ENERGY confidence with PHIL BEARDMORE

CONGREGATION OF THE PASSION OF JESUS CHRIST - GOING ZERO CARBON BY 2025

FINAL REPORT APRIL 2020

Summary and key recommendations

Greenhouse gas emissions from all your buildings are high due to:

- the age and condition of buildings
- reliance on fossil fuels
- lack of control over heating and lighting systems.

:

In some buildings, actions have been taken to reduce emissions, but there is still much to be done to approach zero carbon.

Your biggest sources of known greenhouse gas emissions are

- space and water heating
- followed by, electrical appliances.

On a positive note:

✓ Greenhouse gas emissions from water are negligible.

✔ Emissions from waste and transport are already falling due to actions being implemented locally.

There is currently a piecemeal approach to reducing emissions in your buildings.

Decisions that affect the greenhouse gas emissions of your buildings are taken at a local level with no reference to an overall Province policy. Many of these actions are very successful in reducing your emissions, especially from waste and transport.

However, a more **strategic and collaborative approach** is needed for greater impact, particularly to reduce your emissions from electricity and heating fuels.

The actions recommended in this report should form the basis for a **Province-wide strategy**.

The Province will need to appoint somebody internally or externally to be responsible for the implementation of the transition to zero carbon.

The first step in reducing your emissions is to **reduce demand for energy and water** in your buildings. This includes both energy supplied by fossil fuels, and by lower carbon fuels, such as biomass.

The key steps you need to take in reducing demand for fuels are:

- ✔ **Improving the fabric of the buildings by making them more thermally efficient.**
- ✔ **Using more modern and efficient heating and lighting controls to reduce demand.**

There is a case for **greater collaboration between sites**.

For, example:

- ✔ **Buildings at Herne Bay collaborating on a district heating system.**
- ✔ **Inter-trading of renewable energy generated by your sites.**

Energy efficiency should always come first; renewable energy generation without energy saving is not sustainable.

This being said, some of your sites have been blessed with an abundance of **potential sources of renewable energy**, particularly St Non's and Minsteracres.

Some of your buildings have the potential to become individually zero carbon, and some don't.

It will be necessary to **offset or remove your remaining greenhouse gas emissions**:

- ✔ preferably by generating more renewable energy than you need and exporting it;
- ✔ or by ethical offsetting schemes.

In this reporecommend the actions that will make most difference in getting the Province towards zero carbon by 2025. There are also suggestions for how you might go about them, including where external help is available.

The focus is on prioritising and implementing change in the right order to maximise the impact of your actions.

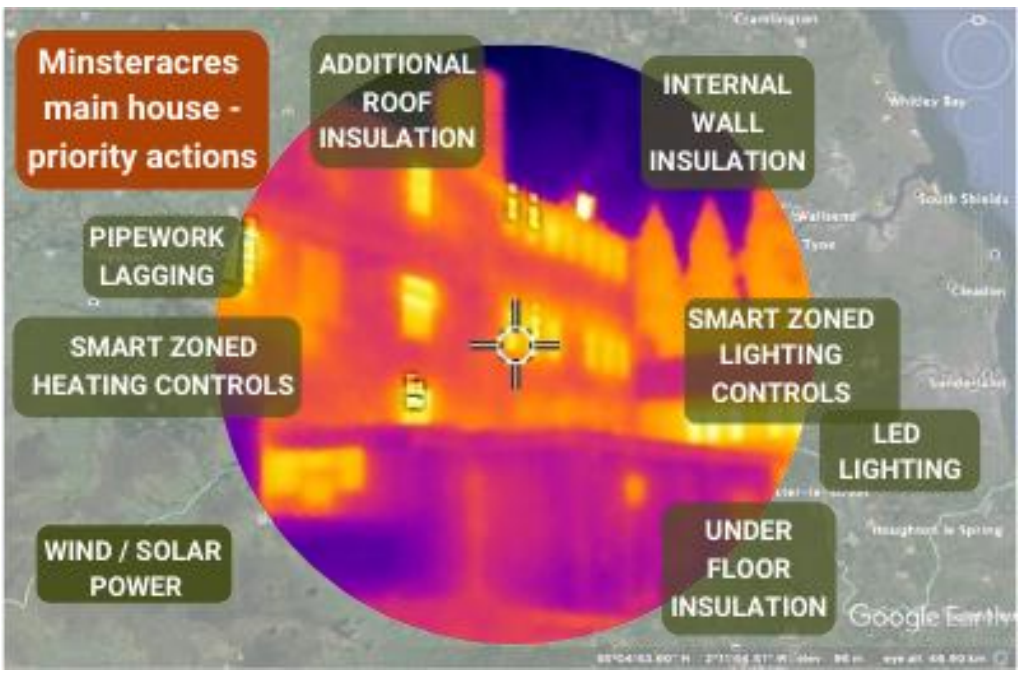
Some of the actions recommended in this report will cost you very little, or nothing, in financial outlay; some of the actions will be expensive. In many cases, actions will have a short-term return on investment; in other cases, actions will have a longer-term return on investment.

A mixture of both short and long-term investments will be needed to achieve the moral investment that the Province wishes to make to achieve zero carbon. This report makes ambitious recommendations that match the Province's ambitious aim to achieve zero carbon.

Priority actions for each site

The following graphics summarise the priority actions for your sites with greatest greenhouse gas emissions. These sites are ranked by emissions, with the greatest first. Each graphic includes a thermal image of the building, showing heat loss, taken from the more comprehensive thermography report at the end of this main report.

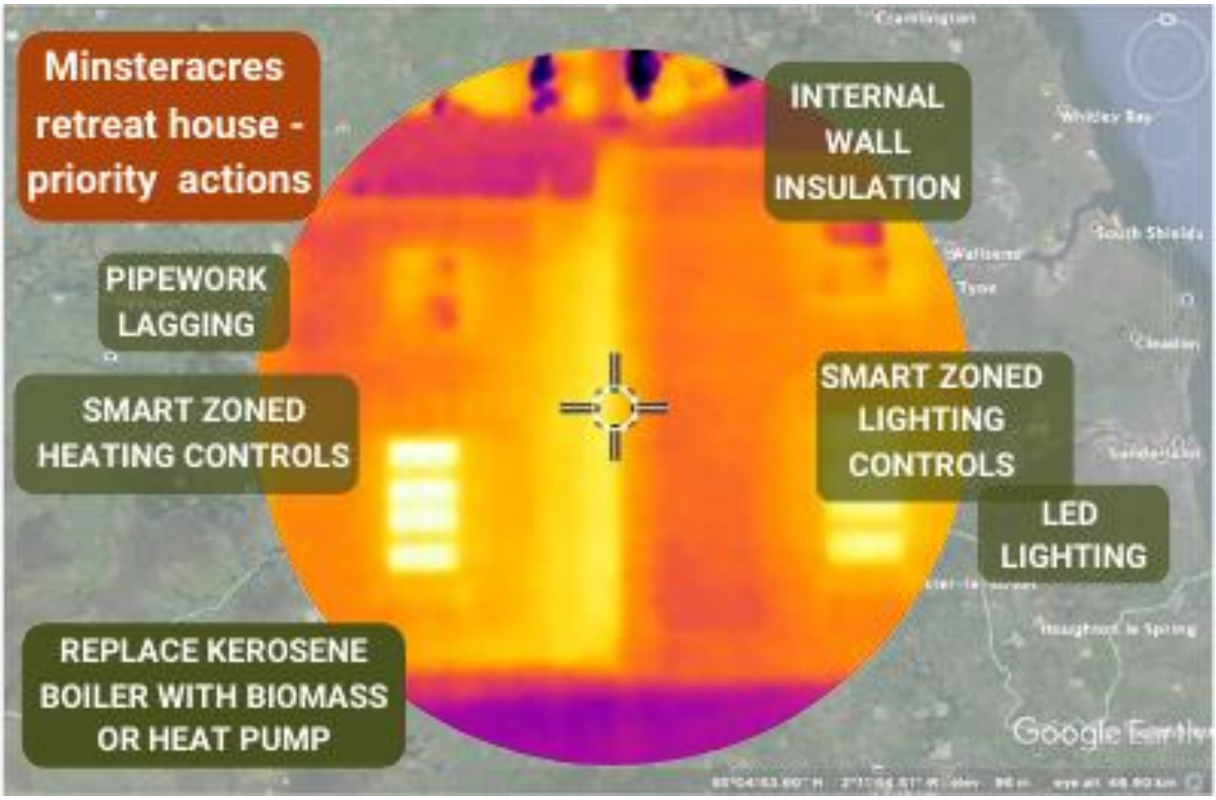
Figure 1



Minsteracres Main House

Electricity is your biggest source of greenhouse gas emissions here; followed by woodchip and LPG. Heat loss through the building fabric is very high. There is a lack of heating and lighting controls. The priority actions are developing wind and/or solar power; smart zoned lighting controls; continuing to implement LED lighting; smart zoned heating controls; pipework lagging and insulating the building where permissible.

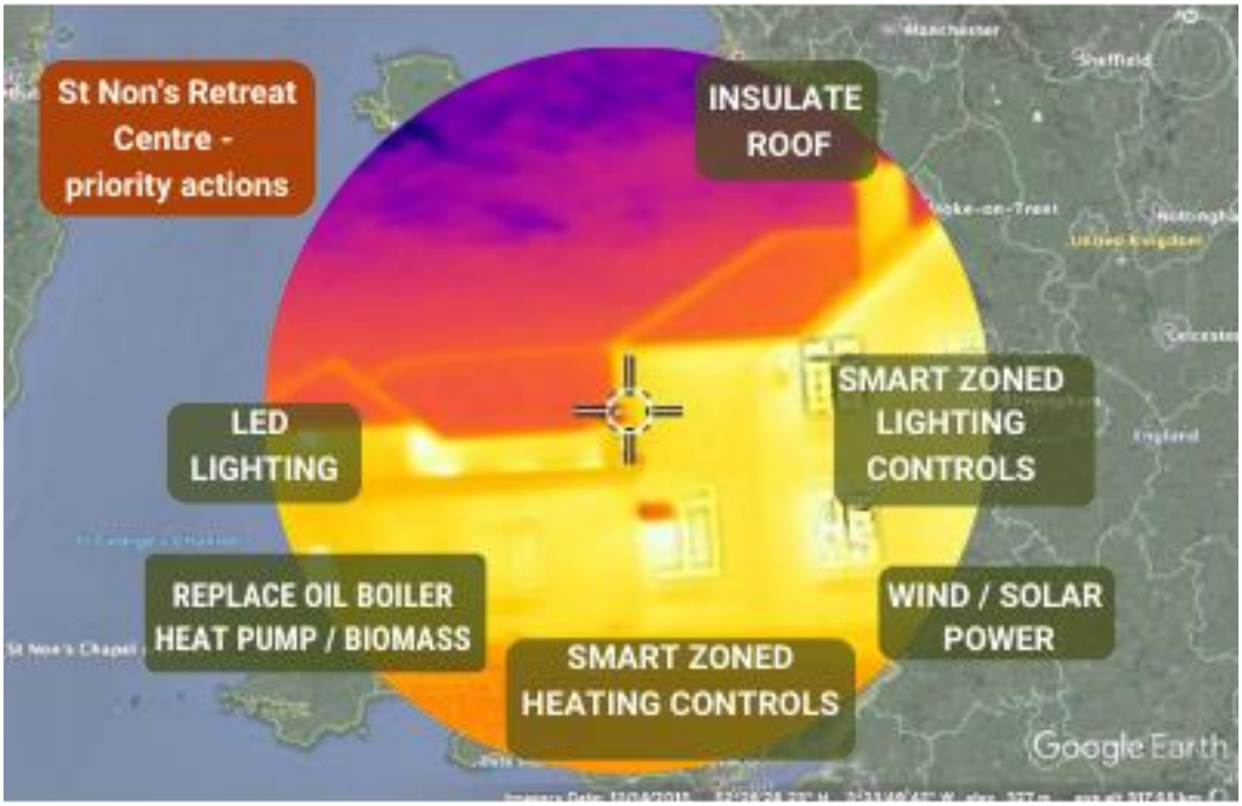
Figure 2



Minsteracres Retreat House

Kerosene heating oil is your biggest source of greenhouse gas emissions here, followed by electricity. Heat loss from the fabric of the building is very high. The kerosene boiler is inefficient and has high emissions. There is a lack of heating and lighting controls. Priority actions here are replacing the kerosene oil boiler with a biomass boiler, or a ground source heat pump; insulating the building where possible; smart zoned heating controls; smart zoned lighting controls; and continuing to implement LED lighting.

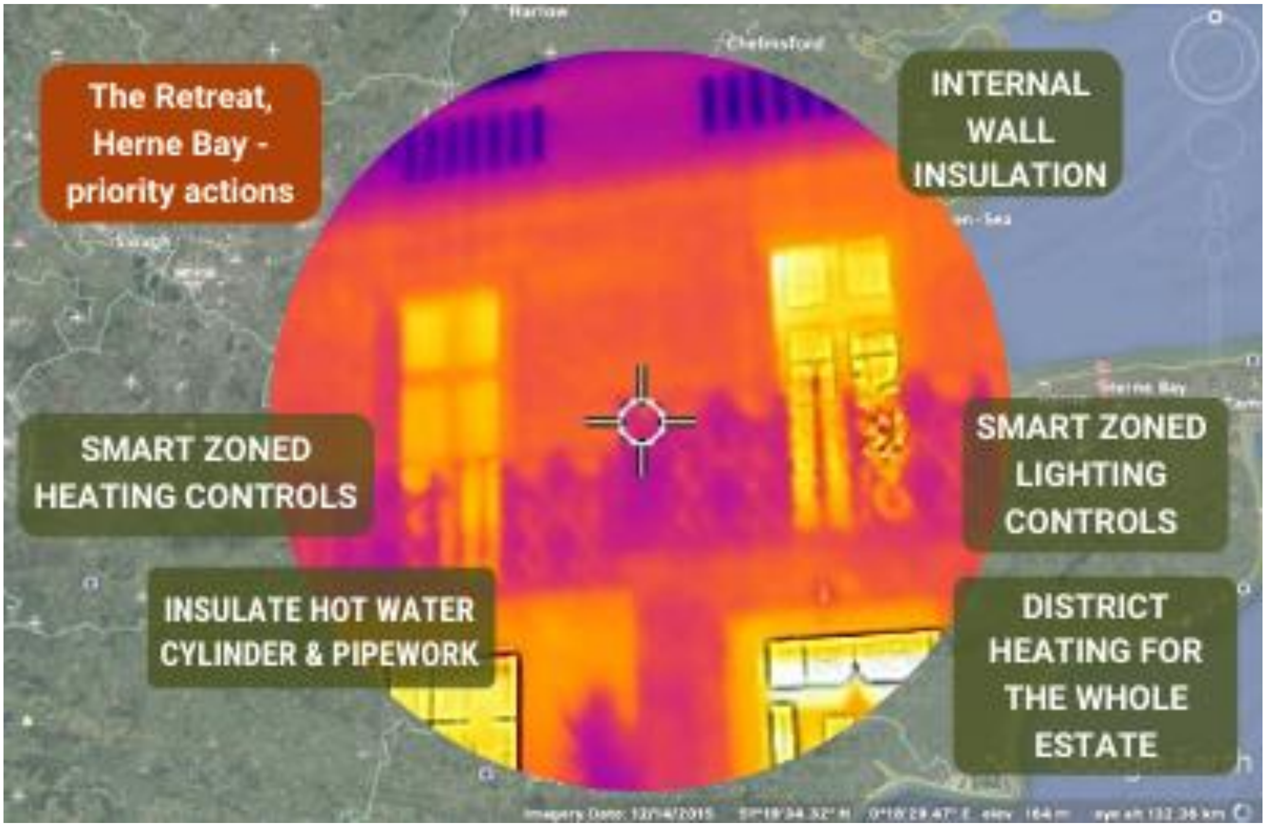
Figure 3



St Non's Retreat House

St Non's has the highest greenhouse gas emissions per square metre of all of your sites. Kerosene heating oil is the biggest source of emissions, followed by electricity. Heat loss from the fabric of the building is very high. The oil boiler is efficient but has very high greenhouse gas emissions. There is a lack of heating and lighting controls. Priority actions are: insulate the walls; additional roof insulation; replace the kerosene oil boiler with a ground source heat pump or biomass boiler; smart, zoned heating controls; LED lighting and smart, zoned lighting controls; generation of renewable electricity from wind and/or solar energy.

Figure 4



The Retreat, Herne Bay

Mains gas is the biggest source of greenhouse gas emissions here, followed by electricity. Heat loss from the fabric of the building is very high. The heating system is efficient although there is substantial heat loss. There is a lack of heating and lighting controls. Priority actions are internal wall insulation; heating and lighting controls; insulation of hot water cylinder and pipework; and the option of district heating for the whole estate.

Contents

1.0 Introduction

The Congregation of the Passion of Jesus Christ is a Religious Order of men in the Catholic Church with a mission to “keep alive the memory of the Passion of Jesus Christ”. The heart of the Passion of Jesus is God’s passionate love for all people and all creation.

It is because of this mission that you, **St Joseph’s Province, in the UK, wish to make all your operations zero carbon by 2025.**

I was engaged by the Province in November 2019, to advise you on how to move towards zero carbon across your various UK sites and buildings. This includes some buildings owned by the Province but occupied by other organisations.

My brief in November 2019 was to recommend those actions that are needed to achieve zero carbon by 2025 and that is what this report will outline.

If you identify funds to enable recommendations to go ahead, then my original proposal in September 2019 included provision for further work by me to help you with procurement.

2.0 Methodology

The aim of this report is to advise the Province on how to make the transition towards Zero Carbon in the following operations:

- Buildings (including the use of energy, water, and other resources)
- Transport
- Waste
- Procurement
- Land use
- Lifestyle.

Methodology:

- Developing a baseline of carbon emissions for all activities, including the use of energy and water in buildings; transport; procurement; land use. Where data is not available, proxy indicators will be used.

- Site visits to the buildings listed in Table 2 below.

- Thermal imaging surveys of all your buildings.

- Action planning for moving towards zero carbon. This includes suggested alternative actions to reduce carbon emissions ethically elsewhere, if carbon neutrality cannot be achieved by 2025 in your own operations.

- An environmental management strategy that the Province can implement and monitor.
-

Table 1 - schedule of buildings

9 Riverdale Gardens	LS21 1SX
Minsteracres – main house	DH8 9RU
Minsteracres – retreat house	DH8 9RU
Minsteracres – walled garden eco community	DH8 9RU
Minsteracres – youth centre *	DH8 9RU
St Non's Retreat Centre	SA62 6BN
The Retreat, Herne Bay	CT6 8SP
Other buildings at Herne Bay – Our Lady of the Sacred Heart, Hall, Bar, Cottage *	CT6 8SP
Jacaranda	CT6 8PH
Martha House	N16 9RT
Austin Smith House	B11 4NX
Belgrave Road	L17 7AG
Province Office, Coventry	CV1 5NP

*Buildings marked with an asterisk * were not included in the original schedule, however I paid brief visits to them while in the locality.*

2.1 My approach

In aiming to reduce your carbon emissions from operations such as building use and transport, the starting principles are as follows:

1. *Quantifying which current actions have the most negative environmental impacts.*

2. *Quantifying which future actions to reduce carbon emissions will have the most positive environmental impacts.*

3. *Understanding the return on investment of our future actions.*

In this report, I have used indicators in Table 3 (below) to measure the Province's environmental impact:

Table 2

Aspect	**Unit of measurement**
Energy use in buildings	kWh per m^2
Carbon dioxide emissions from buildings	Kg CO^2 per m^2
Water use in buildings	Litres per person per day
Transport	Mileage per fuel
Overall CO^2 emissions	Tonnes of CO^2

References to CO^2 include CO^2 equivalent greenhouse gases such as nitrous oxide, methane.

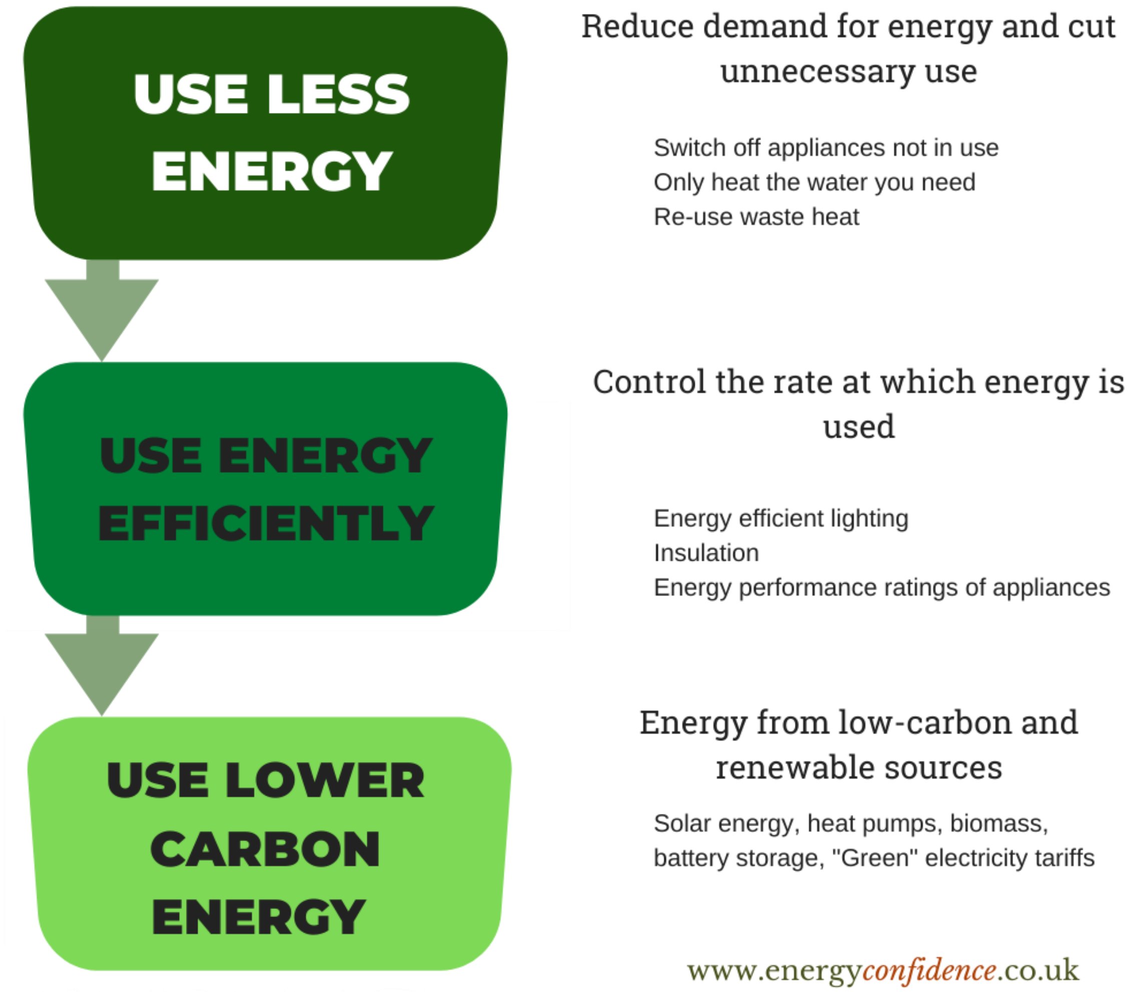
I will now go through a series of hierarchies that explain how we will prioritise actions to reduce greenhouse gas emissions from energy, water, transport and waste. In the action plans for each building that follow later in this report, the statements in the hierarchies will be repeated as goals (e.g. use less energy; use energy more efficiently; use lower carbon energy). The recommended actions in each action plan will related to these hierarchy goals.

2.1.i The energy saving hierarchy

The energy saving hierarchy tells us the order of priority in which we should do things in order to save energy in the most sustainable way (starting at the top of the hierarchy).

The most sustainable energy of all, is the energy that we don't use. Therefore, energy efficiency comes first, before renewable energy, in the hierarchy. Energy efficiency is the most renewable form of energy, because it continually renews itself.

Figure 5



The fabric of a building is a key factor in the energy performance of a building. The fabric includes walls, roofs, floors, windows, doors.

Heating, cooling and ventilation systems are other key factors, as well as lighting.

The energy saving hierarchy also applies to situations other than buildings where energy is used, such as transport (see 2.1.iii below).

2.1.ii The water saving hierarchy

The water hierarchy tells us the order in which we should do things to save water most sustainably, (starting at the top of hierarchy).

Figure 6

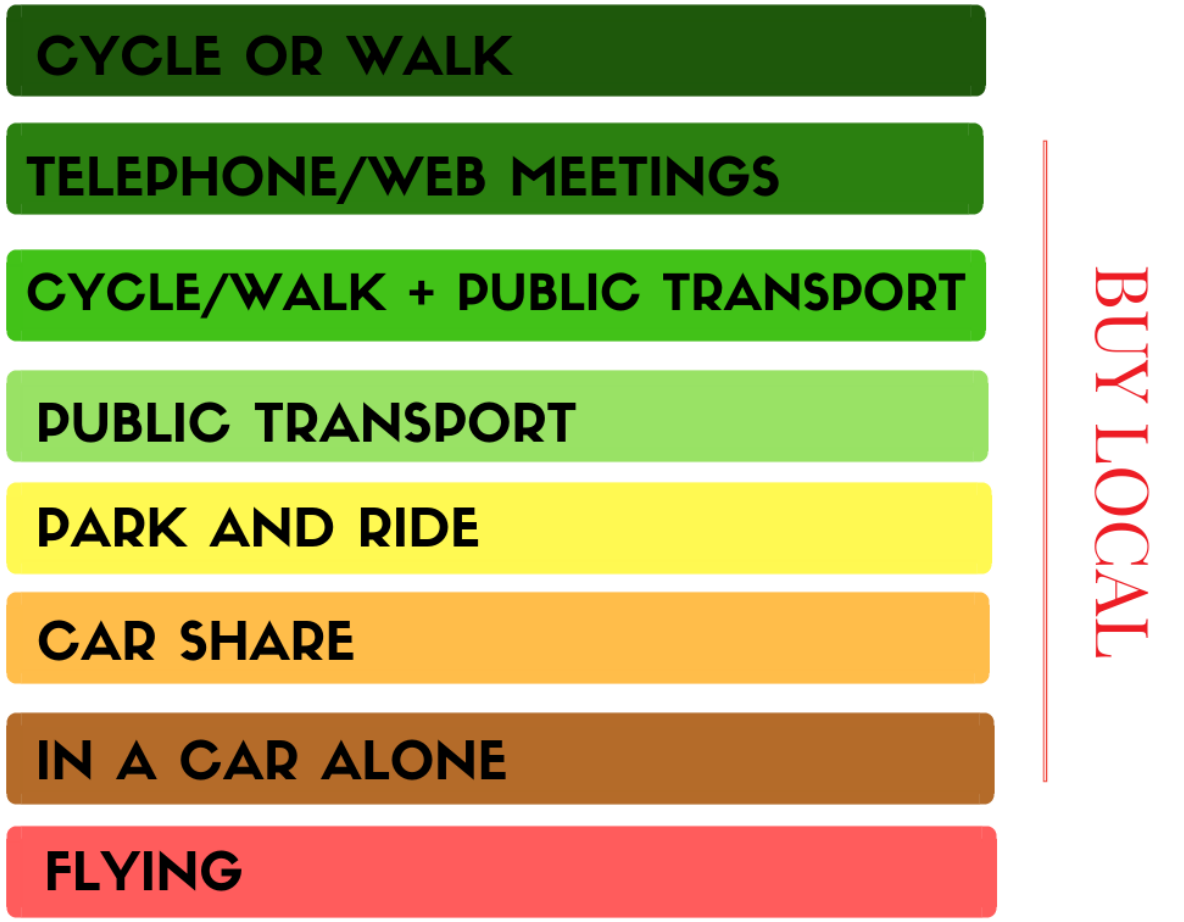
Your greenhouse gas emissions from water use are negligible as a proportion of your overall emissions. Nevertheless, water is a precious natural resource that should be conserved.

This is particularly the case where your buildings are located in areas of the country where water is scarce, such as Herne Bay and Tottenham.

2.1.iii The transport hierarchy

The transport hierarchy tells us the order in which we should do things to reduce our environmental impact (starting at the top of the hierarchy).

Figure 6



We need to consider the transport hierarchy before the energy hierarchy in planning travel operations. This means that we need to reduce the need to travel (in accordance with the transport hierarchy), before we consider the fuel that we use to power motorised vehicles (e.g. petrol versus electric vehicles).

It is a mistake to begin planning a transport strategy by thinking about the energy source of the mode of transport (e.g. electrically powered vehicles versus petrol vehicles) because this gets us away from reducing the need to travel, which is the most sustainable way to reduce carbon dioxide emissions from travel.

2.1.iv The waste hierarchy

The waste hierarchy tells us the order in which we should do things to reduce our waste in the most sustainable way (starting at the top of the hierarchy).

Figure 7

REPAIR	Maintain and repair things to prolong their lives
REDUCE	Design things with lower materials input Build things to last Reduce packaging Don't buy things that aren't needed
RE-USE	Put things to another use without processing Upcycle Junk modelling
RECYCLE	Composting Anaerobic digestion Process waste into new materials or products
LANDFILL	Landfill Incineration without electricity and heat recovery

2.1.v How heat is lost from buildings

Heat attempts to escape from a building through physical processes such as:

- Conduction, where heat is transferred through a solid structure:
    - Building elements such as walls, roofs, glazing, floors, joists and rafters are all examples of this.
    - Junctions between building elements, such as wall/floor, wall/roof, window and door reveals, or steel wall tiles are examples of thermal bridges. A thermal bridge is where differences in the thermal conductivity of building materials enable heat to be transferred out of the building.
    - Conduction of heat through the molecules in a solid building material can take place in any direction; heat can be transferred downwards as well as upwards; through the floor as well as the roof.
    - Interior corners of buildings make a larger surface area of solid molecules available through which warm air can make its escape.

- Convection, where heat is transferred upwards through a gas, namely the air inside a building:

- This drives warm air upwards towards the roof, where it will seek to escape. Whether the warm air succeeds in escaping through the roof, depends on the conductive thermal properties of the roof as outlined in the paragraph above.

In practical terms, this means that in most building types, the greatest heat loss occurs through the walls, and the second greatest heat loss occurs through the roof.

Heat loss through glazing is typically less. Because although the rate of heat loss per square metre through glazing is higher than in walls or roofs, the area of wall is typically greater than the area of glazing. This means that the total amount of heat lost through walls is higher than the total amount of heat lost through glazing.

Figure 8 below shows how heat is typically lost from a dwelling.

Figure 8

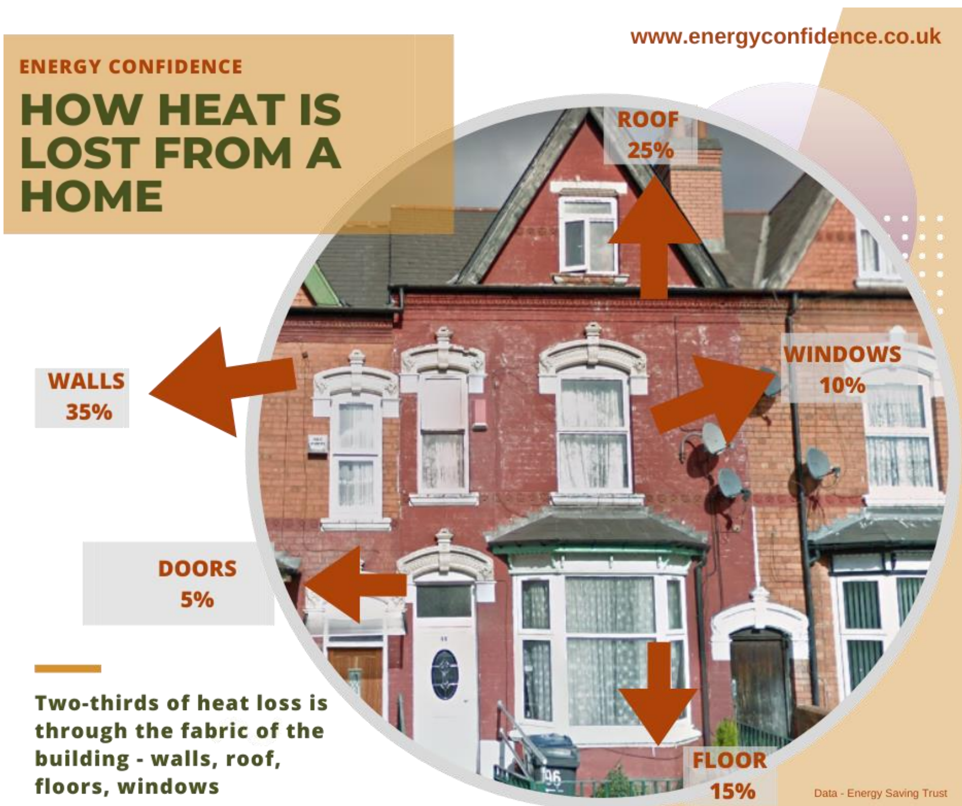
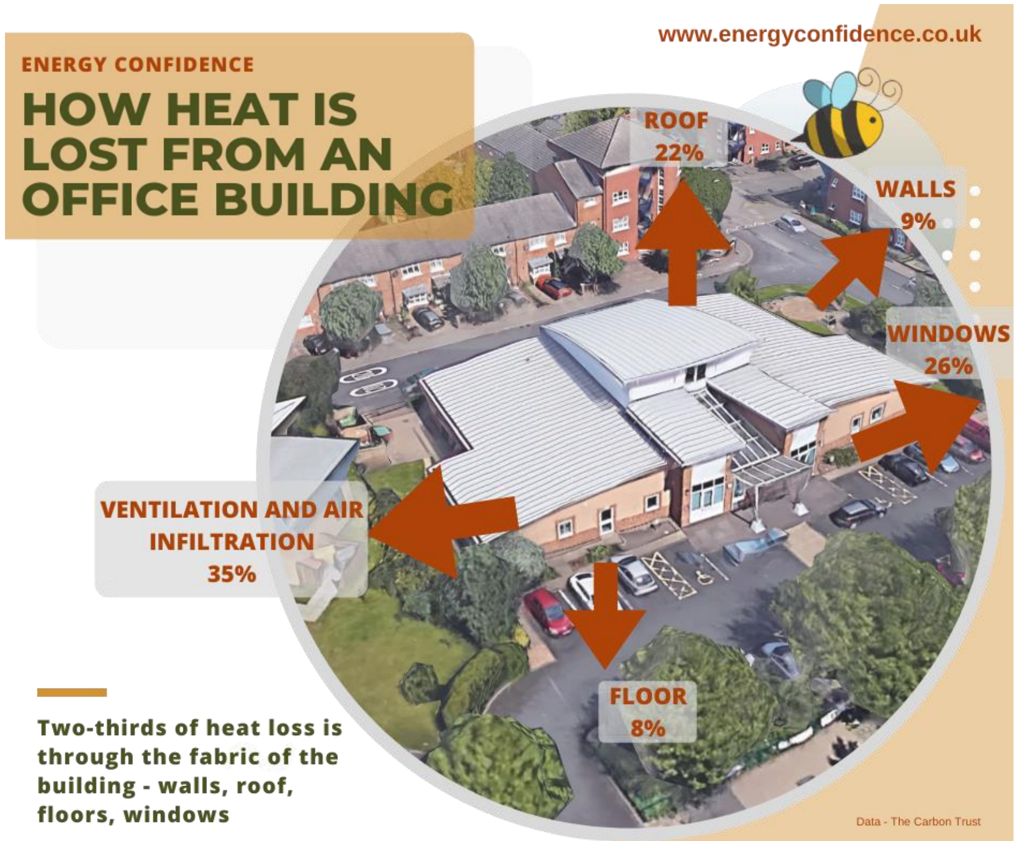


Figure 9 below shows how heat is typically lost from an office building.

An office building will typically have more surface area of windows and less surface area of wall compared to a dwelling; and more air infiltration due to people going in and out of the building more frequently. Therefore, the heat loss profile is different in an office to a dwelling.

Figure 9



Some buildings of particular construction types are partial exceptions to these rules.

Buildings that have unusually high surface areas of glazing will be exceptions.

Parts of Minsteracres, such as the East Wing, have a greater surface area of glazing compared to walls. In such instances the heat loss through glazing will be higher than in figure 5 above.

Single-storey buildings have a higher ratio of roof to wall. In these instances, heat loss through the roof will be greater than through the walls. Examples of this are Jacaranda and the Walled Garden buildings, at Minsteracres.

2.1.vi Ventilation and air quality

There is always some moisture in the air in a home. Some of your homes have issues with condensation and damp.

The key steps to avoiding condensation and damp in a home:

1. Produce less moisture.
2. Ventilate to remove moisture.
3. Heat the home adequately.
4. Insulate the home to keep heat in.

Sources of Moisture in a home that produce substantial volumes of water vapour:

- People - a person sleeping for 8 hours in a bedroom produces 8 litres of water vapour in the atmosphere. If the bedroom is inadequately heated or ventilated, then the water vapour will condense on cold spots, such as internal corners, junctions of wall and ceiling, and windows.
- Drying clothes indoors
- Cooking
- Showering/bathing

Potential sources of ventilation:

- Natural ventilation such as windows, trickle vents, and air bricks.
- Mechanical ventilation such as extractor fans.

The way we live in homes can interfere with ventilation, such as putting furniture against outside walls without a gap or putting too many clothes in a wardrobe. Most UK homes lack adequate ventilation.

It is important to remember the difference between draughts and ventilation:

- Draughts are unplanned and uncontrolled movement of air from one place to another.
- Ventilation is designed and controlled movement of air from one place to another, enabling air changes. The flow and temperature of air change is planned and controlled.

Ventilation is essential for reducing condensation and enabling gas and biomass appliances to burn safely.

A home that is inadequately heated or insulated is prone to problems with water vapour condensing into water due to low air temperatures. Maintaining a stable temperature is preferable to short bursts of heat.

Air quality

Adding insulation is one of the top recommendations for improving the energy efficiency of a building. When adding insulation to a building, a side-effect can be to reduce the number of air changes per hour. This can lead to issues with air quality. When adding insulation to a building it is often necessary to add ventilation as well.

2.2 Net zero greenhouse gas emissions – what does it mean for the Province?

Greenhouse gas emissions include not only carbon dioxide, but other greenhouse gases such as methane and nitrous oxide. Where we refer to carbon dioxide in this report, we mean carbon dioxide equivalents, and all greenhouse gases.

The Congregation of the Passion of Jesus Christ has set a goal of…

Net Zero greenhouse gas emissions by 2025.

The Carbon Disclosure Project describes Net Zero for a company[1] as…

'achieving a state in which the activities within the value chain of a company result in no net impact on the climate from greenhouse gas emissions. This is achieved by reducing...greenhouse gas emissions, in line with 1.5°C pathways[2], and by balancing the impact of any remaining greenhouse gas emissions with an appropriate amount of carbon removals.' [3]

I propose that the Province use the above description of Net Zero as its goal.

2.2.i. Reaching Net Zero for the Province means the following:

- 🌎 Your current greenhouse gas emissions are 199,609 kg
- 🌎 20% of your predicted savings on greenhouse gas emissions will be achieved through **energy efficiency**, by implementing the recommendations of this report
- 🌎 20% of your predicted savings on greenhouse gas emissions will be achieved through displacing kerosene heating oil with **renewable heat** in the form of biomass at Minsteracres Retreat House
- 🌎 60% of your predicted savings on greenhouse gas emissions will be achieved through generation of **renewable electricity** at Minsteracres and St Non's.

Energy efficiency is the most cost-effective and least risky way of reducing greenhouse gas emissions, and therefore the most sustainable. Renewable heat and renewable electricity are riskier. Relying on renewable heat and electricity generation to achieve 80% of the emissions savings to achieve Net Zero is not an ideal situation. Furthermore, limiting this last figure to 80% is entirely dependent on successfully implementing energy efficiency measures to achieve 20% of your predicted savings. The importance of implementing the energy efficiency measures in achieving Net Zero sustainably, cannot be under-estimated.

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[1] Company includes a charitable institution such as the Province.
[2] As outlined in the IPCC special report on Global Warming of 1.5 degrees https://www.ipcc.ch/sr15/
[3] https://sciencebasedtargets.org/wp-content/uploads/2019/10/Towards-a-science-based-approach-to-climate-neutrality-in-the-corporate-sector-Draft-for-comments.pdf

The Province should aim to achieve Net Zero in 2025. This allows you time to implement the actions proposed in this report in a timely manner. However, it also shows the necessary level of urgency in responding to the climate emergency. It gives you a realistic possibility of limiting climate change as proposed by the IPCC special report on limiting global warming to 1.5 degrees.

2.3 The importance of data

Data is very important in understanding your baseline greenhouse gas emissions.

The datasets that are most useful for the purposes of this report are:

- Meter readings of electricity, water, gas meters
- Quantities supplied of non-mains fuels e.g. kerosene, LPG and woodchip
- Mileage of vehicles and other transport methods
- Thermal imaging
- Maps
- Energy Performance Certificates

Ideally, data for the supply of fuels and water should contain accurate and regular meter readings, or quantities of fuel supplied, going back for at least 12 months.

Where these datasets are not available, the following methods have been used:

- proxy datasets
- estimates based on extrapolating meter readings using seasonal adjustments
- estimates based on average figures for the property size and type

Manual estimates of this type are more reliable than the automated estimates that energy providers sometimes use in the absence of meter readings.

Benchmarking can be a useful factor in understanding greenhouse gas emissions and environmental impact.

Some benchmarks we have used in this report are:

- The average UK household uses 177 kWh of energy per m2 [4] - this benchmark has been used for your domestic properties (Otley, Liverpool, Birmingham, Jacaranda)
- Pubs and offices benchmarks are taken from What Colour is your Building? [5]
- Average water consumption in dwellings - Waterwise https://www.ccwater.org.uk/households/using-water-wisely/averagewateruse/
- Average water consumption in hotels - Waterwise https://waterwise.org.uk/wp-content/uploads/2019/09/CIRIA-2006_Water-Key-Performance-Indicators-and-Benchmarks-for-Offices-and-Hotels.pdf

2.3.i Data quality issues in this report

Data quality issues affecting this report, where data is incomplete or unavailable, include:
Table 3

Data quality issue	Method used to mitigate the data quality issue
Absence of water metering data at many of your buildings	Used estimates [6] [7].
9 Riverdale Gardens - absence of bills; estimated bills; account errors by British Gas	David Williams kindly provide meter readings, enabling me to produce more accurate data.
Jacaranda - absence of billing data	Estimated figures based upon property type, size and appliances in use.
Herne Bay bar area - absence of electricity billing data and limited electricity metering data	Estimated figures based upon property type, size and appliances in use.
Minsteracres - absence of electricity sub-metering data	Estimated figures based upon property type, size and appliances in use.
Thermal images that are of below average quality due to rain	There is little that can be done with this other than interpret the images to the best of our ability – backed up by

4 http://www.nef.org.uk/themes/site_themes/agile_records/images/uploads/NPI_Benchmarking_Report_For_Superhomes_FINAL.pdf
5 https://cundall.com/Knowledgehub/What-Colour-Is-Your-Building-.aspx?categoryid=71
6 https://www.ccwater.org.uk/households/using-water-wisely/averagewateruse/
https://waterwise.org.uk/wp-content/uploads/2019/09/CIRIA-2006_Water-Key-Performance-Indicators-and-Benchmarks-for-Offices-and-Hotels.pdf

7 https://www.theguardian.com/environment/2007/aug/02/ethicalliving.ethicalliving

	observation of the building fabric.
Absence of Energy Performance Certificates (EPCs) for all properties apart from 96 Ivor Road. EPCs can give us useful information such as kWh/m2; floor area; predicted energy consumption.	Estimate these figures using bills, Google Earth, observation of building.

2.4 Tackling climate change in heritage environments

Listed Buildings

Two of your sites have listed building status.

Historic England has produced a range of technical guides for installing energy efficiency actions in historic buildings. These include insulating roofs, walls, floors, and other building components. [8][9]

National Parks

One of your sites, St Non's, is located in a National Park.

There is a precedent for building a solar farm in a National Park, in the Peak District. [10]

Pembrokeshire National Park has published guidance on renewable energy. This states that applications for small and medium scale renewable energy installations "will be considered favourably". There are already wind turbines that have been installed in the Pembrokeshire National Park. [11]These guidance notes and policies should be referred to when planning potential renewable energy installations at Minsteracres and St Non's.

2.5 Acknowledgements

I acknowledge with thanks:

8

9 https://historicengland.org.uk/advice/technical-advice/energy-efficiency-and-historic-buildings/

10 https://www.peakdistrict.gov.uk/learning-about/news/archive/2014/news/landmark-decision-on-solar-panels-in-peak-district-national-park

11 https://www.pembrokeshirecoast.wales/Files/files/Dev%20Plans/RenEngTechUpdateApril14.pdf

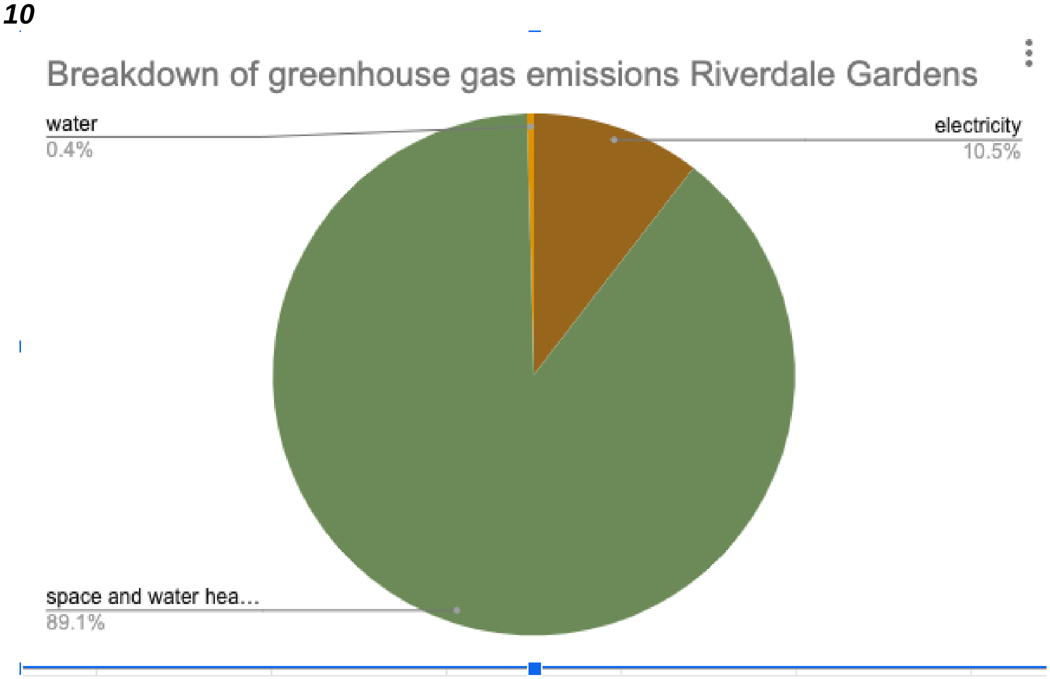
- The assistance of members of the Passionist community in showing me round their buildings and homes.
- Claire Campbell, for editing thermal imaging, assistance on the St Non's site visit, and proof reading.
- Louise Heaps of The Word Kitchen for copy editing.
- The work of Narec Distributed Energy, and their report to Minsteracres on renewable energy.
- Eco Birmingham (formerly Northfield Ecocentre), and their report to Austin Smith House, 96 Ivor Road, Birmingham on energy saving.

3.0 9 Riverdale Gardens, LS21 1SX - baseline

Aspect	Unit of measurement
Energy use (all fuels)	179 kWh per m^2
Carbon dioxide emissions per m^2	37.5 kg CO^2 per m^2
Total carbon dioxide emissions	3829 kg CO^2
Water use	149 Litres per person per day

The breakdown of your greenhouse gas emissions is shown in figure 10 below:

Figure 10



Key observations – Riverdale Gardens:

- *Consumption of energy is average.*
- *Energy consumption would be above average if not for the solar panels with battery storage, which mean that electricity consumption is well below average.*
- *Gas consumption is above average.*
- *Water consumption is average.*

3.1 9 Riverdale Gardens, LS21 1SX - detailed observations and opportunities

3.1.i Building Fabric - 9 Riverdale Gardens, LS21 1SX [12]

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Walls	Walls are believed to have insulated cavity walls – as built in approximately 1995, after the building regulations made cavity wall insulation mandatory in new build homes. Thermal imaging shows little heat loss from walls - no red patches where radiators are situated.	***Energy Hierarchy Goal: Use energy efficiently*** Additional wall insulation is not essential if gas continues to be the heating fuel. However, if a heat pump were installed then additional wall insulation - either external or internal – would be essential. (see Glossary for why additional insulation would be essential for a heat pump)
Roof area(s)	Loft has 100mm mineral wool insulation, probably as built in 1995. Loft is half boarded across the insulation. Loft hatch is uninsulated. It feels warm in the loft. Thermal imaging shows worst heat loss is from	***Energy Hierarchy Goal: Use energy efficiently*** Loft insulation needs to be increased to 300mm to be fully effective. The loft hatch should be insulated. Any areas with missing mineral wool insulation - e.g. around eaves - should have additional insulation. As an alternative to mineral wool insulation in the rafters, the underside of the roof could be insulated.

[12] In this table and similar tables in this report, we have used a traffic light system in the second column to categorise current situations according to the severity of the greenhouse gas emissions they cause. Hence where text is highlighted in red then actions in the third column should be taken as the highest priority; actions in orange are also recommended.

	eaves and roof, suggesting insulation is incomplete.	
Doors and windows	Double-glazed throughout. Thermal imaging shows heat loss around front door.	***Energy Hierarchy Goal: Use energy efficiently*** Draught-proof front door. When the windows/doors come to the end of their lives they should be replaced with double-glazed window with the best possible u-values. Triple glazed windows would give some additional energy and CO^2 savings but would not be cost-effective.
Floors	There are no underfloor areas that could be insulated. Seals between floors and walls are sufficiently tight.	
Letterboxes/keyholes	There are not excessive draughts through letterboxes or keyholes.	
Preventing heat loss from radiators	Radiator reflective foil is not present	***Energy Hierarchy Goal: Use energy efficiently*** Radiator reflective foil should be used where radiators are located on external walls.

3.1.ii Primary heating system and controls, 9 Riverdale Gardens, LS21 1SX

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat source	Worcester Bosch Greenstar 25 condensing combi boiler - believed to be 3-4 years old.	***Energy Hierarchy Goal: Use lower carbon energy*** An air source heat pump could reduce the use of fossil fuels, if sufficient electricity were generated and stored from solar electricity.
Is the primary heat source regularly serviced/		***Energy Hierarchy Goal: Use energy efficiently*** Ensure annual service of boiler is carried

maintained?	No - there is a contract with British Gas, but they have not done an annual service visit for more than 12 months.	out. This is also vital for gas safety reasons.
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	British Gas Smart Linked Thermostat and Timer - functions as timer and room thermostat, located in hallway. Timer is used properly. Radiators all have Thermostatic Radiator Valves.	***Energy Hierarchy Goal: Use energy efficiently*** As the house has low heat consumption and is under-occupied, little would be gained by upgrading heating controls, if the gas boiler continues to be the primary heat source. If a new heat source were installed such as a hybrid heat pump, then upgraded controls would be necessary.

3.1.iii Secondary heating system and controls, 9 Riverdale Gardens, LS21 1SX

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of secondary heat source	There is a gas fire in the lounge, but it is seldom used. Portable electric heater.	***Energy Hierarchy Goal: Use less energy*** Use of the portable electric heater should be discouraged as it will be using grid electricity not PV electricity due to time of use.
Is the secondary heat source regularly serviced/ maintained?	No - there is a contract with British Gas, but they have not done an annual service visit for more than 12 months.	***Energy Hierarchy Goal: Use energy efficiently*** Ensure annual service of fire is carried out. This is also vital for gas safety reasons.

3.1.iv Hot water, 9 Riverdale Gardens, LS21 1SX

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Description, age and condition of hot water source	Worcester Bosch Greenstar 25 condensing combi boiler - believed to be 3-4 years old.	***Energy Hierarchy Goal: Use lower carbon energy*** If an air source heat pump were used as the primary heat source, then a separate hot water source would be needed. This could be the existing gas boiler as currently, or an electric immersion heater, which could be lower carbon if sufficient electricity were generated and stored.
Is the hot water source regularly serviced/ maintained?	No - there is a contract with British Gas, but they have not done an annual service visit for more than 12 months.	***Energy Hierarchy Goal: Use energy efficiently*** Ensure annual service of boiler is carried out. This is also vital for gas safety reasons.
Are the hot water controls adequate? Are they smart?	British Gas Smart Linked Thermostat and Timer - functions as timer and room thermostat, located in hallway. Timer is used properly. Radiators all have TRVs.	***Energy Hierarchy Goal: Use energy efficiently*** The house has low heat consumption and is under-occupied. Therefore, little would be gained by upgrading heating controls, whilst the gas boiler continues to be the primary heat source. If a new heat source were installed such as a hybrid heat pump, then upgraded controls would be necessary.
Are there any leaks from hot water pipework?	No	
Is hot water pipework insulated?	Yes	

3.1.v Lamps and lighting controls - 9 Riverdale Gardens, LS21 1SX

	Observations of current situation. Is it efficient, or wasteful?	**Opportunities for saving energy**
Description, age and condition of lamps	Lamps are a mixture of incandescent and CFLs. There is a fluorescent tube in the kitchen. 2 x external lights are rarely used.	***Energy Hierarchy Goal: Use energy efficiently*** Replace fluorescent tube in kitchen with LED fluorescent. Replace remaining incandescent bulbs with LED bulbs. When external bulbs fail, replace them with LEDs.
Is use of natural light made where available?	Yes	
What lighting controls are present? Are they adequate?	On/off switches are adequate for this property	

3.1.vi Kitchen/utility room appliances - 9 Riverdale Gardens, LS21 1SX

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age, energy rating, and condition of appliances	Washing machine is approximately 3-4 years old and is A++ rated. Washing machine is used once a week at a temperature of 40 degrees. Fridge/freezer - age unknown.	***Energy Hierarchy Goal: Use energy efficiently*** When appliances wear out, they should be replaced with the highest rated appliances possible. This is a thrifty, one-person household with low energy consumption ***Energy Hierarchy Goal: Use lower carbon energy*** The use of the washing machine and cooker should be loadshifted wherever possible to times of peak availability of solar electricity -

	Microwave, cooker/hob.	i.e. the middle of the day, especially between the Spring and Vernal equinoxes. The weather forecast can be used to predict forthcoming days when it would be best to use the washing machine.
Are fridges/freezers defrosted? Are they kept full when in use?	Yes	
Can washing be dried outside?	Yes	
Horticultural use of water	Low maintenance garden with no need for watering.	

3.1.vii Bathroom appliances, 9 Riverdale Gardens, LS21 1SX

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Showers/baths	Shower is fed by boiler. This is the most efficient option. Occupier does not spend long in the shower. There is no bath present.	
Toilet flushing	Single flush WCs in both bathrooms	***Water Hierarchy Goal: Reduce*** Install water displacement devices (hippos) in both WCs.

3.x How can 9 Riverdale Gardens reduce its dependence on fossil fuels for space and water heating?

Reducing CO^2 emissions from heat and hot water is a priority.

As the building and heating systems are quite efficient, the higher than average consumption of gas is most likely to be caused by under-occupation.

An air source heat pump would not be able to supply sufficient heat to the property for the following reasons:

- Demand for space and water heating is 16,706 kWh per annum.
- Peak demand is expected to be 81 kWh per day in February, of which most is for space heating.
- If additional insulation were installed at the property, then the daily demand for space heating in February could be expected to fall to 61 kWh.

The solar panels at the property are expected to generate approximately 4,000 kWh per annum. As there is a battery, then all of this can be used on site. The total estimated output for the solar panels in February is 180 kWh, i.e. 6.43 kWh per day.

If a heat pump with a Coefficient of Performance of 3.0 were installed at the property, then it would need an electrical input of 21 kWh per day to produce a heat output of 63 kWh during that day. Therefore, the solar panels would not be able to produce sufficient output to power an air source heat pump. It would still be necessary to import approximately 14 kWh of grid electricity per day for space heating alone. It would also be necessary to heat hot water separately; either through maintaining the gas boiler for hot water; or through an electric immersion heater, which would also need to import grid electricity during the winter months.

An air source heat pump would not be a cost-effective option and would fail to provide adequate heat to the building.

The PV with battery is capable of meeting most or all of the building's electricity needs with very little imported grid electricity and therefore making the building practically zero carbon for electricity, especially if the imported grid electricity is from a genuine renewable electricity tariff.

The building cannot currently avoid using fossil fuels for heat, and therefore the priority for the building is to reduce heat demand as much as possible. CO^2 emissions that cannot be eliminated from the building will need to be offset elsewhere.

Solar thermal could be a cost-effective way of reducing emissions from the building by displacing gas with the sun for pre-heating hot water.

3.xi Priority actions for 9 Riverdale Gardens LS21 1SX

The actions with the greatest impact on reducing greenhouse gas emissions are listed first.

1. **Loft insulation needs to be increased to 300mm to be fully effective. The loft hatch should be insulated. Any areas with missing mineral wool insulation - e.g. around eaves - should have additional insulation. As an alternative to mineral wool insulation in the rafters, the underside of the roof could be insulated.**

2. **Draught-proof front door.**

3. **Radiator reflective foil should be used where radiators are located on external**

walls

4. **Ensure annual service of boiler is carried out.**

5. **Replace fluorescent tube in kitchen with LED fluorescent. Replace remaining incandescent bulbs with LED bulbs.**

6. **The use of the washing machine and cooker should be loadshifted wherever possible to times of peak availability of solar electricity - i.e. the middle of the day, especially between the Spring and Vernal equinoxes. The weather forecast can be used to predict forthcoming days when it would be best to use the washing machine.**

7. **Install water displacement devices (hippos) in both WCs.**

4. Minsteracres - DH8 9RU

4.1.i Baseline for whole estate at Minsteracres [13]

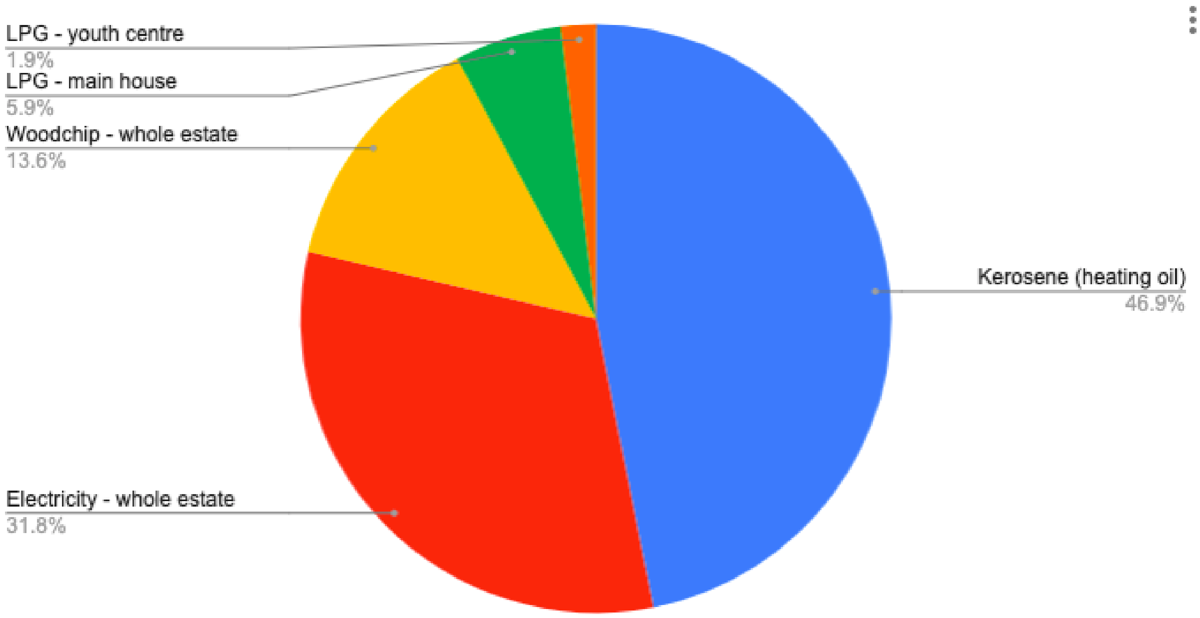
Energy use (all fuels)	160.4 kWh per m^2
Carbon dioxide emissions per m^2	13.3 kg CO^2 per m^2
Total carbon dioxide emissions	86306 kg CO^2
Water use	190 Litres per person per day

4.1.ii Breakdown of total carbon dioxide emissions

Source of emissions	**kg CO^2**
Kerosene (heating oil)	40459
Electricity - whole estate	27421
Woodchip - main house	11550
LPG - main house	5072
LPG - youth centre	1648
Woodchip - Walled Garden buildings	156 - estimated

[13] Including Walled Garden buildings; stable building; church; youth centre; monastery.

Figure 11



Key observations – Minsteracres:

- *Kerosene heating oil is the biggest single contributor to your greenhouse emissions.*
- *Biomass is low carbon but not zero carbon, it accounts for 13.6% of your emissions.*

4.1.iii Baseline for Minsteracres main house (including Old Laundry)

Energy use (all fuels)	265 kWh per m^2
Carbon dioxide emissions per m^2	12.25 kg CO^2 per m^2
Total carbon dioxide emissions	39186 kg CO^2
Water use	190 litres per person per day

Key observations:

- *Energy use in kWh/m^2 in some parts of the estate is relatively low because of under-occupation, e.g. walled garden buildings; youth centre.*
- *Energy use in kWh/m^2 in the main house is very high, due to very high heat loss from the building, lack of heating controls, and high demand for lighting.*
- *Carbon dioxide emissions in kWh/m^2 across the whole estate are relatively low due to the impact of the use of a low-carbon heating fuel, biomass. The same is true for the main house.*

- *The building is listed, which limits your ability to undertake improvements to the fabric of the building*

4.2.i Building fabric, Minsteracres Main House DH8 9RU

The main house is a listed building internally and externally. This limits or disallows the possibility of some actions – such as external wall insulation, double glazing or roof-mounted solar panels.

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Walls	Walls are thermally massive but uninsulated. Thermography shows substantial heat loss through walls. Slate roof.	***Energy Hierarchy Goal: Use energy efficiently*** Internal wall insulation could be installed in some "downstairs" areas of the house with minimal impact on the appearance of the house - e.g. guest bedrooms, kitchens, dining areas, bathrooms, and offices. Most of the Old Laundry could have internal wall insulation. There is no option for insulating the walls in the "Upstairs" areas of the house e.g. library and meeting areas, due to the negative impact that insulation would have on the internal or external appearance of the house
Roof area(s)	Loft space has some insulation. Thermography shows some heat loss through roofs.	***Energy Hierarchy Goal: Use energy efficiently*** Additional insulation would be beneficial. There are known asbestos issues which prevent top-up insulation being done on a DIY basis. Asbestos needs to be treated before insulating.
Doors and windows	There are deep, uninsulated window reveals throughout the main house - these are a thermal bridge that is causing heat loss. Building is mostly single-glazed with a small amount of double glazing. Thermography shows substantial heat	***Energy Hierarchy Goal: Use energy efficiently*** As the window reveals are square in shape, internal wall insulation could be fitted to the window reveals to prevent heat loss. ***Energy Hierarchy Goal: Use energy efficiently*** Secondary glazing could be fitted to the inside of the window reveals, especially in the "downstairs" areas of the house, such as kitchen and dining areas, and the guest bedrooms.

	loss through single-glazed windows.	
Floors	Thermography shows significant heat loss through the floor of the main house to the cellar below.	***Energy Hierarchy Goal: Use energy efficiently*** The ceiling of the cellar should be insulated. A means of horizontal support for the insulation will need to be installed - as insulation material is lightweight then this need not be difficult. Light fittings in the cellar would need to be repositioned or relocated to the cellar walls.
Preventing heat loss from radiators	Radiators in the large meeting rooms have DIY radiator foil behind them. No other radiators in the building have radiator reflective foil.	***Energy Hierarchy Goal: Use energy efficiently*** All radiators on external walls should have radiator reflective foil placed behind them.

4.2.ii - Primary Heating System, Minsteracres main house DH8 9RU

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat source	Woodchip boiler – very good condition – installed 2014	
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	No. Heating system has manual timers/programmers/ thermostats. There is one room thermostat for the whole building.	***Energy Hierarchy Goal: Use energy efficiently*** Upgrade heating controls to fully smart and zoned heating controls.

	A new pump was fitted in 2014 but some rooms furthest from the boiler are hardest to heat. The library was noticeably overheated on the day of my visit. It is noticeable that there is little seasonal fluctuation in the consumption of woodchip throughout the year, which also suggests that the heating controls are not adequate.	
Other	Radiators in some parts of building (e.g. meeting rooms) are very old.	***Energy Hierarchy Goal: Use energy efficiently*** These radiators could be replaced with more modern ones that imitate the appearance of the original ones. Radiators are removable therefore are not part of the listing.
	Parts of the building have very high ceilings and stratification of air is causing heat to be wasted.	***Energy Hierarchy Goal: Use energy efficiently*** Destratification fans would prevent heat waste in parts of the building with high ceilings. They would need to be sensitively sited to avoid visual intrusion. They would not need to be on the whole time – they could be turned off while a meeting was in progress – but they should be on at other times when those rooms with high ceilings are being heated. The Church at Minsteracres would also benefit from destratification fans.

4.2.iii Secondary heating systems, Minsteracres main house DH8 9RU

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of secondary heat source	Portable electric radiators were observed in the library, in some guest rooms and the Silvertop Suite lounge.	***Energy Hierarchy Goal: Use less energy; use energy efficiently*** Portable electric radiators should be discouraged as they are higher carbon than biomass. Smart, zoned heating controls would help to heat the right areas at the right time. This would benefit vulnerable residents who are likely to need more space heating at different times, and make portable electric radiators less necessary.

4.2.iv Hot water, Minsteracres main house

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of hot water source	Woodchip boiler – very good condition – installed 2014 The estimated hot water demand for the Main House is 134,280 kWh per annum.	
Is the hot water source regularly serviced/ maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Hot water is stored in 3 x 2000 litre hot water cylinders, a timer is used to control the hot water.	
Are there any leaks from hot water pipework?	None were observed.	***Water Hierarchy Goal: Reduce*** Due to the size of the house, a water leak detection service would be worthwhile.

Is hot water pipework insulated?	Uninsulated hot water pipework was observed in the cellar, thermography shows substantial heat loss through the pipework.	***Energy Hierarchy Goal: Use energy efficiently*** Insulate hot water pipework in the cellar.

4.2.v Lamps and lighting controls, Minsteracres main house DH8 9RU

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of lamps	There is an ongoing programme of replacing incandescent and CFL lamps with LEDs.	***Energy Hierarchy Goal: Use energy efficiently*** Continue to replace incandescent and CFL lamps with LEDs as the old lamps wear out. This needs to include bulkhead lighting and fluorescent tubes, which were observed in the kitchen area.
Is use of natural light made where available?	Yes	
What lighting controls are present? Are they adequate?	On/off switches only. I did not observe any timer or Passive Infra-Red lighting controls. No "turn this light off when leaving the room" stickers were observed.	***Energy Hierarchy Goal: Use energy efficiently*** Install smart wireless lighting controls, particularly in areas that are intermittently used, such as corridors and communal bathroom areas. (In corridors, lighting controls can be sequential).

4.2.vi Kitchen and utility room appliances, Minsteracres main house, DH8 9RU

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age, energy rating, and condition of		***Energy Hierarchy Goal: Use energy efficiently*** Install a variable speed drive to the cooker

appliances	Kitchen appliances are reasonably modern and in good condition.	hood.
Are fridges/freezers defrosted? Are they kept full when in use?	Yes	
Can washing be dried outside?	Yes – an outdoor drying area is used.	
Horticultural use of water	There is some horticulture on site, but I did not see any water butts.	***Water Hierarchy Goal: Re-use*** Water butts should be used, they need to be close to where water is needed for horticulture but in a location where any visual impact will be limited.
Urns and kettles	Urns are generally in use for tea and coffee in meeting rooms and dining areas, except the Bethany Lounge, where I observed a kettle in the kitchen.	***Energy Hierarchy Goal: Use energy efficiently*** Could an urn or hot water boiler be used in the Bethany Lounge kitchen instead of a kettle?

4.2.vii Bathroom appliances at Minsteracres main house DH8 9RU

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Showers	Most showers run off the biomass boiler, which is more efficient than electric showers. No baths in use. There are some electric showers in communal bathrooms.	***Energy Hierarchy Goal: Use energy efficiently*** ***Water Hierarchy Goal: Reduce*** Put up stickers and shower times to encourage users to limit shower times. ***Energy Hierarchy Goal: Use energy efficiently*** When the electric showers come to the end

		of their lives, replace with showers fed by the biomass boiler .
Toilet flushing	Most toilets are single flush. A minority of toilets have displacement devices ("Hippos") installed, or dual-flush toilets in Silvertop Suite bathrooms.	***Water Hierarchy Goal: Reduce*** Options for reducing water waste from the toilets: - Ideally replace them with dual-flush toilets or composting toilets. - Alternatively, install displacement devices ("Hippos") in cisterns.
Taps	Most taps in bathrooms have only manual on/off controls.	***Water Hierarchy Goal: Reduce*** Options for reducing water waste from the taps: - Ideally replace them with self-closing, motion-controlled taps. - Alternatively, install flow restrictors. Communal bathroom areas are the highest priority for these actions.
Towel rails	In some bathroom areas (Silvertop), towel rails were observed to be on 24/7.	***Energy Hierarchy Goal: Use energy efficiently*** Where towel rails are fitted their use should be encouraged, as they discourage people from drying towels on radiators. Timers should be added to all towel rails to prevent them being used 24/7.
		Energy Hierarchy Goal: Reduce demand for energy Waste Water Heat Recovery Systems (WWHRS) should be considered for pre-heating the water used by the showers. The emissions savings will be lower here (where the water is heated by a renewable fuel) than they would be in a building where a fossil fuel is used to heat the water.

4.2.viii Other observations from Minsteracres main house DH8 9RU

Consumption of woodchip

Woodchip is used as a fuel for heating and hot water at Minsteracres main house. Consumption of woodchip does not fluctuate throughout the year as one would expect. It is quite flat throughout the seasons.

There are two factors about the main house that would cause the consumption to be flatter than expected:

- Firstly, occupancy is higher in summer than winter, therefore demand for hot water is higher in summer than winter.
- Secondly, the building is under-occupied in winter but the whole building is heated during winter with no zonal control of heating.

Nevertheless, peak demand for hot water when the building is fully occupied is such that consumption in the summer months should be much lower than it is.

This suggests two things:

1. Too much hot water is being stored during periods of low occupancy.
2. Empty parts of the building are being unnecessarily heated (which is what I observed when I visited the site).

Actions that could correct this are:

- Experimenting with the hot water settings during periods of low occupancy, to reduce the amount of hot water that is being stored in the cylinders. This should be done incrementally and monitored until the optimum settings are found.
- Installing smart, zoned heating controls so that empty parts of the building are not heated unnecessarily; the smart controls could also be used to control hot water to meet demand without waste.

Environmental awareness

The house is run on a thrifty basis:

- high levels of recycling, including food waste going to anaerobic digestion.
- little evidence of building users being wasteful.
- although heating and lighting controls are not modern, building users are diligent and not leaving things switched on that should be turned off.

4.2.x Voltage optimisation at Minsteracres

Voltage optimisation is an option for Minsteracres, especially if a ground source heat pump is installed at the Retreat House, and for the heat pump at the Monastery.

Voltage optimisation would need to be installed downstream of the secondary meters of these two buildings. However, without a heat pump at the Retreat House, voltage optimisation would be less worthwhile.

I'd recommend that an installer of voltage optimisation is asked to come out and measure the voltage going into the building and identify any savings to be made from voltage optimisation.

4.2.xi Priority actions for Minsteracres main house

The actions with the greatest impact on reducing greenhouse gas emissions are listed first.

1. **Internal wall insulation to those areas that can be insulated, including window reveals.**
2. **Additional loft insulation.**
3. **Underfloor insulation.**
4. **Lagging of uninsulated hot water pipework.**
5. **Smart, zoned heating controls.**
6. **Secondary glazing to the "Downstairs" areas of the house.**
7. **Radiator reflective foil on radiators placed on outside walls.**
8. **Continue to upgrade to LED lamps in all fittings including fluorescents and bulkheads.**
9. **Upgrade to smart lighting controls.**
10. **Prevent water waste by adding tap restrictors to bathroom taps or replacing with motion-sensitive self-closing taps.**
11. **Prevent water waste by replacing single-flush toilets with dual-flush toilets**
12. **Install Hippos in cisterns.**

See also 4.6 below, on renewable heat and electricity across the Minsteracres estate.

4.3 Minsteracres Retreat House

4.3.i Building Fabric, Minsteracres Retreat House

	**Observations of current situation**	**What actions can you take to improve?**
Walls	Uninsulated solid walls	***Energy Hierarchy Goal: Use energy efficiently*** Internal wall insulation could be fitted in most of the building.

Roof area(s)	300mm loft insulation	
Doors and windows	Some windows are single-glazed, some double-glazed. Unheated porch.	***Energy Hierarchy Goal: Use energy efficiently*** Add secondary glazing to all windows that are currently single-glazed.
Floors	Uninsulated solid floor.	Ensure tight seals where walls meet floor.
Preventing heat loss from radiators	Radiators do not have reflective radiator foil	***Energy Hierarchy Goal: Use energy efficiently*** Add reflective radiator foil to all radiators that are on outside walls.

4.3.ii Primary Heating System, Minsteracres Retreat House

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat source	100 kW kerosene boiler, 15-20 years old. Boiler is oversized because it was bought second hand.	***Energy Hierarchy Goal: Use lower carbon energy*** Replace with a low carbon heating source such as biomass, or ground source heat pumps – in the latter case, only if the building is going to be highly insulated.
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	No. Manual programmer for hot water and heating.	***Energy Hierarchy Goal: Use energy efficiently*** Smart, zoned heating controls should be installed.

4.3.iii Hot water, Minsteracres Retreat House

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of hot water source	45kW kerosene boiler. 15-20 years old. The boiler is oversized because it was bought second hand.	***Energy Hierarchy Goal: Use lower carbon energy*** Extend the biomass boiler to the Retreat House in accordance with the recommendations of the Narec Distributed Energy report. Alternatively, if a heat pump was installed, then a separate hot water source would be necessary. This could be an electric immersion heater, with solar thermal to pre-heat the water.
Is the hot water source regularly serviced/ maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Yes	
Are there any leaks from hot water pipework?	None observed.	
Is hot water pipework insulated?	Some uninsulated pipes were observed.	***Energy Hierarchy Goal: Use energy efficiently*** Add lagging to uninsulated pipework.

4.3.iv Lamps and lighting controls at Minsteracres Retreat House

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve it?
Description, age and condition of lamps	There is an ongoing process of replacing incandescent and CFL lamps with LEDs.	***Energy Hierarchy Goal: Use energy efficiently***

		Continue to replace incandescent and CFL lamps with LEDs as the old lamps wear out. This needs to include bulkhead lighting and fluorescent tubes.
Is use of natural light made where available?	Yes	
What lighting controls are present? Are they adequate?	On/off switches only. I did not observe any timer or Passive Infra-Red lighting controls. No "turn this light off when leaving the room" stickers were observed.	***Energy Hierarchy Goal: Use less energy*** Install smart wireless lighting controls, particularly in areas that are intermittently used, such as corridors and communal bathroom areas. (In corridors, lighting controls can be sequential).

4.3.v Bathroom appliances at Minsteracres Retreat House

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Showers	Showers run off the kerosene boiler.	***Energy Hierarchy Goal: Use lower carbon energy*** Change the fuel source to a low carbon fuel, such as biomass, by extending the Main House biomass boiler. Put up stickers and shower timers to encourage users to limit shower times.
Toilet flushing	Toilets are single flush.	***Water Hierarchy Goal: Reduce*** Options for reducing water waste from the toilets: - Ideally replace them with dual-flush toilets or composting toilets. - Alternatively, install displacement devices ("Hippos") in cisterns.
Taps	Most taps in bathrooms have only manual on/off controls.	***Water Hierarchy Goal: Reduce*** Options for reducing water waste from the taps:

		- Ideally replace them with self-closing, motion-controlled taps. - Alternatively install flow restrictors. Communal bathroom areas are the highest priority for these actions.
Towel rails	Fuses have been removed from towel rails to save energy.	Towel rails are useful as they discourage people from drying towels on radiators. As an alternative to disconnecting towel rails, timers could be added to towel rails to prevent them being used 24/7.
		Energy Hierarchy Goal: Reduce demand for energy Waste Water Heat Recovery Systems (WWHRS) should be considered for pre-heating the water used by the showers. The emissions savings will be higher if kerosene continues to be used to heat up water. If kerosene is replaced by a renewable fuel such as woodchip or solar to heat hot water, then the emissions savings will be lower.

4.3.vi Kitchen and utility room appliances at Minsteracres Retreat House

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age, energy rating, and condition of appliances	LPG gas tumble dryer is quite old.	***Energy Hierarchy Goal: Use energy efficiently*** Replace with a more modern and efficient LPG tumble dryer.

4.3.vii Priority actions for Minsteracres Retreat House

In order of priority:

1. **Install internal wall insulation where practical.**

2. **Install secondary glazing on windows that are currently single-glazed.**
3. **Fit radiator reflective foil to all radiators located on external walls.**
4. **Replace kerosene boilers for space and water heating with lower carbon fuel sources (see 4.6 below).**
5. **Upgrade to smart, zoned heating controls.**
6. **Add lagging to uninsulated hot water pipes.**
7. **Continue to replace lamps with LEDs.**
8. **Upgrade to smart lighting controls.**
9. **Install dual-flush toilets (or add Hippos to existing cisterns).**
10. **Install flow restrictors to taps, or upgrade to motion-sensitive self-closing taps.**

4.4 Walled Garden Eco Community at Minsteracres

4.4.i Building fabric - Walled garden Eco Community at Minsteracres

	Observations of current situation	**What actions can you take to improve?**
Walls	Uninsulated solid walls. Thermographics show high heat loss.	***Energy Hierarchy Goal: Use energy efficiently*** *Buildings running east to west:* - Internal wall insulation could be fitted on north-facing wall, and on the walls at the east and west of the buildings. External wall insulation is also an option. - Internal wall insulation could be fitted on the south-facing wall, however as the new bathroom has been recently tiled, this would lead to a thermal bridge. - Therefore, external wall insulation would be a better option on the south-facing wall. This would not interfere with any of the plants growing against the section of freestanding wall to the east of the building. *Buildings running north to south:* - Internal wall insulation could be fitted on all walls. External wall insulation is also an option. Due to the condition of some areas of external wall,

		this could present problems with installing external wall insulation; when getting quotes for internal and/or external wall insulation then the installer's advice should be sought.
Roof area(s)	Buildings have a mixture of pitched and flat roofs. *Buildings running east to west:* Pitched roof areas incomplete or missing loft insulation. Loft hatches uninsulated. Flat roofs uninsulated. *Buildings running north to south:* Pitched roof areas incomplete or missing loft insulation. Loft hatches uninsulated. Flat roofs uninsulated. *Office area:* Roof needs replacing. due to its condition	***Energy Hierarchy Goal: Use energy efficiently*** Insulation should be topped up in all pitched roof areas, and loft hatches should be insulated. Flat roofs should be insulated. Replace roof in Office area.
Doors and windows	Single-glazed throughout - except for the textile room. Deep, insulated window reveals.	***Energy Hierarchy Goal: Use energy efficiently*** Add secondary glazing to all windows that are currently single-glazed. Add internal wall insulation to window reveals. Thermal curtains would also help prevent heat loss through windows.
Floors	Uninsulated solid floor.	Ensure tight seals where walls meet floor
Preventing heat loss from radiators	Radiators are very old and in poor condition, rust is present on some radiators. Uninsulated hot water	***Energy Hierarchy Goal: Use energy efficiently*** Add lagging to uninsulated hot water pipework, including in unheated areas, such as the Workshop. Add reflective radiator foil to all radiators that are on outside walls.

	pipework. Radiators do not have reflective radiator foil.	

4.4.ii - Primary Heating System, Walled Garden Eco Community, Minsteracres

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat source	80 kW woodchip boiler installed 2013. Manually fed with wood pellets into hopper - boiler is badly sited for loading.	
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	No. There is a manual programmer/timer; no room thermostat was visible; no thermostatic radiator valves on any radiators. Building is currently under occupied.	***Energy Hierarchy Goal: Use energy efficiently*** Minimum - add thermostatic radiator valves to all radiators; add room thermostat. Ideally - smart, zoned heating controls. This would give more control over the temperature in different parts of the building.

4.4.iii , Hot water, Walled Garden Eco Community, Minsteracres

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of hot water source	Electric immersion heater.	***Energy Hierarchy Goal: Use lower carbon energy***

		Use timer on immersion heater to coincide with availability of solar electricity if installed. Use woodchip boiler to supply hot water to a thermal store.
Is the hot water source regularly serviced/ maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Yes	
Are there any leaks from hot water pipework?	None were observed.	

4.4.iv Lights and lighting controls at Walled Garden Eco Community, Minsteracres

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve it?**
Description, age and condition of lamps	Most of the building has non-LED lamps.	***Energy Hierarchy Goal: Use energy efficiently*** Replace with LED lighting throughout, including fluorescents in textile room, dining room and resource room.
Is use of natural light made where available?	Yes, although there is little external light.	***Energy Hierarchy Goal: Use energy efficiently*** Sunpipes could be installed in areas of the buildings with flat roofs; this would reduce the need for electric lighting.
What lighting controls are present? Are they adequate?	On/off switches only. This is adequate for most areas of the building but not bathrooms.	***Energy Hierarchy Goal: Use less energy*** Bathrooms; install motion sensitive lighting controls - passive infra-red.

4.4.v Bathroom appliances at Walled Garden Eco Community, Minsteracres

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Toilet flushing	Single flush toilets.	***Water Hierarchy Goal: Reduce*** Options: - Replace with dual-flush toilets or composting toilets. - Install displacement devices (Hippos) in existing cisterns.

4.4.vi Ventilation and condensation issues at Walled Garden Eco Community, Minsteracres

When I visited in January 2020, the bathroom was being refurbished in the walled garden building that runs from east to west. Whilst the new bathroom has an energy saving shower and water saving taps and toilet, the bathroom is unheated, uninsulated and has only basic ventilation. It has the potential to be a cold spot in the building and to have problems with condensation and damp.

Internal wall insulation would be exceptionally disruptive in this bathroom now, due to the installation of new tiles and shower. It is partly for this reason that I have recommended external wall insulation in this building.

I also recommend that heating be added to this bathroom, such as a wet radiator running off the existing woodchip boiler, or a fan-assisted storage heater. The storage heater should be set to charge during the middle of the day between the spring and vernal equinoxes, when solar electricity is available, and set to charge at night between the vernal and spring equinoxes, to use cheaper and lower-carbon off-peak electricity.

There is also a problem with condensation and damp in the kitchen of the walled garden building that runs from north to south. Users of the kitchen need to be reminded to ventilate the kitchen while cooking - by opening the windows. Kitchen cupboards on the outside wall have damp in them as they are in a cold spot. The cupboards should ideally be repositioned to an internal wall to reduce the risk of damp.

4.4.vii Priorities for action at Walled Garden Eco Community, Minsteracres

The actions with the greatest impact on reducing greenhouse gas emissions are listed first:

1. **Insulate walls, pitched roofs, flat roofs and window reveals.**

2. **Add secondary glazing to all single-glazed windows.**
3. **Add lagging to uninsulated hot water pipework.**
4. **Add TRVs and room thermostat as a minimum; ideally install smart, zoned heating controls to give maximum control over heating and temperature.**
5. **Use woodchip boiler to provide hot water rather than the immersion heater.**
6. **Install LED lamps throughout.**
7. **Prevent water waste by replacing single-flush toilets with dual-flush toilets (or install Hippos in cisterns).**
8. **Add heating to the newly refurbished bathroom.**

4.5 Youth Centre, Minsteracres

Priorities for action at Youth Centre, Minsteracres

The actions with the greatest impact on reducing greenhouse gas emissions are listed first.

1. **Continue with proposed replacement of roof and install sunpipes at the same time (excluding dormitories).**
2. **Install cavity wall insulation if the cavity is of sufficient thickness [14]. (External wall insulation is a possible alternative if necessary.)**
3. **Install TRVs in all radiators.**
4. **Reposition room thermostat from boiler cupboard; it should be in a corridor area with no draughts.**
5. **Replace single-glazed windows with double-glazed windows.**
6. **Prevent water wste by replacing single-flush toilets with dual-flush toilets (or install Hippos in cisterns).**
7. **Install solar thermal to pre-heat hot water for the hot water cylinder.**

4.6 Recommendations – renewable heat and electricity across the Minsteracres estate

The following fossil fuel inputs at Minsteracres are those that it is desirable to displace with renewable sources of energy:

- Kerosene, 155767 kWh, for space heating and hot water to the Retreat House building
- Mains electricity, 107267 kWh, supplying electricity to the whole estate.

[14] An installer can test for the thickness of the cavity

4.6.i Renewable Heat at Minsteracres

Heat Option 1: extend the biomass boiler

The Narec Distributed Energy report makes the case for extending the existing biomass boiler at Minsteracres to provide space heating and hot water to the Retreat House. This would be financially viable, technically achievable and low carbon.

There are other forms of low-carbon heating that could be used for the Retreat House, and it is to these alternatives that we now turn our attention.

Heat Option 2: ground source heat pump

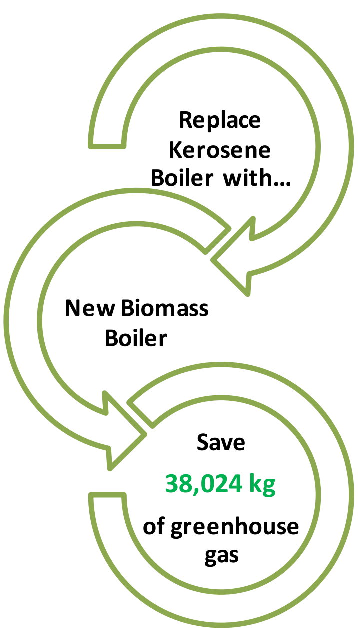
A ground source heat pump would be an alternative low-carbon way of providing space heating to the Retreat House. The Retreat House is currently inadequately insulated. If internal wall insulation were installed in the Retreat House to bring the U-values of its walls up to the standards of the current building regulations, then a ground source heat pump could be a viable way of heating the building.

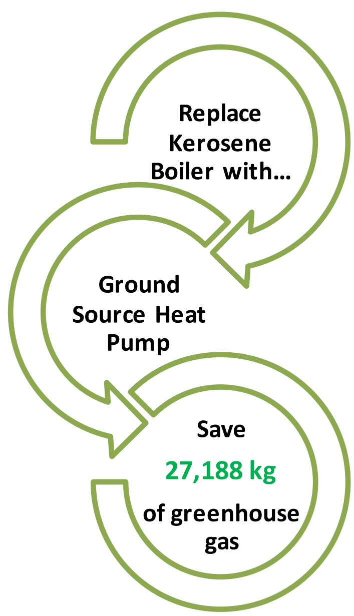
Impact of action on greenhouse gas emissions

The current emissions from biomass and kerosene at Minsteracres are 52,009 kg CO^2.

The following diagrams shows the emissions savings to be made by implementing options 1 or 2, described above:

Figure 12





The ground source heat pump would not provide water heating to the Retreat House, and a separate source of hot water would be necessary if this option was chosen.

Possible hot water sources for the Retreat House (if ground source heat pump option is used for space heating):

Heat Option 2a:

Figure 13

Immersion Heaters → powered by locally generated renewable electricity (wind and solar on site) → **ZERO greenhouse gas emissions.** **(ground source heat pump could also be powered by renewable electricity)**

Heat Option 2b:

Hot Water Boiler → fuelled by LPG or kerosene → This would wipe out the emissions savings from the ground source heat pump, therefore making this option unviable.

Heat Option 2c:

Solar Thermal to pre-heat hot water (producing around 50% of your annual demand for hot water.) → Immersion heater (Grid Electricity) OR LPG hot water boiler (to produce remaining 50% of your hot water) → **Save 11,726 kg of greenhouse gas emissions.** **(This is the combined savings with the ground Source Heat Pump)**

Recommended options:

Without on-site renewable energy generation:

- **Heat Option 1 - extend the biomass boiler**. This would be the lowest carbon option without new renewable energy generation.
    - By extending the biomass heating system to meet demand for space and water heating at the Retreat House, the **total emissions** from the biomass would rise from 11,550 kg CO^2, to **13,985 kg CO^2**. This is considerably lower than the current emissions from biomass and kerosene (52,009 kg CO^2) offering a great saving.

With on-site renewable energy generation:

- **Heat Option 2a, ground source heat pump and immersion heaters**. If you decide to implement renewable energy generation from wind and solar on site, then this is the best option for renewable heat.
    - This would be a **zero-carbon** option, as all the electricity for your ground source heat pump and your electric immersion heater would be generated from zero carbon sources – the wind and sun. (This would be a lower carbon option than extending the biomass boiler.)
    - The existing kerosene boiler could be kept as a backup to the ground source heat pump; however, if your generation and storage of renewable electricity were sufficient, then you would need little or no kerosene.

Impact of potential new insulation on Heat Option 1 and Heat Option 2a

It should be remembered that for a ground source heat pump to be viable to heat the Retreat House, then the Retreat House would need to be properly insulated (as recommended in 4.2.i above).

If the Retreat House were insulated, then this would reduce demand for space heating in the building.

If heat demand were reduced by 10%, and if biomass were used to heat the Retreat House, the greenhouse gas emissions from the biomass would fall from 13,985 kg CO^2, down to 12,586 kg CO^2.

If the Retreat House were heated by a Ground Source Heat Pump (option 2a outlined above), then the insulation would have no effect on its greenhouse gas emissions, as this heating option is already zero carbon.

The insulation would, however, reduce the demand for electricity from wind and solar, which would keep down the costs of capital investment in wind and solar energy.

4.6.i Renewable Electricity at Minsteracres

Renewable Electricity Option 1: building-mounted solar electricity panels

The Narec Distributed Energy report makes the case for building-mounted solar electricity (photovoltaic) panels on an area of the roof of the Main House with least visual impact, with a capacity of 14.4 kW. This is a technically sound and financially viable proposition.

Renewable Electricity Option 2: ground-mounted solar farm

- **100 kW wind turbine, plus a 100 kW solar farm, could therefore, meet all your electricity generation needs**. This is provided there is enough battery storage to meet peak demand (e.g. for space heating on winter evenings).

The Narec Distributed Energy report correctly says that electrical supply equipment to the site will need upgrading if electricity is generated on site for export to the national grid. A renewable energy feasibility study (see below) should look at whether the cost of this upgrade could be avoided if you went off-grid.

Location

The maps below show possible locations of a wind turbine and a solar farm, and of rooftop solar thermal. This is a very broad-brush approach as it is intended as a visualisation and is no substitute for a full feasibility study. The grey rectangles represent potential locations of solar farms. [15]

Figure 15

The solar thermal map below, shows the position for solar thermal that would have the least visual impact – which would be advantageous in getting planning permission.

Figure 16

[15] Maps created using www.scribblemaps.com.

Feasibility

Around 6 years ago, Minsteracres commissioned a report into the feasibility of a wind turbine on site. Although I have not yet seen a copy of this report, I understand that it concluded that the cost of connecting the turbine to the national grid would be prohibitively expensive. I believe that it would be worthwhile for you to now consider the feasibility of wind energy once again, for the following reasons:

- The economics of a grid connection have changed.
- Off-grid generation is now more of a possibility due to falling battery prices which eliminates grid connection costs.
- Second-hand wind turbines can be used in off-grid applications, bringing down the capital costs.
- Commercial electricity prices have risen and will continue to rise.

A full renewable energy feasibility study for the Minsteracres estate should be commissioned, with the following terms of reference:

Heat demand

- The demand for space heating and hot water at the Main House and Retreat House should be properly modelled, including the impact of energy saving actions such as insulation, smart heating controls, and better management of hot water demand.

Ground source heat pump (GSHP) for space heating at Retreat House

- What size heat pump would be needed to meet heat demand?
- Is the heat distribution system, including radiators, adequate for a GSHP?
- Are there any parts of the Retreat House suitable for retrofitting underfloor heating?
- Is there space for laying a slinky coil, or for a borehole?
- Is the ground suitable for a slinky coil or borehole? This may involve a separate geotechnical survey.
- Is the electrical supply suitable for a GSHP?
- Could the GSHP be used for cooling, e.g. to unheated areas where refrigeration equipment is kept?
- What would be the costs of installing a GSHP?
- Would the GSHP qualify for the Renewable Heat Incentive?
- Could a slinky be self-installed, reducing the installation costs?

Electricity generation - wind and solar

- What can we learn from case studies of relevant wind energy projects?
- Stakeholder engagement
- Choosing suitable turbine(s)/solar panels; system size, location, income, grid connection or off-grid.
- Local use of electricity
- Impact assessments
- Warranties
- Business planning
- Planning permissions
- Lease agreements
- Licences
- Energy Services Cooperative ownership options
- Raising capital
- Community share issue
- Procurement
- Installation
- Commissioning
- Maintenance
- Income distribution
- Decommissioning
- Repowering

Solar thermal

- Choosing suitable panels, system size, location, income
- Planning permissions
- Warranties

- Lease agreements
- Licences
- Energy Services Cooperative ownership options
- Raising capital
- Community share issue
- Procurement
- Installation
- Commissioning
- Maintenance
- Income distribution
- Decommissioning
- Repowering

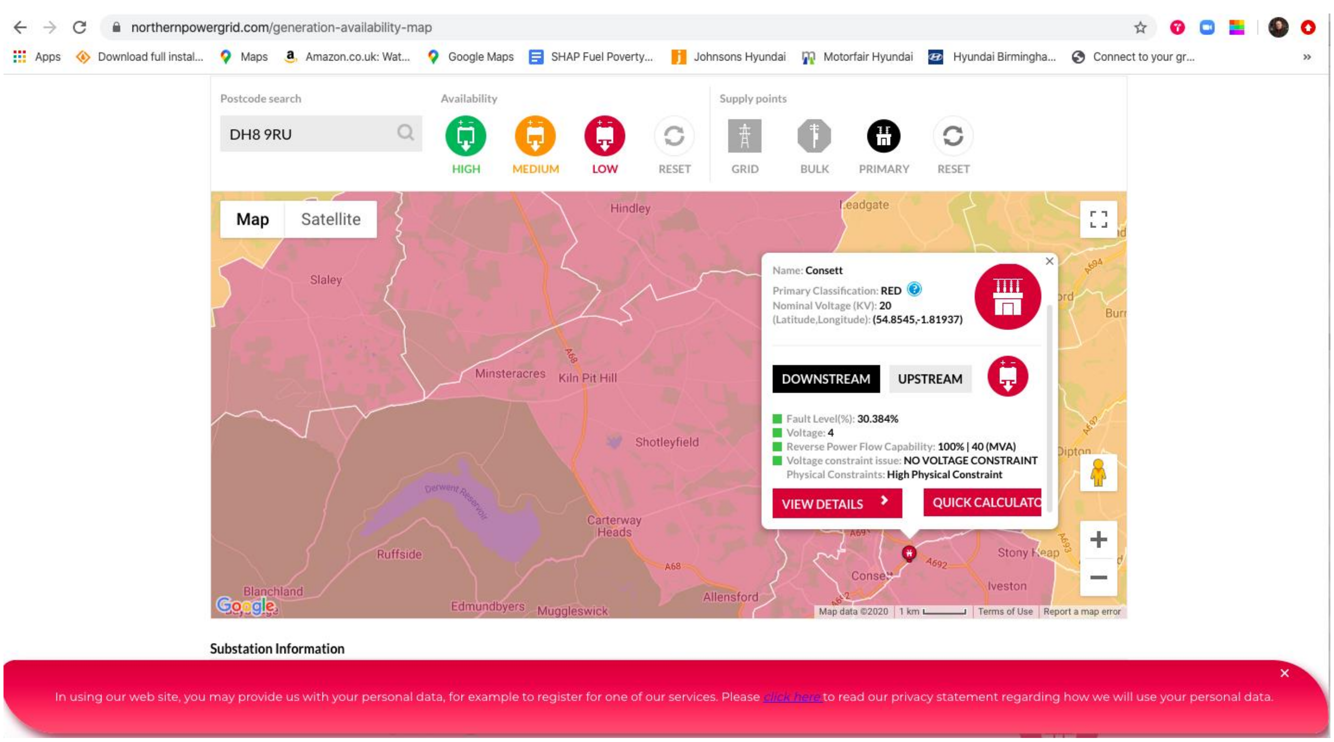
On-grid vs Off-grid

The following map shows that Minsteracres is in an area where capacity for connecting renewable electricity generation to the National Grid is limited.

This means that if you had a grid-connected wind or solar farm, then the cost of reinforcing the grid locally would need to be factored into the cost of the wind or solar farm.

If, however, you had an off-grid solar or wind farm, then reinforcement costs would not be a factor.

Figure 17



4.6.iii Ownership options

Renewable energy cooperatives are an established and successful way to raise funds and transfer risks on renewable energy projects.

They can raise funds through community share issues. This is where repayable, non-transferrable and dividend-bearing shares are issued – either directly by the renewable energy cooperative itself, or more commonly, through an ethical investment platform (such as Sharenergy, Abundance Investment or Ethex). Such shares can be issued through an ISA envelope, which creates a fiscal incentive for ethical investors. The cooperative then sells renewable electricity or heat to the property owner.

The advantage for property owners such as yourselves is that the cooperative takes all the development, financial and operational risks away from you. Your organisation benefits by reducing its greenhouse gas emissions, making progress towards energy independence, and by buying renewable electricity at a cheaper rate than you would otherwise buy through a regular electricity supplier.

PowerPaired is a renewable energy match-making service that pairs asset owners with community energy groups. [16] This could be a way for renewable electricity generation to be developed at Minsteracres by a third party, mimimising development and operation risks for the Province.

4.6.iv Rural Community Energy Fund (RCEF)

The Rural Community Energy Fund could meet the cost of a full feasibility study into renewable energy options at Minsteracres.

More information can be found at https://www.gov.uk/guidance/rural-community-energy-fund.

Please note that the RCEF is available in England only (and therefore could not be used for St Non's).

4.6.v BEST funding

The Narec Distributed Energy report into renewable energy at Minsteracres refers to the availability of capital grant funding through the BEST Project (Business Energy Saving Team). This appears to be available during 2020. Therefore, it would be suitable for quick wins such as the extension of the biomass system, which could be completed by the end of 2020.

It would also be suitable for a 14.4 kW rooftop solar electricity project, although this would need planning permission, and so you would need to move quickly to be able to access this funding by the end of 2020.

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[16] www.powerpaired.org

Developing a wind energy or solar electricity project at Minsteracres would not be complete by the end of 2020 either due to planning issues. Therefore, it would be unlikely that you could use BEST funding towards these projects.

BEST funding could also potentially be used towards a ground source heat pump or solar thermal project at Minsteracres. However, if you received this funding it is likely that it would make you ineligible for the Renewable Heat Incentive. If it comes to a choice between BEST funding of up to £24,999 and the Renewable Heat Incentive, then a careful comparison of the pros and cons of the two sources of finance would need to be made.

4.6.vi Durham County Council

Funding may be available through Durham Council for some of the actions recommended in this report. [17]

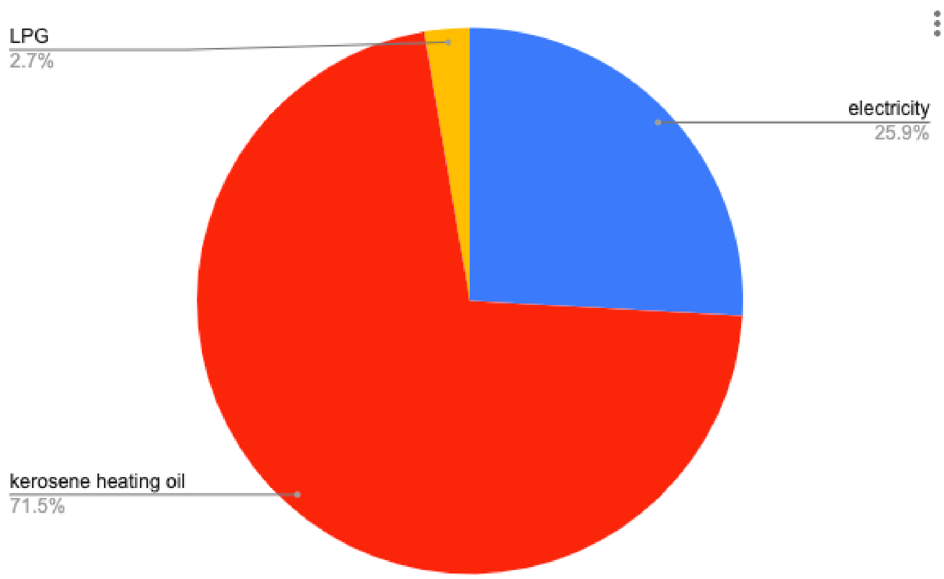
5. St Non's, SA62 6BN

5.1 Baseline, St Non's Retreat Centre, SA62 6BN

Energy use (all fuels)	361 kWh per m^2
Carbon dioxide emissions per m^2	93.2 kg CO^2 per m^2
Total carbon dioxide emissions	36,518 kg CO^2
Water use	190 Litres per person per day

Figure 18

[17] https://www.durham.gov.uk/beep



Key observations:

- *Very high energy use per m²*
- *Very high greenhouse gas emissions.*
- *Very high greenhouse gas emissions per m²*
- *Space and water heating, and lighting, are the key sources of greenhouse gas emissions.*

The building is not listed but is located in the Pembrokeshire Coast National Park.

5.2.i Building fabric, St Non's Retreat Centre, SA62 6BN

	**Observations of current situation**	**What actions can you take to improve?**
Walls	Uninsulated solid walls. Thermography shows substantial heat loss through walls Scaffolding was in situ on the south elevation of the building when we visited, as repairs are being carried out to prevent water ingress	***Energy Hierarchy Goal: Use energy efficiently*** External wall insulation to the whole building would be the most effective way to limit heat loss from the building. The insulation could be overlaid with natural stone cladding to replicate the original appearance of the brickwork. Internal Wall Insulation could alternatively be fitted throughout the building; this would be more disruptive and may not be as effective as external wall insulation in preventing heat loss. Internal wall insulation should be fitted to the interior

	from rain and prevailing winds.	of the dormer windows on the top floor.
Roof area(s)	Pitched roof was replaced in 2014 Loft space in the east wing is partly insulated with 100mm of insulation (including under boards). Insulation is incomplete, with gaps, in all areas of the loft, especially under the eaves. The loft hatch is also uninsulated. The loft space in the west wing is believed to have similar levels of insulation to the east wing. Thermography shows heat loss from pitched roof, and in particular from the eaves, and through chimneys. The building also has some areas of flat roof - thermography shows little heat loss from these areas as they are unheated areas of the building.	***Energy Hierarchy Goal: Use energy efficiently*** Both loft areas - top up loft insulation to 300mm, ensuring no gaps in insulation; it is particularly important to insulate around the eaves, as they are prone to thermal bridging. Insulate the loft hatch. Alternatively, insulation could be installed under the rafters, as in this example How to Insulate Timber Rafters Due to the condition of the ladder to the east wing loft, it would need to be replaced in order to allow proper access for the work to be carried out. Install chimney balloons to prevent heat loss from chimneys.
Doors and windows	There is a mixture of double-glazed and single-glazed windows and doors. The south elevation has all been double-glazed due to the prevailing winds and rain. East elevation	***Energy Hierarchy Goal: Use energy efficiently*** Replace all single-glazed windows with double-glazed windows. Sash windows and windows with aluminium frames are a priority for replacement, as they have most heat loss. The round decorative window in the Chapel is single-

	ground floor is also double-glazed. Other windows are single-glazed; most window frames on the north and west elevations are aluminium, which is particularly poor. The west elevation of the east wing has sash windows, which are also particularly poor. The "cames" on the Chapel window (the metallic pieces holding the small panes of glass together) also have very high heat loss. Thermography shows substantial heat loss through single-glazed windows.	glazed; it would be a challenge to design a double-glazed version of it; secondary glazing would have less impact on its visual appearance. Other decorative windows in the Chapel would prevent a similar design challenge. If it proves impossible to replace the decorative windows with double-glazed replicas, then smart zoned heating controls should be used to ensure the Chapel is only heated when in use.
Floors	There is no cellar. There were no noticeable gaps between floors and walls through which heat could escape.	
Preventing heat loss from radiators	Radiators on outside walls do not have radiator reflective foil; no radiators have radiator shelves.	***Energy Hierarchy Goal: Use energy efficiently*** Fit radiator reflective foil behind all radiators on external walls; fit radiator shelves above all radiators on both internal and external walls.

5.2.ii Primary heating system at St Non's Retreat Centre, SA62 6BN

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat	New 64 kW kerosene boiler fitted 2019, replacing 2	***Energy Hierarchy Goals: Use energy efficiently; use lower carbon energy***

source	smaller kerosene boilers. Very good condition. There are no secondary heating sources in the building.	The lowest carbon option would be to insulate the building as in 5.2.i above, and to install a ground source heat pump, with onsite generation of wind and solar to power the heat pump. The kerosene boiler could be retained for hot water. Alternatively, the kerosene boiler could be replaced with an LPG hot water boiler for a slightly lower-carbon option. Solar thermal could be installed to preheat the water and reduce the input of fossil fuels. Alternatively, if wind and/or solar power were available, the existing electric immersion heater could be used for hot water and charged at times that wind/solar/off peak grid electricity was available. Another low carbon heating option would be to replace the kerosene boiler with a biomass boiler for space heating and hot water.
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	Heating controls are used effectively but are not adequate to manage and control heat demand. Timer/programmer in use TRVs throughout Large parts of the building are over-heated when unused.	***Energy Hierarchy Goal: Use energy efficiently*** Upgrade to smart, zoned heating controls to give maximum control over which parts of the building are heated, and at what times. This would help to balance the supply of heat to the building (for example, on the day I visited, the south-facing rooms were noticeably warmer than the rest of the building). Bleed radiators throughout the building regularly.

	The building is under-occupied in December and January but is over-heated during this time. Some radiators not emitting heat evenly	
	The Chapel has a very high ceiling, and stratification of air is causing heat to be wasted	***Energy hierarchy goal: use energy efficiently*** A destratification fan would reduce heat loss. It would need to be switched on when the chapel was empty but heat was still needed; it could be turned down while people were in the chapel.

5.2.iii Hot water systems at St Non's Retreat Centre, SA62 6BN

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Description, age and condition of hot water source	New 64 kW kerosene boiler fitted 2019, replacing 2 smaller kerosene boilers. Very good condition. New hot water cylinder.	***Energy Hierarchy Goal: Use lower carbon energy*** If a Ground Source Heat Pump were installed, a smaller hot water boiler would supply hot water to the existing cylinder instead of the kerosene boiler. LPG would be a lower carbon fuel than kerosene for this boiler. Solar thermal could be installed to preheat the water and reduce the input of fossil fuels. Alternatively, if wind and/or solar power were available, the existing electric immersion heater could be used for hot water and charged at times that wind/solar/off peak grid electricity was available. Another low carbon option would be to replace the kerosene boiler with a biomass boiler for space heating and hot water.

Is the hot water source regularly serviced/ maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Yes, the hot water controls are adequate.	
Are there any leaks from hot water pipework?	None were observed.	

5.3.iv Lights and lighting controls at St Non's Retreat Centre, SA62 6BN

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve it?**
Description, age and condition of lamps	There is a mixture of lamp types throughout the building (and its exterior) of incandescents (including bulkheads and fluorescents), halogen lamps, CFLs and LEDs	***Energy Hierarchy Goal: Use energy efficiently*** Replace non-LED lamps with LEDs. Fluorescent tubes are a priority, as are halogen lamps. Not forgetting to include bathroom vanity lights and external lighting.
Is use of natural light made where available?	Yes	Sunpipes could be fitted in some rooms on the top floor to reduce the need for electric light. Sunpipes should not be fitted in bedrooms as they can keep people awake on summer mornings.
What lighting controls are present? Are they adequate?	On/off switches only, including in corridors. No "turn it off" stickers were observed.	***Energy Hierarchy Goal: Use less energy*** Upgrade to smart intelligent lighting controls. Put up "turn it off" stickers.

5.3.vi Kitchen and utility room appliances, St Non's Retreat Centre, SA62 6BN

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age, energy rating, and condition of appliances	Main kitchen: Gas tumble dryer Electric appliances are reasonably modern Gas cooker hood does not have a variable speed drive Sisters' living area kitchen A+ rated freezer and fridge, jug kettle Washers/dryers in Sisters' utility room are not used	***Energy Hierarchy Goal: Use energy efficiently*** Replace with most efficient appliances when they wear out. Install a variable speed drive to the cooker hood.
Are fridges/freezers defrosted? Are they kept full when in use?	Yes	
Can washing be dried outside?	There is a washing line, but the wind is so strong sometimes that the wind blows the washing off the line, so they use the gas tumble dryer.	
Horticultural use of water	There is no horticulture on site.	
Urns and kettles	Urns and hot water boilers are in use in meeting areas in preference to kettles; there appear to be no kettles in bedrooms.	
Other	Kitchen in Sisters' living area does not have washing up bowl.	***Energy Hierarchy Goal: Use energy efficiently*** Buy a washing up bowl.

	2 fridges in main kitchen in same room as the gas cooker.	Fridges can't realistically be moved elsewhere. Consider options for relocating fridge contents to locations away from the gas cooker. There is a small fridge in the Dining Room that is currently turned off.

5.3.vii Bathroom appliances at St Non's Retreat Centre, SA62 6BN

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Showers	Most showers fed by kerosene boiler Some 9kW electric power shower with water saving shower head	***Energy Hierarchy Goals: Use energy efficiently; use lower carbon energy*** Replace shower heads with water saving shower heads. Put shower timers and stickers asking guests to take 4-minute showers in all shower rooms and in guest literature. The lowest carbon option would be to have showers fed from a low carbon heat source e.g. immersion heater powered by wind or sun; immersion heater with solar thermal; biomass boiler.
Toilet flushing	All toilets are single-flush with no water displacement devices.	***Water Hierarchy Goal: Reduce*** Install water displacement devices ("Hippos"). Replace toilets with dual-flush or composting toilets.
Taps	Manual controls only.	Install flow restrictors on taps. Replace taps with self-closing taps with motion sensors.
		Energy Hierarchy Goal: Reduce demand for energy Waste Water Heat Recovery Systems (WWHRS) should be considered for pre-heating the water used by the boiler-fed

		showers. The emissions savings will be higher if kerosene continues to be used to heat up water. If kerosene is replaced by a renewable fuel such as woodchip or solar to heat hot water, then the emissions savings will be lower.

5.3.viii Possibilities for generating renewable heat and electricity at St Non's Retreat Centre, SA62 6BN

Whilst St Non's has very high greenhouse gas emissions, the locality has been blessed with an abundance of potential renewable energy sources – wind, solar, ground source heat, wave, and tidal, among others. If one or more of these sources of energy can be harnessed, then it could make substantial inroads into St Non's greenhouse gas emissions.

Your current demand for space heating and hot water at St Non's is 100,488 kWh. This is met by a 64kW kerosene boiler.

Renewable heat at St Non's

Options for renewable space and water heating are:

Heat Option 1: ground source heat pump *(space heating only - separate source of water heating required)*

The Kerosene boiler could be replaced by a ground source heat pump of similar size. The building will need to be insulated to bring its U-values up to the standard of the current building regulations for a heat pump to work effectively. A trench could be dug to the east of the building; a borehole is a possible alternative.

Current demand for hot water at St Non's is estimated to be 30,000 kWh per annum. A ground source heat pump would **not** be able to meet this demand and a separate source of hot water would be necessary if this option was chosen. (These are listed below.)
It should be noted that St Non's has a single-phase electricity supply. Therefore, an upgrade to a three-phase electricity supply would normally be needed to power a heat pump. Alternatively, some heat pump manufacturers will fit devices to convert single-phase power to three-phase. [18]

A ground source heat pump can also be used for cooling; e.g. to cool unheated areas of the building that are used for storing ambient food, or for refrigeration.

Heat Option 2: biomass

[18] https://www.kensaheatpumps.com/heat-pumps-and-single-phase-electricity/

The Kerosene boiler could be replaced by a biomass boiler. The boiler would be located in the current boiler room and would supply space heating and hot water to the whole building. A full feasibility study should be undertaken.

Impact of action on greenhouse gas emissions

The current emissions from kerosene space and water heating at St Non's are 26,101 kg.

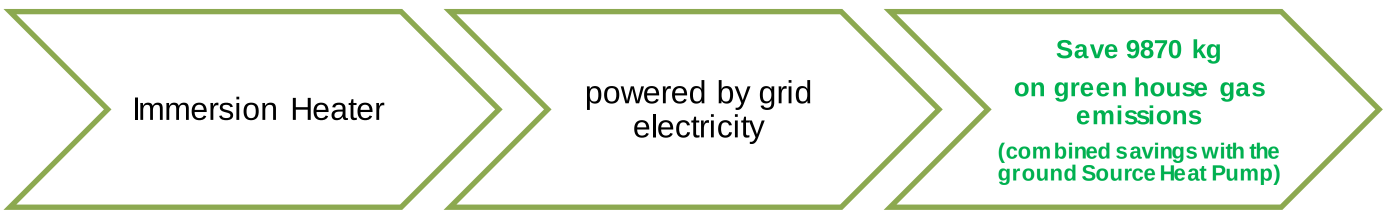
Replacing the Kerosene boiler with a ground source heat pump and immersion heater powered by wind and solar, would save 26,101 kg of greenhouse gas emissions.

Replacing the Kerosene boiler with a biomass boiler, would save 24,530 kg of greenhouse gas emissions.

Possible hot water sources (if ground source heat pump option is used for space heating):

Heat Option 1a: existing electric immersion heater

Figure 19

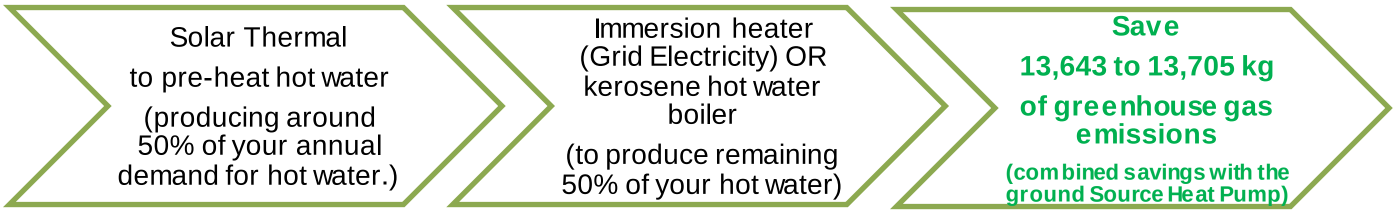


Heat option 1b: existing kerosene boiler

Figure 20

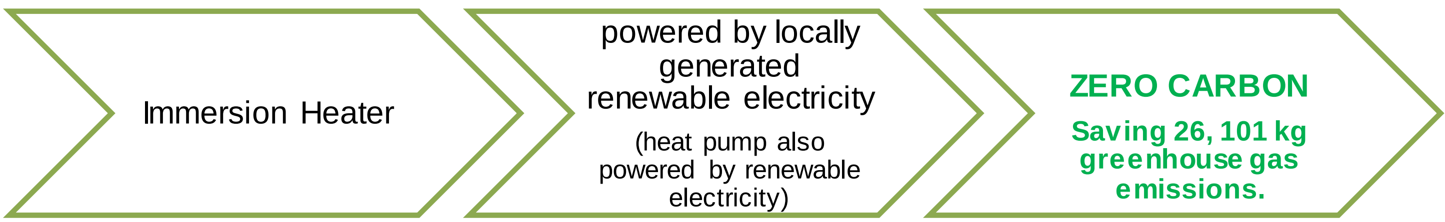
Heat option 1c: new solar thermal

Figure 21



Heat option 1d: immersion heater with locally generated renewable energy (making St Non's self-sufficient)

Figure 22



Heat option 1e: woodchip boiler (to replace existing kerosene boiler)

Figure 23

The most low-carbon and sustainable option is to insulate the building; install a ground source heat pump with electric immersion heater, powered by locally generated electricity from wind and solar.

Renewable electricity

Renewable Electricity Option 1: ground-mounted solar farm

Since the roof space at St Non's is relatively small, a way of generating larger amounts electricity from the sun is a ground-mounted solar farm. This would enable you to generate more of your own electricity than roof-mounted solar, with lower build and maintenance costs.

Renewable Electricity Option 2: ground-mounted solar farm plus wind turbine

The two ways of generating large amounts of renewable electricity at St Non's, namely wind, and ground-mounted solar PV, are not mutually exclusive. Having a combination of wind and ground-mounted solar PV could enable you to generate electricity at all times of the day and night, throughout the year.

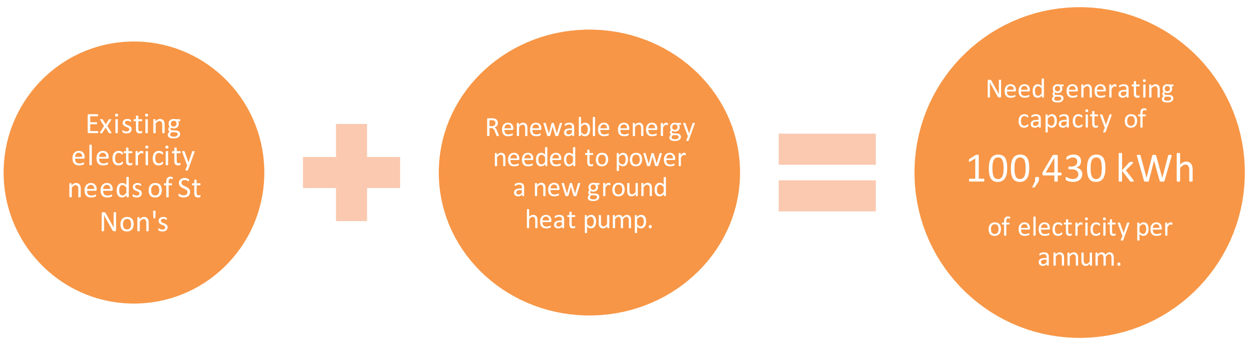
Renewable Electricity Generation Needs at St Non's

With battery storage, you could be independent of the grid for your electricity. Your renewable electricity could help to power both your lighting and other electrical appliances on site, as well as heat generating appliances (such as the options outlined in the section above).

The diagrams below show how much electricity you need to generate per annum at St. Non's.

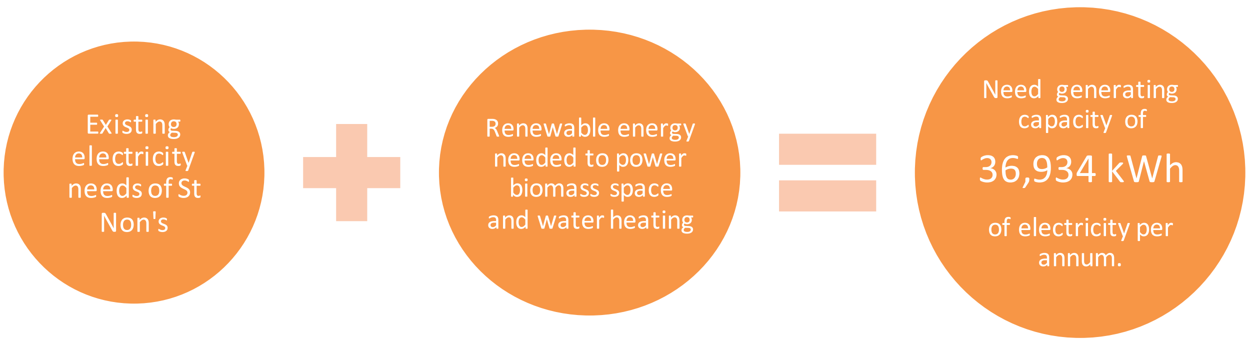
Zero-Carbon Option:

Figure 24



Next Lowest Carbon Option:

Figure 25



How to generate Renewable Electricity to meet St Non's needs

- **50 kW wind turbine** – expected to produce approximately 80,000 kWh per annum at an average wind speed of 5 metres per second.

- **A 50 kW solar farm** – could be expected to produce approximately 47,000 kWh of electricity per annum. An area of land approximately 310 square metres (e.g. 18m x 17m) would be needed.

- **A 50 kW wind turbine plus a 50 kW solar farm could therefore meet all your electricity generation needs,** provided there were sufficient battery storage to meet peak demand (e.g. for space heating on winter evenings).

A mixture of wind and solar electricity with battery storage would be the best way of ensuring that St Non's would be **zero carbon**, day and night – and throughout all seasons of the year. There would be little or no use of grid electricity. Wind turbines produce most energy during the colder months and at night (which is when your electricity demand for heating is highest), while solar farms produce most energy during the sunnier months and during daylight. Battery storage helps to iron out the intermittency of renewable energy generation.

Alternative Options:

There are three other sources of renewable electricity within a short distance of St Non's. These would be more technically complex than wind or solar but are worth further exploration.

These are:
- hydro power (from the River Alun, 1 km away);
- wave power; and
- tidal power (both from the sea nearby).

Location

Below is a map showing potential locations for a solar farm (grey rectangles) and a wind turbine. This is a broad-brush map and is not intended to be a substitute for a full feasibility study.

Figure 26

Feasibility

A full feasibility study into the potential for ground source heat pump, biomass, wind and solar should be undertaken for St Non's. This could also include wave power, tidal power and hydro power.

Terms of reference for the feasibility study would include:

Heat demand

- The demand for space heating and hot water at St Non's should be properly modelled, including the impact of energy saving actions such as insulation and smart heating controls.

Ground source heat pump for space heating

- What size heat pump would be needed to meet heat demand?
- Is the heat distribution system, including radiators, adequate for a GSHP?
- Are there any parts of St Non's suitable for retrofitting underfloor heating?
- Is there space for laying a slinky coil or for a borehole?
- Is the ground suitable for a slinky coil or borehole? This may involve a separate geotechnical survey.

- Is the electrical supply suitable for a GSHP?
- Could the GSHP be used for cooling, e.g. to unheated areas where refrigeration equipment is kept?
- What would be the costs of installing a GSHP?
- Would the GSHP qualify for the Renewable Heat Incentive?
- Could a slinky be self-installed, reducing the installation costs?

Biomass for space and water heating

- What type of biomass boiler and what size boiler would be needed to meet heat and hot water demand?
- Would wood pellets be a suitable feedstock in terms of fuel quality?
- Consultation with planning authorities (including National Park) over flue appearance
- Vehicular access for delivery of fuel
- Plant space and fuel storage
- Costs of project
- Sources of funding including RHI, Welsh Government Energy Service

Electricity generation - wind, solar, hydro, wave, tidal.

- What can we learn from case studies of relevant wind energy projects?
- Stakeholder engagement
- Choosing suitable turbine(s)/solar panels; system size, location, income, grid connection or off-grid
- Local use of electricity
- Impact assessments
- Warranties
- Business planning
- Planning permissions
- Lease agreements
- Licences
- Energy Services Cooperative ownership options
- Raising capital
- Community share issue
- Procurement
- Installation
- Commissioning
- Maintenance
- Income distribution
- Decommissioning
- Repowering

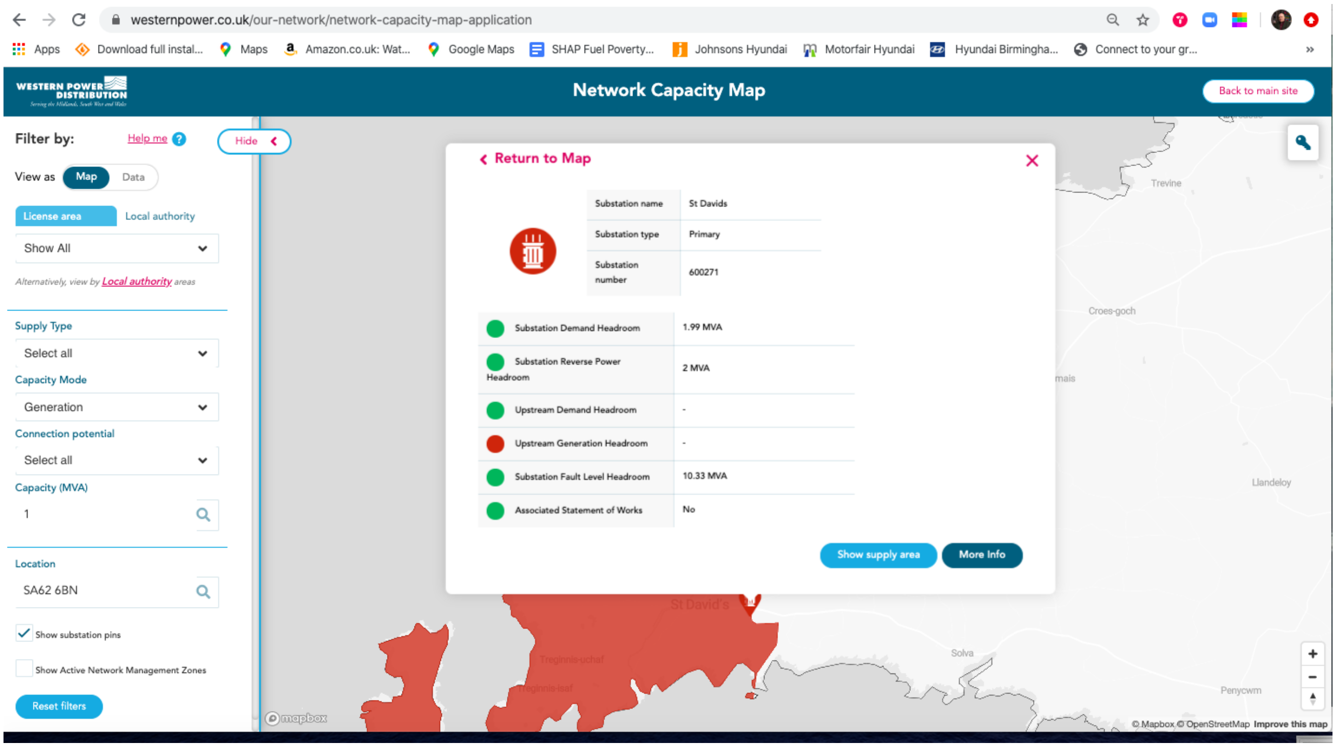
Solar thermal

- Choosing suitable panels, system size, location, income
- Planning permissions
- Warranties
- Lease agreements
- Licences
- Energy Services Cooperative ownership options
- Raising capital
- Community share issue
- Procurement
- Installation
- Commissioning
- Maintenance
- Income distribution
- Decommissioning
- Repowering

On-grid vs Off-grid

The following map shows that the capacity of the grid near St Non's for additional renewable electricity generation is limited. Therefore, if you built a grid-connected wind or solar farm, the cost of reinforcing the grid may need to be built into the cost of a wind or solar farm. If, however, you went for an off-grid wind turbine or solar farm, then there would be no costs for reinforcement of the national grid.

Figure 27



5.3.ix Ownership options

Renewable energy cooperatives are an established and successful way to raise funds and transfer risks on renewable energy projects.

They can raise funds through community share issues. This is where where repayable, non-transferrable and dividend-bearing shares are issued – either directly by the renewable energy cooperative itself, or more commonly, through an ethical investment platform such as Sharenergy, Abundance Investment or Ethex. Such shares can be issued through an ISA envelope, which creates a fiscal incentive for ethical investors. The cooperative then sells renewable electricity or heat to the property owner.

The advantage for property owners such as yourselves is that the cooperative takes all the development, financial and operational risks away from you. Your organisation benefits by reducing its greenhouse gas emissions, making progress towards energy independence, and by buying renewable electricity at a cheaper rate than you would otherwise buy through a regular electricity supplier.

PowerPaired is a renewable energy match-making service that pairs asset owners with community energy groups. [19]

5.3.x Welsh Government Energy Service

[19] www.powerpaired.org

The Welsh Government Energy Service supports community groups (including charities) in Wales to develop energy efficiency and renewable energy projects that will lower carbon emissions and provide cost savings, income generation and wider community benefits. Launched in October 2018, the service provides financial and technical support to help public sector and community groups across Wales to develop their own renewable energy schemes. I recommend that you apply to the Energy Service to undertake a feasibility study as outlined above.

The Welsh Government Energy Service also helps with the capital costs of renewable energy schemes that go ahead.

5.3. Xi Voltage Optimisation

Voltage optimisation could be an option for St Non's, if a ground source heat pump is installed. Without a heat pump, voltage optimisation would be less worthwhile. An installer of voltage optimisation should be asked to come out and measure the voltage going into the building, and identify any savings to be made from voltage optimisation.

5.4 Priorities for action at St Non's Retreat Centre, SA62 6BN

1. **Insulate the walls; external wall insulation is preferable, internal wall insulation is an alternative;**
2. **Extra insulation in both loft areas;**
3. **Replace single-glazed windows with double-glazed windows where possible; priority to sash windows and aluminium frames;**
4. **Replace the kerosene oil boiler with lower carbon alternatives e.g. ground source heat pump and immersion heater powered by wind and solar energy; biomass.**
5. **Smart, zoned heating controls;**
6. **Replace non-LED lamps with LEDs; priority to fluorescent tubes;**
7. **Upgrade to smart, intelligent lighting controls throughout;**
8. **Replace shower heads with water and energy saving shower heads;**
9. **Install water displacement devices in toilets, or replace all toilets with dual-flush or composting toilets;**
10. **Install flow restrictors on bathroom taps or replace taps with self-closing taps with motion sensors.**
11. **Undertake a feasibility study into generating renewable electricity locally from wind and/or sun.**

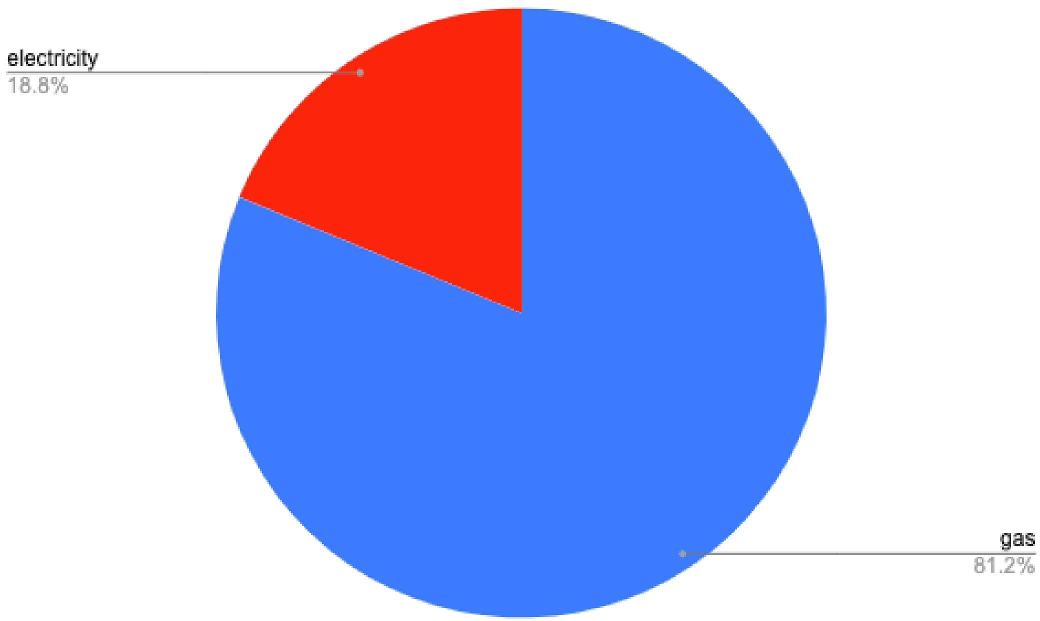
6. The Retreat, Main House, Herne Bay, CT6 8SP

6.1 Baseline - The Retreat, Main House, Herne Bay, CT6 8SP

Energy use (all fuels)	197.6 kWh per m^2

Carbon dioxide emissions per m^2	41.9 kg CO^2 per m^2
Total carbon dioxide emissions	25,402 kg CO^2
Water use	190 Litres per person per day

Figure 28



Key observations – The Retreat:

- *High energy use per square metre*
- *High greenhouse gas emissions*
- *Very high greenhouse gas emissions per square metre*
- *Space and water heating are responsible for most of your greenhouse gas emissions*
- *Listed building with limited opportunities for improving the fabric of the building.*

6.2.i Building fabric, The Retreat, Main House, Herne Bay, CT6 8SP

	**Observations of current situation**	**What actions can you take to improve?**
Walls		***Energy Hierarchy Goal: Use energy efficiently***

	Uninsulated solid walls. Thermography shows substantial heat loss through walls.	Internal wall insulation. Internal walls have little clutter on them and are suitable for IWI throughout the building.
Roof area(s)	No loft space. Flat roof with equipment on top. Roof assumed uninsulated as built.	
Doors and windows	Single-glazed throughout. Skylight to roof.	***Energy Hierarchy Goal: Use energy efficiently*** Secondary glazing of windows throughout. Replacement of skylight with double-glazed skylight.
Floors	There are two uninsulated cellar spaces of approximately 8m x 4m each, thermography shows minimal heat loss through floor.	
Preventing heat loss from radiators	No radiators have reflective radiator foil or radiator shelves.	***Energy Hierarchy Goal: Use energy efficiently*** Radiators should be fitted with radiator shelves. Where radiators are on external walls, they should be fitted with reflective radiator foil.
Other	Heat is escaping from the Main House to the Church via the unheated corridor that connects the two buildings.	***Energy Hierarchy Goal: Use energy efficiently*** An internal door should be fitted in this corridor to prevent heat loss from the Main House to the Church, subject to fire risk assessment.

6.2.ii Primary heating system at The Retreat, Main House, Herne Bay, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**

Description, age and condition of primary heat source	2 x Vaillant system boilers. Very new and in very good condition. Gas consumption has fallen by 7.8% per annum, which, notwithstanding other factors such as occupancy factors and weather, is likely to be caused by having new boilers.	***Energy Hierarchy Goal: Use lower carbon energy*** District heating or District Micro-CHP system for the whole site, including Church, hall, club, cottage. *See 6.2.viii for further explanation.*
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	No - manual programmer and timer only. Building is under-occupied and empty rooms are heated throughout. Room thermostat located in corridor. All radiators have TRVs.	***Energy Hierarchy Goal: Use energy efficiently*** Upgrade to fully smart, zoned heating controls.
Heat loss from radiators	No radiator foil or radiator shelves present.	***Energy Hierarchy Goal: Use energy efficiently*** Radiator shelves should be fitted to all radiators. Radiator reflective foil should be fitted to all radiators on external walls.
	The Chapel has a very high ceiling, causing heat to be wasted through stratification.	A destratification fan would reduce heat loss. It would need to be switched on when the chapel was empty but heat was still needed; it could be turned down while people were in the chapel.

6.2.iii Secondary heating systems, The Retreat, Main House, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of secondary heat source	Portable electric radiators and fan heaters were observed in some rooms,	***Energy Hierarchy Goals: Use less energy; use energy efficiently*** Portable electric radiators and fan heaters should be discouraged as they are higher carbon than gas. Smart, zoned heating controls would help to keep the right areas at the right time, benefitting vulnerable residents who are likely to need more space heating at different times, and make portable electric radiators less necessary.

6.2.iv Hot water systems at The Retreat, Main House, Herne Bay, CY6 8SP

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of hot water source	2 x Vaillant system boilers. Very new and in very good condition. 2 x 210 litre unvented hot water cylinders. These cylinders are uninsulated and are giving off a large amount of heat. Uninsulated hot water pipes in the boiler cupboard are also giving off a large amount of heat. Thermography shows substantial heat loss. Gas consumption patterns between summer and winter	***Energy Hierarchy Goal: Use energy efficiently*** Insulate the hot water cylinders and pipework.

	are flatter than expected, this is likely to be due to excessive gas being used for hot water as the cylinders and pipework are uninsulated.	
Is the hot water source regularly serviced/ maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Programmer and timer in use.	
Are there any leaks from hot water pipework?	None observed.	

6.2.v Lights and lighting controls at The Retreat, Main House, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of lamps	Lamps are a mixture of: fluorescents, incandescents, halogens, CFLs, LEDs.	
Is use of natural light made where available?	Yes	Sunpipes could be fitted to corridor areas and en-suites on first floor to reduce the need for electric lighting.
What lighting controls are present? Are they adequate?	On/off switches only, including in corridors. No “turn it off” stickers were seen.	***Energy Hierarchy Goal: Use energy efficiently*** Upgrade to smart, intelligent lighting controls. Fit “turn it off” stickers by light switches. Label light switches.

6.2.vi Kitchen and utility room appliances, The Retreat, Main House, Herne Bay, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age, energy rating, and condition of appliances	Appliances are fairly modern (e.g. washing machine, dishwasher) apart from Hotpoint dishwasher which is quite old, and the dining room fridge/freezer which is quite old.	***Energy Hierarchy Goal: Use energy efficiently*** Replace dishwasher and dining room fridge/freezer with more modern, efficient models. Install variable speed drive to cooker hood.
Are fridges/freezers defrosted? Are they kept full when in use?	Yes	
Can washing be dried outside?	Yes	

6.2.vii Bathroom appliances at The Retreat, Main House, Herne Bay, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Showers	Showers run off gas boiler.	***Energy Hierarchy Goal: Use energy efficiently*** Insulate hot water cylinder and pipework. Fit energy and water saving shower heads. Put up shower timers and signs encouraging users to limit showers to 4 minutes.
Toilet flushing	Mostly single-flush No displacement devices fitted.	***Water Hierarchy Goal: Reduce*** Fit displacement devices ("Hippos") in cisterns. Replace toilets with dual-flush or composting

		toilets.
Taps	Bathroom taps have manual on/off controls only.	***Water Hierarchy Goal: Reduce*** Fit flow restrictors to taps. Replace taps with self-closing taps with motion sensors.
		Energy Hierarchy Goal: Reduce demand for energy Waste Water Heat Recovery Systems (WWHRS) should be considered for pre-heating the water used by the showers. As mains gas is likely to be the fuel used to heat up water in future, then WWHRS would save a substantial amount of greenhouse gas emissions here, although it remains a relatively expensive measure.

There is greater evidence of wasteful behaviours at this property than is the case at your other buildings.

These include:

- Tea towels being dried on a radiator;
- Washing up being done under a running tap;
- Printer left switched on when not in use;
- Windows being left open in an overheated room on a cold day.

6.2.viii Potential for district heating or district micro-chp across the whole site

The Herne Bay site has five buildings with five separate heating systems. Two of the heating systems are modern and efficient (main house and bar); the other three are inefficient (hall, Church, cottage). Of the three inefficient systems, two of them would benefit from being replaced (Church and hall), while the third (cottage) is barely used and replacing it would have little impact.

Instead of having five separate heating systems, the Herne Bay site could be suitable for a district heating system, where a single heat source provides space and water heating to the whole site.

This achieves efficiencies by:

- Eliminating the waste that arises from having four or five separate heating systems firing up at different times of the day.
- Balancing the heat demands of different types of building at different times of the day, night, and week.

District heating can use biomass or mains gas as a fuel source. If mains gas is used, then district heating is one of the most low carbon uses of mains gas, lower than individual gas boilers.

In a district heating system, insulated pipework carries heat from the heat source to the different parts of the site. The pipework can be buried underground between buildings.

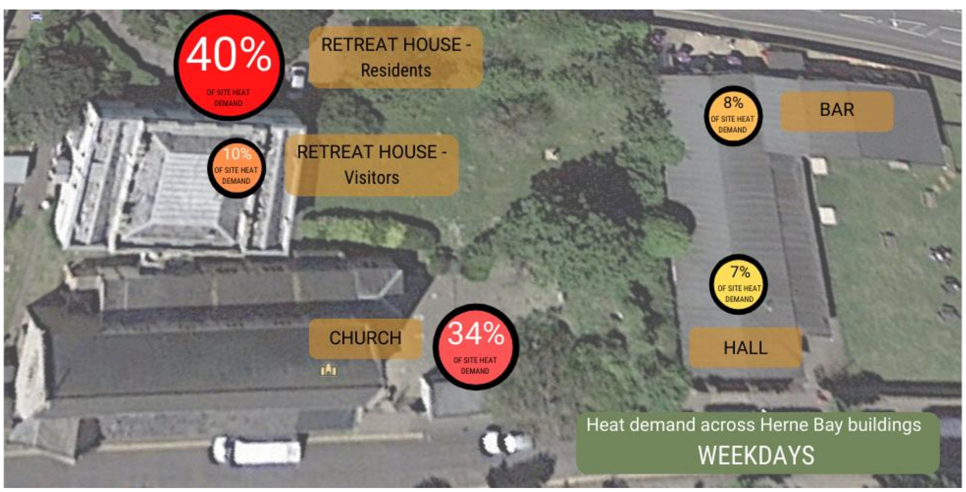
A district heating system can have more than one heat input. At Herne Bay, it would be worth retaining one of the more efficient boilers (e.g. in the bar or the main house) as a back-up for peak times, or to provide hot water during periods of low demand.

Micro-CHP (micro combined heat and power) is similar to district heating in being able to supply a whole estate, however micro-chp also produces a small amount of electricity as a by-product. This electricity would have lower greenhouse gas emissions than grid electricity.

The following three maps show the estimated heat demand in the various buildings across the Herne Bay site on weekdays, week evenings, and weekends. [20]

The first map shows heat demand on weekdays.

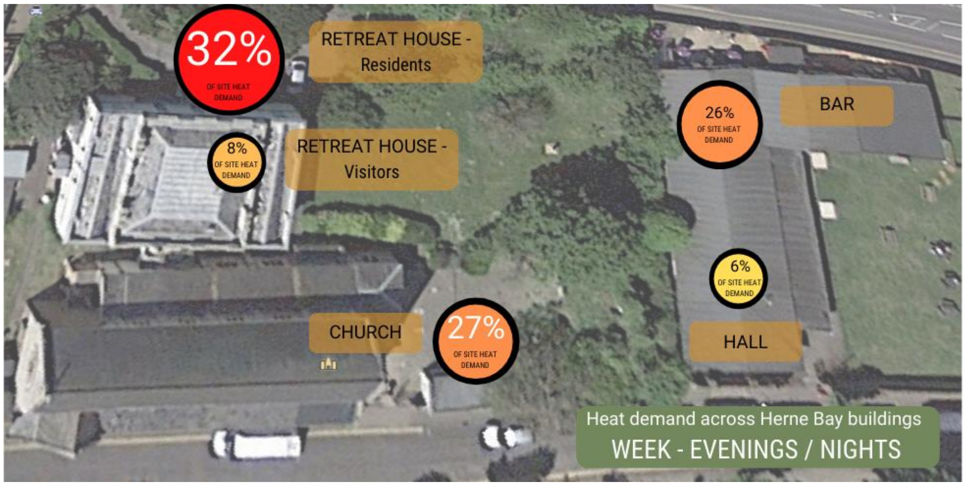
Figure 29



The second map shows heat demand on week evenings/nights. The share of heat used by the bar has increased.

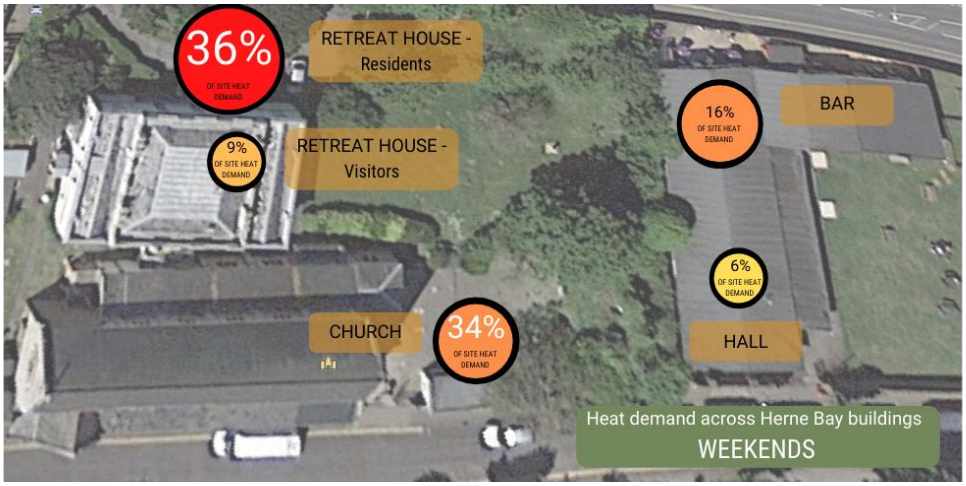
Figure 30

[20] These estimates are based on actual gas consumption and estimated usage of buildings at different times of the day and we week. These figures could be refined relatively easily by taking meter readings over a period of a week during the heating season.



The third map shows heat demand at weekends. Demand for heat in the Church is at its highest. Demand for heat in the bar is also high.

Figure 31



The boiler room in the Church would be a potential location for the central boiler. Heat meters would be installed in each building, so that the Province would bill each building for the amount of heat that they used.

Heating engineers with experience of district heating should be invited to provide quotes. Both mains gas and biomass should be considered as fuel sources.

The following issues need to be taken into consideration if biomass is to be the fuel:

- What type of biomass boiler and what size boiler would be needed to meet heat and hot water demand?
- Would wood pellets be a suitable feedstock in terms of fuel quality?
- Consultation with planning authorities over flue appearance.

- Vehicular access for delivery of fuel.
- Plant space and fuel storage.
- Costs of project.
- Sources of funding including Renewable Heat Incentive.

6.2.ix Priorities for action at The Retreat, Main House, CT6 8SP

1. **Internal wall insulation.**
2. **Secondary glazing.**
3. **Insulate hot water cylinders and hot water pipework.**
4. **Upgrade to smart, zoned heating controls.**
5. **Upgrade to intelligent lighting controls.**
6. **District heating or district micro-CHP for the whole site.**
7. **Fit cistern displacement devices to single-flush toilets or replace toilets with dual-flush toilets.**
8. **Fit flow restrictors to bathroom taps or replace taps with self-closing taps with motion sensors.**
9. **Fit energy and water saving shower heads.**
10. **Educate building users about energy saving behaviours.**

7.0 Other buildings at The Retreat, Herne Bay, CT6 8SP

The following buildings were not on my itinerary of buildings to visit; however, I paid brief visits to them as I was on site, while waiting for it to get dark enough for thermal imaging:

- Hall
- Bar
- Church
- Cottage
- Shop

7.1 Baseline - other buildings at The Retreat CT6 8SP

7.1.i Our Lady of the Sacred Heart Church CT6 8SP - baseline

Energy use (all fuels)	194.3 kWh per m^2
Carbon dioxide emissions per m^2	40.7 kg CO^2 per m^2
Total carbon dioxide emissions	15,254 kg CO^2
Water use	Negligible

7.1.ii Retreat Hall - baseline

Energy use (all fuels)	58.32 kWh per m^2
Carbon dioxide emissions per m^2	12.5 kg CO^2 per m^2
Total carbon dioxide emissions	3860 kg CO^2
Water use	190 Litres per person per day

7.1.i Bar area - baseline [21]

Energy use (all fuels)	181 kWh per m^2
Carbon dioxide emissions per m^2	38.6 kg CO^2 per m^2
Total carbon dioxide emissions	10172 kg CO^2
Water use	Above average [22]

7.2.i Building fabric - The Retreat, Herne Bay CT6 8SP - other buildings

	**Observations of current situation – is it efficient, or wasteful?**	**What actions can you take to improve?**
Walls	Bar and Hall areas have part cavity walls, built 1970s, assumed uninsulated. Church has solid walls, Cottage has solid walls, including kitchen extension.	***Energy Hierarchy Goal – use energy efficiently*** Insulate cavity walls of Bar and Hall areas. Cottage could have external wall insulation, however, streetlight is in the way on the front elevation and also EWI would affect aspect of street, where Church is the neighbouring building. Alternatively, internal wall insulation for the front elevation of the cottage, and external wall insulation on the remainder of the building. However, if occupancy of cottage continues to be low, then insulation will not be cost-effective.
Roof area(s)		***Energy Hierarchy Goal – use energy efficiently***

[21] This is based on an estimate of electricity consumption as no billing data for electricity, and limited metering data, was available.
[22] I have not seen water bills for the Bar; however due to the nature of the urinals and taps in the bathooms, water consumption is likely to be above average.

	Bar and Hall have mostly flat roof - assumed as built in 1970s - one area of pitched roof above unheated entrance hall. Church has uninsulated pitched roof. Cottage has pitched roof, assumed uninsulated.	Insulate flat roof areas on Bar and Hall. Loft insulation could be fitted in cottage, but if it continues to be under-occupied then this would not be a cost-effective action.
Doors and windows	Bar and hall areas - double-glazed throughout. Cottage - single-glazed throughout including door. Church - decorative single-glazed windows.	***Energy Hierarchy Goal – use energy efficiently*** Double glaze cottage windows, but if it continues to be under-occupied then this would not be a cost-effective action.
Preventing heat loss from radiators	Bar area has radiator shelves on all radiators but no radiator reflective foil on radiators positioned on external walls. Gas convector heater downstairs in cottage has metal radiator cover and metal grille.	***Energy Hierarchy Goal – use energy efficiently*** Put radiator reflective foil behind radiators on external walls. Remove metal radiator cover and metal grille, so convector heater can work more efficiently. If it is necessary to protect vulnerable people from scalding, then a guard should be placed around the convector heater that does not prevent heat transfer from the convector heater to the air in the room.

7.2.ii Primary heating systems at The Retreat, Other buildings, Herne Bay, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of primary heat sources	Hall area has Warm Air Boiler, installed 2013. Bar area has new Worcester Bosch condensing combination boiler. Shop has electric on peak heaters. Cottage is heated by 2 gas convector radiators, one upstairs, one downstairs. Church has gas central heating, Stelrad boiler, at least 10 years old and possibly much older. Parts are difficult to obtain.	***Energy Hierarchy Goal – use lower carbon energy*** District heating or District Micro-CHP system for the whole site, including Main House, Church, hall, club, cottage.
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	No Hall area - has timer/programmer but was set to manual on the day of my visit. Room thermostat was set to 30 degrees (this may have been to provide a short-term boost as an activity was about to start).	***Energy Hierarchy Goal – use energy efficiently*** Ensure timer/programmer is used Room thermostat should be set between 18 and 21 depending on the activity It is quite warm behind the bar and this may not be an ideal position for the room thermostat; could it be repositioned to

	Bar area - has programmer/timer in use; room thermostat behind bar Radiators have TRVs. Shop - electric on-peak radiator has on/off switch only. Cottage - downstairs convector heater has timer in use and sign saying don't leave on; upstairs convector heater has on/off switch only. Church - has timer in boiler room and room thermostat in church	somewhere that is heated but cooler than the bar, e.g. corridor? Fit a timer to the on-peak radiator; a night-storage heater would be lower-carbon. Ideally a timer should be fitted to the upstairs convector although if the cottage continues to be underused, then it wouldn't be a cost-effective energy saving action. If a district heating option is viable for the whole site, then fully smart controls would be installed.
Secondary heating sources	I did not see any secondary heating sources in use.	
Stratification of air	The Church has a very high roof, and heat is being wasted due to stratification of air.	***Energy hierarchy goal – use energy efficiently*** A destratification fan would reduce heat loss. It would need to be switched on when the Church was empty but heat was still needed; it could be turned down while people were in the Church. It would need to be sensitively located.

7.2.iii Hot water systems at The Retreat, other buildings, Herne Bay, CT6 8SP

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**

Description, age and condition of hot water source	Hall area has instantaneous electrical water heater in kitchen. Bar area, including kitchen and bathrooms, gets hot water from condensing gas boiler. Hall area bathrooms are believed to get hot water from the Bar's condensing gas boiler. Cottage has instantaneous electric water heater.	***Energy Hierarchy Goal – use lower carbon energy*** Solar thermal, with a hot water cylinder, could be used to pre-heat water for the bar, to reduce the input from the gas boiler. As the bar is not a listed building, it would be a permitted development. If the estate is suitable for district heating, then hot water would be supplied from the district heating.
Is the hot water source regularly serviced/ maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Hall area - kitchen water heater has on/off only. Combination boiler in bar supplies hot water on demand. Cottage water heater has on/off only.	***Energy Hierarchy Goal – use energy efficiently*** Install a timer on the hall area kitchen water heater. If solar thermal were installed, a timer/programmer would be added. A timer would not give cost-effective energy savings as long as the cottage remains underused. If the estate is suitable for district heating then hot water would be supplied from the district heating, with smart controls.
Are there any leaks from hot water pipework?	None observed.	

7.2.iv Lights and lighting controls at The Retreat, other buildings, CT6 8SP

	Observations of current situation – is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of lamps	Hall area bathrooms - LED fluorescents. Hall area - main meeting/activity room - non-LED fluorescents. Bar area - LEDs including beer cellar, LED fluorescent in kitchen. Bar area bathrooms - LED fluorescents and bulkheads. Various external lighting, non-LED bulkheads. Cottage - incandescents and non-LED fluorescents.	***Energy Hierarchy Goal – use energy efficiently*** Replace fluorescents in hall with LED fluorescents. Replace external lamps with LED bulkheads. Replace incandescents and non-LED fluorescents with LED lamps.
Is use of natural light made where available?	Yes	***Energy Hierarchy Goal – use less energy*** As the building has a flat roof, and is single storey, then extensive use of sunpipes could be made to reduce the need for electric lighting.
What lighting controls are present? Are they adequate?	Hall area bathroom LED fluorescents - on/off switches only. Bar area LEDs - on/off only Bar area bathroom LEDs - on/off only.	***Energy Hierarchy Goal – use energy efficiently*** Install PIR (passive infra-red) sensors in bathroom areas in hall and bar.

7.2.v Kitchen and bar appliances, The Retreat, other buildings, Herne Bay, CT6 8SP

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?

Description, age, energy rating, and condition of appliances	Hall area kitchen - gas hob and ovens are reasonably modern. Hall area kitchen extractor fan is quite old. Dishwasher, deep freeze in bar are quite modern. Drinks fridge in bar is on 24/7 but lights off at night.	***Energy Hierarchy Goal – use energy efficiently*** Replace with the most efficient white appliances possible when they wear out. Replace with a heat recovery extractor fan when the current one reaches the end of its useful life. As the contents of the drinks fridge are non-perishable, a timer should be added so that the fridge goes off completely when the bar is shut and comes on a couple of hours before it opens.
Are fridges/freezers defrosted? Are they kept full when in use? Correctly positioned?	Ice-making machine is located in bar area where it is quite warm. Chest freezer in outhouse (used for food bank) - overheats in summer due to transparent corrugated plastic roof.	***Energy Hierarchy Goal – use less energy*** Ideally the ice-making machine should be relocated to the cellar where it is cool This is a good location in winter but a poor location in summer. Options are; add some kind of shading to transparent roof to cool the outhouse; relocate freezer to a cooler location (e.g. cellar in main house).
Can washing be dried outside?	I did not observe a washing machine in any of these buildings.	
Are dishwashers used on a full load?	Yes	Ensure dishwasher continues to be used on a full load.

7.2.vi Bathroom appliances at The Retreat, other buildings, Herne Bay, CT6 8SP

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**

Hand dryers	Hall and bar - Modern blown-air hand dryers.	
Toilet flushing	Hall and bar - Dual flush. Cottage - single flush.	***Water Hierarchy Goal – Reduce*** Add cistern displacement device (“Hippo”) to cottage toilet.
Urinals	Hall and bar - Urinals are not believed to have PIR controls.	***Water Hierarchy Goal – Reduce*** Install PIR controls in gents’ bathrooms to control water flow to urinals.
Taps	Hall and bar - Mostly manual on/off controls only .Some motion-controlled taps - e.g. ladies’ bathroom in bar.	***Water Hierarchy Goal – Reduce*** Fit tap flow restrictors to hot and cold-water taps in bathrooms; or Replace manually-controlled taps with self-closing taps with motion sensors.

7.2.vii Air conditioning at The Retreat, other buildings, CT6 8SP

	Observations of current situation	**What actions can you take to improve?**
Description, age, condition of air conditioning appliances?	3 x new air conditioning units.	***Energy Hierarchy Goal – use lower carbon energy*** Consider solar cooling.
Is the air conditioning regularly serviced/ maintained?	Yes	***Energy Hierarchy Goal – use energy efficiently*** Ensure air conditioning vents are part of the cleaning schedule.
5.3 Are the air conditioning controls adequate? Are they smart?	Not known if variable speed drives are present.	***Energy Hierarchy Goal – use energy efficiently*** Consider a variable speed drive for the air conditioning units.

7.3 Priorities for action at The Retreat, other buildings, CT6 8SP

In addition to the observations above, it should be noted from the energy baseline that:

- The bar area has very high consumption of gas over a period of several years. We can expect this to fall somewhat as the bar has a new condensing boiler. However, the lack of insulation to the building will contribute to this high gas usage.
- The room thermostat is located in the bar, which is not an ideal position.
- Electricity demand in the hall is erratic from month to month and is not in line with the seasonal pattern of consumption that one would normally expect for electricity consumption.
- There are two possible sources of unexpected peaks in electricity demand in the hall:
    - fluorescent lamps being left on due to lack of lighting controls
    - the instantaneous electric water heater in the kitchen being left on due to lack of controls.

Priority actions are therefore:

1. **Insulate cavity walls of Bar and Hall areas.**
2. **Insulate flat roof areas on Bar and Hall.**
3. **District heating or District Micro-CHP system for the whole site, including Main House, Church, hall, club, cottage.**
4. **Ensure timer/programmer is used for Hall area heating ; Room thermostat should be set between 18 and 21 depending on the activity.**
5. **Solar thermal to pre-heat hot water for the Bar and bathrooms.**
6. **Install a timer on the hall area kitchen water heater.**
7. **Replace fluorescents in hall with LED fluorescents.**
8. **Replace external lamps with LED bulkheads.**
9. **Install sun pipes throughout hall/bar area.**
- **Install PIR sensors to contro lights and urinals in bathrooms.**
10. **Fit flow restrictors to bathroom taps or replace with self-closing taps.**
- **Consider a variable speed drive or solar cooling for the air conditioning in the bar.**

8. Jacaranda, Herne Bay, CT6 8PH

8.1 Baseline, Jacaranda, CT6 8PH

I have not seen any fuel bills from Jacaranda, and as the home has been unoccupied for some while, they would not be that informative. The following figures are therefore estimates of the likely emissions of the property when occupied.

Energy use (all fuels)	120 kWh per m^2
Carbon dioxide emissions per m^2	26 kg CO^2 per m^2
Total carbon dioxide emissions	2823 kg CO^2
Water use	125 Litres per person per day

Energy and water use are expected to be below average even when the house is occupied, nevertheless there are still actions that need to be taken to reduce your emissions.

8.2.i Building fabric - Jacaranda, Herne Bay, CT6 8PH

	**Observations of current situation**	**What actions can you take to improve?**
Walls	Cavity walls, believed to be uninsulated. Thermography shows heat loss through walls.[23] Unheated porch.	***Energy Hierarchy Goal – use energy efficiently*** Cavity wall insulation.
Roof area(s)	Pitched roof is partly boarded and has 150mm of loft insulation including under boards. Loft hatch is insulated. Kitchen extension has flat roof.	***Energy Hierarchy Goal – use energy efficiently*** Additional loft insulation either above boards or under rafters. Flat roof insulation to kitchen extension.
Doors and windows	Double-glazed throughout.	
Preventing heat loss from radiators	Radiators do not have radiator panels nor radiator reflective foil.	***Energy Hierarchy Goal – use energy efficiently*** Add radiator panels, and radiator reflective foil where radiators are positioned on external walls.

8.2.ii Primary heating and hot water system at Jacaranda, Herne Bay, CT6 8PH

[23] Although the central heating was not turned on when I visited, the house was warm, as it had absorbed solar heat during the day, hence the possibility of the thermal imaging camera detected heat escaping from the house even though the central heating was switched off.

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of primary heat and hot water sources	Worcester Bosch condensing combination boiler, good condition and quite new.	***Energy Hierarchy Goal – use lower carbon energy*** An Air Source Heat Pump (possibly a hybrid gas/ASHP system) could provide space heating to the building; more baseline information on heat consumption is needed; gas boiler would be kept as a backup and used for hot water.
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	Programmer, timer, TRVs, assumed room thermostat; these are adequate for a small property assuming the presence of a room thermostat can be confirmed.	
Secondary heating sources	Electric decorative fire.	***Energy Hierarchy Goal – use lower carbon energy*** The electric fire should ideally be disconnected, as electricity is a higher carbon fuel than the gas central heating.

8.2.iii Lights and lighting controls at Jacaranda, Herne Bay, CT6 8PH

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of lamps	A mixture of fluorescent tubes, Halogen lamps, Incandescent lamps, CFLs	***Energy Hierarchy Goal – use energy efficiently*** Replace all fluorescent tubes, halogens, incandescents with LED lamps.

Is use of natural light made where available?	Yes	***Energy Hierarchy Goal – use lower carbon energy*** As the property is single storey, sunpipes could be fitted to reduce the need for electric lighting.
What lighting controls are present? Are they adequate?	On/off switches - these are adequate for a building this size.	

8.2.iv Kitchen and bathroom appliances, Jacaranda, Herne Bay, CT6 8PH

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Description, age, energy rating, and condition of appliances	Kitchen appliances are reasonably modern and efficient. Shower runs off gas boiler.	
Are fridges/freezers defrosted? Are they kept full when in use? Correctly positioned?	Not in use as unoccupied.	
Can washing be dried outside?	Yes	
Are dishwashers/ washing machines used on a full load?	Property unoccupied so not known.	***Energy Hierarchy Goal – use less energy*** As this is a low occupancy property, washing up by hand would be more efficient use of energy and water than a dishwasher, if possible.
Toilet flushing	Dual flush	
Ventilation	There is some damp. Old extractor fan.	Damp may be temporary, caused by under-heating as property is unoccupied. Cavity wall insulation, a new energy recovery

		extractor fan, and having the heating on in the bathroom for an hour a day while unoccupied (using the timer and turning the other TRVs down) would help.

8.3 Priorities for action at Jacaranda, Herne Bay, CT6 8PH

1. **Cavity wall insulation.**
2. **Additional roof insulation.**
3. **Replace all fluorescent tubes, halogens, incandescents with LED lamps.**
4. **Install Sunpipes.**
5. **Consider hybrid gas/Air Source Heat Pump heating system.**

9. Martha House, 70 Sherringham Avenue, N16 9RT

9.1. Baseline - Martha House, 70 Sherringham Avenue, N16 9RT

Energy use (all fuels)	145.2 kWh per m^2
Carbon dioxide emissions per m^2	31.8 kg CO^2 per m^2
Total carbon dioxide emissions	5010 kg CO^2
Water use	105 Litres per person per day

10 people living in an end terrace with 5 bedrooms.

Key Observations:

- Energy and water use per person and per square metre are both relatively low due to thrift and economies of scale achieved by having 10 people living in a 5-bedroom home, with shared meals and facilities.
- Nevertheless, absolute emissions are quite high, and your water use is 1046 litres per day. As this property will move on to compulsory water metering shortly, then there is a need to reduce your water consumption as well as your energy consumption.

9.2.i Building fabric - Martha House, 70 Sherringham Avenue N16 9RT

	Observations of current situation	**What actions can you take to improve?**
Walls		***Energy Hierarchy Goal – use energy efficiently***

	Original 1930s building, end terrace with cladding, uninsulated solid walls. 1990s extension to side and rear of building has uninsulated cavity walls. Chimneys are blocked. off to prevent draughts	Front and rear elevations - external wall insulation. Side elevation (west) - Cavity Wall Insulation if cavity is of suitable size for insulation.[24] Otherwise, internal wall insulation, as there are few fixtures and fittings on the external walls. The side elevation is not suitable for external wall insulation because of street furniture that is too close to the wall to allow for sufficient thickness of insulation (a cable box and a streetlight). A new energy efficient extractor fan and water saving toilet could be fitted in the upstairs en-suite at the same time. Ensure roof and sides of bay windows are insulated.
Roof area(s)	Main building has pitched roof with 300mm loft insulation Extension has 300mm loft insulation.	
Doors and windows	Double-glazed throughout including front door. Bay window on both floors, front elevation. Unheated porch.	***Energy Hierarchy Goal – use energy efficiently*** Ensure roof and sides of bay windows are insulated.
Preventing heat loss from radiators	Radiators do not have radiator shelves or radiator reflective foil.	***Energy Hierarchy Goal – use energy efficiently*** Radiator shelves. Radiator reflective foil where radiators are positioned on external walls.

9.2.ii Primary heating system at Martha House, 70 Sherringham Avenue , N16 9RT

[24] When I visited the property, it was reported that an insulation contractor had visited and said that the cavity walls could not be insulated. My interpretation of this is either that a. The cavities are too narrow to insulate, or b. The contractor could not make the funding available stack up to make it possible to insulate it for free, because only part of the house has cavity walls. Or a combination of a. and b. It would be worth getting an insulation contractor to assess the depth of the cavity and reporting back on whether or not it can be insulated. If so then this would be at cost, as it's unlikely to be free. RETROFIT WORKS?

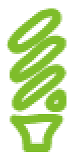
	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat source	Baxi condensing combination boiler, approximately 3 years old, good condition.	
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	Timer/programmer and room thermostat are located in the vestibule and are in use. Thermostatic radiator valves on all radiators except the following which do not have TRVs - side bedroom in extension, en-suite; upstairs bathroom.	***Energy Hierarchy Goal – use energy efficiently*** Upgrade to smart heating controls to give more control over-heat and to combat condensation and damp. Install TRVs inside bedroom and upstairs bathroom.
Secondary heating sources	I did not see any secondary heating appliances.	

9.2.iii Hot water systems at Martha House, 70 Sherringham Avenue, N16 9RT

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of hot water source	Hot water from Baxi condensing combination boiler.	***Energy Hierarchy Goal – use lower carbon energy*** Solar thermal to pre-heat water and reduce the input from the gas boiler.

Is the hot water source regularly serviced/maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Timer/programmer is in use, controls are adequate.	
Are there any leaks from hot water pipework?	None observed.	

9.2.iv Lights and lighting controls at Martha House, 70 Sherringham Avenue, N16 9RT

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Description, age and condition of lamps	Halogen spotlights; incandescents including bulkheads, fluorescents; some CFLs; some LEDs.	***Energy Hierarchy Goal – use energy efficiently*** Replace all halogens, bulkheads and fluorescents with LED spotlights, LED bulkheads and LED fluorescents.
Is use of natural light made where available?	Yes	
What lighting controls are present? Are they adequate?	On/off switches are adequate for the property.	

9.2.v Kitchen and bathroom appliances, Martha House, 70 Sherringham Avenue, N16 9RT

	**Observations of current situation. Is it efficient, or wasteful?**	**What actions can you take to improve?**
Description, age, energy rating, and	Shower off boiler x 3	

condition of appliances	Electric shower with 3 litres per minute flow. Towel rail x 2 Dual-flush toilet x 1 Fridge-freezer - 2 years old New washer/dryer Single-flush toilet with no hippo x 3	***Energy Hierarchy Goal – use less energy*** Encourage residents to use towel rails rather than dry towels on radiators in bedrooms. ***Water Hierarchy Goal – Reduce*** Install Hippo cistern displacement device; or replace with dual-flush toilet or composting toilet.
Are fridges/freezers defrosted? Are they kept full when in use? Correctly positioned?	Yes	
Can washing be dried outside?	I did not observe a washing line.	***Energy Hierarchy Goal – use less energy*** Ensure there is a washing line.
Are dishwashers/washing machines used on a full load?	Yes	
	Upstairs bathroom - bath has leaking tap with leakage of 300ml per minute.	***Water Hierarchy Goal – Reduce*** Fix leak.

9.2.vi Ventilation and condensation issues at Martha House, 70 Sherringham Avenue, N16 9RT

Observations:

- Right front bedroom:
  - damp was observed
  - the bedroom has inadequate ventilation
  - there is a wardrobe positioned on an external wall
  - there was a towel drying on the radiator.

- Left front bedroom:
  - damp was observed, particularly around the bay window.

The steps that would mitigate the problems with condensation and damp are:

- Insulate the home, particularly the walls and the bay windows.
- Smart heating controls could deliver heat to the two affected rooms at times when it was not needed in the rest of the house.
- Additional ventilation could be provided by passive wall vents, or MVHR.
- Ideally, wardrobes and other large items of furniture should not be placed on outside walls.
- Residents should be encouraged to dry towels on washing lines or towel rails instead of on radiators in bedrooms.

9.3. Priorities for action at Martha House, 70 Sherringham Avenue, N16 9RT

1. **Insulate the walls and bay windows.**
2. **Upgrade to smart heating controls.**
3. **Install TRVs on two radiators.**
4. **Install solar thermal.**
5. **Replace incandescent lamps with LED lamps.**
6. **Fix leaking tap.**

10. Austin Smith House, 96 Ivor Road, B11 4NX

10.1 Austin Smith House, 96 Ivor Road, B11 4NX - baseline

Energy use (all fuels)	222 kWh per m^2
Carbon dioxide emissions per m^2	47.75 kg CO^2 per m^2
Total carbon dioxide emissions	7639 kg CO^2
Water use	73 Litres per person per day

Eight people live here. Mid-terrace with side entry downstairs only. 5 bedrooms.

Key Observations:

- Energy use per square metre has fallen from kWh per m^2 297 in 2013 due to energy saving behaviours by the residents and physical actions such as roof insulation on the top floor.
- Water use overall is high, but water use per person is relatively low due to economies of scale of communal meals.
- Energy use and CO^2 per m^2 at this property remain very high.
- Unfortunately, the age and construction of the building means there is limited scope for further reductions to be made.

10.2.i Building fabric - Austin Smith House, 96 Ivor Road, B11 4NX

	Observations of current situation	**What actions can you take to improve?**
Walls	Main house is uninsulated solid wall. There is a layer of insulated plasterboard on the walls of the top floor. Kitchen extension back wall is cavity wall, believed uninsulated. Thermography shows substantial heat loss through walls.	***Energy Hierarchy Goal – use energy efficiently*** Fitting external wall insulation to the front of the house would affect its appearance. Fitting external wall insulation to the entry wall would restrict wheelchair access to the entry and would be in breach of the building regulations. The largest area of the home that it suitable for external wall insulation is the wing (the walls marked by red lines in the image below). Have kitchen wall tested for existing insulation and insulate if necessary. 
Roof area(s)	Loft has recent insulation. Wing does not have a loft space to insulate. Thermography still shows heat loss through roof as the roof is	

	difficult to completely insulate.	
Doors and windows	Double-glazed throughout. Thermography shows substantial heat loss through doors and windows.	
Floor	Uninsulated suspended timber floor.	***Energy Hierarchy Goal – use energy efficiently*** Under-floor insulation.
Preventing heat loss from radiators	Radiators have no radiator shelves and no radiator reflective foil.	***Energy Hierarchy Goal – use energy efficiently*** Install radiator shelves. Install radiator reflective foil where radiators are located on outside walls or chimney walls where possible (some radiators are too close to the wall to allow for foil, e.g. front room downstairs).

10.2.ii Primary heating system at Austin Smith House, 96 Ivor Road, B11 4NX

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of primary heat source	Condensing combination boiler, 3 years old, good condition.	
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop	Programmer/timer are in use; TRVs on all radiators.	***Energy Hierarchy Goal – use energy efficiently*** Upgrade to smart heating controls. These would give greater control over heating and enable colder rooms to be heated for longer

or smartphone?		to prevent condensation. Smart heating controls would also mean that individual rooms could be given a heating boost, without the use for electrical heating appliances.
Secondary heating sources	Secondary heating appliances are in use: Front room - fan heater on wall and oil-fired radiator Middle bedroom 1st floor - has electric radiator only.	

10.2.iii Hot water systems at Austin Smith House, 96 Ivor Road, B11 4NX

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age and condition of hot water source	Hot water from condensing combination boiler, 3 years old, good condition.	There is not enough south-facing roof space for solar thermal to be technically viable.
Is the hot water source regularly serviced/maintained?	Yes	
Are the hot water controls adequate? Are they smart?	Programmer/timer is adequately used.	
Are there any leaks from hot water pipework?	None were observed. There is a dripping tap in the downstairs bathroom.	***Water Hierarchy Goal – Reduce*** Fix the dripping tap.

10.2.iv Lights and lighting controls at Austin Smith House, 96 Ivor Road, B11 4NX

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of lamps	Mostly new LED lamps, with some CFLs. Showers run off condensing gas boiler with energy/water saving shower heads (flow measured at 3.3 litres per minute which is low).	***Energy Hierarchy Goal – use energy efficiently*** Replace CFLs with LEDs when they reach the end of their lifetime.
Is use of natural light made where available?	Yes	***Energy Hierarchy Goal – use lower carbon energy*** Sunpipes could be installed in some areas of the house to make use of daylight instead of electric light; e.g. in wing first floor; second floor bedrooms.
What lighting controls are present? Are they adequate?	On/off switches are adequate	

10.2.v Kitchen and bathroom appliances, Austin Smith House, 96 Ivor Road, B11 4NX

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age, energy rating, and condition of appliances	Kitchen and utility room appliances are reasonably modern and energy efficient	

	Dual flush toilet downstairs bathroom; upstairs WC room.	
Are fridges/freezers defrosted? Are they kept full when in use? Correctly positioned?	Yes	
Can washing be dried outside?	Yes	
Are dishwashers/washing machines used on a full load?	Yes	
	No washing up bowl in kitchen. Some members of the household wash up under a running tap, despite being reminded not to do this.	As there are 8 people living in the house, then a dishwasher would be more energy and water efficient than washing up by hand. In any case, a washing up bowl should be purchased, and continued reminders should be made about not washing up under a running tap.

10.2.vi Ventilation and condensation issues at Austin Smith House, 96 Ivor Road, B11 4NX

- Mould was observed in the downstairs bathroom.
- Extractor fans in the downstairs and upstairs bathrooms are reasonably modern but not the most efficient. Heat recovery extractor fans would help.
- Residents should be reminded not to dry towels directly on radiators.
- Additional insulation would also help reduce the risk of condensation.

10.3 Priority actions at Austin Smith House, 96 Ivor Road, B11 4NX

1. **External wall insulation to the wing, cavity wall insulation to the kitchen, under-floor insulation.**
2. **Upgrade to smart heating controls.**
3. **Use a dishwasher.**
4. **Install heat recovery extractor fans in both bathrooms.**
5. **Switch to a Green Gas tariff.**

11. 12 Belgrave Road, Liverpool, L17 7AG

11.1 12 Belgrave Road, Liverpool, L17 7AG - baseline

These figures are estimates as the property is under-occupied

Energy use (all fuels)	66.5 kWh per m^2
Carbon dioxide emissions per m^2	14.6 kg CO^2 per m^2
Total carbon dioxide emissions	1485 kg CO^2
Water use	Currently lower than average – fewer than 100 litres per person per day – but would be higher than average if house fully occupied.

Key Observations:

- Greenhouse gas emissions at this property are very low as it is under-occupied, with no permanent resident, mainly being used for meetings and with one person staying overnight occasionally.

11.2.i Building fabric at 12 Belgrave Road, Liverpool, L17 7AG

	**Observations of current situation**	**What actions can you take to improve?**
Walls	Mid-terrace with uninsulated solid walls.	***Energy Hierarchy Goal – use energy efficiently*** External wall insulation to rear elevation. External wall insulation could be fitted to the front elevation, but it would affect the appearance of the house. Internal wall insulation to the front elevation would be less effective. Flat roof insulation to the bay window on the top floor.
Roof area(s)	Loft is insulated, including hatch.	
Doors and windows	Double-glazed throughout. Letterbox insulated.	

11.2.ii Primary heating system at 12 Belgrave Road, Liverpool, L17 7AG

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of primary heat source	Condensing combination boiler, 13 years old, good condition.	
Is the primary heat source regularly serviced/ maintained?	Yes	
Are the primary heating controls adequate? Are they smart? Can they be used remotely by laptop or smartphone?	Programmer/timer are used when building is occupied. TRVs on all radiators. Mobile room thermostat is located in bathroom.	***Energy Hierarchy Goal – use energy efficiently*** Relocate room thermostat to hallway downstairs.
Secondary heating sources	Secondary electrical heating appliances are in use: Front room - for boost when building has been empty; Second bedroom.	***Energy Hierarchy Goal – use lower carbon energy*** Discourage use of electrical heating appliance in bedroom.

11.2.iii Hot water systems at 12 Belgrave Road, Liverpool, L17 7AG

	Observations of current situation. Is it efficient, or wasteful?	What actions can you take to improve?
Description, age and condition of hot water source	Hot water from condensing combination boiler, 13 years old, good condition.	
Is the hot water source regularly serviced/maintained?	Yes	

Are the hot water controls adequate?	Yes	
Are there any leaks from hot water pipework?	None observed.	

11.2.iv Lamps and lighting controls at 12 Belgrave Road, Liverpool, L17 7AG

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve it?**
Description, age and condition of lamps	Mostly CFLs , living room has a mixture of LED and halogen candles.	Replace CFLs with LEDs when they reach the end of their lifetime. Replace halogen candles with LEDs .
Is use of natural light made where available?	Yes	
What lighting controls are present? Are they adequate?	On/off switches are adequate.	

11.2.v Kitchen and bathroom appliances at 12 Belgrave Road, Liverpool, L17 7AG

	Observations of current situation. Is it efficient, or wasteful?	**What actions can you take to improve?**
Description, age, energy rating, and condition of appliances	Kitchen and utility room appliances are reasonably modern and energy efficient, except fridge which is quite old. Electric shower.	***Energy Hierarchy Goal – use energy efficiently*** Replace fridge with a more efficient model.

	Toilet is single-flush.	***Energy Hierarchy Goal – use energy efficiently*** ***Water Hierarchy Goal – Reduce*** Install water saving shower head if house becomes regularly occupied. Install Hippo cistern displacement device if house becomes regularly occupied.
Are fridges/freezers defrosted? Are they kept full when in use? Correctly positioned?	Yes	
Can washing be dried outside?	Yes	
Are dishwashers/washing machines used on a full load?	Yes, when occupied.	

11.2.vi Potential for solar energy at 12 Belgrave Road, Liverpool, L17 7AG

Solar Electricity

The house has an area of south-facing roof that is suitable for solar panels, if the house becomes regularly occupied. There would be minor shading from a chimney.

Solar electricity would be the easiest solar energy option. There is an airing cupboard that could be used for a battery.

Solar electricity would not be particularly cost-effective but could make a substantial reduction in your greenhouse gas emissions.

Solar Thermal

Solar thermal could also work, but it would be essential to install a hot water cylinder. The airing cupboard could be used for this.

Solar thermal could be more cost-effective than solar electricity, as you would qualify for the domestic Renewable Heat Incentive.

These options should only be taken forward if the house becomes regularly occupied.

12. Province office, Coventry

The Province rents a small office at St Peter's Centre in Coventry. As the office is small and rented then there is limited scope for intervention. The building was constructed in 2001 and is relatively thermally efficient. My observations are as follows:

- There are 4 fluorescent tubes in the office that should be replaced with LED fluorescent tubes
- The two radiators in the office are on outside walls and should have radiator reflective foil and radiator shelves
- The shared bathroom that is nearest the office has a single flush toilet and washbasin taps with manual controls. The toilet could be modified with a cistern displacement device; and the washbasin taps modified with flow restrictors.
- There are uninsulated hot water pipes in the bathroom, these should be lagged.
- There are two non-LED bulkhead lamps in the bathroom that should be replaced with LED bulkheads.
- On the stairwell nearest the office, there is a radiator with a metal radiator cover. This should be removed to allow the radiator to work properly, and if necessary, a metal grille should be placed around the radiator to protect vulnerable building users.

On the day of my visit (19th March) I learned that the Province was about to move down the corridor to an identical office next door in the St Peter's Centre. This office has exactly the same needs for action as the current office; LED fluorescent tubes; radiator reflective foil and radiator shelves.

Although I did not visit the rest of the building (which was in the process of being closed down due to Coronavirus), it can be anticipated that the same issues that I saw in this office and bathroom are likely to be the case throughout the building.

13 Transport actions

13.1 Cycling

Bike parking should be provided at the following locations:

- Minsteracres main house
- Minsteracres walled garden eco-community
- Minsteracres youth centre
- St Non's
- The Retreat
- Herne Bay - main building and hall

Sheffield stands should be used for bike parking, as they are the most secure (although the risk of bike theft is low in these locations).

A small selection of bike maintenance accessories should be kept at the following locations:

- Minsteracres main house
- Minsteracres walled garden eco-community
- Minsteracres youth centre
- St Non’s
- The Retreat
- Herne Bay - main building and hall
- Belgrave Road, Liverpool
- Austin Smith House, Birmingham
- Martha House, London.

These accessories should include: a foot pump; Allen keys; adjustable spanner; tyre levers; inner tubes; puncture repair outfits; muc-off brushes; chain bath; citrus degreaser; lubricant; rags (for removing excess lubricant from the chainset).

13.2 Vehicles

The Province already has a policy of encouraging public transport instead of private vehicles, and it is clear that members of the community are keen to follow this policy.

Electric vehicle charging points could be installed at the following locations (car icons show the proposed locations):

- Minsteracres main house

Figure 32

Figure 33

- Minsteracres walled garden eco-community

- St Non's [25]

Figure 34

- The Retreat, Herne Bay – the best location is the one at the front of the main house

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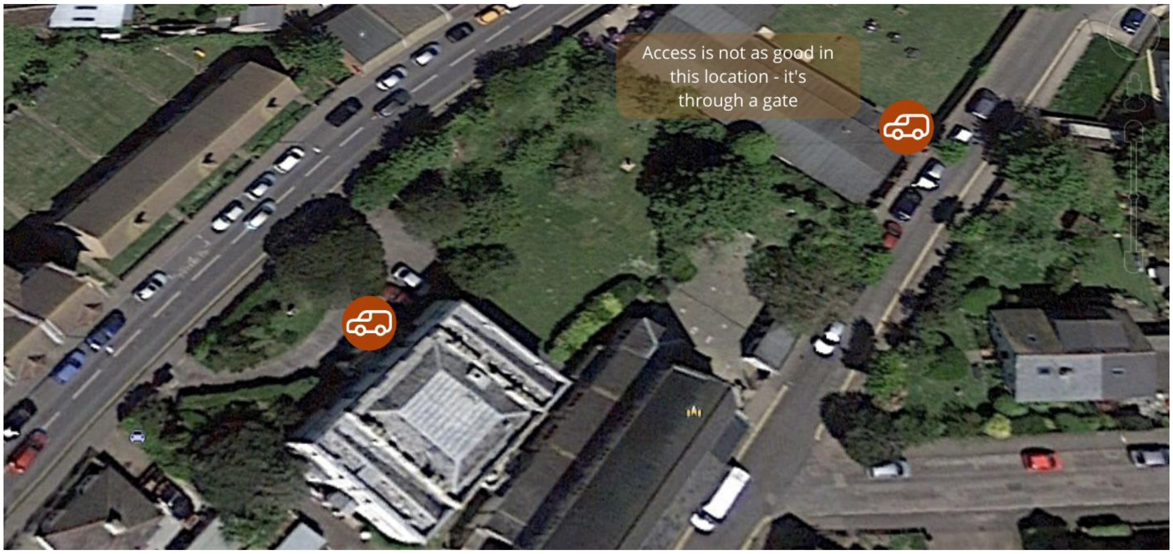
[25] This image also gives an indication of the strength of the wind at St Non's, by looking at the washing line, on the left of the image

Figure 35



On all of your sites, charging point locations close to the electricity meter would reduce the need for cabling.

In the following locations, electric vehicle charging points could potentially be directly powered by renewable energy generated on site:

- Minsteracres main house
- Minsteracres walled garden eco-community
- Minsteracres youth centre
- St Non's.

At Herne Bay (or other locations where on-site renewable electricity is not being generated), then the electricity should come from either a certificated green tariff; or users should be encouraged to charge their cars at night, when grid electricity has lower carbon intensity.

13.3 Flying

The Province already has a policy of discouraging members from using air travel.

14. Environmental policies

Minsteracres has an environmental policy, which could be used as a template for each of the buildings, and for the Province as a whole. The policy should be reviewed by the Trustees annually.

14.1 Green Visitor Guides

Minsteracres has a Green Visitor Charter that could be used as a template for each site (e.g. where the Minsteracres Charter says "we replaced our oil burning boilers with a woodchip boiler", the Charter for other sites would refer to actions being taken on that site).

The Minsteracres Charter contains most of the behaviours that need to be encouraged among guests and visitors. One additional behaviour that could be added to the Charter is **Repair** - i.e. encouraging visitors to maintain and repair things such as clothes, tools and equipment, bicycles.

15. Energy procurement

The best way to provide renewable electricity to a site, is to generate it on site using energy from the sun, wind, hydro, etc. The second-best way to provide renewable electricity to a site, is to buy a green electricity tariff. Some of your sites are already on electricity tariffs that are advertised as providing green electricity. However, not all electricity tariffs labelled as "green" are the same.

There are two types of green electricity tariffs:

1. Offered by energy suppliers who directly buy renewable energy, through agreements such as Power Purchase Agreements with renewable energy generators.
2. Based on Renewable Energy Certificates of Origin (REGOs). A REGO is a certificate issued by Ofgem to renewable electricity suppliers to prove their electricity is renewable. However, REGOs can be bought and sold, in a separate market to the supply of renewable electricity. This means that an energy supplier can buy fossil fuel generated electricity, then buy REGOs alongside fossil fuel generated electricity, and call it a green tariff; legally. But the customer isn't getting green electricity, and no new green electricity is being generated. REGO-based green tariffs have been criticised as "greenwash". It is cheaper for these suppliers to buy fossil-fuel generated electricity plus REGOs, than to buy renewable-generated electricity.

Your larger sites are using energy brokers to procure fuel, including Inter-Diocesan Fuel Management (IFM). IFM have recently signed an agreement with British Gas to provide "green electricity" to Catholic sites. However, British Gas' green tariff is based on REGOs, not renewable energy generation.

I recommend that the Province should consider which green tariffs it wishes to buy. While procuring energy through a broker is usually the best option, regrettably, the brokerage market does not give much choice to businesses in green tariffs. For both domestic and non-domestic sites, it can be better to go directly to suppliers to procure green electricity, than to go through a broker. In any case, it is always advisable to look for green tariffs based on generation and not REGOs.

Some suppliers also offer Green Gas. This gas is greener than regular mains gas, because a small amount of it (e.g. 10%) is generated through renewable processes such as anaerobic digestion, and the rest of the greenhouse gas emissions are offset.

Green tariffs are potentially a good idea; you should be aware of their limitations, and that REGOs do not lead to additional renewable energy generation.

The most sustainable option is to generate your own renewable electricity and heat where possible.

15.1 Inter-trading of renewable electricity through Blockchain

Exciting developments in Blockchain mean that if you generated your own renewable electricity at sites such as Minsteracres or St Non's, then you could sell it directly to your other sites that don't have the same renewable electricity generating capacity (such as Herne Bay, Birmingham, Tottenham, and Liverpool).

Trials of this are already happening in the UK.

In Hackney, London, renewable electricity is generated on the roofs of tower blocks, and is sold to residents living in the flats, whose homes individually can't have solar panels as they have no roof space.

A Blockchain platform is used for buying and selling electricity. It's an innovative solution to the failure of the regulated UK energy market to offer choice to consumers in renewable electricity.

Blockchain has the potential to enable buildings in the Passionist community to inter-trade renewable electricity among each other, to
help achieve carbon neutrality.

16. Offsetting

Figure 36

Sites that could be made **zero carbon** by a mixture of energy efficiency and renewable energy generation on site:

Minsteracres (whole site)	St Non's

Sites that can be made **lower carbon**, mainly by energy efficiency, and some renewable energy on site:

Herne Bay Liverpool	Otley Birmingham Tottenham

IMPACT

Remaining carbon dioxide emissions from the lower carbon sites: maximum of **73,785 kg CO2 per annum**.	If implement all actions recommended in this report, this could fall to: **66,406 kg CO2 per annum**

Ways to displace remaining emissions

The greenest and most sustainable way to displace these emissions would be to generate renewable electricity or heat elsewhere.

- You would need to generate, and export between 260,000 kWh and 290,000 kWh of renewable electricity per annum.
- This is equivalent to the output of a 225-kW wind turbine; or a 100-kW wind turbine plus a 100-kW solar farm.

Minsteracres or St Non's could be potential locations, if the electricity could be exported to the grid.

If Minsteracres and/or St Non's turn out not to be suitable for grid connection (following feasibility studies), then the next best option is to support the generation of renewable electricity elsewhere.

The most ethical way to do this is through ethical investment platforms such as Sharenergy, Ethex, or Abundance Investment.

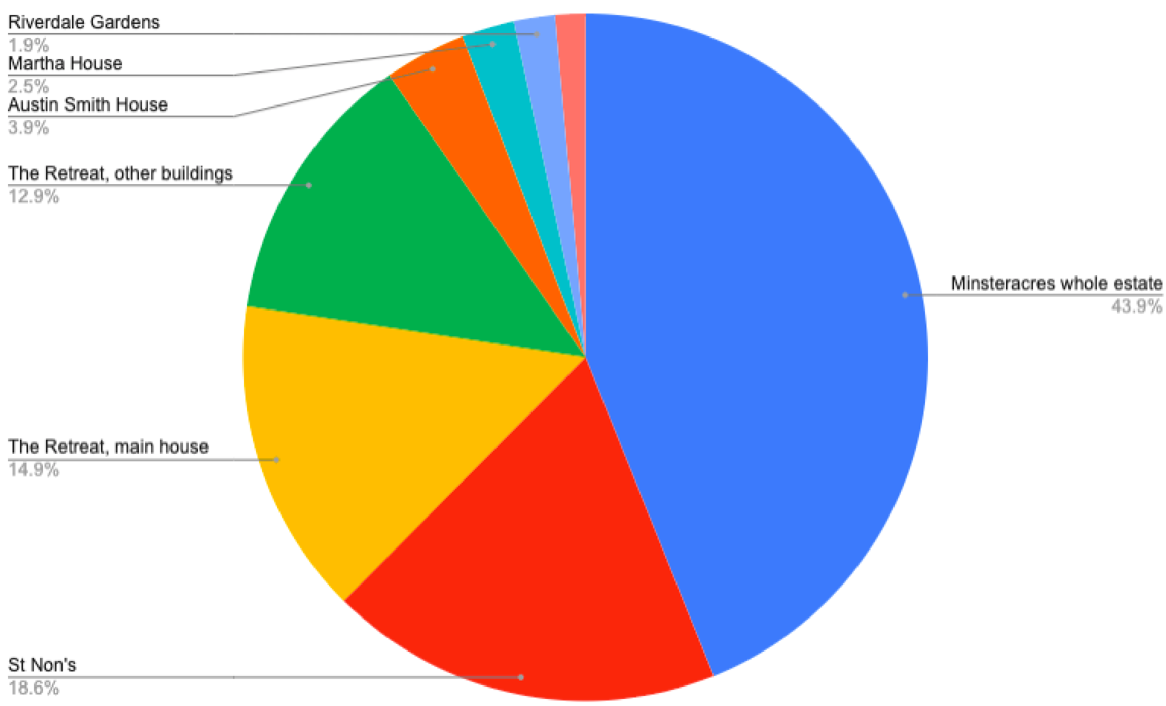
Otherwise, carbon offsetting schemes can be used. Ethical Consumer magazine recommends the Gold Standard offset scheme – https://www.goldstandard.org/.

Ethical Consumer magazine does not recommend tree planting as a means of offsetting. For more information, please read – https://www.ethicalconsumer.org/energy/short-guide-carbon-offsets.

17. Conclusions

The following pie chart shows how your greenhouse gas emissions are shared out among your sites: (Belgrave Road Liverpool is not included because its emissions are negligible while not regularly inhabited).

Figure 37



Your biggest sources of greenhouse gas emissions are (in order):

1. Minsteracres
2. St Non's
3. Herne Bay.

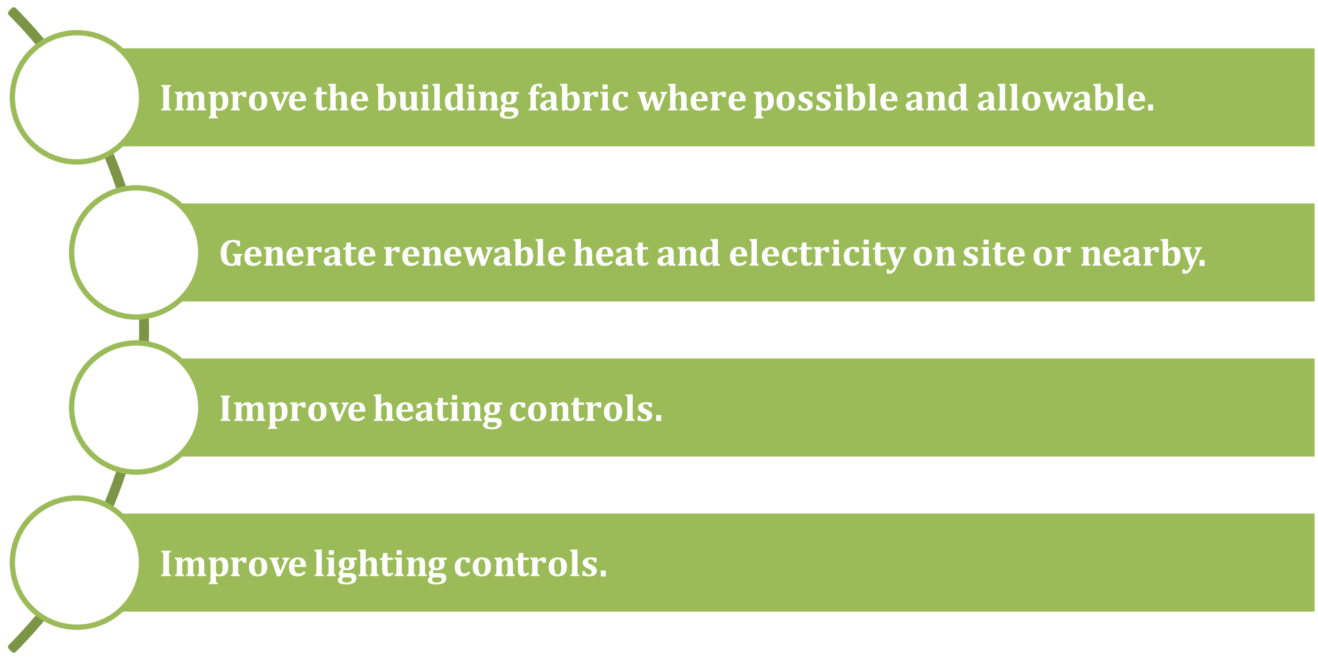
Action at these sites is critical to making substantial reductions in the Province's greenhouse gas emissions and making progress towards net zero emissions.

The factors that contribute most to these sources of emissions are:

- Poor building fabric at all sites.
- Reliance on fossil fuels for heating and electricity.
- Inadequate heating controls.
- Inadequate lighting controls.

The priority actions at these sites are:

Figure 38



Remaining sites

Your other sites, while having lower absolute emissions, all have relatively **high energy use and emissions per square metre.**

The following tables show your greenhouse gas emissions and energy use per square metre across all sites.

Table 5 – energy use per square metre

Site	kWh / m2
St Non's	361
Minsteracres main house	266
Austin Smith House	222

The Retreat, Main House	198
Riverdale Gardens, Otley	179
Minsteracres, whole site	160
The Retreat, other buildings	146
Martha House	145
Jacaranda	120

Table 6 – greenhouse gas emissions per square metre

Site	kg CO2 / m2
St Non's	97
Austin Smith House	43
The Retreat, Main House	42
Riverdale Gardens, Otley	37
Martha House	31
The Retreat, other buildings	31
Jacaranda	26
Minsteracres whole site	13
Minsteracres main house	12

The factors that contribute to the emissions of your remaining sites are:

- Poor building fabric.
- Reliance on fossil fuels.
- And in some cases, heating controls.

Priority actions for these sites include:

Figure 39

- Improving the building fabric.
- Improved heating controls.

Managing implementation of actions

Going forward, you may need expert help in implementing some actions.

Some can be managed by members of the Passionist community themselves.
For example; replacement of lamps; minor energy and water saving actions; and ongoing monitoring.

The areas where you may need external help are those with a greater time commitment and where specialist expertise is needed, such as:

- Managing the installation of more complex energy saving actions such as smart heating and lighting controls or external wall insulation.
- Renewable energy generation – including heat pumps, solar and wind.
- Setting up monitoring systems to enable you to implement them in future.

18. Recommendations and action plan

Column 6 of this table includes an estimate of whether the CO^2 saving per £ invested is high, medium, or low. This is a financial measure of the actions as well as an environmental measures. Most of the actions are rated as medium or high in terms of CO^2 saving impact. There are few actions that are low; those that are low tend to be mainstream actions that would ordinarily have been done previously, such as glazing.

DIY actions should be undertaken by the most competent person available.

While many actions are assigned to the Building Manager as the responsible person, most of these actions could be delegated. 'Building Manager' can refer to more than one person, where there are multiple buildings on site (e.g. Herne Bay, Minsteracres).

Table 7 – action plan

Action	What	How	When	By Whom	CO^2 saving impact per £ invested
Adopt environmental policy across Province	Adapt Minsteracres policy	Agreed by Trustees	By April 2020	Trustees	None directly
Minsteracres - See 4.2 - 4.6 for more details of Minsteracres actions					
Minsteracres - building fabric - walls	Insulate walls and window reveals where possible - *main house; Retreat House; Eco Community; Youth Centre*	Appoint contractor	By December 2020	Building manager	MEDIUM
Minsteracres - building fabric - roofs	Insulate roof spaces - *main house; Eco*	Appoint contractor	By December 2020	Building manager	HIGH

	Community Replace roof - *Youth Centre*		As planned		
Minsteracres - building fabric – glazing	Secondary glazing - *main house; Retreat House; Eco Community* Double-glazing - *Youth Centre*	Appoint contractor Appoint contractor	By December 2020 By December 2020	Building manager Building manager	LOW
Minsteracres - building fabric - floors	Underfloor insulation - *main house*	Appoint contractor	By December 2020	Building manager	MEDIUM
Minsteracres - building fabric - other	Radiator reflective foil to radiators on outside walls - *main house; Retreat House; Eco Community*	DIY	By December 2022	Building manager	LOW
Minsteracres - heating and hot water systems	Upgrade heating controls to smart and fully zoned heating controls - *main house* Lagging of uninsulated hot water pipework - *Main house cellar; Retreat House; Eco Community* Replace kerosene boiler with low carbon alternative; GSHP or biomass	Appoint contractor DIY Appoint contractor	By December 2020 By December 2021	Building manager	HIGH HIGH HIGH

	extension; associated hot water systems e.g. solar thermal *Retreat House* Add TRVs and room thermostat - or smart heating controls - *Eco Community; Youth Centre (TRVs)* Reposition room thermostat in corridor - *Youth Centre* Use timer on immersion heater to coincide with availability of solar electricity - *Eco Community* Solar thermal - *Youth Centre* Stratification fans *-Main house*	Plumber Electrician Electrician Electrician Appoint MCS registered contractor Appoint contractor	By December 2021 By December 2020 By December 2020 By December 2021 By December 2021		HIGH HIGH HIGH MEDIUM HIGH
Minsteracres - lamps and lighting controls	Continue with upgrading to LEDs including bulkhead and fluorescent; *Main house; Retreat House; Eco Community*	DIY	By December 2020	Building manager	HIGH

	Install smart lighting controls - *main house; Retreat House* Sunpipes - *Eco Community; Youth Centre* when replacing roof PIR bathroom lighting controls - *Eco Community*	Electrician DIY Electrician			HIGH MEDIUM LOW
Minsteracres - water saving actions	Hippos in toilets; Dual-flush or composting toilets. *Main house*; *Retreat House; Eco Community; Youth Centre* Tap flow restrictors; Self-closing, motion-controlled taps - *Main house*; *Retreat House* Water butts; *Main House* Put up stickers and shower timers - *whole site*	DIY for Hippos Appoint contractors for toilet replacement DIY Appoint contractor DIY DIY	By December 2022	Building manager	HIGH MEDIUM LOW HIGH
Minsteracres - minor energy	New radiators - *main house*	Contractor	By December 2022	Building manager	LOW

and water saving actions	Discourage electric heaters	DIY			MEDIUM
	Engage water leak detection service - *Whole site*	Contractor			MEDIUM
	Install VSD to cooker hood - *main house*;	Electrician			MEDIUM
	Urn/hot water boiler - in Bethany Lounge	DIY			HIGH
	Timers on towel rails - *main house; Retreat House*	Electrician	By December 2025		MEDIUM
	Ensure tight seals where walls meet floor - *main house; Retreat House; Eco Community*	DIY			MEDIUM
	Upgrade to more efficient LPG tumble dryer - *Retreat House*	DIY			MEDIUM
	Showers – Waste Water Heat Recovery systems *Main house and Retreat House*	Appoint contractor	By December 2021		MEDIUM
Minsteracres - ventilation	Address ventilation issues outlined in		By December 2021	Building manager	None directly

	4.4.vi - *Eco Community*				
Minsteracres - renewable energy generation	Undertake feasibility study as outlined in 4.6.i	Apply to Rural Community Energy Fund to pay for feasibility study	By June 2020	Building manager	Potentially HIGH Depending on outcome of study
St Non's - see 5.2 for detailed actions					
St Non's - building fabric - walls	Insulate walls and dormers	Appoint contractor	By December 2020	Building manager	MEDIUM
St Non's - building fabric - roofs	Top up insulation in both loft spaces Install chimney balloons	Appoint contractor DIY	By December 2020 By December 2021	Building manager Building manager	HIGH MEDIUM
St Non's - building fabric - glazing	Replace single-glazed windows with double-glazed where possible	Appoint contractor	By December 2020	Building manager	LOW
St Non's - building fabric - other	Install radiator shelves and radiator reflective foil to radiators on external walls Bleed radiators regularly	DIY DIY	By December 2021 By March 2020	Building manager Building manager	MEDIUM HIGH
St Non's - heating and hot water systems	Replace kerosene boiler with low carbon heating option following feasibility study	Appoint contractors with relevant accreditation (e.g. MCS)	By December 2021	Building manager	HIGH

	Upgrade to smart heating controls Stratification fan - chapel	Electrician Appoint contractor	By December 2020 By December 2021	Building manager Building manager	HIGH HIGH
St Non's - lamps and lighting controls	Replace non-LED lamps with LEDs, especially fluorescents and halogens Upgrade to smart, intelligent lighting controls Install sunpipes on top floor (not bedrooms) Put up "switch it off" stickers	DIY Electrician Building contractor DIY	By December 2020 By December 2020 By December 2021 By March 2020	Building manager Building manager Building manager Building manager	HIGH HIGH LOW HIGH
St Non's - water saving actions	Water saving shower heads Shower timers and stickers Hippos, or Dual-flush/composting toilets Flow restrictors, or Self-closing taps with motion sensors	DIY DIY DIY Plumber DIY Plumber	By December 2020 By December 2020 By December 2020 By December 2020	Building manager Building manager Building manager Building manager	HIGH HIGH HIGH MEDIUM MEDIUM
St Non's - minor energy and water	Replace kitchen appliances	DIY	Ongoing	Building manager	MEDIUM

saving actions	with more efficient models when they wear out Install a variable speed drive to the cooker hood Buy washing-up bowl for Sisters' kitchen Get survey/quote for voltage optimisation Showers – Waste Water Heat Recovery System	 Electrician DIY Electrician	 By December 2021 By April 2020 By December 2021	 Building manager Building manager Building manager	 MEDIUM HIGH MEDIUM
St Non's - renewable energy generation	Undertake renewable energy feasibility study for the site in accordance with 5.3.viii	Apply to Welsh Government Energy Service programme for support	By December 2020	Building manager	Potentially HIGH Depending on outcome of the study
Herne Bay - see 6.2 for detailed actions					
Herne Bay - building fabric - walls	Internal wall insulation - *Main House* Cavity wall insulation - *Hall and Bar areas; Jacaranda*	Appoint contractor Appoint contractor	By December 2020 By December 2020	Building manager Building manager	MEDIUM HIGH
Herne Bay - building fabric - roofs	Insulate flat roofs - *Hall and Bar areas;*	Appoint contractor	By December 2020	Building manager	HIGH

	Jacaranda Additional loft space insulation - *Jacaranda*				 MEDIUM
Herne Bay - building fabric - glazing	Secondary glazing throughout - *Main House* Replace skylight with double-glazed skylight -*Main house*	Appoint contractor	December 2020	Building manager	LOW LOW
Herne Bay - building fabric - other	Install radiator shelves Install radiator reflective foil where radiators are on outside walls - *Main house; Bar area; Jacaranda*	DIY	December 2020	Building manager	MEDIUM
Herne Bay - heating and hot water systems	District heating or District Micro-CHP system for the whole site, including; *Main house; Church; hall; club; cottage.* Smart, fully zoned heating controls - *Main House* Discourage electric	Appoint contractor Electrician	December 2021 December 2021	Building manager Building manager	HIGH HIGH

	heaters - *Main House*		April 2020	Building manager	HIGH
	Insulate hot water cylinders and pipework				
	Solar thermal with cylinder & timer - *Bar area*	DIY	December 2020	Building manager	HIGH
	Install timer on kitchen water heater - *Hall area*	Appoint MCS registered contractor	December 2020	Building manager	MEDIUM
	Destratification fan - *Chapel*				
		Electrician	December 2020	Building manager	HIGH
		Appoint contractor	December 2021	Building manager	HIGH
Herne Bay - lamps and lighting controls	Upgrade non-LEDs to LEDs, with priority to incandescents and halogens, including external lighting - *Main house; Hall area; Jacaranda*	DIY	December 2020	Building manager	HIGH
	Sunpipes to first floor (not bedrooms) - *Main house; Hall area; Bar area; Jacaranda*	Building contractor	December 2021	Building manager	LOW

	Upgrade to smart, intelligent lighting controls - *Main house* "Turn it off" stickers by lights; label switches PIR controls *Hall and Bar bathrooms*	Electrician DIY Electrician	December 2020 December 2020 December 2020	Building manager Building manager Building manager	HIGH HIGH HIGH
Herne Bay - water saving actions	Water saving shower heads - *Main house* Shower timers and signs - *Main house* Hippos, or Dual-flush/composting toilets - *Main house; Cottage* Tap flow restrictors, or Self-closing/ motion sensitive taps - *Main house; Hall area; Bar area (where absent)* Fit PIR controls to urinals - *hall and bar*	DIY DIY DIY Plumber DIY Plumber Electrician	December 2020 December 2020 December 2020 December 2020 December 2020	Building manager Building manager Building manager Building manager Building manager	HIGH HIGH HIGH MEDIUM HIGH HIGH
Herne Bay - minor energy	Internal door to be fitted	Appoint contractor	December 2020	Building manager	MEDIUM

and water saving actions	between *Main House and Church*				
	Remove metal grille and radiator cover from convector - *Cottage*	DIY	December 2020	Building manager	MEDIUM
	Energy efficient kitchen appliances - *Main house*	DIY	December 2020	Building manager	MEDIUM
	Install variable speed drive to cooker hood - *Main house*	Electrician	December 2020	Building manager	MEDIUM
	Ensure timer/ programmer and room thermostat used correctly - *Hall area*		March 2020	Building manager	HIGH
	Reposition room thermostat - *bar area*	Electrician	December 2020	Building manager	HIGH
	Fit a timer on electric radiator - *shop*	Electrician	December 2020	Building manager	MEDIUM
	Fit heat recovery extractor fan in kitchen of hall area - *Hall area*	Electrician	When current fan reaches end of life	Building manager	MEDIUM
	Fit heat recovery extractor fan – *Jacaranda*	Electrician	December 2020	Building manager	MEDIUM
	Showers – Waste Water	Appoint	December	Building	MEDIUM

	Heat Recovery System	contractor	2021	manager	
Herne Bay - behavioural actions - *Main House*	Educate building users about energy and water saving behaviours	DIY	March 2020	Building manager	HIGH
Herne Bay - cooling and refrigeration	Add timer plug to drinks fridge - *Bar area*	DIY	December 2020	Building manager	MEDIUM
	Relocate ice-making machine to cellar - *Bar area*	DIY	December 2020	Building manager	MEDIUM
	Shade transparent roof on outhouse to keep chest freezer cool - *Outhouse*	DIY	December 2020	Building manager	MEDIUM
	Solar cooling - *bar area*	Specialist contractor	December 2020	Building manager	HIGH
	Ensure air conditioning vents are part of the cleaning schedule - *Bar area*	Cleaners	March 2020	Building manager	HIGH
	Variable speed drive for air conditioning units - *Bar area*	Electrician	December 2020	Building manager	HIGH

Martha House - see 9.2 for details					
Martha House - building fabric - walls	External wall insulation - front and rear, including roof and sides of bay windows; cavity wall or internal wall insulation; west.	Appoint contractor	December 2020	Building manager	MEDIUM HIGH
Martha House - building fabric - other	Radiator shelves Radiator reflective foil where radiators are on outside wall	DIY	December 2020	Building manager	MEDIUM MEDIUM
Martha House - heating and hot water systems	Upgrade to smart heating controls Solar thermal with cylinder TRVs to be fitted inside bedroom and upstairs bathroom	Electrician Appoint contractor with MCS registration Plumber	December 2020 December 2021 December 2020	Building manager Building manager Building manager	MEDIUM MEDIUM HIGH
Martha House - lamps and lighting controls	Replace all halogens, bulkheads and fluorescents with LED spotlights, LED bulkheads and LED fluorescents	DIY	December 2020	Building manager	HIGH

Martha House – water saving actions	Install Hippo cistern displacement device; or replace with dual-flush toilet or composting toilet	DIY or plumber	December 2020	Building manager	HIGH MEDIUM
	Fix water leak in upstairs bathroom	Plumber	April 2020	Building manager	HIGH
Martha House - behavioural actions	Encourage residents to dry towels on towel rails not radiators		December 2020	Building manager	HIGH

Austin Smith House - see 10.2 for detailed actions					
Austin Smith House - building fabric - walls	External wall insulation to the wing; test kitchen wall for insulation and insulate if necessary	Appoint contractors	December 2020	Building manager	MEDIUM
Austin Smith House - building fabric - floors	Under-floor insulation	Appoint contractors	December 2020	Building manager	MEDIUM
Austin Smith House - building fabric - other	Install radiator shelves	DIY	December 2020	Building manager	MEDIUM
	Install radiator reflective foil where	DIY	December 2020	Building manager	MEDIUM

	radiators are located on outside walls or chimney walls				
Austin Smith House - heating and hot water systems	Upgrade to smart heating controls	Electrician	December 2020	Building manager	MEDIUM
Austin Smith House - lamps and lighting controls	Replace CFLs with LEDs when CFLs reach the end of their lifetime	DIY	December 2020	Building manager	HIGH
Austin Smith House - water saving actions	Fix dripping tap in downstairs bathroom Buy washing up bowl Buy and use dishwasher	Plumber DIY DIY	March 2020 March 2020 December 2020	Building manager Building manager Building manager	HIGH HIGH MEDIUM

12 Belgrave Road - see 11.2 for detailed actions					
12 Belgrave Road - building fabric - walls	External wall insulation to rear elevation Insulate flat roof on upstairs bay window	Appoint contractors	December 2020	Building manager	MEDIUM MEDIUM
12 Belgrave Road - building fabric	Install radiator shelves	DIY	December 2020	Building manager	MEDIUM

- other	Install radiator reflective foil where radiators are located on outside walls or chimney walls	DIY	December 2020	Building manager	MEDIUM
12 Belgrave Road - heating and hot water systems	Relocate mobile room thermostat from bathroom to hallway downstairs	DIY	April 2020	Building manager	HIGH
12 Belgrave Road - lamps and lighting controls	Replace CFLs with LEDs when CFLs reach the end of their lifetime Replace halogen candle lamps with LEDs	DIY	December 2020	Building manager	HIGH HIGH
12 Belgrave Road - water saving actions	Fit Hippo cistern displacement device if property becomes regularly used	DIY		Building manager	HIGH

19. Monitoring strategy

It is important to monitor the results of carbon saving actions, so that you can demonstrate how much progress is being made towards zero carbon.

The data that you need to gather is:

- Metered electricity consumption in kWh – preferably from smart meters
- Metered gas consumption in kWh – preferably from smart meters
- Heat generation and consumption as recorded by smart heating controls or heat meters
- Electricity generation as recorded by electrical output meters
- Metered water consumption in cubic metres (converted to litres) where water metering is present
- Delivered quantities of kerosene, in litres
- Delivered quantities of woodchip, in cubic metres
- Delivered quantities of LPG, in litres

Metering data should be gathered monthly.

If the energy supplier reliably reads the meter on a monthly basis, including via a smart meter, then this data can be used. Otherwise, your staff can take meter readings and record them on a Google spreadsheet or similar.

Smart heating controls will give you an additional depth of monitoring.

Table 8 *below shows where smart meters are/are not currently present across the Province.*

Location	**Gas Smart Meter?**	**Electricity Smart Meter?**
Properties on the gas network		
Riverdale Gardens	✕	✔
Herne Bay Main House	✔	✕
Herne Bay bar	✕	✕
Herne Bay hall	✕	✕
Herne Bay church	✕	Supplied from Main House
Jacaranda	✕	✕
Belgrave Road	✕	✕
Austin Smith House	✕	✕
Martha House	✕	✕

Properties off the gas network		
Minsteracres ...	Not applicable	✔
St Non's	Not applicable	✕

•

Where smart meters are not yet present, you should contact your energy suppliers to get them fitted if practical to do so. Smart meters are invaluable in monitoring your greenhouse gas emissions as they provide such a depth of data on a regular basis.

A brief annual report showing the results should be produced showing savings in kWh and litres, and the financial return on investment on the actions. It should also report on greenhouse gas emissions avoided as a result of the actions.

20. Glossary

This glossary contains explanations of many of the carbon-saving actions recommended in this report, particularly the more innovative ones.

The glossary follows the energy and water saving hierarchies – so we start with actions that reduce demand.

20.1 Building Fabric

Our aim in treating the building fabric is to improve the U-values of building elements such as; walls, roofs and floors.

U-values are a measurement of how effective building elements are as insulators. The lower the U-value, the more effective the building element is at preventing heat loss. Our benchmark is the 2010 Building Regulations referenced in column C in the table below. We should aim for U-values that meet the levels shown in column C. Heat pumps should never be fitted unless the building is brought up to the U-values in column C.

Table 9

A. Building element	B. Threshold U-value $W/(m^2K)$	C. Improved U-value $W/(m^2K)$
Wall - cavity insulation	0.70	0.55
Wall - internal or external insulation	0.70	0.3
Floor	0.70	0.25
Pitched roof - insulation at ceiling level	0.35	0.16
Pitched roof - insulation between rafters	0.35	0.18

Flat roof or roof with integral insulation	0.35	0.18

If the current U-value of a building element is higher than the Threshold U-value in Column B, then the building element must be improved to the Improved U-value level.

For example, if the wall has a current U-value of 0.70 or above, then it needs to be improved through cavity, external or internal insulation to the Improved U-value in the right-hand column of the table.

As all of your buildings were built before 2010, then it is reasonable to assume that their walls and roofs will have U-values that are equal to or higher than the Threshold U-values in Column B, and therefore, they would benefit from additional insulation to bring them closer to the target U-values in column C.

Where improvements to the fabric of a building have been made since 2010, then it is reasonable to assume that the building component has a U-value close to the target U-value in Column C, and therefore, needs no further action. Examples of this are loft spaces at Belgrave Road, and Martha House.

Where insulation has been installed but there are known to be gaps in the insulation, or insufficient depth of insulation (such as St Non's loft or Minsteracres main house loft), then it should be assumed that the U-value is less than the target value in Column C, and therefore, further insulation is necessary.

20.1.i External solid wall insulation

A breathable insulating membrane is added to the outside of the building, finished with render. Lime is a sustainable material for render.

Enabling works will include;

- deeper window and door cills;
- repositioning of rainwater goods and external services such as lighting, pipework.

It involves minimal disruption to the interior of the building.

This is a highly effective way of keeping heat in the building and reducing condensation and damp. It can improve the external appearance of the building but is not suitable for listed buildings (such as Minsteracres or the Main House at The Retreat, Herne Bay).

20.1.ii Internal solid wall insulation

Where external wall insulation is not appropriate then insulated boards can be applied to the internal walls. Internal wall insulation may leave thermal bridging in a way that external wall insulation does not. Often, building owners install IWI on a room by room basis, perhaps when rooms are less occupied, rather than all at once. This minimises disruption but is more expensive than having it all done at once.

Enabling works will include repositioning of power sockets, skirting board and door architraves.

Both internal and external wall insulation can achieve final U-values in line with the Building Regulations. There is a body of opinion that says that internal wall insulation is a better option for controlling condensation than external wall insulation in very old brick buildings, as external wall insulation may limit the natural breathability of brickwork.

It is possible to specify insulation materials or thicknesses of insulation which exceed the target improved U-values in Column C above. The additional cost of these solutions may not deliver value for money in terms of fuel bill or carbon dioxide savings, especially in a non-domestic building that is unoccupied at night. The cost benefit should be carefully considered before procuring insulation methods that exceed the requirements of the building regulations.

20.1.iii Cavity wall insulation

A house built after around 1930 will usually be built with two layers of brick, with a cavity between the two layers. Also, where an extension is added to an older house, it will have cavity walls. If the house or extension was built after 1995 then it will have cavity wall insulation as built. If it was built between 1930 and 1995, then it may have uninsulated cavity walls.

A cavity wall is insulated by making small holes in the mortar between bricks and using a machine to blow insulation into the cavity. As such, it cannot be done on a DIY basis.

When adding cavity wall insulation to a home, it is important to make sure the house is adequately ventilated to prevent condensation. It may be necessary to add ventilation.

20.1.iv Pitched roof - insulation at ceiling level

Mineral wool or a natural insulation product is placed between the joists in the loft space. It slows down the transfer of heat upwards, keeps the building warm, and avoids greenhouse gas emissions. It is one of the most cost-effective energy saving measures. It’s important to make sure the whole loft space is insulated. Two areas commonly missed out are the eaves and the loft hatch (a separate insulation pillow product is available for the loft hatch). Insulation should be laid to a depth of at least 270mm.

In boarded lofts, the boarding is usually too shallow to allow 270mm of insulation. To ensure the correct depth of insulation in a boarded loft, carpentry is used to extend the depth of the joists from the standard 100mm up to 270mm. Boarding can then be laid across the newly extended 270mm joists, after putting in 270mm of insulation between the joists.

20.1.v Pitched roof - insulation between rafters

If insulating between the joists is not possible, then insulating between the rafters is an alternative. This video shows how it is done. Please note that insulating between the joists achieves a higher final U-value than insulating between the rafters.

20.1.vi Flat roof insulation

Flat roofs lose a lot of heat if uninsulated. Insulation is usually added above the deck, between two layers of waterproof membrane. This can be done on a DIY basis but is best done professionally. If the structure is strong enough, then a living roof or green roof is sometimes an option. An alternative to flat roof insulation is to replace the flat roof with a pitched roof, and to insulate the pitched roof in the normal manner.

20.1.vii Under floor insulation

In a typical dwelling, up to 15% of heat loss can be through the floor. If there is a cavity underneath the floorboards, then it is a suspended timber floor. Airbricks on the outside wall below floor level are another indicator of a suspended timber floor. If there is a cellar below then insulation can be fitted from below. If there is a cavity under the floorboards that is not accessed via a cellar, then the floorboards are lifted, and the insulation is placed under the floorboards between the joists.

Insulation can be laid over a concrete floor. If a concrete floor is being replaced, then it is necessary to insulate it to comply with the building regulations. Insulation can then be placed below the new slab.

20.1.viii Radiator shelves and reflective foil

Radiators are often placed on outside walls. This means that some of the heat generated will heat the wall rather than the air. If the wall is poorly insulated (as is the case at most of your buildings) then a proportion of the heat will escape to the outside.

Radiator reflective foil is silver and reflects heat back into the room. This saves heat loss and makes the room feel warmer, quicker and for longer. Radiator reflective foil is purchased from a DIY store in a roll, cut to size with a craft knife, and fitted behind the radiator with double-sided tape without having to remove the radiator. A DIY alternative is kitchen foil, fitted using a 1m wooden ruler and double-sided tape or blu-tack. This is cheaper but takes longer to fit and doesn't last as long. Overall, manufactured radiator foil is a better option.

Placing a shelf above a radiator helps to throw heat forward into the room where it is needed, rather than upwards towards the ceiling. You can buy easy-fit floating radiator shelves from DIY websites , or make shelves on a DIY basis. The shelf can also be used to store things on (but not houseplants as suggested in the images on some DIY websites, as the soil would dry out quickly).

20.1.ix Types of insulation material

Most commercially available insulation products include artificial materials such as polyurethane. They are effective at reducing heat loss and the associated CO2 emissions; however, they do have environmental side-effects. Also, there is embodied energy in the manufacture of these materials which results in carbon dioxide emissions. It is important to remember that the net environmental impact of these insulation materials is positive.

There are a number of natural and sustainable insulation materials that have less environmental impact than mass-produced artificial insulation products. These sustainable insulation materials include cork, flax and hemp.

The Superhomes network[1] has ranked insulation materials by their climate friendliness, as shown in the table below. The calculation of embodied carbon in Column B is determined by embodied carbon emitted during manufacture, minus any sequestered carbon per cubic metre of material. The top 6 natural materials in the table have a negative value. This means they absorbed carbon dioxide from the atmosphere while they were growing. Unlike plastics, they are renewable materials.

Table 10

A. Material	B. Embodied carbon ($kgCO^2e$) [2]
Cork slab (300kg/m^3)	-155
Cork slab (160kg/m^3)	-70
Cork board	-65
Woodwool board	-35
Flax	-5
Recycled loose cellulose	-1.9
Glassfibre quilt	3
Rockwool	7
Glassfibre slab	8
Expanded corkboard	9
Rockwool (60kg/m^3)	13
Expanded polystyrene	15
Rockwool (100kg/m^3)	20
Cellular sheet glass	28

The above table does not include sheep's wool. This is more sustainable than artificial materials but less sustainable than plant-based materials (such as cork and other woods, hemp, or flax), as it is derived from a domesticated animal with a carbon footprint of its own.

The table does not include hemp, however, hemp is considered to be approximately equivalent to flax in its embodied carbon. Some sustainable insulation products include both hemp and flax.

Natural insulation materials are often more breathable than artificial insulation products. Breathability helps to reduce the risk of condensation. They tend to be more expensive than artificial products, but their lower environmental impact means that they should be used if the budget is available.

Some insulating materials have received negative press, such as sprayfoam insulation, for their lack of breathability. There are many user-led websites where people post their good and bad experiences of energy saving building materials.

When buying insulation products either on a DIY basis or via a contractor, you should assure yourselves that the insulation materials do not pose any fire risk.

20.1.x Building fabric improvements and wildlife habitat mitigation

Older buildings, such as most of those in this report, are full of holes. These holes in the walls and roofs are important habitats for many species of wildlife, including; birds, bats and invertebrates. When the building is insulated and made more airtight, these habitats may be lost. This is especially the case where external wall insulation is involved. An assessment should be carried out as to which species use these habitats and what artificial habitats should be incorporated to mitigate for this loss. Examples of artificial habitats include; bird, bat and insect boxes (the exact type will depend on what species are currently using them).

20.1.xi Chimney balloons

A chimney balloon is a way of reducing heat loss through open chimneys. It prevents warm air from escaping from the room below and prevents cold air from coming down the chimney. The balloon inflates against the chimney walls. There is an air vent in the side of the chimney, allowing some necessary circulation of air. It is important to measure the chimney carefully to ensure the right size balloon is purchased. The flue of a gas fire must not be permanently blocked. If a chimney balloon were fitted in a chimney with a gas fire, the manufacturers state that the balloon would deflate in the presence of hot air rising from the fire, allowing the flue to work properly. The manufacturers recommend a warning label and to only use with a gas fire with extreme caution.

20.1.xii Environmental impact of glazing materials

uPVC window frames have an environmental cost, as they contain toxic chemicals. Even when uPVC frames are recycled, there is a considerable input of energy into the recycling process which releases dangerous chemicals into the air and water supplies. While uPVC windows do save energy and greenhouse gas emissions, sustainable hardwood window frames achieve a similar energy saving performance – without the negative environmental impacts of uPVC.

20.2 Heating and hot water systems and controls

Any new gas boiler that you buy will be a condensing boiler. Combination boilers don't need a separate hot water tank; system boilers have a separate hot water tank to store hot water. The advantage of the latter is that they work with a solar thermal system.

The efficiency of a heat pump is measured by its Coefficient of Performance.

20.2.i Smart heating controls

The types of heating controls found in most buildings (programmer/timer,; room thermostat,; thermostatic radiator valves), require manual setting and an understanding by building users of how to use them.

Smart heating controls are more automated and can be controlled remotely by computer, smartphone or tablet. This gives the building manager a greater degree of control over energy costs and greenhouse gas emissions.

Some smart heating controls can detect patterns of use and smartly adjust themselves accordingly.

Smart heating controls are not cost-effective in homes with moderate or average consumption of fuel for heating. They can be very cost-effective in buildings that use large amounts of fuel for heating.

20.2.ii Location of room thermostats

There are differences of opinion over where to locate a room thermostat but generally speaking, it is best on an interior wall – away from direct sunlight, air vents, the kitchen, windows and doors. Ideally, it should be placed toward the centre of the building.

20.2.iii Radiator cases and air circulation

Radiator cases increase the amount of energy used to heat up a radiator. Wet radiators work mostly by convection; a heat transfer method that relies on the circulation of air around the radiator to get warm air around the room quickly and efficiently. The shape of the radiator is designed to facilitate this circulation of air. As radiator cases tend to inhibit this circulation, then they make the radiators work less efficiently. It is for this reason what we recommend the removal of radiator cases.

In addition, metal radiator cases act as a heat store, slowing down the heating up of a room, and can lead to the occupiers using portable electric heating appliances to warm it up more quickly.

If it is necessary to protect vulnerable residents from burning by radiators, then a wire cage can be used for this purpose without compromising the energy efficiency of the radiator.

20.2.iv Air destratification fans

In a building with a ceiling height of more than 2 metres, stratification can occur. This is a tendency for warm air to rise and push colder air downwards. This means that the air nearest to the ground, which is where people are present, is colder than the air nearest to the ceiling. This creates a gradient of air, with colder air nearer the ground, and warmer air nearer the ceiling.

Stratification happens naturally, through solar radiation heating up the building, and artificially, as warm air rises from radiators or other heat distribution devices near ground level.

A destratification fan is located near the ceiling, and is designed to push warmer air downwards, where it is needed. This reverses the gradient of air, so warmer air is now nearer the ground, and cooler air nearer the ceiling.

The Carbon Trust estimates that a destratification fan can reduce heating costs by up to 20%.

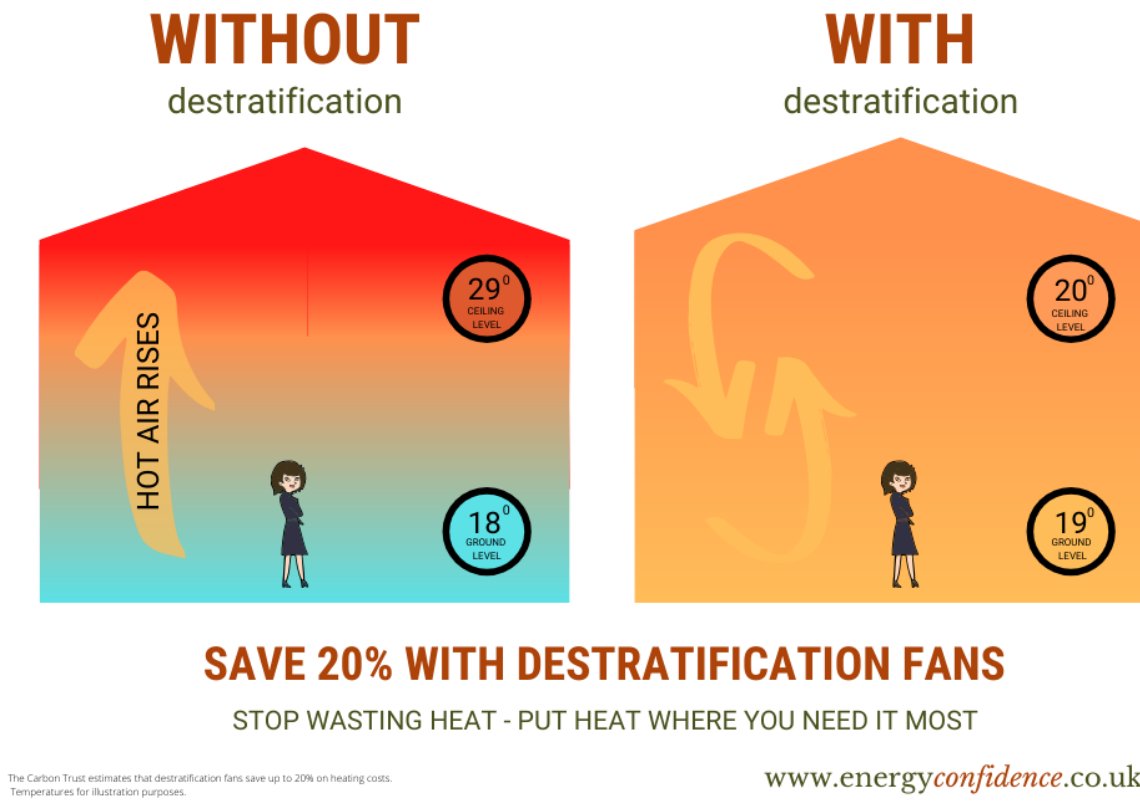
Design considerations for a destratification fan include:

- Specifying the right size of fan for the height and floor area of the space being heated
- Noise made by the fan
- Positioning the fan correctly for optimum destratification, and to avoid draughts
- Timers and controls of the fan, including variable speed drives.

A destratification fan can also be used for cooling in summer.

Figure 40 below illustrates how destratification fans work in a building with a high ceiling such as a church, chapel or atrium.

Figure 40



20.3 Bathroom and kitchen appliances

WRAP and Waterwise recommend the following standards of water efficiency[3]:

Table 11

	A. Baseline practice	B. Efficient practice	C. Highly efficient practice
WC	6 litres per flush	4.5 litres per single flush	3.5 litres per single flush
Urinal	7.5 litres per hour	3 litres per hour	0 litres per hour
Tap (basin)	12 litres per minute	6 litres per minute	4 litres per minute
Tap (kitchen)	12 litres per minute	8 litres per minute	6 litres per minute
Washing machine	10 l/kg dry load	8.5 l/kg dry load	7 l/kg dry load
Dishwasher	1.2 l/place setting	1.0 l/place setting	0.7 l/place setting

Appliances should be procured for kitchen and bathrooms that meet the standards set in column B as a minimum, and ideally column C. Plumbing supplies, and white goods, are now sufficiently labelled with their water consumption that you can procure to these standards with confidence.

20.3.i Waterless urinals and composting toilets

Waterless urinals are increasingly used as a way of reducing water consumption. Odours and blockages are controlled chemically rather than using water to flush. The environmental impact of the chemicals used for odour and blockage control is considered lower than the environmental impact of conventional urinals which will still use chemicals as well as water.

There are 3 techniques used to control odours and blockages;

- microbiological control
- liquid barrier systems
- valve barrier systems.

Composting toilets are most frequently used where water is not available for flushing, however, they can still be used in situations where water is available. A properly designed composting toilet requires no chemicals and has no smell. The waste is mixed with sawdust and then needs to be taken to a slow compost pile.

20.3.ii Washing-up bowls

A washing-up bowl reduces the capacity of a sink by approximately half, and therefore reduces the amount of water and heat necessary to wash up by approximately half.

In a larger home, a dishwasher may be a more environmentally friendly alternative to washing up by hand. A modern, energy and water efficient dishwasher, with environmentally friendly detergents, will have lower energy and water use than washing up by hand. In a smaller home, then washing up by hand may be the better option.

Hand washing would be more sustainable if a building has access to either;

- a renewable source of heating hot water, (such as solar thermal or PV plus immersion heater), or;
- harvested rainwater or sustainably abstracted water[4];

Otherwise, a dishwasher used as outlined above would be the better option.

Ivor Road and Sherringham Avenue are examples of larger homes where a dishwasher is likely to be a more sustainable option than hand washing.

20.3.iii Shower types

The choice of shower depends on the water pressure system in the building.

System types:

- A conventional boiler cold water tank in the loft and a hot water cylinder (typically in an airing cupboard), has low water pressure and relies on gravity to get hot water to taps and showers. This places limitations on the types of shower and taps that it will work with.

- A combination boiler has a high-pressure water vented system. It is fed directly with mains pressure cold water, which is heated and pumped around the home at nearly mains pressure. A combination boiler is suitable for most types of shower and taps.

- A system boiler with a hot water tank (but no cold-water tank) is an unvented high-pressure water system. It stores water at mains pressure in a hot water cylinder. It gives the most options for different types of shower and taps.

Shower Types:

- *Manual mixer showers* mix cold water with hot water from an unvented system boiler or combination boiler; they will also work with a conventional boiler with the introduction of a pump. This also applies to…
- *Thermostatic mixer showers,* which operate like a manual mixer but are thermostatically controlled so the water temperature stays relatively constant.
- *Power showers* are like a thermostatic mixer but with the addition of a pump, so they work with a conventional boiler, as well as an unvented system boiler, or a combination boiler.

- *Digital showers* additionally have smart wireless controls enabling the user to more effectively control water flow and temperature, including setting them from another room. They work with all types of boiler. They have the potential for energy and water saving by controlling flow, temperature and duration of shower.

- *Electric showers* will work with any type of boiler including conventional boilers.

Water saving shower heads

An older shower head will typically use 10 litres of water per minute, whereas a water saving shower head will use 7-8 litres per minute. It also saves energy as well as water.

Water saving showers use the following methods to save water:

- They aerate the water, to reduce the amount of water needed to produce the same flow.;
- They use a flow restrictor, which reduces the flow rate as the water pulsates, while providing a regulated and constant flow.

20.3.iv Urns, kettles and Eco Boilers.

Where guests are drinking large amounts of hot drinks in meeting room areas or kitchens, then an urn saves money relative to a kettle. Where a kettle is in use, people will tend not reheat the same water repeatedly, wasting energy. An urn keeps the water hot, saving on reheating the water. As with a kettle, only the amount of water to be used should be boiled. An urn should have gradations on the side showing the fill level for amount required. Stickers can be placed on the side of an urn to indicate "fill to this level if there are 10 people in the meeting", etc.

A more efficient option in some instances is an Eco Boiler, such as the Marco Eco Boiler range.[5] These have insulated tanks that retain heat and offer better temperature control than a kettle or urn. They are powered by a 13-amp plug and are easily plumbed into a kitchen water supply. They are far more efficient than a kettle or urn, and therefore have lower greenhouse gas emissions.

20.3.v Flow restrictors and sensor taps

Flow restrictors mix water with air. This controls the amount of water that flows through the tap without affecting the water pressure.

Sensor taps have a valve that detects the presence of a person's hands near the tap. The taps will be fitted with a battery that ensures the electricity needed to operate the valve. The sensor tap shuts off after a fixed time, saving water and energy.

20.3.vi Low flush and zero flush toilets, and cistern displacement devices

Water use of toilet types

- *High Flush* – Older single-flush toilets use between 7 and 9 litres of water per flush.
- *Low Flush* – Modern dual flush toilets flush with between 2.5 and 4 litres of water.
- *Zero Flush* – Composting toilets use no water at all and the composted waste can be added to a compost bin.

Cistern displacement devices

As a cheaper alternative to replacing a toilet, a cistern displacement device is an inflatable plastic device that decreases the volume of the water in the cistern by approximately one litre. This in turn reduces the amount of water used in flushing by one litre. This type of measure is often sufficient to meet a building's water saving targets to get its water use down to sustainable levels.

- A Hippo is the most common type of displacement devices. They are cheap to buy, and some water suppliers give them away free to householders.
- Some people use a housebrick in the cistern to achieve the same effect, and to avoid plastic use, but this is not advisable due to potential corrosion of the brick.

20.3.vii. Waste Water Heat Recovery Systems

Waste water heat recovery systems are a way of reducing the amount of fuel required to heat water for showers. WWHRS recovers the heat from the waste water that comes out of the shower, and uses the heat to pre-heat cold water going into the shower or hot water cylinder.

Where there are multiple boiler-fed showers in a building then WWHRS is worth considering.

The following video shows how one type of WWHRS works. Please note that this is a manufacturer's video – other WWHRS systems are available.
https://www.youtube.com/watch?v=J2cM0URzWj4

20.4 Ventilation

Adequate ventilation is essential in a building with high airtightness, such as an old building with high levels of retrofitted insulation. Ventilation ensures comfort for building users and prevents condensation.

Some strategies to ensure adequate ventilation are;

- Using trickle vents on windows
- Mechanical extract ventilation (MEV) – constant low-level extraction from bathrooms and kitchens combined with trickle vents in windows. The extraction can be boosted at times of potentially higher humidity, such as cooking. There is a widespread myth that mechanical extraction is expensive to run, however modern extractors can have a power rating of only 5 Watts (0.005 kiloWatts), which means that their running costs are less than 2p per day. [6]
- Mechanical ventilation with heat recovery (MVHR) – this recovers heat from the air that is being extracted.

20.5 Lamps and lighting controls

20.5.i PIR

PIR motion sensors (passive infra-red) should be used to control lighting in areas that are intermittently or infrequently used, e.g. bathrooms.

20.5.ii Smart wireless lighting controls

Most buildings are over-lit and waste energy due to inadequate lighting controls.

A smart wireless lighting control system comprises;
- wireless sensors
- switches
- dimmers

- and remote controls.

These all maximise energy savings from lighting.

They can be used in individual rooms such as bedrooms or bathrooms; in corridors; or in whole buildings. They are particularly useful for areas of buildings that are occasionally or intermittently used, such as the corridors of larger buildings, bathrooms, meeting rooms.

As they are wireless, no wiring is required. This significantly reduces the cost of having smart lighting and, therefore, maximises the amount of greenhouse gas emissions achieved for your investment.

Smart wireless lighting systems can be scheduled to control lighting by time of day, or by sensing external light levels, such as dusk and dawn. The controls can also respond to the presence or absence of people in the location, so empty bedrooms, offices, corridors and bathrooms are not lit unnecessarily.

Smart wireless lighting control kits are available for buildings of all types, including homes and businesses. Software associated with the controls enables you to monitor performance and adjust settings if necessary.

20.6.iii Sunpipes

Include hybrid subpipes

A *sunpipe* is a reflective tube that works like a mini skylight. It gathers sunlight from the roof, and channels it through the tube into the room below. Sunpipes (also known as solar tubes) are a form of renewable energy that partially or completely replaces artificial lighting, giving a better quality of life.

Issues to consider;

- Need to ensure the sunpipe is fitted and insulated correctly so that heat cannot escape where the sunpipe meets the roof, nor rain enter the building.
- Need to get on the roof to install the sunpipe.

Hybrid sunpipes are available, which combine natural daylight with an in-built LED light fitting. These provide natural light during the day and low-energy LED lighting at night.

In this video [7] a householder talks about his experience of retrofitting sunpipes in Canada.

20.7 Motors, fans and drives

20.7.i Variable Speed Drives (VSDs)

Most motors, fans and drives in a building (such as boiler pumps, heat pumps, air conditioning, cooker hoods) operate at a single speed. This is like having a car or a bike that only has one gear.

It takes more energy to make the machine produce the energy necessary to create movement of air or water. Motors, fans and drives do not need to work at full speed all the time. A variable speed drive is like a gearbox for the motor or fan, that varies the speed in accordance with how fast the motor or fan needs to go at any particular moment. The VSD will automatically select the speed at which it needs to operate for maximum energy efficiency.

Variable speed drives (also known as variable frequency drives) have a short return on investment for motors, fans and drives that use significant amounts of electricity such as heat pumps, air conditioning, cooker hoods, larger boiler pumps, swimming pool filtration pumps and machine tools.

VSDs are not necessary on smaller appliances such as domestic boiler pumps, or desktop fans (the latter will have manually controlled variable settings anyway).

20.7.ii Voltage Optimisation (VO)

The nominal voltage supplied to electricity consumers in the UK is 230V. In practice, monitoring of the voltage being imported into your building from the national grid will show a voltage of anything between approximately 216V and 253V (as a tolerance of plus or minus ten per cent is allowable) with an average of 240V.

Newer electrical equipment that has been manufactured since 1995 is manufactured for a voltage of 230V. Spikes in the voltage of the electricity being supplied to such as building in the 230V-240V range mean that unnecessary electrical energy is being used.

A voltage optimisation device is a transformer that harmonises the voltage coming into the building. This irons out spikes that lead to unnecessary electrical energy being used. VO works best when there are appliances that use a variable voltage, such as heat pumps. As such, it is worth considering if you install ground source or air source heat pumps at Minsteracres, St Non's or The Retreat at Herne Bay.

20.8 Renewable heating and cooling

20.8.i What is a heat pump and how does it work?

A heat pump is a device that uses a small amount of electricity to move heat from one place to another.

A heat pump is like a fridge in reverse. A fridge cools by removing heat from a place where you want to reduce the temperature. It puts the heat elsewhere, reducing the temperature. A heat pump does the opposite. It removes heat from outside the building , and puts it inside the building where you want it, increasing the temperature.

Some heat pumps can be used for both heating and cooling. They provide cooling by running in reverse.

The following videos introduce how a heat pump works:

https://www.youtube.com/watch?v=2sHIgkMSpIM

https://www.youtube.com/watch?v=oCkeyZbkh5c [8]

The component parts of a heat pump are:

1. Evaporator coil
2. Compressor
3. Condenser coil
4. Expansion valve

Heat is brought into a first heat exchanger - the Evaporator - from the air outside or from the soil. This heat, which is at a low temperature or “Low Grade”, causes the molecules in the refrigerant in the Evaporator to get excited. This causes the refrigerant to evaporate from a liquid to a gas.

The Compressor then compresses the refrigerant gas, making its volume smaller. This drives up the temperature of the refrigerant gas. Low Grade heat therefore becomes hotter , and more useful for heating a building.

In the Condenser, a second heat exchanger, the refrigerant gas is then condensed, or turned back into a liquid. At this point, the heat in the refrigerant is then absorbed by cooler water from the central heating system, via the heat exchanger. This heat is then used to either heat radiators or underfloor heating, or to heat water, or both.

The cooled refrigerant then passes through an Expansion valve which decreases the pressure of the refrigerant. This decrease in pressure decreases the temperature of the refrigerant, then the refrigerant goes back into the Evaporator so the cycle can start again.

The following video from the USA shows the process of evaporation, compression, condensation and expansion (in the USA they use the term “liquify” rather than “condense”):

https://www.youtube.com/watch?v=g39nM7GbSJA

Types of Heat Pump

In an Air Source Heat Pump, the “fuel” is air drawn into the Evaporator from the atmosphere outside.

In a Ground Source Heat Pump, the “fuel” drawn into the Evaporator is heat contained in the soil.

The soil at a depth of 1-2 metres below the surface maintains an average temperature of 8-10 degrees Centigrade throughout the year in the UK. This is solar energy absorbed by the soil, rather than geothermal energy from the earth’s core. The soil is an excellent heat store, which is why plants, animals and fungi like to live and grow there. This storage of solar heat by the soil explains why the temperature on the London Underground in winter is higher than the temperature at street level.

The relatively stable temperature of the soil throughout the year compared to the fluctuations of air temperature means that a GSHP is more efficient than an ASHP.

In a GSHP, a network of slinky coils made of high-density polyethylene pipe filled with water and antifreeze is buried 1-2 metres below the surface of the soil. The slinky absorbs stored heat from the soil and transports it to the heat pump. Alternatively, a borehole can be sunk, if the soil or geology is not suitable for a slinky.

A heat pump system uses a type of antifreeze to prevent the pump from failing in cold weather.

An ASHP is usually placed outside the building, as its air is drawn from outside. This saves space. Even if the air temperature is below zero, an ASHP can extract sufficient heat energy from the air to heat a building.

A GSHP can be placed inside or outside the building, with the water from the slinky coil being piped into the GSHP where it stands. A space of approximately 1 x 3 metres is required for the GSHP and so space needs to be found within the building , or an outbuilding constructed to accommodate a GSHP.

A GSHP needs a large amount of ground space to accommodate a slinky. Typically, 700 square metres will be required - 100 metres in length by 7 metres in width. This would also allow room for an excavation vehicle. A geotechnical survey will need to be commissioned to assess the suitability of the soil for accommodating a slinky.

The following video shows the process of installing a slinky: -

https://www.youtube.com/watch?v=mUCxQUmf-tY

Slinky coils can be self-installed by a competent DIY-er hiring excavation equipment. The tasks involved are principally excavation, laying the slinky, backfill, reinstatement of turf. The head DIY person could be helped by volunteers or people on a work placement, community payback or corporate awayday. This would not only reduce the cost but create a sense of ownership over the GSHP installation.

A Water Source Heat Pump (WSHP) uses a water source as fuel, rather than the air or the soil. The water source can be a canal, lake or aquifer.

The following video shows an ASHP in operation in an off-gas home in the West Midlands:

https://youtu.be/HsFFJTB16N0

Things to consider when deciding if a heat pump is a viable solution

1. The heat demand for the building must be clearly understood.
2. A heat pump should only normally be installed if mains gas is not available for heating the building.
3. The thermal efficiency of a building must be maximised. Therefore, a heat pump should not be installed in a building that does not comply with the current building regulations.
4. Heat pumps work best with underfloor heating an option, or larger, low temperature radiators.
5. There needs to be space for digging trenches to lay slinky coils or for boreholes for a GSHP.
6. Most heat pumps need a three-phase electricity supply, although some manufacturers supply a device to convert single-phase to three-phase.
7. Are there opportunities for renewable electricity generation that could help power the heat pump?
8. Can the heat pump be used for cooling?
9. At what times of the day and night will the heat pump be needed for providing heat?
10. The economics of a heat pump should be understood, including whether it qualifies for the Renewable Heat Incentive.

Use of a ground source heat pump for cooling

A ground source heat pump has additional potential for cooling compared to an air source heat pump. This is because soil is more efficient as a source of cooling than air, as the ground is a solid and the air is a gas. The soil is good for storing heat and cold as its molecules are closer together than liquids or gases such as the air.

When the GSHP extracts heat from the ground to provide heat to the building, the temperature in the ground falls. This cold stored in the ground can provide some or all of the air conditioning/cooling requirements of the building, such as in the kitchen. This is called Passive Cooling.

Passive Cooling uses the low temperature of the GSHP ground loop to cool the building via a fan coil. Passive Cooling bypasses the heat pump. This means that the only parts of the GSHP that use electricity for Passive Cooling are the circulation pump and the distribution fan, so not the heat pump itself.

Heat extracted from the building during the cooling process goes back into the ground and is stored for future use. This future use can be just later the same day – to provide hot water or space heating for another part of the building when the outside temperature falls. Or this future use could be further ahead, such as a change in the season from summer to autumn. This is because the ground is a good heat store, that is capable of storing heat from one season of the year to another. This means that heat is being re-used by the heat pump.

Passive Cooling via a GSHP works when demand for heating is greater than demand for cooling.

20.8.ii Solar thermal

Solar thermal (sometimes known as solar hot water) is a different, simpler technology to solar electricity. Solar thermal directly converts heat from the sun into hot water. This is used for hot water applications such as; washing hands in bathrooms; kitchen operations that need hot water such as hand washing and light dishwashing; bathroom applications such as boiler-fed showers and baths; and spa applications.

Solar thermal is not used for space heating in this country. It is not suitable for modern dishwashers or washing machines, which generally have a cold-water feed as they operate at lower temperatures nowadays.

Where there is regular and constant demand for hot water for washing hands, such as in washrooms, bathrooms and in a kitchen, then solar thermal can be a viable technology.

Solar thermal pre-heats water, reducing the need for fossil fuel input from water heating appliances (such as immersion heaters, gas boilers). Even on relatively cold days in winter, the solar thermal system will succeed in raising the temperature of cold water which reduces the need for input from an immersion heater. On warmer days of the year, between the spring and autumn equinoxes, a solar thermal system can provide most or all of a building’s hot water demand without any input from an immersion heater. Hot water can be stored overnight in a highly insulated thermal store and will retain its heat for the remainder of the day – and the next day in case that proves to be cloudy.

A smaller roof area is needed for solar thermal than for solar electricity. Solar thermal can also work on a south-facing wall. There are two types of solar thermal panels;

- *Flat-plate* works best on a pitched roof.
- *Evacuated tube solar thermal panels* can be used on roofs or on walls. In an evacuated tube system on a wall, the tubes are usually vertical although there are examples of them being mounted horizontally.

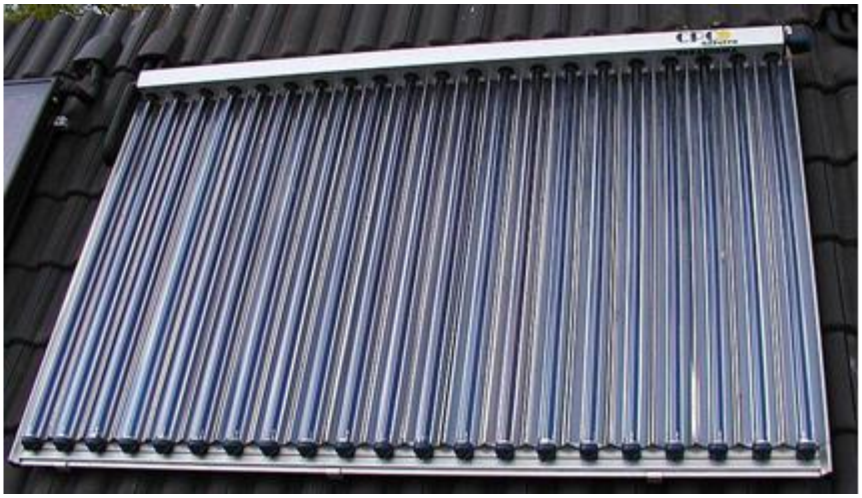


Figure 41: Solar thermal - evacuated tube [9]

With an evacuated tube system, tubes with a Compound Parabolic Concentrator (CPC) can be used. Rather than there being a gap between each tube, the tubes are closer together and the CPC has a curved mirror behind each tube. This mirror reflects additional heat into the tubes and maximises the absorption of heat by the tubes.

Solar thermal is most viable when displacing grid electricity or kerosene as the fuel for heating water.

20.8.iii Biomass

The following issues need to be considered when deciding whether to use biomass for space and water heating:

a. Feedstock type – woodchip, wood pellets, agricultural residues, etc.
b. Boiler type
c. Planning consent is not needed; however, the planners should be consulted. The potential visual impact of flues is the major planning issue . As long as the biomass boiler confirms to relevant clean air standards and is operated in accordance with the manufacturer's instructions, then it should be possible to overcome planning issues.
d. Transport of feedstock and vehicle movements – ensure there is good vehicular access to the building for delivery of feedstock. Consider the impact of feedstock delivery on neighbours.
e. Plant space and fuel storage – space would need to be found for the boiler inside the building or an outbuilding constructed; woodchip would need to be kept in an outbuilding, which would need to be constructed, or by arrangement with other buildings on site.

f. Funding – the capital costs of a biomass project can be crowdfunded or outsourced to an energy services company.
g. Fuel quality – woodchip should be procured according to its calorific value, not by volume.

Costs of a biomass boiler would include:

h. Planning and consulting
i. Capital investment in boiler, pipework, radiators, controls
j. Infrastructure e.g. fuel store
k. Administration and insurance

Operations-related costs include:

l. Fuel cost
m. Labour cost for operating the boiler – these should be manageable in a small boiler
n. Maintenance costs
o. Licences
p. Disposal of ash or other residue

Biomass from sustainable sources could be a better option environmentally than a heat pump that is reliant on fossil fuel electricity. A heat pump in an insulated building where the electricity is from locally generated renewable energy, is a lower carbon alternative to biomass.

20.8.iv Solar cooling

If conventional air conditioning is used to cool the building instead of a GSHP, then solar cooling is an innovative technology that can be used to reduce the running costs of air conditioning.

Solar cooling is a new technology to the UK. It uses the heat captured by a solar thermal system to excite the molecules in the refrigerant gas of an air conditioning unit by heating them more efficiently than electricity would do. This causes the refrigerant gas to work more efficiently, since as Albert Einstein predicted a century ago, a refrigerant gas works better at high temperatures without expanding. The hotter the refrigerant gas becomes, the more it absorbs heat. This process substantially reduces the demand for electricity to heat the refrigerant gas and excite its molecules.

Solar cooling is quite widespread in the USA and the Caribbean. There are case studies of solar cooling in the UK that show very favourable results. There is a high level of synergy between the availability of solar heat and the need for cooling. This means the return on investment of solar cooling is potentially shorter than other forms of small-scale renewable energy, and comparable to the return on investment of mass-market energy saving measures such as LED lighting.

Although I am not aware of anyone who has applied, I believe that solar cooling may qualify for the Renewable Heat Incentive (see below) partly because solar cooling may not need any subsidy to be viable, and because the work involved in applying for the RHI may not be necessary to make it financially viable.

20.9 Renewable electricity

20.9.i Solar electricity (photovoltaic)

Solar electricity panels turn radiation from the sun into electricity. This electricity can be used for a variety of applications including; lighting, cooking, computers, immersion heaters and appliances. It is not generally used for space heating in this country.

Due to the abolition of the renewable energy Feed-In Tariff, smaller solar electricity installations, such as those on a typical house, are not currently financially viable.

Smaller solar electricity installations will become viable again in the future, as the price of solar panels and battery storage falls , and the price of electricity rises. If Government policy changes then there may be new financial incentives for solar.

To make a solar electricity installation viable you need;

- a space capable of accommodating around 50 kW of solar panels
- a building using around 40,000 kWh of electricity per annum, with constant electricity demand including the summer.

Ground-mounted solar electricity has lower build costs and maintenance costs than roof-mounted.

20.10 Energy saving in food preparation

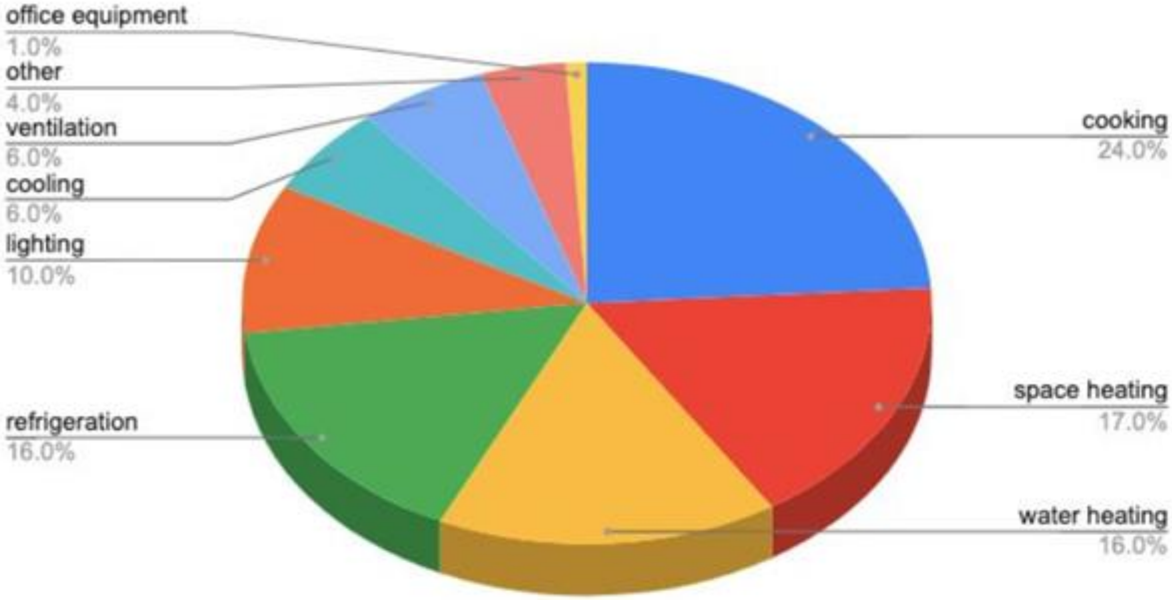
Food preparation and catering are activities where significant amounts of energy can be wasted. Opportunities for energy saving in catering at sites such as Minsteracres, St Non's, Herne Bay, include:

- Catering apparatus, particularly cooking, washing and refrigeration equipment
- Heating, ventilation and lighting
- Energy management

The Carbon Trust says that only 40% of the energy consumed in a kitchen is meaningfully used in the preparation and storage of food; most of the remaining 60% is wasted by being dispersed into the kitchen as heat. [10]

The following chart shows how energy is used in a typical kitchen:

Figure 42



When procuring new kitchen equipment, the following guidelines should be used:

- Consider running costs above capital costs; you should compare the power rating and energy consumption of appliances before purchasing.
- Induction hobs are a highly energy efficient technology for cooking.
- Combi-ovens also have low running costs.
- A more efficient deep-fat fryer can use up to 50% less energy.
- You should consider washing machines and dishwashers for their water consumption as well as their energy consumption.

Recommended behavioural measures in a kitchen to prevent heat being wasted:

- Use correctly sized pots and pans.
- Do not over-fill saucepans and kettles, use lids to retain heat
- Switch off grills, hobs and fryers immediately after use.
- Make a note of cooking equipment preheat times and keep them on display.
- Keep hot storage of cooked food to a minimum.
- Switch on equipment only when necessary; discourage staff from turning equipment on at the beginning of a shift.
- When pans come to the boil, turn hobs down to the minimum setting to simmer.
- Use microwave ovens to reheat small amounts of food.
- Switch off extractor fans when not in use.

- Fridges and freezers should be placed in a colder location - not next to cookers or other heat source, and ideally in an unheated separate area to the kitchen.
- Ensure staff close fridges and freezers immediately, and don't leave them open.
- Defrost and clean fridges and freezers regularly, and check seals for tightness.

20.11 Renewable heat incentive

The Non-Domestic Renewable Heat Incentive is a government scheme that pays owners of certain types of renewable heat installations per kWh of renewable heat that they generate. Heat pump, solar thermal and biomass installations qualify for RHI. The RHI can make the difference between a renewable energy installation being financially viable or not. The RHI application process is unnecessarily complicated even for small installations, and so sufficient time needs to be allocated to writing the application. I estimate that around two days are needed to write the application and follow up any enquiries from Ofgem, who administer the scheme.

You should seek assurance from potential installers that the system that they propose to install will qualify for the RHI and cross-reference this with the directory of eligible products[11] if in doubt. There are some ASHPs on the market which do not qualify for the RHI (this does not mean that there is anything wrong with those products, simply that their manufacturers feel that they can get their products to market without putting themselves through the paperwork involved with the RHI).

It should be noted that if a renewable energy installation is funded by a public grant[12], then it is not eligible to receive the RHI . Funding an installation through crowdfunding and then claiming RHI may be more financially viable than the receipt of a public grant, and the decision to apply for a public grant should be carefully weighed up against other funding routes.

Installations funded by private donations[13] are not excluded from the RHI or FIT. You should check with Ofgem as to whether a particular grant funder is considered public or private.

The RHI is paid to the recipient over a 20-year period, and therefore, you will need a sufficiently long lease or licence over the building to be able to apply. Recipients of the RHI will need to take and submit meter readings from the heat meter on their renewable heat appliance.

If you are considering applying for the RHI then it is advisable to keep an eye out for announcements from Ofgem about the RHI. At some stage in the future there is a risk that the government will abolish the RHI.

There is also a domestic RHI, which is broadly similar to the non-domestic RHI.

20.12 Smart metering

Most of your buildings do not have smart meters for electricity (or gas, for those buildings that have mains gas).

Definitions of a smart meter vary, but what they all have in common is the ability for the meter to automatically read itself and send the meter reading to the supplier wirelessly. Some smart meters will have user-friendly functionality such as hand-held or smartphone displays, others do not interact with the user at all (such as the electricity meter at Riverdale Gardens).

Smart meters are meant to be interoperable, that is, they maintain their smart functionality even if the user changes utility supplier. However, some of the earlier generation of smart meters, including many installed by British Gas, are not interoperable. This means they lose their smart functionality if the user changes supplier. In this instance, although the new supplier's billing system will believe (because the data tells it to) that the meter is smart, and will therefore be expecting automatic meter readings, the meter readings do not arrive, and so the new supplier's billing system reverts to estimated billing.

Smart meters would be very helpful in your buildings to help you monitor your progress in reducing your greenhouse gas emissions. You should ask your energy suppliers when they plan to fit smart meters.

20.12.i Time-of-use tariffs and Seasonal Time-of-Day tariffs

These are electricity tariffs that vary in price according to the time of day or the time of year. They are becoming more widespread due to smart meters. Minsteracres already has a time-of-use tariff (day/night). Where buildings are on a TOU or STOD tariff now or in the future, it is advisable to look at ways that electricity consumption, e.g. for baking, some cooking, immersion heaters, washing machines, dishwashers, can be shifted to times of cheaper electricity. When electricity is at its cheapest on TOU tariffs, it is also of lower carbon intensity, because it has lower fossil fuel input than electricity supplied at peak times.

Some suppliers are also now offering Agile tariffs. Agile tariffs go beyond TOU and STOD tariffs. Agile tariffs are electricity tariffs where the electricity supplier will temporarily drop the price of electricity at relatively short notice (hours or even minutes) and notify the user that the price is going to fall. The user may take advantage by shifting demand for electricity to match the temporary price fall. The electricity supplier will let the building manager know (via an email or a smartphone notification) when the price drop will happen, how long it will last and what the temporary price is. The building owner can then choose to accept the offer with one click and take advantage by shifting demand for electricity.

In your buildings, an agile tariff could be used for tasks like heating up the immersion heater and using a dishwasher or washing machine. Periods of agile pricing can also coincide with periods where demand for cooling and air conditioning is highest, due to peaks in the input of solar electricity to the grid. There are carbon saving benefits as well as financial benefits to agile tariffs, as the carbon content of electricity during periods of agile pricing is lower.

20.13 Electric vehicle charging points

There are three types of electric vehicle charging points currently:

- *Rapid Chargers* are available as AC and DC. They operate at between 43kW and 50kW of power. They can deliver 80% of the charge to a typical EV in less than an hour. Where you are charging users to charge their vehicles, then a software platform works with the charger to enable users to pay to charge their cars. There is an industry open standard protocol - OCPP - with which software platforms should comply.
- *Fast chargers* are the most common charger in use. They operate at between 7kW and 22kW and will charge an EV in 4 hours.
- *Slow chargers* operate at up to 3 kW. They are trickle chargers. They are suitable for overnight charging, especially where cheaper night rate electricity tariffs are available, or for charging where solar power is available. Some of them are suitable for connection at a domestic level, simply using a 3-pin plug, with no software required, if you are not charging people to use the EV charging point. While not as convenient as fast or rapid chargers, slow chargers place less stress on the National Grid and are therefore less likely to lead to spikes in the carbon intensity of grid electricity.

Where there is space to install more than one charging point, there is a good case for having a mixture of fast, rapid and slow charging points.

The Government Office for Electric Vehicles (OLEV) offers a voucher-based grant scheme towards the cost of EV charging points, which can be accessed via installers. Grants are available for businesses and households to install charging points.

20.14 The Energy Company Obligation

The Energy Company Obligation (ECO) is the main way in which domestic energy saving measures are meant to be funded in the UK. ECO has been widely criticised for not getting the right measures to the right households. ECO funding is a bit of a lottery – you can't guarantee that you will be able to get the right funding at the right time for the right measures. The main reason for this is because the energy companies, who fund the scheme, cherry-pick the measures they wish to fund, going for the low-hanging fruit. ECO should be accessed if available for your domestic premises, but it's important to manage expectations as the plug can be pulled on a funding offer at short notice.

There is no equivalent of ECO for businesses or charities.

Appendix 1 - thermography report

This is a separate document.

Appendix 2 What would happen if you could not achieve Net Zero by energy efficiency and by generating renewable heat and electricity?

The most sustainable method of removing greenhouse gas emissions is to generate additional renewable electricity over and above what you need to provide renewable heat and power to your own estate.

Where this is not possible, the Province should only allow methods of greenhouse gas removals that are recognised as sustainable. The Province should follow the Royal Society's guidance on sustainable removals. These methods include afforestation; biochar; and some forms of carbon capture and storage. [26]

Ethical Consumer magazine's website recommends Gold Standard as the most ethical marketplace for offsetting. As Ethical Consumer is the leading authority in its field, then I endorse its recommendations.

Please note that biomass should not be considered a fully zero carbon fuel. [27]

While carbon dioxide emitted by biomass during combustion is offset by the absorption of atmospheric carbon dioxide by the biomass feedstock while it was alive, the same cannot be said for other greenhouse gases emitted by biomass during combustion. These gases, namely methane and nitrous oxide, are not offset by the feedstock while it was alive. Therefore, the emissions of these gases must be included in the calculations of greenhouse gas emissions, and I have included them in this report.

Those emissions are nevertheless quite small compared to those of fossil fuels. Hence a kWh of heat produced by burning gas produces 13 times as many greenhouse gas emissions as a kWh of heat produced by burning biomass.

[26] https://royalsociety.org/~/media/policy/projects/greenhouse-gas-removal/royal-society-greenhouse-gas-removal-report-2018.pdf

[27] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/829336/2019_Green-house-gas-reporting-methodology.pdf