ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary the Virgin
2buy2 Church of England Audits

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Mary the Virgin 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 is a Grade I listed church which has origins in the Saxon period, but this church is largely a C16 church with some C15 parts. The church is built of red sandstone with a Welsh slate roof and has a porch and vestry added in 1877.

The church retains ornate wooden pews throughout the nave and most of the North and South aisles. The lady chapel makes use of flexible seating and the Wilbram chapel has box stalls, but these are not currently used. The South porch is the main entrance to the church for services and has three doors as well as access to the more recently installed toilet. Heating is provided by a Remeha boiler to cast iron radiators and exposed pipework which runs at low level in trenches and around the perimeter of the church. 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. 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 are used as the action plan for the church in implementing these recommendations over the coming years.

Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)
Upgrade incoming electrical supply capacity to power decarbonised heat solution	0	N/A	£32,100	N/A	Faculty	N/A
Optimise control system settings	11,637	£1,164	Nil	Immediate	List A (None)	2.09
Fit timed fused spurs to hot water heaters	486	£146	£270	1.85	List A (None)	0.10
Change existing lighting for low energy lamps/fittings	459	£138	£1,209	8.77	Consult DAC	0.10
Install draught-proofing to External Doors	2,327	£233	£3,200	13.75	Consult DAC	0.42

Replace heating system for electrical based heating solution	63,343	£3,487	£55,739	15.99	List B	10.96

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

Based on current contracted/market prices of 30p/kWh and 10p/kWh for electricity and mains gas respectively.

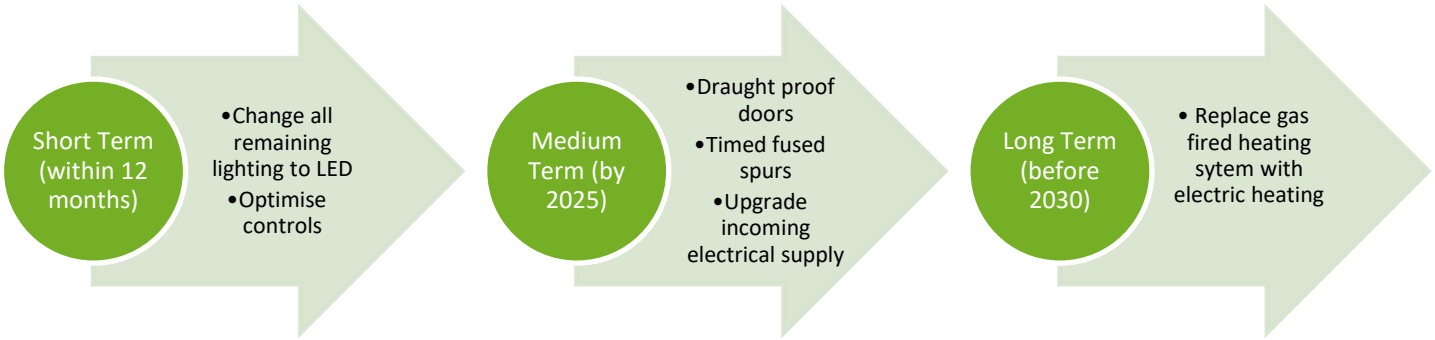
If all measures were implemented this would save the church £5,167 per year and reduce its carbon footprint by 13.67 tonnes (93%).

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 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 St, Weaverham, Northwich CW8 3NJ, was completed on the 14th of December 2022 by David Legge. David is an experienced energy auditor with over 10 years' experience in sustainability and energy matters in the built environment. David is a fully qualified ESOS lead assessor with CIBSE and a CIBSE Low Carbon Consultant and a fully qualified ISO50001 lead auditor.

St Mary the Virgin	
Church Code	609131
Gross Internal Floor Area	595 m^2
Listed Status	Grade I

The church typically used for 7 hours per week for the following activities

Type of Use	**Hours Per Week (Typical)**	**Average Number of Attendees**
Services	5 hours per week	60
Meetings and Church Groups	2 hours per week	Varies

There is additional usage over and above these times for festivals, weddings, funerals, and the like.

4. Energy Usage Details

St Mary the Virgin uses 3,852 kWh/year of electricity, costing in the region of £1,200 per year, and 77,580 kWh/year of gas, costing £7,800. The total carbon emissions associated with this energy use are 15 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site. St Mary the Virgin has one main electricity meter, serial number 21M0421032. There is one gas meter serving the site

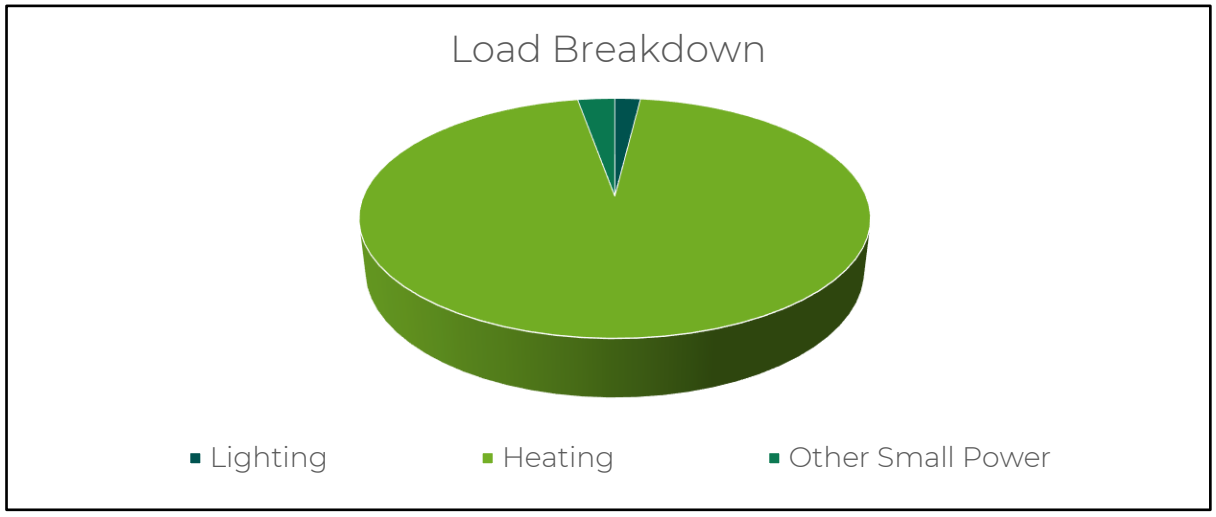
Utility	Meter Serial	Type	Pulsed output	Location
Electricity	21M0421032	1 phase 100A	Yes	SW corner nave

All the meters are AMR connected and as such energy profile for the entire energy usage should be possible. Half hour meter data has been provided for the purpose of this report and this has been used to verify the data.

4.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	Nearly all LED fittings but PAR38 lamps in South porch as well as 2D bulkheads remain	2%
Heating	Gas fired Remeha boiler provides heating to oversized perimeter pipework and cast iron radiators throughout	95%
Hot Water	Electric point of use water heater to the kitchenette and WC	0%
Other Small Power	Organ power, sound systems, kitchen equipment and other plug in loads	3%

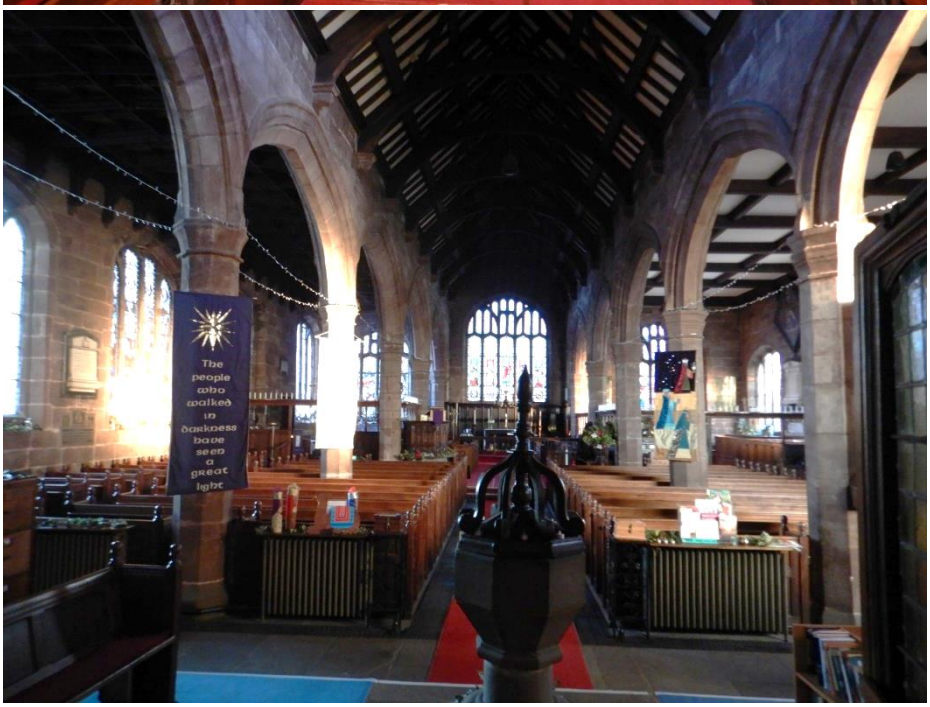


As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site.

4.2 Energy Benchmarking

In comparison to national benchmarks for church energy use St Mary the Virgin uses 68% less electricity and 13% less heating energy than would be expected for a church of this size.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
St Mary the Virgin (electric)	595	3,852	6.47	20.00	-68%
St Mary the Virgin (gas)	595	77,580	130.39	150.00	-13%
TOTAL	595	81,432	136.86	170.00	-19%



5. Efficient / Low Carbon Heating Strategy

The energy used for heating a church typically makes up around 80% to 90% of the overall energy consumption. Putting in place a heating strategy that is energy efficient and low carbon is, therefore, of the highest priority

The Church of England is in the process of reviewing its heating guidelines. The process has already established some principles for heating that can help churches as they seek an acceptable combination of comfort, conservation, affordability, and environmental care. The principles can be found at https://www.churchofengland.org/sites/default/files/2020-04/CBC%20Heating%20guidance%20principles%20FINAL%20issued.pdf

As the principles make clear, every church's strategy will be unique to it, informed by many factors, including the nature of its usage, the system it's starting from, the conservation needs of the building, and the resources available. The strategies in this audit are designed specifically for your church.

Our recommendations on heating generally fall within three major areas. Firstly, for all churches we make recommendations that will help to reduce energy wastage and, as a starting point, to optimise the system that you already have

Secondly, we recommend options for many churches that focus on heating people rather than the full volume of the church. Some of the changes that can help with this will be 'soft' changes – others will relate to the heating system itself.

Finally, we make recommendations about moving away from fossil fuels. Moves away from fossil fuels are key to cutting emissions. For most churches, this will involve moving from gas, oil or LPG to electricity. Electricity currently creates carbon emissions around the same level as mains gas, but the carbon emissions associated with it are reducing rapidly as the UK builds more renewable energy and decommissions its remaining oil and coal fired power stations. Mains gas does have some potential to reduce its carbon content through the use of biogas and hydrogen but these are less developed solutions and will be unable to deliver 'zero carbon mains gas'. Some local areas may also be considering the option of district heating networks.

While moving away from fossil fuels may not always be possible, as the principles state, "churches should be expected to have at least carefully considered the option of moving away from fossil-fuel based heating (gas and oil boilers) towards electric-based heating." And if such options are not viable now, the churches "can try to be ready for a future retro-fit when technology and the grid has progressed."

The church is currently used on a Sunday and a Wednesday for services during a typical week. The church uses the gas fired boiler to heat the church for all services and the boiler has reached the end of its serviceable life.

It is recommended that as the pews are being retained, that under pew electric heating would offer the most efficient heating solution for the church as detailed below. This would be supplemented with electric panel heaters to the lady chapel, coffee area, vestry, and other spaces to provide a warm environment throughout the church.

The installation of under pew heaters could be undertaken in phases with a first phase of heating installed to provide sufficient pew heaters for a typical Sunday eucharist congregation of 60 people with additional heaters added as a second phase to cover the whole church.

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

Decarbonised Heating Viability	Feasibility	Notes:
Air to Water Source Heat Pump	No	Unsuited to current heating pipework and heat emitters
Air to Air Source Heat Pump	No	Does not suit use of building
Water Source Heat Pump	No	No water source locally
Ground Source Heat Pump	No	Significant archaeology
Under Pew Electric Heating Panels	Yes	Explained in text
Electric Panel Heaters (to provide supplemental heating only)	Yes	Explained in text
Over door air heater (to provide a warm welcome at the door)	Yes	Explained in text
Overhead Infra-Red Heaters	No	Visual intrusion to the church would do harm, least preferred heating source due to comfort
Heated chair cushions	No	Other solutions preferred

The recommendation is therefore that the church consider an electric heating solution to be installed in phases, as described below.

5.1 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:

Area	Type/ Size	Length (mm)	Watts	Area Heated	Number required
Phase 1 - S centre - all pews	Electric Under Pew 650W	948	650	Pew Only	44
Phase 1 - choir stalls	Electric Under Pew 450W	702	450	Pew Only	16
Phase 1 - Vestment heater	Electric Low Level 300W	525	300	Vestments	1
Phase 2 - N centre	Electric Under Pew 650W	948	650	Pew Only	33
Phase 2 - S aisle	Electric Under Pew 650W	948	650	Pew Only	20
Phase 2 - N aisle	Electric Under Pew 650W	948	650	Pew Only	12

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.

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 in Oxford Diocese 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.

5.2 Install Electric Panel Heaters

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 in the areas specified in the table below on a time delay switch and remove the existing radiators.

Area	Type/ Size	Length (mm)	Watts	Number required
Vestry	Overhead Far IR Bar Heater 1.5kW	1580	1500	1
Choir vestry	Electric Far IR Wall Panel 1200W	1200	1200	2
Coffee area	Electric Far IR Wall Panel 1200W	1200	1200	3
Lady chapel	Electric Far IR Wall Panel 1200W	1200	1200	7
Wilbram chapel	Electric Far IR Wall Panel 1200W	1200	1200	7

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

5.3 Install an Overdoor Heater

In order to achieve the sense of a 'warm welcome' into the church an over door air heater could be provided. This would also help to provide warmth to the rear of the church. Such an over door unit must be sized to cover the whole width of the door.

A variety of overdoor air heaters are available on the market and can be installed by an electrician. The heaters that will cover the entire width of the door tend to be larger output units, which will require a dedicated electrical cable of the correct size run to them. The church should resist the temptation to reduce the size and output of the heater to avoid running a new cable, as the output from smaller heaters and of those with insufficient width tends to be disappointing.

Area	Type/ Size	Length (mm)	Watts	Area Heated	Number required
Phase 1 - Overdoor heater	Overdoor air heater 6kW	1105	6000	Entrance Only	1

5.4 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 thought to be SP Energy Networks - www.spenergynetworks.co.uk; 0300 1010 444 (Central and Southern Scotland, Merseyside, Cheshire, North Wales and North Shropshire))

The cost of bringing in a new 3 phase supply can range from £300 to £50,000 but the DNO will provide a quotation for free so it is well worth obtain a quotation in the short term so that decisions can be made on a well-informed basis.

6. 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, this should include:

6.1 Improve Heating Control Settings

The church's heating is controlled by an Sunvic Select XL controller.

The timings and settings on this were reviewed as part of the audit. Based on this review, there are opportunities to adjust these controls to provide more efficient energy usage of the building and a more comfortable environment for the congregation.

There are two important principles in setting efficient heating settings to support a comfortable church. The first is that most historic buildings survive very well without being heated and that in a number of cases the later addition of heating has actually cause fabric issues (such as the drying out of timbers, drawing damp through walls into a warmer and drier environment, or causing issues beneath metal roof covings where warmer moist air becomes trapped). In most cases the fabric of a historic building would prefer not to be heated, and the constant 'yo-yo' up and down of the heating is damaging. The second principle is that to provide comfort to occupants one either needs to provide an immediate injection of heat close to where the congregation are, such as under pew heaters or radiant heaters, that warms the air around the people but makes no attempt to heat the entire air volume of the church.-Having the heating switch on for an hour or two once or twice a day in the misconceived idea that it will 'take the cold off the building' is the most damaging heating strategy for the fabric and does very little to provide comfort as the heat is lost before the next heating session. It is better to leave the building unheated when it is not occupied and then have a longer period of heating before the time when there are services or the like. Given this we would advise that the following adjustments are made:

- Set the timeclock to only run the heating system when the church is occupied; currently the heating switches on for long periods when the church is not in use

Adjust the set point on the boilers to 75°C flow.

The adjustment of the heating system should be above to be carried out by any member of the church who is competent in using the controls. It is recommended that the heating settings are recorded, and a copy posted next to the control system, together with the name and phone number of a person to contact if there is a problem.

7. Energy Saving Recommendations

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

7.1 New LED Lighting

The lighting makes up a relatively small overall energy proportion of the electricity used within the church. There are some areas of the building which have had efficient LED lights installed but there still remains a large number of inefficient PAR and SON fittings within the lobby, WC, and external areas.

It is recommended that the fittings scheduled in Appendix 1 are all changed for LED. There are a vast number of specifications of LED lights on the market, but it is recommended that any LED light should come with branded chips and drivers and offer a 5 year warranty. An example of such a range of fittings is available from http://www.qvisled.com/

If all the lights were changed on a simple "like for like" the total capital cost (supplied and fitted) would be £1,200. The annual cost saving would be £140 resulting in a payback of around 8.8 years. This estimate includes for the supply of the lights, the labour to install them and the access required. It does not include for any upgrade to the wiring or a new lighting design both of which the church may wish to consider. 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/.

7.2 Timers on Fuse Spurs to Water Heaters

There are a number of electric point-of-use water heaters to provide hot water for hand washing. This only needs to heat the water to the required temperature when the building is in occupation but at the moment this heater is directly wired in without any form of time control and therefore maintains it set temperature 24/7.

It is recommended that the heaters are fitted with a 24 hour/7 day timeclock to replace the fused spur switch. An example of such a unit would be a TimeGuard FST77. They should be set up with times to match the times that the building is occupied. This will prevent the standing losses from the unit wasting energy during periods when the building is not occupied.

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

7.3 Draught Proof External Doors

There are a number of external doors in the church. The historic timber doors do not close tightly against the timber surround and hence a large amount of cold air is coming into 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 (see link below) is often used in heritage environments to provide appropriate draught proofing.
http://www.theenergysavers.co.uk/application/files/1714/7197/4194/National_Trust_Case_Study.pdf

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.

8. 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 PV	No – not sufficient demand
Battery Storage	No – no viable 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.

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.

9. 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/

10. 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 the replacement of existing boilers so long at the same pipe work, fuel source and flues are used. It can also be used to replace heating controls.

All other works 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 and this will be required for items such as PV installations.

11. Offsetting

As you take action to reduce your emissions, you may also wish to offset those that you cannot yet reduce. If you would like to engage in offsetting, it is important to use a reputable scheme. The Church of England recommends Climate Stewards, which has a simple calculator that can help you to work out how much you would need to offset. https://www.climatestewards.org/

Climate Stewards encourages people to 'reduce what you can and offset the rest' as part of your journey to Net Zero carbon emissions. They provide training and resources to help you understand climate change and its impacts, and to calculate the carbon footprint from your activities including travel, energy, expenditure, and food. Their online carbon calculators for individuals and smaller organisations are free to use, and they provide bespoke carbon footprint audits for larger organisations.

Having reduced as much of your organisation's carbon footprint as you can, there will always be unavoidable emissions from your work and travel. Carbon offsetting allows you to compensate for the negative impact of your carbon emissions by funding projects which take an equivalent amount of CO_2 out of the atmosphere. These either involve locking up ('sequestrating') CO_2 as trees grow or reducing emissions by using low-carbon technology such as fuel-efficient cookstoves or water filters.

Climate Stewards has a close relationship with all their project partners in Ghana, Uganda, Kenya, Tanzania, Nepal, and Peru. They work closely with them to design, develop, implement, and monitor projects which will not only mitigate carbon, but also bring tangible benefits to the local community - including improved health, savings in time and money previously spent on buying or collecting fuel, and improvements in local biodiversity. Each project is assessed using their Seal of Approval protocol which enables us to assess and monitor carbon mitigation and ensure robust, sustainable, and transparent partnerships.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
External	4	100W LED Flood	£159	£800	5.03
Lobby	2	PAR38 LED	£27	£34	1.26
WC	3	2D LED 11W	£7	£176	25.74