Energy Audit and Survey Report

St Mary's Church, Church Street, Bloxham

"There is a plan to reduce global carbon emissions to net zero by 2050. The plan will work. It involves all of us. We need to begin now, in our homes and workplaces and churches"

Revd Dr Stephen Croft, Bishop of Oxford

Version Control

Author	Reviewer	Date	Version
Paul Hamley	Matt Fulford	16th October 2019	2.0

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1 Executive Summary

An energy survey of St Mary's Church, Church Street, Bloxham 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, Church Street, Bloxham is a Grade I listed church dating from the 13th Century incorporating a significant 15th Century chapel, with major restoration in 1864 by G.E. Street. It is considered to be one of the finest examples of 14th and 15th century architecture.

There is both gas and electricity 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	To be actioned by who / when?
Boiler – replaced by condensing boiler at 93% efficiency	15,000	£585			List B	
Under pew heaters in choir stalls	Potential 50% less than current heaters 100	Comfort improved			List B / Faculty	
Replace four remaining non-LED floodlights in chancel	416	£55			List B	

Medium Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Radiant panels to replace radiant bar heaters in nave	Balance greater efficiency with more use of church in week	Reduces costs incurred by greater use during week			List B	
New vestry construction – will be fully insulated. Potential for heat pumps (air source)	Heat pumps will use less electricity than direct methods	N/A			Faculty	

Long Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Install LED lights to replace CFL bulbs when due [3x lifetime, two purchases of 76 bulbs avoided]	100 [low]	minimal	Same as LED	5 Lifetime average 20 years	List A	

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

Based on current contracted prices of 11.0067p/kWh (electricity, evening & weekend), 13.2739p/kWh (electricity, day) and 3.8833p/kWh for electricity and mains gas respectively.

If all measures were implemented this would enable the church to increase the hours of use of the building without significant increase in energy costs. With group procurement of 100% clean electricity, the church could achieve both fossil fuel free status, reduction in electricity costs, and long-term reduction of maintenance costs with no boiler to service or maintain.

2 Introduction

This report is provided to the PCC of St Mary's Church, Church Street, Bloxham 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 Mary's Church, Church Street, Bloxham, OX15 4FT was completed on the 3rd October 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 Mary's Church, Church Street, Bloxham	
Gross Internal Floor Area	600 m^2
Listed Status	Grade I
Typical Congregation Size	65 morning 12 evening
Occasional events	400 Christmas

The church typically used for 8 hours per week for the following activities:

Services	4 hours per week
Meetings and Church Groups	1 hour per week
Community Use	1 hour per week (concerts)
Occasional Offices (Weddings, Funerals)	2 hours per week (15W, 18F per year)

3 Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Mary's Church, Church Street, Bloxham and have been reviewed against the current market rates for energy. Current electricity rates are:

Day Rate	13.2739p/kWh	In line with current market rates [12.99 to 13.77p/kWh]
Evening / Weekend Rate [more relevant]	11.0067p/kWh	Below current market rates
Standing Charge	20p/day	In line with current market rates

The current gas rates are:

Single / Blended Rate	3.8833p/kWh	Above current market rates as standing charge included

The above review has highlighted that there are opportunities to gain cost savings from improved procurement of the energy supplies at this site. We would therefore recommend that the church obtains a quotation for its gas and electricity supplies from the Diocese Supported parish buying scheme, http://www.parishbuying.org.uk/energy-basket. This scheme only offers 100% renewable energy sourced electricity (currently 20% renewable gas) and therefore it is an important part of the process of making churches more sustainable. The exact rates are dependent on the market at the time of application and the number of churches in the "basket", but they will be less than for a single customer.

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.

4 Energy Usage Details

St Mary's Church, Church Street, Bloxham used 11,114 kWh/year of electricity from September 2018 to August 2019, costing in the region of £1,500 per year [£1,493], and 82,448kWh/year of gas, costing £3,361.

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

Utility	Annual use 01/09/2018 – 31/08/2019	Total including standing charges and VAT
Gas	82,448kWh	£3,204
Electricity	11,144kWh	£1,459

St Mary's Church, Church Street, Bloxham has one main electricity meter, serial number E10BG33804 There is one gas meter serving the site, serial number K0052016D6.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E10BG33804	Atlas Mk10D Smart meter		Electrical cupboard, rear of church
Gas – Church	K0052016D6	Unknown		External gas meter cupboard, not accessible by church

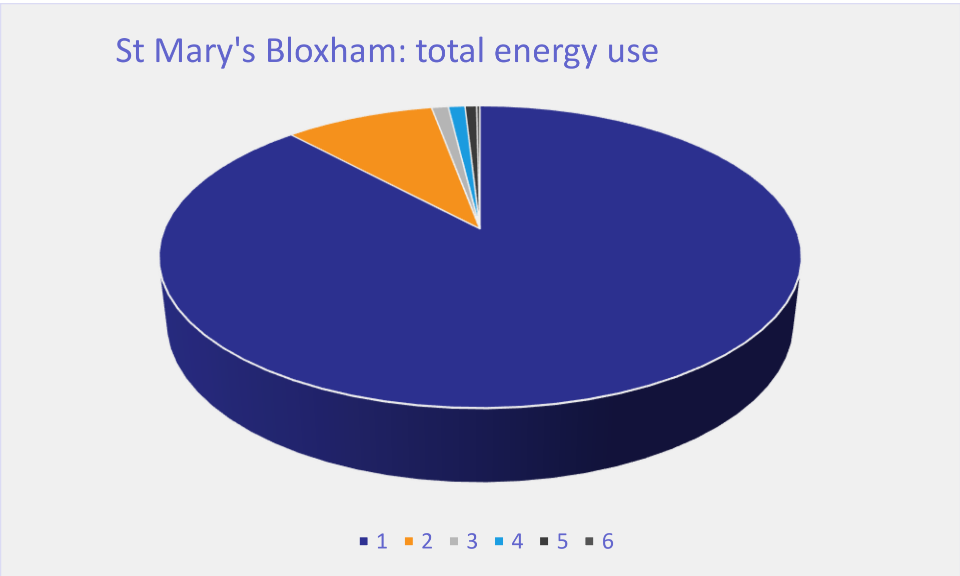
All the meters are AMR connected and as such energy profile for the entire energy usage should be possible.

4.1 Energy Profiling

The main energy use within the church can be summarised as follows:

Gas	82,448kWh
Electricity annual consumption	11,144kWh
Annual use hours (8 per week)	416
Average load	26.8kW
Internal load, heat and light (estimated)	23kW

Service	Description		Estimated Proportion of Usage
Heating (gas)	Trench pipes only, background heating		88%
Heating (electric)	6 radiant heaters above pillars in nave 4 radiant heaters on chancel walls	est 24kW est 8kW	9%
Lighting (internal)	40 15W & 36 x 11W **CFL** Light circuits 17-22 4 LED floodlights 4 halogen floodlights 2 mercury vapour lamps 1 automatic porch light Total	1000W 200W 100W 1000W 200W 20W 2.5kW	1%
Lighting (external)	Spire floodlights Gate floodlights Unknown but stated to be recent	est 2.5kW	1%
Hot Water	Two urns 2 hours/week = 624kWh/year	6kW	0.7%
Other Small Power	Audio system	0.5kW	0.2%



Key 1: Gas 2: Electric heating 3: Lighting (internal)
4: Lighting (external) 5: Hot water 6: Small power

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

4.2 Energy Benchmarking

In comparison to national benchmarks for Church energy use St Mary's Church, Church Street, Bloxham uses 7% less electricity and 9% less heating energy than would be expected for a church of this size.

	Size (m^2 GIA)	St Mary's Church, Church Street, Bloxham use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Mary's Church, Church Street, Bloxham (elec)	600	18.5	20	10	93%
St Mary's Church, Church Street, Bloxham (heating fuel)	600	137	150	80	91%
TOTAL	600	155	170	90	91%

Use of low-level constant (gas) heating, topped up by radiant electric heating (using traditional heating elements) gives a lower than average result.

There is potential for improvement both in the background heating (more efficient boiler) and newer infrared radiant panels.

5 Energy Saving Recommendations

5.1 Lighting (fittings)

The lighting makes up a relatively small overall energy load within the building.

Most of the lamps appear to be compact Fluorescent lamps (CFLs), which in time should be replaced by LEDs. This will reduce power from around 15W per lamp to 10W, so a minimal saving on electricity but, on average give a longer lifetime. It is worth looking at Parish Buying to make a bulk order, rather than fitting piecemeal as CFLs come to the end of their life. CFLs have lives of 8000-20000 hours, so if recently installed the majority of them should continue to function for ~20 years based on 8 hours per week use, although that is likely to increase. When they begin to fail is the time to make a bulk order. Consider the colour temperature; a lower number gives a warm, yellow light (2700K), whilst higher numbers give a bright, white light (4000K, which can confusingly be referred to as “cool”) whereas daylight is 6500K. [Think about heating a piece of iron in a forge from red hot up to white hot].

The two mercury pendant lamps above the altar are of uncertain power rating – this type of lamp is relatively efficient if they are recent examples.

The chancel has eight spotlights, four of which are LED, the others appear to be halogen, probably 250 or even 500W bulbs. These should be replaced by LED floodlights.

There is also a broken reading light on the south side choir stall. This should be removed if no longer required. Replacement units using LED strips are in use in Lambeth Palace Chapel.

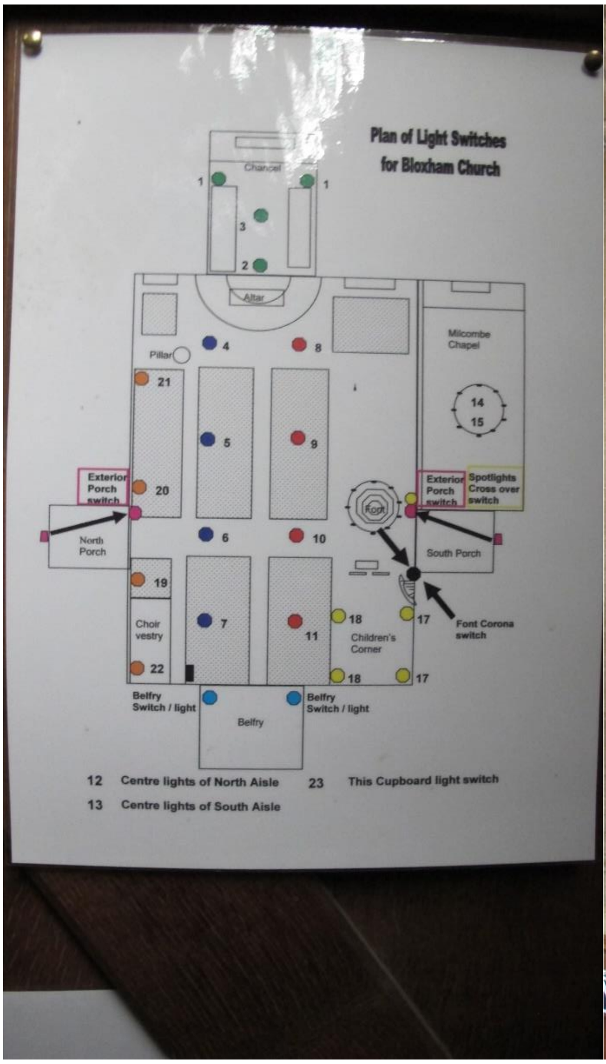
Figure 1 Nave lighting is provided by 8 sets of 5 bulbs

Figure 2 The Millcombe Chapel is well lit by natural light from four perpendicular windows

Figure 3 Mercury vapour lamps at front of nave. Note the low pitch roof

5.2 Lighting (control for internal lights)

Controlled from switch banks; a helpful colour coded diagram assists in switching relevant lights on.



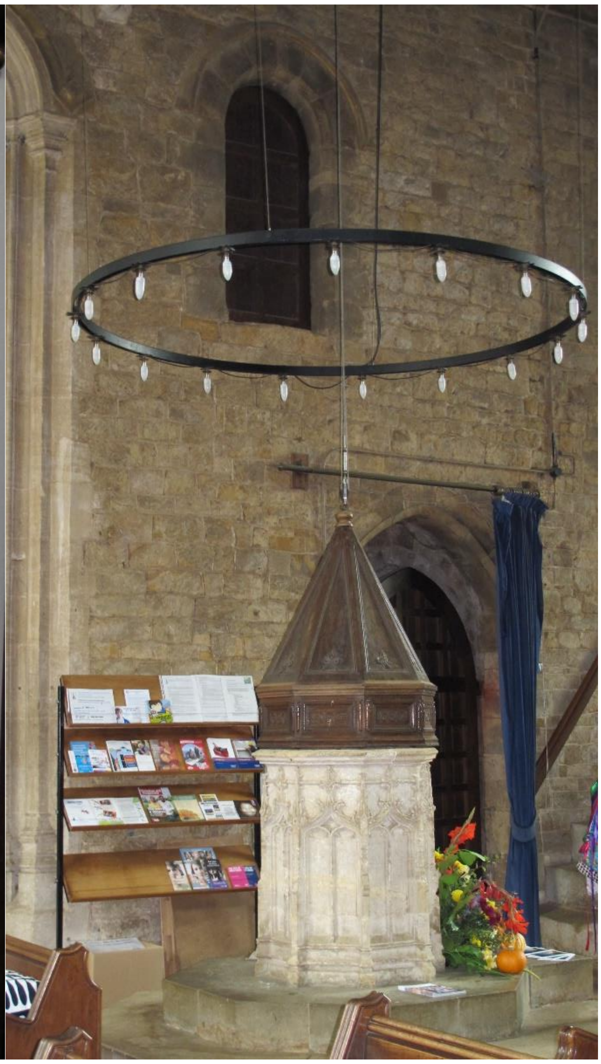


Figure 4 Switch diagram **Figure 5** Font lighting ring

Figure 4 is an excellent example of lighting controls allowing the lighting level to be easily adjusted for different activities, levels of occupancy, or types of event. Figure 5 shows how a curtain is available to cover the door to the porch for particularly cold or windy days.

5.3 Lighting (control for external lights)

Not explored. External floodlights stated to be "recent".

It is suggested that the steeple floodlights are controlled by a timer and light meter so that they are only on from dusk, and the timer switches them off at a suitable time which should be no later than 11pm.

Gate lights should be controlled by a PIR detector so they only come on when a person is detected. The time illuminated should be long enough for an elderly person to make their way into the church.

5.4 Heating Overview

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 National Trust and English Heritage.

Occupants comfort depends to an equal extent on air temperature and radiant surface temperature.

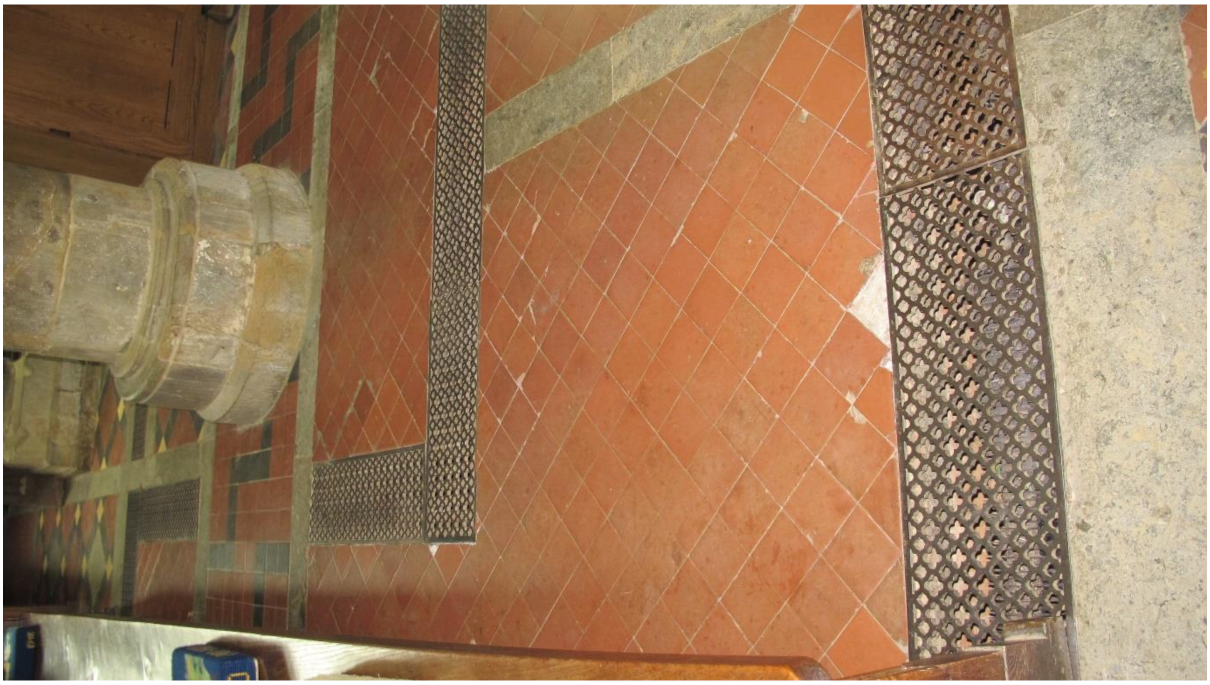
Adjacent cold surfaces such as pillars and walls, which readily accept radiant heat from bodies can be covered with soft furnishings (traditionally, tapestries were used for this purpose, and wooden panelling in some churches). At St Mary's it appears that most of the congregation sit away from the walls and pillars. The overhead radiant heaters are above the pillars.

Heating pipes are located in trenches covered with cast iron grilles – these are thought to date from the restoration by G.E. Street in 1864. This is a form of underfloor heating, albeit with the large pipes distributed with large gaps, rather than a network of closely spaced small pipes. The church has considered a new underfloor heating system; which would require removal and relaying of the tiled floor (Street) and considers that this would not be granted by a faculty.

It would also require excavation in order to lay an insulating barrier layer underneath the heating pipework, so would be major work to cover c. 500m^2 of the main church.

The church plans to shorten the pews so that they are moveable to create flexibility for worship and multiple uses of the building. This means that under pew heaters are not easily able to be incorporated although in many ways they would be an ideal solution if the pews were to be fixed or mainly fixed in the same location.

Figure 6 Victorian underfloor heating trenches



5.5 Optimisation of temperature (with existing or replacement equipment)

Maintaining a base temperature of 10-12°C (conservation heating) is practised in many historic listed buildings. If the thermostat is operating correctly, then during the summer (June, July, August) the heating should not come on. In May, the heating should be turned off – this may result in a rather cool church, depending on the weather, but the church will then retain the "coolth" for the first part of summer.

As the church has a high thermal mass, keeping the boiler off throughout September will save money, as it will retain the heat from the summer. If a September turns out to be particularly cold, it will be easy to turn it on.

The church intends the nave to be in use much more during the week; with the possibility of hosting a Citizen's Advice Bureau. A system which maintains a base temperature is compatible with regular use (not so with a church which is only used once per week). Top up heat for weekday use would continue to be provided by radiant heaters, although there would be a need to consider siting extra ones in the rear area where the CAB is to be located.

5.6 Space Temperature Set Point

The boiler is controlled by a Drayton Digistat 3 and is located next to the pulpit. It was set for manual operation. It can be programmed for six separate temperatures per day.

A manual is available online at https://www.draytoncontrols.co.uk/sites/default/files/Digistat%2B3%20%28U.%26I.%20Guide%29.pdf.

Currently, the boiler appears to be used to provide background heat to 13°C, with the overhead radiant electric heaters being used to provide a comfortable environment when occupied. It is recommended that this background level could be set lower (10°C suggested as the minimum for conservation heating; but weather patterns might mean the minimum temperature except in deepest winter is around 8°C).

The frost setting of 5°C is also at the high end of what is recommended. A level of 2 degrees would be acceptable and still avoid pipes from freezing. With any new boiler installation there should be a 2-stage frost regime installed where on the first stage just the pumps come on to circulate the water in the system and at the second stage the boilers fire. The use of a Glycol based inhibitor can avoid the need for frost protection altogether.

Figure 7 Drayton Digistat 3

Due to the volume of water, the length of the heating pipes and the thermal mass of the church, and that all heat is transferred from pipes in trenches, the church will heat up very slowly. A church with conventional radiators would be expected to heat at 1-2°C per hour; in this case 0.5°C per hour is likely. This heating system is used to maintain a constant base temperature in the church, so it does not become too cold. As mentioned section 5.4, this source of heat is not required during the summer, and economies can be made in the pre and post summer period.

5.7 Underfloor Heating System options

Minimisation of operating costs (whilst retaining optimal temperature).

Long term operating cost reduction would be best achieved by installing modern underfloor heating connected to a heat pump. However, UFH is already ruled out due to the tiled floor. They work most efficiently when the heat output is at low or medium temperatures, as is the case at St Mary's.

Replacement of the boiler with a modern condensing boiler.

Straightforward – but consider ongoing annual maintenance/ safety check costs, the likely rising price of gas as North Sea production continues to fall, short boiler lifetime and high CO_2 emissions.

Replacement of the boiler (a design with efficiency of 76% when new) with a condensing boiler (up to 93% efficiency) AND setting the boiler operating parameters such that the return water temperature is always below 55°C will increase efficiency. The latter will be easily achievable as the system is used to deliver a low background heat and is not connected to high temperature radiators.

5.8 Boiler Room Issues

Figure 8 Entrance to the boiler room

Figure 9 Existing boiler; the Ideal Concord range is listed as having an efficiency of 76%.

The existing boiler lid is heavily rusted with a pool of water on it. Inspection revealed a circular hole cut into the crown of the brick arch immediately above, which probably contained a flue for a previous boiler – the collar of this flue is still present in the concrete panel above the boiler room. Water has been percolating down this hole; this should be addressed before changing the boiler. The leak may be from the flue collar itself, or water running horizontally between the concrete panel and the brick arch under it. If the hole is filled, the situation should still be monitored .

Figure 10 Presumably an old flue hole, above the boiler, probable source of the water.

Figure 11 External evidence of former flue

5.8 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 consumption by over 10% andhelps the building to heat up quicker.

5.9 Insulation of Pipework and Fittings

Pipework in the boiler room should be fully insulated to prevent heat loss to the surrounding air. Some of the lagging was noted to be loose and starting to drop off. Valves and some joints were seen to be unlagged. Exposed areas of pipework contribute significantly to wasted heat loss from the system and make the plant room unnecessarily warm. The exposed hot surfaces also represent a health and safety risk of burns for those working in the area.

It is recommended that these areas of expose 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.

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).

Figure 12 Sections of pipe and valves are not lagged

5.10 Electric Heating Panels

Figure 13 Location of existing radiant heaters in nave

Figure 14 Unidare 4000 heater

Infrared heaters will be more efficient (deliver the same heating effect with lower power consumption). There may be an option of angling the panels for optimum effect.

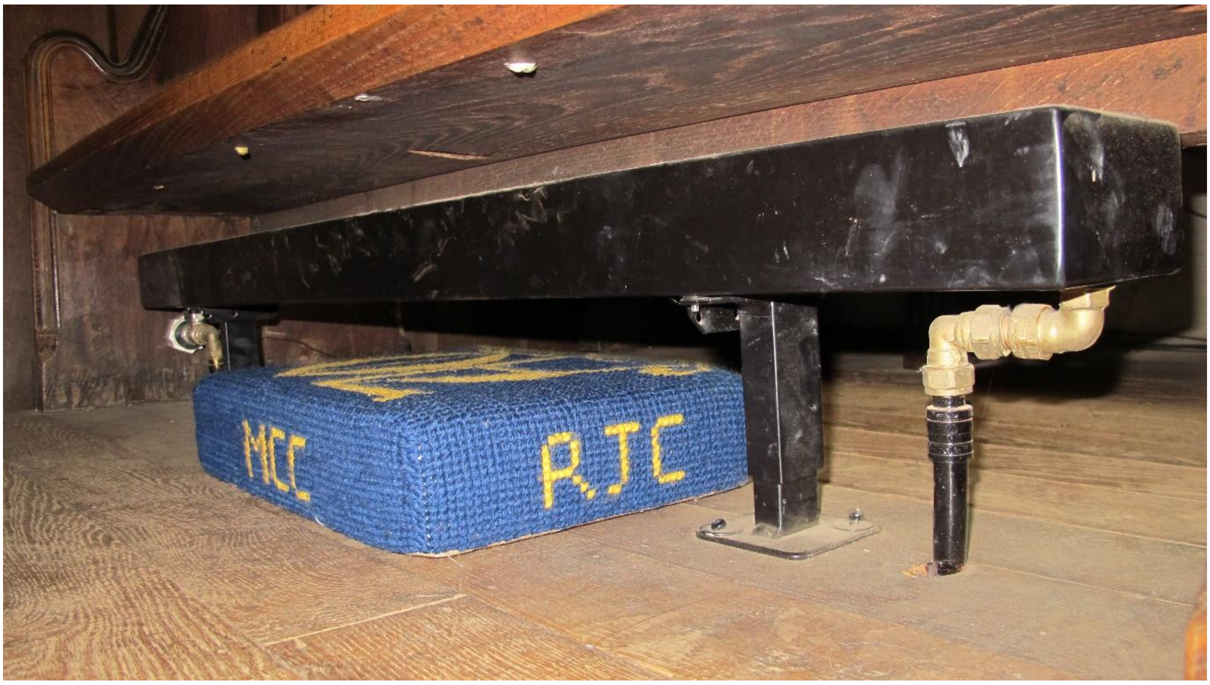
As well as replacement of the heaters located over the pillars, the church can consider whether new panel heaters would be appropriate for use within the Milcombe Chapel or at the rear of church where the CAB area is proposed.

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.

Some suppliers are able to supply panels in bespoke colours to blend in (camouflaged!), even possibly disguised as works of art.

5.11 Under Pew Heaters – Chancel

Figure 15 Current under pew heating in chancel is linked to central heating system. It is considered to be mainly heating the underneath of the pew and is not effective at heating people.



Modern under pew heaters can replace the existing under pew heaters under the front choir stalls which are described as uncomfortable and heating the woodwork too much.

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 to the adjacent vestry / organ area where there would be power, or alternatively to the new vestry area on the south side and incorporated with its redevelopment. (All cabling should be in armoured cable or FP200 Gold when above ground) to the both rows of pews quite easily).

5.12 Roof Insulation

The nave has an exposed hammerbeam roof.

The chancel has an exposed roof of curved ribs, some of which are carved with a toothed pattern.

It might be possible to fit insulation panels between the beams; however, given that most of the church heating is radiant, this would have a small effect.

5.13 Quattro Seal

The external doorways have the original historic timber doors on them, where these do not close tightly against the stone surround a large amount of cold air will enter the church around the side and base of these doors.

It is recommended that draught proofing is fitted to all external doors. 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

5.14 Other Fabric Measures

Curtains may be used to assist in making a draught screen around a doorway.

Black plasticine may be used as a remedy for sealing small gaps around draughty heritage windows.

6 Other Recommendations

Electric Vehicle Charging Points

The church has a car parking area next to the hall. In order to make a visible statement on the churches mission of stewardship and to facilitate more sustainable transport choices by those both visiting the church and using the hall, the church may wish to consider installing an electric vehicle charging point, probably on the side of the church hall to allow visitors to charge their electric car.

Installing a unit such as a Rolec Securi-Charge http://www.rolecserv.com/ev-charging/news/view/Robust-EV-Charging-With-Rolecs-SecuriCharge-EV-Wall-Unit-Coin-Token-PAYG would allow the church to be able to sell tokens or have a coin operated device that would at least cover the costs of the electricity use and could make a small income.

Proposed vestry replacement

A new build vestry is proposed to replace the present inadequately insulated modern construction. It is suggested that this should be constructed to high insulation standards to minimise heat loss. It should be provided with an independent heating system, allowing the room to be brought to a comfortable temperature without having to heat the whole church; thus, it can be used for small group meetings. Consideration should be given to radiant infrared panel heating and an Air Source Heat Pump. The proposed usage hours for the room should inform the decision over the proposed solution.

7 Renewable Energy Potential

The potential for the generation of renewable energy on site has been reviewed and the viability noted.

Renewable Energy Type	Viable	Comments
Solar PV	Yes	Low priority
Battery Storage	Yes	Low priority
Wind	No	
Micro-Hydro	No	
Solar Thermal	No	
Ground Source Heat Pump	Yes technically	Permission unlikely
Air Source Heat Pump	Yes	As part of the new build element
Biomass	No	

There is potential for a small PV array on one of the low angled roofs as they do not appear to be visible from the road or other buildings. 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 churches electricity consumption is already very small and the consumption during the daytime when the sun is shining is likely to be very low indeed, therefore while technically viable only a very small number of panels (maximum of around 4) would be worth considering if at all.

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. It would then be worth evaluating whether a solar PV array plus battery would provide electricity for existing or new infrared radiant heaters (and possible heat pump) more cost effectively than a 100% renewable electricity contract.

8 Funding Sources

This audit programme offers each participating church the chance to apply for a grant of up to £150 towards implementing some of the audit's recommendations. An application form is included with this report.

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 .

Trust for Oxfordshire's Environment (TOE) does have some funds available (over and above the small implementation grants of £150 available through this scheme) to support energy efficiency improvements in community facilities. If your church is used by the wider community, visit www.trustforoxfordshire.org.uk or contact admin@trustforoxfordshire.org.uk to find out if your project is eligible for a grant of up to about £5,000.

9 Faculty Requirements

It must be noted that all works intended to be undertaken should be discussed with the DAC at the Diocese.

Throughout this report we have indicated our view on what category of permission may be needed to undertake the work. This is for guidance only and must be checked prior to proceeding as views of different DACs can differ.

Under the new faculty rules;

List A is for more minor work which can be undertaken without the need for consultation and would include changing of light bulbs within existing fittings, repair and maintenance works to heating and electrical systems and repairs to the building which do not affect the historic fabric.

List B is for works which can be undertaken without a faculty but must be consulted on with permission sought from the Archdeacon through the DAC. This includes works of adaptation (but not substantial addition or replacement) of heating and electrical systems and also the replacement of existing boilers so long at the same pipe work, fuel source and flues are used. It can also be used to replace heating controls.

All other works will be subject to a full faculty.

Works which affect the external appearance of the church will also require planning permission (but not listed building consent) from the local authority and this will be required for items such as PV installations.

10 Other Observations

The church has a positive vision for using church as the centre for the community, which is missional through seeking to host advice services. It has good potential for becoming more friendly to the environment if it incorporates more energy efficient technologies during re-ordering and construction of a new vestry.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Chancel					
Non-LED floodlights	4	Currently 250W to 500W each. Change to LED floodlights			