Energy Efficiency and Zero Carbon Advice

St Michael's, Tilehurst

PCC of St Michael's

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Michael's 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 Michael's dates back to the 13th century, the tower is 18th century, and there was a major rebuild in 1855. In 1993 an extension to the north side of the church provided a large meeting room and kitchen, toilets, a parish office and a new vestry all built round a cloister garden 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 over the coming years.

Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)
Contact suppliers to arrange for the meters to be changed to smart meters	None	None	Nil	N/A	None	N/A
Switch electricity (and gas) suppliers to ones which provide 100% renewable (or green gas) supplies	None	None	Nil	N/A	None	Offset 3.13 tonnes
Install Endotherm advanced heating fluid into heating system(s)	13,626	£398	£1,120	2.81	List A (None)	2.51
Insulate exposed pipework and fittings in plantrooms	7,171	£209	£600	2.86	List A (None)	1.32
Fit timed fused spurs to hot water heaters	162	£25	£90	3.64	List A (None)	0.04

Add or Replace draught strips to external doors	2,725	£80	£450	5.65	List A (None)	0.50
Change existing lighting for low energy lamps/fittings	7,999	£1,221	£9,685	7.93	Faculty	2.03
Install a Solar PV array to roof of building (assumed 100% of energy generated used in building)	8,000	£1,221	£12,500	10.24	Faculty	2.03
Install PIR motion sensors on selected lighting circuits	25	£4	£47	12.36	List B	0.01
Replace existing boilers for high efficiency, low NOx condensing boiler of approx 70kW to serve extension only.[1]	7,153	£209	£8,400	40.20	List A (None)	1.32
Replace heating system for electrical under pew system in the church	72,553	£143	£39,581	276.11	Faculty	12.29

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

Based on current contracted prices of 15.26p/kWh and 2.921p/kWh for electricity and mains gas respectively.

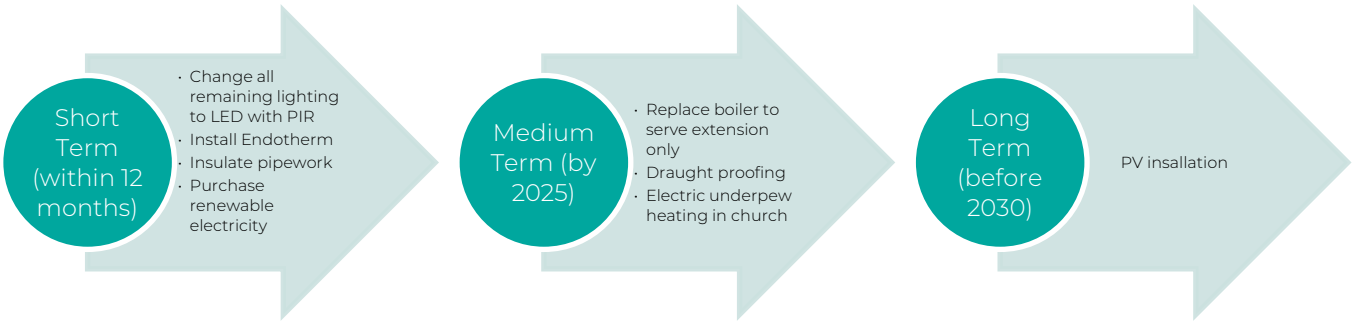
If all measures were implemented this would save the church £3,509 per year.

[1] The Reading Borough Council drive to Net Zero by 2030 may preclude the installation of a new gas boiler and therefore a hybrid Air Source Heat Pump with gas boiler peak load top up could be an alternative consideration.

2. The Route to Net Zero Carbon

The Diocese of Oxford's Diocesan Synod has set a target of reaching Net Zero Carbon by 2035, or as soon thereafter as is possible. General Synod, meanwhile, has set a target for the Church of England to reach a limited-scope Net Zero Carbon target by 2030. Our diocese will need to respond to the national target. which, as it is presently framed, means that every church, cathedral, church school and vicarage in the C of E will need to reach net zero - or compensate for residual emissions - within the next ten years.

This church has a clear route to become net zero by 2035 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Michael's to give them advice and guidance as to how the church can be improved to be more energy efficient. In doing so the church will also become more cost effective to run and seek to improve the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Michael's, New Lane Hill, Tilehurst, Reading RG30 4JX was completed on the 6th October 2020 by Matt Fulford. Matt is a highly experienced energy auditor with over 15 years' experience in sustainability and energy matters in the built environment. He is a chartered surveyor with RICS and a CIBSE Low Carbon Energy Assessor. He is a Member of the DAC in the Diocese of Gloucester and advises hundreds of churches on energy matters.

St Michael's	
Church Code	627473
Gross Internal Floor Area	708 m^2 (inc. extension)
Listed Status	Grade II

The church typically used for 58 hours per week for the following activities

Type of Use	Hours Per Week (Typical)
Services	8 hours per week
Office and extension rooms	50 hours per week

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

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	15.26 p/kWh	In line with current market rates
Standing Charge	43.01 p/day	N/A

The current gas rates are:

Single / Blended Rate	2.921 p/kWh	Below current market rates
Standing Charge	40.0 p/day	N/A

The electricity and gas is supplied by British Gas and is not purchased on a renewable tariff.

Going onto a renewable tariff is an important part of the process of taking churches towards net zero. The church is therefore encouraged to consider the Parish Buying Scheme, which uses the power of group purchasing to offer economies of scale in the procurement of energy. Its 'Green Energy Basket' tariff delivers 100% renewable electricity and 20% green gas. We would recommend that the church obtain a quotation for its gas and electricity supplies from the scheme: http://www.parishbuying.org.uk/energy-basket.

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 Michael's uses 12,360 kWh/year of electricity, costing in the region of £1,886 per year, and 143,428 kWh/year of gas, costing £4,189.

This data has been taken from the annual energy invoices provided by the suppliers of the site. St Michael's has one main electricity meter, serial number E11Z38202. There is one gas meter serving the site, serial number M025A0515711D62001.

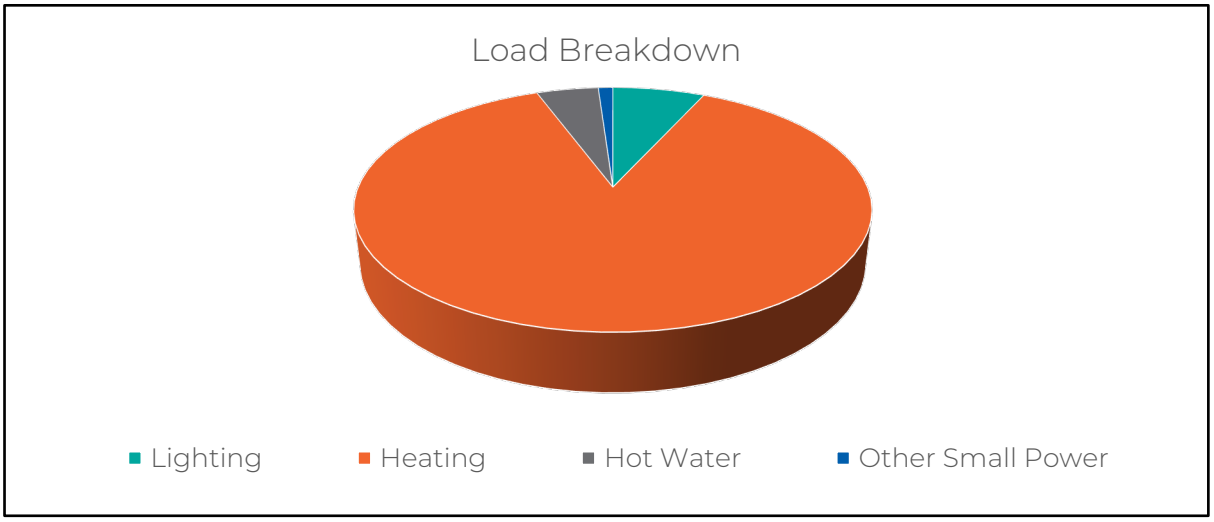
Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E11Z38202 (3 phase 100A)	Atlas EDMI Mk10D	Full AMR Connected	Base of tower
Gas – Church	M025A0515711D62001	Itron MDA25	Pulse Block but no AMR	Boiler room

The electricity meter is AMR enabled, but the gas is not connected. If it were an energy profile for the entire energy usage would be possible. Once it is connected the usage can be monitored more closely, and the patterns of usage reviewed against the times the building is used.

5.1 Energy Profiling

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

Service	Description	Estimated Proportion of Usage
Lighting	Mainly fluorescent and AR11 fittings with some LED	7%
Heating	Gas heating to church and extension - church heated to background level constantly in winter	87%
Hot Water	Hot water the WC's, kitchen and the like	5%
Other Small Power	Office and kitchen appliances, electric heating to Morlais room.	1%



As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site.

5.2 Energy Benchmarking

In comparison to national benchmarks for church energy use St Michael's uses 13% less electricity and 35% more heating energy than would be expected for a church of this size.

	Size (m^2 GIA)	St Michael's use kWh	St Michael's use kWh/m^2	Typical Church use kWh/m^2	Variance from Typical
St Michael's (elec)	708	12,360	17.46	20.00	-13%
St Michael's (heating fuel)	708	143,428	202.58	150.00	35%
TOTAL	708	155,788	220.04	170.00	29%

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 has 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 it remaining oil and coal fired power stations. Mains gas does have some potential to reduce its carbon content through the use of biogas 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 more efficient and less carbon intensive and one way to achieve this is to consider a transition to electrical heating where this also represents a more efficient and comfortable solution for churches..

The church can been considered as having two main elements. The church itself, which is used sporadically for a limited number of hours in the week, and the extension which is used regularly and frequently. The church is currently set to be on 24/7 during the heating season to a background temperature of around 13°C which is increased manually on the room thermostat by the organ to 20°C for services.

The extensions heating distribution system is relatively modern and makes use of radiators and floor trench heating units. This is in good condition and has many years of service left in it. It would be difficult at this stage to easily move this heating system and usage style to a heat pump and it is therefore recommended that the gas boilers which serve both the church and the extension are replaced for a high efficiency gas condensing boiler serving the extension only. There could be an option now to consider air source heat pump (ASHP) to provide background heating levels with either a gas boiler to provide peak heating demand top up in conjunction with the ASHP (typically terms a 'hybrid heat pump') or top up with electric infrared panels but both of these would add in an additional system and is considered uneconomic in the current situation.

For the church it is recommended that the heating is moved to an all-electric under pew heating system which will provide improved comfort to the occupants and is an efficient, low carbon heating solution providing heat for only the time when the church is being used.

6.1 Install Electric Under Pew Heaters

As indicated above, the most efficiency way of providing thermal comfort into the church would be to heat this, only when it is required, with electric underpew heaters. There are now good, modern purpose made under pew heaters on the market (contact the Diocese for details of churches who have installed this) and installing these would allow for the gas fired heating to be removed. The pew heaters only need to be turned on around 20 minutes prior to a service and the church can be unheated at other times.

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 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 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.

We would suggest that the following church electric heaters could be considered:

Area	Type/ Size	Length (mm)	Watts	Number Required
Choir	Electric Under Pew 450W	702	450	4
Choir	Electric Under Pew 300W	525	300	10
Choir	Electric Under Pew 650W	948	650	2
Altar	Electric Far IR Wall Panel 700W	1200	700	1
Communion Rail	Electric Far IR Wall Panel 350W	600	350	1
Nave	Electric Under Pew 650W	948	650	60
South Aisle	Electric Under Pew 650W	948	650	14
North Aisle	Electric Under Pew 650W	948	650	20
Rear nave	Electric Far IR Wall Panel 580W	1000	580	3

Cable runs to the pew heaters should run along the along the existing routes (all cabling should be in armoured cable or FP200 Gold when above ground) to the pews. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

The existing gas fired radiator system to the church could then be removed.

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.

Figure 1 - BN Thermic Under Pew Heaters

6.2 Replace the Existing Boiler for a High Efficiency Condensing Boiler

The existing gas boiler within the church is now around 20 years old and as such is reaching the end of its serviceable life. Boiler efficiencies have also improved since this boiler was originally installed and therefore replacing the boiler for a new, high efficiency, Low NOx gas condensing boiler will deliver gas savings through more efficient combustion and heat transfer in any new boiler.

Installing a new gas boiler now will lock the church into a gas / fossil fuel based solution for the lifetime of the new boiler (around 20 years) and therefore an important decision needs to be made as to whether the PCC and the local Reading Borough Council is seeking to transition to a net zero carbon position within that period and therefore should consider installing a (hybrid) heat pump technology in lieu of a gas boiler. The options for a heat pump are covered in section 9 of this report.

A replacement gas boiler, which would serve the extension only, can be undertaken by a competent mechanical engineering company and it would make sense to install new VSD pumps and undertake the pipework insulation as part of these works. The heating system could also be flushed clean and refilled with inhibitor and advanced heating fluids (such as endotherm) on completion to maximise the efficiencies.

7. Improve the Existing Heating System

In the years before the replacement of the existing heating system it is recommended that measures are taken to improve the efficiency of the existing heating system, this should include:

7.1 Advanced Heating Fluid

In order to improve the efficiency of the heating system further it is recommended that an advanced heating fluid 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.

These products can be self-installed.

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 New LED Lighting

The lighting makes up a relatively small overall energy proportion of the electricity used within the church, and large areas are lit by relatively inefficient fluorescent and AR111 fittings.

There are some areas of the building which have had efficient LED lights installed but there still remains a large number of inefficient fluorescent and AR111 within the church and extension.

It is recommended that the fittings scheduled in Appendix 1 are all changed for LED. There are a vast number of specifications of LED lights on the market but it is recommended that any LED light should come with branded chips and drivers and offer a 5 year warranty.

The replacement of the AR111 units for LED lamps in the same fittings is possible. It has been trial unsuccessfully by the church with the LED units resulting in flicker. This is likely to be used to an incompatibility between the LED lamps and the LV transformer that will sit behind the fittings. These transformers would therefore need to be changed at the same time as the lamp which can be undertaken by any competent electrician.

If all the lights were changed on a simple “like for like” the total capital cost (supplied and fitted) would be £9,685. The annual cost saving would be £1,221 resulting in a payback of around 7.9 years. This estimate includes for the supply of the lights, the labour to install them and the access required. It does not include for any upgrade to the wiring or a new lighting design both of which the church may wish to consider.

8.2 Lighting Controls (Internal)

There are several lights which currently remain on all the time in areas such as utility room, base of the tower, rear lobby areas and the like. Some of these areas are only used occasionally and for a short amount of time and as such, the light does not need to remain on constantly. There are also spaces which benefit from a good amount of natural daylight coming in through the windows where artificial lighting is not required for much of the year during the day.

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 consider 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 Timed Fused Spur to Hot Water

There is an electric point of use water heater in the utility room to provide hot water for hand washing. This only needs to heat the water to the required temperature when the building is in occupation but at the moment this heater is directly wired in without any form of time control and therefore maintains its set temperature 24/7.

It is recommended that the heaters are fitted with a 24 hour/7 day timeclock to replace the fused spur switch. They should be set up with times to match the times that the building is occupied. This will prevent the standing losses from the unit wasting energy during periods when the building is not occupied.

Such units can be purchased at any electrical wholesaler and fitted by your existing electrician or any NICEIC registered electrical contractor.

8.4 Insulation of Pipework and Fittings

The pipework within the boiler room has the majority of its straight lengths insulated but the more

complex shaped pipework fittings, such as valves, have been left uninsulated. These 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.

8.5 Draught Proof External Doors

There are a number of external doors in the church. These have the original historic timber doors on them, but these do not close tightly against the stone surround and hence a large amount of cold air is coming in to the church around the side and base of these doors.

It is recommend that the draughtproofing around the door is improved and draught strips are added. This could be achieved in a number of ways.

For timber doors that close onto a timber frame there are products on the market that are a liquid sealing system to provide good quality draught proofing and some are used extensively in heritage buildings.

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.

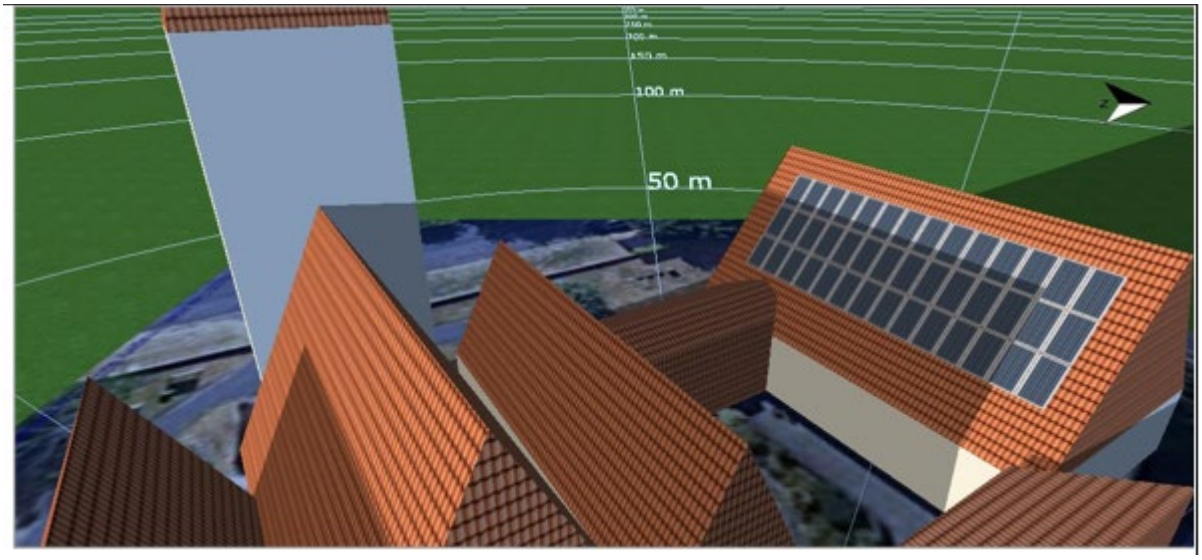
Simple measures such as having a ‘sausage dog’ style draught excluder laid along the base of a door, using plasticine of the right colour to fill gaps where daylight can be seen and putting painted fridge magnetic over large keyholes can all be simple DIY measures which are effective.

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 - To upper slop of south facing roof over extension
Wind	No – no suitable land away from buildings
Battery Storage	Yes – In conjunction with PV panels
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	No – not ideal heat distribution system, could be possible with supplementary direct electric heating
Ground Source Heat Pump	No – archaeology in ground and radiator system

The 3D modelling below show the suitable location of the PV panels.



There is potential for a PV array on the roof of the extension. 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. As the extension has office use during most days and other daily activities there is likely to be a steady and consistent demand for electricity from the building which these solar PV panels could provide. While the second roof to the south aisle would be even better for PV panels this would be very visible to the extent it is not an acceptable location however the roof to the extension is much

more discrete although suffers from some shading at certain times of the year. A full analysis of the PV system is included alongside this report.

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.

An air source heat pump could potentially be used to supply heat into the heating system in the extension building. The heat distribution through the radiators in here is reported to be insufficient at present and an air source heat pump will run at reduced temperatures therefore making this situation worse. This could be improved by installing larger radiators within the building but this will involve significant cost and disruption. Even then an air source heat pump would likely require to have a mechanism to boast is performance in cold weather and this would be achieved through a supplemental gas boiler in what is typically described as a 'hybrid heat pump' solution. It would also be possible to add in supplementary direct electric panel heaters. Neither are ideal solutions in this building and its usage pattern therefore the primary advice of this report is to replace the gas boiler for a high efficiency unit to serve the extension. This should be reviewed with the development of heat pumps at the time of boiler replacement.

10. 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 .

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.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Boiler room	1	5ft Single LED	£4	£88	22.30
Base of tower	2	5ft Single Proteus LED	£36	£255	7.09
South aisle	11	AR111 LED	£97	£468	4.84
South aisle	5	5ft Single LED	£28	£439	15.59
Nave	24	AR111 LED	£211	£1,020	4.84
Nave	12	5ft Single LED	£68	£1,054	15.59
North Aisle	12	AR111 LED	£105	£510	4.84
North Aisle	12	5ft Single LED	£68	£1,054	15.59
Chancel	10	AR111 LED	£88	£425	4.84
Chancel	8	5ft Single LED	£14	£702	50.65
Old vestry	1	5ft Single Proteus LED	£14	£127	9.00
Rear lobby (1993 extension)	1	2D LED 11W	£6	£75	13.01
Utility room	1	5ft Single LED	£8	£88	11.00
Song room	4	2D LED 11W	£31	£235	7.59
Sacristy	3	2D LED 11W	£23	£176	7.59
Morlais Room (2x 1.5kW dimplex QXD)	18	600 x 600 25W Panel	£377	£1,347	3.57
Kitchen	2	5ft Single LED	£28	£176	6.24
The west room	2	2D LED 11W	£16	£118	7.59

1 The Coaches, Fields Road, Chedworth, GL54 4NQ

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