Energy Efficiency and Zero Carbon Advice

St Paul's Church, Bedford
PCC of St Paul's Church

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of St Paul's Church, Bedford was undertaken by ESOS Energy to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use. This audit has been provided in conjunction with 2buy2, the Church of England's Parish Buying scheme provider and is subsidised from Total Gas & Power, the Parish Buying schemes principal energy suppliers.

St Paul's Church, Bedford is a mediaeval church dating from the 14th century, with 19th century transepts. 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 and a clear path towards net zero carbon. 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 and the route to net zero carbon diagram below are used as the action plan for the church in implementing these recommendations over the coming years.

Energy and decarbonisation recommendations	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/yr)
Switch electricity suppliers to ones which provide 100% renewable supplies	None	None	Nil	N/A	None	3.1 (from electricity Offset)
Replace lamps in rectangular floodlights with LED lamps	700	£210	£120	0.5	List A	0.15
Install timers to water heaters	unknown	unknown	£400		List A	
Install reflective radiator panels	2% 3,200	£678	£100	0.5	List A	0.57
Flush and clean central heating system	5% 8,000	£1,700	£500	0.5	List A	1.4
Door draughtproofing	2% 3,200	£678	£500	1	Consult DAC	0.57
Install secondary glazing in office	1% 1,600	£340	£100	0.5	Faculty	0.29
Install solar photovoltaic panels	15,000	£4,500	£19,500	4.5	Faculty	3.2
Obtain quotations for a heat pump system	See below				Faculty	
Consider registering for Eco Church	The Eco Church programme, which is recommended by the Church of England, helps congregations care for the environment in all aspects of church life. The programme is free; you can, however, make a donation to A Rocha UK towards its costs.					
Create a procurement policy for appliances (and other goods)	Commit to buying only appliances with the new energy efficiency ratings of A, B or C at the lowest when those you currently have reach the end of their useful life. (NB ovens, air conditioners and space or water heaters are still on the older rating scale, so for these, try for A+++.)					

Alternative Options for Future Heating	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/yr)
Air to Water Heat Pump	160,000 gas 64,000 electric use	£14,705	£72,000	5	Faculty	15.3
Air to Air Heat Pump	160,000 gas 40,000 electric use	£21,905	£81,000	4	Faculty	20.3
Ground Source Heat Pump	160,000 gas 40,000 electric use	£21,905	£180,000	8.5	Faculty	20.3

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

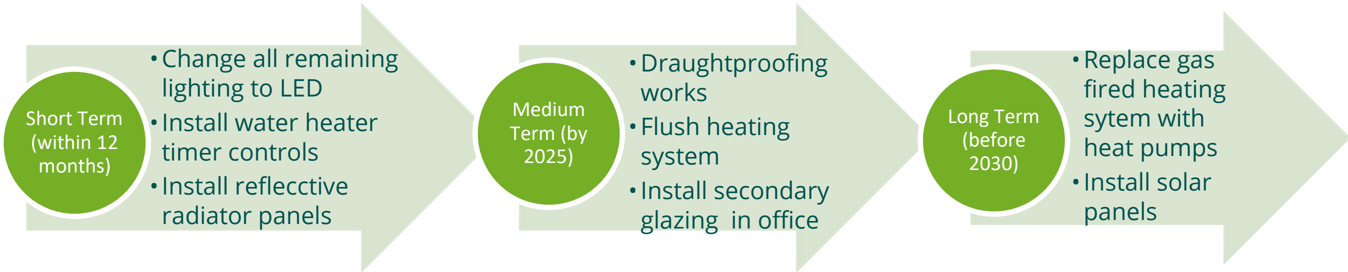
Figures in the table are based on current market price of 30p/kWh for electricity and the contracted price of 21.191p/kWh for mains gas. The carbon figures are based on the DEFRA 2022 carbon emission factors of 0.21107 for electricity, 0.18 for gas and 0.27 for oil. Do note that as energy prices increase, payback periods decrease.

2. The Route to Net Zero Carbon

Our Government has committed to move towards Net Zero Carbon – the point at which we have reduced emissions as much as we can and then balanced any residual emissions through removal of carbon from the atmosphere. They have done this as part of a worldwide agreement which aims to limit global warming to well under 2 degrees Celsius, with an aim of keeping it below 1.5 degrees Celsius. This will help protect all of us from the impacts of climate change.

In February 2020, the Church of England's General Synod set its own Net Zero Carbon target. The first stage of this target covers energy used by churches, cathedrals, schools, vicarages, other church buildings, as well as emissions caused by reimbursed transport. The target date is 2030.

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 Paul's Church, Bedford 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 Paul's Church, Bedford, St Paul's Square MK40 1SQ was completed on the 16th January 2023 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.

St Paul's Church, Bedford	
Church Code	632282
Gross Internal Floor Area	1,250 m^2
Volume	9,800m^3
Listed Status	Grade I
Average Congregation Size	100

The church is typically used for 12 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)
Services	6 hours per week
Community Use	6 hours per week
Occasional Offices	4 Weddings 12 Funerals

In addition, the office is in regular use throughout the week.

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by the church.

The current electricity rates are:

Day Rate	37.95p/kWh
Night Rate	26.47p/kWh
Standing Charge	Unreported

The current gas rates are:

Single / Blended Rate	21.191p/kWh
Standing Charge	538.82p/day

Supplier: Yu Energy

The electricity is supplied by Yu Energy, 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 procuring its electricity from suppliers that offer 100% renewable electricity, and in some cases 'green' or 'carbon neutral' gas.

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

VAT	20% has been charged by Positive Energy, SSE and Yu Energy	The church is 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	100% charged	As the church 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. The church is a charity and therefore can claim VAT exemption status. As such the PCC of St Paul's Church, Bedford should send the supplier at VAT declaration confirming this and check all supplies on other sites. VAT declarations are available from the suppliers website and can usually be found by typing the suppliers name followed by "VAT Declaration Certificate" into most website search engines.

5. Energy Usage Details

St Paul's Church, Bedford uses between 15,000 and 19,000 kWh/year of electricity, costing in the region of £5,000 per year, and around 160,000 kWh/year of gas, costing £34,000. The total carbon emissions associated with this energy use are 31.9 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site, and data provided by Tom Otley on 23rd January.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E11Z 95245	EDMI Atlas Mk10A 3 phase 100A	Yes	Electrical cabinet under organ
Gas – Church	M040 K00176 22 D6	Honeywell Bk-G25M metric	Yes	External brick cabinet, north side of churchyard

All the meters are AMR connected and as such energy profile for the entire energy usage could be obtained from the supplier.

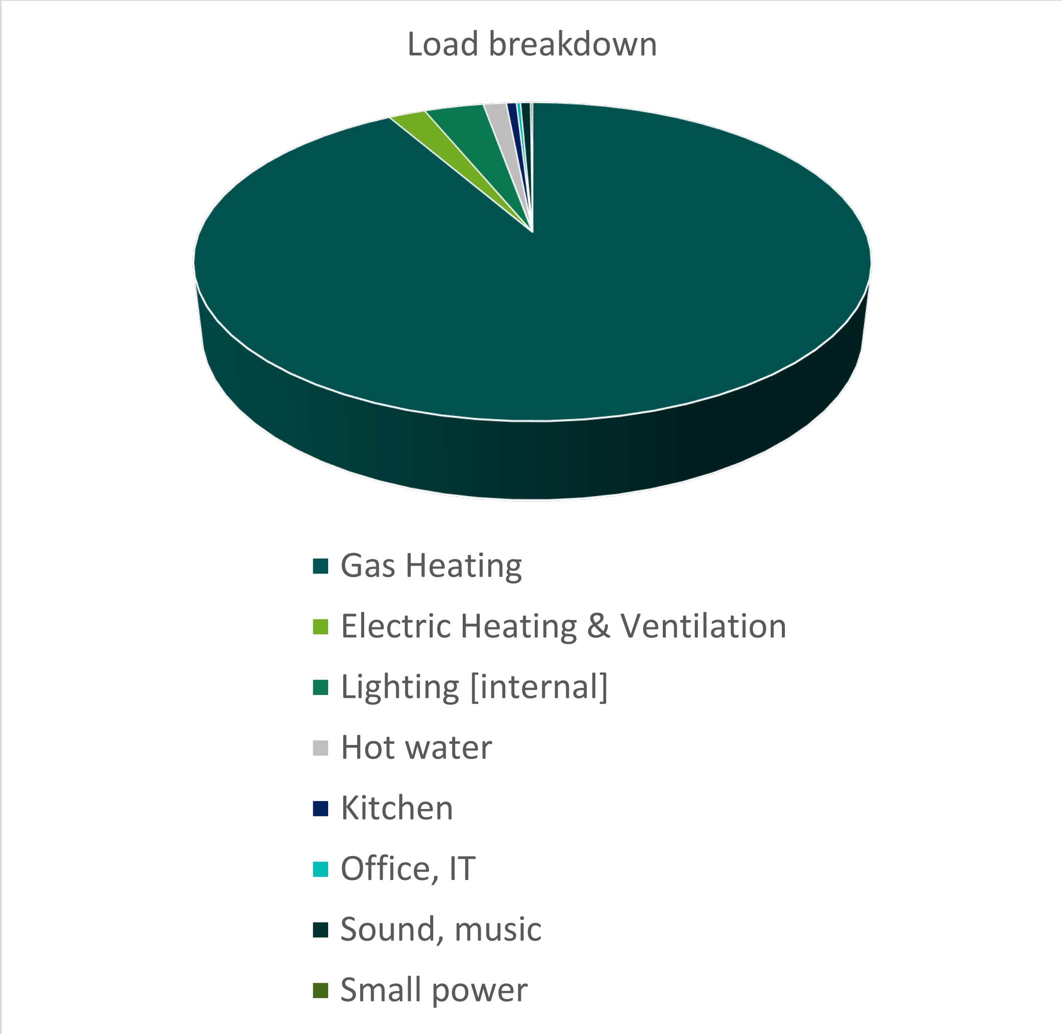
5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	Main Potterton NXR 3i (800 hours) Subsidiary boiler Gas hob and cooker	 200 28	 160,000	 91.6%
Heating [Electric]	Boiler circulation pumps - main Subsidiary Fan heater – meeting room Convector heater - office	1200W 100W 2 3	960 40 700 2000 TOTAL 3,700	2.1%
Lighting [Internal]	CHURCH 1750 hours use including daily opening 11:00-15:00 132 LED of three types 31 LED spotlights 4 bulkhead lights 6 R7s lamp floodlights in aisle windows Lighting in foyer, office, meeting rooms, toilets	 800W 400W 112W 1500W 500W	 1400 700 200 2600 1000 TOTAL 5,900	3.4%
Hot Water (electric)	Fixed water heater, Lincat x 2 Kettle Dishwasher	3 3 3	1,500 300 500	1.3%
Kitchen (Hall)	Used twice per month Microwave Fridge x 2	 1 300W	 50 950	0.6%
Office	One workstation Photocopier	200W 0.5	300 100	0.2%
Sound, Music	Sound system Organ	0.5 1	400 600	0.6%
Small Power	Vacuum cleaner	1.5	200	0.1%

Sum of annual electricity use estimates : 14,500kWh

Annual site electricity consumption, 2022: 14,519kWh



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.

Both chancel above and nave have decorated ceilings.   Seating is by chairs, precluding under pew heating.

6. Efficient / Low Carbon Heating Strategy

6.1 Overview

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 near future. 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' in the foreseeable future

It is therefore important to review and set out a plan to make heating more efficient and less carbon intensive. One way to achieve this is to consider a transition to electrical heating where this also represents an efficient and comfortable solution for churches. Electricity currently has carbon emissions of 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 oil and coal-fired power stations.

6.2 Present Heating System

The church is currently heated by a gas fired boiler which was installed relatively recently and appears to have a further 10-15 years serviceable life before requiring replacement. Boiler pipework insulation is good and a dirt separator is fitted.

It should be noted that the government Net Zero review proposes no new boilers may be installed post 2033, so the church should plan for the boiler to be replaced by an alternative heating method.

The boiler provides heating to 12 cast iron column radiators around the perimeter of the church, including the south chapel. The chancel has three pressed steel radiators. The Alexander and Anderson rooms, office and toilets are also heated by pressed steel radiators.

The church makes use of moveable chairs, seating for around 180 provided plus 25 in the south chapel. There are fixed choir stalls in the chancel.

The church is used once per week on a Sunday for service and the typical congregation size is 100. The heating is set to come on Tuesdays, Wednesdays and Fridays for regular events. The boiler, at 180kW output is reported to be of high enough power to only require a few hours preheating to raise temperature.

6.3 Future Heating Options

The various options for a decarbonised heating solution have been reviewed in the table below.

Decarbonisation Heating Solution	Viablity
Air to Water Source Heat Pump	Unsuited to current heat emitters – would require new fan assisted radiators
Air to Air Source Heat Pump	Potential, but requiring replacement of heating system
Ground Source Heat Pump	Potential but unsuited to current heating pipework and heat emitters – would require new fan assisted radiators
Water Source Heat Pump	No – no water source locally
Under Pew Electric Heating Panels	No – no fixed pews
Electric Panel Heaters (to provide supplemental heating only)	No – not required
Over Door Air Heater (to provide a supplemental warm welcome at the door only)	No – architecture around door would not permit unit to be fixed
Overhead Infra-Red Heaters	No – visual intrusion to the church would do harm, least preferred heating source due to comfort. Distance of seating from walls is too great
Heated Chair Cushions	Useful for small services in chapel, but unmanageable for a large congregation in individual chairs.

The recommendation is therefore that the church consider a heat pump solution, engaging with installers to obtain quotes and select a solution for long term installation.   Note that these technologies will become commonplace in the UK over the next decade.

It is recommended that the church investigates the experiences of the pioneer churches who have installed heat pump technology, including St Mary the Virgin, Ashford town centre, and Hethel, Norfolk.

6.4 Air to Water Source Heat Pumps

Air-to-Water Source Heat Pumps (AWSHPs) work by having an external unit which sucks air in and extracts the heat from it. It concentrates this heat and puts it directly into water that can then flow through the heating system. They work most efficiently when trying to produce water temperatures in the heating system between 40°C and 50°C. They tend to warm up slowly and steadily and are therefore well suited to situations where the heating is required for long periods of the day, and with heating systems that have a low temperature requirement such as underfloor heating systems. As they warm up spaces slowly, it is important that the warmth being slowly emitted is retained within the building so that the overall heat levels build up. This requires good levels of insulation and air tightness to ensure that the heat loss is lower than the heat being emitted. AWSHPs provide around 3 units of heat for every 1 unit of electricity used in the heat pump; they therefore have a Coefficient of Performance (CoP) of 3.

The Centre for Sustainable Energy model[1] can be used to estimate heat load for the building.

Heat Load (kW) = Volume V (m^3) x Insulation Factor

Insulation Factors

Condition	Factor kW/m^3
Poorly insulated with open or broken windows, draughty doors (add 5%)	0.034
Poorly insulated (assume no interventions)	0.033
Some insulating features	Estimate value
Well insulated	0.022
Insulated to 2010 regulations	0.013

Area	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Church	9,800	0.033	320

Therefore, a heat pump of 320 kW output would be required. This is larger than the current output of the boiler, 180kW. It may be that the current system is able to heat the air rapidly and the heating is switched off before much heat loss through external (thick) walls has occurred and so the boiler power is adequate.

AWSHPs require the installation of external units, which look like air conditioning modules in well ventilated external locations. These external units will need an electricity supply and pipework running from them to the heating system. They will also need a drain nearby as the back of the units can build up moisture, which condenses and sometimes freezes on the coils. The larger units do create some low-level noise and therefore the location and baffling of the units may need to be considered carefully.

The existing boiler room may offer the best location by de-roofing all or part of the structure to create an area screened from view but well ventilated.

[1] www.cse.org.uk/local-energy/download/estimating-the-heat-demand-of-a-hypothetical-community-building-79

Examples of external units for AWSHP comprising of three smaller 3kW units and two larger 10kW units (which deliver 37kW output each).

A case study of a church which has installed this solution is available at [Heat pumps and fabric improvements make a rural church warm and well used : St Anne in Ings | The Church of England]

6.5 Air to Air Source Heat Pumps

Air-to-Air Source Heat Pumps (AASHP) work by having an external unit which sucks air in and extracts the heat from it. The pumps concentrate this heat and put it into a refrigeration gas (in the same way as a fridge or freezer works). This refrigeration gas is then piped inside the building in a small pipe where is it then allowed to expand in an internal unit with a fan. This heat is then blown out into the space. This system is identical to an air conditioning system, but it works in reverse to heat the space. As warm air is blown into the space this type of system can heat spaces from cold relatively quickly. AASHPs provide around 4.5 units of heat for every 1 unit of electricity used in the heat pump; they therefore have a Coefficient of Performance (CoP) of up to 4.5.

The Centre for Sustainable Energy model[2] can be used to estimate heat load for the building.

Heat Load (kW) = Volume V (m^3) x Insulation Factor

Insulation Factors

Condition	Factor kW/m^3
Poorly insulated with open or broken windows, draughty doors (add 5%)	0.034
Poorly insulated (assume no interventions)	0.033
Some insulating features	Estimate value
Well insulated	0.022
Insulated to 2010 regulations	0.013

[2] www.cse.org.uk/local-energy/download/estimating-the-heat-demand-of-a-hypothetical-community-building-79

Area	Volume m³	Insulation Factor kW/m³	Heat Required (Space heating) kW
Church	9,800	0.033	320

Therefore, a heat pump of 320 kW output would be required.

AASHPs require the installation of external units which look like air conditioning modules in well ventilated external locations. These external units will need an electricity supply and pipework running from them to the heating system. They will also need a drain nearby as the back of the units can build up moisture, which condenses and sometimes freezes on the coils. The larger units do create some low-level noise and therefore the location and baffling of the units may need to be considered carefully.

Examples of external units for AASHP comprising of three smaller 3kW units and two larger 10kW units.

Internal units come in a variety of styles. The most appropriate internal units for most churches are floor mounted units which look very similar to a fan convector heater.

FVXM - Floor Mount Air Conditioning Unit

Designed to fit rooms of any size and shape, it blends well with the interior due to the new design which incorporates more flowing lines and softer edges. These units are ideal when it is not possible to fit a high level wall mount unit for aesthetic or practical reasons.

They are suitable for a wide range of applications including domestic, small to medium offices and commercial uses.

All these units do have a fan element within them and therefore a small amount of fan noise is emitted. This tends to be less than a fan convector heater on a boiler-based system and similar to the noise from a fridge or freezer. Air conditioning units are commonplace in hotel rooms, indicating that the noise is low enough even to be suitable for sleeping environments.

A case study of a church which has installed such a solution is available at 5. Air-source heat pumps at Hethel Church - All Saints Church, Hethel - A Church Near You

6.6 Ground Source Heat Pumps

These units have a high Coefficient of Performance, typically delivering 4kW of heat per kW of electricity consumed. They deliver heat through water radiator systems, although as the water provided is at around 50ºC rather than 70 to 80ºC, often larger radiators, fan assisted radiators or operating for longer periods (or a combination) are required. Therefore they are suited to buildings in regular use. St Paul's use pattern is currently low, although its location and function as the civic church could mean that it has potential for greater use.

An example of a town centre church on a compact site which uses a ground source heat pump to heat its nave is St Mary the Virgin, Ashford town centre. This church hosts an arts centre for the town, utilising the seating capacity (of about 400) of the church. Boreholes radiate from a manhole sized opening in a corner of the churchyard.

GSHP systems cost in the order of £1000 per kW of heat delivered, so £180k for this site.

6.7 Heated Pew / Seat Cushions

Most are now familiar with the concept of heated seats within cars; the same solution is also used in some outdoor venues such as alfresco dining and sports stadiums. These provide a heated cushion to sit on: the direct warmth from the contact areas provides a degree of comfort even when the surrounding space is cold. This can be a useful solution for churches which only have chairs (having removed pews) and/or for small congregations where there are few other alternatives.

There are a variety of heated seat cushions on the market. Some are directly plugged into a power socket (similar to an electric blanket). Others have battery packs, which can be charged and then connected to a seat pad. This makes them more flexible and avoids trailing leads. The more advanced products have a pressure sensor which means heat is only provided when someone is sitting on the cushion. Heated pads for 'benches' can also be used to heat a pew or could even be adapted to form a heated kneeler for the communion rail.

It is recommended that the church consider using a set of 10-20 heated cushions to provide heating to the south chapel area which would be suitable for smaller services.

A case study of a church using heated cushions is available at https://www.churchofengland.org/about/environment-and-climate-change/towards-net-zero-carbon-case-studies/marown-church-tries-new

The chapel, seated using chairs.

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. These should include:

7.1 Clean the Existing Heating System

Magnetic sludge will build up and circulate within heating systems. Where there is no magnetic particle filter, this will preventing the proper and efficient operation of the system by reducing both the ability of the boiler to heat up the water and the output of the radiators. It is similar to how scale build up can adversely affect kettles and showers.

The system will have been drained and should have been flushed and cleaned when the boiler was installed. If this is over five years ago, 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 in which 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 and 15%. This can dramatically improve comfort for the congregation.

8. Energy Saving Recommendations

In addition to having a revised 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 Reflective Radiator Panels

The church is heated by radiators served from the boiler. These radiators are located on the external, uninsulated walls and have no reflective or insulated surfaces directly behind them at present. They therefore lose much of their heat into the masonry of the wall behind the radiator rather than giving it out into the body of the church.

In order to improve the insulation directly behind the radiators, a reflective panel can be installed. This helps to make sure more of the heat from the radiator goes into the space and requires less overall heating from the boiler to achieve the set point. There are a wide variety of reflective panels for installing behind radiators on the market. It is recommended that these panels are installed behind all radiators within the building.

The installation of radiator panels can be carried out by anybody competent in basic DIY and does not require the radiators to be removed.

8.2 Floodlights

The lights under the windows providing uplighting are floodlight cases are believed to contain 118mm R7s halogen lamps. These lamps are typically rated at 250W (but may be 500W).

LED replacements are available – note that to provide sufficient illumination, large cylindrical lamps are required, typically 20 or 30W power. Those with a central connector will not fit in the luminaire as there is not enough space between the lamp and the reflector. Lamps with off centre connectors are available which fit.

Alternatively the entire units could be replaced by rectangular LED floodlight units.

8.3 Timers on Fuse Spurs to Water Heaters

There are two Lincat electric hot water heaters (for tea-making and the like) located around the church. These only need to heat the water to the required temperature when the building is in occupation. These should normally be switched off and a notice posted. If hours of use of the building increase, 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 Draught Proof External Doors

There are a number of external doors in the church. Where the doors do not close tightly against the surround, a large amount of cold air can enter the church around the side and base of these doors.

It is recommended that the draughtproofing around the 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 is often used in heritage environments to provide appropriate draught proofing.

For timber doors that close onto a stone surround, traditional solutions can be used such as 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 also be used. Keeping the door maintained in a good condition is also important.

It is necessary to check with the DAC before undertaking any form of draughtproofing that involves work on the fabric of the door.

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.

Such measures should be considered carefully around bat conservation needs to ensure that access points bats use are not disturbed. Check your draught excluding plans with the Bat Conservation Trust's free helpline: 0345 1300 228 https://www.bats.org.uk/

8.5 Secondary Glazing

The church as a whole is not used for enough hours to justify the high cost of secondary glazing which needs to be conducted sensitively. The office is formed from what may have been a porch at the west end of the south aisle. Staff sit in close proximity to two stained glass windows. These are in an area not viewed by visitors, and important windows within the church, they would be suitable to have secondary glazing installed. This would reduce heat loss in the office which should be heated independently of the rest of the church.

The introduction of secondary glazing would considerably reduce the heat loss through the existing windows and improve both thermal comfort and noise levels, as well as providing added security.

Any possible installation would need to be carefully specified. There are two options:

i) A permanent installation requiring new fixed frames
ii) Utilising acrylic panels, which can be ordered cut to size (but should probably be ordered oversize and trimmed on site with a craft knife). These are often fixed by self-adhesive magnetic tape applied to the acrylic and to (wooden) window frames. If the stonework is uneven this is unlikely to work, and use of blu tack or black plasticene to make a seal around the edge is suggested. In this case, the panels would be removable and no drilling or modification to the window stonework would be required.

Stained glass windows in the office, the desk is adjacent.

8.6 Office Heating

The office should continue be heated by an electrical method, independent of the main church heating. A portable convector heater is just as efficient as adding radiant heaters to the walls, (they are often obstructed by furniture and hence less effective). It is suggested that a heated office chair is investigated to complement a convector heater. If heat pumps are installed, a separate unit should be fitted for the office and regularly used spaces forming the entrance area.

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 Photo Voltaic (PV)	Yes – small system
Battery Storage	No – low evening use

The church has a sporadic electricity use which will be low on summer days when PV generation is high. A solar PV system which is sized to cover the needs of the office and lighting around the foyer and toilets, etc (which are not lit well from outside) would be viable. The low angle roofs behind parapets would allow panels to be non-visible from ground level.

The current annual electricity use is around 14,500kWh. hours annual use gives an average load of 29kW.

If heat pumps are added extra load of 80 to 100kW would be expected. It is recommended that solar panels are added after a heat pump system is installed so that the overall electrical load can be understood accurately and the system sized appropriately.

The roof area is approximately 1,000m^2, much of which consists of low angle roof behind parapets, so not visible from the ground (Note the recent planning decision in favour of installing solar panels on King's College Chapel, Cambridge).

An 100m^2 system could generate 15kW peak, costing around £19,500.

The following formula calculates annual generation:

Annual Generation (kWh) = Area x 0.15kWp/m^2 x 1000kWh/kWp x Orientation Factor x Overshading Factor.

Roof Section	Area / m^2	System Size / kW peak	Orientation factor	Shading factor	Annual Generation, kWh
All	100	15	180 degrees / 35^0 1.0	1	15,000

Battery storage is not strictly a renewable energy solution, but it does 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 solar PV is no longer generating. It therefore extends the usefulness of the existing solar PV system particularly in this sort of church. This is a new but fast-growing technology with prices expected to fall substantially over the next 2 to 3 years.

10. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available on this Parish Resources page: https://www.parishresources.org.uk/resources-for-treasurers/funding/

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 includes the installation of under pew heaters to pews which are made in or after 1850 and are not of historic interest.

All other works, including the like for like replacement of gas and oil boilers 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. This includes items such as solar PV installations.

12. Other Issues

12.1 Bats in Churches

The Bat Conservation Trust has a project with the Church Buildings Council Natural England, the Church of England, Historic England and the Churches Conservation Trust to address bat issues: *www.churchofengland.org/resources/churchcare/advice-and-guidance-church-buildings/bats-churches*