ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary's, Beaminster
PCC of St Mary's

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1. Executive Summary

An energy survey of St Mary's 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 dates back to Norman times and it was added to or adjusted during the C13, C15 and C16. It was then restored in 1860 and 1889. The church is heated from a gas boiler to underfloor heating, with wall mounted fan heaters to boost the heat if required. The lighting is currently from SON lamps. 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)
Fit timed fused spurs to hot water heaters	162	£21	£90	4.27	List A (None)	0.04
Optimise control system settings	8,100	£263	£1,200	4.56	List A (None)	1.49
Install Endotherm advanced heating fluid into heating system	5,400	£176	£960	5.47	List A (None)	1.00
Install PIR motion sensors on selected lighting circuits	8	£1	£24	23.27	List B	0.00
Install a Solar PV array to roof of building	4,907	£1,308	£30,451	23.28	Faculty	1.24
Install Draughtproofing to External Doors	1,620	£53	£1,600	30.39	List B	0.30
Replace heating system for electrical based heating solution	20,729	£62	£4,596	73.84	Faculty	3.40
Change existing lighting for low energy lamps/fittings	3,389	£441	£37,442	85.00	Faculty	0.86

Install an Air Source Heat Pump into the building to replace existing heating system	10,800	-£1,229	£48,000	-39.07	Faculty	0.88

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

Based on current prices of 17.62/10.01 p/kWh and 3.25p/kWh for electricity (day/night) and mains gas respectively.

All of the above measures would not be possible to implement concurrently but the optimal approach reduce the churches carbon footprint by 9.21 tonnes.

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 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, St Marys Church, Church Street, Beaminster DT8 3BA was completed on the 11th March 2021 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's	
Church Code	634003
Gross Internal Floor Area	312 m^2
Listed Status	Grade I

The church typically used for 12.5 hours per week for the following activities

Type of Use	Hours Per Week (Typical)
Services	3 hours per week
Meetings and Church Groups	3 hours per week
Community Use	6.5 hour per week

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

4. Energy Usage Details

St Mary's uses 7,500 kWh/year of electricity, costing in the region of £1,200 per year, and 54,000 kWh/year of gas, costing £2,216. The total carbon emissions associated with this energy use are 12 CO_2e tonnes/year.

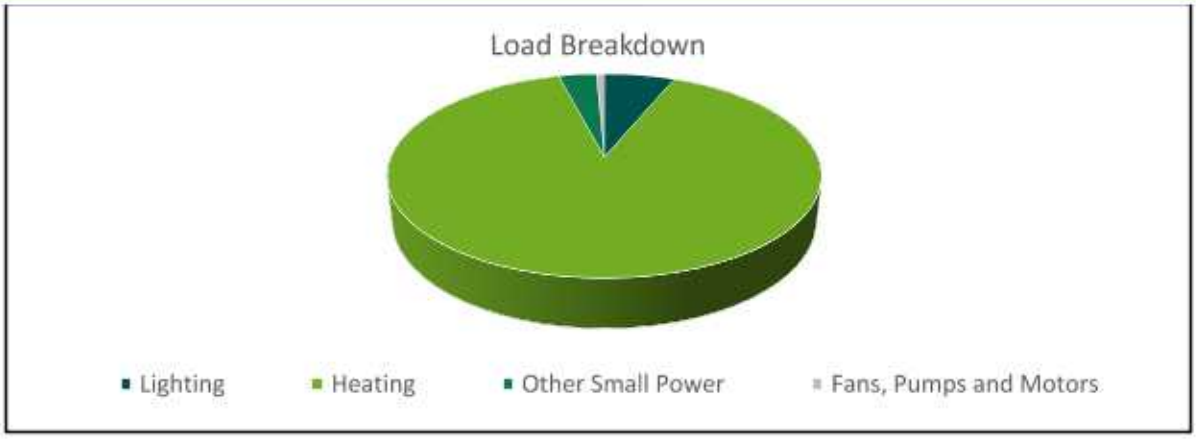
This data has been taken from the annual energy invoices provided by the suppliers of the site. St Mary's has one main electricity meter. The church already has a three phase supply to it to support ASHP and solar PV. There is one gas meter serving the site, serial number EO16K1341515D6.

It is recommended that the church consider asking their suppliers to install smart meters so that the usage can be monitored more closely, and the patterns of usage reviewed against the times the building is used.

4.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	Lighting is predominantly provided by inefficient SON floodlights to all areas.	6%
Heating	Heating is provided by a Vaillant condensing gas fired boiler to insulated underfloor heating and wall mounted fan convectors.	90%
Other Small Power	Organ, sound system, kitchen appliances and other plug loads	3%
Fans, pumps, motors	Heating pumps and fan convector motors.	1%



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's uses 20% more electricity and 15% more 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's (elec)	312	7,500	24.04	20.00	20%
St Mary's (gas)	312	54,000	173.08	150.00	15%
TOTAL	312	61,500	197.12	170.00	16%

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 proposed heating strategy for the church would be to reduce the background heating from 16°C to 12°C as detailed below whilst using the current gas boilers.

Secondly, as the church is used for both the main Sunday service and smaller services during the week, it is suggested that the smaller services and choir practices are held in the Hillary chapel. The installation of far IR wall mounted heaters to Hillary chapel would provide local heat but avoid the need to heat the entire church for these events.

It is also worth considering the introduction of an overdoor air heater to main North porch entrance as this would create an air curtain to reduce cold air ingress and also gives a feeling to parishioners as they enter of a warm church.

It is recommended that electric under pew heaters are installed to choir stalls and far IR electric heater panels to chancel (these could be installed at any point and do not rely on the failure of the gas boilers). The gas boilers still have 15 years of serviceable life and ideally earlier in this period, and depending on the availability of funding and commitment to achieving net zero carbon, the installation of an Air Source Heat Pump (ASHP) is suggested as underfloor heating (UFH) already exists within the church which provides ideal distribution for low temperature heat produced by ASHP. This would require the church to then be occupied and used for longer periods throughout the week as intermittent usage of the church is more likely to result in the ASHP constantly heating an empty space.

The PCC report that there is currently a proposal to install 2no. 16kW ASHP whilst retaining the gas boilers for peak lopping. In the long term, once the gas boilers have reached the end of their serviceable life, it is suggested that gas is removed altogether from the site and ASHPs with additional electric panel/IR heaters to boost output are sized to be able to meet 100% of the load (it is noted that technology will have evolved somewhat in 15 years time so will need to be revisited at this point if gas has not been removed from site beforehand). The PCC should discuss this with their ASHP designer/installer and whether ASHPs and supplementary electrical heating (as detailed below) would be able to provide sufficient heating in winter, albeit at a lower Coefficient of Performance (COP). A whole life cost approach should be presented to ensure there is a balance between capital costs, seasonal COP and associated running costs.

5.1 Install Electric Under Pew Heaters

As outlined above, the move to electric heating at the church will involve a number of different electric heat emitters. For the choir stalls the most appropriate form of heating is underpew heaters, which will provide heat to that specific space.

Two of the most popular under pew heaters within churches are BN Thermic PH65 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating.

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

Install BN Thermic Under Pew Heaters suspended from brackets from the underside of the choir stalls, 2 on each side.

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 the both rows of pews. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

The under pew (see photo below) and panel heaters have been recently installed at St Andrews Church, Chedworth, Gloucestershire, GL54 4AJ. The church is open in daylight hours so can be viewed at any time.

5.2 Install Electric Panel Heaters

It is recommended that the PCC consider installing electrical panel heaters to the Hillary chapel as well as to the chancel on a time delay switch.

Suitable electric panel heaters would be far infrared panels such as https://www.warm4less.com/product/63/1200-watt-platinum-white- . These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch such as https://www.danlers.co.uk/time-lag-switches/77-products/time-lag-switches/multi-selectable-time-lag-switch/159-tlsw-ms so they cannot be left on accidently after use.

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 the space and only need to be on for short periods of time. 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 the building can rapidly and economically be brought into used for short or unplanned meetings if needed.

6. Improve the Existing Heating System

In the period 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 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 should be sized to cover the whole width of the door

6.2 Improve Heating Control Settings

The church's heating is controlled by 2 Honeywell controllers located in the kitchen area at the West end of the church. How to use these controllers are used is not well understood by the PCC / churchwardens, and as such the heating system is not well managed.

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.

The instructions on how to use the controllers should be found and any 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 may require the support of the heating maintenance engineer to test the controls and detail how the controls work. 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.

6.3 Endotherm Advanced Heating Fluid

In order further to improve the efficiency of the heating system it is recommended that an advanced heating fluid (http://www.endotherm.co.uk/) be added to the heating system.

This fluid in in addition to and complements any existing inhibitors in the heating system and is added in a similar way. The fluid reduces the surface tension of the water and increases its capacity to transfer and hold heat; this in turn works to improve the ability of the boiler to transfer heat into the heating system and the ability of the radiators and other heating elements to give out their heat into the rooms. Case studies have demonstrated that the addition of this fluid into heating systems reduces heating energy consumptions by over 10% as well as helping the building heat up quicker.

Endotherm can be self-installed.

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. The lighting is predominantly SON fittings within the main body of the church.

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/

Instead of a simple "like for like" change, the costs shown are for the installation of LED track lighting, which will allow for much greater flexibility of the lighting which will be more sympathetic to the church. As such the total capital cost (supplied and fitted) would be £37,442. The annual cost saving would be £577 resulting in a payback of around 64 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/

There are some fittings such as the vestry lighting where the existing fitting can be made more efficient by simply changing the bulb/lamp within the existing fitting to w new LED bulb/lamp. This could be carried out by competent members of the churches internal team, very cost effectively and would be a List A item so no permissions would be required.

7.2 Lighting Controls (Internal)

There are several lights which currently remain on for longer than is necessary in areas such as vestry, toilet areas and the like. Some of these 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.

7.3 Timers on Fuse Spurs to Water Heaters

There is an electric point of use water heater in the kitchen 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.

7.4 Draught Proof 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 stone surround more traditional solutions 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 be used. Keeping the door maintained in a good condition is also important.

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	Yes – church already in the process of doing this
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 – will work well with existing underfloor heating
Ground Source Heat Pump	No – archaeology in ground and radiator system

The PCC noted during the survey that a solar PV has already been commissioned and is being installed within the next 12 months. There is potential for a small PV array on the church's South roof. The current arrangements around solar panels mean that to be financially viable the building on which they are mounted needs to consume the vast majority of the energy that they

produce. The church's energy consumption is currently small but as ASHP are likely to be installed, it will be technically viable to install a number of panels.

The building is currently heated from a gas boiler which provides hot water into the heating system. The use of fossil fuels for heating means that it will not be possible for the building to become zero carbon without changing the heating system. A boiler also has heat and other efficiency losses within it, which means that the efficiency of a boiler in converting the gas into the heat is typically around 80 to 95% (depending on the age and type of boiler). Air source heat pumps use electricity to power the heat pump which takes heat from the air and puts this into water which can then go into the heating system. A heat pump can create around 3-4 units of heat for every one unit of electricity.

The existing boiler is not yet approaching the end of its serviceable life and it is therefore recommended that the replacement of the existing boiler for an air source heat pump is undertaken over the coming few years to accelerate the drive to a net zero carbon church as other factors will allow.

A new air source heat pump is likely to need a heating capacity of around 120kW (equating to an input of 32kW with an associated seasonal Coefficient of Performance of 3.75) and location of the external units would need to be considered and agreed although the South side of the church is less obtrusive. As heat pumps operate on a low temperature basis the current underfloor heating system will be very suitable for use with the ASHP.

Good local renewable companies can be contacted for further detailed assessment of heat pumps and quotes or contact www.yourfutureenergy.co.uk

There are currently government incentives available for installing air to water heat pumps, but these are subject to future change and adaption so should be reviewed at the time of implementation.

9. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available at https://www.parishresources.org.uk/wp-content/uploads/Charitable-Grants-for-Churches-Jan-2019.pdf .

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/

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Nave/side aisles	31	3 Spot Track lights	-£71	£31,000	-434.18
Vestry (under bell tower	2	5ft Single LED	£10	£233	22.79
External	2	100W LED Flood	£55	£400	7.26
External	2	100W LED Flood	£271	£400	1.48

The nave/side aisle lighting does not include a like for like replacement, but considers the cost of a track spot lighting system which may enhance the church welcome and allow for more adaptive lighting. Like for like replacements would be far cheaper and offer a beneficial payback but the PCC must consider that any replacement lighting will likely remain for some years to come.