Energy Audit and Survey Report

St Michael and All Angels, Marden

PCC of St Michael and All Angels Church

Version Control

Author	Reviewer	Date	Version
Paul Hamley	Matt Fulford	31st January 2020	1.0

Contents

1. Executive Summary

An energy survey of St Michael and All Angels, Marden was undertaken by ESOS Energy Ltd 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 Michael and All Angels, Marden has Saxon roots. The chancel arch is the oldest surviving stonework of probable 12th century age; with 14th century aisles. The vestry at the south west corner dates from 1887. Electricity only is supplied to the site.

The church has a number of ways in which is 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 is used as the action plan for the church in implementing these recommendations over the coming years.

Short Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)	£/tonne of CO2
Switch electricity supplier to one which provides 100% renewable supply	Nil	5-15% savings possible	Nil	immediate	None	N/A	N/A
Draughtproofing maintenance	Low	Low	Low	Under 1 year	List A	Low	-
Purchase temperature datalogger	Medium	Medium	Low	Under 1 year	None	Moderate	-
Install electric under pew heaters	High	Medium	High	Typically, 8 to 12 years	Faculty	High	
Install solar photovoltaic panels on vestry and porch roof	Medium	High	High	Typically, 10 to 12 years	Faculty	Moderate	

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

2. Introduction

This report is provided to the PCC of St Michael and All Angels, Marden to provide them with 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 Michael and All Angels, Marden, ME17 4BU was completed on the 18th November 2019 by Dr. Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group developing advice for the Church of England and authored the "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE Associate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church.

St Michael and All Angels, Marden	**606238**
Gross Internal Floor Area	435 m^2
Listed Status	Grade I
Typical Congregation Size	65

The church typically used for 9.5 hours per week for the following activities

Services	6 hours per week
Meetings and Church Groups	2 hours per week
Community Use	Occasional concerts
Occasional Offices	1.5 hours average 6 weddings 8 funerals

Church annual use 500 hours

Heating hours: Church 300 hours

Estimated footfall 7,000 people

3. Energy Procurement Review

No energy bills or consumption data have been provided to support this report.

In comparison to national benchmarks[1] for Church energy use, St Michael and All Angels, Marden would be expected to use 10,000kWh of electricity and 75,000kWh of heat (for space heating) per year. These benchmarks do not take hours of use into account, but the church is of average size and with equivalent use to many rural churches.

When the PCC have actual energy data, they should compare their usage against this benchmark.

	Size (m^2 GIA)	St Michael and All Angels, Marden Expected usage kWh	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2
St Michael and All Angels, Marden (elec)	435	10,000	20	10
St Michael and All Angels, Marden (heating fuel)	435	75,000	150	80
TOTAL	435	85,000	170	90

75,000 kWh of heat requires 7,000 litres of oil.

We would recommend that the church obtains a quotation for electricity supply from the Diocese Supported parish buying scheme, http://www.parishbuying.org.uk/energy-basket. This scheme only offers 100% renewable energy sourced energy and therefore it is an important part of the process of making churches more sustainable.

It is unclear whether 20% VAT and CCL are being charged.

If this is the case, the PCC should send the electricity supplier a VAT declaration confirming that the organisation is a charity and has VAT exemption status.

[1] CofE Shrinking the Footprint – Energy Audit 2013

4. Energy Usage Details

4.1 Annual Consumption

The consumption of electricity and oil were unreported

Meter Details

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E10BG16612	EDMI Atlas Mk7c	Yes	Upper vestry above porch

The electricity meter (left) is AMR connected and as such energy profile for the annual usage should be possible. There is a submeter to record the floodlighting consumption (right).

5. Energy Saving Recommendations (Electricity)

5.1 Lighting (fittings)

Internal lights are reported to be all LED

5.2 External Lighting

One LED floodlight is fitted.

Timings are ON 1930 OFF 0030   and ON 2100 OFF 2345

i.e. 5 hours or 2 hours 45 minutes

6. Energy Saving Recommendation (Heating)

6.1 Heating System

The church currently uses a Ferroli oil fired boiler installed in 2005, serving fan assisted convector heaters for space heating.   A new Evo Plus circulating pump was fitted in 2018 at cost of £2,500.

This is reported to have significantly speeded up church heat up times.

Such a system requires long heat up times.   Sections 6.3 and onward consider optimisation and maintenance of the current system.

6.2 Heating Strategy

The church is recommended to develop a boiler replacement plan.

The long preheating times required to achieve comfort, the uncertain oil price and its large carbon footprint (the highest of any heating method) mean alternative options should be considered.

Direct electric heating by under pew heaters with some radiant heating would give more flexibility and allow the church to be zoned.   Further details are in Section 7.

The rest of this section focuses on optimisation and maintenance of the existing radiator based central heating system.

6.3 Discourage Background Heating

As with most medieval churches, this church would have survived most of its life without any form of heating. The modern additional of heating is not needed to preserve the fabric but only to provide thermal comfort to occupants. The previous trend of 'conservation heating' for fabric issues is now largely considered to be unnecessary and is being avoided by the likes of National Trust and English Heritage. The only times when background heating may be required is if there are historic wall paintings or to for the preservation of large artefacts such as tapestries. The organ (and other sensitive areas such as historic papers stored in the vestry) may require some local background heating specific to that area. In general, sensitive paper records should be removed for storage in the county archive and organs can be installed with a local background tube heater such as https://www.dimplex.co.uk/product/ecot-4ft-tubular-heater-thermostat within the organ casing in order to provide the heat where it is required. The fabric is often subject to the greatest damage by humidity (which is naturally higher when the air is warmer as warmer air has greater capacity for holding more moisture), as a result of large temperature swings (from central heating systems turning on and off) and from the excessive drying out/baking of timbers where high temperature heating units have been fixed to them (such as overhead heaters fixed to timber wall plates).

6.4 Boiler Timing Optimisation

Experiments in the Diocese of Lichfield at over 50 churches have established that hot water radiator heating can be optimised by being switched off 45 minutes before the end of the service.

Purchasing of a temperature datalogger will allow the time for the church to heat (in different weather conditions) to be understood, as well as the time to switch off to be optimised. This would require someone with a computer to plug in the device and download the readings.

A suitable model retailing for around £40 is https://www.lascarelectronics.com/easylog-data-logger-el-usb-1/

6.5 Controls

The timer is located in the upper vestry.

A thermostat is located in the church on the south west pillar (near to the vestry), set to 66°F (18.9°C).

A frost thermostat set to 4°C is located in the boiler room.

6.6 Boiler Maintenance; Clean / Flush Existing Heating System

To ensure longevity, the system should be periodically flushed and cleaned to remove any scale and corrosion. The church should have a record of when this was done last.

It is strongly recommended that the heating system is cleaned to remove sludge from the system, this is done by using a chemical clean and/or power flush procedure where cleaning chemicals are put into the system which is then turn 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 to 15%. This can dramatically improve comfort for the occupants.

6.7 Magnetic Particle Filter

The boiler did not appear to be fitted with a magnetic particle filter, as illustrated below. This apparatus catches any rust or metal particles and prevents them being deposited on the boiler heat exchanger. One should be installed if it is planned to continue using the water heating system long term. There is a magnetic filter on the oil input pipe.

6.8 Corrosion Inhibitor

This should be added to the system when your boilers are serviced annually.

Fernox protection was added on 7/4/10. The church should check with its heating engineer and enquire if any been added since.

6.9 Endotherm Advanced Heating Fluid

In order to improve the efficiency of the heating system further it is recommended that an advanced heating fluid (http://www.endotherm.co.uk/) is 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 works to improve the ability of the boiler to transfer heat into the heating system and for the radiators and other heating elements to give out their heat into the rooms. It does this by reducing the surface tension of the water and increasing its capacity to transfer and hold heat. 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.

6.10 Insulation of Pipework and Fittings

Insulate exposed pipework and fittings in boiler room

The pipework is uninsulated and areas are corroded. Valves are likely to seize in this condition.

These exposed areas of pipework contribute significantly to wasted heat loss from the system.

It is recommended that these areas of exposed pipework are insulated with standard pipe insulation and fittings are insulated with bespoke made flexible insulation jackets. These wrap around the various elements but can be removed and then replaced for any servicing activities.

A free survey and quotation for the supply and installation of insulation of pipework fittings can be arranged through ESOS Energy Ltd (contact Adrian Newton 0117 9309689, adrian@esos-energy.com).

7. Alternative Heating Systems

A church with low hours of use per week will always fall back to "base" temperature between heating events (it will take around 24 hours for the temperature to fall from 20 to 12°C). A system which can heat rapidly, without sending most of the heat to the ceiling first, and in addition can be configured to heat small areas independently for small services or midweek meetings will be more efficient than one which seeks to heat up the whole volume.

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Electric heating systems offer rapid heating (i.e. without the hours of preheating necessary to raise a cold church from 10 degrees) so offer advantages in churches heated once or twice per week

7.1 Under Pew Heating

The first option is to consider installing under pew electric heating. Although electricity is currently more expensive than oil per kWh, this form of heating requires little preheating time and delivers heat directly to the congregation and overall will deliver a cost saving.

An advantage of underpew heating is that each heater can be switched individually to fit with congregation size. All Saints, Hollingbourne is an example of a church heated entirely by underpew heating.

There are four alignments of pews at Marden, and together with the choir stalls with two pew heaters in the longer pews, this would require between 90 and 100 heaters. This will require the existing incoming electricity supply to be increased if all pews were to be installed with a heater.

Heaters with an output of 300-400W seem to be more suitable than 500W models according to reports from different churches.

100 x 400W =40kW. Cost at £140-180 per heater installed = £14,000 to £18,000.

With annual church use of 500 hours, and current estimated heating hours including preheating of 300hours, this would consume only 12,000kWh.

The church is quite full of pews, so extra radiant heating would probably not be required except for the vestry.

For replacement, two most popular under pew heaters within churches are BN Thermic PH30 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating. Cable runs to the pew heaters could run along the North and South walls (all cabling should be in armoured cable or FP200 Gold when above ground) to the both rows of pews quite easily.

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.

7.2 Overhead radiant heating for the church

Another option would be to use radiant (glowing) heating elements – these normally look unsightly when hung from ceilings or attached to walls, but have been successfully deployed in churches hung from chandeliers, where they can be combined with lighting if desired.

The image below is from St Catherine's, Faversham, which is heated solely by chandelier mounted radiant heaters suspended from arch centres. Costs are approximately £500 per 1kW element.

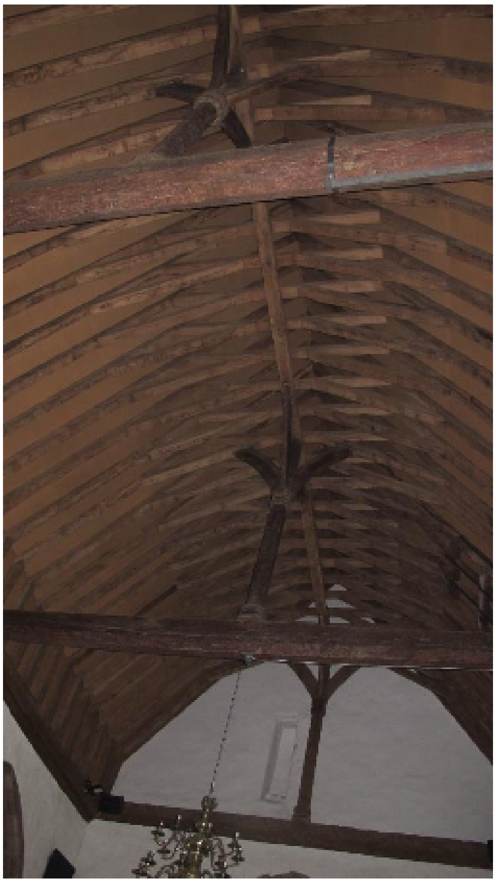
At Marden, if similar chandelier heaters were suspended from the midpoints of the six arches in the nave, they would probably have to be of larger diameter than above, possibly with eight elements each. The outside portions of the aisle seating would be furthest from the source of heat: these might require some additional ceiling mounted white rectangular far infrared panels.

Costs of around £24,000 for six chandeliers with 8 x 1kW heating elements delivering 24kW, to which extra radiant panels would probably be required around the walls/

This is considerably more cost than estimated for the under pew heating, for less heat output, and added visual intrusion.

7.3 Overhead far infra-red radiant heating panels for the church

The nave roof structure is too high, has beams spaced too closely together as shown in the image below, and has intervening tie beams, so is unsuitable for installing rectangular far infra-red radiant panels.



7.4 Use of Electric Radiant Heating panels for the vestry

For areas of the church without pews which still need heating, primarily the vestry of 19m^2 area, heat can be provided either by electric convector heaters (which lose heat to the ceiling), or electric radiant heating provided by rectangular far infra-red panels which emit only heat and could be medium temperature ceiling mounted panels form the vestry.

Far infrared panels come in three types, low surface temperature designed for ground level installation and safe for schools (55ºC) and hospitals (42ºC), medium temperature, and high temperature at 150ºC designed for installation under high ceilings. In churches they have been successfully installed under ceilings, often in aisles between the beams. Normally available in white, they can be sourced in other colours including marching to stonework or brickwork, or decorated. https://www.suryaheating.co.uk/custom-image-heating-panels.html

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 can not be left on accidently after use.

Costs are £350-500 wall mounted and £500-700 ceiling mounted far infrared panels.

7.5 Heat Pumps

The relatively low hours of use for the church, with regular use mostly on Sunday means that the church will be intermittently heated. Any system has to raise temperature from the base temperature it has dropped back to (churches take about 24 hours to cool from 20 to 12°C and continue to cool if the weather is cold enough). A heat pump would have to work very hard to raise temperature rapidly in a large space, thus consuming lots of electricity and technically the heat pump could struggle to perform in this regard as they can go into a freeze cycle when trying to rapidly heat cold buildings with poor insulation qualities. For optimum efficiency, they deliver low grade heat (warm water) at a constant rate, so are suited to regularly / constantly used buildings where the temperature is maintained. Heat pumps are not recommended for churches which are used mostly on a once per week basis.

ASHPs consume electricity, but deliver between 2.5 and 4 times the amount of heat in kWh that they consume. Heat pumps work by circulating refrigeration fluid and taking heat from a reservoir (the air or ground) and upgrading it (the fluid gets hot when compressed – in the building. When it evaporates it cools, and warms up again in contact with the external heat supply, air or ground. The Coefficient of Performance (COP) relates the amount of heat energy delivered to the electricity used. It is normally between 2 and 4.

ASHP systems are often less efficient than this when the air temperature is cold and when they are heating a building from cold. A move to ASHP powered central heating would allow for 100% renewable heating if electricity is procured from a 100% renewable source (including Parish Buying), or from onsite generation. For St Michael and All Angels, with oil fired heating delivering an estimated 75,000kWh of heat annually, a COP of 3 would require 25,000kWh; 30,000kWh at COP 2.5.

This needs to be compared with the estimate for direct electric underpew heating of 12,000kWh –Direct heating also allows for specific zones to be heated – ASHP driven central heating will still heat the whole building with heat rising to the ceiling.

Costs of a heat pump in the 50kW range are about £40,000. The pump, looking like an air conditioning unit requires a well ventilated location, possibly in the boiler room with extra ventilation ducts or louvres.

7.6 Comparison of Costs for Alternative Heating Methods

Heating Method	Estimated Hours of use p.a.	Power /kW	Annual use /kWh	Capital Cost /£	Running Cost p.a. /£
Oil fired space heating	300	100	75,000		£3,500 7000litres oil @50p/l
Under Pew	300	40	12,000	18k	£1,620
Radiant Chandelier mounted (add below)	300	40	12,000	36k	£1,620
Ceiling mounted far infra-red Panels in addition to above					
Air Source Heat Pump	300	50	30,000	40k	£4,000
Vestry far IR panels	30	4	120	2k	£16

Note that the costs for Radiant chandelier and ceiling mounted panels should be added.

8. Energy Saving Measures (Building Fabric)

8.1 Draught Proofing to Doors

There are a number of external doors to the building. These timber doors will benefit from maintenance and draughtproofing to prevent large amounts of cold air is coming into the church around their sides and bases.

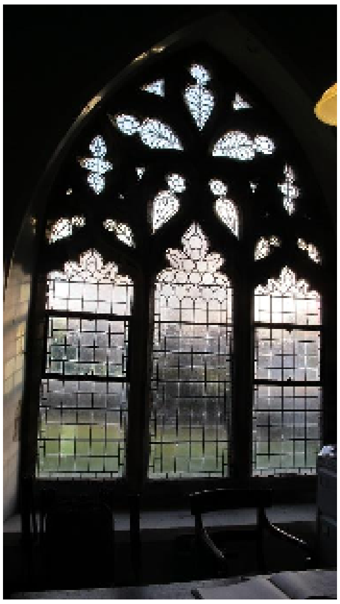
Where a timber door closes against a timber frame it is recommended that draught proofing is fitted. A product called QuattroSeal (see link below) is often used in heritage environments to provide appropriate draught proofing.
http://www.theenergysavers.co.uk/application/files/1714/7197/4194/National_Trust_Case_Study.pdf. Note this cannot be used where the timber door closes directly against a stone surround.

Other simple measures such as using a small fridge magnet painted black over the large keyhole or the use of 'sausage dog' type draught excluders at the base of little used doors can prove to be very effective. Doors should be reviewed in daylight and gaps where the light shines through sealed or filled in whatever the most appropriate way is for the specific door.

Daylight is visible under the Lady Chapel door to the left, and around the top right frame of that in the image on the right.   A large gap was observed under the tower west door.

8.2 Windows

If there are draughts caused by cracks between glazing and window frames, or with hopper windows not shutting correctly, a temporary solution is to use black plasticine to fill gaps. Two hopper windows in the vestry require repair; £16.5k had been raised towards a £20k repair quote.   The work should be VAT recoverable.



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 PV	Yes, south aisle roof hidden by parapet
Battery Storage	Yes
Wind	No – no suitable land away from buildings
Micro-Hydro	No – no water course
Solar Thermal	No – insufficient hot water need
Ground Source Heat Pump	No – archaeology in ground and radiator system
Air Source Heat Pump	Not economically viable
Biomass	No – not enough heating load as well as air quality issues

9.1 Solar PV potential

The roof of the south aisle porch which is hidden by the parapet offers a location for solar panels.

The suitability of the location would have to be confirmed with your architect regarding extra weight and wind loading on the roof structure. The area available is approximately 20m x 3m.

A 60m^2 area generating 0.15kWpeak/m^2 gives a 9kWpeak system. A 1kWpeak system facing south at the optimum angle can generate 1000kWh annually in Kent, and a total annual generation of 9000kWh.

Using recent costs for large installations of £1,200 per kWPeak including scaffolding, the system cost is £10,800. This does not include cost of any battery. [Average 2018 domestic installation costs were £1,667 per kWpeak]. The inverter would be located below the array in the above porch room, next to the distribution board. Options include installing a battery so that all of the energy generated can be used.

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 therefore investment into this may be worth delaying at this stage. Most of the electricity generated by solar PV should be useable on site, especially if a battery is included.

The government has advertised a "Smart Export Guarantee" to begin in 2020 which would pay for electricity generated and exported to the grid (the Feed in Tariff having ended). The rates are determined by individual purchasing utility companies and are low (up to 5.5p/kWh).

10. 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-Nov-2019.pdf

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 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.

12. Report Circulation

In addition to the PCC, this report is also sent to:

1. Your DAC secretary and your DEO, because
    - They maybe be able to offer you help and support with implementing your audit
    - They want to look across all the audits in your diocese to learn what the most common recommendations are.
2. Catherine Ross, the officer in the Cathedral and Church Buildings team centrally who leads on the environment, who wants to learn from all the audits across the country. She will be identifying cost-effective actions churches like yours might be able to make.