ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary the Virgin Church, Studham
PCC of St Mary the Virgin

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of St Mary the Virgin Church, Studham was undertaken by ESOS Energy to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use. This audit has been provided in conjunction with 2buy2, the Church of England's Parish Buying scheme provider and is subsidised from Total Gas & Power, the Parish Buying schemes principal energy suppliers.

St Mary the Virgin Church, Studham is a Grade I listed church with parts dating from 1220. Electricity is supplied to the site, heating is by oil.

The church has a number of ways in which it can be more energy efficient and a clear path towards net zero carbon. Our key recommendations have been summarised in the table below and are described in more detail later in this report. It is recommended that this table and the route to net zero carbon diagram below are used as the action plan for the church in implementing these recommendations over the coming years.

Energy and decarbonisation recommendations	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/yr)
Complete LED lighting installation	175	£56	£100	2	List A	0.03
Install secondary double glazing to kitchen modern north door	1% 320	£15	£25	2	List B	0.08
Flush and clean central heating	7% 2,240	£183	£500	3	List B	
Install reflective radiator panels	2% 640	£52	£50	1	List A	
Purchase some heated cushions for "top up " heating	N/A		Unknown		None	
Under Pew heating (full installation costed)	32,000 oil 3,100 electric use	£1,620	£16,760	10.5	List B	8.0
Consider registering for Eco Church	The Eco Church programme, which is recommended by the Church of England, helps congregations care for the environment in all aspects of church life. The programme is free; you can, however, make a donation to A Rocha UK towards its costs.					
Create a procurement policy for appliances (and other goods)	Commit to buying only appliances with the new energy efficiency ratings of A, B or C at the lowest when those you currently have reach the end of their useful life. (NB ovens, air conditioners and space or water heaters are still on the older rating scale, so for these, try for A+++.)					

The church should check any faculty requirements with the DAC Secretary at the Diocese before commencing any works.

Figures in the table are based on current market prices of 32p/kWh for electricity and the recent price of 82.91p/l for oil.

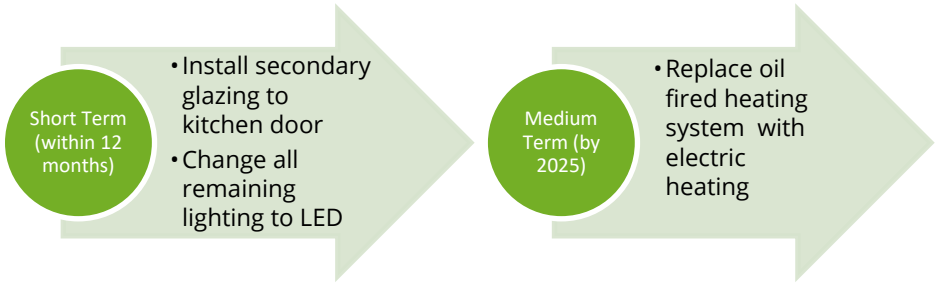
The carbon figures are based on the DEFRA 2022 carbon emission factors of 0.211 for electricity, 0.18 for gas and 0.27 for oil. Do note that as energy prices increase, payback periods decrease.

2. The Route to Net Zero Carbon

Our Government has committed to move towards Net Zero Carbon – the point at which we have reduced emissions as much as we can and then balanced any residual emissions through removal of carbon from the atmosphere. They have done this as part of a worldwide agreement which aims to limit global warming to well under 2 degrees Celsius, with an aim of keeping it below 1.5 degrees Celsius. This will help protect all of us from the impacts of climate change.

In February 2020, the Church of England's General Synod set its own Net Zero Carbon target. The first stage of this target covers energy used by churches, cathedrals, schools, vicarages, other church buildings, as well as emissions caused by reimbursed transport. The target date is 2030.

This church has a clear route to become net zero by 2030 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Mary the Virgin Church, Studham to give them advice and guidance as to how the church can be improved to be more energy efficient. In doing so the church will also become more cost effective to run and seek to improve the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Mary the Virgin Church, Studham, Church Road LU6 2NW was completed on the 23rd January 2023 by Dr Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group developing advice for the Church of England and authored the "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE Associate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church.

St Mary the Virgin Church, Studham	
Church Code	632326
Gross Internal Floor Area	225 m^2
Volume	1,540 m^3
Heat requirement	51 kW
Listed Status	Grade I
Average Congregation Size	20

The church is typically used for 5 hours per week for the following activities

Type of Use	Hours Per Week (Typical)
Services	3 hours per week
Meetings and Church Groups	<1 hour per week
Community Use	2 hours per week averaged [6 school visits, 2 concerts)
Occasional Offices	2 Weddings 10 Funerals

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by the church.

The current electricity rates are:

Day Rate	17.8512p/kWh
Evening / weekend Rate	13.7030p/kWh
Standing Charge	37.5391p/day

The electricity is supplied by Total Energies, and is purchased on a renewable tariff (although the supplier's overall fuel mix disclosure is only 50%).

A review has also been carried out of the taxation and other levies which are being applied to the bills. These are:

VAT	5%	The correct VAT rate is being applied.
CCL	not charged	The correct CCL rate is being applied.

The above review confirmed that the correct taxation and levy rates are being charged.

The church is a charity and therefore can claim VAT exemption status. This should always be done when changing supplier.

VAT declarations are available from the suppliers website and can usually be found by typing the suppliers name followed by "VAT Declaration Certificate" into most website search engines.

5. Energy Usage Details

5.1 Annual Consumption Data

St Mary the Virgin Church, Studham used 853kWh/year of electricity in 2022, costing £331 per year, and 32,160 kWh/year of oil (3,000 litres), costing £1,561. The total carbon emissions associated with this energy use are 8.86 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	109EE00648	Iskra Single Phase	Yes	Porch

All the meters are AMR connected and as such an energy profile for the entire energy usage could be obtained from your supplier.

5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

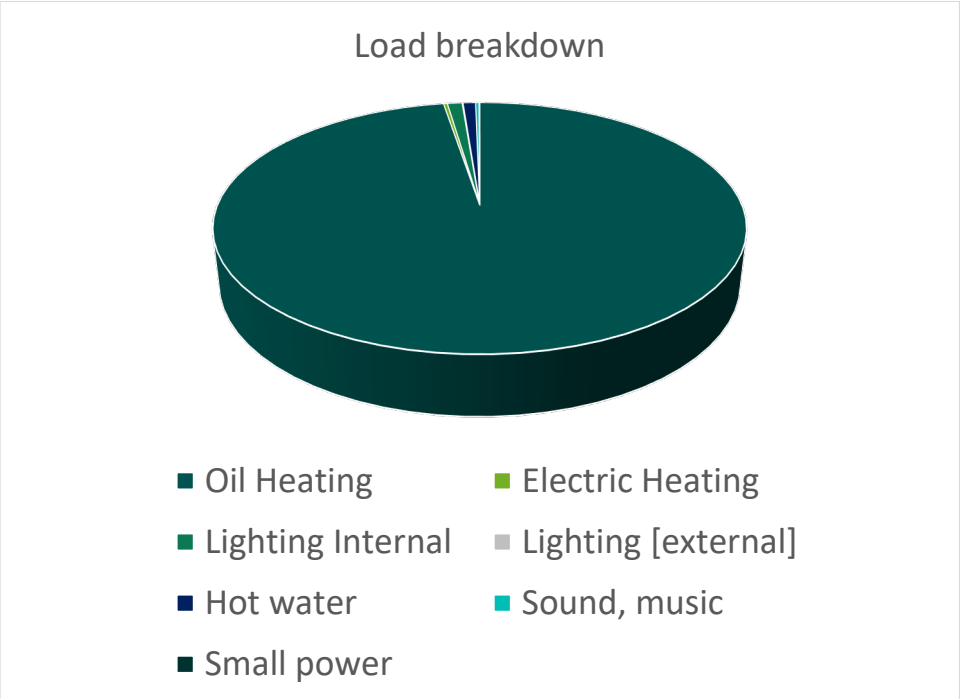
	Equipment	Power kW	Annual Consumption kWh
Heating [Oil]	Grant 160-200 multi pass boiler 85% efficiency, 58kW output [470 hours operation]	68	32,000

Heating [Electric]	Boiler circulation pump [470 hours] Toilet extractor fan	150W	70 20
Lighting [Internal]	Church 270 hours use PAR 38 spotlights (chancel) 7 x 80W Compact fluorescent 6 x 18W Pendant non LED 18 x 7W LED floodlights 8 x 50W Kitchen recessed LED 3 x 7W Bulkhead 1 x 28W TOTAL	 560W 108W 126W 400W 21W 28W 1,250W	 TOTAL 350
Lighting [External]	floodlight		20
Hot Water (electric)	Fixed water heater under sink (10 litres, Ariston) - normally turned off Urn	3 2	200 100
Sound, Music	Organ	1	80
Small Power	Vacuum cleaner	1.5	20

Sum of electricity use estimates: 860kWh

Annual church electricity consumption, 2022: 853kWh

Annual church electricity consumption, 2021: 1,714kWh



As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site. The other significant loads are lighting and hot water.

6. Efficient / Low Carbon Heating Strategy

6.1 Overview

The energy used for heating a church typically makes up around 80% to 90% of the overall energy consumption. Heating also often uses gas or oil as its primary fuel. These are fossil fuels with high carbon emissions and little opportunity to decarbonise in the near future. Mains gas does have some potential to reduce its carbon content through the use of bio gas and hydrogen, but these are less developed solutions and will be unable to deliver 'zero carbon mains gas' in the foreseeable future.

It is therefore important to review and set out a plan to make heating more efficient and less carbon intensive. One way to achieve this is to consider a transition to electrical heating where this also represents an efficient and comfortable solution for churches. Electricity currently has carbon emissions of around the same level as mains gas, but the carbon emissions associated with electricity are reducing rapidly as the UK builds more renewable energy and decommissions its remaining oil and coal-fired power stations.

6.2 Heating System Description

The church is currently heated by a Grant 160-200 oil fired boiler which was installed prior to 2000. It is no at the end of its life and likely to require replacement within the next few years. The recent Government Net Zero Review proposes that no new boilers should be installed post 2033 (replacing a previous 2035 proposal).

The boiler provides heating to six cast iron column radiators located at the rear of the nave and one at the front of each aisle. The aisles are also fitted with six single wall pressed steel radiators plus two double wall in the south aisles and a further four pressed steel radiators of various sizes in the chancel.

The church makes use of fixed wooden pews and there are fixed choir stalls in the chancel.

The church is used once per week on a Sunday for service and the typical congregation size is 20 with 10 at the midweek service. The heating is set to come on several hours earlier in the winter to ensure the church is warm for this service.

6.3 Future Heating Options

The various options for a decarbonised heating solution have been reviewed in the table below.

Decarbonisation Heating Solution	Viable
Air to Water Source Heat Pump	No – unsuited to low hours of use, current heating pipework and heat emitters
Air to Air Source Heat Pump	No – unsuited to low hours of use of building
Water Source Heat Pump	No – no water source locally
Ground Source Heat Pump	No – unsuited to low hours of use of building, archaeology in church yard
Under Pew Electric Heating Panels	Yes
Electric Panel Heaters (to provide supplemental heating only)	No – distance from walls to nave centre too wide
Over Door Air Heater (to provide a supplemental warm welcome at the door only)	Possibly
Overhead Infra-Red Heaters	Potentially, but tend to be least preferred due to visual impact and less comfortable heat output.
Heated Chair Cushions	Alternative to under pew heaters (but less power)

The recommendation is therefore that the church obtain detailed quotations for under pew and suspended radiant overhead heating as described below. A small number of portable heated cushions may be considered for "top up" heating.

6.4 Install Electric Under Pew Heaters

Electric under pew heaters provide a high level of thermal comfort to people sat in the pews. They are not installed to try and heat the entire air volume of the church, instead thermal comfort is achieved through a flow of warm air rising past the person in the pew. This means that the heaters should be installed under the entire length of all the pews that are likely to be used.

These heaters warm up almost instantly and a flow of warm air over the pew area is created within around 15 minutes of their being turned on. This significantly reduces the amount of preheating required before each use of the building and can make electric heating cost competitive with gas. It is important that this reduced 'on time' is properly reflected in any comparisons with other types of heating.

Ducting (above, right) could be used to run cabling to under pew heaters.

We would therefore suggest that the following works could be considered:

For a full installation

Install under pew heaters suspended from brackets from the underside of the pew seat as follows:

Aisles, 12 pews x one 650W heater

Nave, 29 pews x two 650W heaters in each row between uprights

1 pew (rear of N. nave) 2 x 450W heaters

Total installed power 30.8kW

Capital price estimate £16,700

Operating cost: 3 hours/week x 30 hours + extra = 100 hours x 31kW x 32p/kWh = £992.

A full installation delivers more heating than required for the normal congregation of twenty. Only selected pews could be fitted. Otherwise, only the required units need to be switched on.

Cable runs to the pew heaters could utilise the existing heating pipe trenches (all cabling should be in armoured cable or FP200 Gold when above ground) to both rows of pews. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

A case study of a church which has adopted this solution is available at https://www.churchofengland.org/about/environment-and-climate-change/st-andrews-chedworth-electric-heating

Photos of installations are shown below. In addition, several churches have recently installed such systems. If you would like to find out about churches whom you could ask about their experiences, please contact the diocese.

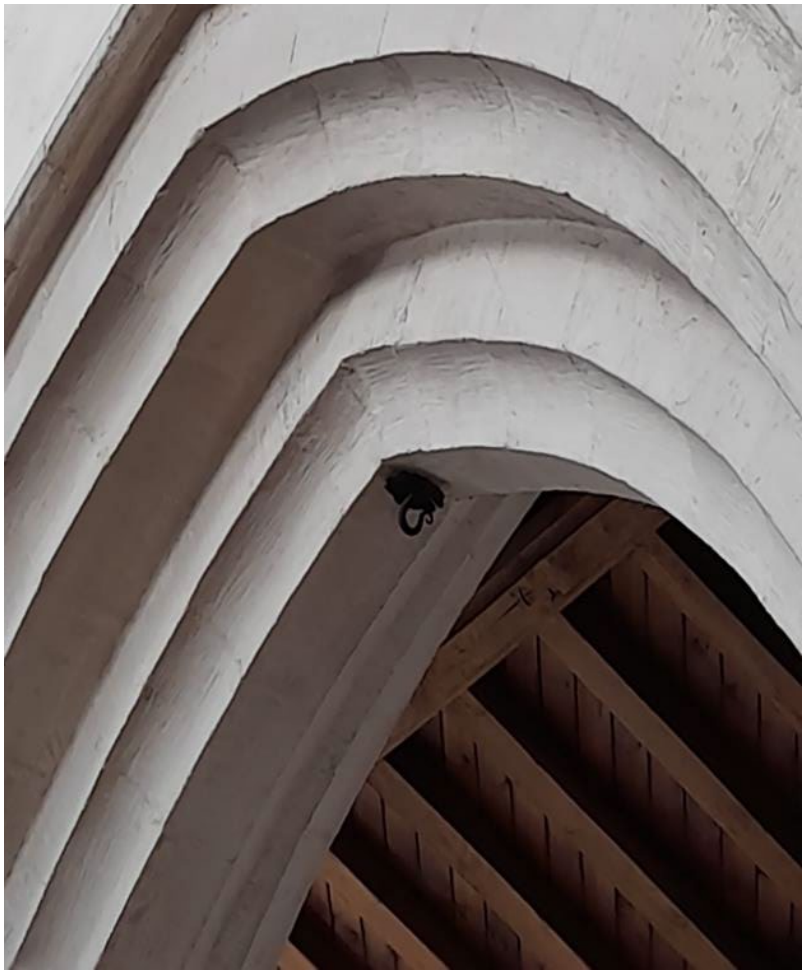
Brown BN Thermic 650W under pew heaters fixed to underside of pew seats for pews which have no solid backs.

Black 650W Norel under pew heaters fitted to solid pew backs.

6.5 Overhead Infrared Heaters

An option for heating the people, rather than all the air in the space, is to use overhead infrared heaters. These come in a variety of forms from the traditional that have a visible red-light glow emitted from them, to ceramic units and the more modern 'black heat' units which have no visible light. In most cases the distance from the heater to the people being heated needs to be no more than around 2.5 to 3m, although this varies slightly between heater types (therefore a mounting height of between 3m to 4m is typical). Units mounted outside of their heating range are likely to give poor performance. This form of heating provides heat from above and can leave lower limbs and feet feeling cold; therefore some people find this form of heating less comfortable, especially for longer periods of time. Comfort perceptions tend to improve in spaces where people are standing and more able to move around but reduce in areas where they are sitting in a fixed position for more than around 15 minutes. Some of these units can also have extremely high surface temperatures, and care should be taken not to mount them directly next to historic timbers or fabric that may be impacted by high heat levels.

There are some units on the market that incorporate a large chandelier type unit with both lighting and heating. At St Mary's there are existing tethering rings under the arches which could be used to suspend either chandeliers with radiant quartz heaters mounted on them, or "black heat" infra-red disc heaters. In each case the heaters would be at the height of the column capitals. Three pairs would line up over the majority of the seating; costings are for this number of units as that is directly comparable to the under pew heating. The rear bays above the unseated area could have a further pair of units (this is also an option to consider to provide heat to this area along with under pew heaters).



6.6 Heated Pew / Seat Cushions

Most are now familiar with the concept of heated seats within cars; the same solution is also used in some outdoor venues such as alfresco dining and sports stadiums. These provide a heated cushion to sit on: the direct warmth from the contact areas provides a degree of comfort even when the surrounding space is cold. This can be a useful solution for churches which only have chairs (having removed pews) and/or for small congregations where there are few other alternatives.

There are a variety of heated seat cushions on the market. Some are directly plugged into a power socket (similar to an electric blanket). Others have battery packs, which can be charged and then connected to a seat pad. This makes them more flexible and avoids trailing leads. The more advanced products have a pressure sensor which means heat is only provided when someone is sitting on the cushion. Heated pads for 'benches' can also be used to heat a pew or could even be adapted to form a heated kneeler for the communion rail.

It is recommended that the church consider obtaining some heated cushions to provide "top up" heat for midwinter and those who feel the cold.

If the trial is successful the church may wish to consider installing additional plug sockets at the end of the pews where heated seat cushions are likely to be used to allow for the plug in versions to be used.

Longitudinal plug in cushions can be considered as an alternative to under pew heaters. One manufacturer is Kovo Schidt.

A case study of a church using heated cushions is available at https://www.churchofengland.org/about/environment-and-climate-change/towards-net-zero-carbon-case-studies/marown-church-tries-new

6.7 Upgrade to 3 Phase Electricity Supply

To be able to have sufficient electrical power to supply enough energy into an electrical heating system, the church will need to increase the existing electrical supply from single phase 100A supply to a 3 phase 100A supply.

The upgrade to the supply has to be carried out by the District Network Operator in the areas.

The DNO in your area is: UK Power Networks

The cost of bringing in a new 3 phase supply can range from £300 to £30,000. The DNO will provide a quotation for free, so it is well worth obtaining a quotation even if plans are not yet certain, so that decisions can be made on a well-informed basis.

7. Improve the Existing Heating System

In the years before the replacement of the existing heating system it is recommended that measures are taken to improve the efficiency of the existing heating system. These should include:

7.1 Clean the Existing Heating System

Magnetic sludge builds up and circulates in heating systems. This will prevent the proper and efficient operation of the system by reducing both the ability of the boiler to heat up the water and the output of the radiators. It is similar to how scale build up can adversely affect kettles and showers. The church should have a record in the Log Book of when the system was last cleaned. If this has not been conducted within the last 10 years and the current heating is to be retained, it is strongly recommended that the heating system is cleaned to remove this sludge from the system. This is done by using a chemical clean and/or power flush procedure in which cleaning chemicals are put into the system, which is then turned on and run through a filter consisting of high-power magnetics to remove the sludge.

The cleaning of a heating system can be carried out by any competent heating engineer and typically increases the efficiency of a system by 10 to 15%. This can dramatically improve comfort for the congregation.

7.2 Reflective Radiator Panels

The church is heated by radiators served from the boiler. The majority of the radiators are located on the external, uninsulated walls and have no reflective or insulated surfaces directly behind them at present. They therefore lose much of their heat into the masonry of the wall behind the radiator rather than giving it out into the body of the church.

In order to improve the insulation directly behind the radiators, a reflective panel can be installed. This helps to make sure more of the heat from the radiator goes into the space and requires less overall heating from the boiler to achieve the set point. There are a wide variety of reflective panels for installing behind radiators on the market. It is recommended that these panels are installed behind all radiators within the building.

The installation of radiator panels can be carried out by anybody competent in basic DIY and does not require the radiators to be removed.

8. Energy Saving Recommendations

In addition to having a revised heating strategy there are also a number of other measures that can be taken to reduce the amount of energy used within the church.

8.1 Complete LED Lighting

The lighting makes up a relatively small overall energy proportion of the electricity used within the church.

Energy savings can be achieved by replacement of the following:

Non LED spotlights in the chancel using the same fittings.

[These fittings can be made more efficient by simply changing the bulb/lamp within the existing fitting to a new LED bulb/lamp. This could be carried out by competent members of the churches internal team, very cost effectively and, unlike a change of fittings, would be a List A item, so no permissions would be required.]

Guidance on lighting, produced by Historic England for churches, can be found at: https://historicengland.org.uk/advice/caring-for-heritage/places-of-worship/making-changes-to-your-place-of-worship/advice-by-topic/lighting/

8.2 Timers on Fuse Spurs to Water Heaters

The electric point of use water heater in the kitchen which provides hot water for hand washing is normally turned off. This should continue to be managed by a clear notice - this will prevent the standing losses from the unit wasting energy during periods when the building is not occupied (particularly along the copper pipework) which can amount to 1,000kWh per year costing £320 at market rates.

If the building, or unit come into more regular use, it is recommended that the heater is fitted with a 24 hour/7 day timeclock to replace the fused spur switch. This should be set up with times to match the times that the building is occupied.

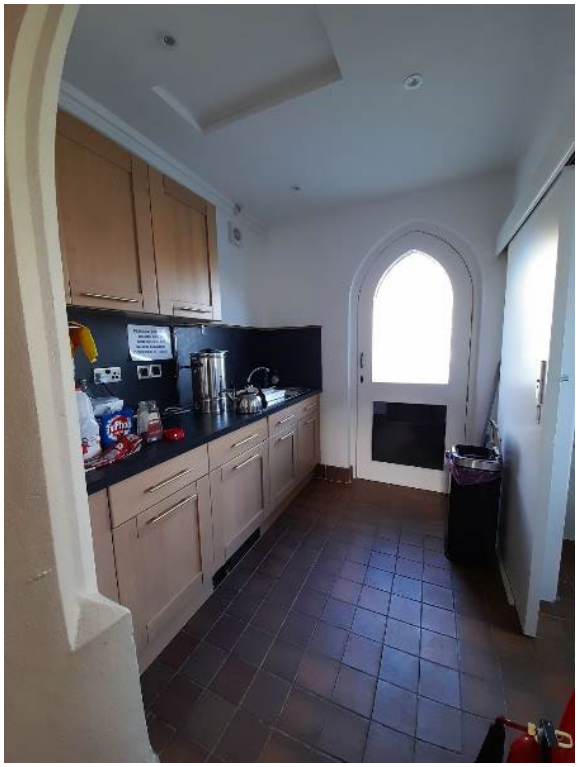
Such units can be purchased at any electrical wholesaler and fitted by your existing electrician or any NICEIC registered electrical contractor.

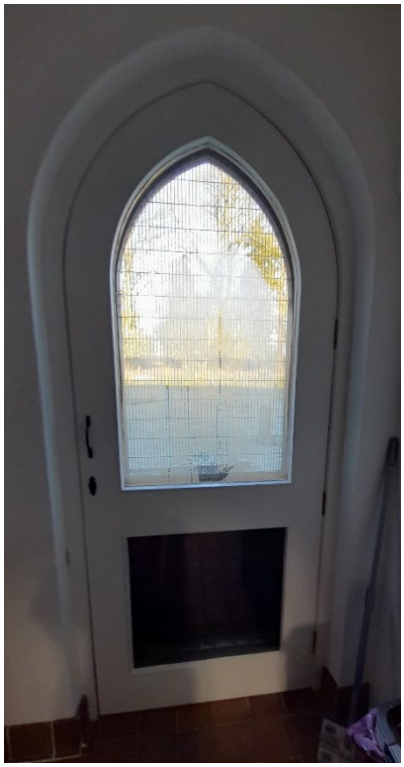
8.3 Secondary Glazing

The external door at the north side of the kitchen is single glazed. It is positioned inside a much older door which is fitted with a metal grille. Condensation was observed on the glass during the audit.

The introduction of secondary glazing would considerably reduce the heat loss through window and improve thermal comfort for those in the kitchen, as well as providing added security.

This could be done cost effectively using an acrylic sheet. There are several suppliers online who can supply sheet cut to size. It should be installed with an air gap ideally of 15mm between panes, with an air tight seal made. This could be done either on the inside or outside of the door.





9. Renewable Energy Potential

The potential for the generation of renewable energy on site has been reviewed and the viability noted.

Renewable Energy Type	Viable
Solar Photo Voltaic (PV)	No – not sufficient demand.
Battery Storage	No – no viable solar PV

Now that the Feed in Tariff scheme has come to an end, the installation of solar PV panels in situations where there is not almost full usage of the electricity generated on site is not really viable. The energy consumption of the site is very low, at less than 1,000kWh per annum. Although future heating is likely to be electric, meeting the once weekly demand for heat would require a large solar PV installation which would otherwise not be required.

Having reviewed the site it is not considered that there is good viability for any renewables and instead a good clear focus on reducing the energy demand of the building should continue with a targeted approach on reducing the heating energy.

10. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available on this Parish Resources page:
https://www.parishresources.org.uk/resources-for-treasurers/funding/

11. Faculty Requirements

It must be noted that all works intended to be undertaken should be discussed with the DAC at the Diocese.

Throughout this report we have indicated our view on what category of permission may be needed to undertake the work. This is for guidance only and must be checked prior to proceeding as views of different DACs can differ.

Under the new faculty rules:

List A is for more minor work which can be undertaken without the need for consultation and would include changing of light bulbs within existing fittings, repair and maintenance works to heating and electrical systems and repairs to the building which do not affect the historic fabric.

List B is for works which can be undertaken without a faculty but must be consulted on with permission sought from the Archdeacon through the DAC. This includes works of adaptation (but not substantial addition or replacement) of heating and electrical systems and also includes the installation of under pew heaters to pews which are made in or after 1850 and are not of historic interest.

All other works, including the like for like replacement of gas and oil boilers will be subject to a full faculty.

Works which affect the external appearance of the church will also require planning permission (but not listed building consent) from the local authority. This includes items such as solar PV installations.

12. Other Issues

12.1 Bats in Churches

The Bat Conservation Trust has a project with the Church Buildings Council Natural England, the Church of England, Historic England and the Churches Conservation Trust to address bat issues: *www.churchofengland.org/resources/churchcare/advice-and-guidance-church-buildings/bats-churches*