Energy Efficiency and Zero Carbon Advice

St Margaret's Church, Lee, Lewisham
PCC of St Margaret's Church

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of St Margaret's Church, Lee, Lewisham 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.

St Margaret's Church, Lee, Lewisham is a Grade II* listed church dating from 1840 with substantial additions in 1876, presenting a 13th century style with lancet windows. It has a rectangular footprint, crypt and west tower. [Historic England reference 1193189]. There is both gas and electricity supplied to the site.

The church has a number of ways in which it can become 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)
SHORT TERM						
Complete installation of interior LED lighting	500	£102	£800	8	List A	0.13
Proceed with project to install exterior LED lighting	3,200	£655	Unknown quotation		List B	0.81
Draughtproofing works	1% 2,500	£105	£500	5	Faculty	0.46
MEDIUM TERM						
Replace Crypt boiler with heat pump	17,500 gas	Equivalent without solar power	£12,000		Faculty	2.1 without solar power
Install radiant panel heaters for infrequently used crypt areas	None, area currently unheated	None	£2,500		List B	
Replace Church boiler with Air to Air Source heat pump \	232,500 gas	Equivalent without solar power	£112,500		Faculty	28 without solar power
Install solar photovoltaic panels in non-visible areas	23,280	£4,770	£43,500	9	Faculty	5.9

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

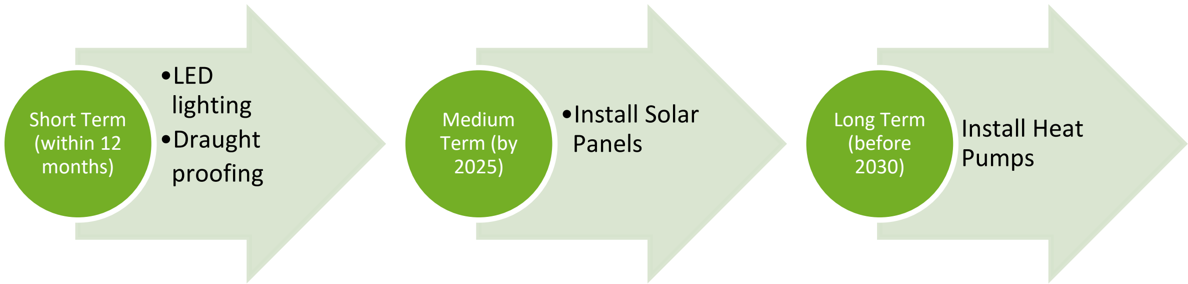
Based on current contracted prices of 20.49p/kWh and 4.218p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church around £5,600 per year in operating costs.

2. The Route to Net Zero Carbon

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

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



3. Introduction

This report is provided to the PCC of St Margaret's Church, Lee, Lewisham 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 with improvements in 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 Margaret's Church, Lee, Lewisham, SE13 5EA was completed on the 25th July 2022 by Dr. Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Church Energy Advisors Network developing advice for the Church of England and authored the "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE affiliate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church and has been an assessor for EcoCongregation.

The church was represented by Amie Dutchin.

St Margaret's Church, Lee, Lewisham	CHURCH	CRYPT
Church Code	637258	
Gross Internal Floor Area	600m^2	350m^2
Volume	6,060m^3	770m^3
Heat requirement	200kW	25kW
Listed Status	Grade II*	Grade II*

The church is typically used for 23 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	8 hours per week	140
Church Meetings and Groups	6 hours per week	45
Community Use	7 hours per week	12 concerts annually Café in crypt
Occasional Offices	8 weddings 15 funerals 10 baptisms	100 100 50

Annual Occupancy Hours: 1,200

Estimated Footfall: 17,000

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	20.49p/kWh	Below current market rates
Standing Charge	35.00p/day	N/A

Supplier, Contract End Date

The current gas rates are:

Single / Blended Rate	4.218p/kWh	Below current market rates
Standing Charge	Zero	N/A

Supplier, British Gas

The above review has highlighted that when the current contracts expire, there will be opportunities to gain cost savings from improved procurement of the energy supplies at this site using a group purchasing scheme. The current rates are lower than the market rate and should be retained at present.

We would therefore recommend that the church looks into 100% renewable tariffs and obtains quotations for its gas and electricity supplies from group purchasing schemes such as the Big Church Switch scheme, Charity Buying group and the Diocese Supported Parish Buying scheme, http://www.parishbuying.org.uk/energy-basket.

These scheme offers 100% renewable electricity and a proportion of renewable gas and therefore are an important part of the process of making churches more sustainable.

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

VAT	20% (gas)	The organisation 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	100% charged	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.

Whenever monthly electricity consumption exceeds 1,000kWh, or gas consumption exceeds 4,397kWh (52,000kWh per annum), 20% VAT is charged unless the customer has submitted a VAT declaration form. This should always be done when changing supplier.

The church is a charity and therefore can claim VAT exemption status.

Excess VAT paid can be reclaimed for the past three years.

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.

A detailed explanation is available here: https:// perfect-clarity.com/vat-on-church-utility-bills/#:~:text=There%20is%20no%20VAT%20chargeable%20on%20Church%20water%20bills

5. Energy Usage Details

5.1 Annual Consumption

St Margaret's Church, Lee, Lewisham used 65,895 kWh/year of electricity in the year from 24th June 2021 to 14th February 2022 (scaled to one year), costing £14.333. Approximately 50,000kWh of this powered the mobile phone installation, giving the church an annual consumption of £16,000kWh.

The church used 245,926kWh of gas from 8th October 2020 to 7th September 2021 (11 months); so approximately 250,000kWh annually over the same period, costing in the region of £14,200 including standing charge and VAT.

This data has been taken from a list of monthly electricity expenditure provided by the church.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Church	L85A 43132	EDF mechanical	No	Crypt, kitchen, rear cupboard
Gas – Church	E040 K01804 15 D6	Elster themis Bk-G25E metric	Yes	Crypt, cupboard next to kitchen.

The gas meter is AMR connected and as such an annual gas use profile for the site could be obtained from the supplier. Replacement of the electric meter by a Smart meter should lead to more accurate billing.

Three phases of power are supplied.

A submeter records the mobile phone mast installation use.

Moblie phone quaterly costs (4G mode) were around 12,500kWh; an annual consumption of 50,000kWh.   From early 2022, 5G equipment has been installed and six month's figures indicate an annual comnsumption of around 70,000kWh.

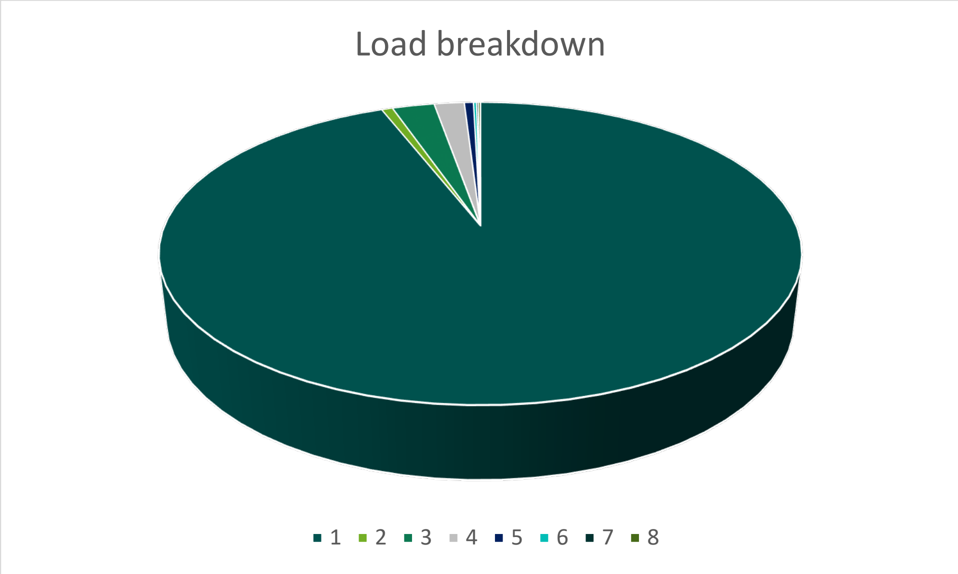
5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	CHURCH 5 x Hamworthy UR265 non condensing boilers; each 77.5kW input, 59.4kW output, 600 hours use CRYPT Vaillant EcoTEc Pro 28 boiler 625 hours	387 28	 232,500 17,500 TOTAL 250,000	93.9%
Heating [Electric]	Boiler pumps Radiator fans (12)	0.5 2.4	320 1440	0.7%
Lighting [Internal]	CHURCH 1200 hours use Chancel 30 spotlights (all LED) Nave & Aisles ~ 100 spotlights. If all LED; CRYPT 51 ceiling mounted (mix LED & 50W) 19 Wall mounted up lights 8 bulkheads 8 spotlights 7 fluorescent F58W (low use)	 600W 2000W 1400W 380W 320W 800W 406W	 720 3000 2900 100 TOTAL 6720	2.5%
Lighting [External]	25 Floodlights, 5 hours per night average	2.63	4800	1.8%
Hot Water	Fixed water heater, Heatrae Sadia Supreme 170 (5 hours per week, normally off) 2 Coffee machines, (5 hours per week, normally off) Commercial Dishwasher, Duo 750. 2 hours per week	3 3 6.84	260 520 685 TOTAL 1465	0.5%
Kitchen	Fridge (on constantly) Cooker (food warming only)	0.1 3	300 180 TOTAL 480	0.18%
Sound, Music	Sound system Organ	1 1	200 100	0.11%
Small Power	Vacuum cleaner Fire alarm Wifi	1.5 0.1 0.1	150 100 100	0.13%

Sum of estimates: 15,875kWh

Annual Church electricity consumption, 2021: 16,000kWh



KEY *1 Gas heating* *2 electric heating* *3 Lighting internal* *4 Lighting external*

5 Hot water *6 Kitchen* *7 Sound, music* *8 Small power*

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 Church, Lee, Lewisham uses 38% less electricity and 68% more heating energy than is average for a church of this size.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
St Margaret's Church, Lee, Lewisham (elec)	Overall 950	16,000 Does not include mobile phone use	16.8	27	-38%
St Margaret's Church, Lee, Lewisham (gas)	950	250,000	263	156	+68%
TOTAL	950	266,000	280	183	+53%

There is currently no benchmark data available which takes hours of use and footfall into account. [1] CofE Shrinking the Footprint – Energy Audit 2013.

6. Efficient / Low Carbon Heating Strategy

6.1 Reducing Environmental Impact

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 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 coal fired power stations. Mains gas does have some potential to reduce its carbon content through the use of bio gas and hydrogen but these are less developed solutions and will be unable to deliver 'zero carbon mains gas'.

It is therefore important to review and plan to increase building efficiency and become less carbon intensive. 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.

6.2 Forward Planning

Whilst there are plans to add hydrogen to the network, and "green" gas from anaerobic digestion; some suppliers offering up to 20% "green gas" tariffs, the majority of the gas supply will continue to be fossil fuel for the next decade. The economics of hydrogen production and the need to replace some pipework make full decarbonisation of gas unlikely.

If the gas boiler is repaired or replaced, then long term, the boiler will need to be made hydrogen ready. Some 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.

The church should develop a boiler replacement plan, by obtaining detailed quotations for the options presented in this report. Where electric heating can be obtained at similar or lower operating cost, this is recommended.

6.3 Site Heat Demand

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

Area	Area m²	Volume m³	Insulation Factor kW/m³	Heat Required (Space heating) kW
Church	590	6060	0.0033	200
Crypt	360	770	0.0028	25

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

The site uses around 250,000kWh of gas yearly. The church is heated for 20 hours weekly during the heating season.

Area	Estimated split kWh	Boiler power kW	Annual use hours	Hourly cost
Church	232,500	387	600	£16.32
Hall	17,500	28	625	£1.18

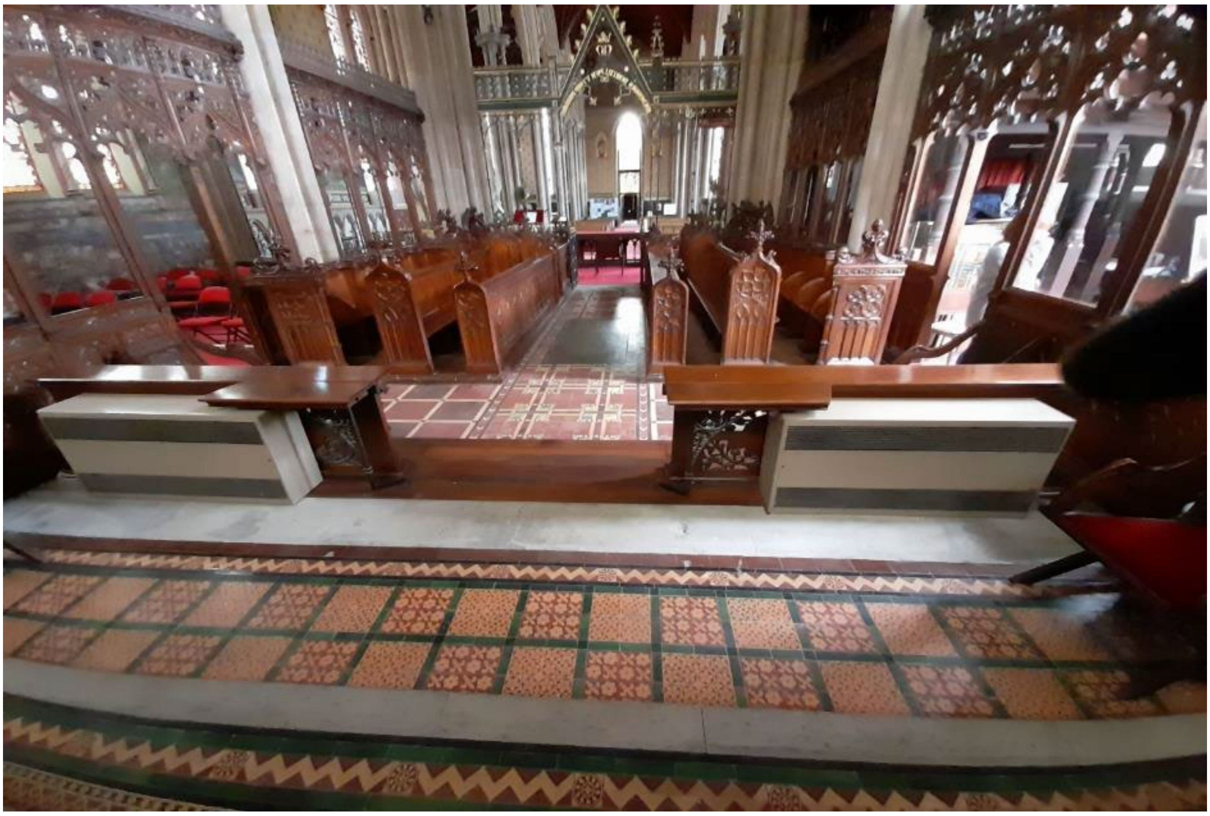
Cost per hour = Boiler power kW x gas price p/kWh

6.4 Heating System Description

The church is heated by five Hamworthy UR265 boilers [387kW total input, 297kW total output, efficiency 76%] with 12 fan assisted radiators in the church delivering 25kW each. Fan speed can be varied (to reduce noise).

Fan Speed Control

The majority of the 12 fan assisted radiators are painted to match the walls. Some are not visible to the public – these are in the chancel. This establishes precedents for location and camouflage of AASHP fan units.



Two further fan assisted radiators are hidden inside these metal screens at the rear.

The building has a large volume with a uniformly high ceiling and large windows in places.

Crypt boiler, 28kW

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 Magnetic Particle Filter

If the system is being retained, or the radiators are to be re-used with a heat pump, then it is recommended that a magnetic particle filter is fitted. This traps magnetic sludge which can cause reduction in boiler efficiency and radiators.

8. Future Heating Options

8.1 Options Overview

The church is currently seated by movable pews. It is proposed that these be replaced by stackable pews. Neither option is suited to under pew heaters.

The walls are highly decorated and the nave is wide, both factors rule out wall mounted radiant panels. The vaulted roof (above) is unsuited to installation of radiant infra red panels for obvious aesthetic reasons. Chandelier mounted radiant heaters could be suspended from the arch centres and this would align with the majority of the seated areas, but this is a small proportion of the space and it would not heat the rest of the area.

Future heating options for the church include installing a heat pump. If this is not possible, a high efficiency condensing gas boiler.

The crypt area currently heated by a boiler can transition to a heat pump. The unheated areas could be fitted with overhead radiant infra red panels if necessary.

8.2 Heat Pump Overview

Heat Pumps are a low carbon method of creating heat.

As the hours if use of a building increase, so do heating costs.

Electrically operated heat pumps can provide between 2.5 times and 5 times the amount of heat in kW which they consume in electricity (This is termed the Coefficient of Performance, CoP). They are compatible with underfloor heating, which typically runs at fairly low water temperatures, but not with high temperature heating systems. When replacing gas boilers directly, sometimes larger radiators are required, or fan assisted radiators, or running the system for longer periods to achieve the same temperature (but at less power input).

With electricity prices now only three times more per kWh than gas (it was about four times), heat pumps are becoming steadily more cost effective. Refrigeration technology is mature and reliable; the units appear to offer lower maintenance costs compared to gas boilers.

Heat pumps generally deliver water at around 55°C (although there are higher temperature ones on the market which require more energy to run); thus are compatible with a building which is regularly used and can be supplied with constant, medium heat, rather than a full power heat up on Sunday mornings.

Air source to water [ASHP] systems deliver between 2.5 and 3 times the amount of heat in kWh to water that they consume.

Ground source systems [GSHP] are more efficient (since the average ground temperature is higher than the average air temperature), but require either a borehole, or extensive trench digging.

Ground Source Heat Pumps supplying water at around 50°C are more efficient than their Air Source equivalent. Where a site has a daily requirement for heat (and thus high daily expenditure), the lower operating costs of a ground source pump outweigh the higher capital costs.

Air to Air systems [AASHP] deliver warm air through indoor fan units and have a CoP rating of up to 5 and they can also provide cooling. The latter would be suitable where there are no radiators, or life expired / poorly sited units and spaces heated intermittently.

Some of the extra electricity required to run heat pumps can be obtained from solar PV panels. Some types of heat pump can provide cooling – solar powered cooling in summer is very efficient. The small available area of the south aisle roof means that the majority of electricity will still be required from the grid.

8.3 Key Questions

To assist a decision, these questions should be asked of potential heat pump installers.

- Is the existing system of fan assisted radiators sufficient to work with heat pumps supplying warm water at 45 to 50°C?

If not, then either additional fan assisted radiators will be required, or an Air to Air system should be chosen, with circulating refrigerant and new internal fan units.

- What is the life expectancy of the existing radiators and pipework?

If low, changing to an AASHP system would give the lowest operating costs and capital costs.

8.4 Air to Air Source Heat Pumps Overview

Air to Air Source heat pumps require internal fan units, blowing warm air, connected to external units – they do not require radiators. Systems provide summer cooling as well as winter heating and can deliver up to 4 to 5 times the amount of heat which they consume in electricity.

It is probable that the heat requirements of the main hall end of the building can be met by two or three units located in the same positions as the existing heaters.

Four of the units below supply one floor of an office of area 165m^2, which is similar to the total of the main hall, toilets, nursery office and kitchen areas. This gives a heating capacity of 21kW for an electrical load of around 1.5kW. The CoP is between 3.2 and 3.9 depending on the type of internal unit chosen.

There are a wide variety of internal units for ceiling, high wall and low wall mounting.

The church has a network of underfloor heating ducts, currently used for cabling. This could be used to run the heat pump refrigerant pipework and possibly install some internal fan units (although the dimensions of the duct may need to be increased).

External units would need to be found locations which were non viewable or hidden in some way, but need to be well ventilated for this method to be viable. Extending the recessed external access to the crypt would offer a potential location.

8.5 Air to Air Source Heat Pumps Costs

Pumps to supply 250kW of heat (with capital cost estimated at £450 per kW output: £112,500) would deliver the same amount of heat annually as the current system.

The capital cost could be reduced by installing a lower power system – in order to deliver the same amount of heat annually, the system would need to operate for more hours. This is positive for a heat pump system which are suited to delivering heat gradually.

Operating at a Coefficient of Performance of 4, an 250kW heat output requires 63kW of electricity supply. This is close to the maximum which can be provided by a three phase supply.

At current costs of 20.49p/kWh, the annual cost for 250,000kWh/CoP 4 = £12,806, which is similar to current gas expenditure. An air to water system operating at a CoP of 2.5 would be significantly more expensive.

8.6 Location for Heat Pump Equipment

There are underfloor ducts which could serve as a conduit for AASHP pipework.

An extension of the sunken area on one or both sides could serve as a location for heat pump plant. Ideally, air source equipment is located on south facing elevations. This is also the side facing away from the main road.

The north east aspect of the building, viewed from the edge of the church yard.

6.8 Cost Comparison

Item	Power output kW	Power input kW	Operating cost	Capital Cost
Current gas boiler	297	387	£13,015	N/A
Replacement boiler [3]	250 suggested	270	~ £10,650	Unknown
Air to Air Source Heat Pump	250	62.5	£12,800 [4]	£112,500

A condensing boiler operating at 93% efficiency rather than 76%, and with a lower output – giving lower capital cost. Longer preheat times would be required. Operating costs are reduced due to the increased efficiency and assume consumption of the same amount of gas.

The future gas price is unknown. Further increases may render it more expensive than the heat pump option. The lifetime of the pipework and current radiators is an important factor in reaching a decision.

Heat Pumps can use 100% renewable electricity from the grid. Any solar power generated on site will reduce their operating costs. In addition, heat pumps can provide free summer cooling, with solar power.

Quotations for Heat Pumps should be obtained (including enough information to allow calculation of operating costs) and compared with capital and operating costs for a high efficiency replacement boiler.

If a heat pump installation is found to be not yet viable then the option of a high efficiency boiler should be pursued.

6.9 Radiant Overhead Heating Panels in the Choir Vestry

This area of the crypt is currently unheated.

If heating is required in the future, then given the occasional and short duration pattern of use, direct electric heating is recommended. Either a portable electric convector heater could be used (the lowest cost option for very low use), or radiant heating panels attached to the ceiling (this becomes more desirable as hours of use increase and does not encumber the floor with trailing wires).

4kW of far infra red panels would cost in the region of £2,500 installed

9. Energy Saving Recommendations - Equipment

9.1 New LED Lighting

The lighting makes up a relatively large overall energy proportion of the electricity used within the church. The extensive floodlighting comprising 25 lamps of a variety of types and loads is proposed for replacement. A proposal has been received by the church to replace the current

2,630W of floodlighting with 868W. It is recommended that a LED floodlighting scheme is implemented. The proposal viewed would save approximately 3,200kWh annually based on an average of 5 hours floodlighting per evening.

Within the building, interior lighting is understood to be LED within the church.

There are a large number of spotlights, around 30 in the chancel and 100 in the nave and aisles.

Any non LED lamps should be changed in the short term.

In the crypt, the remaining non LED bulbs in the ceiling mountings and up-lights should be changed, prioritising removal of any remaining halogen lamps.

When the seven fluorescent 58W strip lights become due for replacement, it is recommended that all should be replaced by LED strip lighting. The whole units should be replaced, not just the bulb.

There are a vast number of specifications of LED lights on the market but it is recommended that any LED light should come with branded chips and drivers and offer a 5 year warranty. An example of such a range of fittings is available from http://www.qvisled.com/

9.2 Lighting Controls (Internal)

Areas such as toilets 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.

9.3 External Lighting Controls

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

It is therefore recommended that in conjunction with the LED floodlighting scheme, the timer (or a replacement) is programmed to switch off the external lights between 11pm and 6am daily and also over the weekend if not required. A timeclock with a time and day capacity is recommended over those that only have time of day capacity. Sangamo (http://sangamo.co.uk/) make a wide range of commonly used timeclocks which any qualified electrician can install.

10. Energy Saving Recommendations – Building Fabric

10.1 Install Ceiling Insulation

The loft space between the roof and ceiling was not inspected.

In all cases where there is 100mm or less of insulation within accessible roof spaces it is recommended that insulation be added to prevent heat loss and create a more comfortable environment for the occupants of the building. The church has medium hours of use and a very high heating energy use, so this would be beneficial.

The ceiling/roof of a building is the largest contributing area to heat loss from a building as heat rises. The insulation of such spaces can therefore have a dramatic impact on both the efficiency of the heating system and the temperature of the space below.

Approximate costs for 525m^2 of ceiling at £9.50/m^2 are £5,000.

10.2 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 into the church around the side and base of these doors.

It is recommended 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 a product called QuattroSeal (see link below) is often used in heritage environments to provide appropriate draught proofing. http://www.theenergysavers.co.uk/application/files/1714/7197/4194/National_Trust_Case_Study.pdf

For timber doors that close onto a stone surround more traditional solutions such brush draught strips rebated into the edge of the door by a skilled joiner. Other traditional methods such as using hessian or felt pads tacked to the door could be used and keeping the door maintained in a good condition is important.

Simple measures such as having a 'sausage dog' style draught excluder laid along the base of a door, 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.

10.3 Windows

Where there are broken windows such as in the choir vestry end of the crypt on the north side, these should be repaired – a temporary repair using tape and plastic sheet will prevent draughts. Plasticene can be used to close gaps in opening panels such as hopper windows and this is easily removable. Any rusted areas should be repaired thoroughly, as rust expands and bends the metal leading to further leaks and damage to glass.

Crypt window, with holes

10.4 Secondary Glazing

Where there are smaller single glazed windows in regularly used areas of the crypt; these are worth installing secondary glazing.

Given the windows in the crypt are relatively small and have a more simple surround they would be suitable to have secondary glazing installed as they are also not primary or important windows within 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, and companies such as https://www.selectaglaze.co.uk/heritage-listed-buildings or https://www.stormwindows.co.uk/ can provide very discrete and appropriate systems for all types of spaces.

For the windows in the non-public areas of the crypt; if there is sufficient use, then either inexpensive seasonal glazing film can be installed, or removable internal panels cut using a craft knife from 2mm polycarbonate sheet. Depending on the type of window reveal, these panels can be fixed using magnetic tape.

11. Saving Recommendations (Water)

11.1 Tap Flow Regulators

Where there is regular use by children, or heavy public use, tap flow regulators are recommended. The over provision of water for hand washing is not only a source of excessive water use, but in the case of hot water, it is also a source of wasted energy in the heating that has to go into providing the hot water.

The flow rate of the taps can be easily regulated by fitting flow regulators within the taps. It is recommended that flow regulators such as those manufactured by neoperl (http://www.neoperl.net/en/) are fitted into all the viable hand wash basin taps to save on both water and heating of the hot water.

These regulators can be self-installed or by any good facilities staff.

11.2 Detergents for Cold Water Hand washing

Use of cold water for hand washing can be just as effective as using hot.

https://www.nhs.uk/news/lifestyle-and-exercise/cold-water-just-as-good-as-hot-for-handwashing/

12. 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
Battery Storage	Future potential
Wind	No – no suitable land away from buildings
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	Operating expenditure high
Ground Source Heat Pump	Capital expenditure high
Air to Air Source Heat Pump	Yes

12.1 Solar Photovoltaic Panels

The sections of south facing roof in the valleys between the aisles and nave offer locations for solar panels.

These areas of around 100m^2 each. This could generate 0.15kWpeak/m^2 giving a 30kWpeak system. A 1kWpeak system can generate up to 1000kWh annually.

The angle of the church roof is approximately 45°.

Assuming that the maximum amount of roof space could be, and was used for panels, 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	Useable area / m^2	System Size / kW peak	Orientation factor	Shading factor	Annual Generation, kWh
North aisle, Nave	200	30	170 degrees / 45^0 0.97	0.8	23,280

This is the maximum likely figure, which may be reduced by factors such as the weight of panels (due to roof strength) and access space between panels. The ability of the roof structures to support the extra loads should be discussed with the church's inspecting architect.

The maximum potential generation is greater than the church centre's annual recent electricity use (16,000kWh). If no heat pumps are installed, the system should be sized appropriate for the present electricity consumption.

If heat pumps were installed, this would require extra power. With a current gas use of 250,000kWh, if heat pumps achieved an average of CoP 4 this would require 62,500kWh of electricity, so there would still be reliance on grid electricity (which should be sourced from a 100% renewable supplier).

The system should be specified for future addition of a battery, when battery costs reduce as this would extend system usefulness into the evening.

Battery Storage is not strictly a renewable energy solution but provides 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. This is a new but fast-growing technology.

Using average 2019 installation costs (£1,450 per kWpeak); a 30 kWpeak system would cost £43,500.

13. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available at www.parishresources.org.uk/resources-for-treasurers/funding/

This includes a 77 page guide to funders and their criteria:

https://www.parishresources.org.uk/wp-content/uploads/Charitable-Grants-for-Churches-Jan-2020.pdf .

14. 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.