ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St. Mary the Blessed Virgin
Diocese of Leeds

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St. Mary the Blessed 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 Blessed Virgin is a Grade II listed church located in the village of Gomersal, on the outskirts of Bradford and Leeds. The church was first constructed in the 1851 with repairs and redesigns throughout its life. In 2002 there was a significant refurbishment works carried out, and underfloor heating was installed to improve efficiency and comfort levels of the church. Internally, there are chairs set up which can be moved to suit the needs of the space. Heating is provided by a gas-fired boiler to multiple underfloor heating zones around the church, with a few radiators serving the chancel, vestry, and toilets.

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)
Improve pipework lagging and insulation on existing boiler	1,109	£133	£261	1.96	List A	0.20
Fit timed fused spurs to hot water heaters	162	£49	£90	1.85	List A	0.03
Change existing lighting for low energy lamps/fittings	507	£152	£555	3.65	Faculty	0.10
Install PIR motion sensors on selected lighting circuits	120	£36	£360	10.00	List B	0.02
Install draughtproofing to external doors	642	£77	£1,600	20.77	List B	0.12
Install point of use water heaters	1,215	£146	£400	2.74	List B	0.22
Replace heating system for electrical based heating solution	71,269	-£3,241	£60,000	N/A	Faculty	12.62

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

Based on current market prices of 30p/kWh and 12p/kWh for electricity and mains gas respectively.

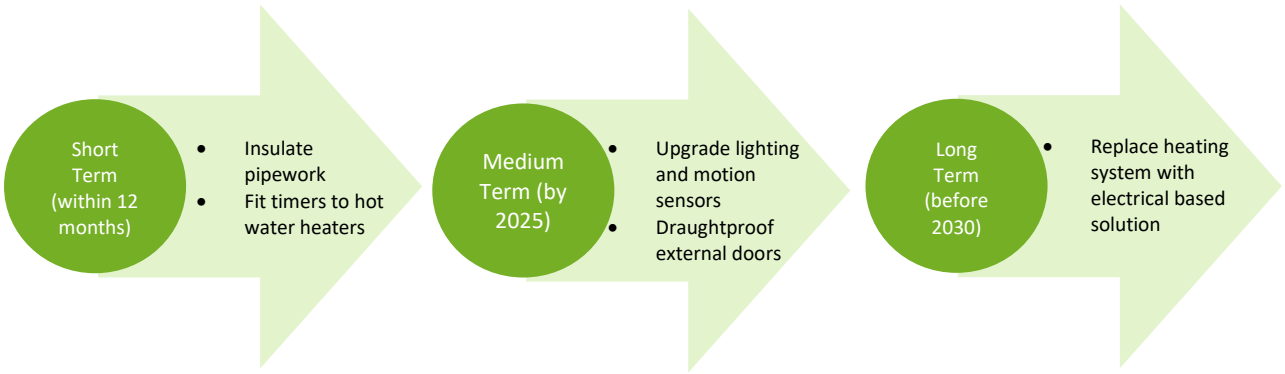
If all measures were implemented this would save the church £593 per year and reduce its carbon footprint by 13.3 tonnes (56.3%)

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 balance 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 Blessed 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 Blessed Virgin, Spen Lane, Gomersal, BD19 4LS was completed on the 8th December 2022 by Nathan Tonkin. Nathan is an experienced energy auditor with over 4 years' experience in sustainability and energy matters in the built environment.

St. Mary the Blessed Virgin	
Church Code	646255
Gross Internal Floor Area	341 m^2
Listed Status	Grade II

The church typically used for 14 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	2.5	30-45
Meetings and Church Groups	6.5	10
Community Use	5	10-15

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

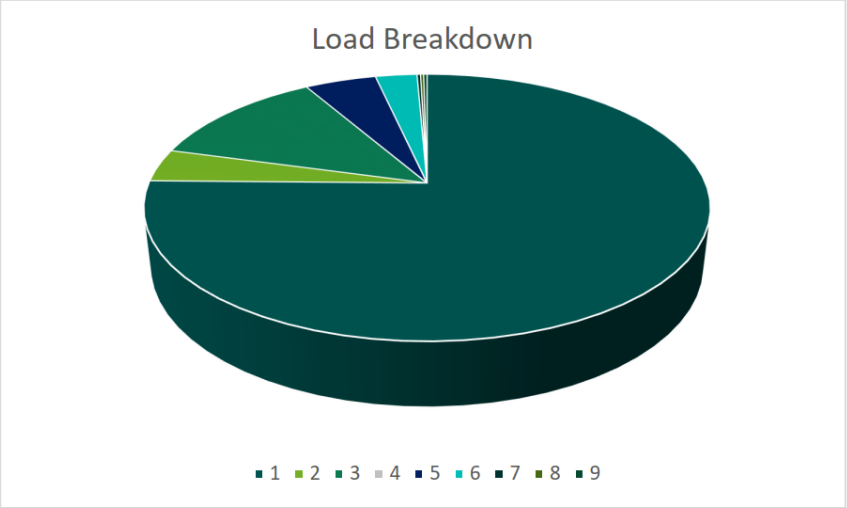
4. Energy Usage Details

4.1 Annual Consumption

St Mary the Blessed Virgin, Gomersal uses 21,481 kWh/year of electricity (2021-22 data), costing in the region of £3,308 per year, and 106,903 kWh/year of gas, costing around £2,138.

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

4.2 Energy Profiling



KEY *1 Gas heating 2 Electric heating `3 Lighting internal 4 Lighting external*

5 Hot water `6 kitchen 7 Office 8 Sound, music 9 Small power

4.3 Energy Benchmarking

In comparison to national benchmarks for church energy use St Mary the Blessed Virgin uses 214% more electricity and 109% more heating energy than is average 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 Blessed Virgin (elec)	341	21,481	62.99	20	214.97%
St. Mary the Blessed Virgin (gas)	341	106,903	313.50	150	109.00%
Total	341	128,384	376.49	170	121.47%

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 bio gas 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 current heating arrangement is gas fired boilers distributing heat via underfloor heating zones and hot water radiators situated around the church. The current heating boiler was installed in 2019, and therefore any plans to replace this should be considered when the boiler comes to the end of its serviceable life in 10-15 years. Hot water is also provided by this boiler and should be replaced with under-sink electric hot water heaters before any work is carried out on the heating system.

The approach to the heating system could be achieved in two main ways, as detailed below.

5.1 Install Electric Panel Radiators

Simply replacing all existing radiators with electrical counterparts is a simple, cost-effective solution to decarbonise the church. Due to the existing underfloor heating this will negate any benefit from this and so should be considered only as a temporary solution before air source heat pumps are installed into the system.

Electric panel radiators are very versatile and can be programmed in a large variety of ways. It is easy for certain zones to be set on different circuits so heating particular areas or even individual radiators are able to be switched on and off where required.

The current electrical supply is sufficient so will not have to be upgraded to three phase supply.

For energy calculations, it has been assumed the same amount of energy is used by these radiators as the existing gas system. Due to the price of electricity being more than gas, this has lead to more being spent per year on heating the building. However, due to the smarter controls available it's expected this system will use less energy per year than the existing system.

5.2 Install Air Source Heat Pump

The efficiency advantages of heat pumps mean that in some circumstances they can work out at equivalent or cheaper operating cost than gas despite the higher cost of electricity per kWh. This effect is increased if electricity is generated on site by solar power.

Electrically operated heat pumps can provide between 2.5 times and 5 times the amount of heat in kW which they consume in electricity (This is termed the Coefficient of Performance, CoP).

They are compatible with underfloor heating, which typically runs at fairly low water temperatures, but not with high temperature heating systems. When replacing gas boilers directly, sometimes larger radiators are required, or fan assisted radiators, or running the system for longer periods to achieve the same temperature (but at less power input).

With electricity prices now only three times more per kWh than gas (it was about four times), heat pumps are becoming steadily more cost effective. Refrigeration technology is mature and reliable; the units appear to offer lower maintenance costs compared to gas boilers.

Ground source systems are more efficient (since the average ground temperature is higher than the average air temperature), but require either a borehole, or extensive trench digging.

Air source systems deliver between 2.5 and 4 times the amount of heat in kWh to water that they consume. Air to Air systems deliver warm air through indoor fan units and have a CoP rating of up to 5 and they can also provide cooling. The latter would be suitable where there are no radiators, or life expired / poorly sited units and spaces heated intermittently.

For this church, an Air to Water system could be installed into the existing pipework with the underfloor heating being a great example of offsetting the lower temperatures achieved through such systems.

Ground Source Heat Pumps supplying water at around 50°C are more efficient than their Air Source equivalent. Where a site has a daily requirement for heat (and thus high daily expenditure), the lower operating costs of a ground source pump outweigh the higher capital costs.

For this church to install heat pump technology not lot of infrastructure work would have to be carried out before the heat pump is installed, making this a prime example for this technology to be installed. The electrical supply has already been upgraded to three phase supply in order to accommodate the increased load due to electrical heating.

As mentioned, heat pumps work on lower temperatures so are ideal for installation alongside underfloor heating. The church floor has already been upgraded to accommodate this so this solution would work particularly well.

ASHPs require the installation of external units which look like air conditioning modules in well ventilated external locations. These external units will need an electricity supply and pipework running from them to the heating system. They will also need a drain nearby as the back of the units can build up moisture, which condenses and sometimes freezes on the coils. The larger units do create some low-level noise and therefore the location and baffling of the units may need to be considered carefully.

A suitable place to install the heat exchangers should also be identified. While onsite a possibility of placing them on the north facing wall, next to the boiler room entrance, was identified, a qualified installer should be consulted about positioning of such equipment.

6. 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.

6.1 Improve pipework lagging and insulation on existing boiler

The current boiler is well within its serviceable life so any upgrades to the heating system should be considered in 10-15 years. In the meantime, to improve efficiency, improving the insulation in the boiler room is very low cost and can often pay itself back within a year or two. While the majority of the straight lengths have been insulated, the more complex shaped pipework fittings, such as flanges and valves, have been left uninsulated.

These exposed areas of pipework contribute significantly to heat loss from the system and make the plant room unnecessarily warm. 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.

6.2 Fit timed fused spurs to hot water heaters

There are various electric hot water heaters and water boilers (for tea making and the like) located around the church. These only need to heat the water to the required temperature when the building is in occupation but at the moment these heaters are directly wired in without any form of time control and therefore maintain their 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.

6.3 New LED Lighting

The lighting makes up a relatively large overall energy proportion of the electricity used within the church. The majority of the lights are compact fluorescent bulbs in the nave, with a few spot lights around the churches other rooms.

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.

If all the lights were changed on a simple “like for like” the total capital cost (supplied and fitted) would be £555. The annual cost saving would be £152 resulting in a payback of around 3.7 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/

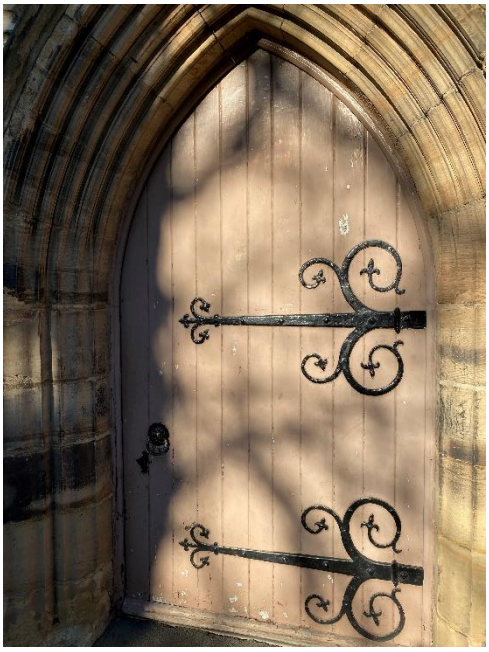
6.4 Lighting Controls

There are several areas are only used occasionally and for a short amount of time so that, in actuality, the light does not need to remain on constantly. There are also spaces which benefit from a good amount of natural daylight coming in through the windows, such that artificial lighting is not required for much use during the year.

It is recommended that a motion sensor is installed on these specific lighting circuits so that the lights come on only when movement is detected in the space and turn off approximately two to five minutes after the last movement has been detected (note that the duration of the time lag after which the light goes off needs to be considered alongside the type of light that is fitted. LED lights are much more suited to being switched off after only a short duration than some fluorescent lights). These movement sensors, commonly called PIRs, also have light sensors integrated into them so they can be used to make sure that the light does not come on if there is already sufficient daylight in the space.

Your existing electrician or any NICEIC registered electrical contractor can install PIR sensors onto existing lighting circuits. This can be carried out without significant disruption to the use of the space.

6.5 Install draughtproofing to external doors



There are a number of external doors in the church. The historic timber doors do not close tightly against the stone 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.

7. 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
Wind	No – no suitable land away from buildings
Battery Storage	No – no viable PV
Micro-Hydro	No – no water course
Solar Thermal	No – insufficient hot water need
Biomass	No – not enough heating load as well as air quality issues
Air Source Heat Pump	Yes – existing underfloor heating and electrical supply
Ground Source Heat Pump	No – archaeology in ground and radiator system

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.

Battery Storage is not strictly a renewable energy solution, but battery storage does however provide a means of storing energy generated from solar PV on site to be able to be used at peak times or later into the day when the PV is no longer generating. It therefore extends the usefulness of the existing PV system particularly in this sort of church. This is a new but fast-growing technology with prices expected to fall substantial over the next 2 to 3 years.

8. 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/

9. 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.

10. 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 CO2 out of the atmosphere. These either involve locking up ('sequestrating') CO2 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 (years)
Nave	21	12W LED lamp	£50.5	£315	6.24
Chancel	2	12W LED lamp	£4.8	£30	6.24
Entrance	9	LED Spotlamps	£78.6	£135	1.72
Kitchen	1	LED Spotlamps	£8.7	£15	1.72
Choir Vestry	4	12W LED lamp	£9.6	£60	6.24