Energy

Energy for a Sustainable Future

Scottish Canals

GeoAtlantic Project: Feasibility and design of ground source or water source heat pump systems

TURNER SERVICES

Progressive, Sustainable Technical Services

This GeoAtlantic project was carried out by Turner Services working with ALIenergy and Scottish Canals between September and the end of November 2020

A GeoAtlantic project on behalf of:

ALIENERGY
ARGYLL, LOMOND & THE ISLANDS ENERGY AGENCY

working with

Scottish Canals

co-financed by:

Interreg
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1. Executive summary

1.1 Project background

This project, a feasibility study of the potential for ground or water source heat pump systems across the Scottish Canals buildings estate, forms part of the GeoAtlantic project and as such covers those buildings located within the defined Atlantic Area of Scotland. The project is co-financed through the GeoAtlantic project by the Interreg Atlantic Area Programme through the European Regional Development Fund (https://www.atlanticarea.eu/page/2).

Argyll, Lomond and the Islands Energy Agency (ALIenergy) (https://alienergy.org.uk/) is a partner in the European GeoAtlantic project (http://geoatlantic.eu/?lang=en) which aims to boost local energy transition from fossil fuels and encourage the development of geothermal energy including ground and water-source heat pumps.

Scottish Canals (https://www.scottishcanals.co.uk/) is a non-departmental public body which is responsible to the Scottish Government for the management and development of five Scottish canals (Union, Monkland, Forth and Clyde, Crinan and Caledonian Canals) as well as the surrounding estate.

By using these assets wisely, Scottish Canals' intention is to: "enhance the future quality of life for Scotland's inhabitants and to help create a more successful, sustainable country. Scottish Canals approach to managing climate change has two main strands: mitigation to reduce our impacts and adaptation to manage the effects of climate change."

As part of this project ALIenergy has been working with Scottish Canals to investigate the potential for ground or water source heating systems for use in buildings owned by Scottish Canals, many of which are situated adjacent to canal waterways and are variable in nature.

Turner Services responded to the Invitation to Tender for the project in July 2020 and was awarded the contract in mid-August 2020. Turner Services is a Glasgow based renewable energy specialist with over 15 years' experience of the feasibility, design, installation and maintenance of heat pump systems. More information on Turner Services can be found in section below.

COVID-19 meant that the project was modified to enable the work to proceed as a desk-based exercise with no requirement for travel / site visits. Turner Services did manage to conduct visits to Scottish Canal sites at Auchinstarry, near Kilsyth on the Forth and Clyde Canal and the site of the Scottish Canals head office at Applecross Street in Glasgow.

Turner Services would like to acknowledge the support of those members of Scottish Canals staff who helped to gather data at the various stages of the project and the project team consisting of Lynda Mitchell, Manager of ALIenergy and Olivia Lassiere, Scottish Canals Environment Manager and Project Manager who both demonstrated their passion for low-carbon energy solutions through their enthusiasm and feedback.

1.2 Project conclusions

The vast majority of the buildings in the Scottish Canals estate are over 30 years old with many over 100 years old. What this feasibility study highlights is that while many have been adapted and

refurbished over the years, they remain outside the heat pump (low flow temperature) comfort zone which can be defined as having a rate of heat loss of up to 80W/m² (watts per square metre - this is calculated by dividing the total heat loss of the property (in Watts) by the total heat and floor area). By comparison, current building regulations are the equivalent of around 30W/m² for domestic and 40W/m² for non-domestic buildings.

A 'fabric first' approach to refurbishment that includes significantly improving the draught-proofing and insulation levels of buildings will both reduce heat loss and, with it, the heat demand. It will also increase the number of buildings across the estate that become suitable for low temperature and low carbon heating systems like water and ground source heat pumps. Indeed, installing heat pumps, where appropriate, and wet heating systems could become part of the refurbishment.

The benefit of this is improved comfort levels for the users of the building, easier monitoring and control of the heating system (via online remote control), lower running costs compared to the direct electric heating in the vast majority of Scottish Canals buildings currently and a reduced carbon footprint.

The feasibility study considered the buildings' suitability for water and ground source heat pump systems from the following perspectives:

- building fabric condition - because of the effect on rate of heat loss
- the size of the building - because of the implications for payback and carbon saving (generally better the larger the building)
- the priority placed on the building by Scottish Canals (where known). Buildings leased or rented out were given a lower priority

A closer look was taken at the top 19 most suitable buildings to understand usage patterns and heating profiles, fabric condition, the nature of the site and proximity to the canal etc, existing heating system age and condition.

This report documents the top 10 Scottish Canals buildings in the GeoAtlantic area most suitable for water and ground source heat pumps. A map showing the location of the top 10 buildings is included in Section 5.1 Buildings where a G/WSHP is an appropriate solution.

The reality is that only two of the top 10 buildings lend themselves to this particular low-carbon technology when carbon emissions, system installation cost and system payback are considered.

On the upside, Scottish Canals has a much better understanding of the type of buildings that lend themselves to water and ground source heat pumps. The organisation is keen to explore the potential for these in other buildings as well as the potential for large-scale district heating schemes that use water and ground source heat pumps to harness heat from the 19 reservoirs and 1,500 hectares of land under its stewardship.

The project has also demonstrated the potential for reducing CO_2 emissions and running costs across the top 10 buildings, and beyond, by installing air source heat pumps (ASHP) which were found to offer better or similar payback times and better cost per kilogram of CO_2 reduced (£/kg) at considerably lower installation cost when compared to water and ground source (W/GSHP).

Comparison tables between the two technologies are provided for each of the top 10 buildings.

Taking those buildings in the top 10 where air source was found to be more appropriate, the total cost of installing air source in these buildings is £151,159 compared to £318,102 for the most economical W/GSHP system, which represents a potential investment saving of 52%. The difference in running cost and CO_2 emissions savings between W/GSHP and ASHP is less than 5%.

The total annual CO_2 emissions reduction if all buildings in the top 10 had water or air source heat pumps installed would amount to 102 tonnes CO_2, over 10% of Scottish Canals, total CO_2 emissions as reported in the Statutory Public Bodies Climate Change Duties report for 2018/2019. A summary table with all carbon and cost benefit figures for the top 10 buildings can be found in Appendix 7.

There are two buildings in the top 10 where a water source heat pump proved to be the preferred option, The Boathouse, Auchinstarry and the Scottish Canals Head Office at Applecross Street in Glasgow. During a meeting with Scottish Canals, to present the findings of the feasibility study, it transpired that there are new strategic plans relocating the Head Office location from Glasgow to Falkirk and a timing requirement to upgrade the heating at The Boathouse. As a result, it does not look like these will be suitable locations to consider for the installation of water source heat pumps in the short term. Scottish Canals made the decision not to progress with designs for systems at these locations as part of this project. Both buildings are currently heated with mains gas and the respectable payback times of 7 and 8 years respectively are dependent on a successful Renewable Heat Incentive (RHI) application.

A further positive outcome of the project has been the cleansing of the Scottish Canals Building list data and the detail added to it. Further recommendations on continuing this work and improving the energy efficiency of buildings are made in section 7.2 Energy Efficiency. Section 7 Recommendations also highlights the potential for reviewing the existing energy procurement arrangements for better tariff rates and sourcing electricity from renewable sources.

There are also recommendations in section 7.3 Renewable Energy Solution for Customer Facility Blocks for an air source heat pump solution which could be rolled out as part of the planned refurbishment programme for the Scottish Canals Customer Facility Blocks, of which there are 23 across the buildings estate.

Turner Services believes that this project has pinpointed the potential for water and ground source heat pumps and other renewable energy alternatives across the Scottish Canals estate and the importance of a ‘fabric first’ approach to energy efficiency and carbon footprint reduction. We look forward to supporting Scottish Canals further as the organisation works towards becoming carbon neutral.

2. The team conducting the feasibility study

2.1 Turner Services

Turner Services is part of Turner & Co (Glasgow) Ltd group which was founded in 1912, has a turnover of £160m and over 1,100 employees. There is a diverse mix of companies within the Group, from vehicle and equipment rental services to offshore wind turbine support services. This astute spread of commercial risk combined with careful financial management has established strong financial stability.

Turner Services is 100% owned by the Turner Group and is the technical services division with specialist knowledge, skills and experience in renewable energy, property, fibre, utilities and compliance. This incorporates Ecoliving, the specialist heat pump consultant and installer, founded in 2004 and the early pioneer of heat pump technology in Scotland. Based at the Group head offices in Govan and employing over 150 people our mission is: "Turner Services is committed to contributing to sustainable, low-carbon living and working environments through the delivery of progressive technical services." Ecoliving worked with the Energy Saving Trust in 2007 to pilot heat pump technology in both social and private housing clusters throughout Scotland. Since then the team has worked with Ofgem and with the Microgeneration Certification Scheme (MCS) on consultancy projects as well as with numerous Local Authorities, Registered Social Landlords, M&E consultants and developers.

What sets Turner Services apart is not only the depth and length of experience in heat pump consultancy, design, installation and maintenance but the combination of our technical and consultancy capability with our track record of delivering complete heat pump system solutions. To date, we have been responsible for the design and installation of several thousand heat pump systems.

2.2 Team members

Keith Kemsley, Managing Director

Trained in heat pump design and application by leading manufacturers including NIBE, Mitsubishi, Thermia and Heliotherm. Senior management professional with over 16 years experience of successfully overseeing all elements of water and ground source heating projects from the initial discussions with clients to undertaking feasibility studies with detailed design and costing optimising any grant funding available thereafter overseeing safe, efficient, quality installations and ongoing maintenance.

Gavin Scott, Technical Manager

A qualified heating engineer and recognised industry expert in water and ground source technologies, possibly one of the leading technical experts in the UK, with a full understanding of designing and integrating heat pumps together with distribution systems. His experience includes assisting clients with feasibility studies and appraising the best option based on the property, environment and heating output requirements, supporting our design team with technical assistance, managing installations/maintenance and quickly resolving technical issues.

Agris Baumanis, Technical Designer

A senior member of the technical design team Agris prepares heat loss and carbon calculations,

energy assessments, running costs comparisons together with preparing working drawings, and lifecycle analysis of proposed heating systems, undertaking cost and heat loss evaluations and calculations thereafter preparing detailed schematic drawings which are provided to clients and our installation professionals.

Mark Henderson, Consultant

Mark has 23 years of working in the sustainability field following his passion for promoting solutions that make a difference for people and the planet. He thinks strategically and long-term but is able to dive deep into the detail on consultancy projects. He is experienced at managing teams to successfully deliver projects and is always focused on the best outcome for the client.

Peter Emerson, Installation Manager

One of our site management professionals Peter is able to assess and understand the practicalities of delivering a proposed project.

Caius Fernandes, QHSE Manager

Experienced and qualified QHSE professional who together with his team assists colleagues, clients and their partners with all aspects of quality, health, safety, environmental risk and project management throughout a project's lifecycle.

Please refer to **Appendix 1** for the CVs of each team member.

3. Overview of ground / water source heat pump technology

Heat pumps are energy efficient heating systems that harness and utilise renewable heat energy from the environment. The heat energy is upgraded, via a refrigeration cycle, producing enough hot water at a high enough temperature to supply a building with heating and hot water.

3.1 Types of heat pump

The most appropriate type of heat pump depends on the building's individual needs as well as the characteristics of the site. Each harnesses heat energy from different sources:

- Ground Source - from surface soil or bedrock via a borehole
- Water Source - from a source of surface water or aquifer
- Air Source - from the outside air

Each of these sources capture solar energy throughout the day that can then be utilised and converted into heat energy, providing an environmentally friendly heating system. Heat pumps intelligently heat the building, replacing conventional oil and gas boilers, which are typically about 80-90% efficient and all-electric systems (100% efficient). Today, across the UK, heat pumps provide an effective, environmentally-friendly heating solution within many community, commercial, industrial and public buildings, delivering an annual efficiency of between 250-400% and providing both heating and hot water.

Generally speaking, heat pumps on the European market are as efficient as any in the world. This is because these countries, and Sweden in particular, have led the way in heat pump development since the late 1970s. In the mature Swedish market, several strong manufacturers have competed

with one another to continually improve the product offered to the end customer. Other European and international manufacturers have been forced to invest in product improvements to compete. This has resulted in the following improvements, in particular:

- An increase in efficiency over the past 15 years (ground and water source heat pumps, 5 – 10%, and air source up to 15%)
- More intuitive, user-friendly controls include remote monitoring and software upgrades
- Improved sound insulation and significantly reduced noise from air source heat pump fans
- Increased integration compatibility with hot water cylinders and mechanical ventilation with heat recovery (MVHR) modules

Additionally, training and installation standards have improved in the UK thanks to the MCS (Microgeneration Certification Scheme) requirements. The UK market has grown steadily, if not as dramatically as expected, partly due to mixed political messages over the past 15 years and watered-down low-carbon policies. In the UK government's recently published policy paper (18th November 2020), 'The Ten Point Plan for a Green Industrial Revolution', it states the following ambition: "We will aim for 600,000 heat pump installations per year by 2028...". This is an exponential increase over 10 years considering that research from the Building Services Research and Information Association (BSRIA) indicates that 22,000 heat pumps were installed in the UK in 2017.

The efficiency of heat pumps is measured by the Coefficient of Performance (COP), which is simply how many units of useful energy are produced from each unit of electricity consumed to operate the system e.g. a COP of 4 means that for 1 unit of electricity to run the heat pump, 4 units of heat are delivered. The COP is measured under specific test laboratory conditions with specified supply water or air temperature into the heat pump evaporator and, also, flow temperature from the heat pump to the heating system.

Across Europe, in the last five years, the SCOP, or Seasonal Coefficient of Performance, has become a more widely adopted measurement of efficiency as it describes the average COP during a heating season. It is, therefore, a more accurate reflection of operating efficiency and allows more accurate comparison between different types and models of heat pump.

In calculating the payback of a system we use the SCOP as prescribed by the MCS standards, referred to above. Heat pump manufacturers are required to have each model's SCOP tested and certified by an independent testing body.

Here are examples of the SCOP of the latest models of air and ground source heat pumps of comparable size for the purpose of illustrating the difference in seasonal efficiency. These heat pumps are manufactured and marketed in Europe.

Seasonal Coefficient of Performance (SCOP) @ 45°C* flow temperature:

6 kW Mitsubishi **ASHP** (Ecodan PUZ-WM60VAA) = **4.03**

6 kW NIBE **GSHP** (Fighter S1155 - 6) = **4.34**

11.2 kW Mitsu **ASHP** (Ecodan PUZ-WM112VAA) = **3.99**
12 kW NIBE **GSHP** (Fighter S1155 - 12) = **4.43**

14 kW Mitsu **ASHP** (Ecodan PUZ-HWM140VHA) = **3.77**
16 kW NIBE **GSHP** (Fighter S1155 - 16) = **4.37**

*a 45°C flow temperature is optimal in terms of achieved system efficiency and required heat emitter sizes (radiators). In practice a higher flow temperature (up to 55°C) can be required.

3.2 How does a heat pump work?

A heat pump uses solar heat energy stored in the ground, water or air. This is renewable and totally free! Energy usage is reduced to the electricity required to run the compressor and circulation pumps inside the heat pump which can mean considerable energy savings when compared to a traditional oil or LPG boiler or all-electric heating. The 'low-grade', renewable heat energy in the ground, water or air needs to be harnessed, collected and delivered to the heat pump. There are a number of proven methods for doing this which vary dependent on energy source as well as building and site conditions.

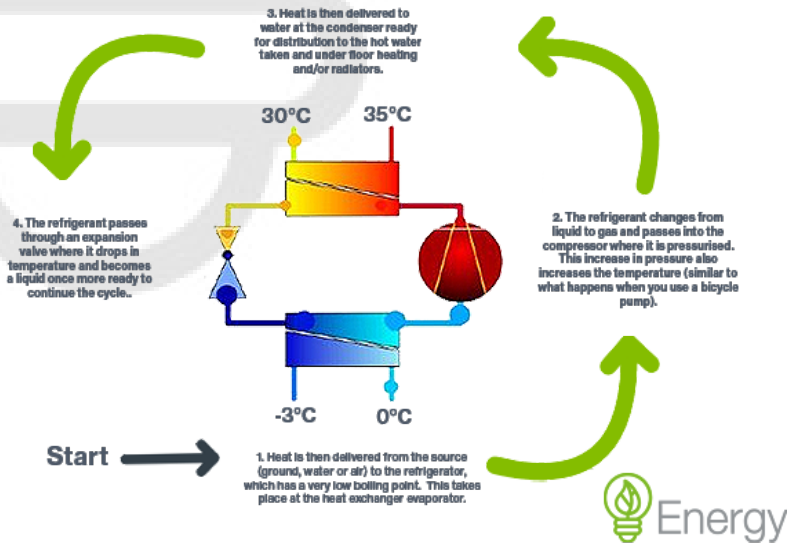
The heat pump refrigeration cycle

Inside the heat pump a refrigeration cycle takes place. This is dependent on the delivery of heat energy to make the refrigerant evaporate. The refrigerant changes from liquid to gas so that it can be pumped to the compressor where it is pressurised which increases the temperature exponentially.

In understanding how a heat pump works it is important to highlight that the refrigerant has a very low boiling point e.g. -20°C (counter intuitive as we are used to thinking about water boiling at 100°C) This means that the 'low-grade' heat even at low temperatures (as low as -20°C in the case of some outdoor air heat pumps) enables evaporation (boiling) to take place.

Once through the compressor, the now hot refrigerant gas passes into a heat exchanger called the condenser where it transfers its heat into relatively cooler water which is then ready to be distributed around the building's heating system or used to heat tap water.

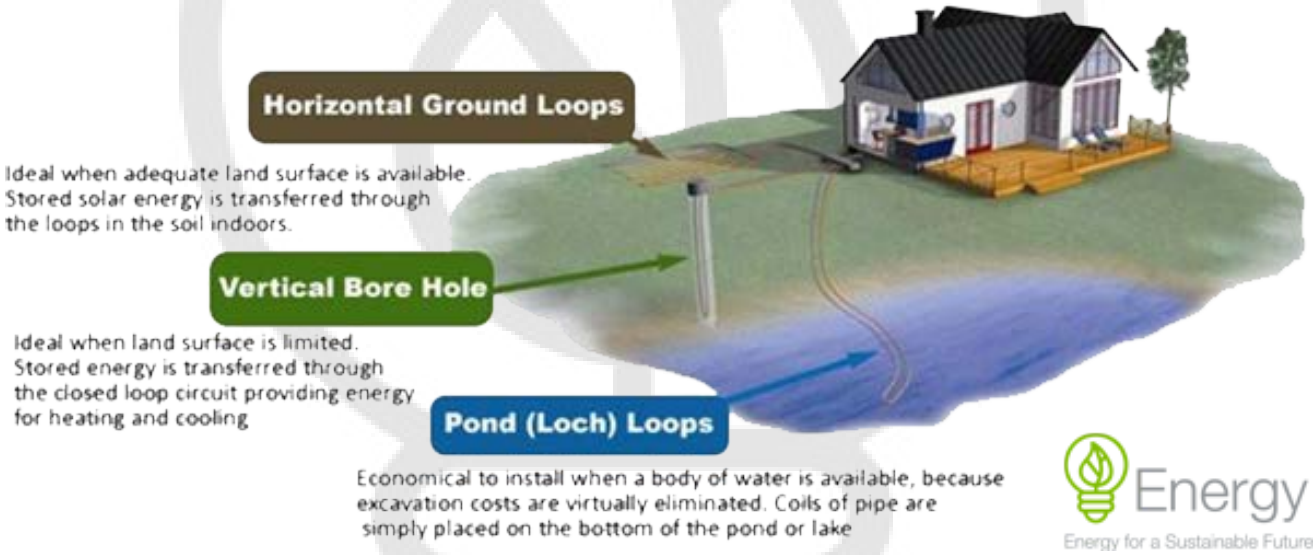
Having delivered its heat energy in the condenser, the refrigerant is cooled and once it passes through the expansion valve it loses its pressure and cools further, returning to a liquid state. This diagram helps to illustrate the heat pump refrigeration cycle and the temperature changes.



3.3 Ground and water source heat pumps

Ground and water source heat pumps (GSHP) are a highly efficient way of tapping into and harnessing solar energy stored in the ground, rock or water. These elements act like a battery and are charged with solar energy which a G/WSHP can then collect as soon as there is a heating demand in the building. Unlike the outdoor air, the ground remains at a constant temperature below the frost line throughout the year and it is this consistent temperature that enables the heat pump to upgrade the heat energy so efficiently through the refrigeration cycle.

A building's heat demand and the characteristics of the land around it determine the most appropriate means of collecting the heat energy. The most common methods for collecting heat are via a 'closed' pipe loop, in the ground, in a borehole or in a body of water as shown below. More compact metal heat exchangers are also an alternative to pipe for water source heat pump systems. These have the advantage of requiring less space and can be secured to the wall of a waterway or suspended below a jetty.



Open loop systems for WSHPs use water from an underground or surface body of water, filtered and pumped through a heat exchanger. Collected energy from underground can be from an aquifer or even abandoned mine workings. After use the water, which is untreated during the process is then returned to the water table. Alternatively, water can be pumped from a nearby body of water e.g. loch, river or canal for use by the heat pump before being returned "downstream" some 3-5 degrees cooler. Key for both options is ensuring a sufficient volume of water is available to meet the demands of the heat pump throughout the year. A back-up system, like a gas or electric boiler, is recommended to provide cover in the event of particularly cold periods and the water freezing.

Note that, in Scotland, abstraction of water is regulated by the Scottish Environment Protection Agency (SEPA). Please refer to Section 4.1, table 2 on page 33 of 'The Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended)', Version 8.4, October 2019, which can be downloaded from the SEPA website. The rate of abstraction required for any of the systems recommended in this report are ≤2000m3/day and therefore, at most, require a simple licence.

Ground and water source heat pumps do not normally require planning permission but this can depend on the location and bye-laws. Where a closed loop borehole system is planned, checks should be made with the Coal Authority in areas where there may be mine workings. Borehole details need to be logged and recorded. As already mentioned, an open loop borehole system is subject to SEPA's controlled activities regulations concerning the abstraction of water.

3.4 What is needed for the long-term success of a heat pump system?

We are aware that Scottish Canals has had heat pumps installed in buildings in the past and that there have been issues and that this has led to the systems not being used and being decommissioned.

Without knowing the details, we do know the factors that need to be considered and implemented for a heat pump system to become a successful solution for the design life of the system. This is based on our 16 years' experience of designing, installing and maintaining heat pump systems as well as our work on behalf of regulatory bodies assessing and rectifying systems that have been installed but don't work to the design criteria.

Appropriate design is a key factor and may sound obvious. However, the whole concept of heat pumps is based on energy efficiency and is in contrast to high temperature systems like gas and oil boilers where it is easy and inexpensive to install an over-sized system i.e. less emphasis on understanding the building heat loss and design as there is margin for error covered by the output capacity of an over-dimensioned boiler.

Heat pumps are low temperature heating systems (usually 35°C - 55°C) compared to fossil fuel boilers (usually 75°C - 90°C). The lower the heating flow temperature from the heat pump to the heating distribution system (e.g. radiators or underfloor heating), the more efficient the system is. Equally, the lower the flow temperature, the bigger the heat emitter (radiators) need to be. This means that the radiators need to be relatively large, compared to gas/oil boiler, and flow temperatures of typically, 45 – 55°C are desirable when designing heat pump systems. This does restrict the type of buildings that heat pumps are suitable for to those below a certain relative Watts per square metre (W/m²) rate of heat loss. The better insulated and airtight a building is, the lower the rate of heat loss. If the relative heat loss is too high, even with 'oversized' radiators, the heat will escape from the room faster than the system can supply and the result will be that the room will not maintain its desired temperature and the heat pump will have to run for so many hours that the cost benefit disappears i.e. we would not design and install a heat pump system in this case.

Consequently, a detailed site survey by an experienced engineer is important to understanding the condition and needs of the building and the potential of the site. An understanding of how the building is used is also key to dimensioning an appropriate system. So too is understanding any existing or future environmental impacts.

The heat pump, hot water cylinder and accessories specified should be from a manufacturer with a long and strong track record. Controls can be as sophisticated as they need to be but should be well documented, user friendly and intuitive to use. Where appropriate, remote monitoring can be invaluable and allows any operating issues to be detected early.

Installation and commissioning should be entrusted to an experienced team who can demonstrate many years' experience of successfully installing systems of that scale and for similar buildings

using the same make of heat pump. The ability to demonstrate a long-term working relationship with the manufacturer or its agents is a worthwhile asset too. The installation should be to a high standard of workmanship and fully compliant with the relevant Microgeneration Certification Scheme (MCS) installation standard.

Another factor in ensuring the long-term success of a system is the ongoing monitoring, maintenance and servicing. This should be discussed with the client at the outset to understand who the appropriate internal person might be to undertake the monitoring. There should be an ongoing relationship with an appropriate contractor who undertakes regular maintenance and servicing and is able to support the internal member of staff over the phone with queries etc.

Also worthy of note here is the fact that 15 years ago, when Scottish Canals installed its first heat pump systems, the heat pump market in the UK was still very young. There was a limited amount of experience, knowledge and best practice being applied. Support infrastructure wasn't in place either. As previously highlighted, heat pump technology, controls and efficiencies have also developed and improved considerably since then.

These are the factors that make all the difference in ensuring a successful heat pump solution for the duration of the system's design life.

3.5 Other renewable energy alternatives

There are other renewable energy alternatives mentioned in this report.

3.5.1 Air source heat pumps

Air source heat pumps (ASHP) work in a similar way to G/WSHPs but collect heat energy from the outdoor air rather than the ground or water.

ASHPs are positioned outside, adjacent to the building, and have a fan that draws in outdoor air over a large heat exchanger harnessing the heat energy in the air, even when temperatures are below zero. The captured energy is then transferred to the refrigerant, triggering the refrigeration cycle. ASHPs usually consist of the external unit (similar to an air-con unit) and an internal unit where hot water is stored and housing the controller and circulation pumps.

As we have already shown, ASHP technology has improved significantly over the last 10 years and although the co-efficiency of performance (COP) can be low during the coldest weeks of the year, taken over a year, the COPs are not so far behind those of G/WSHPs. In the very cold winters of 2009 and 2010 we saw air source heat pumps operating fine although keeping them clear of deep snow is important so that the air flow is uninhibited. Most models are designed to operate in temperatures as low as -20°C and are designed without a back-up.

Just like G/WSHPs, they also qualify for financial reward through the Renewable Heat Incentive **3.6.1 Renewable Heat Incentive**.

Air source heat pumps do not require planning permission when a single unit is installed serving a domestic property, and come under permitted development, as long as the installation follows the relevant MCS installation standard. More detail can be found on the Scottish Government website. In other situations the local planning office should be contacted to determine whether an application needs to be made.

3.5.2 Solar PV

Solar PV is a renewable energy system that uses photovoltaic modules on the roof or facade of a building or ground-mounted to convert light into electricity. Voltaic cells are made up of thin layers of semi-conducting material which generate an electrical charge when exposed to direct light.

The electricity generated is used within the building when there is demand and can either be exported to the grid or stored in batteries when there is no demand. Alternatively, as appropriate, the excess electricity generated can be used to heat water via a connection into the hot water cylinder.

See reference to the The Smart Export Guarantee (SEG) in **3.6.2 Smart Export Guarantee** below which pays generators for kilowatt hours (kWh) exported to the grid.

3.5.3 Solar thermal

Solar energy is an unlimited resource that is free from harmful emissions and waste. Solar collectors on the roof of a building harness the sun's rays to heat water which is then stored in a well-insulated cylinder ready to be used for hot water. Solar thermal systems can be installed both onto a roof or integrated into a roof on homes, commercial properties, new or existing buildings. Solar thermal makes particularly sense where there is a high hot water demand during the summer months.

Once installed, solar thermal systems have virtually no running costs and as well and provide financial savings, can cut your carbon footprint. They also qualify for financial reward through the Renewable Heat Incentive.

3.5.4 Biomass

Biomass boilers are high temperature heating systems that use the burning of wood, woodchip or pellets to produce hot water for heating and domestic hot water. Although out with the scope of this project, it is useful to understand their use and suitability compared to heat pumps.

Biomass boilers are appropriate heating systems for larger domestic and commercial properties where it is difficult to improve the fabric of the building and reduce the rate of heat loss i.e. that require a high temperature through the heating distribution system. Large country houses are a good example of where a biomass system is appropriate, particularly where there is a local supply of fuel (wood that can be chipped on site) which minimises the cost of fuel and carbon emissions associated with fuel deliveries.

Biomass boiler systems consist of the boiler and hot water cylinder(s) in a plant room with a flue rising from the plant room (planning permission usually required). A fuel store close to the plant room is also required to allow economic procurement of the fuel. The bigger the store, within reason, the fewer fuel deliver journeys required and, therefore, the lower the carbon footprint.

Key considerations with biomass boiler compared to heat pump systems include:

- a more hands-on, on-site maintenance requirement (e.g. emptying ash bin, cleaning the flue, dealing with any fuel feed blockages, receiving fuel deliveries)
- a larger footprint when the fuel store is included
- fuel supply procurement and logistics

3.6 Funding and incentives for renewable energy systems

We leverage our experience of financing and industry funding mechanisms to the benefit of clients where possible. We work alongside Scottish government, local government schemes together with other governing bodies and third parties, e.g. Energy Savings Trust, making sure all sources of support funding can be identified and capitalised on for different projects. Our own organisation has established the Turner Innovation Fund which we use strategically to leverage additional third-party funding for client projects.

3.6.1 Renewable Heat Incentive

The **Non-Domestic Renewable Heat Incentive (RHI)** is a government environmental programme that provides financial incentives to increase the uptake of renewable heat by businesses, the public sector and non-profit organisations.

Eligible installations receive quarterly payments over 20 years based on the amount of heat generated. More information is available on the Ofgem website.

The Government announced on 28 April 2020 that the non-domestic RHI scheme would close for new applicants from April 2021. However, in light of the COVID-19 impact on installations, BEIS announced at the beginning of November 2020 a 1-year extension to allow applicants to complete their installations. Our interpretation of this is that to be eligible for the extended timescale, the applicant needs to demonstrate that work was undertaken on the project, even if this was consultancy and not on-site, prior to 17th August 2020: 'projects that had invested resource into project development prior to the publication date of the Notice (17th August 2020).' See this article reporting this and other expected incentives.

This is another article about potential future incentive schemes for renewable heat.

The **Domestic Renewable Heat Incentive (DRHI)** is a similar programme but provides financial incentives to increase the uptake of renewable heat in dwellings. To be eligible the dwelling must have a Domestic EPC (marked top left with 'Dwelling Type').

It is our understanding that the DRHI is only open to private and social landlords and we recommend that Scottish Canals satisfy themselves whether or not they may be eligible to apply for heat pump systems installed in buildings let as single dwellings.

DRHI cash payments are made quarterly over seven years. The amount received depends on a number of factors – including the technology installed, its efficiency and the latest tariffs available for each technology and – in some cases – metering. More information on the DRHI is available on the Ofgem website.

The DRHI for households and organisations has been extended to March 2022.

Please see **Appendix 2** 'Factsheet: The Renewable Heat Incentive - Domestic or Non-Domestic?'

3.6.2 Smart Export Guarantee

The Smart Export Guarantee (SEG) came into force on 1st January 2020. It is an obligation set by the government for licensed electricity suppliers to offer a tariff and make payment to small-scale

low-carbon generators for electricity exported to the National Grid, providing certain criteria are met. This includes solar PV which is mentioned in this report.

Further information on the SEG is available on the Ofgem website.

3.6.3 Other programmes

Other programmes aimed at supporting the transition to a low carbon economy and that are worth investigating further:

Low Carbon Infrastructure Transition Programme (LCITP)

Applications can be submitted between 1 September 2020 and 18 December 2020. Projects will be required to complete installation and commissioning by 30 November 2021.

Energy Industry Voluntary Redress Scheme

The Energy Redress Scheme is only open to registered charities in England, Scotland and Wales, and Housing Associations that are exempted charities.

Other organisations can be involved in delivering Energy Redress funded projects, but the projects must be led by a charity who must submit the application and be responsible for the funding and project delivery.

There could well be other local programmes available and this changes regularly. The information presented here is intended to raise possible sources of funding appropriate to renewable heating, renewable energy and building fabric improvement. It is not a comprehensive list and funding is always dependant on organisation type, other sources of public funding received and the specific nature of the project.

Please refer to the document, 'Summary of financial support schemes 24Aug20v3(006)' in **Appendix 3**.

4. Methodology

4.1 Introduction

Under normal circumstances, for a feasibility study of this nature, we would be carrying out site visits to all relevant buildings in order to conduct a survey of the site, building layout and building fabric condition etc. Due to COVID-19, this contract required all work to be done digitally. We did undertake a few site visits in the central belt in compliance with restrictions at the time.

The methodology used for identifying the most suitable buildings for ground or water source heat pumps was different to what we originally envisaged. In line with the ITT, we expected to receive robust data including a list of all heated buildings, 'whole building energy consumption details for these buildings for the last 3 years', total floor areas, etc. What we discovered, however, was that what little information of this nature was available, was too inconsistent to be relied upon.

See the diagram in **Appendix 4** for our planned decision-making process.

Our brief was to provide a *"clear rationale for selected and rejected options, including a review of the potential for renewable ground/water source heat pumps for all buildings and rationale for the*

selection of the top 10 Scottish Canals buildings which would be suitable for further design/costing work, taking into account carbon, cost and payback period." Then further to "produce technical designs to a stage where quotations for installation could be sought for a minimum of 5 buildings of different types to be agreed by Scottish Canals/ALIenergy".

The actual methodology we used to arrive at a list of 19 buildings is documented here. The process of assessing these and selecting the top 10 buildings can be found in section 5. Review of Potential for Ground / Water Source Heat Pumps, below.

The documents received at tender stage or the start of the contract included:

- ITT Geo 250620 (Requirements, expected outputs and outcomes etc)
- ITT Appendix 1 Building list v1 (Excel list of all buildings in Scottish Canals Estate)
- ITT Appendix 2 Scottish Canals example building types photos

These documents are included in **Appendix 5**.

4.2 Initial approach

Across the Scottish Canals estate there are 278 documented buildings. Our initial approach was to look at the building sub-types as given in the Scottish Canals Building List Excel document provided at tender stage. We looked to understand the characteristics of the different sub-types in order to first ascertain total floor area. We know from experience that the cost benefit of installing G/WSHPs in buildings below around 150m² is poor. This is largely due to the fact that the energy, and therefore, carbon and cost saving is too small to justify the capital expenditure of a G/WSHP system.

The following building sub-types, which include 68 'buildings' were filtered out as being obviously unsuitable or having no heating demand:

'Boat', 'Control Cabin', 'Ground', 'Lighthouse', 'Play Park', 'Pump-out' 'Pub-derelict', 'Roofless Ruin', 'Mess'.

Turner Services added a tracker tab to the Building List Excel document to track each stage of the filtering process. This document is included in **Appendix 6**.

A further 56 buildings were filtered out having been identified as having either no heat demand or no electricity on site or both. We then had 154 buildings left on the Building List Excel document.

4.3 Low priority buildings

Next, in dialogue with Scottish Canals, we looked at priority i.e. asking the question, 'are there buildings which, even if potentially suitable for G/WSHPs, Scottish Canals would rank as low priority when it comes to investment?'. A considerable number of buildings are let as residential dwellings or leased as commercial premises. In most cases, Scottish Canals doesn't pay the energy running costs for these buildings and so the carbon and running cost savings would not impact directly on Scottish Canals annual operating emissions total. This would make the cost benefit very low and while Scottish Canals has an interest in the carbon footprint of these buildings, for the purposes of this feasibility study, they are deemed as a lower priority. This filtering left us with 92 buildings.

Scottish Canals had already identified 25 buildings as 'Low priority' and once these too were filtered out we had 67 buildings.

At this stage, we shared our process and filtered Building List Excel Document and tracker tab with Scottish Canals for confirmation.

We received confirmation and Scottish Canals took the opportunity to cleanse the Building List Excel document data further. Analysis by them highlighted groupings of buildings where, for example, the ground and first floor were listed separately. Rationalising these adjusted the number of buildings to 57.

Seven buildings were not considered due to being out with the funded GeoAtlantic study area. This reduced the number of buildings to 50.

4.4 Building clusters

At this stage, Scottish Canals provided us with ArcMap GIS files identifying locations for all buildings. Also provided were clusters of buildings. These are sites where there are a number of buildings sufficiently proximate for a small district or communal heating system to be considered. We added some clusters and decided that we would continue our analysis and once we had identified those top 10 buildings most appropriate for G/WSHPs we would revisit the clusters to see whether:

1. *any of the final 10 buildings were in one of these clusters*
2. *whether there were any adjacent buildings that merited evaluating the potential for a mini district heating system.*

4.5 Assessment and rating

At the next stage in our selection process members of our team, working together, went through and looked at each of the 50 buildings one by one. We used the ArcMap GIS files, Google Street View and the data that we had been supplied as well as our combined experience to further assess how suitable each building could be for G/WSHPs.

We used a priority rating scale of 1 to 5 where:

1 = 'completely unsuitable' and can be filtered out
2 = 'doubtful but further questions to be answered'
3 = 'possible but further questions to be answered'
4 = 'probable but further questions to be answered'
5 = 'most interesting potential'

At the end of this process we had 25 buildings with a priority rating of '1' which could be filtered out and we had a list of questions for Scottish Canals and further points for clarification on the remaining 25 buildings on the list. For more details on our rationale for filtering out buildings with a rating of '1 – completely unsuitable' please refer to **5.2 Buildings unsuitable for G/WSHPs and rationale**.

Scottish Canals responded to our questions which meant that a further 7 buildings could be classified as unsuitable and filtered out leaving 18 buildings. This was for similar reasons as above e.g. too small or given a low priority by Scottish Canals etc. One building, namely 'CR-001-110 Egg

Shed' on the original SC Buildings List, we discovered was a new build from 2019 and had an Air Source Heat Pump installed and functioning well.

4.6 Gathering further data

The next stage was to obtain a more detailed understanding of the following factors:

- building fabric and any improvements made
- building usage and heating requirement (percentage heated if not 100%)
- domestic hot water requirement
- current heating system and age
- 3 phase electrical supply available

To do this we spoke to members of Scottish Canals staff and we carried out site visits.

In dialogue with Olivia Lassiere, Scottish Canals Environment Manager and Project Manager, we swapped the 'FC-021-020 Auchinstarry Office / Garage' for the 'FC-021-021 Auchinstarry Customer Facility'. This is because it had a WSHP installed some time ago and is an example of a system that is no longer working. This was one of the sites that Turner Services visited to assess the existing, but decommissioned, heat pump systems in the Customer Facility building and in The Boathouse hotel and restaurant building.

Again, in dialogue with Olivia, we added back in 'FG-004-064 Old Basin House'. This was due to it being refurbished and now in a condition where it can be considered for a heat pump system. With this addition, the number of buildings changed to 19.

5. Review of potential for ground / water source heat pumps

With the Building List Excel document now filtered down to 19 buildings representing those with the best potential for G/WSHP systems and with more data on most of these, we set about carrying out a deeper analysis of each.

5.1 Buildings where a G/WSHP is an appropriate solution

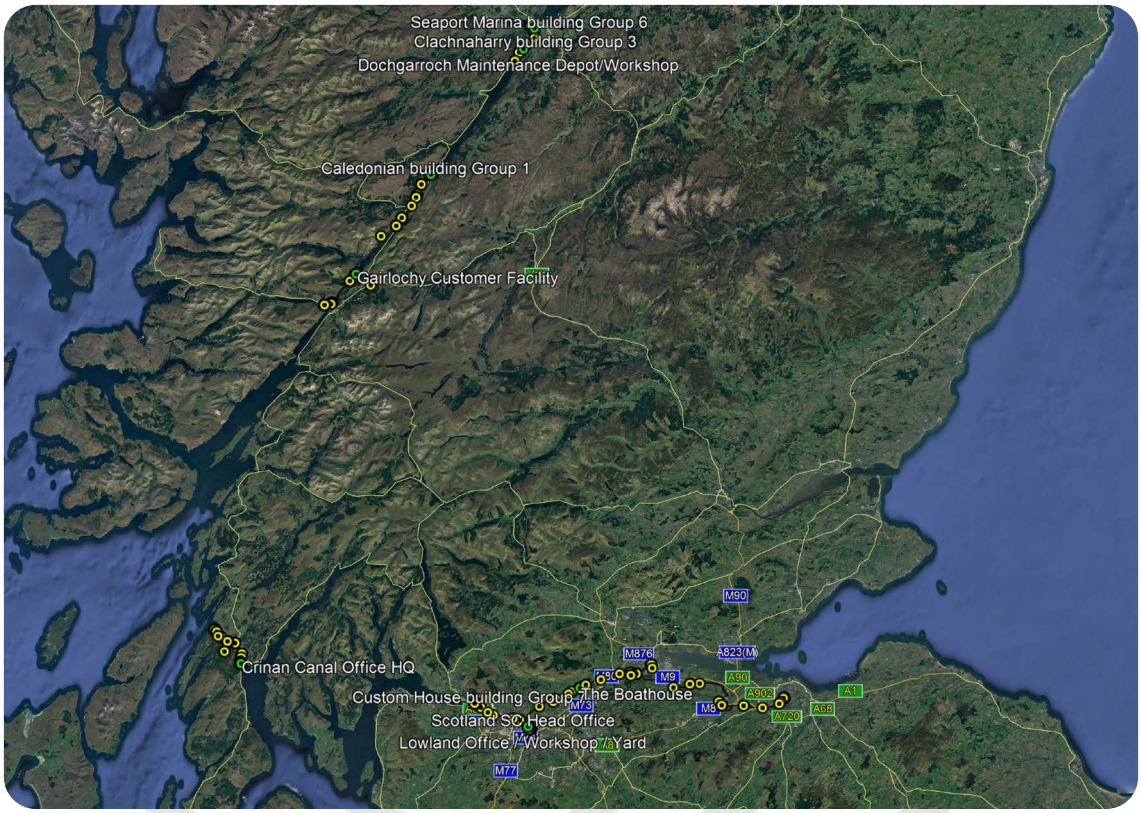
The following buildings were deemed those offering the best potential for G/WSHPs. Further analysis and calculations were conducted on these and a summary is included below in **6. Carbon and Cost Benefit Analysis**.

Please note that:

'Groups' are defined by Scottish Canals and represent separately listed facilities on the Building List Excel Document that are under the same roof.

The reference codes XX-XXX-XXX are unique asset codes from the Scottish Canals asset management database. Longer asset codes are for sub-parts of the building/asset.

	Reference Code	Canal	Building Description	Google Maps Link
1.	*Group 3*			
	CD-001-013	Caledonian	Clachnaharry Sea Lock Office/Customer Facility/Mess	Google maps link
	CD-001-026	Caledonian	Clachnaharry Sea Lock Office Upper Floor	
	CD-001-037	Caledonian	Bressay Cottage	
2.	*Group 6*			
	CD-002-027	Caledonian	Seaport Marina SC Office	Google maps link
	CD-002-004	Caledonian	Seaport Marina Customer Facility	
3.				
	CD-009-009	Caledonian	Dochgarroch Maintenance Depot/Workshop	Google maps link
4.	*Group 1*			
	CD-015-078	Caledonian	Caledonian Canal Centre	Google maps link
	CD-015-078-01	Caledonian	Caledonian Canal Centre Cafe & Shop	
	CD-015-078-02	Caledonian	Caledonian Canal Centre Hotel	
5.				
	CD-029-033	Caledonian	Gairlochy Customer Facility	Google maps link
6.				
	CR-001-075	Crinan	Crinan Canal Office HQ	Google maps link
7.				
	FC-021-024	Forth and Clyde	The Boathouse, Auchinstarry	Google maps link
8.				
	FG-004-028	Forth and Clyde	Scotland SC Head Office, Applecross Street, Glasgow	Google maps link
9.				
	FG-004-029	Forth and Clyde	Lowland Office / Workshop / Yard	Google maps link
10.				
	FG-004-064	Forth and Clyde	Old Basin House	Google maps link



Map of the top 10 buildings with those on the Caledonian Canal northernmost, the Crinan Canal to the west and the Forth and Clyde Canal in the south.

5.2 Buildings unsuitable for G/WSHPs and rationale

From the 19 buildings remaining from the filtering process, the following 9 buildings were found to be unsuitable for a G/WSHP system. The rationale for this is given below for each building.

5.2.1 CD-001-025 Clachnaharry Works-Lock Main Workshop

This is a multi-use building with over half leased to a commercial tenant (Fixed Wing Masts). Northern part of the building is the control tower area for the works lock. There is a small storage area underneath part of the Fixed Wing Masts area. From the workshop, there is an exit out to an open courtyard. There is a building to the left used predominately as an archive store and a small stand-alone toilet block.

Neither the workshop nor the archive store have a functioning heat system. The building fabric is without insulation apart from glass wool insulation, <300mm, between roof joists but in very poor condition. The archive store has single glazed windows. The toilet block has electric heating and hot water but is too small to be considered for G/WSHP in its own right.

The size of this building meant it appeared to have potential for G/WSHP but once we were able to gather further information, the lack of heating requirement and absence of insulation make it unsuitable.

5.2.2 CD-015-026 Fort Augustus (Top) Customer Facility and Office

Multi-use building of approximately 75m² comprising a customer facility with showers & toilets and a laundry room as well as a separate small office space under the same roof.

Concrete floor. Exact level of wall and attic space insulation in unknown but windows are double glazed. Continuous heating via electric panel heaters throughout and hot water requirement.

There are many customer facility blocks across the Scottish Canals estate.

The building fabric condition of these varies but given the number of these buildings and the fact that they have a constant heating and hot water requirement, this represents a considerable cost each year. That energy use, in turn, equates to a considerable carbon footprint.

While the typical size of the customer facility blocks is below the floor area that provides an interesting cost benefit for G/WSHPs, it is worth considering other means of reducing the energy consumption. Please refer to section **6.1.5. CD-029-033 Gairlochy Customer Facility**, for the options outlined there which are also applicable to this building.

5.2.3 CD-039-038 Banavie Top Customer Facility

A more recently constructed customer facility block of approximately 70m² with similar multi-use and facilities. This customer facility block is in good condition and should have a lower heat loss rate than the older versions.

While the typical size of the customer facility blocks is below the floor area that provides an interesting cost benefit for G/WSHPs, it is worth considering other means of reducing the energy consumption. Please refer to section **6.1.5. CD-029-033 Gairlochy Customer Facility**, for the options outlined there which are also applicable to this building.

5.2.4 CD-041-024 Corpach Sea Lock Office
CD-041-029 Askaig Corpach Supervisors Office and Mess
CD-041-033 Corpach Sea Lock Customer Facility

These three buildings have been listed and counted separately in our numbers referred to in our methodology and on the Building List Excel document and tracker tab. They are separate but so close to each other that they have been considered together with the potential for a mini-district heating scheme with one heat pump serving all three.

While the combined floor area of this cluster of buildings would be within the range of what makes sense for a G/WSHP, the challenge here is the high relative heat loss due to poor levels of insulation, single glazing etc. Generally speaking, buildings where the heat loss is higher than 80 W/m² (Watts per square metre) are not suitable for low temperature heating systems like heat pumps.

These buildings would need to be refurbished and insulated for heat pumps to become an appropriate heating solution. Certainly worth revisiting following fabric upgrade.

5.2.5 CR-001-081 Steamer Terminal

The multi-use, Steamer Terminal building consists of an office/meeting room, kitchen, cafe area and toilet. We were not able to collect much information on this building and so have had to base our assessment on photographs from Google Earth from 2015.

Based on this, it appears that the windows are single-glazed and we have no evidence of improved insulation.

The building is large enough, and the assumed energy use sufficiently high, that there could be a cost benefit from installing a heat pump system. However, this would only make sense following refurbishment that included insulating the building to reduce the rate of heat loss.

5.2.6 FC-021-021 Auchinstarry Customer Facility

This customer facility block comprises toilets, showers and a laundry room and follows a similar size and layout to other buildings of this type. Built within the last 20 years, a small water source heat pump was installed.

Engineers from Turner Services visited this site and assessed the water source heat pump in the customer facility block and the one installed in the adjacent Boathouse restaurant and hotel. The heat pump has been decommissioned and electric heaters installed. The wet heating system with radiators is still intact.

The engineers' assessment is that the water source heat pump is around 15 years old and the cost of system fault-finding and possible re-commissioning could be more than the cost of replacement with an alternative renewable energy system. Again, for a building of this size it is difficult to realise a cost benefit for a G/WSHP system.

However we recommend looking at other means of reducing the energy consumption. Please refer to section **6.1.5. CD-029-033 Gairlochy Customer Facility**, for the options outlined there which are also applicable to this building.

5.2.7 Group 7

FC-056-029 Custom House Bowling Office
FC-056-032 Custom House Flat

Google Maps Link

The Custom House building at Bowling has recently been refurbished and a gas boiler installed. The refurbishment will have reduced the heat loss to make a lower temperature heating system like a heat pump appropriate. However, we suspect the radiators fitted will be sized for the high temperature, gas boiler system.

The fact that the refurbishment has been carried out will reduce the heat demand and carbon emissions.

If the gas boiler hadn't been installed, we would be recommending an ASHP. Replacing existing radiators with larger ones appropriate for a low temperature system is relatively easily done without causing too much disruption. This can be borne in mind for the future.

6. Carbon and cost benefit analysis

In this section we provide analysis of the top 10 buildings found to be most appropriate for a G/WSHP. Our analysis is based on the data available within the timescale of the project. The digital nature of the project, due to COVID-19, meant that we did not carry out site surveys on these buildings, apart from a few. (Auchinstarry Customer Facility, The Boathouse, Scotland SC Head Office, Lowland Office/Workshop).

There is a description, recommendations and a quick summary section for each building. The quick summary includes the top-level figures in terms of existing heating, estimated annual energy usage and cost, carbon saving and system payback time. A table with the full set of heat loss, technology options and carbon and cost benefit analysis data etc. can be found in **Appendix 7**. The full calculations are included in **Appendix 8**. In the quick summary for each building and alternative renewable heat system the buildings are ranked 1 to 10 (where '1' is first), for CO_2 emission reduction and payback. The ranking is only given against the technology which scores highest for each building.

Assumptions

Energy prices and CO_2 emission rates used:

System	CO_2 emission (kg/kWh)	Efficiency	£/kWh
Mains Gas	0.18	90%	£0.042
LPG	0.21	90%	£0.072
Oil	0.25	85%	£0.048
Direct electric	0.23	100%	£0.150
HP (SCOP 3.56)*	0.06	356%	£0.042

*HP – Heat Pump; SCOP – Seasonal Coefficient of Performance

Renewable Heat Incentive (RHI) Tariffs **3.6.1 Renewable Heat Incentive** used:

Technology	Tariff
GSHP Non-Domestic Tier 1	£0.097
GSHP Non-Domestic Tier 2	£0.029
ASHP Non - Domestic	£0.028

The amount of the energy generation (kWh) that will be compensated using Tier 1 tariff is calculated:
Rated capacity of the heating system (kW) x 1314 x Tier 1 tariff
Remaining kWh will be compensated using Tier 2 tariff.

*GSHP – Ground source heat pump; ASHP – air source heat pump

Costings

A site visit is important for assessing whether an existing wet radiator system can be used and what alterations are required. Included here in the 'Estimated Cost of Installation' figures are allowances for upgrading or installing a wet radiator distribution system where this is necessary. Please see the summary of calculations for the top 10 buildings in **Appendix 7**.

A notional sum only has been included for the cost of installation of the collector system in the case of water source heat pumps. The actual cost will be subject to detailed site survey and discussions with the Scottish Canals Engineers. The cost of boreholes and the installation of collector pipe in the borehole is included. A notional sum only has been included for the cost of groundworks and associated pipework and accessories. The actual cost will be subject to detailed site survey and agreement on location of boreholes and pipe runs. Annual maintenance costs have not been included. These depend on the size and nature of the system. An annual site visit is recommended for commercial systems and the average cost of this is £300 - 500.00 + VAT / year.

The cost per kg of CO_2 reduced (£/kg) is assuming 15-year life expectancy of the system.

We recommend that a site survey and detailed heat loss calculation be carried out prior to the installation of a heat pump system in any of these buildings. Any designs should also be reviewed at this stage. Accurate and detailed costs for installation can also be ascertained.

6.1 Top 10 most suitable buildings for a G/WSHP solution

6.1.1 Group 3

CD-001-013 Clachnaharry Sea Lock Office/Customer Facility/Mess
CD-001-026 Clachnaharry Sea Lock Office Upper Floor
CD-001-037 Bressay Cottage

Google Maps Link

This is a 2-storey, multi-use building. The left-hand side ground floor is an office space (sea lock office) combined with a welfare area and a customer facility comprising a shower and toilet facility. Upstairs left is the district supervisor's office space. On the right-hand side is a 2-storey residential house. The standalone building to the right is a single-story stone shed with pitched roof used as a store and drying room facility (sea lock store).

The operational parts of the building are currently heated with electric storage heaters (see photo in Appendix 9). There is a constant heating requirement. The windows are single-glazed but have had secondary glazing fitted. The attic areas have <300mm glass wool insulation throughout. A hot water tank with immersion supplies hot water and there is an electric shower in the customer facility.

The Sea Lock Store has concrete floor and stone walls with single glazing. The drying room area is electrically heated.

The residential house, Bressay Cottage, comprises porch, entrance hall, bathroom, living room and kitchen on the ground floor with 2 bedrooms upstairs. There is an open fire in the living room which is used all day. Heating and hot water is provided by an oil boiler which is over 15 years old (see photo in **Appendix 9**). The windows are single-glazed with only the kitchen having secondary glazing.

Recommendations

The Clachnaharry Sea Lock building is included here for its size (when combined with the residential half), the fact that over half of the building is used operationally by Scottish Canals and because the chances are high that the oil boiler will need replacing very soon. Water and ground source heat pumps are options here. Water, open loop taking water from the canal upstream of the lock, and ground source using boreholes. Both are doable but considerably more involved and costly than an air source system. Reducing the heat loss of the building would be important prior to installing a low temperature heating system. A site survey would need to be carried out to determine the placement of over-sized radiators and potential location of a hot water cylinder. These unknowns mean that we do not recommend that this building goes into the top 5.

Quick summary

Clachnaharry Sea Lock Office			
Recommended System Type	WSHP		Ranking in top 10
Existing Heating	Electric / Oil		
Est. Heat Demand (kWh/year) / Cost	50,664 / £7,599		
CO_2 Emission Reduction	8,370	(kg/year)	
Running Cost Reduction	5,458	(£/year)	
Potential RHI Income	3,962	(£/year)	
System Payback Time with RHI/without *	4.1/7.0	(years)	
Estimated Cost of Installation	38,228	(£)	
Cost per kg of CO_2 Reduced *	0.30	(£/kg)	

Clachnaharry Sea Lock Office			
Recommended System Type	ASHP		Ranking in top 10
Existing Heating	Electric / Oil		
Est. Heat Demand (kWh/year) / Cost	50,664 / £7,599		
CO_2 Emission Reduction	8,078	(kg/year)	7
Running Cost Reduction	5,268	(£/year)	
Potential RHI Income	1,413	(£/year)	
System Payback Time with RHI/without *	4.4/5.5	(years)	4/4
Estimated Cost of Installation	29,187	(£)	
Cost per kg of CO_2 Reduced *	0.24	(£/kg)	

*Our recommendations include improving the building fabric as a first measure which creates a longer timeline to the point where the RHI could be applied for. Indeed it may push this potential heat pump installation beyond the RHI application deadline thereby making the payback much shorter for ASHP (5.5 versus 7 years). With the RHI the difference in payback is that it is 4.5 months shorter for a WSHP. This however needs to be balanced with the pragmatic view that the capital expenditure is approx. £9,000 (30%) more.

6.1.2 Group 6

CD-002-027 Seaport Marina SC Office

CD-002-004 Seaport Marina Customer Facility

Google Maps Link Old image – there is no longer an oil boiler following the refurbishment approximately six years ago. Heating is now all electric.

This 2-storey building houses an office space combined with a meeting room, welfare/toilet facilities and an external access store on the ground floor. There is also a small plant room. Upstairs is the main Caledonian Canal office comprising a customer service reception, a breakout area and two small offices. To the east end of the main building is a single-storey customer facility comprising shower and toilet facilities and a laundry area. There is a plant room to the rear. All areas have electric storage or panel heaters (see photo in Appendix 9) with hot water supplied from an immersion tank. The heating demand is constant. The windows are double-glazed. Insulation levels are unconfirmed.

Recommendations

The Seaport Marina Office and Customer Facility is on this shortlist thanks to the estimated 268m² area of the building and the high energy costs due to constant use of the all-electric heating and potential running cost and carbon savings.

A water source heat pump is an option here with either an open loop or closed loop system utilising the protection of the marina pontoon. Both involve crossing the blockwork with flow and return pipework between the building and the canal wall. The same pipework will need to be routed back to the plant room at the rear of the customer facility.

We have run calculations for an ASHP system to make the comparison in terms of payback and carbon saving. Both alternatives include fitting a wet radiator system. A site survey would need to be carried out to determine:

- where insulation could be relatively easily improved

- the siting of over-sized radiators and running of pipework back to the plant room
- the routing of flow and return pipework from the canal back to the plant room

Quick summary

Seaport Marina Office and Customer Facility			
Recommended System Type	WSHP open loop		Ranking in top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	66,744 / £10,012		
CO_2 Emission Reduction	11,027	(kg/year)	
Running Cost Reduction	7,191	(£/year)	
Potential RHI Income	4,427	(£/year)	
System Payback Time with RHI/without *	3.3/5.4	(years)	
Estimated Cost of Installation	38,559	(£)	
Cost per kg of CO_2 Reduced *	0.23	(£/kg)	

Seaport Marina Office and Customer Facility			
Recommended System Type	ASHP		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	66,744 / £10,012		
CO_2 Emission Reduction	10,642	(kg/year)	4
Running Cost Reduction	6,940	(£/year)	
Potential RHI Income	1,862	(£/year)	
System Payback Time with RHI/without *	3.4/4.3	(years)	3/3
Estimated Cost of Installation	29,518	(£)	
Cost per kg of CO_2 Reduced *	0.18	(£/kg)	

* our recommendations include improving the building fabric as a first measure which creates a longer timeline to the point where the RHI could be applied for. Indeed it may push this potential heat pump installation beyond the RHI application deadline thereby making the payback shorter for ASHP (4.3 versus 5.4 years). With the RHI the difference in payback is that it is 1.5 months shorter for a WSHP. This however needs to be balanced with the pragmatic view that the capital expenditure is approx. £9,000 (30%) more.

6.1.3 CD-009-009 Dochgarroch Maintenance Depot/Workshop

Google Maps Link

The building contains a General Maintenance Workshop on the ground floor with 3 small side rooms utilised for storage & trade work, leading into a drying area. Upstairs there are welfare and office facilities. The building construction is steel framed brick with part metal cladding dating

from the early 1990s. Refurbishment took place in 2005. There is double glazing throughout. The main workshop area is heated on demand. Heating in the upper level and downstairs toilet is on during working hours. Heating in the drying room is constant use 24/7.

Hot water is supplied from a Megaflow electric storage tank with 125 Litres capacity and 2 x 3 kW elements.

Recommendations

The Dochgarroch Maintenance Depot/Workshop is on this shortlist thanks to the size of the heated area and the potential for running cost and carbon savings by converting from all-electric to a heat pump system.

A water source heat pump is an option here with either an open loop or closed loop system utilising the protection of the marina pontoon. Both involve crossing the tarmacked road with flow and return pipework between the building and the canal wall.

A ground source heat pump would avoid the need to cross the road with pipework, drilling boreholes instead in the yard to the north of the building. Equally, an ASHP system could be installed in this fenced-off yard.

We have summarised the calculations for WSHP open loop, GSHP and ASHP to make the comparison in terms of payback and carbon saving. All alternatives include fitting a wet radiator system which should be easily achieved given the nature of the building, subject to detailed site survey.

Quick summary

Dochgarroch Maintenance Depot/Workshop			
Recommended System Type	**WSHP open loop**		Ranking in top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	52,567 / £7,885		
CO_2 Emission Reduction	8,925	(kg/year)	
Running Cost Reduction	5,820	(£/year)	
Potential RHI Income	2,946	(£/year)	
System Payback Time with RHI/without	3.9/5.9	(years)	
Estimated Cost of Installation	34,488	(£)	
Cost per kg of CO_2 Reduced	0.26	(£/kg)	

Dochgarroch Maintenance Depot/Workshop			
Recommended System Type	GSHP with boreholes		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	52,567 / £7,885		
CO_2 Emission Reduction	8,925	(kg/year)	4
Running Cost Reduction	5,820	(£/year)	
Potential RHI Income	2,946	(£/year)	
System Payback Time with RHI/without	5.2/7.8	(years)	3/3
Estimated Cost of Installation	45,626	(£)	
Cost per kg of CO_2 Reduced	0.34	(£/kg)	

Dochgarroch Maintenance Depot/Workshop			
Recommended System Type	ASHP		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	52,567 / £7,885		
CO_2 Emission Reduction	8,382	(kg/year)	4
Running Cost Reduction	5,466	(£/year)	
Potential RHI Income	1,466	(£/year)	
System Payback Time with RHI/without	2.5/3.1	(years)	3/3
Estimated Cost of Installation	17,125	(£)	
Cost per kg of CO_2 Reduced	0.14	(£/kg)	

6.1.4 Group 1

CD-015-078 Caledonian Canal Centre

CD-015-078-01 Caledonian Canal Centre Cafe and Shop

CD-015-078-02 Caledonian Canal Centre Hotel

Google Maps Link Old image from 2011

The Caledonian Canal Centre was opened following major refurbishment and fit-out in 2018. On the ground floor is a tourist destination comprising a café/take away area, a commercial kitchen, office space and a rented commercial retail outlet (Kiltane). There is also a decking

area to the rear, plant room and welfare area. On the first floor are 7 en-suite rooms, bookable for accommodation, and housekeeping storage.

Heating is all electric via panel heaters and hot water is provided by an LPG boiler.

Recommendations

The Caledonian Canal Centre is on this shortlist thanks to its size, the fact that the newly refurbished fabric of the building is well suited to a low temperature heating system and the fact that the current heating system is all electric and so expensive to run. LPG is almost twice as expensive as mains gas and a heat pump would deliver the hot water requirement along with the heating.

The site is very tight and there is a road between the building and the canal. There is a lock at this point of the canal which would add a level of complexity that would make a water source option challenging and expensive.

The tight nature of the site would also make it a challenge for ground source, although in practice boreholes could be drilled to the front of the building. Given that this area has been recently reinstated this may not be considered an attractive alternative.

An air source heat pump system, subject to detailed site survey to identify the most appropriate location, would probably be the most feasible option. This would also require the installation of a wet heating system. The most appropriate means of installing this would need to be considered following a detailed site survey.

Quick summary

Caledonian Canal Centre			
Recommended System Type	ASHP		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	104,612 / £15,691		
CO_2 Emission Reduction	17,225	(kg/year)	2
Running Cost Reduction	11,234	(£/year)	
Potential RHI Income	2,918	(£/year)	
System Payback Time with RHI/without	2.8/3.5	(years)	2/2
Estimated Cost of Installation	39,346	(£)	
Cost per kg of CO_2 Reduced	0.15	(£/kg)	

Caledonian Canal Centre			
Recommended System Type	**GSHP with boreholes**		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	104,612 / £15,691		
CO_2 Emission Reduction	17,340	(kg/year)	2

Caledonian Canal Centre			
Running Cost Reduction	11,308	(£/year)	
Potential RHI Income	6,146	(£/year)	
System Payback Time with RHI/without	4.9/7.5	(years)	2/2
Estimated Cost of Installation	84,668	(£)	
Cost per kg of CO_2 Reduced	0.33	(£/kg)	

6.1.5 CD-029-033 Gairlochy Customer Facility

Google Maps Link

The Gairlochy Customer Facility was constructed in 2007 and houses toilets and showers, a store, laundry and plat room.

An IDM Terra Heat water source heat pump was installed but has since been decommissioned because it didn't meet the showers and laundry requirement.

Recommendations

The Gairlochy Customer Facility is on this shortlist for two reasons:

1. it is worth investigating whether the heat pump could be replaced with a more modern and therefore efficient model that would achieve the temperature and hot water demands. This would require a site visit to try and ascertain whether the water source collector system is useable and sized such that it would service a new heat pump. We have calculated for this option based on full system replacement.
2. it highlights this building type, of which there are many across the Scottish Canals network, and invites us to look at the figures around an alternative renewable energy package for this building type, namely ASHP and solar PV. For more on this renewable energy solution and its potential, please see section **7.3 Renewable Energy Solution for Customer Facility Blocks**, below.

We have calculated the benefits of an ASHP on its own and also an ASHP and Solar PV package to make the comparison with replacement of the water source heat pump.

The external ASHP unit can by sited on the most discreet elevation of the building with the internal unit located in the plant room, store or laundry area, depending on the facility block.

Quick summary

Gairlochy Customer Facility			
Recommended System Type	**WSHP open loop**		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	16,048 / £2,407		
CO_2 Emission Reduction	2,841	(kg/year)	2
Running Cost Reduction	1,852	(£/year)	
Potential RHI Income	999	(£/year)	
System Payback Time with RHI/without	10.0/15.4	(years)	2/2
Estimated Cost of Installation	28,613	(£)	
Cost per kg of CO_2 Reduced	0.67	(£/kg)	

Gairlochy Customer Facility			
Recommended System Type	**ASHP**		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	16,048 / £2,407		
CO_2 Emission Reduction	2,745	(kg/year)	9
Running Cost Reduction	1,789	(£/year)	
Potential RHI Income	447	(£/year)	
System Payback Time with RHI/without	5.1/6.4	(years)	5/5
Estimated Cost of Installation	11,492	(£)	
Cost per kg of CO_2 Reduced	0.28	(£/kg)	

Gairlochy Customer Facility			
Recommended System Type	**ASHP & Solar PV***		Ranking in Top 10
Existing Heating	Electric		
Est. Heat Demand (kWh/year) / Cost	16,048 / £2,407		
CO_2 Emission Reduction	3,321	(kg/year)	
Running Cost Reduction	2,199	(£/year)	
Potential RHI Income	447	(£/year)	
System Payback Time with RHI/without	6.1/7.7	(years)	
Estimated Cost of Installation	16,217	(£)	
Cost per kg of CO_2 Reduced	0.33	(£/kg)	

*Based on a 4kW, 11 panel solar PV system. Electricity used on site and SEG income reflected in Running Cost Reduction figure. Please refer to Appendix 10 for Solar PV Performance Calculation.

6.1.6 CR-001-075 Crinan Canal Office HQ

Google Maps Link

This building has been used as the Crinan Canal HQ which has now moved across the courtyard to the Steamer Terminal building. It is currently unoccupied and due for full renovation in a few years with a view to letting it out as tourist accommodation.

The ground floor is heated by an oil boiler which is around 5 years old. Upstairs there are electric storage heaters.

Recommendations

The plans to renovate this building create a good opportunity to incorporate renewable heat. Improved insulation and air tightness will create a building suitable for a low temperature heating system. Over-sized radiators can be specified to maximise system efficiency. Allowance can also be made for a plant room to house a heat pump and hot water tank.

Ground source is an option for this building. There is limited available land for a ground collector system but plenty of space for drilling boreholes in the back garden area.

Another option is an ASHP with the external unit sited at the back or side of the building. If space inside is limited, and the garage is to be retained, another option worth considering is to site the external unit behind or to the western side of the garage and to create a plant room in the garage and then run insulated pipework into the house.

Summaries of the calculations on both of these options can be seen below.

Quick summary

Crinan Canal Office HQ Building			
Recommended System Type	**GSHP with boreholes**		Ranking in Top 10
Existing Heating	Oil		
Est. Heat Demand (kWh/year) / Cost	39,991 / £1,919		
CO_2 Emission Reduction	9,657	(kg/year)	
Running Cost Reduction	890	(£/year)	
Potential RHI Income	2,583	(£/year)	
System Payback Time with RHI/without	16.0/62.5	(years)	
Estimated Cost of Installation	55,690	(£)	
Cost per kg of CO_2 Reduced	0.38	(£/kg)	

Crinan Canal Office HQ Building			
Recommended System Type	ASHP		Ranking in Top 10
Existing Heating	Oil		
Est. Heat Demand (kWh/year) / Cost	39,991 / £1,919		
CO_2 Emission Reduction	9,524	(kg/year)	5
Running Cost Reduction	803	(£/year)	
Potential RHI Income	1115	(£/year)	
System Payback Time with RHI/without	13.0/31.0	(years)	9/7
Estimated Cost of Installation	24,895	(£)	
Cost per kg of CO_2 Reduced	0.17	(£/kg)	

6.1.7 FC-021-024 The Boathouse, Auchinstarry

Google Maps Link

The Boathouse at Auchinstarry comprises a restaurant and hotel extending to 950m² in total floor area. The facilities are leased out and a new tenant has recently taken over the lease.

Engineers from Turner Services visited this site and assessed the existing water source heat pump which has been decommissioned and a gas boiler installed (see photo in **Appendix 9**).

The engineers' assessment is that the Wiessman 43kW water source heat pump is around 15 years old. The collector system is not holding pressure and is probably damaged. The pipework and wiring in the plant room is over complex.

Recommendations

Our recommendation is to replace the heat pump system with a new water source heat pump for the following reasons:

- the cost of system fault-finding, repair and possible re-commissioning could be significant with no guarantee of reinstating a resilient system that remains operational
- the installed system is around 15 years old and heat pump technology has improved significantly during this time in terms of efficiency and user-friendly controls
- installing a new system with guarantees, within the RHI qualifying timescale, means that it could qualify for RHI payments for the next 20 years.

We recommend an open loop system using the protection of the pontoon in the marina. The existing wet heating system with radiators (see photo in Appendix 9) seems to be in good working order and already sized for a low temperature heating system. We recommend retaining the existing gas boiler as a back-up to the heat pump in the event of longer periods of low temperatures and the freezing of the canal. We have heard that the gas boiler may not be sufficient to deliver the heating and hot water demands of the building and while this would remain an issue if nothing was done, it should be a sufficient back-up to a new heat pump system. We recommend further investigation of the existing system to either confirm that the gas boiler is under-sized for the building or to identify other issues. The existing heat pump will need to be removed and the plant room re-fitted.

A GSHP with boreholes is also an option at this site and again, we have run the calculations on an ASHP for comparison.

Quick summary

The Boathouse, Auchinstarry			
Recommended System Type	**WSHP open loop**		Ranking in Top 10
Existing Heating	Gas		
Est. Heat Demand (kWh/year) / Cost	116,650 / £4,899		
CO_2 Emission Reduction	16,176	(kg/year)	3
Running Cost Reduction	738	(£/year)	
Potential RHI Income	6,493	(£/year)	
System Payback Time with RHI/without	5.6/55.0	(years)	7/8
Estimated Cost of Installation	40,597	(£)	
Cost per kg of CO_2 Reduced	0.17	(£/kg)	

The Boathouse, Auchinstarry			
Recommended System Type	**GSHP with boreholes**		Ranking in Top 10
Existing Heating	Gas		
Est. Heat Demand (kWh/year) / Cost	116,650 / £4,899		
CO_2 Emission Reduction	16,176	(kg/year)	
Running Cost Reduction	738	(£/year)	
Potential RHI Income	6,493	(£/year)	
System Payback Time with RHI/without	9.4/92.0	(years)	
Estimated Cost of Installation	68,272	(£)	
Cost per kg of CO_2 Reduced	0.28	(£/kg)	

The Boathouse, Auchinstarry			
Recommended System Type	ASHP		Ranking in Top 10
Existing Heating	Gas		
Est. Heat Demand (kWh/year) / Cost	116,650 / £4,899		
CO_2 Emission Reduction	16,213	(kg/year)	
Running Cost Reduction	763	(£/year)	
Potential RHI Income	3,254	(£/year)	
System Payback Time with RHI/without	8.1/42.0	(years)	
Estimated Cost of Installation	32,400	(£)	
Cost per kg of CO_2 Reduced	0.13	(£/kg)	

6.1.8 FG-004-028 Scotland SC Head Office

Google Maps Link

The Scotland SC Head Office building is just under 1000m² including the adjacent and connected cabin-style office extension. Turner Services visited the building. It is currently heated by a gas boiler (15+ years old) and wet radiator system (see photo in Appendix 9). Additional heating and cooling is delivered via multiple air to air heat pumps and convector fan units.

Recommendations

The head office is a flagship building and one of the largest in the Scottish Canals estate with a considerable footprint in terms of carbon emissions and energy usage.

Our recommendation is for a water source heat pump system utilising the building's proximity to the canal basin. An open loop system extracts water, pumping it from the canal and returning it at another point 'downstream'. The area required for plant in the water is minimal which has an advantage here where the basin needs to be kept clear for traffic movements and docking. Flow and return pipework would be routed from the canal to the plant room. The existing gas boiler would be employed as a back-up to the heat pump, until it needs replaced, in the event of longer periods of low temperatures and the freezing of the canal.

Included in our calculations is the upsizing of radiators to ensure best system efficiency associated with a low temperature heat pump system.

Again, we have run the calculations on an ASHP for comparison.

Quick summary

Scotland SC Head Office, Applecross Street			
Recommended System Type	**WSHP open loop**		Ranking in Top 10
Existing Heating	Gas		
Est. Heat Demand (kWh/year) / Cost	165,055 / £6,932		
CO_2 Emission Reduction	22,806	(kg/year)	1
Running Cost Reduction	992	(£/year)	
Potential RHI Income	12,978	(£/year)	
System Payback Time with RHI/without	6.5/91.0	(years)	8/10
Estimated Cost of Installation	90,167	(£)	
Cost per kg of CO_2 Reduced	0.26	(£/kg)	

Scotland SC Head Office, Applecross Street			
Recommended System Type	**ASHP**		Ranking in Top 10
Existing Heating	Gas		
Est. Heat Demand (kWh/year) / Cost	165,055 / £6,932		
CO_2 Emission Reduction	21,148	(kg/year)	
Running Cost Reduction	-89	(£/year)	
Potential RHI Income	4,605	(£/year)	
System Payback Time with RHI/without	21.8/-	(years)	
Estimated Cost of Installation	98,368	(£)	
Cost per kg of CO_2 Reduced	0.31	(£/kg)	

6.1.9 FG-004-029 Lowland Office / Workshop / Yard

The heated areas in this building consist of two offices, a toilet, a drying room and a welfare area totalling 70m². Turner Services carried out a site visit and survey.

There is a high heating demand 5 – 7 days a week and up to 25°C+ currently delivered due to poorly controllable direct electric heaters (see photo in Appendix 9). Currently the offices have approx. 50mm insulation.

Recommendations

The scale of the premises makes the case for a G/WSHP challenging but our recommendation is that it is worth exploring the cost and carbon benefit of an ASHP, given the constant usage and nature of the current heating system.

Insulation levels could easily be increased in some areas. A wet radiator system would be relatively easy to fit as this is a functional building and pipework can be run through plasterboard walls. This is included for in our costings. There is plenty of space for an ASHP.

Quick summary

Lowland Office / Workshop / Yard			
Recommended System Type	**ASHP**		Ranking in Top 10
Existing Heating	Direct Electric		
Est. Heat Demand (kWh/year) / Cost	14,950 / £2,242		
CO_2 Emission Reduction	2534	(kg/year)	10
Running Cost Reduction	1,652	(£/year)	
Potential RHI Income	417	(£/year)	
System Payback Time with RHI/without	5.7/7.1	(years)	6/6
Estimated Cost of Installation	11,737	(£)	
Cost per kg of CO_2 Reduced	0.31	(£/kg)	

6.1.10 FG-004-064 Old Basin House

Google Maps Link

Old Basin House at Applecross Street has recently been refurbished with plans for an ASHP to be installed.

Recommendations

Although the site is tight, there is space for a borehole to be drilled just south of the gable facing Applecross Street. However, the plans show little space for a plant room or other area large enough to accommodate a GSHP and cylinder etc. This and the comparatively low heat demand help to make an ASHP the preferred option for Old Basin House.

It is unclear what has been planned in terms of distribution system and whether radiators have already been fitted. Over-sized radiators can be specified to maximise system efficiency.

The external ASHP unit can be sited at the outside corner of the new extension on the east elevation. The internal hot water cylinder can be located in the corner of the kitchen against the shared wall to the WC.

Quick summary

Old Basin House, Applecross Street			
Recommended System Type	**ASHP**		Ranking in Top 10
Existing Heating	Direct Electric		
Est. Heat Demand (kWh/year) / Cost	25,156 / £3,773		
CO_2 Emission Reduction	3,581	(kg/year)	8
Running Cost Reduction	219	(£/year)	
Potential RHI Income	701	(£/year)	
System Payback Time with RHI/without	16.7/70.0	(years)	10/9
Estimated Cost of Installation	15,380	(£)	
Cost per kg of CO_2 Reduced	0.29	(£/kg)	

6.2 Buildings selected for technical design

With the top 10 buildings selected, the task was to select 5 buildings to take to a further stage with designs developed. Turner Services shared the draft report with Olivia Lassiere, Scottish Canals Environment Manager and Project Manager, and Lynda Mitchell, Manager of ALIenergy with a view to getting feedback on which 5 buildings should be selected.

An online meeting was arranged by Olivia Lassiere with her colleagues at Scottish Canals and the Turner Services project team members were invited to present their findings with the objective of reaching a decision on the 5 buildings. The Turner Services team provided more information on the project and presented the details of their findings on the top 10 buildings. This stimulated good discussion and different perspectives were voiced by the Scottish Canals staff who between them represented the leadership team, estates, engineering services and new project development. A copy of the presentation can be found in Appendix 11.

The tables below summarise the ranking of each of the top 10 buildings based on:

1. CO_2 Emission Reduction
2. System Payback Time with and without the Renewable Heat Incentive (RHI)

The first table shows the ranking based on payback with RHI and then the second table the ranking taking the combined average of both the CO_2 Emission Reduction and payback with RHI.

Ranking of top 10 buildings (1 = First/Top)

Ranking of top 10 buildings (1 = First/Top)			
CO_2 Emission Reduction		System Payback Time with RHI	
1	Scotland SC HO	1	Dochgarroch Maint. Depot
2	Caledonian Canal Centre	2	Caledonian Canal Centre
3	The Boathouse	3	Seaport Marina
4	Seaport Marina	4	Clachnaharry Sea Lock Office
5	Crinan Canal HQ	5	Gairlochy Customer Facility
6	Dochgarroch Maint. Depot	6	Lowland Office / Workshop
7	Clachnaharry Sea Lock Office	7	The Boathouse
8	Old Basin House	8	Scotland SC HO
9	Gairlochy Customer Facility	9	Crinan Canal HQ
10	Lowland Office / Workshop	10	Old Basin House

Ranking average - CO_2 reduction and payback (with RHI) - top 10 buildings (1 = First/Top)					
Combined Ranking Average	Building	Ranking	Preferred System	Estimated current heating cost £/m²	Estimated cost of installation
2.0	Caledonian Canal Centre	1	ASHP	28	£39,346
3.5	Seaport Marina	2=	ASHP	37	£29,518
3.5	Dochgarroch Maint. Depot	2=	ASHP	41	£17,125
4.5	Scotland SC HO	4	WSHP open	7	£90,167
5.0	The Boathouse	5	WSHP open	5	£40,597
5.5	Clachnaharry Sea Lock Office	6	ASHP	50	£29,187
7.0	Crinan Canal HQ	7=	ASHP	7	£24,895
7.0	Gairlochy Customer Facility	7=	ASHP	49	£11,492
8.0	Lowland Office / Workshop	9	ASHP	32	£11,737
9.0	Old Basin House	10	ASHP	6	£15,380

This second set of tables shows the ranking based on payback without RHI and then the ranking taking the combined average of both the CO_2 Emission Reduction and payback without RHI.

Ranking of top 10 buildings (1 = First/Top)			
CO_2 Emission Reduction		System Payback Time NO RHI	
1	Scotland SC HO	1	Dochgarroch Maint. Depot
2	Caledonian Canal Centre	2	Caledonian Canal Centre
3	The Boathouse	3	Seaport Marina
4	Seaport Marina	4	Clachnaharry Sea Lock Office
5	Crinan Canal HQ	5	Gairlochy Customer Facility
6	Dochgarroch Maint. Depot	6	Lowland Office / Workshop
7	Clachnaharry Sea Lock Office	7	Crinan Canal HQ
8	Old Basin House	8	The Boathouse
9	Gairlochy Customer Facility	9	Old Basin House
10	Lowland Office / Workshop	10	Scotland SC HO

Ranking average - CO_2 reduction and payback (NO RHI) - top 10 buildings (1 = First/Top)					
Combined Ranking Average	Building	Ranking	Preferred System	Estimated current heating cost £/m²	Estimated cost of installation
2.0	Caledonian Canal Centre	1	ASHP	28	£39,346
3.5	Seaport Marina	2=	ASHP	37	£29,518
3.5	Dochgarroch Maint. Depot	2=	ASHP	41	£17,125
5.5	Scotland SC HO	4=	WSHP open	7	£90,167
5.5	The Boathouse	4=	WSHP open	5	£40,597
5.5	Clachnaharry Sea Lock Office	4=	ASHP	50	£29,187
6.0	Crinan Canal HQ	7	ASHP	7	£24,895
7.0	Gairlochy Customer Facility	8	ASHP	49	£11,492
8.0	Lowland Office / Workshop	9	ASHP	32	£11,737
8.5	Old Basin House	10	ASHP	6	£15,380

There are, of course, other factors in considering which buildings to take to the next stage. These include future plans for these buildings, potential funding for the installation and the broader strategic plan for the Scottish Canals estate. A number of these factors were raised and discussed in the online meeting.

When comparing the feasibility of water and ground source heat pumps with air source heat pumps for the buildings ranked in the top 3, it was found that air source is a more attractive renewable heating solution for these buildings, all of which are currently heated with direct electricity:

1. Caledonian Canal Centre
2. Seaport Marina
3. Dochgarroch Maintenance Depot

This conclusion is based on the data summarised in the tables for each building in 6.1 Top 10 most suitable buildings for a G/WSHP solution, above, where the comparative data can also be seen. The following criteria were considered:

- System payback
- Cost of installation
- Complexity of installation
- Cost per kg of CO_2 reduced

The next two buildings in the ranking order are both currently heated by mains gas:

4. Scotland SC HO, Applecross Street, Glasgow
5. The Boathouse, Auchinstarry

A water source heat pump was found to be the most appropriate system for these with the payback, within a reasonable timeframe of less than 8 years, based on receiving the Renewable Heat Incentive (RHI).

During the process of meetings and conversations between Turner Services and Scottish Canals staff, strategic and operational factors were discussed. Scottish Canals is now considering relocating their head office and due to this ongoing operational uncertainty felt it inappropriate to progress plans and designs at this stage. In terms of the Boathouse at Auchinstarry, this restaurant and hotel is leased out and has, just recently, changed hands with a new leasee taking up occupancy. Turner Services discovered that there have been issues with the existing gas boiler heating system and that this is a potentially sensitive point of discussion with the new leasee which may well have to be resolved in a matter of weeks, given the winter season, by replacement with an upsized gas boiler in the short term. For these commercial reasons Scottish Canals decided not to proceed with water source heat pump designs for these two locations at the present time.

For the remaining 5 buildings in the top 10, a comparison between water or ground source heat pumps and air source showed that, for each of these, air source was the more attractive option:

6. Clachnaharry Sea Lock Office
7. Crinan Canal HQ
8. Gairlochy Customer Facility

9. Lowland Office / Workshop
10. Old Basin House

The focus of this project is on the feasibility of water and ground source heat pumps (W/GSHPs) as is the funding related to it. This, along with Scottish Canals' decision not to proceed with designs for the two buildings shown appropriate for this particular technology, mean that there remain no suitable buildings to develop designs for.

7. Recommendations

7.1 Energy supplier

In the course of collating data for this report, we have noticed a wide range of different tariff rates being applied across the Scottish Canals estate. While the data available was a snapshot, it would seem that there is a wide discrepancy of rates of between £0.08 and £0.89 / kWh (kilowatt hour). Scottish Canals currently procures its electricity supply from EDF via the Scottish Government framework contract.

Based on the 2018/2019 snapshot we have seen, the Scottish Canals annual electricity running cost was in excess of £389,727 for approximately 2,344,295 kWh consumed, which averages out at £0.166 / kWh. This can be compared to a standard domestic electricity tariff of £0.1988 including standing charges and VAT (rates September 2020 from Nottingham Energy Partnership).

This electricity usage of 2,344,295 kWh represents a carbon footprint of 539 tonnes CO_2.

We recommend the following:

- investigate and sense check the different tariff rates applied across the Scottish Canals estate
- negotiate a lower tariff rate (where possible under current contractual arrangements or look to change supplier)
- investigate green tariffs where electricity comes from renewable sources like wind power.

We also discovered that at many sites it is difficult to determine what electricity is used for heating and energy within the building, what is used operationally and what is used by customers. This is due to metering limitations. We recommend investigating the use of sub-metering, particularly at sites with high electricity usage, to help understand the energy usage better, to make improvements in energy reduction and to be able to track these more specifically.

7.2 Energy efficiency

In our analysis of the Scottish Canals buildings estate we have gained an understanding of the age and condition of the buildings. While outside the remit of this project, as part of our analysis, we have observed that there is the potential for energy savings. We recommend investigating the cost benefit of addressing energy efficiency measures within the larger operational buildings in particular. These didn't make our shortlist for G/WSHPs but are large enough that the cost benefit in terms of energy and running cost savings could be interesting. Clearly, there would also be a carbon saving as well as creating more comfortable living and working environments for Scottish Canals staff and customers. Examples of these include the Steamer Terminal at Ardrishaig and the Corpach Sea Loch buildings.

Irrespective of the type of heating system installed, improving the energy efficiency of a building will reduce energy consumption, running costs and carbon emissions.

It is useful to assess energy efficiency measures in the following order:

Draughts

Draughts contribute to high levels of heat loss and discomfort and can be fairly straightforward and inexpensive to remedy. Heat loss is particularly high during windy weather when the heat within the building can be sucked out. Sealing draughts around windows and doors and fitting draught excluders on doors are some of the simple measures that can have a positive impact in terms of reducing heat loss and increasing indoor comfort levels.

Mechanical

By mechanical here we mean plumbing and external rainwater management. Leaky taps or cylinders inside the building can lead to dampness, mould and potential health issues. If there are leaks on the domestic hot water system this will increase water heating demand and cost as well as carbon emissions. Externally, leaks through the roof, from rainwater goods and downpipes can lead to dampness, damage to building fabric over time and accelerate heat loss. Again, remedies are easily implemented.

Insulation

Adding or improving the insulation in a building can have a significant effect on reducing heat loss and, at the same time, increasing energy efficiency and carbon savings. The comfort level experienced by the users of the building also dramatically improves. Given the age and nature of the Scottish Canals buildings estate, we would recommend contracting a specialist with experience of older and historical buildings for surveying and proposals.

Ventilation

Ventilation is important for the health of the building and its users. Where comprehensive insulation measures can be implemented, this can affect the natural ventilation of the building and may require a review of the most appropriate ventilation options.

Behavioural

Often underestimated or even overlooked in building management, operation and maintenance, the behavioural patterns and awareness of staff and other building users can have a significant effect on energy efficiency. Providing easily understood information, signage and ongoing training can go a long way towards improving energy efficiency. Technology can be helpful in automating control but should be well communicated, understood and embraced by building users.

We recommend continuing the work on collating data relevant to the energy efficiency of the buildings across the Scottish Canals estate. This is the same data represented in the columns of the ‘Questions’ tab in the Scottish Canals Building List Excel Document in Appendix 8. This will provide a more detailed understanding of where improvements in energy efficiency can be made and make it easier to assess where refurbishment needs to be prioritised. Refurbishment that includes significant improvement in insulation and the other measures outlined in this section above, will lower heating running costs and CO_2 emissions and will present more opportunities for significant savings by installing heat pumps.

This should also help Scottish Canals meet its obligations when it comes to the minimum Energy Performance Certificate (EPC) standards required in commercial buildings visited by members of the public and buildings rented out as domestic dwellings.

7.3 Renewable energy solution for Customer Facility Blocks

The nature of the Customer Facility Blocks is that they contain toilet and showering facilities, laundry and drying and sometimes an office, sometimes a plant room or store. They vary in age and fabric condition. The total floor area of the Facility Blocks varies from approximately 60 to 80m².

An air source heat pump (ASHP) option is one that could lend itself well to this building type across the Scottish Canals estate. These buildings are small in floor area but with a constant heating demand. The lower installation cost of an ASHP system improves the payback and significantly reduces the carbon emissions compared to direct electric. The external ASHP unit can by sited on the most discreet elevation of the building with the internal unit, which includes the hot water cylinder, located in the plant room, store or laundry area, depending on the facility block.

Solar PV on the roof is another option which will help to offset CO_2 and reduce energy costs by delivering electricity delivered on-site. This would work well in conjunction with all-electric systems in older Facility Blocks where the poorer building fabric condition means that the heat loss rate is too high for a low-temperature heat pump system. Where there is a south-facing roof elevation, or within 30° to the west or east, panels can be installed on this elevation. An alternative is panels on both west and east roof elevations where the building gable is oriented to the south.

Solar PV also makes sense on the newer or refurbished Facility Blocks where an air source heat pump is a feasible option. We have calculated the benefits of an ASHP on its own and also an ASHP & Solar PV package to make the comparison (see tables in section 6.1.5. CD-029-033 Gairlochy Customer Facility). The heat pump control system can be configured to prioritise charging of the hot water cylinder during the middle of the day when the solar PV array is most likely to be generating electricity. This maximises the use of the on-site electricity generated.

We recommend drawing up a shortlist of:

1. Facility Blocks built within the last 20 years
2. Facility Blocks where refurbishment is planned

The buildings on the shortlist can then be surveyed / assessed to confirm their suitability for both ASHPs and Solar PV. A generic design can then be adapted for site specific layouts and building orientation. An installation plan can then be agreed based on budgets and the Facility Block refurbishment plan. There is the potential to maximise value and take advantage of economies of scale by appointing a single contractor to work with in implementing the plan.

7.4 Potential of other water and land resources for renewable heat

This project has focused on the potential for water and ground source heat pumps for the buildings within the Scottish Canals estate. There are other water and land resources including 19 reservoirs covering an area of 8,094ha and these supply the canals with the 332 million litres of water which flow through the canals each day. There are also large swathes of land.

We recommend a separate project to map areas where there could be a match between community and new housing development heating need with Scottish Canals water and land resources. This could open up the potential for Scottish Canals to receive revenue through either:

- leasing the use of the water or land resource for renewable heating or other renewable energy generation by others or
- developing renewable energy schemes in partnership with others and becoming an Energy Services Company (ESCO) to sell heat or other renewable energy to end customers.

We understand that there is potential for this at Fort Augustus.

Appendix 1

Keith Kemsley
Managing Director

Working in the renewable sector for over 16 years Keith has extensive knowledge of a range of technologies and the funding available to support these. He provides consultation, design and installation support to clients on suitable sustainable solutions that deliver best value and increase the energy efficiency of their properties.

Keith's role

In 2004 Keith founded Ecoliving Ltd which consulted, designed, installed and maintained a range of renewable technologies including biomass boilers; combined heat and power; air and ground source heat pumps; and solar PV within both commercial and domestic properties. In December 2016 after 13 years Ecoliving Ltd was bought by Turner & Co (Glasgow) Ltd and became part of their property management division with Keith taking the helm of this at the end of 2019.

With his background and experience of renewable technologies Keith has extensive knowledge of designing, installing and maintaining these across a range of sectors. Keith develops strong relationships with clients, as well as their consultant partners, assisting and supporting them with energy projects from designing the most sustainable solution to applying for funding to support the project and overseeing the safe delivery of quality installations with high levels of client and user satisfaction.

Keith has extensive knowledge of funding routes available to support renewable technology installations and is experienced at supporting clients to successfully complete these. Keith has also developed strong working relationships with a range of manufacturers and keeps abreast of component technical developments, improved installation techniques and training courses available.

Qualifications and training

- BPEC Certificate - Ground Source Heat Pump Installer
- BPEC Certificate - Solar Domestic Hot Water Systems
- BPEC Certifications - Unvented Hot Water Storage
- City and Guilds Level 3 Diploma - Green Deal Domestic Advice
- Electrical (Foundation) Course
- IOSH - Directing Safely for Small to Medium Enterprises
- Manual Handling Awareness
- Mitsubishi Ecodan Heating Design and Installation
- NIBE Product and Service
- NIBE Service and Maintenance
- Work Safe Home Safe

Skills

- Strategic management
- Project and commercial management
- Team leadership and motivation
- Partnering and collaboration
- People management
- Listening and evaluating
- Developing and maintaining client relationships
- Keeps abreast of new technologies
- Knowledge of funding solutions

TURNER SERVICES

Progressive, Sustainable Technical Services

Gavin Scott
Technical Manager

A qualified, competent heating engineer Gavin has over 30 years' consultation, installation, servicing and maintenance experience. His renewable heating specialist knowledge and expertise is unrivalled. With his design credentials, practical experience and technical skills problems are quickly resolved and suitable solutions devised.

Gavin's role

A qualified plumber and heating engineer with over 30 years' industry experience and the last 15 of these dedicated to the design, installation, commissioning and maintenance of renewable technologies and particularly biomass boilers, air and ground source heat pumps. He has attended numerous training courses and is familiar with all the leading manufacturer systems including Mitsubishi, Daikin, NIBE, Harrgassner. Indeed Gavin is widely regarded as one of the UK's leading technical specialists in these renewable technologies and keeps abreast of new systems that become available, design improvements, installation techniques and best practice throughout our sector.

Involved at all stages of a project lifecycle Gavin works together with manufacturer partners, clients plus where applicable their consultant partners, and internally with colleagues to make sure that the proposed design is the best technical solution making improvements as required to deliver the most robust and sustainable solution. Thereafter he oversees the installation and commissioning make sure that the client is fully satisfied with the workmanship, service and the system installed. Gavin also uses his extensive technical knowledge to troubleshoot, quickly diagnosing faults occurring both related to the design of installed heating systems as well as their ongoing operation thereafter identifying any actions that can be taken to improve this.

Qualifications and training

- City & Guilds Advanced Craft Plumbing
- City and Guilds Level 2 Award in F Gas and ODS Regulations Category 1
- BPEC Domestic Vented and Unvented Water Systems
- BPEC Solar Domestic Hot Water Heating
- BPEC Water Supply Byelaws 2014
- IOSH Managing Safely
- CSCS card
- International Powered Access Federation (IPAF) training
- Water Byelaws
- Manufacturer training courses:
  - Daikan DUKSE18 Altherma (High Temp) Installation
  - Daikan ASHP Services
  - Harrgassner Module 2
  - HETAS Wood Biomass Installer
  - Innasol Module 2, 3, 4 and 5 Biomass;
  - Mitsubishi Ecodan Installation Commissioning and Servicing / Heating Design and Installation
  - Mitsubishi Ecodan Service and Fault Finding
  - NIBE Product and Service
  - Woodpecker Installation Course
- training attended: asbestos CAT A awareness; CoSHH; customer care; emergency first aid; face fit qualitative testing; lone working; manual handling; risk assessment; slips, trips & falls, working at height; Work Safe Home Safe

Agris Baumanis
Technical Designer

Agris is a trained, qualified and experienced renewable technology design professional. He makes sure that all client design parameters are thoroughly assessed with suitable solutions devised optimising energy efficiency relevant to property archetypes in full accordance with each client's specification and technical requirements.

Agris's role

A qualified, skilled technical design professional Agris has over 5 years' experience within the renewable technology sector. A trained and certified Domestic Energy Assessor Agris is experienced at accurately assessing the energy efficiency of properties making recommendations on where improvements can be introduced and thereafter completing an Energy Performance Certificate. He is also experienced at using thermal imaging tools to assess the energy efficiency of properties and highlight areas where heat is being lost thereafter analysing the results to optimise energy usage and provide recommendations on where improvements can be introduced.

Agris attends initial surveys taking accurate measurements and thereafter designing the full system layout detailing the positioning of the components to be installed highlighting potential issues with space with all aspects undertaken in accordance with MCS guidelines, each client's technical requirements plus all current regulations and statutory requirements. For solar PV he completes generation simulations and for heating installations he calculates the energy supply / demand modelling, radiator sizes required for the property archetype, internal/external pipe-work routing, heat loss calculations and thereafter completes detailed design drawings in Autocad. These are available to our installation team with copies also provided to clients for their asset management records.

Qualifications and training

- AP Degree in Energy Technology
- BA in Management
- MSc Sustainable Engineering Renewable Energy Systems
- City and Guilds Level 3 Certificate in Domestic Energy Assessment
- AoFAQ Level 3 Emergency First Aid at Work
- Ecodan Design and Application Part 1
- Asbestos Awareness
- Health and Safety Awareness
- Hargassner Registered Installer Training Module 1
- Member of the International Association for Impact Assessment
- Work Safe Home Safe

Skills

- Assessing technical design requirements
- Using thermal imaging tools
- Proficient in computer aided design applications
- Completing accurate design drawings
- Problem solving
- Time management
- Report writing
- Flexible approach
- Keeping abreast of energy system design best practice
- Creative insight

TURNER SERVICES
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Mark Henderson
Consultant

Mark has 23 years of working in the sustainability field following his passion for promoting solutions that make a difference. He thinks strategically and long-term, diving deep into the detail on projects. He is experienced at managing teams to successfully deliver projects and is always focused on the best outcome for the client.

Mark's role

Mark co-founded Ecoliving Ltd in 2004. One of the first significant players in heat pumps in Scotland, Ecoliving developed competency and experience across a broad range of microgeneration technologies for domestic and commercial applications, including ground, water, outdoor air and exhaust air heat pumps, biomass boilers, solar thermal and solar PV. In December 2016 Ecoliving Ltd was bought by Turner and became part of their property management division. Mark exited the business in 2017 and now lives full-time with his family in Sweden.

With 12 years renewable energy technologies experience, Mark is well versed with property survey, appropriate system design and managing the installation and ongoing maintenance of microgeneration systems. He has been lead consultant on numerous feasibility study projects for clients evaluating the most appropriate renewable energy solutions for their property portfolio. Mark is experienced at calculating, presenting and communicating the renewable business case.

Now working as a consultant, mentor and coach within the sustainability sector, Mark brings all his diverse experience covering marketing and sales, project management, business development, transformational change coaching and renewable technical know-how into projects which adds value to the results experienced by clients.

Qualifications and training

- Mitsubishi Ecodan Heating Design and Installation
- NIBE Product and Service
- NIBE Service and Maintenance
- Dimplex Heat Pump Installation
- Thermia Ground Source Heat Pump Systems
- Temovex Heat Recovery and Ventilation Design
- IBC Solar PV Design and Installation
- Innasol Biomass Boiler System Design
- Hargassner Biomass Boiler System Design
- Transformational Change Certified Coach

Skills

- Strategic management
- Project management
- Strategic and tactical marketing
- Regenerative leadership
- Organisational development
- Transformational change coach
- Mentoring
- Group coaching and facilitation
- Business case analysis and presentation
- Developing and maintaining client relationships
- Presenting and training

TURNER SERVICES

Progressive, Sustainable Technical Services

Peter Emerson
Installation Manager

With a varied career across a number of sectors Peter has developed a proactive and flexible managerial approach. He builds strong working relationships with client officers and colleagues working together with them to safely deliver quality installation services to all parties complete satisfaction.

Peter's role

Peter is a qualified heating professional with extensive technical competencies, project management and renewable energy installation experience. During his career Peter has worked in a variety of sectors bringing increased skills, competence and technical awareness to assessing and managing energy installation programmes in occupied buildings and environments.

Peter is experienced at managing heating installation programmes in occupied properties and overseeing the safe delivery of quality workmanship and services within the agreed technical specification and scheduled programme with high satisfaction levels.

Peter is customer focussed, taking ownership of client and end user queries that arise making sure that these are quickly and amicably resolved to all party's complete satisfaction drawing support from other team members, supply chain and manufacturer partners as required. He also works with management colleagues overseeing the introduction of changes and improvements to operational and customer care procedures to prevent these happening again in the future.

Safety is always a priority; Peter makes sure that all work tasks are professionally and safely undertaken with all team members complying with our **work safe home safe** approach and installation safety methodologies.

Qualifications and training

- CCN1, HTR1, CEN1, CKR1, CPA1 Combustion Analysis
- City and Guilds BS7671 Level 3 Electrical Installations
- City and Guilds 2394/2395 Inspection and Testing of Electrical Installations
- HNC Electronic and Electrical Engineering
- IOSH Managing Safely
- NVQ Level 2 Time Management
- CITB Unvented Stored Hot Water
- BPEC Water Regulations
- Asbestos Awareness
- Work Safe Home Safe

Skills

- Planning and co-ordination of work tasks
- Quality driven
- Health and safety aware
- Assessing and managing risks
- Effective communicator
- Proactive management approach
- Problem resolution
- Customer focused
- Technically aware

TURNER SERVICES

Progressive, Sustainable Technical Services

Caius Fernandes
QHSE Manager

A qualified professional with practical health, safety, quality, environmental systems and management experience. This includes successfully managing internal and external audits by partners to achieve and maintain certifications and improve internal systems. His strong organisational and communication skills assist him in his role.

Caius's role

Caius was the Turner Services Quality Systems Manager and has recently been promoted to QHSE Manager. In this role he is responsible for all aspects of quality, health, safety, environmental management and compliance with our internal standards plus all current statutory legislation. He also makes sure that Turner Group's '**work safe home safe**' commitment is integral to our culture and promoted throughout our operations. He oversees the maintenance of a training and development matrix for all roles and makes sure that everyone has the competence and qualifications for their position and work types regularly undertaken.

Caius, and his professional QHSE team, supports operational management as required assisting with establishing waste management plans, safe working methods, quality methodologies and the accompanying documentation including CoSHH and risk assessments, method statements.

Caius monitors performance, producing data, providing accurate and timely reporting to senior management, clients and external partners. He is continually looking for ways to enhance ongoing performance and works internally with colleagues and externally with partners to continually improve.

Currently Caius is studying distance learning for an NVQ Level 5 Diploma in health and safety.

Qualifications and training

- BSc (Hons) Business Information Technology
- HND Print Management, Administration and Production
- Prince 2 Foundation and Practitioner
- CIW Site Designer Professional
- Cisco Comp TIA A+ and Microsoft Certified IT Professional
- CIW E Commerce Designer
- IOSH Managing Safely
- ISO 9001:2015 and ISO 14001:2015 Transition Internal Auditor
- ISO 9001:2000 and 2008 Internal Quality Management System Auditor
- ISO 14001:2004 Internal Auditor
- OHSAS 18001:2007 Internal Auditor
- NEBOSH Construction Health and Safety
- NEBOSH Environmental Management

Skills

- Developing QHSE strategy
- Business risk analysis
- Management of safe work sites
- Promoting a positive safety culture
- Safety hazard and risk management
- Supporting QHSE legal requirements
- Auditing and maintaining certifications
- Extensive health, safety and welfare knowledge
- Quality focussed
- Environmentally aware
- Organising and prioritising workload

Appendix 2

ofgem e-serve Making a positive difference for energy consumers

Domestic
Renewable Heat
Incentive (RHI)

www.ofgem.gov.uk/drhi

Version 2.0 March 2016

Domestic

Factsheet: The Renewable Heat Incentive Domestic or Non-Domestic?

For those who aren't sure which scheme to apply to

This factsheet is only a snap shot. For the full picture read our Essential Guide for Applicants.

What is it?

The Renewable Heat Incentive (RHI) is a government financial incentive to promote the use of renewable heat.

By switching to heating systems that use renewable energy, we can help the UK reduce its carbon emissions.

Two schemes

There are two Renewable Heat Incentive schemes – **Non-Domestic** and **Domestic**. This factsheet will help if you don't know which to apply to, as you can only join one. Each has its own website and application process, together with different tariffs, joining criteria and scheme rules.

Key for the Domestic RHI

To join the Domestic RHI, the property your renewable heating system is in must be capable of getting a domestic **Energy Performance Certificate (EPC)**. The EPC is the proof we need that your property is assessed as a domestic 'dwelling'. Without one, you won't be able to apply and can't join the scheme.

About the EPC

An EPC gives information about a property's energy use, plus recommendations on how to reduce energy and save money. It's required every time you buy, sell or rent a property. An EPC is a requirement to join the Domestic RHI scheme.

You can check to see if you have an existing EPC at your property:

- **for England and Wales, see the Landmark Register**
- **for Scotland, see the Scottish EPC Register.**

If your property doesn't have an existing EPC, and you're unsure whether you will be able to get a domestic one, you may wish to talk to an EPC assessor directly. If you already have an EPC check it has a heat load at the bottom.

Your EPC must be less than 24 months old at the date of application.

Which is for me?

Which of the two schemes to apply to, is clear cut for most people. If your renewable heating system only heats a single home for which you have a domestic EPC, then you can apply to the Domestic RHI scheme. This can include people that own the homes they live in, social and private landlords for properties where one heating system only serves a single household, tenants, and people that build their own homes, or have them built for them and meet certain other requirements.

The Non-Domestic RHI is generally for those with renewable heating systems in commercial, public or industrial premises. This can include small and large businesses, hospitals, schools and organisations with district heating schemes where one heating system serves multiple homes.

Where it can be more complicated,

If your property set-up doesn't quite fit into the standard descriptions above, or if your renewable system supplies heat to more than one building, it can be more difficult to decide which scheme to apply to, or if you'd be eligible to join either.

Several factors need to be considered, but very generally:

- **properties with a home office within a house that has, or can get a domestic EPC, should be eligible for Domestic RHI.**
- **properties with annexes attached to the house are normally covered by one domestic EPC and should be eligible for Domestic RHI.**
- **properties with a main house and a self-contained outbuilding (with its own bathroom and kitchen), both heated by a renewable heating system would normally have an EPC for each, and would not be eligible for the Domestic RHI. They may be for the Non- Domestic scheme.**
- **properties with a main house and other outbuildings all heated by a renewable heating system may not be eligible for the Domestic RHI. They may be for the Non-Domestic scheme.**

As a starting point, you could check for what buildings your EPC was issued, with your EPC advisor.

You can find out more information about this in our Reference Document.

Guide material

We update our guide material regularly. Check the website for the latest versions, to be sure you're reading the most up-to-date information.

Domestic RHI factsheets

An Introduction to the Domestic Renewable Heat Incentive
The Renewable Heat Incentive – Domestic or Non-Domestic?
A Metering and Monitoring Service Package for the Domestic RHI

Domestic RHI Essential Guides

Essential Guide for Applicants
Essential Guide for Installers
Essential Guide to Metering
Essential Guide to Optional Monitoring - Metering and Monitoring Service Package

Domestic RHI Reference Document

Domestic RHI Reference Document

Find out more

Next steps

See our websites for:
Domestic RHI
Non-Domestic RHI
Non-Domestic RHI Guidance Volume 1: Eligibility and How to Apply

For help

For queries regarding Domestic RHI scheme requirements and eligibility:

Energy Saving Advice Service
(England or Wales) **0300 123 1234**
Calls are charged at the standard national rate.
Email energy-advice@est.org.uk

Home Energy Scotland
(Scotland) **0808 808 2282**
Calls are free from landlines and most mobile networks
Online email form

For consumer protection information

Renewable Energy Consumer Code (RECC)
www.recc.org.uk

The Home Insulation and Energy Systems Contractors Scheme (HIES)
www.hiesscheme.org.uk

If you need help with a Domestic RHI application

Domestic RHI Application Support Centre
Telephone: **0300 003 0744**
Email: DomesticRHI@ofgem.gov.uk

Appendix 3

Summary of financial support schemes for landlords, householders and businesses installing renewables and energy efficiency measures- 21st August 2020

The table below shows national schemes that have been providing grant and/or loan support for various energy efficiency, heating and renewable measures and which can support efforts to progress towards EESSH targets. The table includes funding schemes available to all tenures and ones that are available in various of the social or private tenures. Schemes that serve private sector properties only may still be relevant to programmes aimed at delivering EESSH targets as a result of the:

- Need to deliver measures to "blocking" owners, ensuring that works in neighbouring social housing can proceed
- Impact of installation of measures on estate appearance and regeneration activity
- Potential to achieve economies of scale by including private sector properties in social housing programmes.

Funding schemes that can potentially support measures in all social housing tenures have been highlighted in red and ones only available for Registered Social Landlord (RSL) properties have been highlighted in orange. Some of the funding schemes listed may be closed to new applications, but are listed here to confirm their present status.

National schemes can be subject to change at short notice. There are also local schemes which can appear on an ad hoc basis. The introduction of the Scottish Government's Energy Efficient Scotland scheme in 2018 is leading to changes in the design and emphasis of Scottish Government funding schemes and the Energy Company Obligation, transitioned to a new phase in October 2018 and will be concentrating on supporting fuel poor households.

Home Energy Scotland (HES) can advise social housing providers on the range of funding schemes that can support EESSH related programmes.

Availability and delivery of some schemes may be affected by the response to the current COVID 19 crisis.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Company Obligation	Insulation, district heating connection, renewables, heating installation and repair.	Lower income and vulnerable to cold domestic owner occupiers, private sector tenants and social tenants, depending on eligibility criteria	Grant/subsidy scheme providing (subject to eligibility), insulation and heating measures for: • Private sector households in an Affordable Warmth Group (AWG) of benefit and tax credit recipients (some restrictions on access to heating measures in private rented households) • Social housing tenants in properties with lodged EPC ratings of E, F or G (some restrictions on access to heating measures in social housing compared to private sector households) • Non-fuel poor private sector households (for solid wall insulation and district heating) in properties where 66% of adjacent households are eligible • Private sector households declared eligible by a local authority, where it has published criteria for a "flexible eligibility scheme", on grounds of being: ➢ Fuel poor (FP) ➢ Low income and vulnerable to living in a cold home (LIVC) ➢ Non-fuel poor for solid wall insulation but where there is an adjacent property that is declared either FP or LIVC (50:50 basis). There is also be an innovation stream, which will allow energy suppliers to support some innovative measures, for eligible households, which also includes EPC D rated social housing. https://www.ofgem.gov.uk/publications-and-updates/energy-company-obligation-2018-22-eco3-guidance-delivery-draft-comment	Obligated energy suppliers	Ofgem through Energy suppliers and their partners.	From 1st October 2018 to 31st March 2022.	There can be limitations on using ECO funding alongside UK government funded initiatives or where the energy supplier funding is not deemed by Ofgem to be the cause of the measure being installed. ECO cannot be mixed with RHI except when ground source heat pumps are being installed.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Scottish Energy Efficiency Programmes (SEEP) pilots.	Community heating/energy efficiency /renewables	Domestic and non-domestic sectors with some pathfinder pilots managed by local authorities.	SEEP has been superseded by the Energy Efficient Scotland programme which will provide an offer of support to all buildings in Scotland – domestic and non-domestic – to improve their energy efficiency rating. Pathfinder pilots were implemented before 2018. http://www.gov.scot/Topics/Business-Industry/Energy/Action/lowcarbon/LCITP/SEEP	Scottish Government	Pathfinder pilots managed by Local authorities and third sector organisations.	Pilot schemes launched with first phase projects completing by December 2017 and second phase by February 2019. Closed for new applications.	Programme dependent.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Efficient Scotland transition- self funder programme.	A new programme transitioning from the SEEP programme covering a range of heating, renewable and energy efficiency measures.	Private sector households and non-domestic buildings.	The Energy Efficient Scotland programme builds on existing legislation and programmes that are already supporting the improvement of the energy efficiency of homes, businesses and public buildings, as well as the work the Scottish Government is doing with local authorities to develop Local Heat and Energy Efficiency Strategies (LHEES). In 2018, LAs were invited to apply to operate "self-funder" schemes, which supported development and delivery of a 'hand-holding' service for domestic and domestic property owners that are able to pay for measures. These schemes are likely to be delivered in identified areas, with owners being directed to loan and grant funding support, with the assistance of Home Energy Scotland and partner contractors procured for the schemes. https://www.gov.scot/publications/energy-efficient-scotland-transition-programme-application-forms/	Scottish Government	Local authorities and third sector organisations	Bid process for LAs closed on 20th July 2018, projects should be delivered by December 2019 and all grant must be drawn down by 28 Feb 2020.	Private sector households and non-domestic buildings

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Efficient Scotland transition- Decarbonisation Fund	Funding will be for energy efficiency measures (e.g. internal works, insulation) within projects that include decarbonisation activity (e.g. ground source heat pumps, air source heat pumps, biomass, solar PV and storage etc) and the conversion of properties from e.g. oil to these technologies.	Social Rented Households	The Scottish Government invited social landlords to submit Expressions of Interest to deliver energy efficiency and heat decarbonisation programmes within their existing stock. Social landlords should consider blending the funding to join up their own proposals and investments for energy efficiency with decarbonisation activity. Grant funding cannot be used to install heat technologies that are eligible for the Renewable Heat Incentive (RHI). Scottish Government funding was used to support energy efficiency measures as well as work to support deployment and use of renewable technologies. Proposals for any innovative activity or technologies will also be considered favourably. https://www.gov.scot/publications/decarbonisation-fund-application-form/	Scottish Government	Registered Social Landlords	Bid process for phase 2 closed for applications on 25th August 2019 Proposed activities must be completed and functional by 28 Feb 2021, with all relevant Scottish Government financial support claimed by 31 March 2021. There is no confirmation of a third phase.	Programme dependent

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Efficient Scotland: Area Based Scheme (ABS)	Energy efficiency (Targets solid wall and cavity wall and roof insulation measures but may support other measures and can include low carbon emitting heating and renewables, as special projects, where agreed between the LA and Scottish Government).	Domestic owner occupiers and private renting tenants and private landlords where the landlord owns three properties or less.	Area Based Schemes delivered by local authorities and prioritising fuel poor areas aiming to cover the whole of Scotland in around 10 years. Grants, in 2018/19, of up to £7,000 for flats, £7,500 for mid and end terrace and £8,000 for detached and semi-detached, available to each household (up to £10,000 in eligible remote rural and island areas). Local authorities are able to provide higher level grants for works to those in extreme fuel poverty of £12,000 (up to £14,000 in remote rural areas) Measures are supported through ECO as well, where possible. Landlord contributions may be required, where the landlord or tenants do not meet fuel poverty citeria. http://www.energysavingtrust.org.uk/area-based-schemes	Scottish Government	Scottish Local authorities (often route enquiries through Home Energy Scotland)	Currently open	The restriction in households receiving Warmer Homes Scotland support after receiving ABS support has been removed. There may be some restrictions on mixing UK government funding schemes, such as RHI, alongside ABS. Does not allow access to other parts of the HES loan scheme, such as cashback, for ABS funded measures.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Efficient Scotland: Warmer Homes Scotland	Energy efficiency, heating and Renewable measures (subject to survey). Heating measures not available in private rented properties	Domestic owner occupiers and private renting tenants and private landlords where the landlord owns three properties or less and the tenant or landlord meet fuel poverty criteria.	Installation of energy efficiency measures and heating systems, including in some cases renewables measures, to help alleviate fuel poverty. Also includes energy advice, benefits checks and tariff support to all tenures. http://www.energysavingtrust.org.uk/scotland/Take-action/Home-Energy-Scotland/Home-Energy-Efficiency-Programmes-for-Scotland http://www.energysavingtrust.org.uk/heeps-warmer-homes-scotland-scheme	Scottish Government	Warmworks for measure installs Energy Saving Trust/ Home Energy Scotland for enquiries and referrals	Possible extension to 2022.	There are no longer restrictions to accessing Warmer Homes Scotland funding for households previously having received Energy Efficient Scotland Area Based Funding. Does not operate alongside cashback element of the HES loan scheme.

Home Energy Scotland (HES) loan	Energy efficiency measures, and renewables, (from a specified list), energy storage and connections to a renewably powered district heating scheme.	Owner occupiers	Interest free loan of up to £15,000, for installing a variety of energy efficiency measures, such as solid wall insulation, double glazing or a new boiler for owner occupiers and up to three properties for private sector landlords. The household must have loft and cavity wall insulation installed, where practicable. Funding is available on a first come first served basis and is subject to availability. Successful applications that receive loan funding will include an administrative fee of 1.5% of the total loan value, up to a maximum of £150. If installing energy efficiency improvements, applicants are currently eligible to receive a grant for 25% of the cost of some eligible measures up to a maximum available for each improvement and an overall maximum of £3,750. Loan funding is available for the remaining cost, up to a maximum for each improvement. Interest free loan funding can also be offered for up to **100%** of the quoted installation costs for renewables, energy storage systems and partially/fully renewably powered and approved district heating or to maximum amounts relevant to each measure, whichever is lowest. Two home renewables systems per home up to £17,500 in total can be applied for (two whole-house heating systems cannot be applied for, such as an air source heat pump and a biomass boiler). The repayment period varies based on the amount borrowed but those taking out higher value loans will be able to pay back over a period up to 12 years. http://www.energysavingtrust.org.uk/scotland/grants-loans/home-energy-scotland-loan	Scottish Government	Energy Saving Trust	Available in 2019/20 financial year.	Cashback elements of the scheme would not operate alongside other Scottish Government grant schemes.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
HES: gas infill Loan (through the Home Energy Scotland loan scheme)	Connection to gas mains and installation of gas central heating with a mains connection.	Owner occupiers	Interest free loan funding for individuals of up to £5,000 to cover any gas connection and an additional £5,000 for associated heating installation costs (an admin fee is charged to applicants who complete works and claim their loan). The household must have loft and cavity wall insulation installed, where practicable. To request an application form property owners call Home Energy Scotland. To apply a completed application form must be submitted with a quote for the gas connection costs and the new boiler, to EST. Tel 0808 8082282 http://www.energysavingtrust.org.uk/scotland/grants-loans/home-energy-scotland-loan-overview	Scottish Government	Energy Saving Trust	As for the general Home Energy Scotland loan scheme	As for the general Home Energy Scotland loan scheme.
Energy Efficient Scotland: ABS Loan scheme (through the Home Energy Scotland loan scheme)	Energy efficiency measures delivered through EES:ABS and associated repairs	Qualifying owner occupiers and private landlords where the landlord owns up to three properties and the tenant or landlord meet fuel poverty criteria.	Up to £5,000 interest free loan funding available to meet householder contributions for energy efficiency measures delivered through EES:ABS and up to £5,000 for approved repairs necessary to allow measures to be installed. An admin fee is applied to all paid loans. Repayments are made over a maximum of 10 years. To request an application form property owners call Home Energy Scotland. To apply a completed application form must be submitted to EST. Tel 0808 8082282	Scottish Government	Energy Saving Trust	As for the general Home Energy Scotland loan scheme	Only available in conjunction with EES:ABS support.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
EES: Warmer Homes Scotland Loan scheme (through Home Energy Scotland Loan scheme)	Energy efficiency measures delivered through Warmer Homes Scotland	Qualifying owner occupiers and private landlords where the landlord owns up to three properties and the tenant or landlord meet fuel poverty criteria.	Interest free loans of up to £10,000 for homeowners or landlords whose properties are in receipt of an offer of support from the Warmer Homes Scotland Programme managed by Warmworks and who need further assistance to help pay a contribution towards the work. An admin fee is applied to all paid loans. Repayments are made over a maximum of 5 years, if less than £5,000 and ten years if between £5,000 and £10,000.	Scottish Government	Energy Saving Trust	As for the general Home Energy Scotland loan scheme	Only available in conjunction with Warmer Homes Scotland support.
HEEPS Loan scheme for Registered Social Landlords	Energy efficiency, renewables and associated repairs (from a specified list based on ECO eligible measures excluding district heating).	RSLs	Interest free loans of between £30,000 and £1 million are available to housing associations and housing co-operatives to install energy saving measures with the aim of progressing properties towards the required Energy Efficiency Standard for Social Housing (EESSH) standard. Funding is also available for repairs or enabling work to allow eligible energy saving measures to go ahead. Repayments are made over 10 years. https://www.energysavingtrust.org.uk/scotland/grants-loans/heeps/heeps-loan-scheme-registered-social-landlords	Scottish Government	Energy Saving Trust	Currently closed	None

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Private Rented Sector Landlord Loan	Energy efficiency and renewable measures	Private sector landlords	The amount a landlord can borrow depends on how many domestic properties you have in their portfolio: • Landlords with five properties or fewer in their portfolio can borrow up to £100,000. • Landlords with six or more properties in their portfolio can borrow up to £250,000. The amount depends on the number of supported energy efficiency or renewable improvements they want to make. The loan is repayable over up to eight years. Successful loans are subject to an administrative fee of 1.5% of the total loan value, up to a maximum of £250. The fee will automatically be added to the loan value and included in the amount repayable. Applicants with five or fewer properties in their portfolio will not be subject to interest. Applicants with six or more properties in their portfolio will be subject to interest at a rate of 3.5% APR. https://energysavingtrust.org.uk/scotland/grants-loans/private-rented-sector-landlord-loan-overview	Scottish Government	Energy Saving Trust	Ongoing	None

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Resource Efficient Scotland SME loan scheme	Energy efficiency and renewable measures.	SMEs (no longer includes private sector landlords).	Interest free loan (5% if claiming RHI) funding from £1,000 to £100,000 to install energy efficiency measures and renewable technologies. 15% cashback up to a maximum of £10,000. Accessed through Resource Efficient Scotland on 0808 808 2269 for more information about what is required. http://www.energysavingtrust.org.uk/scotland/businesses-organisations/landlords https://www.resourceefficientscotland.com/SMELoan http://www.energysavingtrust.org.uk/scotland/grants-loans/sme-loan-scheme	Scottish Government	Resource Efficient Scotland and Energy Saving Trust	Currently available	Other Scottish Government loan schemes
Home Energy Efficiency Programmes for Scotland Equity Loan Pilot Scheme	Energy efficiency improvements and repairs to building fabric	Domestic owner occupiers and certain private sector landlords that rent two properties or less.	Up to £40,000 based on equity on the property, repaid at point of sale of the house. Piloted in Perth and Kinross, Stirling, Dundee, Glasgow City, Inverclyde, Renfrewshire, Argyll and Bute and the Western Isles local authority areas. Full terms and conditions are available online: http://www.energysavingtrust.org.uk/scotland/grants-loans/heeps/heeps-equity-loan-scheme	Scottish Government	Energy Saving Trust	Currently open and will last until at least the end of March 2021.	Cannot be offered for the same measures funded by other Scottish Government loan schemes..

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
District heating loan scheme	Capital funding support for heat networks/ district heating generated by renewables fuel.	Local authorities Registered social landlords/HA's Businesses Energy Services Companies (ESCOs) Legally constituted community groups	Unsecured loans of up to £1M+ towards capital measures for district heating projects. Interest rate 3.5%. Repayable over 15 years. http://www.energysavingtrust.org.uk/scotland/grants-loans/district-heating-loan	Scottish Government	Energy Saving Trust	Currently open for expressions of interest.	
Communities and Renewables Energy Scheme (CARES) pre-planning and post consent loans	Renewables	Community groups Charities Social housing providers Local authorities Rural businesses.	CARES Enablement Grant – Up to £25K where the value of the grant will be capped based on innovation or scheme complexity and can be used to fund feasibility for energy systems or renewable energy projects, investigation of shared ownership opportunities or work to maximise the impact from community benefit association with renewable energy projects. Example project for local authorities: https://www.localenergy.scot/resources/solar-pv-on-estate-buildings/ Larger grants and loans for revenue and capital will be announced. Check the website for the most up to date position. http://www.localenergy.scot/funding Example project: PV, Storage, EV https://www.localenergy.scot/resources/local-energy-scotland-guides/	Scottish Government	Local Energy Scotland	Apply for enablement grants anytime. Decision-making funding panels for larger revenue and capital grants and loans. Dates to be announced. For details see: https://www.localenergy.scot/funding	Up to 60% intervention rate.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Domestic Renewable Heat Incentive (RHI) (domestic)	Domestic renewables (heat only)	Domestic owner occupiers Registered social landlords Private sector domestic landlords	Ongoing payments for 7 years for the renewable heat required for 20 years of space and/or water heating in a home. https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi	Department for Business, Energy & Industrial Strategy	Ofgem	Open to new applications until end of March 2022.	Other UK and Scottish Government grant schemes and ECO funding for same measure other than for ground source heat pumps.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Renewable Heat Incentive (RHI) (non- domestic schemes)	Renewables (heat only)	Local Authorities Housing Associations SME's Community Groups	Ongoing payments (over 20 years) for renewable heat (including district heating) generated to supply more than one domestic property. https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi/eligibility-non-domestic-rhi https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi	Department for Business, Energy & Industrial Strategy	Ofgem	Open to new applications until end of March 20**21** (for projects holding a Provisional Tariff Guarantee Notice or Tariff Guarantee Notice that was originally applied for on or after 17 July 2019 and before 29 June 2020., full accreditation application s accepted until March 2022)	Other UK and Scottish Government grant schemes and restrictions on ECO for same measures other than ground source heat pumps.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Feed-in Tariffs (FITs))	Renewables (electricity producing only)	Domestic owner occupiers Communities Local authorities Registered social landlords Private sector domestic landlords Commercial Industrial	FITs Ongoing payments for up to 20 years for renewable electricity generated and exported. Smart Export Guarantee to replace FITs post March 2019 allowing payment for exported electricity http://www.energysavingtrust.org.uk/scotland/domestic/improving-my-home/feed-in-tariffs	Department for Business, Energy & Industrial Strategy scheme, paid via levy on fuel bills	Ofgem and energy suppliers	Closed to new applications after March 2019 and the Smart Export Guarantee will come into force from 1 January 2020.	
Smart Export Guarantee	Renewables (electricity producing only)	Potentially all sectors, although arrangements for social housing being considered	A scheme that allows sale of surplus electricity to energy companies https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/807393/smart-export-guarantee-government-response.pdf	Energy suppliers	Ofgem	TBA	Can't combine with historic FITs arrangements.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Help to Heat	Gas connections	All tenures of domestic housing	Gas connection subsidy for private sector households that meet certain ECO eligibility criteria, including benefit criteria, have above average energy bills which significantly reduce their remaining household income or are declared eligible through a local authority ECO flexible eligibility declaration or for ECO eligible social housing. Available where the connection is carried out by SGN, the default gas transporter in Scotland, and sometimes through independent gas transporters as well. The scheme is accessed through the householder. https://www.sgn.co.uk/helptoheat/	SGN (mandated by Ofgem)	SGN	Currently open, but obligation finishes at the end of March 2021.	None identified

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Low Carbon Infrastructure Transition Programme (LCITP)	Renewables /low carbon/district heating	Private, Public Community based low carbon projects	The programme aims to stimulate investment in reducing Scotland's greenhouse gas emissions and support Scotland's economic recovery following the COVID-19 pandemic. LCITP has supported the successful deployment of over 20 demonstration projects and the development of over 30 early stage projects. A funding round was launched in August 2020, with £20 million available to support projects that can accelerate the deployment of low carbon heat in existing social housing, particularly through the installation and/or use of heat pumps. Applications are invited from registered social landlords, local authorities and ESCOs. The funding invitation covers three themes: Theme 1 – renewable heat for rural off gas grid areas Theme 2 – low carbon heat for rural and social housing Theme 3 – integrated low carbon heat systems for social housing across Scotland The maximum grant funding intervention rate will be between 45% and 50% depending on the size of the organisation and the location of the project. Projects will be required to provide 50% match funding, of which 30% SG loan funding can be applied for and a minimum of 20% must be from their own capital or agreed private financing. https://www.gov.scot/publications/social-housing-net-zero-heat-fund-overview/	Scottish Government	Scottish Government in partnership with Scottish Enterprise, Highlands & Islands Enterprise, Scottish Futures Trust and Zero Waste Scotland.	Applications can be submitted between 1 September 2020 and 18 December 2020. Projects will be required to complete installation and commissioning by 30 November 2021.	Subject to the priorities of the scheme. State aid considerations may apply. Challenge Fund is supported by LCITP already.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Warm Homes Fund (WHF)	Gas and low running cost heating installations	Social housing providers, local authorities and other organisations working in partnership with them, to address some of the issues affecting fuel poor households	The WHF is a £150million fund administered by AWS across England, Wales and Scotland, primarily designed to address some of these issues by incentivising the installation of affordable heating solutions in fuel poor households who do not use mains gas as their primary heating fuel. It is envisaged that this fund will be used to supplement local strategic plans and funds blended with local support. The fund will be split into three broad categories: • Urban homes and communities – we anticipate this will involve new gas heating systems which provide space heating and domestic hot water. It could also include heat network solutions. • Rural homes and communities – some of the most severely fuel poor households are those without a mains gas connection in rural locations. This category will therefore primarily focus on 'non-gas' solutions which may include air source heat pumps, oil and LPG. • Specific energy efficient/health related solutions – this may involve national or regional programmes which bring together relevant organisations and charities to promote energy efficiency and health related programmes in relation to fuel poverty. https://www.affordablewarmthsolutions.org.uk/warm-homes-fund/overview?utm_source=sendinblue&utm_campaign=The_Warm_Homes_Fund&utm_medium=email https://www.affordablewarmthsolutions.org.uk/warm-homes-fund/bid-timetable/	National Grid and Community Interest Company, Affordable Warmth Solution	National Grid and Community Interest Company, Affordable Warmth Solution	Operating up to 2021/22. Bid submission window for round 4: closed on 27th September, awards mid November 2019. A bid window for round 5 lasts from 2nd December 2019 – 24th January 2020, covering private sector properties under categories one and two and category 3 for park homes. All installations to complete by end of 2021. The programme will end after that date.	Dependent on programme.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Industry Voluntary Redress Scheme*	The scheme can support anything from making a home more energy efficient, to providing advice that helps consumers keep on top of their bills. Measures will be dependent on the projects that are approved.	Charitable organisations that support energy customers in England, Scotland and Wales. Local authorities and other organisations working directly with charities in relation to such projects can play a role in projects funded by the scheme, however only their charitable partner will be able to submit an application and be responsible for the funding and project delivery.	Supports initiatives through an application process for projects that cover activities including, making homes more energy efficient and providing advice that helps consumers keep on top of their bills. Projects should be of benefit to people in England, Scotland and Wales. The minimum grant that can be requested is £20,000 and the maximum amount is the lesser of £2 million or the total value of the current fund. The scheme can fund projects lasting up to two years, can fund 100 per cent of the project cost and can cover revenue and capital measures. Applications are made through an online system and closing dates for applications will be determined each quarter. https://energyredress.org.uk/about-us	Payments from energy companies who may have breached rules	Energy Saving Trust on behalf of Ofgem	Ongoing	Charities will not be able to apply for funding through this scheme if they or their delivery partners have close links to energy companies in England, Scotland and Wales regulated by Ofgem (examples include suppliers of electricity or gas, electricity or gas network operators and energy generators). Funding cannot support delivery of ECO or other supplier obligations.

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
Energy Investment Fund	Provides financial assistance for renewables development and low carbon technologies	Companies and community groups working in the area of renewable energy at the test or commercialization stage and trying to assemble a funding package.	Building on the Renewable Energy Investment Fund, provides financial assistance for projects that will: • Deliver energy from low carbon and renewable sources, reduce the cost of renewable energy or provide key solutions for renewable energy generation • Provide benefit to the economy of Scotland • Have a demonstrable funding gap for EIF to consider • Increase community ownership of energy projects in Scotland (including community stakes in commercial developments) https://www.scottish-enterprise.com/support-for-businesses/funding-and-grants/accessing-finance-and-attracting-investment/energy-investment-fund	Scottish Government and its enterprise agencies	Scottish Investment Bank (applications supported by Local Energy Scotland)	Previous bidding round deadline for the Energy Investment Fund, was in March 2020.	Dependent on programme

Scheme name	Measures supported	Sectors supported	Description	Funder	Managed by:	End date/ status	Match funding restrictions
SPRUCE- Scottish Partnership for Regeneration in Urban Centres.	Renewable energy projects and energy efficiency schemes	13 LA's, determined eligible for loans and equity investments until end of 2015. Other Local areas may be eligible during the recycling period 2016-2022. Can support social housing schemes.	The programme is split between revenue generating property & infrastructure investments and energy efficiency investments. On the 2nd of these, social housing providers were invited to develop renewable energy projects and energy efficiency schemes as part of the retrofit of their existing housing stock.	Financed through the JESSICA initiative, ERDF (EU) funds and the Scottish Government	AMBER – as the fund manager (with the European Investment Bank acting as Holding Fund Manager)	Initial loan funding was to be utilised / drawn down by the end of 2015. Loan funding is however being recycled by 2022, with stage 7 application process for Regeneration Capital Grant Fund (RCGF) opening in April 2019 and closed for applications on the 10th June 2019.	Dependent on programme.
Warm Homes Discount – industry initiatives	Gas boiler repair and replacement, potential for other support delivered through specific schemes. Energy efficient appliances.	Mostly owner occupiers.	Some energy suppliers offer a Warm Home Discount indirectly by providing customers with the services of a third party to help reduce the cost of their energy. Indirect Warm Home Discounts are also known as Industry Initiatives. Schemes include boiler and electric appliance replacement https://www.ofgem.gov.uk/system/files/docs/2018/08/warm_home_discount_whd_guidance_for_suppliers_-_version_6.1.pdf chap 7	Energy suppliers	Ofgem	31st March 2021.	Project dependent, can't mix with ECO for measures.

Note: In addition to the schemes above, Public Works Loan Board (PWLB) can provide loan funding for LA's to carry out capital infrastructure projects.

Other support

Local Authorities can also use their discretionary powers to assist home owners in mixed tenure blocks, which might extend to measures that deliver against EESSH targets.

Name of programme	Delivered by	Type of funding/assistance	Timing	Eligibility	Amount of funding
Scheme of assistance	Local Authorities	Local authorities have discretionary powers to provide assistance for home owners for work to their properties, including financial assistance. Availability will vary by local authority, but where home owners are unable to carry out repair or improvement works, for example as part of work on mixed tenure blocks, they may be eligible for some financial assistance, this will depend on local priorities,	Annual	Set by the local authority under their Statement of Assistance.	Local Authorities receive a notional allocation within their general capital grant and revenue funding streams, though this is not ring fenced so it is up to each individual local authority to determine how much funding is available

Name of programme	Delivered by	Type of funding/assistance	Timing	Eligibility	Amount of funding
Home Energy Scotland	Energy Saving Trust	Energy efficiency, renewables and transport advice and support	On-going	Potentially any organisation looking for advice and support, including private and social landlords.	None – Home Energy Scotland is funded by the Scottish Government.

Name of programme	Delivered by	Type of funding/assistance	Timing	Eligibility	Amount of funding
Climate Challenge Fund (CCF)	Keep Scotland Beautiful on behalf of the Scottish Government	Support to communities to take local action on the impacts of climate change. A maximum funding limit of £150,000 per organisation per year is in place. CCF can support community projects which increase energy efficiency in homes and community-owned buildings, sustainable transport, waste reduction and recycling and local healthy and seasonal food growing where projects meet the overall eligibility criteria. https://www.keepscotlandbeautiful.org/sustainability-climate-change/climate-challenge-fund/	2008- 2016	To be eligible to apply for any funding from the CCF, organisations need to be: 1. Scottish based 2. Led by the community 3. Operating on a not for profit basis, or a trading company wholly owned by a not for profit organisation (profit making organisations are eligible to apply to the CCF on the condition that they are wholly owned by a Scottish based not for profit organisation) 4. Legally constituted (organisations will need to be legally constituted by the time they submit their Final Application) Community-led organisations from that have applied include: Community-led housing associations as well as community groups.	The final deadline for CCF Development Grants of up to £1,000 was 17 August 2018. These grants are designed to help develop an application for a climate action project. The deadline has passed to submit an Expression of Interest for CCF grants of up to £150,000 per year for projects taking place between 1 April 2019 and 31 March 2021.

Name of programme	Delivered by	Type of funding/assistance	Timing	Eligibility	Amount of funding
SP Energy Networks Green Economy Fund	**SP Energy Networks**	SP Energy Networks have committed to voluntarily contribute up to £20m over a two year period up to 2020, to support initiatives that will benefit the people of Scotland and support Scotland's ambitious green energy plans and local economic growth. The fund will focus on helping our communities invest in low-carbon heating and transport technology, building the infrastructure and the learnings needed for the changes in heating and transport expected over the next decade. The fund will support the Scottish Government's ambitious energy strategy and the UK's drive to a low carbon economy. https://www.spenergynetworks.co.uk/pages/green_economy_fund.aspx	Funding rounds to be announced, with closing dates for two earlier bid rounds having past	To apply you must be a Scottish organisation or a UK organisation with a Scottish footprint i.e. staff based in Scotland. A wide range of organisations are eligible to apply including charities, community groups, housing associations, local authorities, schools, academic institutions and businesses. Where an application comes from a business, particularly large companies, there must be high levels of social and/or economic outcomes. The scheme is not open for individuals to apply for funding.	The minimum grant award is £10,000 and whilst there is no stated maximum threshold the funder is looking to support a range of small, medium and large projects.

Name of programme	Delivered by	Type of funding/assistance	Timing	Eligibility	Amount of funding
Electrification of Heat Demonstration Project	**Changeworks/ Warmworks**	Warmworks and Changeworks are working together, funded by the Department for Business, Energy & Industrial Strategy (BEIS), to install 250 heat pumps in homes across **South East Scotland.** The project aims to make homes warmer and more energy efficient over the longer term, as well as reducing householders' reliance on fossil fuels and traditional sources of heat. It is also intended to provide the UK Government with a greater understanding of the motivators behind householders installing heat pumps, the barriers they face in doing so and how a large-scale rollout of heat pumps might work in the future. https://www.changeworks.org.uk/projects/electrification-of-heat-demonstration-project	Open currently	Homeowners can take part in the project by completing an online form, calling, or emailing Changeworks on des ignated project communication channels. If a household has been identified by Changeworks as being potentially suitable for this project their information will be securely passed to Warmworks who will arrange for a technical survey and for the installation of the most suitable heat pump technology	Installed free for those accepted onto the programme, with 12 months follow on support.

Also

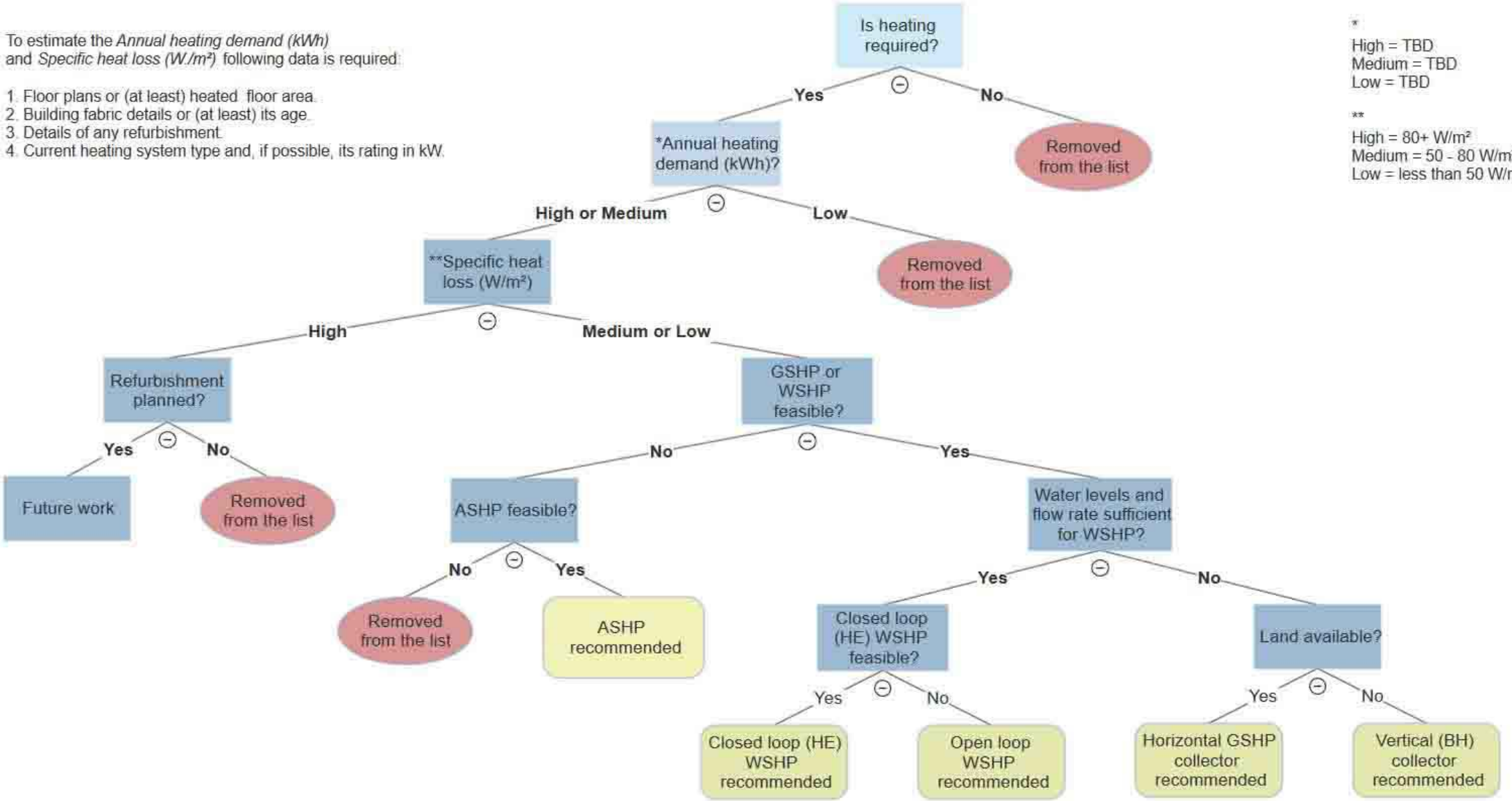
www.Fundingscotland.com - for 3rd sector, run by SCVO in inverness
and
Turn2Us - for individuals https://grants-search.turn2us.org.uk/

Appendix 4

Decision process of the heat pump technology`s feasibility for Scottish Canals

To estimate the *Annual heating demand (kWh)* and *Specific heat loss (W./m²)* following data is required:

1. Floor plans or (at least) heated floor area.
2. Building fabric details or (at least) its age.
3. Details of any refurbishment.
4. Current heating system type and, if possible, its rating in kW.



*
High = TBD
Medium = TBD
Low = TBD

**
High = 80+ W/m²
Medium = 50 - 80 W/m²
Low = less than 50 W/m²

Appendix 5

Appendix 6

Initial ITT list (excluding amalgamated entries)		**v1**	**SC**	**278**
"Boat", "Control Cabin", "Ground", "Lighthouse", "Play park", "Pump out" deselected under ***Sub Type***	No heating demand, low priority or not suitable for HP	v2	TS	225
"Pub-deleric", "Roofless ruin" deselected under ***Sub Type GeoAtlantic***	No heating demand, low priority or not suitable for HP	v2	TS	223
"None" deselected under ***Current heating system type***	No heating demand	v2	TS	171
"None" deselected under ***Current heat distribution system***	No heating demand	v2	TS	168
"no electricity no heating requirement" deselected under ***Ask who/additional building notes***	No heating demand	v3	TS	167
"Leased" properties deselected under ***Leased?***	SC does not pay the bills for these properties, therefore, these are at the bottom of the priority list	v3	TS	121
All but CD-001-013 "Mess" deselected under ***Sub Type***	No heating demand	v3	TS	108
"Yes" properties deselected under ***Leased?***	SC does not pay the bills for these properties, therefore, these are at the bottom of the priority list	v4	TS	92
"low", "low - not a building" deselected under ***SC priority 24-9-20***		v4	TS	67
Starting list approved by SC	**Approved on by Olivia on 30/09/2020**	**v4**	**SC**	**67**
FW-001-024, FW-001-039, FW-001-042 and FW-001-058 (Group 11) amalgamated in one entry - **NDP building Group 11**	All of these are within same building, under the same roof	v5	TS	64
FW-001-022, FW-001-023 and FW-001-057 (Group 8) amalgamated in one entry - **Falkirk Wheel building Group 8**	All of these are within same building, under the same roof	v5	TS	62
CD-002-004 and CD-002-027 (Group 6) amalgamated in one entry - **Seaport Marina building Group 6**	Both are within the same building	v5	TS	61
CD-001-013 and CD-001-026 (Group 3) amalgamated in one entry - **Clachnaharry building Group 3**	Both are within the same building	v5	TS	60
CD-015-078, CD-015-078-01 and CD-015-078-01 (Group 1) amalgamated in one entry - **Caledonian building Group 1**	All of these are within the same building	v5	TS	58
FC-056-029 and FC-056-032 (Group 7) amalgamated in one entry - **Custom House building Group 7**	Both are within the same building	v5	TS	57
"(Blanks)" deselected under In GeoAtlantic area	Outside the scope of the project	v5	TS	38
"1" deselected under ***Review priority***	Due to the size or type of the building , even the smallest ASHP is not economically viable	v5	TS	21
"OK to remove" deselected under ***SC responses***	Not suitable	v6	SC	20
CR-001-110 "Egg Shed" (row #134) removed	New build (2019) with a working ASHP (air source heat pump) system	v6	TS	18
Removed Kytra Customer Facility CD-019-012 #63	Not suitable	v6	TS	17
Removed Water Park Facility Building FG-005-029 #230	Not suitable	v6	TS	16
Removed Dochgarroch Customer Facility CD-010-006 #38	Not suitable	v6	TS	15
Removed Auchinstarry Customer Facility FC-021-021 #177	Not suitable	v6	TS	14
Added back Auchinstarry Customer Facility FC-021-021 #177		v8	TS	15
Added back Old Basin House FG-004-064 #227		v8	TS	16
Removed Auchinstarry Office / Garage FC-021-020 #176		v9	TS	15

Appendix 7

	Current technology	Recommended technology	Unit	Capacity (kW)	Flow T (C°)	SCOP	Heat loss (kW)	Coverage	Floor area (m²)	Specific heat (W/m²)	Annual heating demand (kWh)	Annual fuel demand (kWh)	Estimated cost of install	CO_2 emission reduction (kg/y)	Running cost reduction (£/y)	RHI income (£/year)	Payback time (years)	Payback time with RHI (years)	Cost per kg of CO_2 reduced (£/kg)
Lowland Office / Workshop / Yard	Direct electric	ASHP	Ecodan PUZ-WM60VAA	6	50	3.8	5.08	118%	69	74	14950	3934	£11,737	2534	£1,652.34	£417.10	7.1	5.7	£0.31
Seaport Marina building Group 6	Direct electric	ASHP	2 x Ecodan PUZ-HWM140VHA	28	55	3.26	24.94	112%	268	93	66744	20474	£29,518	10642	£6,940.58	£1,862.16	4.3	3.4	£0.18
		WSHP	Fighter 1345 - 24	28	55	3.55		112%				18801	£38,559	11027	£7,191.45	£4,427.08	5.4	3.3	£0.23
Dochgarroch Maintenance Depot/Workshop	Direct electric	WSHP	Fighter S1155 - 16 3x400V	16	55	3.82	17.64	91%	190	93	52567	13761	£34,488	8925	£5,820.93	£2,946.72	5.9	3.9	£0.26
		GSHP BH closed	Fighter S1155 - 16 3x400V	16	55	3.82		91%				13761	£45,626	8925	£5,820.93	£2,946.72	7.8	5.2	£0.34
		ASHP	Ecodan PUZ-HWM140VHA	14	55	3.26		79%				16125	£17,125	8382	£5,466.35	£1,466.63	3.1	2.5	£0.14
Caledonian building Group 1	Direct electric	GSHP BH closed	Fighter 1345 - 30	35	50	3.58	33.45	105%	558	60	104612	29221	£84,668	17340	£11,308.65	£6,146.02	7.5	4.9	£0.33
		ASHP	3 x Ecodan PUZ-HWM140VHA	42	50	3.52		126%				29719	£39,346	17225	£11,233.94	£2,918.68	3.5	2.8	£0.15
Gairlochy Customer Facility	Direct electric	ASHP	Ecodan PUZ-WM50VHA	5	45	3.9	4.75	105%	49	97	16048	4115	£11,492	2745	£1,789.94	£447.73	6.4	5.1	£0.28
		ASHP	Ecodan PUZ-WM50VHA + 4 kW PV	5	45	3.9		105%				1609	£17,005	3321	£2,199.14	£447.73	7.7	6.4	£0.34
		WSHP	Fighter S1155 - 6	6	45	4.34		126%				3698	£28,613	2841	£1,852.51	£999.10	15.4	10.0	£0.67
Crinan Canal Office HQ	Oil	ASHP	2 x Ecodan PUZ-WM85VAA	17	55	4.11	15.34	111%	260	59	39991	9730	£24,895	9524	£803.50	£1,115.76	31.0	13.0	£0.17
		WSHP	Fighter S1155 - 16 3x400V	16	55	4.37		104%				9151	£37,465	9657	£890.34	£2,583.28	42.1	10.8	£0.26
		GSHP BH closed	Fighter S1155 - 16 3x400V	16	55	4.37		104%				9151	£55,690	9657	£890.34	£2,583.28	62.5	16.0	£0.38
		GSHP BH open	Fighter S1155 - 16 3x400V	16	55	4.37		104%				9151	£36,790	9657	£890.34	£2,583.28	41.3	10.6	£0.25
The Boathouse	Mains Gas	WSHP	Fighter 1345 - 30	35	45	3.75	39.13	89%	910	43	116650	31107	£40,597	16176	£738.79	£6,493.91	55.0	5.6	£0.17
		GSHP BH closed	Fighter 1345 - 30	35	45	3.75		89%				31107	£68,272	16176	£738.79	£6,493.91	92.4	9.4	£0.28
		GSHP BH open	Fighter 1345 - 30	35	45	3.75		89%				31107	£42,285	16176	£738.79	£6,493.91	57.2	5.8	£0.17
		ASHP	3 x Ecodan PUZ-HWM140VHA	42	45	3.77		107%				30942	£32,400	16213	£763.54	£3,254.54	42.4	8.1	£0.13
Clachnaharry building Group 3	Direct electric	WSHP	Fighter 1345 - 24	28	55	3.55	18.80	149%	150	125	50664	14271	£38,228	8370	£5,458.83	£3,962.36	7.0	4.1	£0.30
		ASHP	2 x Ecodan PUZ-HWM140VHA	28	55	3.26		149%				15541	£29,187	8078	£5,268.39	£1,413.51	5.5	4.4	£0.24
Scotland SC Head Office	Mains Gas	WSHP	2 x Fighter 1345 - 40	92	50	3.72	67.11	137%	985	68	165055	44370	£90,167	22806	£992.10	£12,978.37	90.9	6.5	£0.26
		ASHP	2 x CAHV P500YA-HPB	84.8	50	3.2		126%				51580	£98,368	21148	-£89.40	£4,605.02	-	21.8	£0.31
Old Basin House	Mains Gas	ASHP	Ecodan PUZ-WM112VAA	11.2	45	3.99	9.10	123%	169	54	25156	6305	£15,380	3581	£219.85	£701.85	70.0	16.7	£0.29
		GSHP BH closed	Fighter S1155 - 12	12	45	4.43		132%				5679	£37,856	3725	£313.78	£1,797.66	120.6	17.9	£0.68

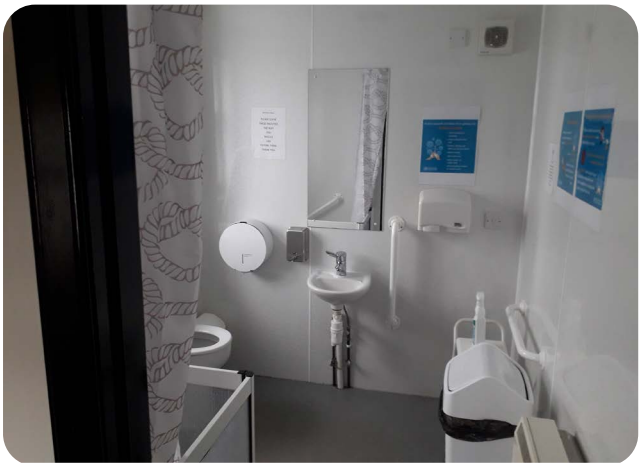
Capacity (kW)	Rated system size (in kW) at design conditions of the recommended
Flow T (C°)	Design flow temperature of the heating medium
SCOP	Seasonal Coefficient of Performance
Heat loss (kW)	Estimated total heat loss of the property (in kW) at design indoor and design outdoor temperatures
Coverage	Coverage (in %) - rated system size divided by total heat loss
Floor area (m²)	Heated floor area of the property (in m²)
Specific heat (W/m²)	Specific heat loss of the property in (W/m²). Total heat loss (W) divided by heated area (m²)
Annual heating demand (kWh)	Estimated annual heating demand for space heat and hot water requirements
Annual fuel demand (kWh)	Estimated annual fuel (electricity) demand used by the system
Estimated cost of install	Estimated cost of install (in £)
CO_2 emission reduction (kg/y)	Estimated annual CO_2 emission reduction if recommended system is installed
Running cost reduction (£/y)	Estimated annual running cost reduction if recommended system is installed
RHI income (£/year)	Estimated annual RHI income based on the estimated demand and recommended system
Payback time (years)	Estimated payback time of the system (in years). CAPEX divided by annual savings achieved with new system
Payback time with RHI (years)	Estimated payback time of the system (in years). CAPEX divided by annual savings achieved with new system plus estimated annual RHI income
Cost per kg of CO_2 reduced (£/kg)	CO_2 emission reduction cost efficiency metric. CAPEX divided by estimated total CO_2 emission reduction over 15 years

Appendix 8

Appendix 9

Internal photographs of the top 10 buildings, where available

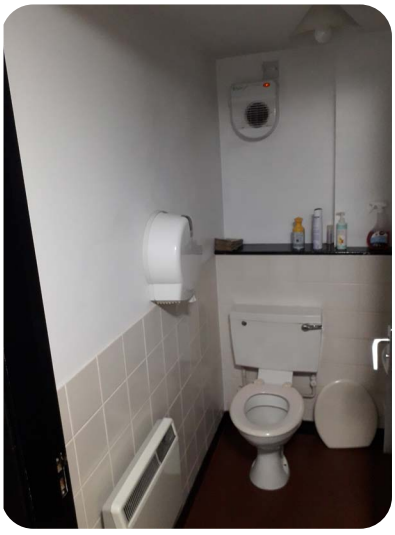
Clachnaharry Sea Lock



Storage heater in customer toilet facility

Bressay Cottage - external oil boiler (15 years' old)

Seaport Marina



Storage heater in office toilet

Direct electric panel heater in meeting room

The Boathouse, Auchenstarry

Installed gas boiler

Decommissioned water source heat pump

Turner Services engineer, Gavin Scott in the plant room

Internal photographs of the top 10 buildings, where available (continued)

Scotland SC Head Office

Existing gas boiler

Hot water cylinder

Mixed radiator types

Mixed radiator types - – would need to be reviewed and upgraded for a heat pump system

Lowland Office / Workshop / Yard

Electric heater

Electric heater in toilet

Appendix 10

Energy
Energy for a Sustainable Future

MCS CERTIFIED

Project Details

Date:	11/11/2020	**Wind Pressure (kPa):**	-1907
Client:	Scottish Canals	**Project number:**	
Address:	Gairlochy Customer Facility, Spean Bridge	**Building EPC:**	C
Post Code:	PH34 4EQ	**New Build / Retro:**	Retrofit

System Details

Panel: Canadian Solar	**CS3L-365MS**	Capacity of PV system (kWp):	4.015
Number of Panels:	**11**	Panel Peak Output (W):	365
Orientation - ° from South:	**10**	Panel dimensions (DxWxL):	35x1004x1698
Inclination °:	**45**	Panel Weight (kg):	18.7
Shade Factor (SF):	**1**	Panel Performance Warranty:	25 years
No. shaded Cells:	**0**	Panel Manufacturing Warranty:	10 years
Number of Strings:	**1**	Irradiation Zone & W/m²:	17 & 832

System Performance Data — 10/02/2021 12:02

Occupancy Archetype: Home all day

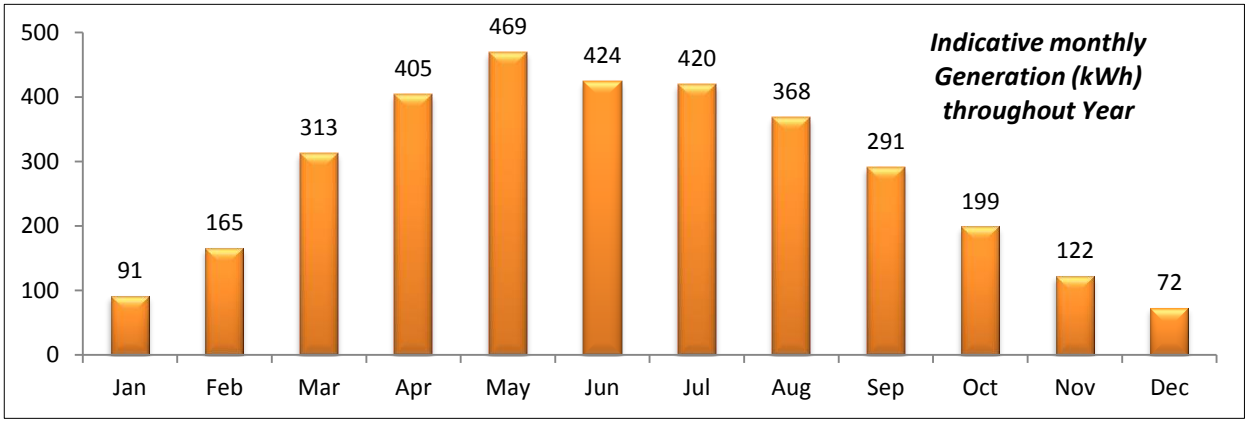
Annual electricity consumption: 3000 to 3499 kWh

No Battery installed

Annual CO_2 savings 779 kg

	1. SEG payment per kWh (£)	0.04
	2. Current cost per kWh (£)	0.15
	3. Estimated Export to the grid	25%
A.	**Total Estimated Generation (kWh)**	
	Solar Radiation (W/m²) x System Capacity (kWp) x Shading Factor (SF)	**3,340**
B.	**SEG income**	
	Total generation (A) x SEG tariff (1) x Export % (3)	**£33.40**
C.	**Value of Electricity used on Site**	
	Generation x Current cost per kWh (2) x Not exported %	**£375.80**

TOTAL POTENTIAL BENEFIT FROM SYSTEM (B + C)	**£409.21**
SYSTEM COST (supply and installation Inc. VAT where applicable)	**£4,725.00**
ANTICIPATED SYSTEM PAYBACK (years)	**11**



"The performance of solar PV systems is impossible to predict due to the variability in solar radiation (sunlight) from location to location and from year to year. This estimate is based on the standard MCS procedure is given as guidance only. It should not be considered as a guarantee of performance." Where the shade factor (SF*) is less than 1 please note that "The shade assessment has been undertaken using the standard MCS procedure - it is estimated that this method will yield results within 10% of the actual annual energy yield for most systems" Where we have used data which we have estimated or taken remotely: This system performance calculation has been undertaken using estimated values for array orientation, inclination or shading. Actual performance may be significantly lower or higher if the characteristics of the installed system vary from the estimated values.

Appendix 11