ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary's Church, Goldington
PCC of St Mary's Church

Author	Reviewer	Audit Date	Version
Paul Hamley	Tamsin Hockett	16th January 2023	1.2

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1. Executive Summary

An energy survey of St Mary's Church, Goldington 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's Church, Goldington consists of a mediaeval nave, original chancel and small east aisle, to which a concrete framed extension to the west was added in 1955. There is both gas and electricity supplied to the site.

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)
Switch electricity (and gas) suppliers to ones which provide 100% renewable (or green gas) supplies	None	None	Nil	N/A	None	Offset 7.0 tonnes
Flush and clean central heating system	7% 2,800	£280	£500	2	List B	0.5
Install reflective radiator panels	2% 800	£80	£40	0.5	List B	0.14
Door draughtproofing	2% 800	£80	£500	6	Consult DAC	0.14
Investigate Secondary glazing for 1955 building	10% 4,000	£400	£15,000	38	Consult DAC	0.72
Purchase some heated cushions for chapel/ old chancel	N/A		Unknown		None	
Install electric under pew heating when boiler requires replacement	40,000 gas 5,700kWh electric used	£2,300	£20,000	8.5	List B	6.0
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 30p/kWh and 10p/kWh for electricity and mains gas respectively. The carbon figures are based on the DEFRA 2022 carbon emission factors of 0.21107 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's Church, Goldington 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's Church, Goldington, Bedford MK41 0AP was completed on the 16th January 2023 by 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's Church, Goldington	
Church Code	632285
Gross Internal Floor Area	350m^2
Volume	2,450m^3
Heat requirement	80kW
Listed Status	Grade II*, includes 1955 building
Average Congregation Size	100

The church is typically used for 9 hours per week for the following activities:

Type of Use	**Hours Per Week (Typical)**
Services	5.5 hours per week
Meetings and Church Groups	4 hours per week
Occasional Offices	6 Weddings 12 Funerals

4. Energy Procurement Review

Energy bill summaries for gas and electricity have been supplied by the church, giving total consumption figures for 2019 to 2022. Individual bills were not supplied.

The current electricity rates are:

Day Rate	30.41p/kWh
Other times Rate	22.56p/kWh
Standing Charge	39.868p/day [£36.38 per quarter]

Supplier: SSE Scottish Hydro (energy mix is 50.4% renewable, accessed 14/2/23).

The current gas rates are:

	Church	**Hall**
Rate	2.907p/kWh	3.172p/kWh
Standing Charge	186.87p/day	100.78p/day

Supplier: SSE gas.

The electricity is not purchased on a fully renewable tariff. Going onto a renewable tariff is an important part of the process of taking churches towards net zero. The church is therefore encouraged to consider procuring its electricity from suppliers that offer 100% renewable electricity, and in some cases 'green' or 'carbon neutral' gas.

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.

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.

This should always be done when changing suppliers.

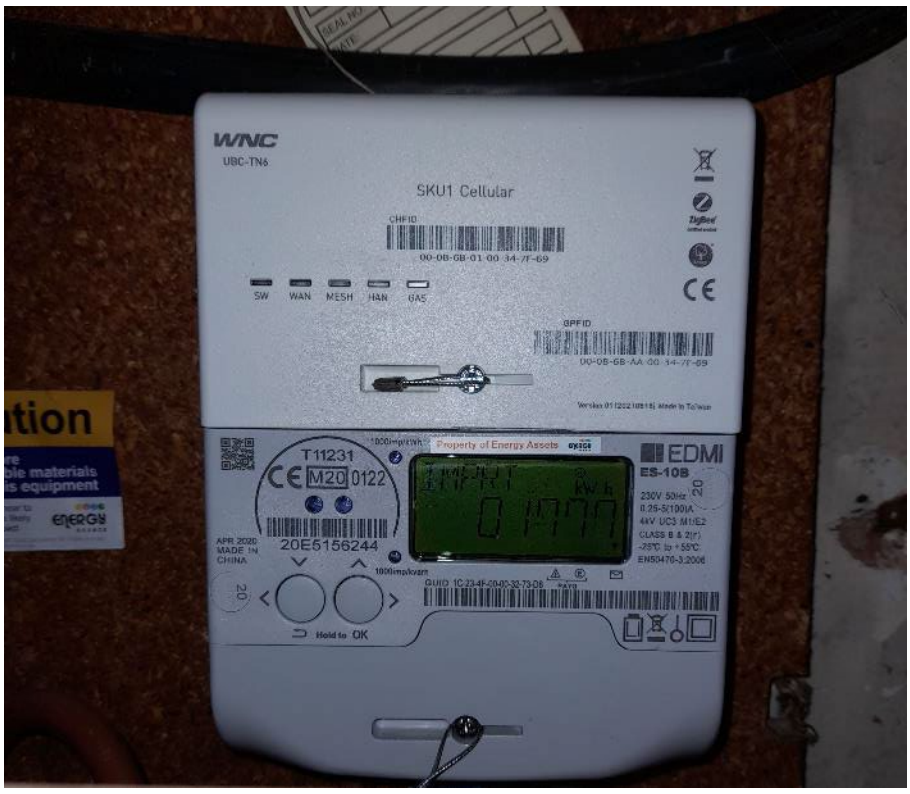
5. Energy Usage Details

St Mary's Church, Goldington uses between 2,000-2,500kWh/year of electricity, costing £466 per year (in 2022). Gas consumption has fallen considerably from 83,000kWh/year pre pandemic to around 40,000kWh during 2022, costing £1,767. The total carbon emissions associated with this energy use are 7.0 CO_2e tonnes/year.

This data has been taken from a list of expenditure compiled by the church with recent data covereing the period 1/1/22 to 25/11/22.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	20E5156244	EDMI ES 10B	Yes	Electrical cabinet, south side of tower
Gas – Church				Not located due to darkness and snow in church yard

It is recommended that the church consider asking their suppliers to install smart meters where not fitted so that the usage can be monitored more closely, and the patterns of usage reviewed against the times the building is used.



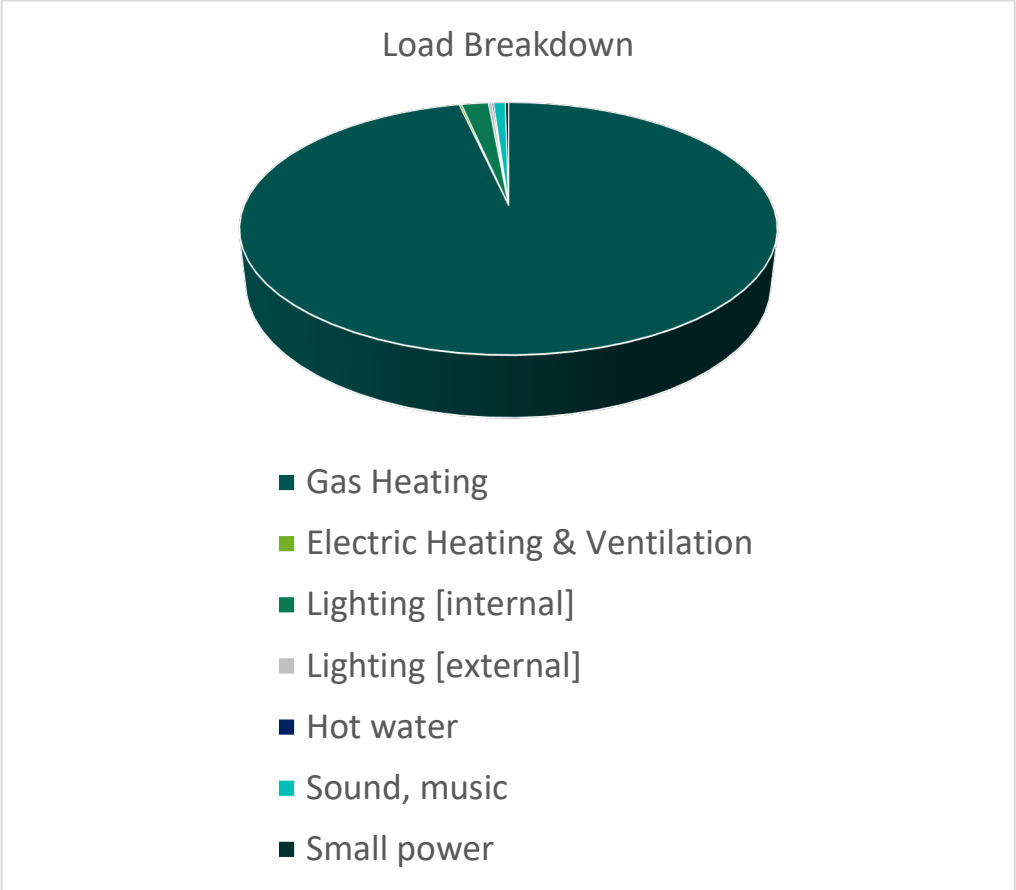
5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	Baxi Commercial WH70 [570 hours operation]	70	Currently 40,000	96.6%
Heating [Electric]	Boiler circulation pumps	120W	70	0.17%
Lighting [Internal]	All LED. 500 hours use Chandelier mounted. 108 x 10W Illuminated cross in tower 40 x 5W Spotlights 8 x 15W Vestry, corridor: low use Bulkhead 5 x 28W Strip light 20W	 1080W 200W 120W 140W 20W	 700 100 TOTAL 800	 1.9%
Lighting [External]	Security lights		30	0.07%
Hot Water (electric)	Quooker hot water (instantaneous) tap in kitchenette in tower	*3*	50	0.12%
Sound, Music	Sound system Organ	0.5 1	250 100	 0.84%
Small Power	Vacuum cleaner	1.5	100	0.24%

Sum of electricity use estimates (church only): 1,400kWh

Annual church electricity consumption, 2022: 1,411kWh



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 load is lighting.

Above: Mediaeval portion of church looking west towards tower.

Below: 1955 portion looking west.

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.

The church is currently heated by a gas fired boiler which was installed circa 2010 and appears to have a further 10 years serviceable life before requiring replacement. The boilers provide heating to cast iron column radiators around the perimeter of the church, including to the altar and chancel. In addition, there is oversized and exposed pipework which contributes to the heating of the church, this is deliberately raised above ground level on the west side of the 1955 building adjacent to the arches, which forms a barrier to movement, and may pose a hazard due to hot pipework (although no more than hot radiators).

The church makes use of fixed wooden pews in both the main 1955 nave and medieval portions, with around ten chairs in the original chancel used as a chapel.

The church is used once per week on a Sunday for service and the typical congregation size is 60 to 100, with around 12 attending a midweek service.

6.2 Existing Heating System

A Baxi Commercial WH70 gas boiler of 70kW, installed in 2010 supplies a network of 12 cast iron radiators of various sizes distribuited around the church. In addition, there are two sections each of 5m length of deliberately raised 2 ½" diameter pipework adjacent to the central pillars of the building.

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 current heating pipework and heat emitters and low hours of use
Air to Air Source Heat Pump	Potential, but only if hours of use were increased significantly
Water Source Heat Pump	No – no water source locally
Ground Source Heat Pump	No – unsuited to current heating pipework and heat emitters and low hours of use, plus archaeology in ground
Under Pew Electric Heating Panels	Yes
Electric Panel Heaters (to provide supplemental heating only)	No – not required

Over Door Air Heater (to provide a supplemental warm welcome at the door only)	No – architecture around door would not permit unit to be fixed
Overhead Infra-Red Heaters	No – visual intrusion to the church would do harm, least preferred heating source due to comfort
Heated Chair Cushions	Suitable for small services held in the old chancel, seated with chairs

The recommendation is therefore that the church consider installation of under pew convector heaters when the current system requires replacement as described below.

6.4 Heat Requirement

The Centre for Sustainable Energy model[1] can be used to estimate heat load for the building.

Heat Load (kW) = Volume V (m^3) x Insulation Factor

Insulation Factors

Condition	Factor kW/m^3
Poorly insulated with open or broken windows, draughty doors (add 5%)	0.034
Poorly insulated (assume no interventions)	0.033
Some insulating features	Estimate value
Well insulated	0.022
Insulated to 2010 regulations	0.013

Area	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Church	2,330	0.033	77
Vestry, etc	120	0.033	4

6.5 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.

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

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

1955 Nave, 18 pews (each 2.65m with one support giving 1.3m spaces) with two 650W heaters in each row between uprights.

Mediaeval aisle, 11 pews (7 of 2.8m, 4 of 2.4m with central support) with two 650W heaters in each.

Total 58 units delivering 37.7kW

Capital cost (at £350 each installed): £20,300

Cable runs to the pew heaters should run along the along the existing routes (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.

The eight high level radiant heaters within the nave should be removed completed with all associated cabling back to the distribution boards.

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.

6.6 Install Electric Panel Heaters

One (or more) radiant heaters could be installed, if required, to heat the vicar – dependent on where they sit or stand and for how long. A heated cushion could also form part of their heating provision.

Electric panel heaters can provide additional heating to areas where there are no pews. Suitable electric panel heaters would be far-infrared panels. These heaters have a strong radiative effect (where heat is reflected to people from the surface) as well as a light convective effect (where air is warmed and moves around to heat the general space). For this reason, these heaters tend to provide a relatively instant sense of heat and comfort within a specific space and only need to be on for short periods of time. The heating effect spreads out from the panel by up to 3 meters, although this is reduced by people and furniture. This means that these heaters provide a useful source of supplementary heating or primary heating for some well-defined areas, but are not very well suited to providing a complete heating solution for a church without other forms of heating (such as under pew). As these heaters warm up almost instantly, this reduces the amount of preheating required before each use of the building and can make electric heating cost competitive with gas. It also means that areas using this form of heating can rapidly and economically be brought into used for short or unplanned meetings if needed.

It is recommended that the PCC consider installing supplementary electrical panel heaters (on a time delay switch) if needed.

These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch so they cannot be left on accidently after use.

If you would like to discuss panel heaters with a church in the diocese that already makes use of them, please contact the diocese.

Electric panel heater installed behind an altar

6.7 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 using a set of ten heated cushions / chair covers to provide heating to the old chancel area which would be suitable for smaller services.

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. This electrical work should be considered to be undertaken at the same time as other electrical recommendations such as LED lighting or under pew heating.

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

6.8 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 - www.ukpowernetworks.co.uk

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

The water in the heating system within the church was inspected as part of the audit in conjunction with thermal imagery on some elements of the heating system. This has identified that the system has magnetic sludge within it. This is preventing 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.

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 between 10 and 15%. This can dramatically improve comfort for the congregation.

7.2 Add Extra Insulation to Boiler Room Pipework

The pipework within the boiler room has the majority of its straight lengths insulated, but the more complex-shaped pipework fittings, such as valves, have been left uninsulated. These exposed areas of pipework contribute significantly to heat loss from the system. The exposed hot surfaces also represent a health and safety risk of burns for those working in the area.

It is recommended that these areas of exposed pipework and fittings are insulated with bespoke flexible insulation jackets. These wrap around the various elements but can be removed and then replaced for any servicing activities. Valves need to be accessible, so covering with bespoke lift off insulation (perhaps using recycled polystyrene packaging) is recommended.

7.3 Reflective Radiator Panels

The church is heated by radiators served from the boiler. These 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

8.1 Draught Proof External Doors

There are a number of external doors in the church. Where doors do not close tightly against their frames or surrounds, a large amount of cold air can enter the church around the side and base of these doors.

It is recommended that the draughtproofing around the door is improved and draught strips are added. This could be achieved in a number of ways:

For timber doors that close onto a timber frame a product called QuattroSeal is often used in heritage environments to provide appropriate draught proofing.

For timber doors that close onto a stone surround, traditional solutions can be used such as brush draught strips rebated into the edge of the door by a skilled joiner. Other traditional methods such as using hessian or felt pads tacked to the door could also be used. Keeping the door maintained in a good condition is also important.

It is necessary to check with the DAC before undertaking any form of draughtproofing that involves work on the fabric of the door.

Simple measures such as having a 'sausage dog' style draught excluder laid along the base of a door (it needs to be sufficiently heavy to stay in place), using plasticine of the right colour to fill gaps where daylight can be seen, and putting painted fridge magnets over large keyholes can all be simple DIY measures which are effective.

Such measures should be considered carefully around bat conservation needs to ensure that access points bats use are not disturbed. Check your draught excluding plans with the Bat Conservation Trust's free helpline: 0345 1300 228 https://www.bats.org.uk/

8.2 Secondary Glazing

The windows of the 1955 building are singled glazed with metal frames at high level. Windows from the north wall of the medieval nave were removed and re-installed in the new north wall.

The introduction of secondary glazing would considerably reduce the heat loss through the existing windows and improve both thermal comfort and noise levels, as well as providing added security. Any possible installation would need to be carefully specified.

The low hours of use of the building means that limited savings would be made from this intervention (with a very long payback period) and the listed status (of the whole building) suggests that permission may not be granted for the 1955 portion.

Nevertheless, the option should be kept in mind as worthwhile should the hours of use of the building increase considerably.

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.

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. Offsetting

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