SAPPHIRE Solo

(Smart Affordable Power and Heat with Integrated Renewable Energy)

Part of

BEIS Heat Pump Ready: Stream 1, Phase 1 Feasibility Study

December 2022

Jon Cape, Douglas Cape, Teri Vogt, and Kenneth Easson
Power Circle Projects Ltd

Power Circle Projects Ltd. www.powercircle.org.uk
Company No. SC663219 VAT No. 353624404
Registered Office: 17 Kenilworth Road, Bridge of Allan, Stirling FK9 4DU

Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

This report sets out the findings and conclusions from a feasibility study for the SAPPHIRE Solo proposition for the optimised deployment of individual domestic heat pumps, at high density. The study is now complete and has been funded as part of the BEIS Heat Pump Ready Programme Stream 1, Phase 1[1].

The study was undertaken in the Altamount and Rosemount areas of Blairgowrie, a town of approximately 9,000 people in Perth and Kinross, Scotland. The area consists mostly of 10- to 20-year-old houses owned by people in the medium income bracket, typical of estates developed as part of small-town expansion across the country in the late 20th and early 21st century.

The study looked at different technology combinations such as combining a heat pump with solar PV and battery storage to reduce running costs, and the possible future role of smart local energy systems to link storage systems thereby generating income to help fund deployment of the systems.

Broadly speaking, the study involved two key elements; a technical assessment of the best way to optimise heat pump deployment for the individual household supported by an energy and financial options appraisal, plus a community engagement element targeting householders and local supply chains.

Technical Assessment

The technical assessment looked at the solar potential for the area and assessed the electrical and thermal load of typical houses. Energy and financial modelling was then undertaken for three technology combinations as shown below:

- Heat pump only
- Heat pump and solar PV
- Heat pump, solar PV, and battery

The following information was input into the energy and financial model, assumptions made around these inputs are explained within this report:

- Average solar generation
- Typical electrical and heat loads for the house types in the area
- Technology costs
- Energy costs
- Heat pump efficiency
- Grants and interest free loans available to Scottish householders

The output from the model was a cost benefit analysis showing the savings a householder could expect to achieve from adopting the technology, the costs associated with paying back available interest free loans, and the long-term savings that could be expected when loans had been paid off. This information was fed back to the local householders as described further below.

[1] https://www.gov.uk/government/publications/heat-pump-ready-programme

Community and Supply Chain

Extensive engagement took place across the target community, this included an online questionnaire, letters, and house-to-house visits. From a community of around 1,000 houses, 130 expressed an interest in the project and provided contact details for follow up. The community engagement culminated in a focus group and open community event. All interested householders received an information pack containing the key findings from the study.

All electricians and heating engineers with an address in Blairgowrie (that could be readily found online) were contacted as part of the project to establish their level of interest in learning more about heat pumps. This culminated in a supplier meeting on the basis for which proposals have been made for follow-up training.

Conclusions

This study has shown that there are considerable benefits to householders in adopting heat pumps, the key challenge at present is the length of the payback period due to the high cost of the technology. Cost benefit analyses were undertaken based on current funding packages available to householders in Scotland with the results for a typical 2-to-3-bedroom house summarised below. The costs benefit analyses were undertaken across a 15-year period, with the typical repayment term on available loan funding being 12 years.

Heat Pump Only

Table 1: Estimated annual savings for heat pump only.

	Annual usage	**Annual cost (GBP)**
Annual electricity usage before install Annual gas usage before install *Total energy usage before install*	2,422 kWh 20,212 kWh *22,634 kWh*	£987 £2,181 *£3,168*
Annual electricity usage after install	8,381 kWh	£2,992
Annual saving after install		**£176**

Table 2: Cost-benefit analysis for heat pump only.

Year	**Loan repayment (£)**	**Saving from heat pump (£)**	**Cost-benefit (£)**
1-5	-1,104	1,502	398
5-10	-1,104	1,399	295
10-15	-442	1,622	1,180

Heat Pump and Solar PV

Table 3: Estimated annual savings for heat pump and solar PV.

	Annual usage	Annual cost (GBP)
Annual electricity usage before install Annual gas usage before install *Total energy usage before install*	2,422 kWh 20,212 kWh *22,634 kWh*	£987 £2,181 *£3,168*
Annual electricity usage after install	7,070 kWh	£2,524
Annual saving after install (not including export income) (including export income*)		 **£644** **£762**

**income derived from export of excess PV output, via a Smart Export Guarantee tariff for example[2].*

Table 4: Cost-benefit analysis for heat pump and solar PV.

Year	Loan repayment (GBP)	Saving from heat pump + PV (GBP)	Cost-benefit (GBP)
1-5	£-3,188	£4,863	£1,676
5-10	£-3,188	£4,108	£921
10-15	£-1,275	£4,705	£3,430

The results detailed in the above tables demonstrate that, as compared to a heat pump only option, the heat pump and solar PV combination adds to overall energy and financial savings for the householder and makes the investment proposition considerably more attractive due to higher returns and earlier payback.

In addition to the above options, we also investigated a heat pump, solar PV, and battery combination which we hypothesised would provide the best savings. Our reasoning was that the battery would be able to deliver additional financial benefits by storing cheaper off-peak electricity in addition to its primary function of storing excess PV output, both for later usage by the household and both displacing expensive on-peak electricity. Unfortunately, this did not prove to be the case. Within the limits of the available funding it was not possible to include a battery large enough to enable these additional savings, based on the assumption that the battery ought to be sized to optimise storage of electricity to meet all household demand for both heating and general usage.

An attractive alternative could be to size the battery only to optimise storage of electricity to meet non-heating demand. This could be combined with either a large hot water cylinder, though this may be problematic in many properties due to the large volume of the tank, or a physically smaller phase-change heat battery to provide thermal storage capacity for the space heating system. UK-based thermal storage manufacturer Sunamp[3] is currently launching a new battery which may be suitable for this purpose, but specifications were not available at time of writing.

[2] https://www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg
[3] https://sunamp.com/

Householder engagement is key to high density heat pump deployment. This project has shown a number of things need to come together to enable this to happen effectively.

- **Effective communication strategy** – Based on our research, the level of knowledge and understanding of heat pumps and associated funding opportunities remains low amongst householders.
- **Grant and loans** – Householders that attended a focus group indicated that the availability of financial support was fundamental to ensuring a willingness to install.
- **On-going support** – Householders were worried about the process of accessing finance, time taken, the user-friendliness of the process, and were looking for support with this.
- **Supply chain** – Access to a proactively engaged supply chain with the necessary skills to deploy and maintain heat pumps was considered fundamental to building householder trust in the technology and willingness to adopt. Householders raised concerns about supply chain maturity during the focus group. Current constraints in the supply chain challenge this.

Engagement with the local supply chain as part of the project showed no existing heat pump installation capability amongst local suppliers (defined as electricians and heating engineers with an address in Blairgowrie). There was however interest in gaining this and recognition that heat pumps were the direction of travel. **Key barriers to uptake of training amongst suppliers were time and difficulty predicting future market demand for renewables**.

Options for future training of the supply chain were appraised which included generic MCS (Microgeneration Certification Scheme[4]) training, manufacturer specific training, and on the job training.

Our assessment concluded that current MCS and manufacturer training schemes alone cannot be relied upon to build supply chain capacity at the rate necessary to deliver both UK and Scottish Government ambitions in relation to heat pump uptake. This is due to a lack of availability and the understandable reluctance of small suppliers to take time out from already busy work schedules.

In addition, the MCS scheme is not well-designed for sole traders or microbusinesses (which represent the majority of heating engineers and electricians undertaking household work) as it requires the establishment of an audited quality management system which represents a considerable administrative burden. Developing suitable accreditation systems and training to suit these types of businesses will therefore be important in promoting future heat pump deployment.

The alternative for small suppliers is on-the-job training with an MCS-certified company with existing experience in heat pump installation which was the route chosen for this project. MCA Renewables, the certified installer involved in this project, were able to offer this opportunity to local suppliers which has already been taken up by one local heating engineer.

[4] https://mcscertified.com/

Recommendations

Our findings suggest the following recommendations for organisations seeking to promote the deployment of heat pumps at high density:

- **Choose an appropriate area for the project**. Heat pumps remain expensive and only certain demographics are likely to consider them. This project has shown a positive response from middle earners based on the current combination of available grants and interest free loans that will cover the majority of installation costs.

- **Take householders with you on the journey**. There is a high level of interest in heat pumps in the aforementioned demographic, both for their potential to save energy and carbon, and to "future proof" properties. Our engagement with the community was based on sharing information not on selling products, which we believe opened people to the conversation.

- **Work with a local partner**. Feedback from the focus group indicated that householders are looking for support throughout the journey. A local partner (such as an energy advice service) that can support householders helps to build trust, makes it easier to start engaging with householders, and provides continuity of support.

- **Work with a trusted installer**. A larger installer is likely to be required to provide the expertise and capacity for large scale deployment. However, local installers will be fundamental to providing the capacity necessary for long-term uptake and maintenance. Projects should cultivate a willingness amongst large installers to participate in capacity building and work with the local supply chain. Our study suggests that peer-to-peer training is likely to be more effective than third party or manufacturer-led training, although the latter may be required anyway.

- **Plan for the future**. In the context of the current funding regime in Scotland, a combination of heat pump and solar PV installation provides the best cost-benefit for the consumer. Further technology combinations incorporating batteries could also be beneficial where the right incentives exist and provide the potential for greater long-term benefits through aggregation and variable energy tariffs. As the market is changing rapidly, technology needs to be selected to meet individual circumstances. High-density schemes should not restrict themselves to a single technology but consider the best options for both the householder and the area.

1. Introduction

Power Circle Projects Ltd (Power Circle) was successful in obtaining £83,870 funding through Stream 1, Phase 1 of the Heat Pump Ready Programme[5] to undertake a feasibility study assessing our SAPPHIRE (Smart Affordable Power and Heat with Integrated Renewable Energy) Solo proposition for the optimised deployment of individual domestic heat pumps at high density[6]. At the heart of this approach is the operation of a heat pump as an integral part of a smart system within the home, potentially also incorporating solar PV and battery storage. The project brought together several partners who worked together in an innovative way to define and analyse the proposition as well as to develop a comprehensive approach to engaging householders in the process.

One of the key challenges of heat pump deployment at any density within on-gas areas is to find a way to switch from gas to electric heating without adding to energy bills. Typically, modern gas boilers have a seasonal efficiency of ~90% whereas air source heat pumps (ASHPs) have a seasonal efficiency of ~300% or greater. Despite this thermodynamic advantage heat pumps typically cost more to run at present because the average unit price of electricity is more than triple that of mains gas. The initial premise of the SAPPHIRE Solo approach was that the benefit of electricity generated onsite from solar PV and the use of lower cost overnight electricity via a battery would enable a switch to heat pumps without adding to heating bills. The study also sought the views of householders and the local supply chain with regard to heat pump deployment. This was important in developing an understanding of how best to engage these stakeholder groups in future high density deployment schemes.

The chosen study area was the Altamount and Rosemount areas of Blairgowrie, a small town of about 9,000 people in the Perth and Kinross local authority area in Scotland. Blairgowrie was chosen as the project team had a good relationship with a local energy advice service (The Heat Project), which provided a link to engagement with the local community.

Altamount and Rosemount was chosen because the area largely consists of relatively recent housing owned and occupied by households in the middle-income bracket. As such, this area may be considered typical of such estates developed as part of small-town expansion in recent decades and is likely to be representative of similar areas across the UK. The area is currently on-gas and was viewed as promising for heat pump deployment as the relatively recent properties there could be expected to be relatively well insulated already. There are no large potential heat providers, nor any potential anchor loads, meaning that the area is unlikely to be suitable for a heat network[7].

1.1. Project Partners

The project was led by **Power Circle**, a social enterprise whose mission is to enable local energy users to access low carbon energy at scale in a way that is affordable, fair, and breaks down social barriers. Power Circle develops, manages, and, where required, arranges funding for low carbon energy projects, in particular smart local energy systems. Within this project, Power Circle was

[5] https://www.gov.uk/government/publications/heat-pump-ready-programme

[6] For the purposes of this feasibility study "high density" was defined as 25% of the domestic buildings within the service area of a secondary substation.

[7] https://heatmap.data.gov.scot/custom/heatmap/

directly responsible for project management, data collation, coordination of project partners, and for energy and financial modelling.

The Heat Project, part of **Blairgowrie and Rattray Development Trust**, are a pre-existing energy advice service covering the local area. They are well known in Blairgowrie and well networked with both suppliers and the local community. They played an important role in raising awareness of the project and supporting the community engagement programme.

MCA Renewables, an MCS-certified heat pump installer, provided advice on installation logistics, system specifications, and supply chain engagement designed to build an understanding of the current skill base and how this could best be developed.

Connect 3 Consultants managed the stakeholder engagement programme across all partners to ensure it was an open and accessible process and provided a focal point for suppliers and householders throughout the project.

The **Energy Systems Research Unit (ESRU) at Strathclyde University** undertook detailed thermal performance and energy system analysis for different house types within the study area to enable the design of suitable solar PV, electric battery, and heat pump systems.

GeoSpatial Insights Limited (GeoSpatial) analysed the rooftop solar potential of the area based on LiDAR data.

ZUoS Ltd (ZUoS) were responsible for analysis of the potential impact of large-scale, high-density heat pump deployment on the local distribution network in liaison with the local DNO, Scottish and Southern Electricity Networks (SSEN).

2. Aims, Expected Outcomes & Objectives

The aim of this feasibility study was to explore ways of making the installation of individual domestic heat pumps at scale and at high density affordable and attractive to the individual householder. High density for the purposes of this feasibility study has been defined as 25% of domestic buildings within the service area of a secondary substation. It was also an aim of this study to build a more in depth understanding of local householder and supply chain attitudes to heat pumps and through this to build an understanding of how best to engage these stakeholder groups in any future deployment.

The study objectives may be summarised as follows:

- Investigate the use of different technology combinations such as combining air source heat pumps with solar PV and domestic batteries to reduce running costs and optimise householder return on investment (ROI).
- Investigate the potential role of smart local energy systems (SLES); consisting of networked domestic storage systems, and the potential for these to generate income to assist in funding deployment and/or incentivising uptake.
- Develop and implement a community engagement plan designed to determine and understand the views of local householders regarding the technology and to identify key hooks which could potentially encourage installations.
- Build an understanding of the existing base of heat pump skills within the local supply chain and of how this existing capability might best be expanded and developed.

The expected outcome from actions undertaken in pursuit of these objectives was that by the conclusion of SAPPHIRE Solo we would have determined the best technology combination, funding mechanism, and engagement strategies to optimise the number of households willing to take forward a heat pump installation within the project area. Thus resulting in the emergence of an effective solution for encouraging heat pump installation at scale and high density in an on-gas area within the current technology, funding, and policy context.

A final further aim was then to develop this solution in preparation for a delivery phase within the project area with learnings resulting from SAPPHIRE Solo also contributing to a methodology designed to make the solution replicable elsewhere.

3. Summary of Work Packages

The project was structured around the following main work packages. These are summarised in the table below with the key activities and deliverables associated with each work package.

Table 5: Summary of key activities and deliverables by work package.

Work Package	Key activities	Deliverables
Data Analysis	LiDAR and OS data survey was carried out to assess the solar potential of the approximately 1,000 houses in the study area to assess the solar potential.	A datafile with initial PV assessment results for each building in the area which was used as the basis for the energy and financial modelling.
System optimisation	Assessment of the electrical and thermal load of four different house sizes which was used to design the optimum system for the house types in the area. This data was fed into the energy and financial model.	Month by month electricity and thermal load profiles. System design.
Funding proposition	Review of funding available to Scottish householders for heat pumps and other renewable technology including discussions with Home Energy Scotland, the administrators of this funding.	Funding proposition setting out funding availability, in the form of grants and loans.
Customer proposition	Based on the estimated electrical and thermal loads and review of technology options, the most suitable technology options and costs were identified.	A customer proposition setting out the works a customer would need to undertake to adapt their home to a heat pump, how the system should be used, and how the householders would benefit.
Energy and financial modelling	Based on the estimated electrical and thermal loads, the costs of technology and available grant and loan funding, various technology combinations were modelled to determine the cost and payback to householders of installing the system.	Cost benefit analyses which were used in the focus group and community feedback event to inform householders of the costs and benefits of the systems.

Work Package	Key activities	Deliverables
Community engagement	A range of community engagement activity was undertaken. This included articles in the local press to raise awareness of the project, a community questionnaire, house to house visits in the target area, a focus group to test findings and a final community event.	A series of reports covering the questionnaire findings and feedback from the focus group and community event. A final householder pack which has been distributed to all households that expressed an interest in the project.
Supply chain engagement	Identifying local suppliers, one to one follow up to explain the project, invitation to a workshop and assessment of training routes for local suppliers.	Supplier workshop report and training plan report.
Local Authority and DNO engagement	Meetings held with both the Local Authority and DNO.	Meeting notes from meeting with Perth and Kinross Council and report on DNO engagement.

4. Methodology for Feasibility Study

This section describes how each of the work packages in SAPPHIRE Solo were carried out:

4.1. Data Analysis

This study looked at the role that different technology combinations could have in reducing the cost of heat pump operation to the householder. This included incorporating solar PV systems. To establish the solar suitability and potential of the houses in the study area, Geospatial Insight (GSI) undertook a survey using building polygons derived from Ordnance Survey maps and remote sensing (LiDAR) to determine roof pitch, aspect, and useable area.

Once pitch, aspect, useable area, and irradiation values were established, onward calculations to estimate the financial and environmental benefits of an installation, including installation cost, on-site electricity savings, and CO_2 savings, were performed. The full report from this survey can be found in Appendix 1.

4.2. System Optimisation

To determine the appropriate size of the heat pump, PV, and battery systems and the likely impact these systems would have on household energy usage it was necessary to assess the probable existing electrical and thermal loads across various dwelling types and the impact the proposed technology combinations might have on these. Electrical and thermal load assessments were therefore undertaken on four different house types based on house size. This work was undertaken by ESRU with input from MCA Renewables.

ESRU used two validated models to develop demand profiles for each house type. One was an occupancy model[8] used to develop profiles for occupancy and linked profiles for individual appliances and for hot water demand[9,10]. The second assessed heating needs using a thermal model[11], where for different house sizes the assumed thermal performance of the building fabric was used to perform a heat loss assessment. Heat gain from occupants and appliances was integrated from the generated occupancy and demand profiles. Heating behaviours were set to average patterns taken from the BEIS 'Energy Follow Up Survey' dataset[12] from 2011 and 2017, with some allowance for probable behaviour changes associated with heat pump use derived from the

[8] Flett, G., & Kelly, N. (2016). An occupant-differentiated, higher-order Markov Chain method for prediction of domestic occupancy. Energy and Buildings, 125, 219-230

[9] Flett, G., & Kelly, N. (2017). A disaggregated, probabilistic, high-resolution method for assessment of domestic occupancy and electrical demand. Energy and Buildings, 140, 171-187.

[10] Flett, G., & Kelly, N. (2021). Modelling of individual domestic occupancy and energy demand behaviours using existing datasets and probabilistic modelling methods. Energy and Buildings, 252, 111373.

[11] Murphy, G. B., Counsell, J., Allison, J., & Brindley, J. (2013). Calibrating a combined energy systems analysis and controller design method with empirical data. Energy, 57, 484-494.

[12] Department of Energy and Climate Change, Building Research Establishment. (2016). Energy Follow Up Survey, 2011. [data collection]. 3rd Edition. UK Data Service. SN: 7471, DOI: 10.5255/UKDA-SN-7471-3. Available from: https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=7471

Renewable Heat Premium Payment (RHPP) scheme dataset[13]. Weather inputs to the heating demand model were local conditions taken from Merra-2 data[14], with 2017 used in constructing the typical profiles described above as it represented a relatively average year, in the context of recent history, in terms of both temperature and solar irradiation.

The above information was used both to determine the appropriate sizing of household systems and to understand how operation of a heat pump powered central heating system may be optimised to deliver space heating and hot water objectives as set by the household, and in addition to understand how the operation of a property's electrical system might be optimised with the use of PV and battery assets to meet household needs in the most cost-effective way. Finally, we also considered opportunities for optimisation to meet the needs of the wider electrical system outside of the home.

4.3. Funding Proposition

A review of potential funding options was undertaken, covering funding available to individual householders through both UK and Scottish Government schemes as well as the option to fund the technology by establishing a new third-party Energy Services Company (ESCo) which could be operated by Power Circle or by another third party and which would take responsibility for raising financing. However, due to the prevalence of existing, highly attractive support schemes available in Scotland, it was determined that the best prospect for high-density deployment remains via individual householders applying to this existing funding[15].

Exact levels of funding, payback periods, and loan terms were investigated through discussion with Home Energy Scotland, who facilitate access to these schemes. Through the Home Energy Scotland loan scheme, owner-occupiers have access to a £7,500 grant for either an air or ground source heat pump plus an additional interest-free loan element, this is in comparison to a UK Government grant of up to £5,000[16]. It should also be noted that since completion of this project the Scottish Government has updated the rules of their funding schemes with respect to heat pumps and other renewable technology. The total grant funding available for heat pumps remains unchanged but additional grant funding is now available for energy efficiency improvements and loan terms for heat pumps and other renewable technologies have been made more flexible.

All modelling and analysis work undertaken as part of this feasibility study was based on the funding regime in place in September 2022.

---

[13] Lowe, R., Department of Energy and Climate Change. (2017). Renewable Heat Premium Payment Scheme: Heat Pump Monitoring: Cleaned Data, 2013-2015. [data collection]. UK Data Service. SN: 8151, DOI: 10.5255/UKDA-SN-8151-1. Available from: https://beta.ukdataservice.ac.uk/datacatalogue/studies/study?id=8151

[14] Pfenninger, Stefan and Staffell, Iain (2016). Long-term patterns of European PV output using 30 years of validated hourly reanalysis and satellite data. Energy 114, pp. 1251-1265. doi: 10.1016/j.energy.2016.08.060. Available from: https://www.renewables.ninja/

[15] https://www.homeenergyscotland.org/heat-pumps/grants-and-funding/

[16] https://www.gov.uk/government/news/five-reasons-to-get-a-heat-pump

4.4. Customer Proposition

Market research was undertaken into different types of heat pump, battery, and PV panels to determine those that would be most suitable for the house types present in the feasibility study area. Recommendations have been made based on price, quality, and service support as well as capability for smart operation. The customer proposition also advises on how householders should use this technology to get the most out of their systems and on tariff optimisation to maximise potential savings.

4.5. Energy and Financial Modelling

Energy and financial modelling was undertaken to provide a cost benefit analysis for householders showing the savings a householder could expect to achieve from adopting the technology, the costs associated with paying back available interest free loans and the long -term savings that could be expected when loans had been paid off. The modelling was undertaken on four house sizes. These were found to be typical of those found in the study area based on a site walk-through and are shown in Table 6 below.

Table 6: Guide to house types.

House type	Size (metres squared)	Guide
Archetype 1	0-100	1 to 2 bedrooms
Archetype 2	100-150	2 to 3 bedrooms
Archetype 3	150-200	3 to 4 bedrooms
Archetype 4	200-250	4 to 5 bedrooms

The model inputs were based on a number of assumptions as set out below.

Average solar generation - This data was taken from the LiDAR survey averaged for each house type.

Assumed electrical and heat loads- This was taken from the system optimisation assessment which worked out typical heat and electric loads for the house type (age and construction method) found in the study area for four different archetypes as shown in Table 6 above.

Costs of technology – This was based on the technology options selected as part of developing the customer proposition and market research on costs.

Energy costs - The baseline assessment was based on a price cap of 34p per kWh for electricity and 10p per kWh for gas (current in October 2022). Two different options were modelled to take account of potential cost increases during the period of loan repayment. The first option assumed 3% per year RPI, the second used the forecasting data available from Cornwall Insights[17]. A comparison of these two options are shown in Figure 1 below.

[17] https://www.cornwall-insight.com/wp-content/uploads/2022/07/Cornwall-Insight-GB-Power-Market-Outlook-to-2030_2022Q2-Final.pdf?utm_source=email

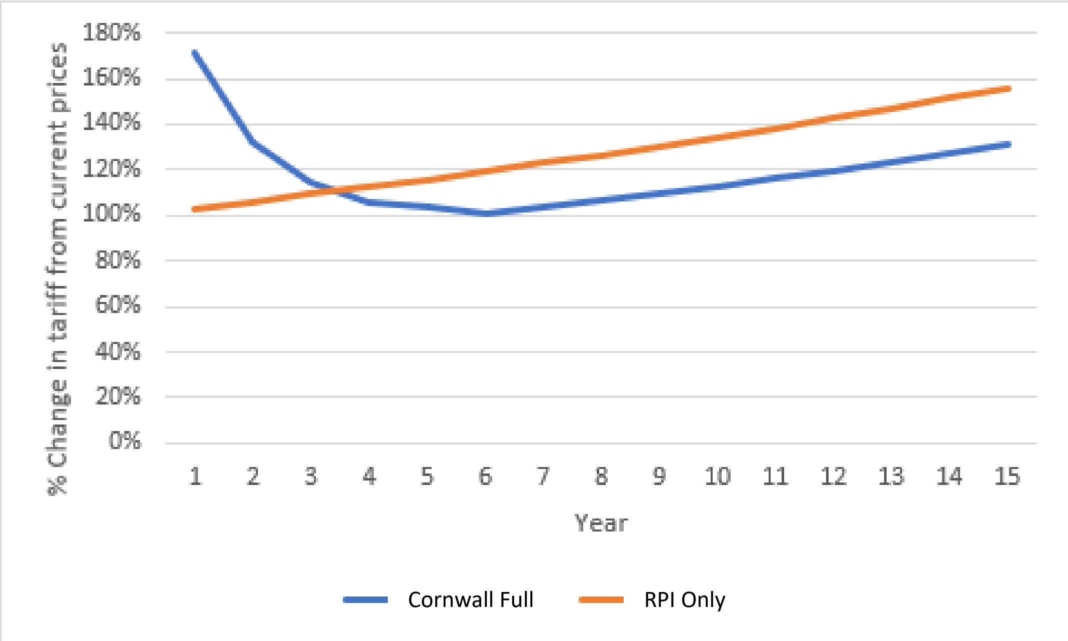

Figure 1: Cost forecast options, Cornwall Insight vs RPI.

The assumed daytime and night-time tariffs used to model the benefits of the battery were:

- daytime = 44p/kWh
- night-time = 11p/kWh

These tariffs were based on our market research, which also suggested that 10p/kWh would be a reasonable assumption for the Smart Export Guarantee[18], see Appendix 2.

Assumptions also had to be made regarding the seasonal coefficient of performance (SCoP) of the heat pump. ESRU undertook research looking at performance based on available performance data[19] from existing heat pumps and recommended that a SCoP of 2.5 be used. This was viewed by MCA Renewables as a major underestimate of likely performance as the underlying technology, levels of experience in the supply chain, and certification schemes have all improved markedly since many of the early heat pump installations from which this performance data was drawn were carried out. Their more recent experience suggests that a SCoP as high as 3.8 can be achieved in practice, which aligns more closely with suggestions made by manufacturers. To reflect both views and in the interest of generating conservative estimates a SCoP of 3.0 was used in our modelling.

[18] https://www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg

[19] Staffell, I., Brett, D., Brandon, N., & Hawkes, A. (2012). A review of domestic heat pumps. *Energy & Environmental Science*, 5(11), 9291-9306.

4.6. Community Engagement

There were three key strands to the community engagement programme:

- Media
- Local stakeholders
- Engagement with householders

The purpose of this three-strand approach was to raise awareness and interest in the project as widely as possible and then to test different approaches to engaging with people in the study area.

4.6.1. Media

The Heat Project, through their local connections, promoted the project in local media though a number of different channels. The below article appeared in the Blairgowrie Advertiser on 16/08/22.

www.blairgowrieadvertiser.co.uk InYourArea.co.uk 16.08.2022 3

CLARE DAMODARAN

Homes could be in heat pump study

Smart community energy system is ultimate aim

An east Perthshire-based project has been announced as the only Scottish initiative to be involved in a study that aims to encourage the use of domestic heat pumps.

Working in partnership with Power Circle, a Scottish social enterprise, the HEAT Project – which is part of Blairgowrie and Rattray Development Trust – is exploring options for undertaking a heat pump project in the Blairgowrie area with funding from the Department of Business Energy and Industrial Strategy (BEIS).

HEAT Project manager Martin Mathers said: "Our aim is to develop a package for households that really reduces their energy use, tackling climate change and hopefully reducing energy bills – a win-win for consumers and the environment.

"A heat pump is a device that absorbs heat from the air, ground or water around a building and converts it into a form that can be used to heat houses.

"Heat pumps can produce three to four times as much heat as the electricity needed to run them and are part of the government's efforts to reduce carbon dioxide emissions from heating and tackling the declared climate emergency.

"Overall aim is to develop a model that makes installation and operation more affordable ... Martin Mathers

"The feasibility study will look at the most cost-effective way to introduce heat pumps for consumers, including the option of installing the pumps in combination with roof-top solar PV panels and battery storage to reduce the running costs of the pumps.

"The solar PV panels and battery would provide electricity to operate the heat pump, which will reduce the amount of energy the heat pump needs to draw from the grid.

"The overall aim of the study is to develop a model that makes the installation and operation of heat pumps more affordable and therefore available to more people in the community."

Power Circle is a social enterprise which supports social housing providers, private house owners, communities, and the private sector to access affordable, low carbon energy, helping them establish smart, local energy systems.

Jon Cape, managing director of Power Circle, commented: "If we can get enough households to take-up this package, there may be the potential to then link the heat pump and PV/battery systems together into a smart community energy system.

"This can help householders get even more benefits."

Over the next few months, the project team will be seeking feedback from the community on the proposals through questionnaires, focus groups and one-to-one discussions.

If you are interested in knowing more and participating in the consultation, get in touch with Martin on 07834 962361, email the team through the contact form on www.theheatproject or complete the online survey at www.theheatproject.org/heat-pumps-survey-in-blairgowrie-scotland/

Initiative Martin Mathers from the HEAT Project – part of Blairgowrie and Rattray Development Trust – beside a heat pump

Figure 2: Blairgowrie Advertiser, 16/08/2022.

An article also appeared in the 2022 Autumn edition of the *Blairgowrie and Rattray Hub Magazine*, produced by the Blairgowrie and Rattray Development Trust[20], which goes out to a distribution list of approximately 6,000 households. In addition, information on the project was included, on 10th August, in an updates email that The Heat Project sends to 195 Blairgowrie households on their database on a regular basis.

The overall aim of this activity was to increase awareness of the project with a view to eliciting more interest once more direct community engagement activities began.

[20] https://www.yumpu.com/en/document/read/67090448/blairgowrie-rattray-hub-magazine-autumn-2022

4.6.2. Local Stakeholders

Presentations on the project were made to the below stakeholders:

- Blairgowrie and Rattray Development Trust
- The Community Council
- Perth and Kinross Climate Change Commission
- The Climate Change and Sustainability Committee of Perth and Kinross Council

In addition, an online questionnaire (see Appendix 3) was circulated through various channels. This included The Heat Project email updates circulated to 195 people and the *Blairgowrie what's happening in and around* Facebook page, which was chosen based on its high level of activity, high follower count (5.7k), and local focus. This questionnaire asked respondents some general questions about heat pumps; for example, what they knew about them, would they install one, and what was their current approach to procuring energy. The purpose of this questionnaire was to get an overview of the level of interest and perception of heat pumps across the local community. The final question asked respondents if they lived in the feasibility study target area and invited them to provide contact details if they had an interest in the project.

4.6.3. Householders

In addition to engagement activity taking place through local media and local stakeholders, householders in the study area were also engaged with directly.

All householders in the area received a letter from Home Energy Scotland informing them about the project and inviting them to sign up to get more information. The letters were sent out in five weekly batches between 23rd August and 20th September 2022 to all 1,000 houses in the study area. A copy of the letter is included as Appendix 4.

This was followed by house-to-house visits undertaken from 5th to 23rd September. The aim was to visit a representative number of houses in each street targeting around 500 houses in total. During the visits some houses were found not to be suitable due to their age and some streets only included housing association properties. When this was discovered no further visits were made in these areas. Further information was provided to those householders that were interested; a copy of this is provided in Appendix 5.

A focus group took place on 20th October the purpose of which was to present early findings and get feedback on:

- Participant's main drivers for exploring renewables
- The likelihood of participants taking up different renewable options and their reasons
- Any options that looked particularly attractive
- Any widely held concerns
- What would most encourage participants to take up any of the options

The participants in these focus groups were invited from a list of householders that had self-referred themselves after receiving the aforementioned letter (Appendix 4) from Home Energy Scotland. These 28 households had proactively sought engagement with the project so were considered the most likely to attend a focus group. An open community meeting was held on 7th November 2020 to which all 130 households that had shown an interest in the project were invited.

4.6.4. Supply Chain Engagement

An important element of the SAPPHIRE Solo project was to engage with the local supply chain. A recent report by the Energy Systems Catapult has identified the retrofit skills shortage as holding back decarbonisation, specifically flagging low carbon heating as an area of concern[21].

It was therefore considered important as part of this project to engage the local supply chain, to explain in more detail the heat pump programme and the proposed combined technology solution, and to understand the best way to support them in gaining the necessary experience to become installers. In support of this aim the following actions were undertaken:

- Local suppliers who had a Blairgowrie address were identified through a combination of local contacts known to The HEAT Project and additional suppliers who were identified via search engine.
- In total, 9 heating engineers and 11 electricians were identified with an address in Blairgowrie, the majority were sole traders.
- These suppliers were contacted by phone to establish their interest in learning more about heat pumps and about the project.
- The 13 suppliers who expressed an interest were invited to a meeting in Blairgowrie on 5th September. Five suppliers attended the meeting and follow up discussions were held with two suppliers who were interested to engage further.
- Based on the meeting and discussion with suppliers a proposed approach to building the capacity of the local supply chain was determined as set out in Section 6.4 with a full report on the proposed approach available in Appendix 6.

4.6.5. Local Authority and Distribution Network Operator (DNO) Engagement

A meeting was held with the team responsible for developing the Perth and Kinross Council Local Heat and Energy Efficiency Strategy (LHEES)[22] on 14th September 2022. LHEES are part of the Scottish Government's strategy to decarbonise heat in buildings by 2045. They will set out the long-term plans for improving energy efficiency and decarbonising heat across the building stock. Each local authority has to develop a plan by the end of 2023 which covers all buildings within their local authority area that are both privately and publicly owned.

Several discussions took place with the local DNO, Scottish and Southern Energy Networks (SSEN), including an in-person meeting on 30th September 2022. The purpose of these discussions was to establish local grid capacity, understand the grid consent process for a high-density scheme, and to understand the potential need for network monitoring.

---

[21] https://www.current-news.co.uk/news/retrofit-skills-shortages-holding-back-home-decarbonisation-finds-energy-systems-catapult.

[22] https://www.legislation.gov.uk/sdsi/2022/9780111053935

5. Findings from Work Packages

Key findings and deliverables from each work package are presented below:

5.1. Data Analysis

The output from the LiDAR and OS assessment indicated good solar potential across the majority of properties in the study area with most having a rooftop PV potential of up to 4kWp or 4-10kWp.

Figure 3: Rooftop solar potential of the study area.

The study data reviewed the solar potential of the area on an aggregated level which identified a total potential of 8.365MW as shown in Figure 3. Based on a total install cost of £12.5m a community system realising this potential could generate, on average, savings of £890k and export revenue of £111k per year with estimated annual carbon savings of approximately 1.2 tonnes per household. At an individual home level, the study showed generation of electricity via solar PV when combined with a heat pump would result in a more favourable heat pump proposition for the household where solar PV installation is practicable. This is despite the relative mismatch between the solar PV annual generation profile and the heat pump annual load profile. The solar generation profiles were used to assess savings in the energy and financial modelling undertaken later in the project. The full report is presented in Appendix 1.

5.2. System optimisation

Electrical and thermal load assessments were completed for the four different house archetypes covered by the study. For illustrative purposes the data for archetype 2 is shown in Table 7 below and used in this report. Equivalent data for other house types is available in Appendix 7.

Table 7: SAPPHIRE Solo, archetype 2.

Type	Bungalow (single storey)
Floor Area	$130m^2$
Cavity Wall Construction	U-value = 0.4
Other U-values	Roof = -0.13 Floor = -0.6 Windows = -2.5
Maximum PV capacity	20kW (based on 1 Auchmore Drive)
PV	South facing, 45deg tilt assumed
DHW thermal store	200 litre
Weather reference year	2020

Anticipated month-by-month electrical demand before and after the installation of the heat pump was calculated as shown in Figure 4 below and matched against the solar profiles.

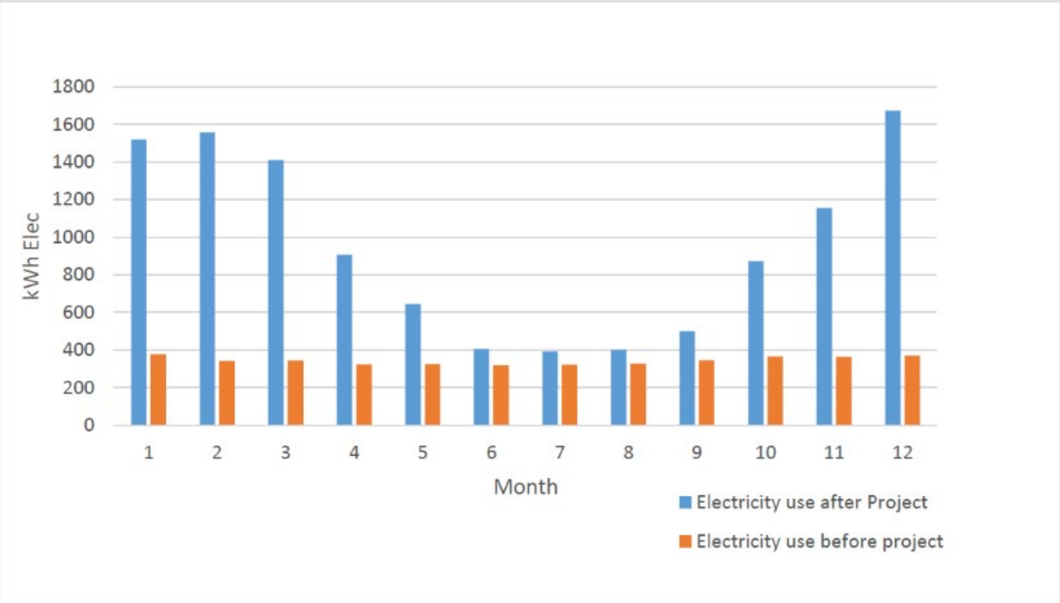

Figure 4: Electrical demand profiles before and after heat pump installation.

Based on the above assessment the following assumption were made:

- The current annual average space heating and hot water demand for a house of this type is approximately 21,000kWh per annum.
- A reasonable estimate for annual average electrical demand following installation of a heat pump would be approximately 5,800kWh annum.

Following therefrom, the below specification was proposed for a system which would meet the heat and electrical demand for an archetype 2 property:

- Estimated heat pump size: 10kW
- Solar PV size: 4 kWp
- Battery size: 5.8 kWh

It was proposed that to optimise the system a smart energy management capability should be incorporated. This could be an existing system such as Hive or Google Nest, if householders already own these, or controllers that come with the heat pump. Heat pumps such as Vaillant have their own programmable controllers for heat and hot water but can also work with third-party systems. Grant heat pumps on the other hand do not have their own programmable controller so householders would be encouraged to use systems such as Hive or Google Nest.

Battery systems vary in their smart capability but have the potential to manage householder energy informed by onsite generation and by the householder's choice of energy tariffs. The Alpha ESS system provides both these capabilities and was therefore recommended. A series of short videos are available[23] which describe the smart energy management system and the householder's app. These are available from Google Play and from Apple's App Store. A demo version of the app is available to householders prior to purchase.

5.3. Smart Local Energy Systems (SLES) and Aggregation Opportunities

In addition to the benefits that may be achieved by an individual household installing a battery storage system, there may be potential to establish a smart local energy system (SLES) composed of networked domestic storage devices to create aggregation opportunities such as provision of grid services. Grid services is a catch-all term referring to specific services such as firm frequency response[24] (FFR) which can be provided to network operators, which can support their operation of the grid and enable it to operate at lower cost and with lower carbon emissions. It should be noted that at present individual households cannot participate directly in this market, it currently requires a specialist delivery partner (known as an "aggregator") and sufficient scale. At present, a minimum of 1MW of "flexible assets" such as batteries are required. This equates to some 300 domestic properties, assuming typical-sized batteries and grid connections, within a given DNO service area (in this case the North Scotland area operated by SSEN). In the context of SAPPHIRE Solo, a major factor in selecting the Alpha ESS was that it already boasts the necessary connectivity and smart capability to participate in aggregation services such as these.

The potential revenue from provision of grid services represents an opportunity to significantly improve the cost-benefit of systems incorporating battery storage. In the case of SAPPHIRE Solo, this could be realised if 50+ households in the Blairgowrie area were to install a domestic battery. The initial grid services opportunity would likely be provision of FFR as mentioned above, with an indicative customer benefit of approximately £105 per year. This has not been factored into our

[23] https://www.alphaess.com/video
[24] https://www.nationalgrideso.com/industry-information/balancing-services/frequency-response-services/firm-frequency-response-ffr

energy and financial modelling as this opportunity is not immediately available, however we expect this to be available to domestic customers within two to three years at time of writing.

In addition to FFR, National Grid has recently launched a Demand Flexibility Service[25] (DFS) paying consumers (via aggregators) to cut usage at peak times. It currently sits alongside other established Balancing Services[26] and the same assets may not participate in both. A present, the DFS programme is due to continue until Spring 2023. Notably, it requires no storage capability or smart assets in the home beyond a smart meter.

The additional benefits that could potentially be achieved by participation in the balancing services outlined above not been factored into the SAPPHIRE Solo customer proposition during phase one due to the long period of time likely required to recruit a sufficient number of households (though this limiting factor does not apply to the DFS) and the complexity such an offering would add to the customer proposition, discussed in detail below.

5.4. Funding Proposition

The optimum funding proposition for individual households was deemed to be the interest free loan and grant funding available from the Scottish Government via Scotland's energy advice service, Home Energy Scotland (HES)[27]. At the beginning of the project we understood from HES that this funding proposition was likely to remain unchanged as it has been in place for a number of years. However, in December 2022 following completion of SAPPHIRE Solo the Scottish Government revised the grant and loan scheme arrangements[28]. **It should therefore be noted that all information in this report is based on the loan and grant scheme that was in place in September 2022**.

Changes to the scheme have not been significant, and in fact make the funding more flexible and accessible than it was. The £7,500 grant-funding element available for a heat pump remains but may now be accessed in isolation rather than requiring householders to also accept the interest-free loan element. Interest-free loans with some grant funding also remain available for other renewable technologies. For example, for a solar PV system at time of writing £6,000 funding is available of which £1,250 may be a grant, subject to conditions, with the remainder available as an interest-free loan.

At the time of the project all householders could access the following interest free loans and cashback. Until the recent changes to the scheme, "cashback" was the term used by HES for the grant funding element of the available support. We have therefore chosen to use the same terminology in this report for the sake of clarity.

---

[25] https://www.nationalgrideso.com/industry-information/balancing-services/demand-flexibility
[26] https://www.nationalgrideso.com/industry-information/balancing-services
[27] Home Energy Scotland is a programme funded entirely by the Scottish Government, administered by the Energy Saving Trust as managing agent, and delivered by four contracted partner organisations (Changeworks, Energy Agency, SCARF, and Wise Group) who provide the actual frontline service across five service areas. More information on the service is available via https://www.homeenergyscotland.org/.
[28] https://www.homeenergyscotland.org/funding/grants-loans/overview/

- **Heat pumps**: funding up to £10,000 (£2,500 interest-free loan plus up to £7,500 cashback)
- **Solar photovoltaic (PV):** interest-free loan £5,000 (no cashback)
- **Energy storage systems (heat or electric batteries):** interest free loan £6,000 no cash back

Householders could also borrow up to £500 (including up to £200 cashback) for "secondary improvements". For example, cylinder thermostats, cylinder jackets, or heating controls. These were not available on their own but required to be combined with a "primary measure", a more significant energy efficiency or renewable technology, in order to be eligible.

All loans were subject to an administration fee up to a maximum of £150. Repayment terms for the loan were as noted below:

- Under £5,000: 5 years
- £5,000 - £9,999: 10 years
- More than £10,000: 12 years

5.5. Customer Proposition

The customer proposition evolved during the project in response to the outputs from the energy and financial modelling and householder feedback. The initial assumption had been that a combination of solar PV, battery, and heat pump would provide the optimum solution for the householder. To assess the impact of the different technology combinations on the cost-benefit analysis the following combinations were modelled.

- Heat pump only
- Heat pump and solar PV
- Heat pump, solar PV, and battery

Additionally, in response to a small number of requests from householders in the house-to-house surveys we also modelled solar PV plus battery and solar PV only installations that did not include a heat pump. During the house-to-house discussions several people indicated that they were not ready to replace their boiler but were interested in installing PV. The results of the PV and battery modelling have been presented to householders in the packs distributed at the end of the project as discussed below. However, these results will not be further discussed in this report as this was not an objective of SAPPHIRE Solo. A copy of the householder pack is included in Appendix 8.

The proposed customer proposition is set out below:

- Review of existing insulation and other building fabric elements, with appropriate measures recommended for each home.

- Review of existing radiators to determine if they can be used or whether new radiators will be required. Plus an investigation to identify the presence of any microbore heating pipework which would require to be replaced[29].
- Air source heat pump (low-temperature air-to-water). Two options were recommended, the Grant Aerona and Vaillant aroTHERM. These were recommended based on price, quality, and available servicing support via the manufacturer's service engineers.
- Rooftop solar PV installation with suitability and sizing individually assessed for each property. The choice of solar panel supplier would depend on market conditions at the time.
- Electric battery sized to enable the householder to benefit from cheaper overnight tariffs while taking into account both heat pump and non-heating electrical load. Alpha ESS batteries were recommended due to ease of installation, smart capability, and existing grid services capability (see Section 5.3 above).
- Replacement, or newly installed hot water cylinder. Most homes in the target area were assessed as being likely to have a combination boiler, thus requiring introduction of a hot water cylinder. Even where a system boiler is present with an existing cylinder, replacement is highly likely to be required to achieve compatibility with the heat pump. The simplest approach was for this to be supplied by the heat pump manufacturer and installed alongside.
- Smart heating controls, either those supplied by the heat pump manufacturer or third-party smart heating control systems such as Hive or Google Nest.
- Change to off-peak electrical tariff with a lower overnight rate, assuming that the household has opted to install a battery. In such cases, an overnight tariff is able to optimise financial return, but it provides no benefit without the battery.
- Financial support derived from existing Scottish Government schemes that combine grant and interest-free loan funding (see Section 5.4 above).

5.6. Energy and Financial Modelling

Energy and financial modelling generated two key outputs:

- Financial savings provided by the system on an annual basis.
- A cost-benefit analysis over 15 years including the cost of capital to finance installation.

These outputs were modelled for the three technology combinations, heat pump only, heat pump and solar PV, and heat pump, solar PV, and battery. Outputs of this modelling for archetype 2 are presented below for illustrative purposes, with the output for all archetypes available in Appendix 8.

Energy Tariff and Solar Assumptions:
Electricity = 34p/kWh
Gas = 10p/kWh
Solar PV, self-consumption by household = 1,406 kWh/year

[29] MCA Renewables indicated that they would recommend strongly against installation of an air source heat pump where microbore pipework is present. This is due to the risk of pipework blocking due to the glycol medium used in the space heating distribution system. Achieving sufficient heat flow to radiators supplied by microbore pipework was also a concern considering the low flow temperatures at which heat pumps operate.

Solar PV, export to grid = 1,177kWh/year (export income = £118/year)

5.6.1. Heat Pump Only

Table 8: Estimated annual savings for heat pump only.

	Annual usage	Annual cost (GBP)
Annual electricity usage before install Annual gas usage before install *Total energy usage before install*	2,422 kWh 20,212 kWh *22,634 kWh*	£987 £2,181 *£3,168*
Annual electricity usage after install	8,381 kWh	£2,992
Annual saving after install		**£176**

Table 9: Cost-benefit analysis heat pump only.

Year	Loan repayment (£)	Saving from heat pump (£)	Cost-benefit (£)
1-5	-1,104	1,502	398
5-10	-1,104	1,399	295
10-15	-4,42	1,622	1,180

5.6.2. Heat Pump and Solar PV

Table 10: Estimated annual savings for heat pump and solar PV.

	Annual usage	Annual cost (GBP)
Annual electricity usage before install Annual gas usage before install *Total energy usage before install*	2,422 kWh 20,212 kWh *22,634 kWh*	£987 £2,181 *£3,168*
Annual electricity usage after install	7,070 kWh	£2,524
Annual saving after install (not including export income) (including export income*)		 **£644** **£762**

**income derived from export of excess PV output, via a Smart Export Guarantee tariff for example[30].*

Table 11: Cost-benefit analysis heat pump and solar PV

Year	Loan repayment (£)	Saving from heat pump + PV (£)	Cost-benefit (£)
1-5	-3,188	4,863	1,676
5-10	-3,188	4,108	921

[30] https://www.ofgem.gov.uk/environmental-and-social-schemes/smart-export-guarantee-seg

10-15	-1,275	4,705	3,430

The results show that the heat pump and solar PV combination adds considerably to the savings for the householder and makes the investment proposition considerably more attractive due to early payback and higher overall cost-benefit.

In addition, we investigated the solar PV, battery, and heat pump combination which should in principle provide the best savings as the battery storage capability offers the dual benefit of increasing PV self-consumption and enabling use of off-peak electricity by charging overnight. This proved not to be the case however (see Appendix 9). Within the scope of available funding it was not possible to include a battery with sufficient storage capacity to realise this opportunity, based on the assumption that the battery is sized to optimise cost savings on all electrical demand, both heat pump and non-heating.

An attractive alternative could be to size the battery only to optimise storage of electricity to meet non-heating demand. This could be combined with either a large hot water cylinder, though this may be problematic in many properties due to the large volume of the tank, or a physically smaller phase-change heat battery to provide a thermal storage capability for the space heating system. UK-based thermal storage manufacturer Sunamp[31] is currently launching a new battery which may be suitable for this purpose, but specifications were not available at time of writing.

5.7. Community Engagement

In this section we report the results of the online survey and community engagement programme.

5.7.1. Online Survey

There were 115 responses to the online survey. Notably, a relatively high proportion of respondents (35%) came from the target area indicating its potential for the pilot study. Full details of the survey findings are provided in Appendix 10. Key highlights are presented below:

- 92% of respondents were concerned about energy prices.
- 14% of respondents changed supplier regularly, 25% had never changed supplier, the others were in between.
- 48% of respondents knew something about heat pumps with 34% having heard of them but not being sure of what they were. 4.7% (5 respondents) already had heat pumps.
- 93% of respondents would consider having a technology combination of solar PV, battery, and heat pump installed.
- The reason most respondents (58%) wanted the technology installed was to provide cheaper heating. However, a significant percentage (34%) indicated that reducing their carbon emissions was the main reason for considering the technology.
- The main reason people did not want the technology installed was that their boiler did not need replacing (57%) with 14% being concerned about cost and lack of knowledge of the technology. Other reasons given were primarily related to lack of confidence in the technology, concerns about their effectiveness in the Scottish climate, and costs.

[31] https://sunamp.com/

- Cost (38%) was the primary issue that would influence respondents decision to install the technology with 20% indicating that the balance between grant and loan funding was important. Only 7% had no interest in installing the technology.

Overall, respondents reported a high level of awareness of heat pump technology. As with any survey the respondents were self-selecting. In this case the respondents were likely to have more of a predisposition to, and interest in, new technology. The fact that 9% of respondents owned an electric vehicle compared to 4.5% in the general population in the UK is illustrative of this fact. Acknowledging this, the survey results indicated a high level of interest in both heat pumps and the proposed technology combination for the project with 93% of respondents indicating that they would consider having a heat pump, solar PV, and battery installed if it reduced energy costs.

A number of negative responses made reference to a well-known local example where a heat pump had failed but these responses were in a minority.

As part of the survey, those living in the target area were asked if they wanted to leave their contact details to obtain further information. 20 positive responses to this question were received and these respondents were provided with further information in the form of a householder briefing sheet, see Appendix 5.

5.7.2. Letters and House-to-House Engagement

There were 28 positive responses to the Home Energy Scotland letters sent to the 1,000 households covered by the study area. In addition, a further 82 people responded positively from the house-to-house surveys, either at the time of the visit or through follow up, in some cases recommended by neighbours. In total, 427 houses were covered as part of the house-to-house surveys. Of the 253 households who we spoke to directly 37% were interested and 24% sufficiently interested to provide their contact details as summarised in Table 12 below.

Table 12: Results of house-to-house engagement.

Households that expressed interest in hearing more and provided contact details.	82
Households that expressed an interest but were not prepared to provide contact details.	31
Households that were not at home.	174
Households that were not interested.	159

A total of 130 households provided contact details to receive further information across the project area broken down in Table 13 below:

Table 13: Households that provided contact details by engagement channel.

Initial community wide survey	20
HES Letters	28
House-to-house visits and word-of-mouth	82
TOTAL	**130**

No strict format was applied to house-to-house visits. The surveyor simply introduced themselves as being from The Heat Project, explained the purpose of the feasibility study, and asked if the householder would like more information. This then led either to a person declining further discussion or a follow-on discussion with the householder. Ultimately the householder was asked if they would like to provide their contact details so they could receive information on the findings of the feasibility study when these became available. Contact was always on the doorstep and ranged from two or three minutes to ten minutes.

In our view, there are several reasons why the positive response rate achieved by house-to-house visits was relatively high.

- The person visiting was from a local organisation with pre-existing name recognition in the area, rather than a private company and/or unknown party.
- It was made clear that the contact was not a sales pitch but an offer to share the findings of a feasibility study specific to the local area.
- Recent increases in energy prices were probably also a factor. Many householders indicated that they were interested in anything that might reduce their energy costs.

Two or three additional persons contacted us after the house-to-house visits as they had heard about the project via word-of-mouth from a neighbour.

During the house-to-house surveys it was established that some houses were not suitable for the project due to their age, meaning they were likely to require considerable improvements to building fabric before a heat pump became a viable option. Some properties were also discovered to be owned by private and social landlords which reduced the pool of eligible households in the study area from 1,000 initially to between 800 and 900.

5.7.3. Focus Group

The focus group meeting was held on 20th October 2022 from 7 to 9pm. There were 11 total attendees representing 8 households. The key learnings from the focus group discussion are presented below; the full report and presentation used at the meeting can be found in Appendix 11.

- Attendees were concerned about energy prices and how they might rise in the future.
- Prior knowledge of renewables was limited so attendees were keen to be informed.
- The level of information presented during the focus group was considered suitable as it gave attendees a basis for considering their own situation.
- The main drivers for considering installation of a renewable energy system were cost, reducing carbon emissions, a desire to future-proof, and the need to replace gas boilers.
- The available grant and loan scheme was seen as a key factor in encouraging uptake.

- There were justifiable concerns over how long it would take for the supply chain and Home Energy Scotland to respond and fears a lot of enthusiasm was being generated which the market might not be able to deliver on.
- There were also concerns about how long funding and grants would be available as these were fundamental to progressing.
- Interestingly, no concerns were expressed about the efficacy of the technology.
- Follow up support, in the form of The Heat Project, was seen as a huge plus to moving forward as it appeared a number of people were daunted by the process that they had to go through to acquire the necessary funding and to procure the technology itself.

5.7.4. Community Event

The 130 households on the contact list were invited to an open community event held in Blairgowrie on 7th November 2022 from 7 to 9pm to present the findings of the feasibility study.

A total of 28 householders attended the event. The presentation covered Government strategy to decarbonise heat, the direction of travel towards electrical energy, air source heat pump technology, the costs and benefits of installing heat pumps, the potential to combine technology, funding routes and impacts for householders.

Time was allocated for questions which were answered by representatives from Power Circle, MCA Renewables and The HEAT Project.

Based on the questions asked and the discussion at the meeting there appeared to be a high level of interest in the technology. The greatest concern from attendees was the potential disruption associated with the need to change pipe work and radiators and the impacts of a household having microbore pipework. At the event 5 people signed up for a house visit from MCA Renewables.

5.8. Supply Chain Engagement

A meeting for five interested suppliers was held in Blairgowrie on 5th September 2022 with representatives from MCA Renewables, Connect 3, and The Heat Project. In addition, follow-up discussions were held with two additional suppliers. The main findings from the supplier meeting are summarised below. The full report can be found in Appendix 12.

- None of the suppliers present had been involved in a heat pump installation, one had been involved in a solar PV installation.
- Similarly, none of them held MCS certification apart from one supplier accredited to install solar PV.
- There was a keen interest, particularly amongst younger suppliers, to learn more about heat pump technology and a general acceptance that this was the direction of travel.
- A key barrier to training was time. All suppliers that attended the meeting were already busy and finding their time to be in high demand. In addition, there was a feeling that market demand for renewables was not yet sufficient to justify taking the time out for specialist training in these technologies.
- For small suppliers, employing one or two people, achieving and then maintaining MCS certification presented a considerable challenge. Part of the process of becoming MCS

certified includes demonstrating the operation of a Quality Management System (QMS) which represents a considerable administrative burden for a small company. Also, a Certification Body must assess whether a company is adhering to the standards which has costs attached.

Based on these discussions a report was prepared looking at options for training the supply chain. Three options were considered as set out below and the benefits and challenges of each discussed.

- Generic MCS training.
- Manufacturer specific training.
- On-the-job training.

The full report is presented in Appendix 6. The assessment came to the following conclusions:

Despite the existence of the MCS and manufacturer training schemes, there are a number of reasons why these schemes alone cannot be relied on to build supply chain capacity at the rate necessary to deliver both the UK and Scottish Government ambitions in relation to heat pump uptake.

The availability of training is limited. There are for example only nine training centres for MCS training in Scotland listed online through a google search, and of the two heat pumps being proposed in this project only one manufacturer has a training centre located in Scotland.

The MCS is not designed for sole traders or micro businesses as discussed above as it requires the establishment of an audited quality management system, which is a considerable administrative burden and needs to be audited. Most heating engineers and electricians that undertake household work in Scotland are sole traders and micro businesses. Developing suitable accreditation systems and training to suit these types of businesses will therefore be important in promoting future heat pump roll out.

The alternative is on the job training with a recognised MCS accredited company that has extensive experience in heat pump installation which is the route being chosen for this project.

MCA, the renewable contractor on this project, has the details of all the local suppliers who are interested in becoming heat pump or solar PV and battery installers. As local projects arise, MCA will seek to work with these suppliers training them on a job-by-job basis in the hope of building longer term relationships and building capacity both in the local area and beyond. At the time of writing one supplier present at the meeting had contacted MCA Renewables to support them in undertaking house visits and quoting for heat pumps which indicates this approach is attractive to small suppliers.

5.9. Local Authority and DNO

Perth and Kinross Council were extremely interested in the project as much of the work they are doing to develop the LHEES is at a strategic level, and they have very little local or house to house data on the basis of which to develop their strategy. Engaging and developing schemes for private householders is a particular challenge. Their evaluations to date have identified that two thirds of the households in Perth and Kinross are owner occupier so this will be a very important demographic in delivering their LHEES.

Discussions with SSEN, the DNO for the project area, revealed that all of the potential project participants are connected under the Blairgowrie Primary Substation.

Blairgowrie has an upstream constraint caused by Coupar Angus Grid Supply Point (GSP). Reinforcement is required at this GSP, which has been driven by an increase of distribution connected low carbon generation (mostly wind and solar) within the area.

Since the GSP is generation constrained, a large addition of solar PV (on aggregate across Blairgowrie) may cause upstream network issues. SSEN have indicated that full network studies will be required before large scale connection of additional solar and battery PV to the network.

Under current network connections processes, suitably type tested heat pumps can be connected to the network as part of the connect and notify process[32]. If large numbers of residents take up heat pumps SSEN has requested a bulk connect and notify spreadsheet is submitted.

A network loading assessment for secondary sub stations was undertaken which indicates they generally have a 20 to 60% levels of loading, with one above 80%.

Network monitoring has been approved for installation on four secondary substations: **Woodlands Park, Auchmore Drive, Rosemount Care Centre and The Neuk. SSEN has agreed to meet this cost.** To obtain a better understanding of network level impacts before and after SAPPHIRE installations, network monitoring is being deployed at the secondary substations. This will provide voltage and power measurements over time (as opposed to a single maximum value). Industry standard for this monitoring provides readings of at least minutely intervals.

The project in Blairgowrie does not come under any of SSEN's Constrained Management Zones (CMZs) or a location where SSEN is procuring flexibility[33]. This means that consumers will not be rewarded for providing flexibility services to the DNO at present.

Provision of grid services to National Grid is possible in this location but would need aggregation with other sites in the SSEN Scotland area to reach the minimum scale of 1MW.

Despite the lack of local flexibility markets within Blairgowrie at present, smart control of the energy assets within the pilot area could provide faster connections and avoid network reinforcement. This component of the project considers how smart network operation and active network management (ANM) could benefit both the DNO and the consumer. The full DNO engagement report is provided in Appendix 13.

[32] https://www.ssen.co.uk/our-services/new-supplies/heat-pump/
[33] www.flexiblepower.co.uk/locations/scottish-and-southern-electricity-networks/map-application-ssen

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

Fundamental to coordinating high density heat pump deployment is the willingness of householders to engage. Householder engagement has been a key part of this project and has shown that a number of things need to come together to incentivise householders to consider heat pump deployment.

- A communication strategy.
- The right incentives in the form of grants and loans.
- Support to householders in accessing grants etc.
- An accessible local supply chain.

6.1. Communication Strategy

Our project has shown that the level of knowledge and understanding of heat pumps amongst householders is low, as well as their knowledge of available funding opportunities. At the focus group most households indicated they had no idea as to what to expect from the meeting but were there to learn more. Interestingly in all our discussions with householders there has been limited scepticism or negativity around heat pump technology as an option. There has been more concern around understanding the implications of installing one, how to apply for grant and loan funding and timescales.

Recommendation: Significant investment in communication with households with the right level of detail and information is necessary to encourage wide scale deployment.

6.2. Incentives and Grants

There was a strong message that the availability of grants and loans were fundamental to the willingness of households to take forward installation of heat pump technology. The best technology combinations within the current funding regime in Scotland enables householders to invest in the technology with levels of personal investment similar to the cost of a new boiler.

Recommendation: Subsidising new technology in the form of grants and loans will continue to be necessary in the medium term to encourage high density deployment. These need to be at a level where the householder investment required is similar to a new boiler. The grant loan process needs to be as visible and user friendly as possible.

6.3. Non-Financial Support to Householders

A very clear message from householders was that they were worried about the process of accessing finance, time taken, ease of process etc. There was strong support for The Heat Project and their role in supporting householders moving forward as a local trusted organisation.

Recommendation: A respected local partner such as The Heat Project in Blairgowrie will be fundamental to high density deployment and it is recommended that a local partner of this nature should be included in all projects in the future until heat pumps become a mainstream technology.

6.4. Local Supply Chain

The supply chain for household renewable technology is significantly constrained at present. Our householder engagement has shown that there is apprehensiveness amongst householders around adopting new technology and concerns about the ability of the supply chain to deliver. An informed, competent supply chain will be an essential part of building householder trust in the technology and willingness to progress.

Recommendation: Ensure that a trusted supply chain partner is part of the large-scale deployment project. They may not necessarily be local but should be willing to bring in the local supply chain and support their capacity to install heat pumps in the future as described in this report. There could be benefits in providing incentives for larger suppliers to do this as well as incentives for other training routes.

6.5. Technology Combination

The study has shown that technology combinations beyond heat pumps can provide additional benefits to the householder. Although this requires additional up-front costs, if the costs of this additional technology can be covered through interest free loans this makes investment considerably more attractive as pay backs are seen more quickly.

Recommendation: Maintain the availability of interest free loans for technology such as solar PV which support the deployment of heat pumps.

6.6. Key Stakeholder Coordination

A co-ordinated methodology involving a number of key stakeholders will be fundamental to future large-scale deployment as shown in Figure 5 below.

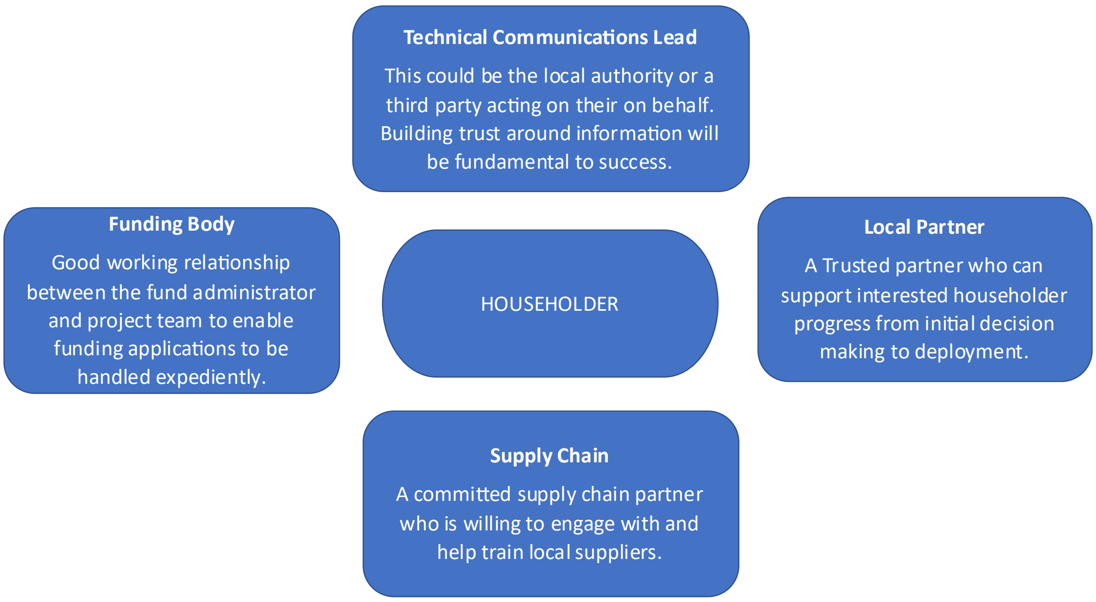

Figure 5: Project Coordination.

Based on our experience in this project we believe the following key stakeholders need to work together for the delivery of a successful project.

Table 14: Key stakeholders and their roles in a co-ordinated high-density heat pump project.

Stakeholder	Role	Interaction
Project Co-ordinator	Due to the range of stakeholders that need to be engaged in a high-density heat pump deployment, a project co-ordinator is required. Their role is to ensure the project stakeholders work in a co-ordinated way and build trust amongst local householders in the target deployment area.	The project Co-ordinator will co-ordinate interaction across the major delivery stakeholders as well as the householders who will be key to uptake.
A trusted local partner	We do not believe we would have achieved the level of engagement we did with the local community if we had not been working with a local organisation that was familiar to and trusted by the local community. The role of the local partner should be to work with the project co-ordinator to build trust based around a communication programme with local householders.	The trusted partner should lead interaction with the community and develop relationships with the supply chain. They should have the capacity to support householders where necessary through the process of decision making to commissioning of the technology.
Local Suppliers	Local suppliers (many of whom are sole traders or micro businesses) are the main contact householders have with the supply chain. Many of these will not have the capacity to deliver on a large-scale deployment project and most are not likely to be certified. The role of the local supply chain is to work within the project to build local capacity to provide on-going maintenance and future installation.	A large-scale deployment programme should seek to engage local suppliers and build local capacity as part of the programme. Our study has suggested on the job training working with a larger accredited supplier is a route to achieving this.
Lead supplier	A large supplier experienced in heat pump deployment will be required as a key project stakeholder as local suppliers are unlikely to have the capacity or skills. Their role should be to build trust with the local community in the technology through for example attending open public meetings and undertaking house visits to discuss technology options. Their role should also be to support the local supply chain build	The lead supplier should be working with the local trusted partner to help build householder trust in the technology as well as identifying and working with any interested local supply chain partners.

	capacity through for example on the job training.	
Funding Body	Large scale deployment could lead to blockages in the processing of funding applications. Engaging with these bodies to make them aware of the project will support this. They may also be in a position to help promote the project and engage with local householders.	The trusted partner and communications lead should build a relationship with the funding body to help expediate applications for funding.
DNO	The DNO are essential stakeholders in terms of understanding the impact on the network as well as agreeing a process for notifying connections.	The project co-ordinator working with the lead suppliers should make early contact with the DNO and ensure on-going communication throughout the project.
Communications lead	Building the interest of local householders is essential to deployment of high-density heat pump schemes. Our experience suggests that considerable effort is required to build interest, trust and understanding. It would be the role of the communications lead to manage this process, provide a point of contact and also a neutral organisation that does not have a vested interest in the project.	The communications lead would provide the key point of contact between the householders and the project team.

Recommendation: Based on the experience gained in this project we would recommend the following key stakeholders are essential to co-ordinating large-scale deployment of heat pumps. A local trusted partner, a lead supplier, local suppliers, funding body, DNO and communications lead.

7. Areas for Innovation

7.1. Consumer Engagement – Recruitment

Although not in itself innovative, we believe this is the first time that such a focused approach has been taken to consumer engagement in relation to renewable energy deployment. Innovative approaches are required to communicate to individual householders the benefits and challenges associated with moving to new technology. A range of approaches are required including access to one-to-one discussions and meetings. Our project has shown that different householders responded to different routes of communication with some responding to surveys, others to letters. The door-to-door visits also stimulated considerable interest in people who had not taken an interest via other means. We believe that important to the success of our approach was asking people to have an interest in sharing information rather than a direct sales pitch, which may have put people off. It was made very clear that the project was about sharing information and not expecting people to sign up to anything as part of the project.

7.2. Consumer Engagement – Retention

Retaining householder interest is probably the biggest challenge at a time when the technology is still poorly understood, the supply chain is immature, there are misunderstandings about the cost benefits, and funding is required. Although people may have an initial interest in heat pump technology translating this to seeking quotes, applying for funding etc. is likely to be more of a challenge. The role of The Heat Project as a trusted project partner will be very important in this. We received specific feedback from the focus group that on-going support to the householder during this process would encourage people to progress. In Figure 6 we have set out what this would look like. Each step of the customer journey from the point of considering a heat pump through to deployment is set out along with how The Heat Project would support householders at each stage. Although The Heat Project has always engaged with householders on energy efficiency this project has enabled them to tailor their support in direct response to householder feedback from the project.

7.3. Installer Training

This project has shown that although larger suppliers are able and willing to send their employees on accredited and third-party training, there are major barriers to doing this for smaller suppliers (with one or two employees or self-employed workers) which make up a significant part of the supplier base.

Based on feedback from the supply chain, additional and more innovative approaches are required to engage this group that are both time poor and have limited administrative support. We have proposed an innovative approach to overcome this where larger accredited suppliers help to build the competence of the local supply base. During this project MCA Renewables was approached by one of the suppliers that attended the supply chain workshop and they have jointly visited three properties looking at the potential to deploy heat pump technology outside the project area.

7.4. Other Innovation

The study has shown that renewable technologies should not be considered in isolation, both in terms of roll out or consumer engagement. This project adopted a multi technology approach, which enabled the householder to build an understanding of the range of options available to them and to make a decision on that basis. It has shown the benefits of installing heat pumps with solar PV, which significantly reduces the long-term costs and increases savings.

Make contact with The Heat Project	**The Heat Project** will contact all householders that have expressed an interest in the project. You can also email them. At this point you can discuss the technology options you would like to progress or decide not to go further. The Heat Project will also offer advice on how you can save energy.
Arrange an installer visit to size and cost technology options	**The Heat Project** will support you in identifying suitable installers who will visit your property to assess its suitability for the technology and size and cost it. The installer will also provide an assessment of benefits specific to your home.
Make contact with Home Energy Scotland	At the same time you should contact **Home Energy Scotland** who need to approve the technology as being suitable for your home. This will be done via a phone call or possibly a house visit. You will then be provided with the necessary paperwork to access grant/loan funding.
Complete grant/loan application	**The Heat Project** will support you, if you need help, to go through the grant/loan funding process.
Application approved	Once your application has been approved you can accept a contractor’s quote and arrange with the contractor an installation date.
Installation and commissioning	On install completion make sure the installer gives you a full explanation on how to get the most out of your system. If you need more help, contact **The Heat Project**.
Consider if you are on the best tariff	If your system includes a battery you could benefit from a time of use tariff. **The Heat Project,** or your installer may be able to help with advice on available tariffs.

Figure 6: Customer journey.

8. Approach for Mobilisation and Deployment Following Recommended Methodology

This project is not progressing to deployment under phase 2 of the Heat Pump Ready Programme. The incentives and support available to householders from the Scottish Government to install heat pumps and supporting technology are currently higher than that available through the Heat Pump Ready Programme Phase 2 funding. The progression of the project relies on individual householders now making the decision to install a heat pump, a process that will continue to be facilitated by The Heat Project, as set out in Figure 6.

Achieving short-term high-density deployment will remain a challenge, although we expect a considerable number of households to install heat pumps in the next year or so - achieving the deployment levels anticipated at the start of the project would have been very challenging. From over 1,000 households contacted as part of the project, 130 have expressed an interest. There was a higher return where one to one contact was made, with 37% of the houses we spoke to through door-to-door contact being interested. This illustrates the intensity of engagement that would continue to be necessary to pursue the density levels hoped for. Some of the key factors that were influencing people's decision making included:

- Age of occupants, with older occupants not feeling it was worthwhile.
- Age of boiler, with many having just installed a new boiler.
- Length of time they thought they might live in the house.
- Time to investigate and pursue funding.

Engaging local heating engineers will be an important factor in encouraging future uptake of heat pumps as they are usually the first point of contact when people require new boilers.

9. Costs to Consumers

Due to the significant incentives for householders to install renewable technology in Scotland the project adopted an individual approach to householder deployment of the technology. The co-ordinated approach has therefore not impacted the cost to the consumer but has encouraged a greater number of consumers in one area to consider adopting the technology due to the availability of information and word of mouth.

If large scale adoption does take place, where consumers look for technology combinations involving a battery, there may be the potential in the future to combine these technologies in a smart local energy system as discussed in Section 5.3, which could provide additional benefits to the consumer.

The project has shown that the cost to the consumer of combining heat pump technology with solar PV provides a better cost-benefit than deployment of a heat pump on its own. The analysis that supports this however assumes that interest free loans are available for the purchase of the solar PV.

10. Long Term Sustainability

Figure 6 shows how the business model identified in Phase 1 of this project will be maintained beyond the life of the Heat Pump Ready Project. All 130 householders who have expressed an interest in the project have a householder pack containing all the relevant information about heat pumps, loans, guidance and cost benefits analysis based on transparent assumptions. They will all be followed up by The Heat Project who will support them progress as appropriate.

This coordinated approach to household and supply chain engagement would be suitable for any other middle-income area with well insulated houses built in the last 20 to 30 years. There are many similar housing developments across the UK where, with the right incentives and coordinated approach, there is likely to be interest in the technology deployment.

Naturally, a coordinated approach to high-density deployment could reasonably be adopted in other types of housing built earlier and typically to a lower standard of thermal performance. However, such a project would need to engage afresh with the greater technical and economic challenge this would present as the resulting economics, and therefore the attractiveness of a customer proposition in such areas, would inevitably be more challenging.

The level of deployment that could take place before 2028 is very difficult to estimate. Based on our experience in this project achieving high density deployment is going to require significantly more effort to educate consumers, provide the right incentives, and develop the supply chain. Local suppliers are not only key to installing heat pumps at scale but also ensuring that when people need new boilers the option of a heat pump is presented to them. This is still a very long way from being the case.

11. Recommendations

The following recommendations are made to those wishing to deploy heat pumps at high density.

- **Choose an appropriate area for the project**. Heat pumps are still expensive and only certain demographics are likely to consider them. This project has shown a very positive response from middle to high earners based on the fact there are currently a combination of grants and interest free loans that will cover most of the cost of deployment.
- **Take householders with you on the journey**. There is a high level of interest in heat pumps in the above demographic both to save energy but also to save carbon and seek to future proof properties. Our engagement with the community was based on sharing learning not on selling, which we believe opened people to the conversation.
- **Work with a local partner**. Feedback from the focus group indicated that householders are looking for support throughout the journey of deploying the technology. A local partner (such as an energy advice service) that can support householders helps to build trust, makes it easier to start engaging with householders and provides continuity.
- **Work with a trusted installer**. A larger installer is likely to be required to provide the expertise and volume for large scale deployment. However local installers will be fundamental to providing the capacity necessary for long-term uptake. There should be a willingness by any large installers to build the capacity and work with the local supply chain. Our study suggests that peer to peer training is likely to be more effective than third party or manufacturer led training, although the latter may be a requirement.
- **Plan for the future**. Based on the current funding regime in Scotland, a combination of heat pump and solar PV installation provides the best cost-benefit balance for the consumer. Further technology combinations incorporating batteries could also be beneficial where the right incentives exist and provide the potential for greater long-term benefits such as aggregation and taking advantage of variable energy tariffs. As the market is rapidly changing, technology needs to be selected to meet individual circumstances. High density schemes should not restrict themselves to one technology but consider the best options for both the householder and the area.

12. Conclusion

This project has not applied for funding through Phase 2 of the Heat Pump Ready Programme for a number of reasons:

I. The householder incentives offered as part of the Phase 2 funding were less generous than those available to them through already available Scottish Government funding. It was therefore not possible to build an additional case to further incentivise householders to take part in a wider project.

II. Although we consider this a viable area for large scale deployment, it is considered unlikely that the levels of deployment set out within the ambitions of the project would be achievable within the prescribed timeline. The rate of project progression depends on decisions being made at an individual household level, which are influenced by a range of factors outside of the control of the project.

III. One key concern that has arisen since project completion, through site visits following the community meeting, is the number of houses that currently have microbore heating pipework. It is anticipated that, in many cases, the cost and disruption of replacing this may prove prohibitive to progressing.

IV. As part of this project, we have built a high level of understanding and interest in a small local area around heat pump deployment which may lead to higher densities of heat pump deployment in this area compared to equivalent areas elsewhere in Scotland over the next few years. The rate of uptake will be monitored by The Heat Project and may provide positive case studies to be shared more widely.

V. In particular, we believe building up interest within the local supply chain will support higher levels of deployment in future as confidence in the technology builds.

VI. The level of engagement now established with the local community will also open wider opportunities around the establishment of local community energy systems in the future, with the option to aggregate household energy assets to provide flexibility services to the grid, enabling further savings for households to be made.