Energy Efficiency and Zero Carbon Advice

St Mary's Church, West Malling
PCC of St Mary's Church

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Mary's Church was undertaken by Inspired Efficiency 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.

St Mary's Church consists of a Norman west tower, 13th century chancel, 14th century vestry with the nave and aisles and all contents dating from 1901. 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 is used as the action plan for the church in implementing these recommendations as part of the reordering process.

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)
Purchase temperature and humidity datalogger	Included in figures below		£50	<1	None	
Discontinue background heating	10% 5,300	£112	Zero	Immediate	None	1.0
Optimise boiler temperature settings for condensing	10% 5,300	£112	Zero	Immediate	None	1.0
Optimise boiler on/off times	5% 2,650	£56	Zero	Immediate	None	0.5
Clean and flush heating system*	7% 3,750	£79	£400	5 years	List A	0.7
Install Endotherm*	10% 5,300	£112	200	2	List A	1.0
Insulate pipework*	5% 2,650	£56	£500	9 years	List A	0.5
Replace all light bulbs with LED fittings	1100	£144	£300 for non dimmable bulbs	2.5	None if bulbs only / Faculty if fittings	0.28
Install PIR controls on selected lighting circuits	100	£13	£150	11.5	List B	0.02
Optimise floodlighting controls	50	6	Zero	Immediate	None	0.01
Draughtproofing measures	3% 1,600	34	£200	£6	List B	0.4

Research Chancel roof insulation options					Faculty	
Research direct electric heating vs heat pump/underfloor heating options					Faculty	
Electric Heating using radiant infra red heaters	53,000 gas Replaced by 36,000 electricity	£2,500 more	£12,000	Greater cost	Faculty	Similar
Electric heating using Air Source Heat Pump	53,000 gas Replaced by 24,000 electricity	£930 more	£20,000	Greater cost	Faculty	3.9
Electric heating using Ground Source Heat Pump	53,000 gas Replaced by 17,000 electricity	Equivalent	£50,000	Similar cost	Faculty	6.7

* items are only recommended where the heating system is to be retained after the current heating season, and not considered if reordering occurs in 2021.

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

Based on current contracted prices of 13.1153p/kWh and 2.1096p/kWh for electricity and mains gas respectively.

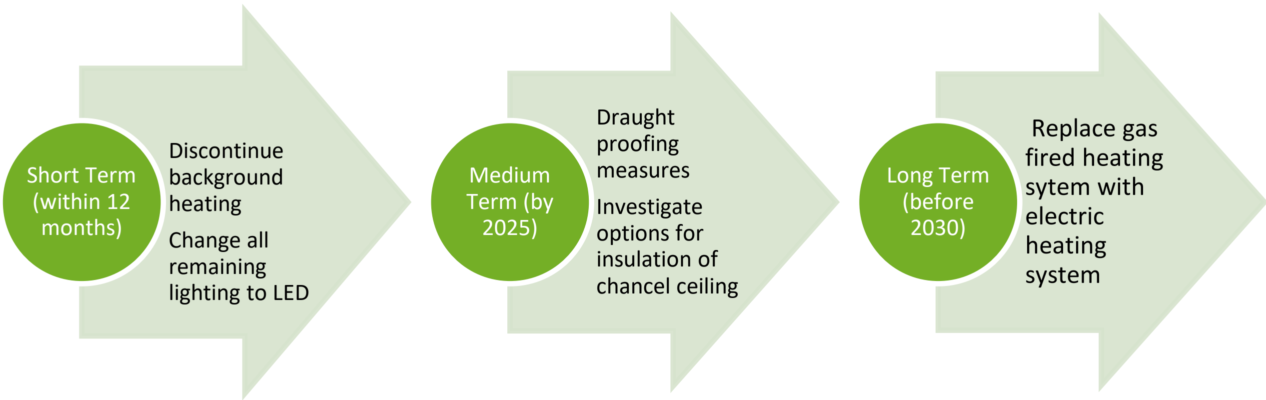
If all energy efficiency measures were implemented this would save the church around £725 per year in operating costs. Changing to underfloor heating with a heat pump will not result in savings due to the extra electricity required, which cannot be generated on site. It will deliver a carbon saving.

Costs will increase dependent on hours of use for whatever heating system is employed.

2. The Route to Net Zero Carbon

The General Synod of the Church of England has indicated that the Church of England should be Net Zero Carbon by 2030. Every church, cathedral, church school and vicarage will therefore need to convert to be a net zero building in the next 10 years.

This church has a clear route to become net zero by 2030 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Mary's Church 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 levels of comfort can be improved. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Mary's Church, St Leonard's Street, ME19 6NE was completed on the 24th September 2020 by Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group developing advice for the Church of England and authored the "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE Associate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church and has been an assessor for EcoCongregation.

St Mary's Church	
Church Code	631180
Gross Internal Floor Area	478 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	3 hours per week	84 Sundays plus 95 cumulative from other weekly services
Meetings and Church Groups	2 hours per week	300 for diocese events, 6 p.a.
Community Use	4 hours per week	200 for school visits and concerts Around 6 each p.a.
Occasional Offices 12 Weddings, 35 Baptisms, 20 Funerals p.a.	5 hours per week average	100

Occupancy Hours 740 hours

Annual Footfall 23,000

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Mary's Church and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single / Blended Rate	13.1153p/kWh	In line with current market rates
Standing Charge	24.5997p/day	N/A

The current gas rates are:

Single / Blended Rate	2.1096p/kWh	Below current market rates
Standing Charge	249p/day	N/A

The church is supplied by Diocese supported Parish Buying scheme. http://www.parishbuying.org.uk/energy-basket. This scheme only offers 100% renewable electricity and 20% renewable gas, thus it is an important part of the process of making churches more sustainable.

A review has also been carried out of the taxation and other levies which are being applied to the bills. These are:

VAT	5%	The correct VAT rate is being applied
CCL	not charged	The correct CCL rate is being applied

The above review confirmed that the correct taxation and levy rates are being charged.

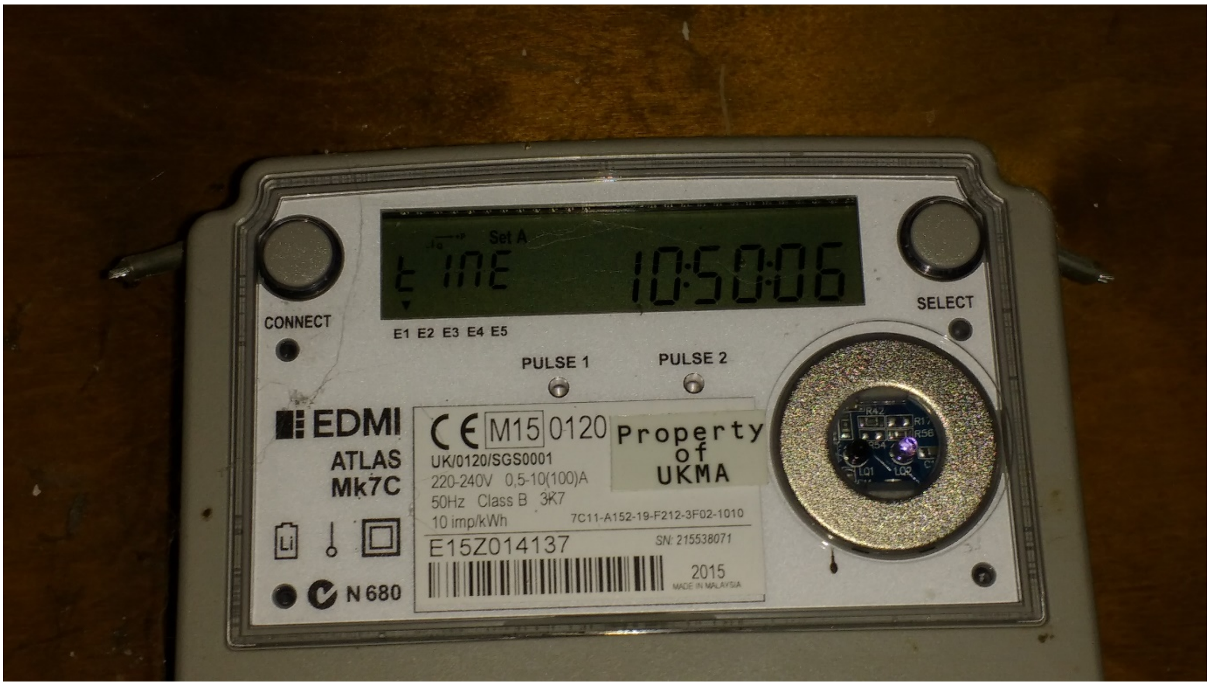
5. Energy Usage Details

St Mary's Church used 2,694 kWh/year of electricity during 2019, costing £453, and 53,647 kWh/year of gas, costing £2,218.

This data has been taken from the annual energy invoices provided by the suppliers of the site and the Energy Footprint Tool entry. St Mary's Church has one main electricity meter, and only a single phase supply. There is one gas meter serving the site.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E15Z 014137	EDMI ATLAS Mk10	Yes	North Porch
Gas – Church	No access to gas meter during site audit			

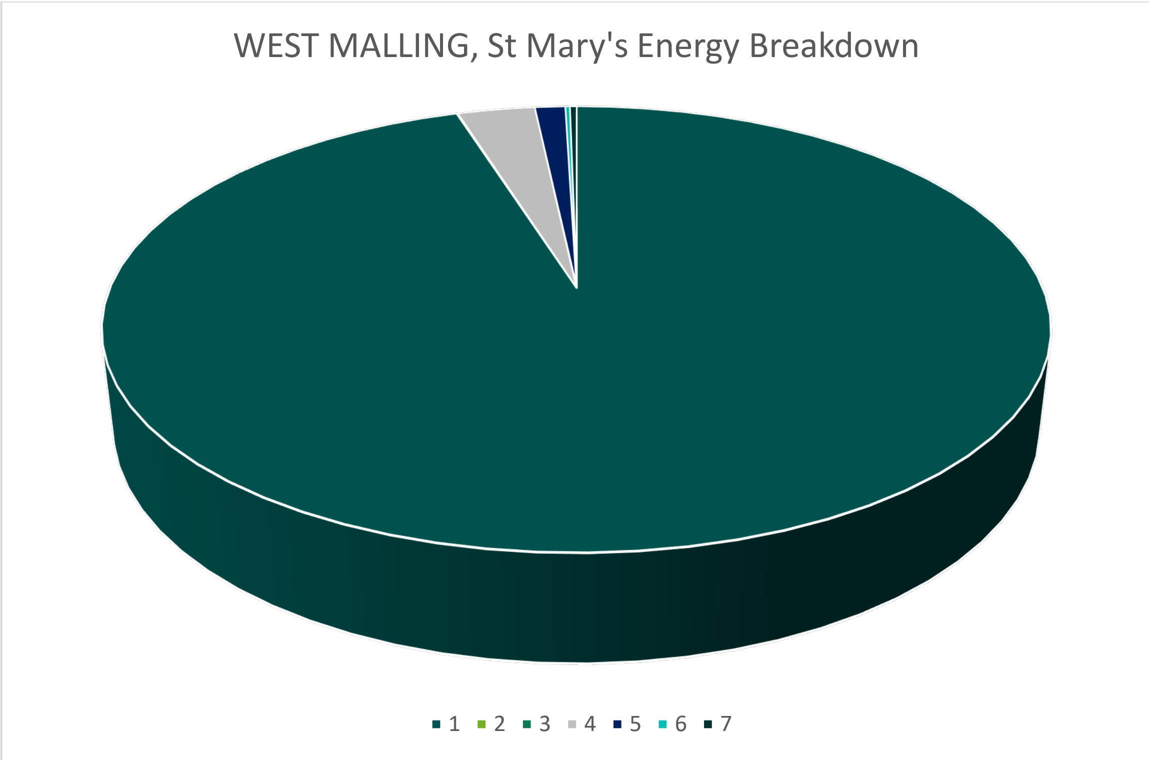
The electric meter is AMR connected and as such energy profile for the entire energy usage should be possible.



5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	Estimated at: Internal 2400W, 1770kWh External 500W, 700kWh	4.4%
Heating	Gas	95.2%
IT Equipment		0.1%
Other Small Power	Vestry electric heater, vacuum cleaner	0.1%
Organ		0.2%



KEY 1 Gas Heating 2 Electric Heating (minimal) 3 Hot water (zero)

4 Internal Lighting 5 External Lighting 6 IT & Small Power 7 Organ

As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site. The other significant load is lighting.

5.2 Energy Benchmarking

In comparison to national benchmarks for church energy use St Mary's Church uses significantly less electricity and 24% less heating energy than the 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's (elec)	478	2,694	5.6	19	-70%
St Mary's (thermal)	478	53,647	112.3	148	-24%
TOTAL	478	56,341	117.9	167	-29%

Benchmark data source: Church of England National Energy Audit, 2013.

6. Efficient / Low Carbon Heating Strategy

The energy used for heating a church typically makes up around 80% to 90% of the overall energy consumption. Heating also often uses gas or oil as its primary fuel, these are fossil fuels with high carbon emissions and little opportunity to decarbonise in the future. Electricity currently generates carbon emissions around the same level as mains gas but the carbon emissions associated with electricity are reducing rapidly as the UK builds more renewable energy and decommissions its remaining coal fired power stations by 2025. 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'. It is therefore a critical element to review and set out a plan to make the building more efficient and less carbon intensive and one way to achieve this is to consider a transition to electrical heating where this represents a more efficient and comfortable solution for churches.

The church is planning a major re-ordering to include the replacement of pews with individual seating and constructing an extension to include a meeting room, kitchen and toilets.

The church intends to use its space for more community events, as the village hall is considered to be inconveniently located. It already hosts primary school visits and concerts for the local area, as well as hosting diocese events, being the largest church in the region.

The existing radiators are mostly set into the wall. The proposal is to replace them with an electrical heating system. Underfloor heating has been proposed. This report considers this proposal and encourages the church to ask detailed questions about its proposed future hours of use, so that it can ascertain whether electrically driven underfloor heating (using an Air or Ground Source Heat Pump) or direct electrical heating is more appropriate.

6.1 Discontinue with Background Heating Strategy

For the period before reordering and with current hours of use continuing, the church should not be heated between periods of use, it is not insulated so most heat added will be lost. Less heat will be lost by having to have a longer preheat period (say from 12ºC to 18ºC) than maintaining the church at 14ºC all week and heating to 18ºC.

Most traditional churches were constructed without any form of heating. The modern addition 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 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. 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).

Providing constant background heating to the church building as a whole is excessive and wasteful of energy. At the very least we would recommend that this background level is reduced to a maximum of 12°C and ideally avoided all together.

6.2 Install Electric Panel Heaters

Electric far infra red panel heaters (non glowing) could be installed in the aisle walls, probably in the same locations as the existing radiators. However, this will not provide a solution for the nave. There are no low level positions in the nave for such heaters. The roof is very high, and its planked construction would make ceiling mounted panels impossible to hide. Recommendations for the nave are detailed in further sections.

Suitable electric panel heaters for the side aisles 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). As such these heaters tend to provide a relative 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 be brought into use, economically, for short or unplanned meetings.

Even if underfloor heating is chosen, it may be suitable to install some radiant panels along at least one aisle to create a warmer zone for the elderly, or for top up heating on the coldest days.

6.3 Install Overhead Radiant Heaters

Chandelier mounted overhead heaters would allow heating of the nave when it is seated using moveable chairs. If this option is chosen it will also heat the aisles; wall mounted panels would not then be required. It is very likely that a three phase supply will need to be provided.

There are eight arches which, if all fitted would cover the entire area seated by the congregation.

Options:

- 8 rings each fitted with six heaters wired in pairs giving the option of 1/3, 2/3 or full power:

Total 48 x 1.5kW = 72kW. This is likely to provide considerably more heat than the current boiler does, since it will be focussed on the congregation rather than circulating via the roof.

- 48 Lower power heaters at 1kW each may be more comfortable and cost effective, providing 48kW.
- 32 1.5kW heaters in 8 sets of 4, delivering 48kW (interspersed with four lights per chandelier, which could be moved from the current fittings).

Heating chandeliers are envisaged to be hung from the arch centres.

Item	Power rating	Number	Total power	Installed cost each	Total cost
IR bar heater	1kW	32	32kW	£580	£18,560
IR bar heater	1kW	48	48kW	£580	£27,840
IR bar heater	1.5kW	32	48kW	£626	£20,032

Given the small extra cost for higher power heaters, installing four per chandelier (interspersed with lighting) gives a 48kW capability more cheaply. Electric heating does not need to replicate the maximum boiler power – only around 80% of this arrives at the radiators and much of it is either absorbed by the wall behind or rises to the ceiling.

6.4 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 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 UK Power Networks - www.ukpowernetworks.co.uk; 0800 029 4282 (London, South East and Eastern England)

The cost of bringing in a new 3 phase supply can range from £300 to £30,000 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.

7. 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. Unless it is to be replaced imminently, this should include:

7.1 Optimise Boiler Temperature Settings

To obtain maximum efficiency from the condensing boiler, the return water temperature must be below 55ºC, (which then allows heat to be recovered by condensing the flue gases). It may be measured using a temperature datalogger on the return pipe. If the output temperature needs to be reduced (which can be done via the boiler control panel), longer operating times will be required, but, a portion of the heat is now coming from the exhaust gases, increasing efficiency.

Modern boilers often have an "Eco" button or other setting to automatically set this temperature.

7.2 Improve Heating Control Settings

Purchase of an inexpensive temperature datalogger will help the PCC to understand the heat loss of the building, providing useful data in advance of reordering and allow for optimisation of the present heating system.

Devices such as the Easylog USB-1 or similar are suggested. The USB-2 model also measures humidity, which ideally should be between 45% and 55% for organ protection.
https://www.lascarelectronics.com/easylog-el-usb-1

- Temperature monitoring will inform the optimum time when heating should be switched on.

- Experiments at over 50 churches with central heating radiators in the diocese of Lichfield have shown that turning the heating off 45 minutes before the end of the service is the optimum, the radiators continue to emit heat for this period.

7.3 Clean the Existing Heating System

Build up of magnetic sludge will prevent the proper and efficient operation of the system by reducing the ability of the boiler to heat up the water and reducing the output of the radiators. It is similar to how scale build up can adversely affect kettles and showers.

It is strongly recommended that the heating system is cleaned to remove this sludge from the system, this is done by using a chemical clean and/or power flush procedure where cleaning chemicals are put into the system which is then turned on and run through a filter consisting of high power magnetics to remove the sludge.

The cleaning of a heating system can be carried out by any competent heating engineer and typically increases the efficiency of a system by between 10 to 15%. This can dramatically improve comfort for the congregation.

It is not recommended to install a magnetic particle filter due to the planned short lifetime of the system.

7.4 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 is 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, by someone who is familiar with the system and competent to depressurise and repressurise it.

7.5 Insulate exposed pipework and fittings around boilers and tanks

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

It is recommended that these areas of exposed pipework 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.

8. 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.

8.1 LED Lighting

Any bulbs changed should be replaced by LED bulbs.

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/

There are some fittings such as the relatively low level pendant groups of four bulbs where the existing fitting can be made more efficient by simply changing the bulb/lamp within the existing fitting to a 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.

8.2 Lighting Controls (Internal)

Where there will be regular visitors during the week, selected lighting circuits should be controlled by person activated PIR detectors.

Detectors should also be fitted to the lobby, kitchen and toilet areas of the new build. As it is proposed to be a single storey building, light pipes would afford a zero energy lighting method during hours of daylight.

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.

8.3 External Lighting Controls

The external floodlight can be controlled by a light sensor so that it does not come on too early.

For efficient operation and to reduce light pollution and nuisance to neighbours it is generally recommended that external lighting is turned off between 11pm and 6am unless required for specific purposes.

A timeclock with a time and day capacity is recommended over those that only have time of day capacity. Sangamo (http://sangamo.co.uk/) make a wide range of commonly used timeclocks which any qualified electrician can install.

8.4 Draught Proof External Doors

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

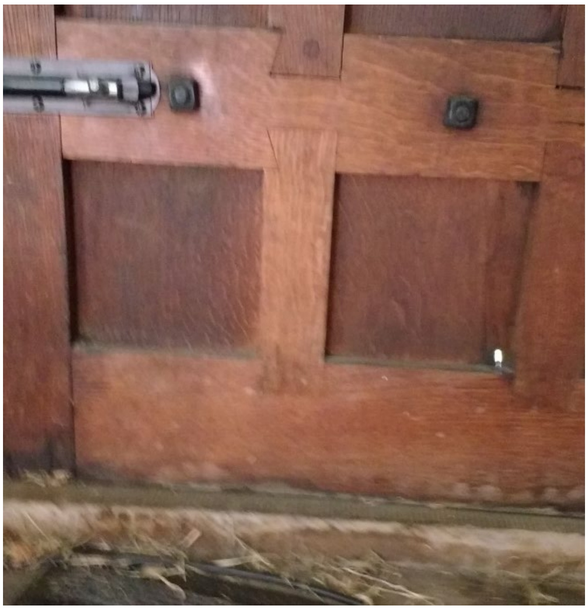
For timber doors that close onto a timber frame a product called QuattroSeal (see link below) is often used in heritage environments to provide appropriate draught proofing.
http://www.theenergysavers.co.uk/application/files/1714/7197/4194/National_Trust_Case_Study.pdf

For timber doors that close onto a stone surround more traditional solutions such 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 and keeping the door maintained in a good condition is 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.

There is a hole in the lower right door panel (where the wood has probably split along the grain).

This can be filled (plasticene or wood filler) and other low cost draught exclusion measures applied to this door which will be replaced, or no longer be an external door after reordering.



8.5 Insulation to Roof

The chancel roof is supported by very thin beams, between which are 20th century (probably) fibreboard panels. The condition of the tiled roof behind these is unknown. As part of reordering, there is potential for replacement of these panels with insulating material. As well as aiming for a more air tight structure for energy efficiency, any effects on humidity must be considered. As the beams are both very thin and probably original, changes in humidity may cause warping. Their small cross section may not give much of a safety factor (i.e. not there is not much more strength than the minimum required to hold up the roof).

It may be that the original mediaeval ceiling was removed. Refitting a ceiling would allow for proper insulation together with appropriate protection for the beams (this has been done in some other churches, for example St Botolph's Hardham, Sussex and is often led by conservation issues).

It is recommended that expert advice in church fabric and the effects of humidity is sought to inform any works and protect the roof against structural problems. Sources of advice may include your architect, the DAC, the Church Buildings Council, Historic England, and Tobit Curteis Associates (a practice specialising in historic building conservation and relevant specialist advice).

The author of this report has worked independently with Dr Robyn Pender, Senior Architectural Conservator at Historic England and suggests that she would be a good source of advice.

Contact Details:

Robyn Pender robyn.pender@historicengland.org.uk

Tobit Curteis enquiries@tcassociates.co.uk

9. Saving Recommendations (Water)

9.1 Tap Flow Regulators

For the new build it is recommended that tap flow regulators are included in the design for the taps.

The over provision of water for hand washing is not only a source of excessive water use, but in the case of hot water, it is also a source of wasted energy in the heating that has to go into providing the hot water. The flow rate of taps can be easily regulated by fitting flow regulators within the taps. It is recommended that flow regulators such as those manufactured by neoperl (http://www.neoperl.net/en/) are fitted into all hand wash basin taps to save on both water and heating of the hot water.

10. 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 –visible roof
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 if hours of use are sufficient
Ground Source Heat Pump	Yes – but archaeology in ground

10.1 Heat Pump Criteria

Heat Pumps work by using electrically driven refrigeration pump technology to extract heat from the air or ground and deliver it into the building – a similar process to a fridge extracting heat from the interior and warming the coils at it's rear. They work best when providing warm water (40-50ºC) on a constant basis to warm a space which is regularly used. When asked to heat a building from cold, they must work at full power, and this is not at their most efficient.

As a rule of thumb, a building should be in use for around 50 hours per week (7 hours per day) for heat pumps to be viable. With less use, the capital costs become too high to justify.

For a building in occasional use, such as a church used twice per week, electric heating panels, with lower capital cost and the ability to heat rapidly are then more cost effective. A short burst of targeted heating is needed covering the 2-4 hours period of use vs several hours warm up from cold needed by a heat pump system.

For a building in heavy use (where the electric panel heaters could be assumed to be on fairly constantly in cold weather), heat pumps offer the advantage of delivering 2 to 4 times the amount of heat that they consume in electricity (this factor is the Coefficient of Performance, COP).

As the average temperature of the ground is warmer than the air (especially true in winter when peak heat demand is experienced), GSHPs can deliver an average COP of 3.5 whereas ASHPs performance is nearer to 2.5 on average.

For churches, archaeology in graveyards can often preclude installation of GSHPs, unless there is space for a borehole. There are around 25 GSHP installations across Church of England churches, including St Mary the Virgin in central Ashford, a heavily used town centre church which is a concert venue. This has a series of boreholes radiating from one corner of the churchyard.

ASHP units look like air conditioning units with fans – clearly they need to be hidden from view if installed on a listed building.   The proposed plant room offers a location – it would need to be provided with sufficient ventilation in it's wall and roof.

If underfloor heating is chosen, then a GSHP would offer lower running costs and be less likely to struggle in a cold winter. Factors against include higher installation costs and the risks of leakage.

A GSHP could be installed within the current boiler room area if the floor was lowered further, rather than in a side located plant room.

An ASHP system may struggle to provide sufficient heat during the coldest period of winter (this will depend on the size of installation; a system which ensures no problems with a temperature of -5°C will be larger than needed for most of the year and more expensive.

One option is to install some radiant IR panel heaters in the aisles to act as a top up for very cold periods and to create a warm zone for the elderly or very young children.

[If it is concluded that hours of use will suggest a direct electric heating solution is the most suitable, chandelier mounted IR heaters are suggested as the method to heat the nave].

Example:

A church near Stow on the Wold installed underfloor heating driven by an ASHP.   Prior to re-ordering, this church had a vision of moving the building into regular use.   Unfortunately, this was not realised and weekly use was still only a couple of times per week, so they could not justify leaving the system running constantly.   Problems with the defrosting mechanism have been reported, as the system is not run for sufficient hours.

The area proposed for the new meeting room fills the gap between the south aisle and the protruding vestry, out as far as the brick structure (stakes can be seen outlining the perimeter).

There are several graves in the area to be moved. Further from the building, the churchyard has an area free of headstones (but not necessarily of burials – does the church have a plan of burials?), so there may be potential to install a Ground Source Heat Pump.

It is recommended that the decision makers in the church, along with your Inspecting Architect / architect designing the new building and re-ordering, visit churches in the locality fitted with underfloor heating, a heat pump, and radiant heating to become aware of the possibilities and pitfalls.

Contact has been made with the wardens of three local churches who received energy audits in 2019-20; they are happy to be contacted and receive a visit.

Contact details:

Overhead radiant infra red heaters, chandelier mounted.

St Catherine's, Preston Lane, Faversham, ME13 8LG

Hilary Tullet, htulett@uwclub.net

Underfloor heated, gas boiler powered. Church in regular daily use, including café.

St Mary the Virgin, Willesborough, Ashford, TN24 0YR

Jerry Fox jerrykfoxy@gmail.com

Underfloor heated (in part), GSHP powered. Church is a regular concert venue.

St Mary the Virgin, central Ashford, TN23 1QG

Ken Blanshard kenneth@realmarmalade.com

11. Cost Comparison

11.1 Capital Cost

The current annual gas use of 53,647kWh, and likely hours of use (530 out of 740 building occupancy hours) requires around 100kW of boiler power output. Most of the boiler's use will be heating the church from cold.

For a heat pump system (whether with underfloor heating or radiators), the pumps are designed to maintain a fairly constant temperature rather than heating the building up from cold. This requires a lower maximum power. 50kW is suggested, approximately the same amount as the overhead radiant heating estimate.

Capital cost (installed costs including wiring. 3 phase supply required)

Item	Number	Cost Each	Total
Three phase supply (required for each option)	1	unknown	unknown
IR radiant heaters, overhead 1,5kW each, total 48kW	32	£626	£20,032
Underfloor heating	250m^2		
Air Source Heat Pump	1, 50kW	£20,000	£20.000
Ground Source Heat Pump	1, 50kW	£50,000	£50,000

11.2 Operating Cost

These figures are based on several assumptions. More accurate information regarding hours and the sizing of a system required are needed to generate accurate figures. The size of a heat pump (operating constantly to maintain a temperature) will be related to the heat loss from the building. Ideally this requires heat loss calculations for the building – but it is known that further insulation and draught proof measures are needed to make heat pumps efficient and viable to reduce this figure.

Technology	Use Pattern	Annual Hours	Installed Power kW	kWh	Operating Cost
Gas Central Heating	1-2 heating episodes per week	530	100+	53,600	£2,200
Radiant IR Panels	Present Demand pattern	530	48	25,440	£3,336 Possible overestimate, reduced power may suffice for small meetings and less cold periods.

ASHP, COP = 2.5	Present Demand pattern	To heat 530, but need to be on more to attain temperature: 1000 (or more) This assumes that 50kW will be enough to heat up from cold; 100kW is available at present	50 heat delivered, 20kW electric load	20,000	£2,623 Probable underestimate, heat pumps not designed for on/off operation of occasionally used large spaces
GSHP, COP = 3.5	Present Demand pattern	To heat 530, but need to be on more to attain temperature: 1000 or more This assumes that 50kW will be enough to heat up from cold; 100kW is available at present	50 heat delivered, 14.5kW electric load	14,500	£1,900 Probable underestimate, heat pumps not designed for on/off operation of occasionally used large spaces
Radiant IR Panels	9am-9pm, 7day/week, Heating Season	Hours of use only within this 2500 hour period. Partial load when needed Estimate 1250 hours [on 48 hours per week for 26 weeks]	48	60,000	£7,870 Possible overestimate. Use of just some heaters for small meetings will reduce costs
ASHP, COP = 2.5	Heating Season	Constant, 4400 hours (6 months)	50 heat delivered, 20kW electric load	88,000	£11,550 Possible overestimate as 50kW is probably more than is needed for constant heating
GSHP, COP = 3.5	Heating Season	Constant, 4400 hours (6 months)	50kW max heat delivered, 14.5kW electric load	63,800	£8,370 Possible overestimate as 50kW is probably more than is needed for constant heating

COP = Coefficient of Performance (how many kW of heat are produced for each kW of electricity used to run the heat pump).

Costs based on current electricity charge of 13.1153p/kWh.

There are several questions for the church to ask before selecting a new heating system. These include:

- How many hours the building will be realistically used during the week.
- How many hours the use will involve small meetings where only a small area of the building could be heated (radiant heating would provide this).
- Is a Ground Source Heat Pump feasible (archaeology and cost).
- If not, can >40 hours a week use, for an Air Source Heat Pump to be justified be guaranteed?

Costs can be estimated from (a) heat loss / amount of heat needed to maintain building temperature (b) average COP for the pump, estimate 2,5 which together give the kW load of the pump and (c) hours.

Detailed heat loss calculations are recommended in order to correctly size a heat pump.

12. 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 .

13. 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.

14. Other Observations

14.1 Possible Asbestos in boiler room

The boiler room was found to be suffering from water ingress. The roofing felt above appears to be cracked, and the ceiling panels have soaked up some water and have warped. Parts of ceiling panel have become detached and fallen to the floor.

It is unclear whether this material is fibreboard, or if it contains asbestos (which it could, due to age of the boiler room building and being installed above a heat source).

It is recommended that the Inspecting Architect should be consulted about this material (which will need to be removed anyway as part of the boiler room removal for re-ordering). The church should have records if an asbestos survey has been conducted.

The exterior downpipe draining the boiler room roof has a leaking top connection, and the drain below was almost blocked with debris; as a result the stairwell was very wet and slippery.