ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St James' Church, Clapham Park
PCC of St James' Church

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of St James' Church, Clapham Park was undertaken by ESOS Ltd to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use.

St James' Church, Clapham Park is a Grade II listed church constructed in 1958. The structure consists of concrete ribs forming the columns and roof vault with brick infill. The roof requires repair, planned for 2023, to rectify loss of mortar leading to leakages and loose coping stones. The ceiling consists of asbestos panels for insulation – these will be removed. The church proposes to use the major repairs as an opportunity to install solar photovoltaic panels and reduce access costs.

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)
Procure utility supplies using a Group Purchasing scheme	N/A	5-15%	Zero	Immediate	None	N/A
SHORT TERM						
Purchase a temperature datalogger	Facilitates and measures items below	Included below	£50	<1	None	Included below
Reduce thermostat setting by 1 degree	10% gas 14,650	£731	Zero	Immediate	None	2.6
Stop continuous heating	Up to 50%. 70,000	£3,493	Zero	Immediate	None	12.9
Install reflective radiator foil sheets	2% gas 2,930	£146	£80	<1	List A	0.5
Turn off chancel radiators	10% gas 14,650	£731	Zero	Immediate	None	2.6
Draught proofing works	1% gas 1,465	£73	£100	<1	List A	0.3
Concentrate midweek events	10% 14,650	£731	Zero	Immediate	None	2.6
MEDIUM TERM						
Change halogen spotlights to LED units	1,700	£296	£500 + access costs	2	List A	0.4
Install secondary double glazing in choir vestry	10% of room 250	£12	£40	4	List A	0.04

Install magnetic particle filter to boiler	Increases system lifetime		£500		List B	
Install solar photovoltaic panels on south aisle roof	25,000	£4,350	£36,250	8.3	Faculty	3.1
Install light pipes within existing skylights	Decreases need for lighting in daytime 500	£87	£700 (7 skylights)	10	Faculty	0.1
LONG TERM						
Install under pew heaters [Costed for full array]	146,000 gas	£7,650 gas E use £4,875 £2,775	£36,848 [112 units]	13	Faculty	26.8
Replace boiler with heat pump	146,000 gas	£7,650 gas E use £4,350 £3,300	£45,000	13	Faculty	26.8

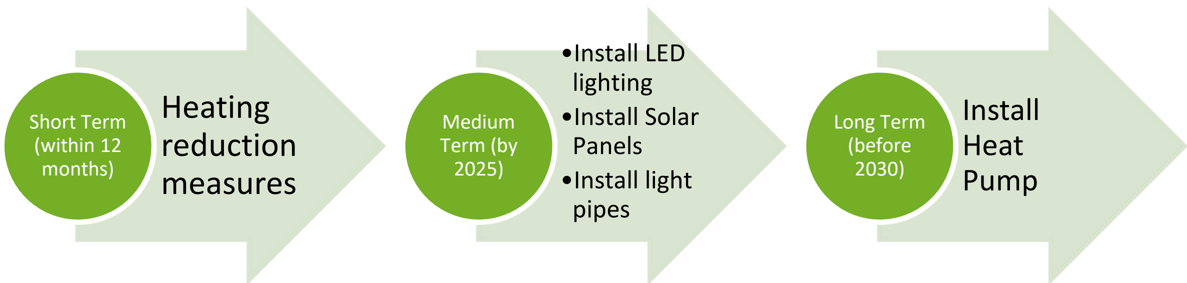
The church should check any faculty requirements with the DAC Secretary at the Diocese before commencing any works. Based on current contracted prices of 17.4p/kWh and 4.99p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church around £9,000 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 2035 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St James' Church, Clapham Park 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 James' Church, Clapham Park, SW4 9PB was completed on the 18th 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 Rev Kit Gunasekera, Vicar and Jim Grover, Church Warden.

St James' Church, Clapham Park	
Church Code	637030
Gross Internal Floor Area	580m^2
Volume	5,300m^3
Heat requirement	165kW
Listed Status	Grade II Historic England ref 1376610

The church is typically used for 18 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	3 hours per week	40
Community Use	15 hours per week	Craft club, drop ins, film club
Occasional Offices	few	100

Annual Occupancy Hours: 950

Estimated Footfall: 4,600

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St James' Church, Clapham Park and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single Rate	17.4p/kWh	Below current market rates
Standing Charge	242/day	N/A

Supplier: EDF

The current gas rates are:

Single / Blended Rate	4.99p/kWh	Below current market rates
Standing Charge	Zero	N/A

Supplier: Total

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	5%	The correct VAT rate is being applied
CCL	not charged	The correct CCL rate is being applied.

The above review confirmed that the correct taxation and levy rates are being charged.

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

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.

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 James' Church, Clapham Park used 6,930 kWh/year of electricity in the year from 13th January 2021 to 21st January 2022, costing £2,744. Gas use was 146,395kWh during 2021, costing £7,669. This data has been taken from quarterly electricity costs, the Energy Footprint Tool submission and monthly gas bills provided by the church.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Church	L71A 01272	mechanical	no	Pantry electrical cupboard
Gas – Church	M025 K00445 14 D6	Elster Bk-G16M metric	Yes	Warden's vestry

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.

The right hand meter only feeds the distribution board.

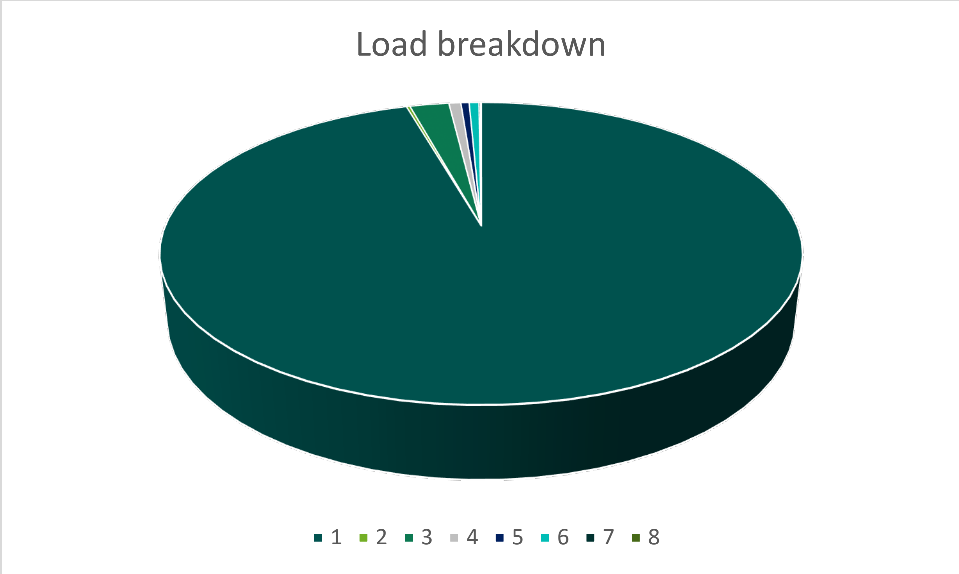
5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	3 x Vaillant EcoMax 635E condensing boilers of 38.8kW input (36.6kW output each) 1250 hours (if at full power)	117	146,500	95.4%
Heating [Electric]	Boiler circulation pump (1250 hours) Portable oil filled radiant heater (choir vestry)	0.2 2	250 70	0.2%
Lighting [Internal]	CHURCH 950 hours use 45 pendant mostly 18W CFL 14 up lights 22 spotlights, 100W halogen ENTRANCE, choir vestry, warden's vestry, toilets, etc 7 bulkhead at 40W 10 fluorescent F58W	 700W 420W 2200W 280W 580W	3000 600	2.3%
Lighting [External]	5 Floodlights, LED 120W each, internally mounted to illuminate east and west windows at night Security lighting, PIR controlled	600W	1080 20	0.7%
Hot Water	Kettle (Sundays) Coffee Machine (Sundays) Urn (Sundays) 3 x Point of use Triton heaters, over sinks in kitchen and toilets	3 2 2 3 each	80 320 200 160 TOTAL 760	0.5%
Kitchen	Fridge Fridge/ freezer	100W 200W	300 600	0.6%
Sound, Music	Sound system 2hours/week Organ 1 hour/week	1 1	100 50	0.1%
Small Power	Vacuum cleaner Photocopier use ~ 1 hour/week	1.5 500W	40 30	0.1%

Sum of estimates: 6.900kWh

Annual site electricity consumption, 2020: 6,930kWh



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 James' Church, Clapham Park uses 40% less electricity and 86% more heating energy than is average for a church of this size.

It is possible that the hours of operation of the hall heating may be contributing to this, as well as a church boiler of low efficiency.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
St James' Church, Clapham Park (elec)	580	6,930	11.9	19	-37%
St James' Church, Clapham Park (gas)	580	146,500	253	148	+70%
TOTAL	**580**	**153,430**	**264**	**167**	**+58%**

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.

The church has realised that when it moves to new utility bill contracts it is likely to be paying double current rates. It plans to make savings of 30% in consumption.

Some of these savings can be made by energy efficiency measures, some by reducing temperature, some require capital outlay.

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

Location	Area m^2	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Church	474	4975	0.0031	154
Choir vestry Office & kitchenette	Each 28	Each 87	0.0033	Each 3
Entrance area	50	150	0.0033	6
Total	580	5300		165

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

The site uses around 146,500kWh of gas yearly (this may vary by 10% depending on use and temperatures).

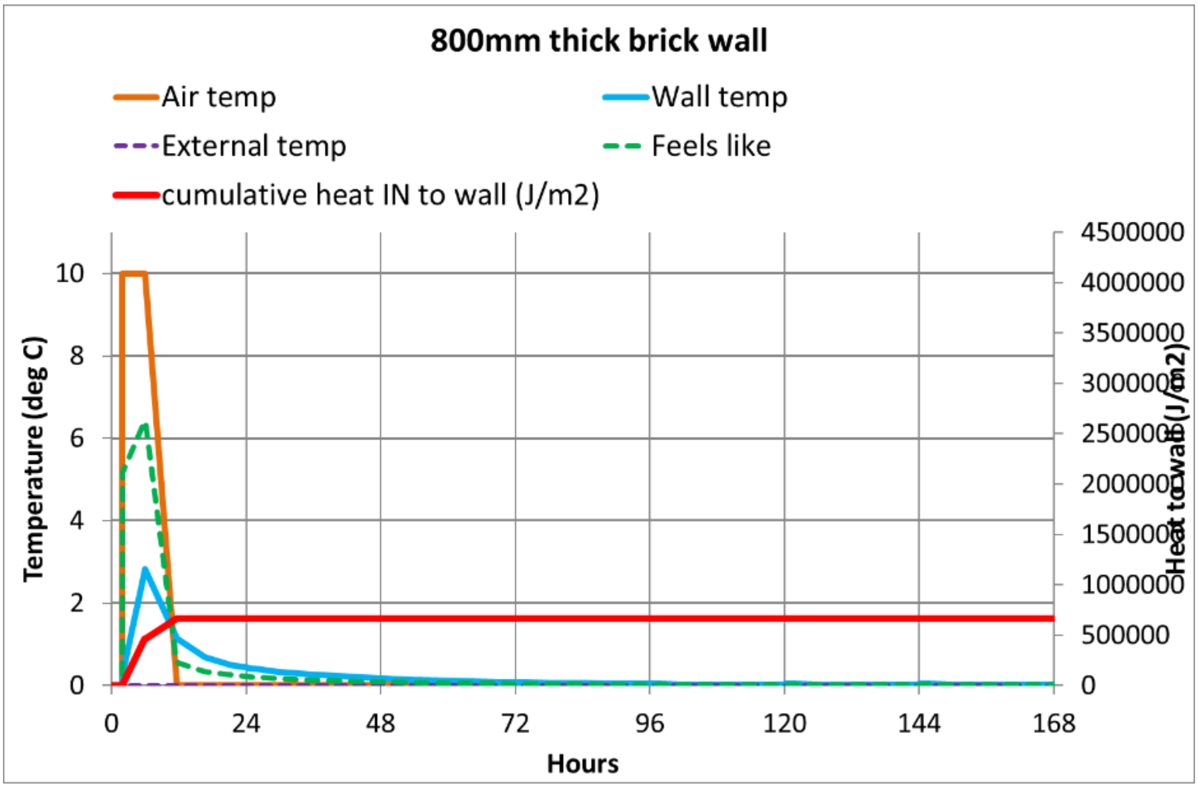
Background heating is used during the heating season, so it is likely that one of the three boilers operates at part power.

The church is estimated to be in use for 950 hours. Assuming that the heating season is 30 weeks, 550 hours of building use require heating. If the boilers were run for this period (with no preheating) and it is assumed they run at full power (to heat the building from cold), this will require 64,350kWh, less than half of consumption. Preheating is always necessary with a space heating system where it takes time for the water to heat, and then warm air rises first to the ceiling.

The large difference between this figure and the actual consumption suggests that savings can be made by eliminating background heating. This and other energy saving options utilising the existing system are discussed in the rest of section 6.

6.4 Discontinue the Background Heating Strategy

The following graphs were circulated to the Church Energy Advisor's Network during 2021. The red line indicates cumulative energy use, and that constant / background heating requires far more heat input than a single heating episode. Churches which are in use on one or two occasions weekly should therefore provide heat only for each event.



Above, one heating episode

Below, background heating

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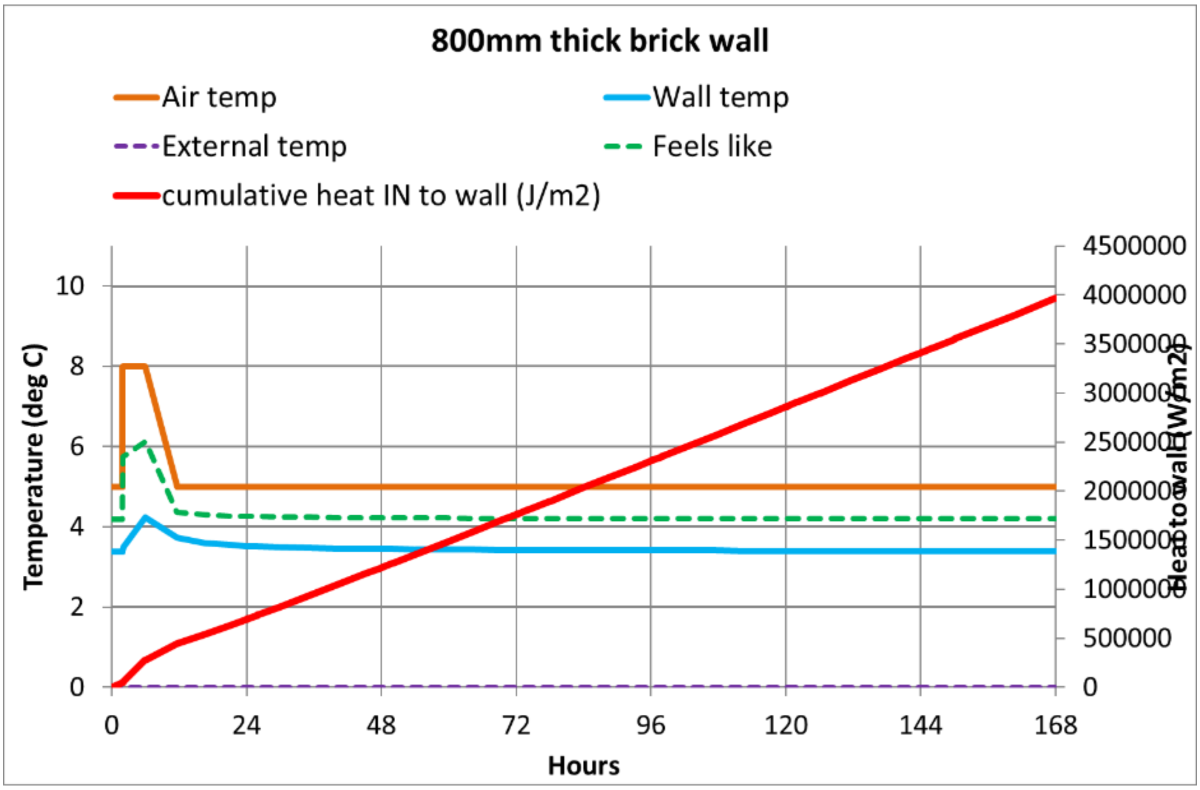


Paper by James Sheehan https://www.cibsejournal.com/general/tidings-of-comfort-and-joy-cost-efficient-church-heating/

Most traditional churches were constructed without any form of heating. The modern additional of heating is not needed to preserve the fabric but only to provide thermal comfort to occupants. The previous trend of 'conservation heating' for fabric issues is now largely considered to be unnecessary and is being avoided by the likes of National Trust and English Heritage. The only times when background heating may be required is if there are historic wall paintings or to for the preservation of large artefacts such as tapestries. The organ (and other sensitive areas such as historic papers stored in the vestry) may require some local background heating specific to that area. In general, sensitive paper records should be removed for storage in the county archive and organs can be installed with a local background tube heater such as https://www.dimplex.co.uk/product/ecot-4ft-tubular-heater-thermostat within the organ casing in order to provide the heat where it is required. The fabric is often subject to the greatest damage by humidity (which is naturally higher when the air is warmer as warmer air has greater capacity for holding more moisture), as a result of large temperature swings (from central heating systems turning on and off) and from the excessive drying out/baking of timbers where high temperature heating units have been fixed to them (such as overhead heaters fixed to timber wall plates)

Providing constant background heating to the church building as a whole is excessive and wasteful of energy. At the very least we would recommend that this background level is reduced to a maximum of 12°C and ideally avoided all together.

6.5 Reducing Heating Energy Consumption

The church is currently heated in constant mode during the winter, but has low hours of use, a maximum of 18 with 8 of these being when the building is open for prayer. Constant or background heating is not recommended since there is a constant heat loss. Specific heating events only lose heat during that heating period. The church has three boilers and several radiators [nave: 10 large, chancel: 8 medium and small, other areas 8], so both heat supply and emission should be high enough to make rapid heating effective. Stopping background heating may result in up to a 50% reduction in gas use. However, the gas use per heating episode will be higher as the starting temperature will be lower. Temperature monitoring at a once per week heated church in Pimlico showed that the temperature did not fall below 12ºC for most weeks of the heating season.

Radiator in nave

- It is recommended that the church purchase a temperature monitor to assist in understanding the system.
- If possible, concentrate winter events on the same midweek day, so residual heat from one heating event can benefit the next (e.g. daytime and evening events on the same day).
- Turning down the temperature (if controlled by thermostat) by one degree saves around 10% of fuel. It is understood that the temperature reaches 18ºC. It is not recommended that it is reduced below 17ºC. [10% reduction]
- Reflective radiator foil should be placed between the radiators and the solid walls (a few radiators are already fitted) [2% reduction]
- There are 10 large radiators in the nave (50% of load), 8 smaller in the chancel (25% of load) and 12 small to medium elsewhere (25% of load).
- Experiment with turning off the chancel radiators. This will produce a temperature gradient along the building which may lead to draughts [reduce from 16 radiators to 10, although this includes the smaller ones [potential 25% reduction *if it works*]
- Turn off the radiator in the pantry area (next to electricity meter and fridge/freezer) [2% reduction].
- Turn off the three radiators in the choir vestry. As the whole building is now planned to be heated for specific events, this area will be cooler. Heating it for short duration events such as by the children's group can be accomplished using electric fan convector heater(s) [6% reduction].

The above energy efficiency measures could save a considerable amount of gas use, particularly switching from constant to "event" heating for which the three boilers giving 105kW output should be sufficient. These changes can be introduced experimentally and reversed if necessary.

6.6 Magnetic Particle Filter

No magnetic particle filter or dirt separator was seen installed within the boiler room.

This device catches magnetic sludge which circulates in central heating systems. It prevents fouling of boiler heat exchangers and blocking of radiator valves, prevents system performance deteriorating and increases system lifetime. If the boiler and radiator system is to be retailed in the medium to long term, a filter should be installed.

7. Future Heating Options

7.1 Key Questions

Establishing a reduced heating requirement baseline of annual kWh use is useful to produce a figure for heat requirement from heat pumps or other forms of replacement heating. This will inform the size of plant required and the capital cost.

The present boilers are at least 13 years old and so are likely to require replacement within the next decade. The church should develop a boiler replacement plan by obtaining detailed quotes from suppliers.

Key questions are "What are the hours of use of the building?" and "Is the present radiator system suitable for heat pump operation?".

With very low hours of use, a large capital expense is unjustified, which supports under pew heating, or sometimes overhead radiant heating. Both of these technologies deliver 1kW of heat for each kW of electricity used.

With high hours of use, obtaining the lowest operating cost per kWh is necessary. This could be achieved using a heat pump system which can deliver 4 or more kW of heat per kW of electricity used. Some systems can also provide cooling.

7.2 Future Heating System Options

The church is currently seated using pews in the nave. There are 28, plus four choir stalls.

If pews are retained, fitting under pew convector heaters is one option.

The hours of use of the church itself of around 18 hours per week may be too low for technical success of an Air Source Heat Pump supplying radiators, or to justify the capital costs of a Ground Source Heat Pump. An Air to Air Heat Pump system, requiring fan heaters to replace some of the existing radiators) is suggested.

The church is recommended to obtain detailed quotes to compare the following options

A] Replace the boiler by a Heat Pump.

B] Install Under Pew electric convector heaters.

Option A is favoured for buildings with high hours of use since heat pumps deliver between 2.5 and 4 times the amount of heat for the amount of electricity they consume, and this will keep operating costs similar to gas. This church has a medium use (18 hours per week), but a high gas use, although this would be significantly reduced if background heating were to be stopped.

Capital costs are highest with a Ground Source system [GSHP] although offering lower operating costs. St James would require an expensive borehole, with the heat pump plant located in the existing boiler room. Air source heat pumps require a location for an external unit which is well ventilated. Both GSHP and ASHP supply warm water at 45 to 50ºC to a radiator network which must have sufficient area to transmit enough heat from the lower temperature water.

It is likely that the existing cast iron radiators will not be considered enough for the large building, so extra radiators may be needed for either of these options.

A third type of heat pump circulates refrigerant rather than water to internal fan units. This system, the Air to Air Heat Pump [AASHP] has begun to be deployed in smaller churches and is also used in church halls and increasingly to heat offices. It employs mature air conditioning technology and can deliver heating and cooling at up to 5 times the electricity input. No laws of physics are broken as heat is removed from a large amount of external air.

Heat pumps are recommended where hours of use are high, if they are compatible with the existing radiator system (or an upgrade of it), or where Air to Air internal units and their pipework can be incorporated. The internal fan units could use the existing radiator locations.

The following options were discussed during the audit but are not recommended:

- Chandelier Mounted Radiant IR Quartz heaters – possible, would be suspended from the roof structure using long cables. Visual glow from elements and localised hot spots.
- Radiant IR roof mounted panels – not recommended as the roof is very high.
- Wall IR roof mounted panels – not recommended, the walls are too far from the nave centre.

7.3 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). 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 systems deliver between 2.5 and 3 times the amount of heat in kWh to water that they consume.

Ground source systems 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^{o}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 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.

7.4 Air to Air Source Heat Pump Details

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.

Four of the small 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. The large units supply three other floors (500m^2) with 75kW output.

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

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.

7.5 Electric Under Pew Heaters

The church is fitted with 28 pews seating the nave including the two side facing and two rear facing seating. If these are to be retained, under pew heating is a straightforward solution which can be applied to all pews, or just a selected number if a congregation is normally small.


Each pew could be fitted with four BN65 650W 91cm length heaters (95cm available between supports), or BN45 450W units.

Using the 650W heaters would require 112 heaters giving a maximum output of 73kW. However, this is above the maximum available from three phases of power delivering a maximum of 23kW each. When lighting and hot water needs are considered, a maximum heating load of under 60kW is sensible

Installed costs (2018 data) for 112 x BN45 at £329 each of £36,848.

The output of 50kW is lower than the figure calculated by model for space heating, 110kW – but the model assumes that heat circulates around the whole building – heat from radiators begins by rising to the ceiling. Heat supplied directly to the congregation does not have to fill the volume of the church first.

System advantages include:

- Individual switching of each unit – useful for small meetings
- The ability to run all units to preheat the building when it is very cold.

Currently the space heating delivers 117kW in total of which around 90% will be to the nave and chancel. Delivery of heat directly to the congregation will require less than space heating. Installing lower power 450W units would give a 50kW output, but for a similar installed cost.

Alternatively a smaller number of 650W units could be used, not installed in every position.

For replacement, two most popular under pew heaters within churches are BN Thermic PH65 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) which are used for the above calculations, or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating.

Cable runs to the pew heaters could run under the wooden pew platforms. All cabling should be in armoured cable or FP200 Gold when above ground. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

The under pew (see photo below) and panel heaters have been recently installed at St Andrews Church, Chedworth, Gloucestershire, GL54 4AJ. The church is open in daylight hours so can be viewed at any time.

7.6 Cost Comparison

Item	Power output kW	Power input kW	Operating cost To supply 100,000 kWh[a]	Capital Cost
Current gas boilers	110	117	£4,990	N/A
Under Pew Heaters (112 units), 450W	50	50	£17,400[b] £4,875	£36,848
Air to Air Source Heat Pump	100	25	£4,350	£45,000
Air Source Heat Pump	100	40	£6,960	£40,000
Ground Source Heat Pump	100	25	£4,350	£100,000

a) This is a reduction from the current annual 146,500kWh gas use costing £7,669 based on assumed savings listed earlier. If these savings cannot be achieved, all operating expenses are increased in proportion by 33%.

b) Direct heating delivered to the congregation rather than space heating will require less heat input. 550 heating hours (7/12 x 950 occupancy hours) x 50kW = 27,500kWh x 17.4p/kWh = £4.875.

Due to the large number of long pews, the capital cost for under pew heaters is approaching that of the air source heat pumps, but with much greater operating costs, which would increase proportionally with increasing hours of use.

If the current cast iron radiators have insufficient area to work with a heat pump, this suggests that an Air to Air Source Heat Pump system is the long term solution.

7.7 Upgrade to 3 Phase Electricity Supply

For under pew heating, the requirement of about 50-60kW is greater than the maximum a single phase of power can provide (23kW).

The church appears to be provided with three phases of power, each to an individual meter, with only one phase being used at present. This should be confirmed.

To be able to have sufficient electrical power to supply enough energy into an electrical heating system the church will need to increase the electrical supply it current has coming in from the existing single phase 100A supply to a 3 phase 100A supply.

The upgrade to the supply has to be carried out by the District Network Operator in the areas.

The DNO in your area is UK Power Networks - www.ukpowernetworks.co.uk; 0800 029 4282 (London, South East and Eastern England)

The cost of bringing in a new 3 phase supply can range from £300 to £30,000 but the DNO will provide a quotation for free so it is well worth obtain a quotation in the short term so that decisions can be made on a well-informed basis.

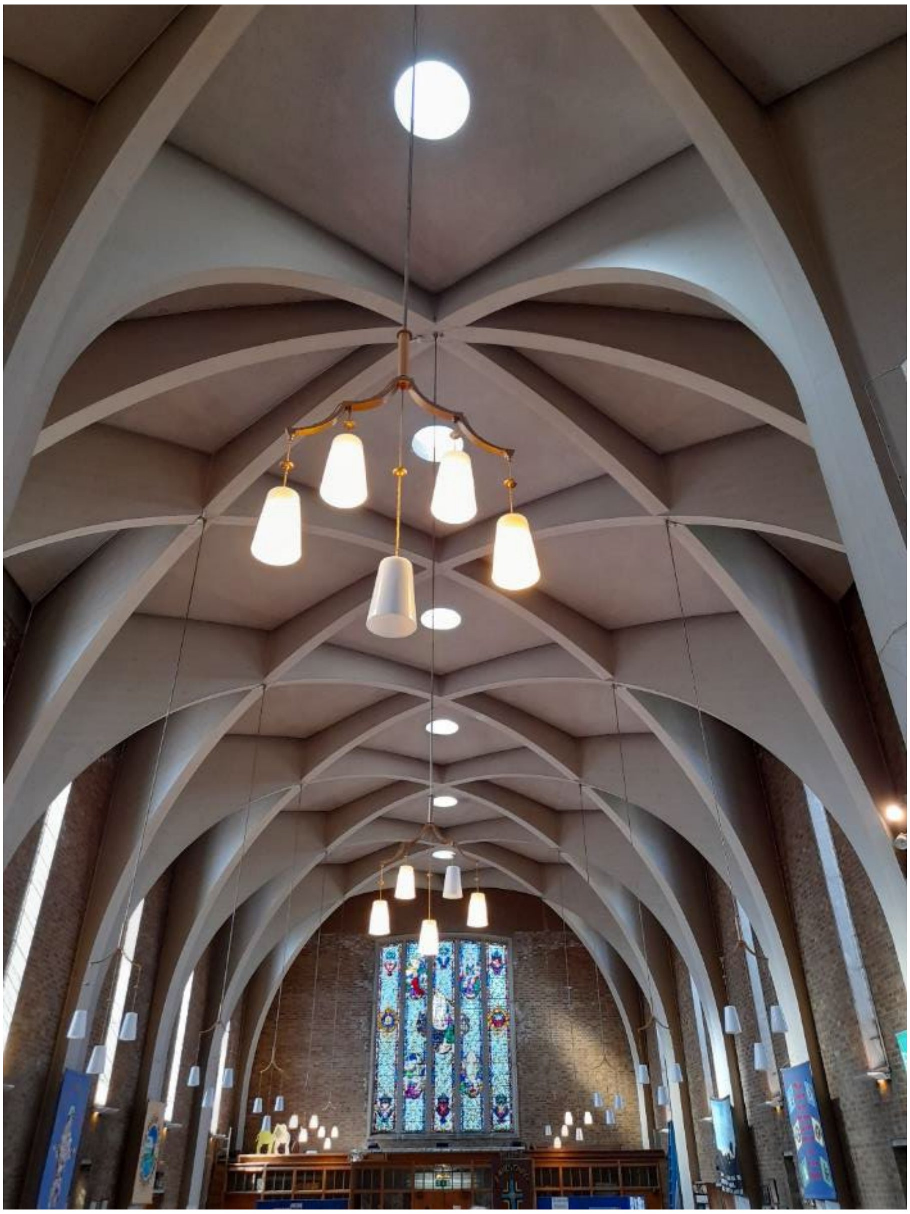
8. Energy Saving Recommendations - Equipment

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 Install LED Lighting

The lighting includes large areas (the chancel) which are lit by relatively inefficient halogen or SON fittings.

It is recommended that the Chancel spotlights (no: 22) which are thought to have 100W halogen bulbs are replaced with LED units, each rated at 15-20W. One of the present spotlights could clearly be observed glowing orange for around 30 seconds after switching off.



The nave pendant lights are mostly 20W compact fluorescent [CFL] “curly” bulbs which should be replaced with the equivalent light output (1200 lumen) LED replacement. Non dimmable bulbs can be fitted; 2700K colour temperature are currently used (warm white).

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/

8.2 Lighting Controls (Internal)

There are several lights in areas such as the vestry and toilet areas and the like which 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. This includes the main body of the church.

It is recommended that a motion sensor is installed on these specific lighting circuits so that the lights come on only when movement is detected in the space and turn off approximately two to five minutes after the last movement has been detected (note that the duration of the time lag after which the light goes off needs to be consider alongside the type of light that is fitted. LED lights are much more suited to being switched off after only a short duration than some fluorescent lights). These movement sensors (commonly called PIRs) also have light sensors integrated into them so they can be used to make sure that the light does not come on if there is already sufficient daylight in the space.

Your existing electrician or any NICEIC registered electrical contractor can install PIR sensors onto existing lighting circuits. This can be carried out without significant disruption to the use of the space.

8.3 Install Reflective Light Pipes in Nave Roof Skylights.

During roof refurbishment, it is recommended to install light pipes in current skylights. This will add a mirrored surface inside the existing cylinder which is around 30cm deep, and bring in extra sunlight.

One company offering these products is Monodraught. Your inspecting architect (or the company involved in roof refurbishment) may be able to source bespoke sized items.

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

For timber doors that close onto a timber frame 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.

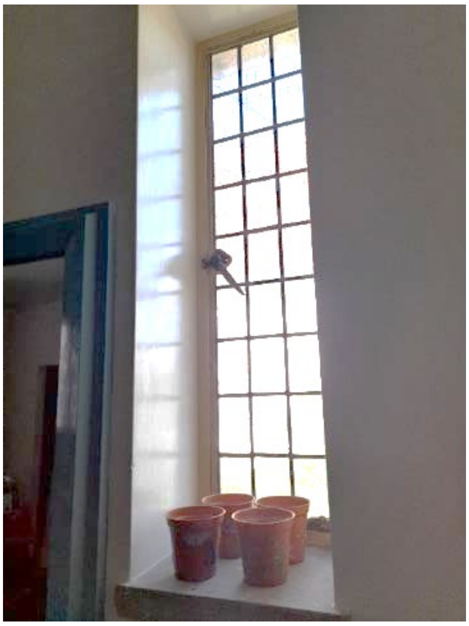
Simple measures such as having a 'sausage dog' style draught excluder laid along the base of a door, using plasticine of the right colour to fill gaps where daylight can be seen and putting painted fridge magnetic over large keyholes can all be simple DIY measures which are effective.

9.2 Windows

Where there are opening lights which do not close completely resulting in draughts, Plasticene can be used to reversibly fill gaps. Any rust or water leakage should be repaired before it causes further damage

9.3 Secondary Glazing

The windows in the vestries which are only occasionally used would benefit from secondary glazing. Permanent installations are expensive at £550/m^2, but 2mm polycarbonate sheet can be obtained and cut to fit, and held in place by adhesive magnetic tape.



9.4 Insulation to Roof

The nave roof is insulated by asbestos panelling. These are planned to be removed during roof refurbishment and replaced by an alternative insulation method.

10. Renewable Energy Potential

The potential for the generation of renewable energy on site has been reviewed and the viability noted.

Renewable Energy Type	Viable
Solar PV	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	Possible
Ground Source Heat Pump	Possible
Air to Air Source Heat Pump	Yes

12.1 Solar Photovoltaic Panels

The large barrel roof, 38m x 12.5m offers an area of around 400m^2.

This could generate 0.15kWpeak/m^2 giving a 60kWpeak system. A 1kWpeak system can generate up to 1000kWh annually, giving a total annual generation of around 10,500kWh.

Current electricity use is around 7,000kWh. A heat pump could use a further 25,000kWh [AASHP supplying 100,000kWh heat]. Much of the heat requirement would occur during winter or evenings, so grid electricity would still be required. If the solar array was sized to provide mid-season electrical heating (it could be run when the sun is shining to store heat in the building fabric, and solar powered summer cooling), this would require an annual generation in the region of 25,000kWh.

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.

	Useable area / m^2	System Size / kW peak	Orientation factor	Shading factor	Annual Generation, kWh
Maximum	400	60	180 degrees / 35^0 1	1	60,000
Optimum	167	25	180 degrees / 35^0 1	1	25,000

The ability of the roof structures to support the extra loads should be discussed with the church's inspecting architect.

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 25 kWpeak system would cost £36,250.

11. Other Items

There is 5cm of water on the concrete floor of the boiler room basement under the redundant oil tank. It is recommended that the church informs its inspecting architect.

There has been previous flooding in the boiler room when the sump pump failed. The water may be:

- Groundwater, from the water table
- From a leaking water supply pipe
- From a leaking drain pipe
- Stormwater run-off occurring if excess water overwhelms the rainwater goods

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.