ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Alfege Church, Greenwich
PCC of St Alfege Church

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of St Alfege Church, Greenwich 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 Alfege Church, Greenwich was constructed in 1711-13 to replace an earlier building on the site, involving reconstruction of the mediaeval tower. It was the first London church designed by Sir Nicholas Hawksmoor. It is a large building with side galleries occupying a prominent position in Greenwich adjacent to a road junction at the commercial centre. The church was heavily damaged in WW2 with the entire interior (apart from the transept staircases) reconstructed from 1946 to 1953. The underfloor heating pipework and roof structure date from this time. [Historic England reference 1358970].

The area is a major tourist destination in London and the church receives up to 1,500 visitors per month in the summer (50 daily). The church has recently received significant funding of around £2.7m to support façade cleaning, installation of internal LED relighting and external floodlighting.

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	CO_2 saving (tonnes of CO_2e/year)
SHORT TERM						
On contract renewal, use a group purchasing scheme	N/A	5-15% (10% £1,450)	None	Immediate	None	N/A
Isolate or disconnect fixed water heater in tower kitchenette	1,000	£142	None	Immediate	None	0.25
Optimise heating timings and level	10% 12.500	£910	None	Immediate	None	2.3
MEDIUM TERM						
Investigate ceiling/loft insulation	10% 12,500	£910	£6,650	7.5	Faculty	2.3
Obtain quotations for Air to Air and Ground Source Heat Pumps	125,000 gas	£4,700 Without solar panels	Air £112k Ground £250k	24 53	Faculty	23.0
LONG TERM						
Install solar panels or tiles if permitted	43,000	£6,140	Panels £65,250 Tiles £96,400	11 16	Faculty, Planning permission	10.9

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

Based on current contracted prices of 14.21p/kWh and 6.5p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church around £11,000 per year in operating costs by removing gas charges and generating around 2/3 of electricity requirements (including heat pumps).

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:

Short Term (within 12 months) — Optimise heating system timings

Medium Term (by 2025) — Install ceiling insulation

Long Term (before 2030) — Install Heat Pump; Solar panels

The roof is not visible from close to the building, but can be seen from further away.

3. Introduction

This report is provided to the PCC of St Alfege Church, Greenwich 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 Alfege Church, Greenwich, SE10 9BJ was completed on the 20th 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 Eco Congregation.

The church was represented by Keith Ison and Malcolm Reid. Jack Edwards, Diocese of Southwark Environment Officer was also present for the audit.

St Alfege Church, Greenwich	
Church Code	637228
Gross Internal Floor Area	1,200m^2
Volume	8,400m^3
Heat requirement	277kW
Listed Status	Grade I

The church is typically used for 29 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	9 hours per week	185
Church Meetings and Groups		160
Community Use	Concerts twice weekly Recitals twice weekly School services (20) Visitors, 1000 monthly in summer	
Occasional Offices	6 weddings 6 funerals	100 100

Annual Occupancy Hours: 1,500

Estimated Footfall: 35,000

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Alfege Church, Greenwich and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single Rate	14.21p/kWh	Below current market rates
Standing Charge	26.64p/day	N/A

Supplier Scottish Power

The current gas rates are:

Single Rate	6.5p/kWh	Below current market rates
Standing Charge	150p/day	N/A

Supplier Pozitive Energy.   Contract end date 16/12/2023

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 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	Electricity: 20% charged on portion of bill allocated to mobile phone mast, otherwise 5% Gas: 20% charged by British Gas over period (at least) December 2021 – May 2022	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 with 20% VAT rate	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 Alfege Church, Greenwich used 21,584 kWh/year of electricity in the year from 11th June 2021 to 11th June 2022 costing £3,322. Two years mobile phone installation data indicate this facility used an extra 17,113kWh annually (not counted in the above figure). This data has been taken from a list of electricity expenditure provided by the church with customer meter readings.

The church used 125,560kWh of gas annually, costing £9,144 (if at 5% VAT rate), giving a combined annual utility bill of £14,615. This data has been taken from a list of electricity expenditure provided by the church with customer meter readings.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Church	L88E 20185	Three phase	No	Crypt, electrical cupboard on south side
Gas – Church	M025 A00039 08 A6	Actaris metric	No	Crypt

It is recommended that the church consider asking their suppliers to install smart meters so that the usage can be monitored more closely, and the patterns of usage reviewed against the times the building is used.

5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

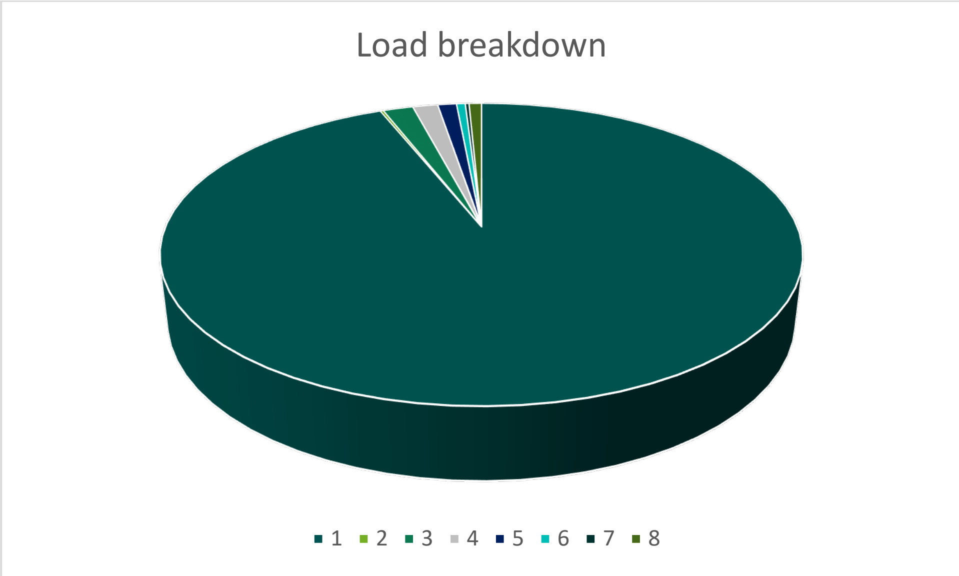
	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	2 x Remeha 210 Eco Pro 120 boilers of 129kW each [485 hours if at full power]	258	125,000	93.9%
Heating [Electric]	Boiler circulating pumps	0.5	250	0.2%
Lighting [Internal]	All LED installed 2020, programmable 56 chandelier mounted 20 candle bulbs, balcony 20 pendants 7 recessed 5 spotlights 20 large up-lights (50W)	1000W 1000W	2400	1.8%
Lighting [External]	All LED installed 2020 Floodlighting recessed into pavements Average of 5 hours nightly = 1825 hours.	1000W	2000	1.5%
Hot Water	Kitchenette in tower: Lincat surface mounted fixed heater Ariston 10 litre under sink unit	3 3	500 1000	1.1%
Sound, Music	Sound system Organ: 2 pumps, 7 hours use per week	0.5 1	340 360	0.5%
Office	1 workstation	0.2	300	0.2%
Small Power	Vacuum cleaner Fire monitoring system	1.5 0.1	100 900	0.7%

Sum of estimates: 8,150kWh

Annual site electricity consumption, 2021: 21,584kWh

There is a large difference between estimated and reported consumption.

Consumption data is post installation of LED lighting. It is unclear whether the end of the restoration and stone cleaning project is part of the audit period.



KEY				
	1 Gas heating	*2 electric heating*	*3 Lighting internal*	*4 Lighting external*
	5 Hot water	*6 Sound, music*	*7 Office*	*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 / hot water.

5.3 Energy Benchmarking

In comparison to national benchmarks for church energy use St Alfege Church, Greenwich uses 33% less electricity and 33% less 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 Alfege Church, Greenwich (elec)	1,200	21,584	18	27	-33%
St Alfege Church, Greenwich (gas)	1,200	125,560	104	156	-33%
TOTAL	1,200	147,144	122	183	-33%

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

<u>Insulation Factors</u>

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	8,400	0.033	277

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

The site uses around 125,000kWh of gas yearly. The church is estimated to be in use for 1,500 hours. A boiler power of 258kW indicates 485 heating hours if it is always running at full power.

6.4 Heating System

The church is heated by two Remeha 210 Eco Pro120 gas boilers with a combined maximum output of 258kW.

These serve the c. 1950 underfloor heating network. No plans were available to show the extent of the facility. There are four pipes which emerge under the inner ends of some pews; these appear to be drain or bleeding points. At 30cm length each, they are too short to act as heat emitters.

The boilers also feed a network of radiators, located in the door porches but mostly at the rear of the balcony providing space heating for the upper half of the building.

The radiators (Zone 1) are heated for a total of 31hours 50 minutes, ranging from 2h50 to 6h20 per day.

The Underfloor system (Zone 2) is heated for a total of 52 hours 10 minutes, ranging from 5 to 9.5 hours per day. Each day has a different number of heating hours which do not seem to correlate well with the reported use.

The underfloor system is believed to be 70 years old; its lifetime is unknown. It is currently in full working order with no leaks.

It may be compatible with a heat pump, but it seems inappropriate to couple a large capital investment with an inaccessible ageing system which is in uncertain condition.

The radiator network consists of relatively small radiators which would probably be considered insufficiently sized for a heat pump system delivering warm rather than hot water.

6.5 Heating Regime

The timings and settings on this were reviewed as part of the audit and there are opportunities to adjust these controls to provide more efficient energy usage of the building and to provide a more comfortable environment for the congregation.

Heating is controlled by a Honeywell controller located in the office.

Two zones are timed separately;

Zone 1 consists of the radiators located at the outer edges of the balcony

Each day has different timings with between 6 hours (Monday) and 9 hours (Thursday) programmed. It was not clear why the specific timings had been set or how this corresponds to the use of the balcony.

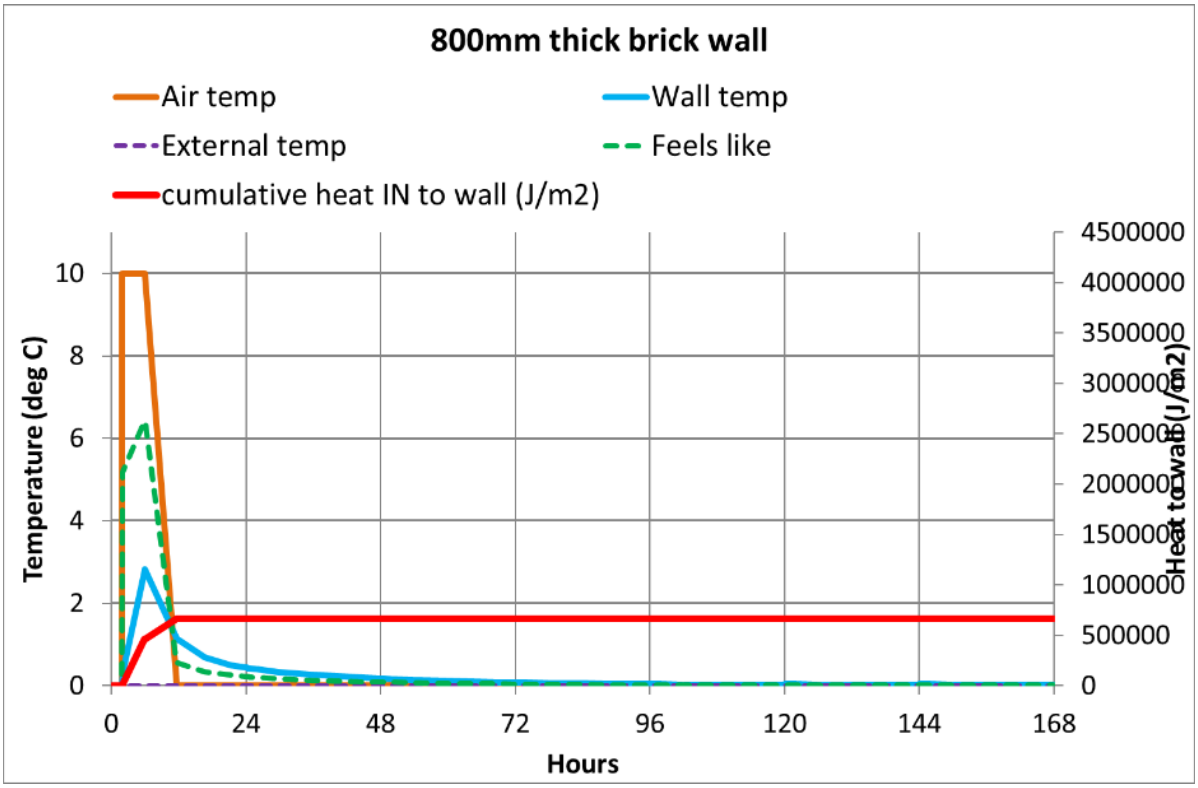
Zone 2 is the underfloor heating under the nave

Again, each day is different with heating start times varying between 07:00 and 09:30 until mid-morning or early afternoon with a further afternoon heating period of between 40 minutes and three hours. Total daily times vary between just under 3 hours and 6 hours 20 minutes.

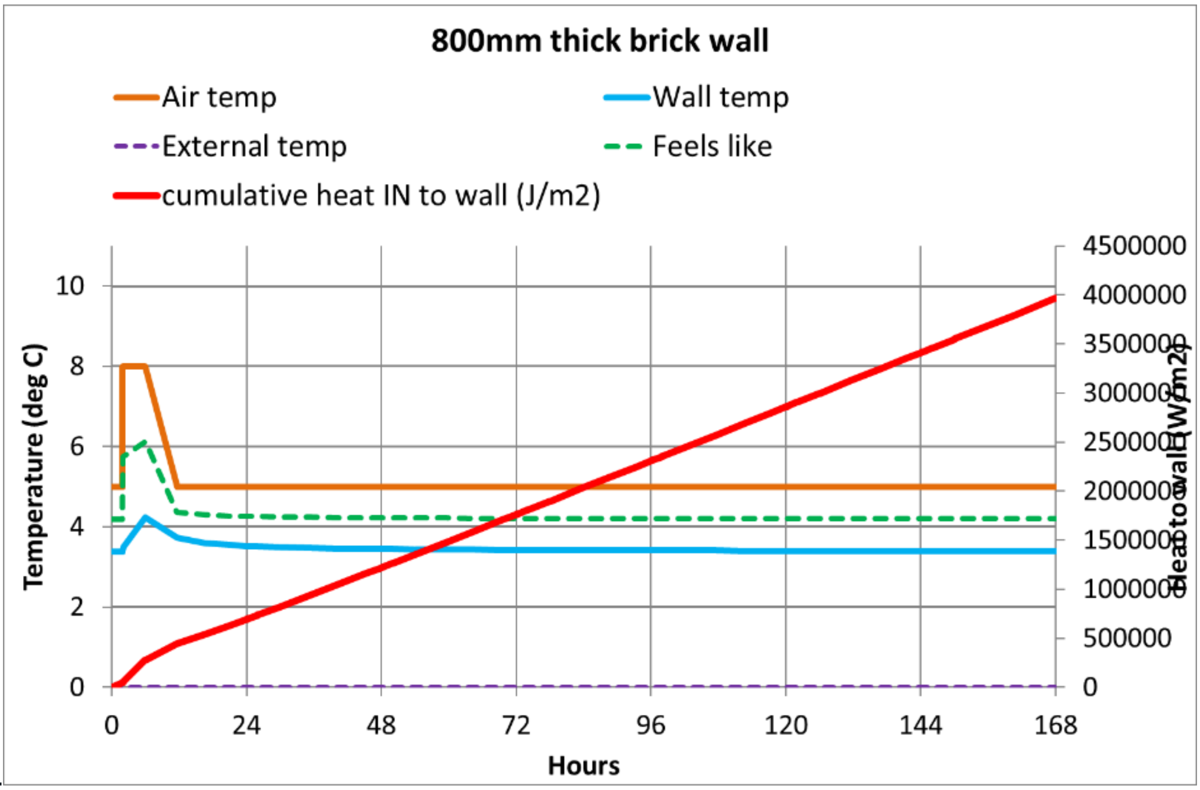
It is recommended that the heating timings are considered against the hours of use of the building during the heating season with the aim of reducing hours of use if possible.

The time taken for the building to warm from the overnight temperature will inform the appropriate start time. For a building heated daily, this will be less than for a once per week heated church.

If there are complete days during the winter when the building is not in use then the heating should not be run – the heat gained during the day will still be lost overnight. The following graphs provided by the Church Energy Advisor's Network show that heat loss for an uninsulated building is significant.



Above, one heating episode   Below, background heating



paper by James Sheehan https://www.cibsejournal.com/general/tidings-of-comfort-and-joy-cost-efficient-church-heating/

There are two important principles in setting efficient heating settings to support a comfortable church. The first is that most historic buildings survive very well without being heated and that in a number of cases the later addition of heating has actually cause fabric issues (such as the drying out of timbers, drawing damp through walls into a warmer and drier environment or causing issues beneath metal roof covings where warmer moist air becomes trapped). In most cases the fabric of a historic building would prefer not to be heated and the constant 'yo-yo' up and down of the heating is the most damaging.

The second principle is that to provide comfort to occupants one either needs to provide an immediate injection of heat close to where the congregation are heaters (i.e. under pew heaters or radiant heaters) that warm the air around the people but makes not attempt to heat the entire air volume of the church or has a long slow building up of heat within the church building (as is generally provided by underfloor heating}.

Having the heating switch on for an hour or two once or twice a day in the mis-conceived idea that it will 'take the cold off the building' is the most damaging heating strategy for the fabric and does very little to provide comfort as the heat is lost before the next heating session. It is better to leave the building unheated when it is not occupied and then have a longer period of heating before the time when there are services or the like.

Given this we would advise that the following adjustments are made.

- Review heating times for each zone against hours of use, particularly for the balcony.
- Adjust the set point on the boilers to 75°C flow
- Reduce the frost settings to 2℃ as it is needed to prevent freezing pipes only

The adjustment of the heating system should be above to be carried out by any member of the church that is competent in using the controls.

6.6 Data and Dataloggers

In order to help optimise heating timings it is helpful to know how quickly the building warms and cools. Purchasing a temperature datalogger such as an Easylog USB-1 of similar will assist in understanding. These items cost around £50.

7. Future Heating Options

7.1 Options Overview

The church is currently seated using pews in the nave and balconies.

The regular use profile of the building argues against direct electric heating (such as under pew heating) as operating costs will be very high. This also applies to ceiling mounted infra red panels and chandelier mounted heating.

Chandelier mounted visible radiant quartz heaters when installed in churches are usually suspended from arch centres. It is not normally considered aesthetically suitable to suspend them from high nave roofs. There is always the issue of hot spots.

The following options were discussed during the audit:

The relatively high hours of use of the building mean that a heat pump would be a viable option.

An Air to Air Source heat pump system would offer a high efficiency and also cooling, but require internal fan units to be found inconspicuous locations.

External Unit locations would be difficult - the perimeter of the church is accessible and highly visible. Potential locations for external units are behind the telephone boxes at the east corner of the churchyard (if there are no burials at this position), or in the corner of the south east car parking area closest to the church, shielded by an existing hedge and requiring one parking space to be used.

Another option may be to place the unit in the crypt near where the existing boiler is, ventilated via the existing grilled vents. Fans may be required to generate sufficient airflow past the heat pump. This may be the best option, avoiding trenching for pipework.

The rationale for using a heat pump to replace the gas boilers is:

i) Environmental – reducing dependency on fossil fuels

ii) Economic – a heat pump delivering 4 x the amount of heat in kWh which it consumes in electricity is clearly 4 x cheaper than "direct" electric heating (e.g. by under pew heater). This is important in a building with high use which is regularly visited and heated each day. The cost relative to gas depends on the ratio of the two rates (which can vary considerably at present). Systems delivering warm air at ground level require less heat input than radiator space heating system which heat the ceiling first. Heat Pump systems are considered to offer lower annual maintenance costs (no annual gas safety check).

iii) Heatwave relief - If the heat pump system installed also provides a cooling function as should be the case for AASHP

7.2 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).

Refrigerant fluid is used to extract heat from large amounts of air, water or ground with a small temperature drop, and this is concentrated to produce a large (internal) temperature rise. An electric pump drives the refrigerant transferring the heat – less energy is required to drive the process than the amount of energy being moved.

Heat pumps 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 55ºC (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) systems deliver between 2.5 and 3 times the amount of heat in kWh to water that they consume.

Ground Source Heat Pumps supplying water at around 50ºC are more efficient than their Air Source equivalent (since the average ground temperature is higher than the average air temperature), but require either a borehole, or extensive trench digging. CoP is 3 to 4.

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 deliver warm air through indoor fan units and have a CoP rating of between 4 and 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 could possibly be obtained from solar PV panels. Some types of heat pump can provide cooling – solar powered cooling in summer is very efficient.

7.3 Replace Boiler with a Heat Pump

If the heating power requirement is the same as the current boiler, a 250kW output Ground Source or Air to Air Heat Pump operating at CoP 4 requires 62kW of electricity. This is near the limit of a three phase supply.

An air (to water) source unit is not recommended due to the lower efficiency (CoP generally 2.5) which would lead to higher operating costs.

A ground source unit would have to supply the existing underfloor heating system (or a replacement), or new radiators on the ground floor.

An Air to Air source system would require locations to be found for internal fan units.

The output required depends on the building heat loss, which could be reduced by around 10% if ceiling insulation were fitted. Heat pumps are suited to semicontinuous operation; so pumps of a lower output intentionally operating for longer periods are worth exploring.

7.4 Key Questions

- What is the projected lifetime of the current underfloor heating system?
- If system lifetime is predicted to be short, can the church envisage sufficient funding for its replacement? (at ~ £1,000/m^2, so cost around £400,000).
  If no, this favours an air to air system.
- Are there potential locations where internal AASHP fan units could be installed, and disguised?

7.5 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. However, they require plumbing to circulate refrigerant. 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.

Four of the small units below supply one floor of an office of area 160m^2. These give a heating capacity of 21kW. The two large units supply 500m^2 of space with an output of 75kW.

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.

Ideally, units would be mounted at or near floor level and blow warm air across the floor. Locations for the internal units might see them surface mounted but painted to match the surroundings, or possibly inserted behind panelling. Pipework would also have to be accommodated – this might be installed in the crypt and emerge vertically to supply each unit from below.

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. Hedge planting has been used to hide oil tanks at some churches. One possible location is to use the car park space nearest the building which is already shielded by a hedge.

A possible location for an external heat pump unit would be to the right of the central tree behind the hedge.

7.6 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, 125,000kWh, as the current system.

Operating at a Coefficient of Performance of 4, an 250kW heat output requires 62.5kW of electricity supply – this would require three phases of power, with lighting etc added and be at the limit of the supply rating.

Annual consumption 125,000kWh/4 = 31,250kWh

At current rate of 14.21p/kWh, annual operating cost = £4,440

7.7 Cost Comparison

Based on current utility prices.

Item	Power output kW	Power input kW	Operating cost	Capital Cost
Current gas boiler	240	258	£9,144	N/A
Air to Air Source Heat Pump, New internal units	250	62.5	£4,440	£112,500
Ground Source Heat Pump	250	62.5	£4,440	£250,000

8. Energy Saving Recommendations - Equipment

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 Fixed Water Heater: Timer Control

An Ariston 1o litre water heater is located under the sink in the kitchenette in the tower. With the relocation of office staff to the hall building, this facility is not needed and should be turned off, with a notice posted, or isolated electrically. There is still a surface mounted water heater provided nearby.

This heater appeared to be turned on all the time. Although the tank itself is insulated, the piping is not and was hot to the touch. This loses a similar amount of heat as an incandescent light bulb. A constant loss of 100W along a length of pipe is around 900kWh annually, costing £128. Note that a tank will only deliver half the volume of hot water which it contains. As the water is drawn, it is replaced by cold, so the second half of the tank will be lukewarm.

9. Energy Saving Recommendations – Building Fabric

9.1 Draught Proof External Doors

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

It is recommended that the draughtproofing around the door is improved, particularly underneath where there is a large gap, 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.

9.2 Insulation to Roof

There may be potential for installing loft insulation, but professional heritage advice is required.

The "warm loft" option would involve suspending insulation under the roof. The same amount of heat would travel upwards through the ceiling as now to begin with, raising the temperature in the roof space (by how much depends on the level of air infiltration through the roof). The inside of the roof and its beams and rafters will become cooler as a result and careful design (with possible extra ventilation) to avoid condensation is necessary.

The "cold loft" option would involve installing insulation above the ceiling. The ceiling is supported by a metal framework and 15 lights are installed in the ceiling. It is unclear whether the ceiling / framework could support the extra load. In addition installing insulation on top of the ceiling structure would obscure the ceiling lighting and cables.

Advice regarding the method of fixing insulation and avoidance of condensation should be sought from your inspecting architect, the Church Building Council and Historic England (Building Services Team).

Ceiling insulation ("cold loft") for an area of 700m^2 would cost approximately £6,650.

Cost £9.50/m^2

10. Other Recommendations

10.1 Electric Vehicle Charging Points

The church has a small car park on the south side of the site which serves the church and also the frequently used church hall. In order to make a visible statement on the churches mission of stewardship and to facilitate more sustainable transport choices by those both visiting the church and using the hall, the church may wish to consider installing an electric vehicle charging point, probably on the side of the church hall to allow visitors to charge their electric car.

Installing a unit such as a Rolec Securi-Charge http://www.rolecserv.com/ev-charging/news/view/Robust-EV-Charging-With-Rolecs-SecuriCharge-EV-Wall-Unit-Coin-Token-PAYG would allow the organisation control over who is allowed to use the unit with a key operated system. Or given the type of use of the building and control over the usage of the car park as a whole a simple 32 amp type 2 wall pod type charger may be most suitable and these are widely available through many suppliers such as http://www.rolecserv.com/ev-charging/product/EV-Charging-Points-For-The-Home.

11. 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 if permissible
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	Operational expenditure too high
Ground Source Heat Pump	Yes if underfloor heating suitable
Air to Air Source Heat Pump	Yes

11.1 Solar Photovoltaic Panels

The church is interested in exploring the potential for installation of solar panels. As a Grade 1 listed building with a visible pitched roof, it is considered extremely unlikely that permission would be granted for installation of glass surfaced panels, including a new product with a matt surface finish.

It is worth the church exploring if permission might be granted for solar tiles which could replace some of the slates. Unless the entire roof was reroofed to achieve a colour match, this would introduce a striped effect across the roof which would probably be unacceptable (although St James the Less, Pimlico was designed to have a two tone roof with slates of different colours forming stripes).

Solar tiles would require wiring under the roof which would add another complication to the process of insulation. No cost data are available for solar tiles, which are manufactured by a number of companies including Imerys, GB Sol and Solecco.

Imerys: www.clayandslateroofingproducts.co.uk/solar-panel-roof-tiles/

www.gb-sol.co.uk/products/pvslates www.gb-sol.co.uk/gallery/pvslate/default.htm

www.soleccosolar.com

Assuming that the maximum amount of roof space could be, and was used for panels, the following formula calculates annual generation. The angle of the roof is approximately 20°.

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
Church	300	45	180 degrees / 20^0 0.96	1	43,200

This is the maximum likely figure, which may be reduced by factors such as the weight of panels (due to roof strength), 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 (36,000kWh). If no heat pumps are installed, the system should be sized appropriate for current electricity consumption.

If heat pumps were installed, this would require extra power. A maximum sized solar PV system would contribute to running heat pumps but grid electricity would be required for much of the heating season.

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

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 45 kWpeak system would cost £65,250.

12. 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 .

13. 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.