4	<4
Upper Greensand Formation	SAND and SANDSTONE, fine-grained, silt, glauconitic, shelly.	2.5	<22	c.26
Permian Basement	SANDSTONE and LIMESTONE	2.4	>1,000	>1,000

Notes & Comments	
Local Borehole Records to Depth	36 m
Anticipated Groundwater Depth	4 m
Expected Rest Water Level	Artesian
Likelihood of Artesian Conditions	High
Confidence in Geological Assessment	Very Good
Notes on artesian likelihood	Artesian conditions noted in local borehole drilled into Upper Greensand Formation. Groundwater level or flow not known.

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3. Classifications, Permissions & Risks

Environment Agency / Scottish Environmental Protection Agency		
Source Protection Zone	None	
Surface Aquifer Classification	None	
Bedrock Aquifer Classification	Principal	Variable secondary to Principal.
Aquifer Vulnerability	High	
Coal Authority		
Reporting Area	No	
Undermining Status	Not Undermined	
Development High Risk Area	No	
Risks		
Unexploded Ordinance Risk	Moderate	

4. Estimated Ground Thermal Properties

Quantity	Estimated Value
Expected Drilling Depth	150 m
Thermal Conductivity	2.4 $W \cdot mK^{-1}$
Diffusivity	0.110 $m^2 \cdot day^{-1}$
Undisturbed Ground Temperature	11 °C
Recommended Grout Conductivity	1.78 $W \cdot mK^{-1}$
Conductivity Test	Required

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5. Budgetary Ground Loop Requirement – Per Archetype

Quantity	Mid-terrace House - 3 bed	End-terrace House - 3 bed	Semi-detached Bungalow - 1 bed	Detached Bungalow - 2 bed
Number of Boreholes	1	1	1	1
Depth	84m	96m	76m	99m
Total Borehole Requirement	84m	96m	76m	99m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	40mm Single
U-Tube Pressure Drop	11.3 kPa	14.8 kPa	8.1 kPa	16.4 kPa
	Detached Bungalow - 3 bed	Semi-detached House - 3 bed	Detached House - 3 bed	Detached House - 4 bed
Number of Boreholes	1	1	1	1
Depth	118m	101m	135m	172m
Total Borehole Requirement	118m	101m	135m	172m
Spacing	12m	12m	12m	12m
U-Tube	40mm Single	40mm Single	40mm Single	45mm Single
U-Tube Pressure Drop	25.2 kPa	17.2 kPa	30.3 kPa	33.9 kPa
N.B. This information is for budgetary purposes ONLY and is not intended for used as final design.				

6. Budgetary Ground Loop Requirement – Averaged across 30 Properties

Quantity	Initial Estimate
Number of Boreholes	30
Depth	153m
Total Borehole Requirement	4,590m
Spacing	12m
U-Tube	40mm Single
U-Tube Pressure Drop	30.0 kPa
N.B. This information is for budgetary purposes ONLY and is not intended for used as final design.	

15.10 Training Module Plan Development (WP5.6)

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Project Gaia:
Training Plan

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EDF Energy R&D UK Centre Limited. edfenergy.com

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Training Plan

Project Gaia is dependent on high community acceptance and positive feedback from customers throughout the customer journey. This can only be done with the support of skilled and knowledgeable resident liaison officers that can guide customers through the customer journey, explain the complex technology and customer offer and provide a single point of contact throughout the process.

Resident liaison officers will be recruited in the area on a fixed term basis to deliver project Gaia.

Due to the relatively low public awareness of heat pump technology and the novel customer proposition to be used in Project Gaia, it is not expected that candidates will be recruited with sufficient prior knowledge to deliver positive customer outcomes. Instead, recruiters will seek candidates with relevant interpersonal skills that will be trained by experienced staff in the required, project specific, areas.

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Heat Pump Technology

Resident liaison officers will require a basic understanding of the technology to be deployed and the installation process so that they can support households through this process, answering technical questions, referring to more knowledgeable staff when appropriate, and explaining the basics of potential counterfactuals.

Material will be adopted from Kensa Heat Pumps and Kensa Contracting's standard CPD and installer training programmes.

Resident liaison officers will be taken on site visits to see in-use Kensa heat pumps and discuss the installation experience with existing customers.

Resident liaison officers will be taken to a live site to experience the noise levels associated with drilling, see the internal disruption to a property, and understand the measures employed to minimise risk to vulnerable households and what can be done to lower impact on quality of life during installation (sequencing of works, temporary heaters etc.)..

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Customer Offer

Resident liaison officers will be taken through the customer offer in depth.

Project staff will justify all costs to consumer including capital spend, finance options, and finance costs.

CPI, RPI, interest rates, payment terms, capital costs and maintenance costs will all be discussed to enable RLOs to answer the majority of questions without delay for the consumer.

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Service Agreements

The service agreement is 6 pages long, has a 40 year term and must be passed on to the next resident on the sale of a property.

This document is complex and a potential barrier to some households in acceptance of the scheme. RLOs will learn this document inside out.

Using FAQs from existing projects using the same terms, the trainer will prime RLOs to be able to answer common questions with confidence and less common questions with ease.

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Consumer protection

As the primary point of contact for all households, RLOs are in a position to learn the needs of their customers and provide appropriate support where needed.

RLOs will be trained in GDPR to ensure all personal and sensitive information is handled correctly and in line with the law.

Vulnerable customers will be identified in a sensitive manner in the CRM. Particular care will be taken to enable these customers to have the same opportunities as other project beneficiaries.

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The Heat Trust

All Project Gaia installations will be registered with the Heat Trust. RLOs will be trained in the basic principles of this customer protection scheme to provide them with the information required to reassure households and secure sign-up.

The RLO training programme will be a 5 day course delivered at the start of Phase 2a, immediately following recruitment.

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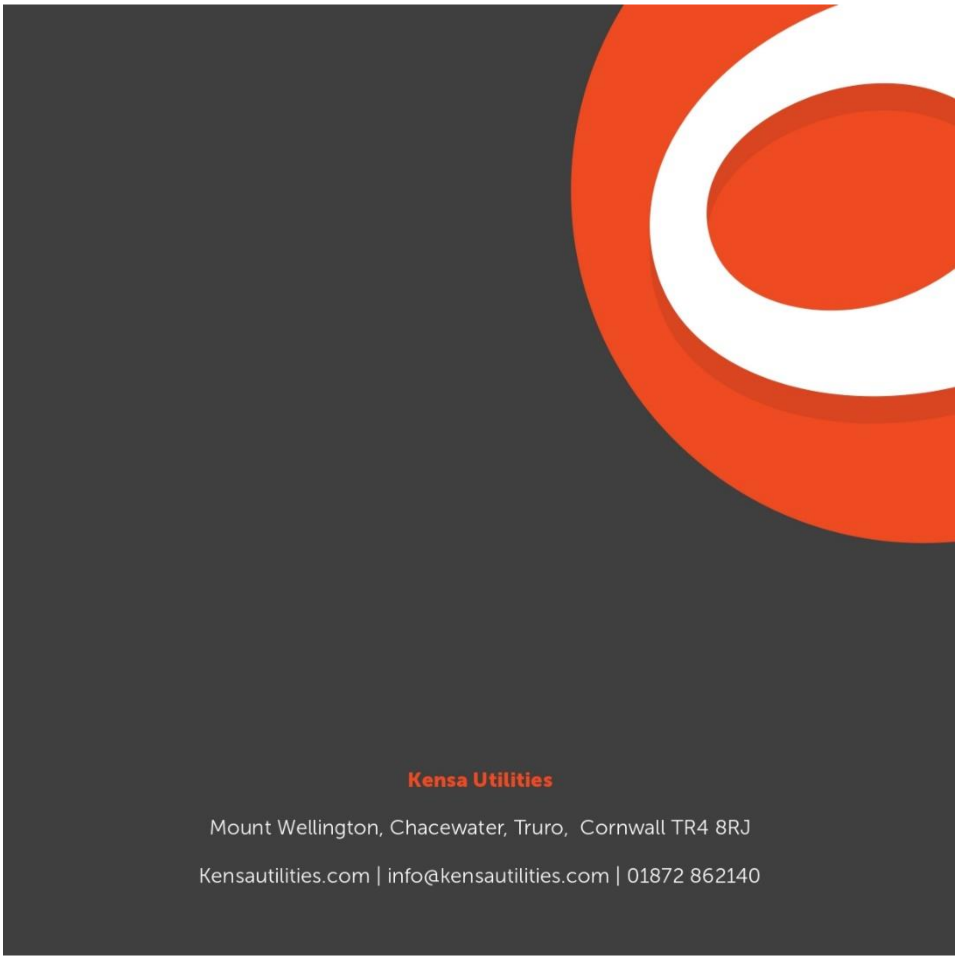
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Mount Wellington, Chacewater, Truro, Cornwall TR4 8RJ

Kensautilities.com | info@kensautilities.com | 01872 862140