Energy Audit and Survey Report

St Margaret's, Oxford

PCC of St Philip & St James with St Margaret's

"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	8th March 2020	2.0

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1. Executive Summary

An energy survey of St Margaret's, Oxford 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 Margaret's, Oxford is a Victorian church constructed of stone in the gothic style between 1883-1893. 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?
Replace non LED floodlights and spotlights	2,000	£280	£280	1	None	Warden
Draughtproofing measures	5%, ,5000	£175	£50	1	None	Warden

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?
Reduce boiler use by installing electric radiant infra-red heating for specific areas which can then be used for short meetings	20,000	0	Dependent on how many areas affected	N/A	Faculty	PCC
Install heat pump technology as part of new build	N/A	N/A	Similar to central heating boiler system	N/A		PCC

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

Based on current contracted prices of 13.9581p/kWh (day), 12.1565p/kWh (night) and 2.0758p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church in the region of £450 operating costs per year.

2. Introduction

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

An energy survey of the St Margaret's, Oxford, OX2 6RX was completed on the 21st November 2019 by Dr. Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group developing advice for the Church of England and authored the 2018 "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 EcoCongregation assessor.

St Margaret's, Oxford	627221
Gross Internal Floor Area Including vestries and porch	800 m^2
Listed Status	Grade II Conservation area
Built	1883-1893
Typical Congregation Size	80

The church typically used for 26 hours per week for the following activities

Services	8 hours per week
Meetings and Church Groups	8 hours per week
Community Use	6 hours per week
Other uses	4 hours per week

Annual use estimate 1500 hours; 875 Heating hours.

Estimated annual footfall 20,000 (based on congregation size and use hours)

4. Energy Procurement Review

Annual energy use data for gas and electricity have been supplied by St Margaret's, Oxford and have been reviewed against the current market rates for energy.

The current electricity rates are:

Day Rate	13.9581p/kWh	In line with current market rates
Night Rate	12.1565p/kWh	In line with current market rates
Standing Charge	30.1519p/day	N/A

The current gas rates are:

Single / Blended Rate	2.0758p/kWh	Below current market rates
Standing Charge	388p/day	N/A
Availability Charge	p/kVA	N/A
Meter Charges	p/day	N/A

The above review has highlighted that the current rates being paid are in line or below current market levels and the organisation can be confident it is receiving good rates and should continue with their current procurement practices.

In advance of the end of the contract (30 September 2021), the church should investigate if the Church of England Parish Buying scheme, or another supplier offering 100% renewable electricity (currently Bulb, Ecotricity and Good Energy) offers the best "green" rates.

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

VAT	Electricity 5% Gas 20% The church has already been informed.	The organization is understood to be a charity and therefore should be benefiting from only be charged a 5% VAT rate. A VAT declaration should be sent to the supplier to adjust this.
CCL	Charged to gas account	As the organisation is being charged the wrong VAT rate, they are also being charged CCL which should not be applied as they are a charitable organisation. Sending the supplier a VAT declaration will remove this charge.

The above review has highlighted that VAT and CCL are being charged when the organisation is understood to be a charity and has VAT exemption status. As such the PCC of St Margaret's, Oxford

should send the supplier at VAT declaration confirming this. Excess tax can be reclaimed for the last three years. The government advice pages are:

https://www.gov.uk/vat-charities

https://www.gov.uk/vat-charities/what-qualifies-for-relief
https://www.gov.uk/vat-charities/how-to-claim-relief

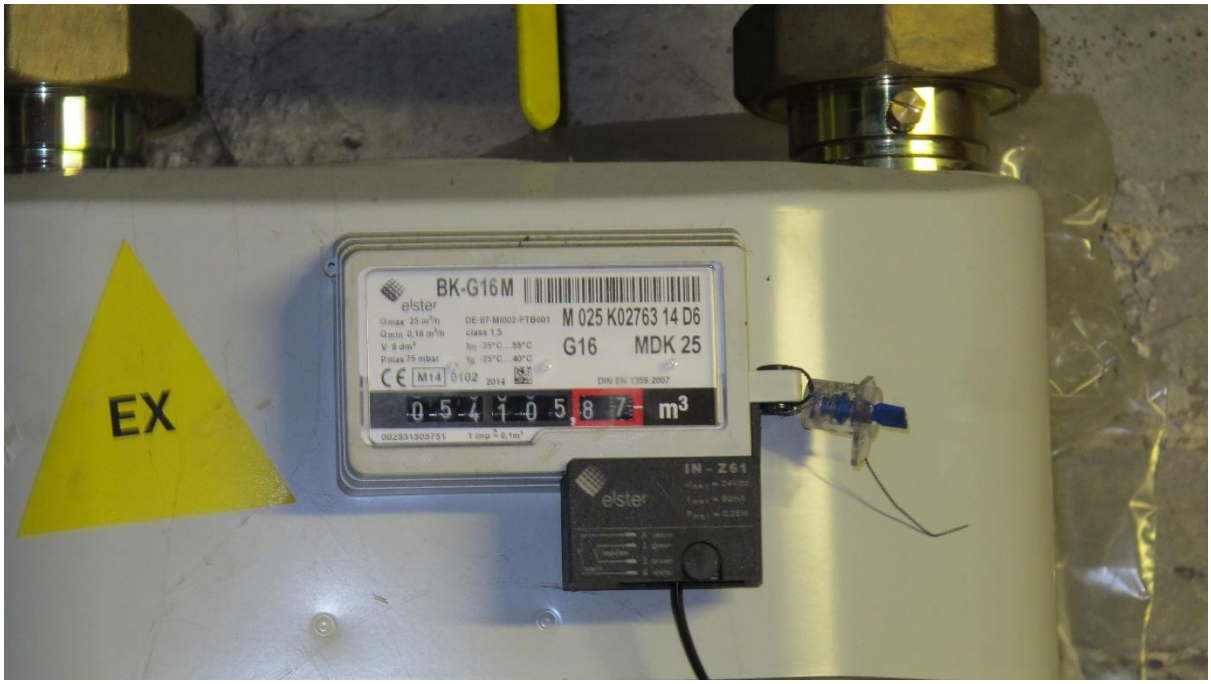
5. Energy Usage Details

5.1 Annual Consumption

Utility	Annual Use/kWh	from	to	Cost
Electricity – Church (non-heating)	7,291			Approximately £1,000
Gas – Church	99,861			£3,489

This data has been supplied by the chruch.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E14UP11125	EDMI Atlas Mk10D	2 pulses	Choir vestry, east wall
Gas – Church	M025 K02763 14 D6	BK-G16M	Yes – pulse block connected	Boiler Room, North wall



It should be possible to obtain an annual use profile from your supplier.

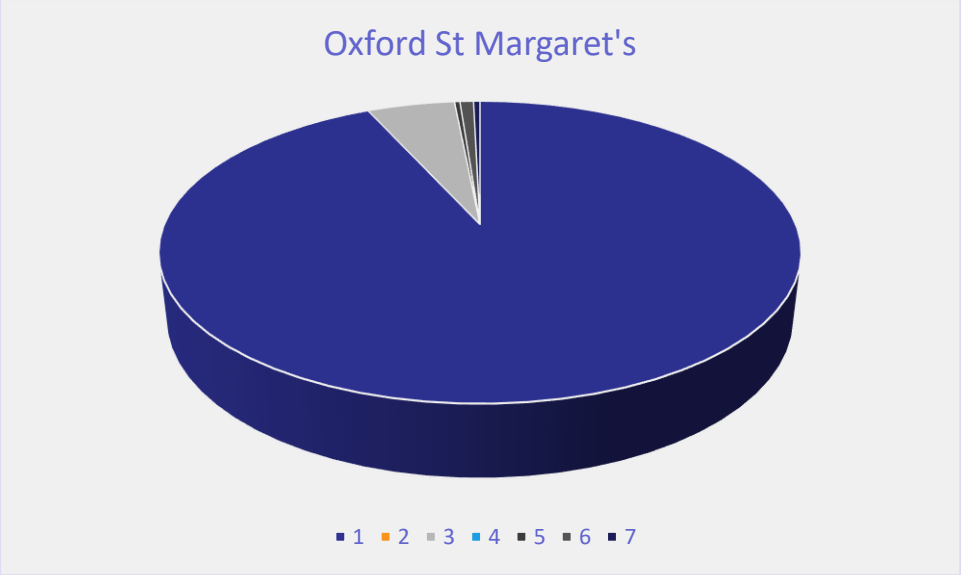
5.2 Energy Profiling

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

The church annual use is estimated at 1500 hours. Assuming that heating is operative for 7 months per annum gives 875 heating hours.

Service	Description	Power	Annual Use/ kWh	Estimated Proportion of Usage %
Heating	Gas Central Heating Two Hamworthy boilers fitted with Riello GS10 or similar burners giving outputs of 42-116kW each. Assume 875 heating hours mostly at full power (heating from cold). Worcester Greenstar 24i boiler in kitchen Junior Combi Mk4. Heats the foyer and baptistry areas, plus kitchen how water. Less use than above say 300 hours	@106kW 24kW	92,660 ~ 7,200 Total < 99,861	
Lighting	Nave 12 high level spotlights 2 floodlights Chancel:4 floodlights S Aisle: 5 Chandeliers x 3 x 20W CFL 1 chandelier 8 x 20W CFL 1 Pendant 30W CFL N Aisle: 4 x 3 x 20W CFL Kitchen 1 x T12, 1.5m Vicar's Vestry: 3 x T8, 1.2m Choir Vestry: 5 x 20W CFL TOTAL, 1500 hours use	 1200W 500W 1000W 300W 160W 30W 240W 80W 150W 100W 3.76kW	 5640	
Hot Water	Kitchen Kettles 2200W & 3000W Burco water heater BC AF WM 3L	 5.2kW 3kW	 200 150	
Other Small Power	Kitchen Fridge Fridgemaster 0MUL55130 Microwave Oven Panasonic NN-ST462M Choir vestry Computer Photocopier Sound system	 150W 900W 300W 50W 1kW	 300 10 100 50 416	
Organ		1kW	416	

Annual electricity consumption (no space heating): 7291kWh



KEY 1 Gas heating 3 Lighting 5 Hot water 6 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.

5.3 Energy Benchmarking

In comparison to national benchmarks for Church energy use St Margaret's, Oxford uses only 45% of the electricity and 83% of the heating energy that would be expected for an average church of this size[1].

	Size (m^2 GIA)	St Margaret's, Oxford use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Margaret's, Oxford (elec)	800	9.1	20	10	45%
St Margaret's, Oxford (heating fuel)	800	125	150	80	83%
TOTAL	800	134	170	90	79%

There is no benchmark data available which takes hours of use and footfall into account.

[1] CofE Shrinking the Footprint – Energy Audit 2013

6. Energy Saving Recommendations (Electricity)

6.1 Lighting (fittings)

The lighting is mostly composed of compact fluorescent lamps with some spotlights and floodlights of unknown type.

It is recommended that any non LED spotlights and floodlights are changed for LED, and that CFLs are replaced by LED when they fail. Many of the currently installed bulbs can be identified as CFL bulbs. The bulbs in the low level chandeliers can be changed by church staff; replacement by LED will approximately half their electricity consumption.

The floodlights and spotlights are fixed at high level and would need to be changed by a lighting contractor. It is recommended that both bulb and their fittings (luminaires) of the spotlights are changed to ensure compatibility.

Parish Buying may offer an economic route to bulk buying of LED light bulbs.

There are a variety of LED floodlights on the market ranging from those around 10-25W retailing at £25 to powerful 12000 Lumen lamps (150W replacing 1200W non LED) at around £75, such as the V-Tac Slimline LED Floodlight 150w Daylight. There is no need to purchase outdoor IP65 rated moisture resistant models. Note that LED lamps also offer savings from 3-4 times longer lifetimes in addition to lower operating costs.

For the spot lights the Megaman range of LED spot (reflector) lights https://www.megamanuk.com/products/led-lamps/reflector/ provides some very suitable substitutes to the current lamps.

7. Energy Saving Recommendation (Heating)

7.1 Heating System and Strategy

The church currently uses gas fired central heating to heat the church. The church is large, with an area of 800m^2 including the entrance area and vestries. Given that the system is successful and not overly wasteful of energy compared to the benchmark value we would recommend that this system is continued with and consideration is given to the following improvements. Section 6 deals with optimising the present system, Section 7 considers alternative heating methods.

The Hamworthy boilers are of unknown age, if greater than 5 years old they will not attain current efficiency standards of 93% for an optimised condensing boiler. It is wise to consider planning for boiler replacement, possibly associated with constructing the extension to the church at the west end.

In the medium term, the boilers will need to be hydrogen ready. Hydrogen is due to be added to the gas grid over the next five year period. If plans to decarbonise the gas grid are implemented; the hydrogen mix will eventually exceed 20% and a hydrogen compatible boiler (and piping) will be required. The transition will be overseen by the regulatory bodies in a similar way to that between town gas and North Sea gas.

Alternatives to gas central heating are discussed in Section 7 for the church to consider.

The church usage profile at around 26 hours per week is too low for underfloor heating to be viable – this requires a church in regular daily use, given the high installation costs of around £1,000/m^2. Under pew heating cannot be employed; the other options are to use radiant infrared heating or an air source heat pump [ASHP] to provide warm water to the existing radiator network.

Radiant infrared heating can be "targeted" to the parts of the church actually in use – so although electricity is around 3.5 times more expensive than gas, you would not be aiming to heat the whole space all of the time. As the church is large, installation of radiant heating for the whole building would be expensive, especially where there are areas which are only sporadically used. It might be usefully installed in specific zones which could then be heated independently and rapidly, allowing such areas to be brought into use for (short) midweek meetings without the expense of heating the whole church from cold. These areas could include the south east chapel area and the rear of the nave.

Air Source Heat Pumps [ASHPs] will use around three times less electricity (in kWh) than the gas they replace, so a similar operating cost to gas. Since this is a large church, large units would be required at a capital cost greater than new boilers (perhaps £20-30k). They require an external location, perhaps possible on the north side of the building if it is not visible, in the existing boiler room area.

ASHPs have to work hard to heat a large church from cold – this means it is very likely that they will have higher running costs than for gas. However, for a building in regular use requiring fairly constant heat, ASHPs can be advantageous by providing steady warmth – this is worth considering as part of reordering: any section of the church planned to be in regular use will benefit from heat pump technology, particularly a new build extension insulated to current standards.

The economics of both electrical heating systems improve where solar power can be installed. As St Margaret's is listed and in a conservation area, with a steeply pitched nave roof and very low parapets to the aisle roof, solar power is unlikely to be permitted.

7.2 Recommendations Summary

- Consider installing a radiant heating method in areas of the church which are to be used for short duration meetings during the week. Also it can be used to supplement gas fired central heating to reduce preheating time.
- Only use the main heating boilers for days when the church is used for several hours – Sundays and any weekday where several meetings are held. Boilers to become hydrogen compatible in medium term (2025).
- Use either radiant electric heating or an Air Source Heat Pump for the new extension.
- Consider changing from boiler to ASHP if use of main church is to become regular, >50 hours/week.

7.3 Avoid Background Heating

Providing constant background heating to an empty church building as a whole is excessive and wasteful of energy. If employed, we would recommend that this background level is reduced to a maximum of 12°C and ideally avoided all together. The temperature in many churches which are heated weekly is maintained at above 10°C except during the coldest weather or where they are in exposed locations.

The modern additional of heating is not needed to preserve the fabric but only to provide thermal comfort to occupants. The previous trend of 'conservation heating' for fabric issues is now largely considered to be unnecessary and is being avoided by the likes of National Trust and English Heritage. The only times when background heating may be required is if there are historic wall paintings or to for the preservation of large artefacts such as tapestries. The organ (and other sensitive areas such as historic papers stored in the vestry) may require some local background heating specific to that area. In general, sensitive paper records should be removed for storage in the county archive and organs can be installed with a local background tube heater such as https://www.dimplex.co.uk/product/ecot-4ft-tubular-heater-thermostat within the organ casing in order to provide the heat where it is required. The fabric is often subject to the greatest damage by humidity (which is naturally higher when the air is warmer as warmer air has greater capacity for holding more moisture), as a result of large temperature swings (from central heating systems turning on and off) and from the excessive drying out/baking of timbers where high temperature heating units have been fixed to them (such as overhead heaters fixed to timber wall plates).

7.4 Boiler Timing Optimisation

No information was available regarding the boiler timings used.

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

A suitable model retailing for around £40 is The Lascar USB-1. The USB-2 model adds humidity monitoring. https://www.lascarelectronics.com/easylog-data-logger-el-usb-1/

7.5 Thermostatic Radiator Valves (TRVs)

Radiators in the church (as below) did not appear to have TRVs fitted.

TRV's can be installed on the existing radiators which could allow for areas to be selectively heated with un-used spaces having the heating turned down.

It is recommended that TRVs are installed on all radiators and users advised as to the best way to operate these once they have been installed. TRV's can be supplied and installed by any good heating engineer.

7.6 Boiler Maintenance; Clean / Flush Existing Heating System

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

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

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

7.7 Magnetic Particle Filter

Neither boiler appears to be fitted with a magnetic particle filter (as shown below). This apparatus catches any rust or metal particles and prevents them being deposited on the boiler heat exchanger. They should be installed if it is planned to continue using the water heating systems long term. Corrosion Inhibitor should be added to the system when your boilers are serviced annually.

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

Endotherm can be self-installed.

7.9 Insulation of Pipework and Fittings

The pipework insulation is in good order. This can be supplemented with further insulation to cover the valve bodies. It is recommended that the 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).

8. Alternative Heating Systems

A church with low hours of use per week will always fall back to “base” temperature between heating events (it may take around 24 hours for the temperature to fall). A system which can heat rapidly, without sending most of the heat to the ceiling first, and in addition can be configured to heat small areas independently for small services or midweek meetings will be more efficient than one which seeks to heat up the whole volume. So, for once a week churches, an electric heating method is optimum (usually under pew where there are pews). For everyday churches, underfloor heating powered by a heat pump can be viable. Underfloor heating is very expensive and disruptive to install, and only suitable for a regularly used building. In between use patterns may benefit from electric heating of small areas to allow rapid heating, e.g. of a chapel.

8.1 Electric Radiant Heating

An alternative to central heating is to use infra-red radiant heaters. However, as previously stated, the large size of the church would lead to high capital costs. Any small areas which might be used for small midweek meetings would benefit from electric heating, giving rapid warm up times and not requiring the whole church space to be preheated for several hours. Installation of radiant heating can also be used as a “top up” to reduce the amount of preheating required.

The aisles could be heated using rectangular far infrared panels attached between the roof beams. These are of the type which emit no visible radiation. The optimum solution for the church will depend on the planned use and frequency of occupation of the building. Suitable electric panel heaters would be far infrared panels such as these 550W panels retailing at £275: https://www.warm4less.com/infrared-heaters/ceiling-panels/ .

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.

The nave of St Margaret’s is too high for ceiling mounted panels to be effective. An alternative approach, which positions heaters around 3 to 4 metres above the ground is to install them on chandeliers. This would fit visually with the existing lighting chandeliers.

St Catherine's, Faversham, is heated entirely by chandelier heaters (below). These are the glowing near infrared type, which are considered acceptable when chandelier mounted. Costs are around £500-600 per installed 1kW heater. Most of the seating at St Margaret's could be covered by four larger chandeliers hung from the centres of the two rearmost pairs of arches; each with 8 x 1kW heaters. This would need to be augmented with some panel heaters in the aisles and rear circulation area. A beam suspended chandelier could be envisaged in the Lady Chapel to the right. The vestries are more challenging due to low ceilings and lots of cupboards and bookcases, so either conventional electric convector heaters in place of central heating radiators, or ceiling mounted far infra-red panels would be appropriate.

Use of chairs means under pew heating is not possible.

9. Energy Saving Measures (Building Fabric)

9.1 Draught Proofing to Doors

There are a number of external doors in the building. These have the timber doors on them; where they do not close tightly a large amount of cold air is coming into the church around the side and base of these doors.

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

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

9.2 Closed Door Policy

The main entry doors in the porch should be kept closed in cold or windy weather and quickly closed behind the congregation by your friendly welcome team!

9.3 Windows

Consideration could be given to installing secondary double glazing inside the windows of the Choir Vestry if it is used regularly as an office. With occational use, the outlay would not be recouped from savings for a very long period.

If there are draughts caused by windows not shutting correctly, a temporary solution is to use black plasticine to fill gaps.

If there is a problem with condensation on the vestry windows, use of a domestic sized dehumidifier will assist to solve the problem. (Note that double glazing will not remove moisture).

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 – not sufficient demand, visible roof
Battery Storage	No – no viable PV
Wind	No – no suitable land away from buildings
Micro-Hydro	No – no water course
Solar Thermal	No – insufficient hot water need
Ground Source Heat Pump	No – archaeology in ground and radiator system
Air Source Heat Pump	Possible but needs a regularly used building to be economic. **Consider for new build.**
Biomass	No – not enough heating load as well as air quality issues

10.1 Air Source Heat Pump

The large size of the church indicates that any heat pump system would also have to be large.

The age of the churchyard indicates significant burials, and lack of sufficient space for ground source heat pump coils.

Air source heat pumps require externally mounted units of similar appearance to air conditioning units. There may be an opportunity to install an ASHP system in the area occupied by the gas boiler; which would need to be converted into an external, well ventilated space.

ASHPs consume electricity but deliver between 2.5 and 4 times the amount of heat in kWh that they consume. This would mean an operating cost of the same order as that of the current gas system; but the system works efficiently when delivering low grade, constant heat rather than heating a building up from cold weekly (when it would be required to operate at maximum capacity and hence least efficiently, raising the cost compared to gas).

11. 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-Nov-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.

12. 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
NAVE	12 spotlights	LED			
	2 floodlights	LED, e.g. 50W			
AISLE - north	4 sets of 3 pendant CFL				
AISLE - south	5 sets of 3 CFL 1 set of 8CFL 1 pendant CFL				
Kitchen	Fluorescent T12 x 5’				
Porch					
Choir Vestry	3 fluorescents T12/T12/T8, 4’				
Choir Vestry	5 pendant CFL				
TOTAL estimate	**3,760W**				

With 1500 annual use hours (a simplification as it implies main lighting is all on when the church is in in use); this gives 5,640kWh annual lighting use.