Energy Efficiency and Zero Carbon Advice

All Saints Church, Loughborough
PCC of All Saints Church

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of All Saints Church, Loughborough 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.

All Saints Church, Loughborough is a Grade I listed church dating from around the 14th century with an additional south aisle added by Scott in 1862, [Historic England reference 1320400]. 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						
Procure utilities from a group purchasing scheme with 100% renewable electricity	Likely 10 to 20%	£250	Zero	Immediate	None	N/A
Door draughtproofing works	3% 3,900	£1065	£200	1	List B	0.71
Install new glass Inner Door	2% 2,600	£710	Unknown	Unknown	Faculty	0.48
MEDIUM TERM						
Install solar photovoltaic panels	40,000 Extra used for heat pumps	£6,000	£58,000	10	Faculty	10.1
LONG TERM OPTIONS						
Install under pew heaters	133,000 gas	greater costs	£49,350	Not recovered	Faculty	24,45 using solar
OR						
Replace boilers with Air to Air Source Heat Pump	133,000 gas	Equal costs using grid. £4,000 using solar.	£90,000	23	Faculty	24.45 using solar

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

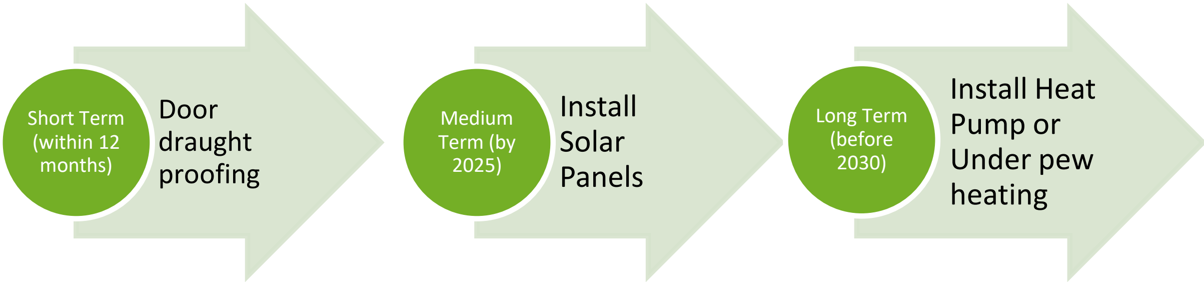
Based on current contracted prices of 15.363p/kWh and 2.665p/kWh for electricity and mains gas respectively.

If all short term measures were implemented this would save the church around £2,000 per year in operating costs. Solar panels have the potential to replace gas costs of £5,000 annually, but there would be a need for grid electricity in the winter.

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 All Saints Church, Loughborough 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 All Saints Church, Loughborough, Steeple Row, LE11 1UX was completed on the 25th May 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 Chris Harvey and Bridget Towle, Treasurer.

All Saints Church, Loughborough	
Church Code	619199
Gross Internal Floor Area	600m^2
Volume	6,500m^3
Heat requirement	214kW
Listed Status	Grade I

The church is typically used for 36 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	11 hours per week	100 main service
Church Meetings and Groups	8 hours per week	20
Community Use	16 hours per week	Orchestra rehearsals weekly Monthly lunchtime concert 4 summer concerts Weekly children's choir Civic Service School visits
Occasional Offices	10 weddings 10 funerals	100 100

Annual Occupancy Hours: 1,900

Estimated Footfall: 24,000

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by All Saints Church, Loughborough and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single / Blended Rate	15.363p/kWh	Below current market rates
Standing Charge	£30.64 Quarterly charge 33.58p/day	N/A

Supplier SSE Business Energy

The current gas rates are:

Single / Blended Rate	2.665p/kWh	Below current market rates
Standing Charge	300p/day	N/A

Supplier Crown Gas & Power, Contract End Date unknown

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 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% normally **One instance of 20%, April 2021 electricity bill**	The correct VAT rate is being applied
CCL	not charged **except month above**	The correct CCL rate is being applied.

The organisation is understood to be a charity and therefore should be benefiting from being charged a 5% VAT rate. A VAT declaration should be sent to the supplier to adjust this.

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

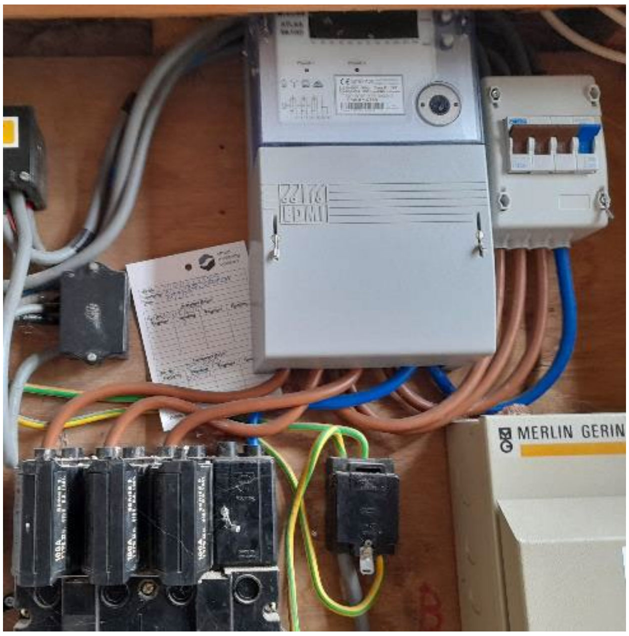
5.1 Annual Consumption

All Saints Church, Loughborough uses around 8,000 kWh/year of electricity, costing in the region of £1,600 per year, and around 138,000 kWh/year of gas, costing £5,000.

This data has been taken from the annual energy invoices provided by the suppliers of the site.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Church	E18UP 16789	EDMI Atlas Mk10D Three Phase	Yes	Kitchen, behind panel
Gas – Church	E040 K02054 16 D6	Elster Themis Bk-G25E	Yes	Trinity Room, cupboard at east end

All the meters are AMR connected and as such an annual energy use profile for the site could be obtained from the supplier.



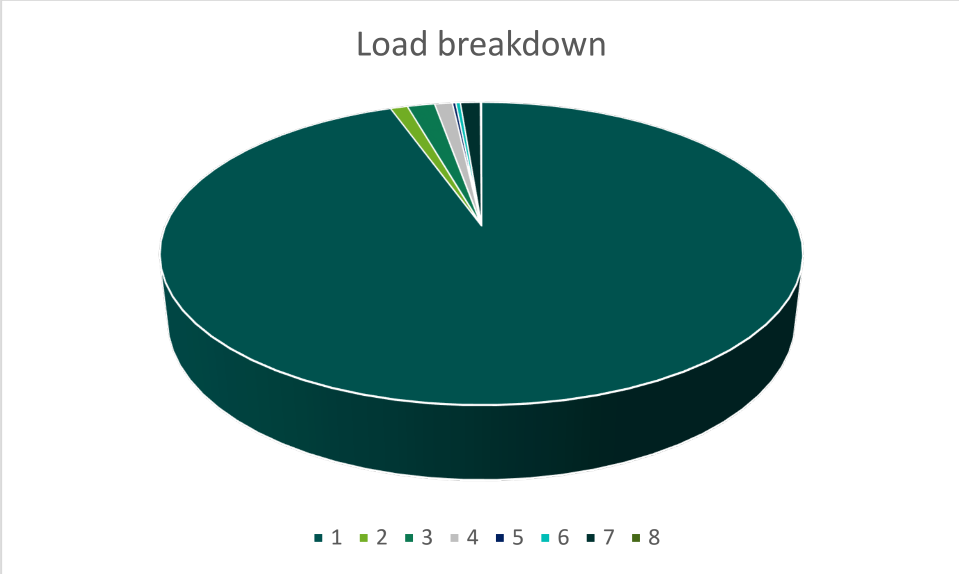
5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	CHURCH 2 X Remeha condensing boilers [A, B] Trinity Room, Kitchen, Hot Water Vaillant Eco Tec Plus 825, installed 2019 [C]		TOTAL 137,740	94.5%
Heating [Electric]	Electric heaters in ringing chamber 3 hours use per week x 30 weeks	6	1,500	1.0%
Lighting [Internal]	CHURCH 1,900 hours use 36 LED spotlights 64 LED pendant 6 LED floodlights Rooms and toilets, c. 500 hours use	1050W 400W	2,000 400 TOTAL 2,400	1.6%
Lighting [External]	6 Floodlights, LED 100W Used from (average) 18:00 to 01:00 daily 3 bulkhead lights, LED 20W	600W 60W	1,500 50	1.1%
Hot Water	Kettle Most HW is supplied by combination boiler B3	3	300	0.2%
Kitchen	Electric cooker Fridge (on constantly) Microwave Oven Toaster	3 0.1 1 3	40 300 10 50 TOTAL 400	0.27%
Sound, Music	Sound system, est 1,500 hours use Organ, est 1,000 hours use	0.5 1	750 1,000	1.2%
Small Power	Vacuum cleaner	1.5	100	0.07%

Sum of estimates: 8,000kWh

Annual site electricity consumption, 2021: 8,000kWh



KEY *1 Gas heating* *2 electric heating (zero)* *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. Floodlighting has the potential for reduction.

5.3 Energy Benchmarking

In comparison to national benchmarks for church energy use All Saints Church, Loughborough uses 30% less electricity and 55% more heating energy than is average for a church of this size.

Longer hours of operation of a large regularly used building contribute to the heating result. A low electricity use is a favourable outcome of installing LED lighting.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
All Saints Church, Loughborough (elec)	600	8,000	13.3	19	-30%
All Saints Church, Loughborough (gas)	600	137,740	229.6	148	+55%
TOTAL	600	145,740	243	167	+45%

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 in the future 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.

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.

In advance of the time when the gas boilers become due for replacement, the church should develop boiler replacement plans by obtaining detailed quotations for the options presented in this report and review these against the changing costs of energy.

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 m³	Insulation Factor kW/m³	Heat Required (Space heating) kW
Church Site	6,500	0.0033	214
Church	6,350	0.033	210
Kitchen Trinity	150	0.028	4

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

The site uses around 138,000kWh of gas yearly. The church is estimated to be in use for 1,900 hours. Assuming that the heating season is 30 weeks, this is 1,100 hours of use when heating is required, although the actual hours may be greater.

It was not possible to determine the power rating of the two boilers. Each were either 31 / 43 / 65 / 89 or 114 kW output (the larger figures are more likely).

Area [boiler]	Estimated split kWh	Boiler power kW	Annual use hours
Church [A, B]	133,000	121 (estimate)	1100
Kitchen Trinity [C]	5,000	30 max 10 used	500

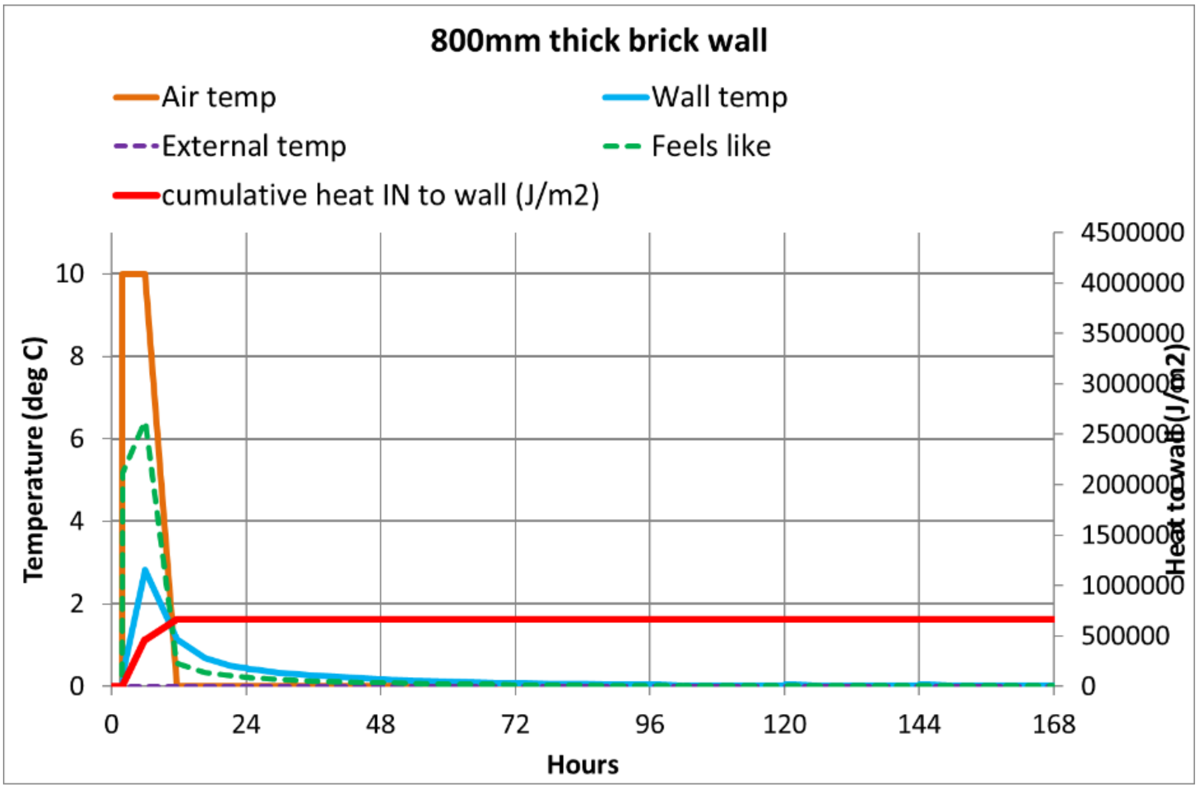
Gas Cost per hour = £5,000p.a. / 1,100 heating hours = 454p/heating hour

6.4 Heating Regime

The church has services, meetings or events held on most days and there are periods, such as in December when the Christmas Tree Festival results in the church being in use for around 11 hours per day for two weeks continuously, then followed by Christmas Services. This will result in a continual requirement for heat, and the building may approach a steady state (rather than one heating event per week).

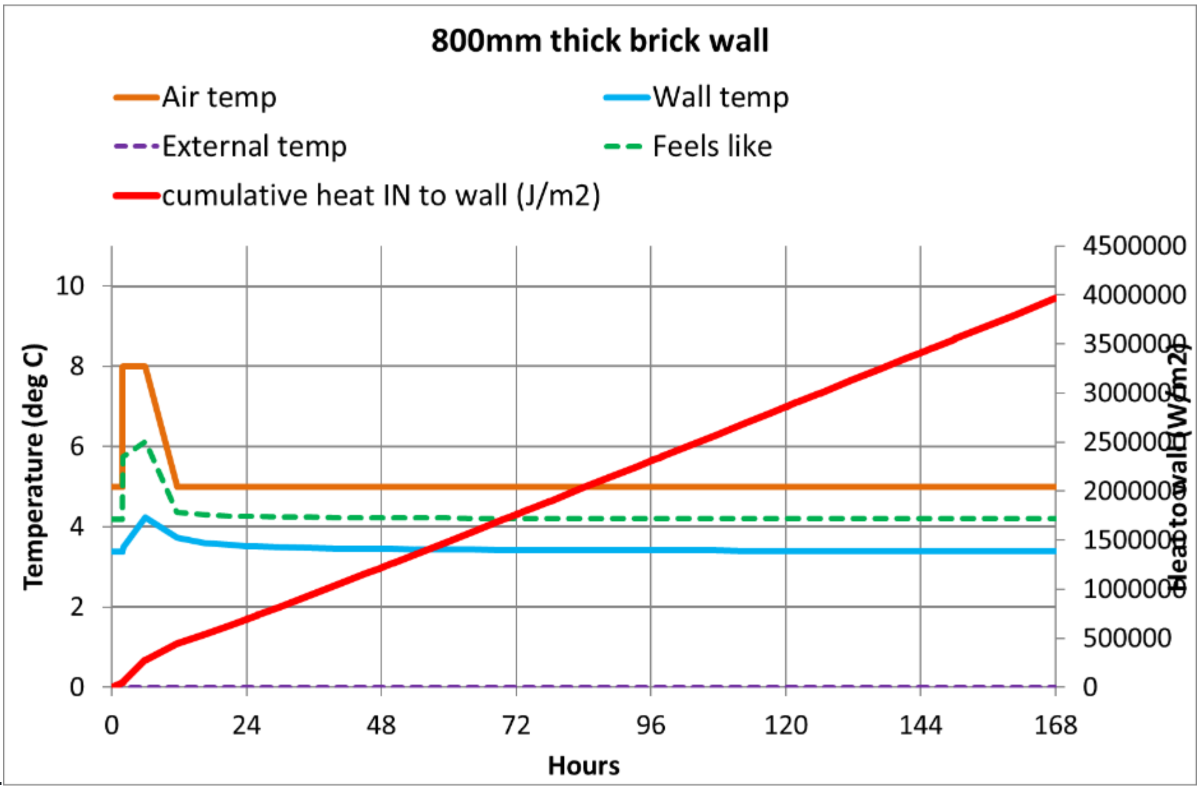
For the “shoulder” parts of the heating season at beginning and end, it is recommended that the church is just heated as required for main services.

The graphs below show that use of constant low level background heating uses much more energy than heating a church from cold. This is most relevant to buildings heated once or twice per week and it is noted that All Saints will have a regular heat requirement at busy periods.



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/

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 Data and Dataloggers

It is recommended that the church purchases a temperature datalogger such as a or similar to understand and hence optimise heating timing.

7.2 Discontinue with Background Heating Strategy

When the church is not in daily use, the heating should only be used as required for events.

Constant heating at lower temperatures followed by warming from, say 14ºC to 19ºC will use more energy than heating from cold (which is often 10 to 12ºC).

7.3 Magnetic Particle Filter

It is recommended that a filter is fitted to the heating system to protect the boilers against sludge which builds up and circulates. This should be in advance of the boiler inlet next to where the blue drain fitting is.

8. Future Heating Options

8.1 Options Overview

The church is seated using pews in the nave. There are 53 pews. Fitting under pew convector heaters is one option, which would deliver heat directly to the congregation and avoid the lengthy preheating which is necessary with space heating at churches which are used sporadically.

As a church with high hours of use, All Saints will store more heat in its fabric and have a higher radiant temperature than a church used only once weekly. A drawback of using any direct electrical heating method is the higher cost per kWh compared to gas, and the longer hours of use required compared to an "average" church, where under pew heating can often be the most cost effective option.

The decorated ceiling precludes the use of high ceiling mounted infra red radiant panels, and the width of the nave precludes wall mounted units.

The nave width also means that arch centre suspended chandeliers carrying radiant quartz heaters would not cover the centre section of the nave, and permission is unlikely for units to be suspended from the nave roof.

Relatively high hours of use mean that the use of heat pumps which deliver more kW of heat than the electricity they consume would lower costs. Whether it delivers lower operating costs than gas will depend on the systems type, plant size and relative costs of the two utilities.

8.2 Under Pew mounted convector heaters

A direct electrical heating method: 1kW of heat supplied per kW of electricity.

This is often the preferred solution for churches with low hours of use which wish to retain fixed bench seating, but as the number of pews and hours of use increases, will become expensive to operate

Only regularly used pews have to be fitted. With a larger installation, only pews in use need the heaters switched on. Alternatively, the whole array can be run to preheat the building in very cold weather. It is likely that All Saints, hosting school and civic events would wish to equip most pews, so a full installation has been costed.

35 solid backed pews of 3.85m (three heaters), 18 pews of 2.5m (two heaters)

Example cost estimate uses BN Thermic BN65 units, 650W, £350 installed cost each

Pew length/m	Number	Units	Total power/kW	Total cost
3.85	35	105	68	£36,750
2.5	18	36	23	£12,600
			91	£49,350

Operating costs: heating for 1,100 hours winter use, all units on = 100,100kWh

At current rate of 15.363p/kWh, annual cost = £15,378. It is very likely that only some of the units would be needed for much of this time.

The output 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.
- Although the heating capacity is less, all of the heat is being delivered where required.

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.

8.3 Enhanced Efficiency Electric Heating: Heat Pump Overview

As the hours of use of a building increase, so do heating costs. Heat Pumps deliver more kWh of heat than electricity used.

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 (usually) with high temperature heating systems. When replacing gas boilers directly, more or 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.

The efficiency advantages of heat pumps mean that in some circumstances they can work out at equivalent or cheaper in operating cost than gas despite the higher cost of electricity per kWh. This effect is increased if electricity is generated on site by solar power.

Air Source and Ground Source produce warm water at around 50ºC and require a network of large radiators to deliver the heat. It is unlikely that All Saints church would be granted permission for the installation of many new radiators and the potential locations are limited.

Five small cast iron radiators are fitted, together with under floor heating pipes.

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.

Air source systems deliver between 2.5 and 4 times the amount of heat in kWh to water that they consume. 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.

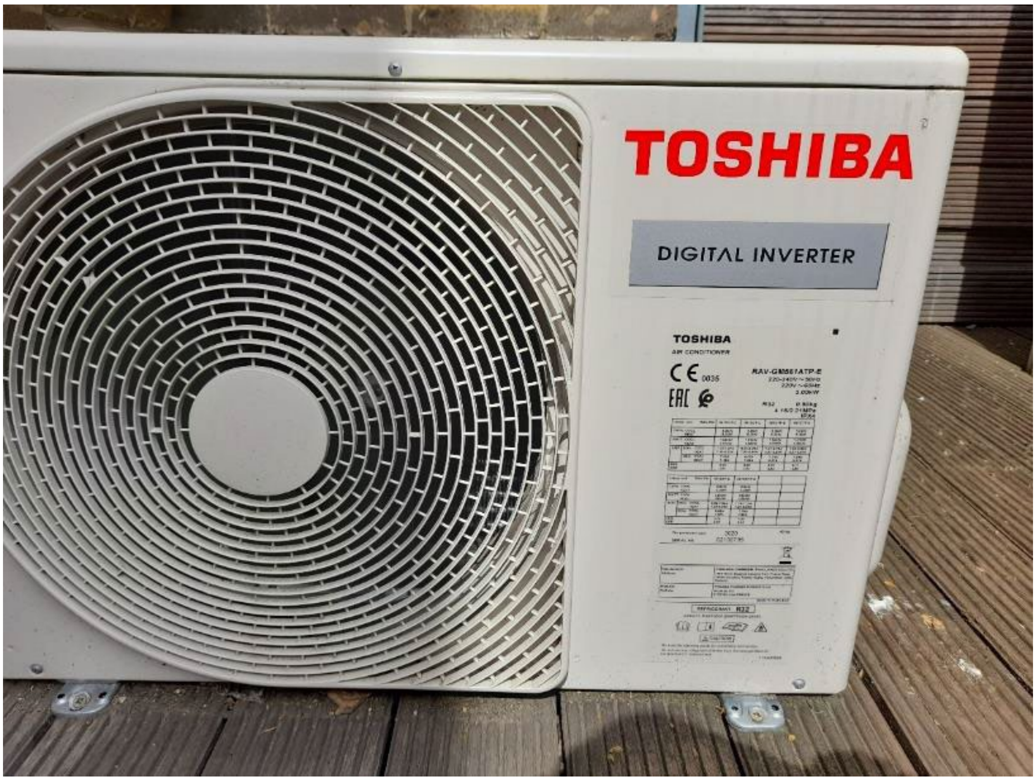
Air to Air Source heat pumps require internal fan units, blowing warm air, connected to external units – they do not require radiators. Systems provide summer cooling as well as winter heating and can deliver **4 to 5 times** the amount of heat which they consume in electricity. They may be suitable for churches which have no pews and no, few or poor radiators.

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.

8.4 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 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 where the current pipe heaters are located. 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 – which could be done by widening the duct immediately under the grilles into the space beside where the pipes run).

Other fan heaters would likely be required above ground, for instance in the present radiator locations and also in difficult to spot areas such as the tower, or corners. The number, location and power of internal units will depend on the manufacturer (there are a wide variety of specifications). Bespoke finishes may be required (i.e. camouflage, not a white finish !).


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. The church perimeter is entirely visible, so changes would be necessary to provide a location for units. Hedge planting has been used to hide oil tanks at some churches. The recessed location of the current boiler room, offers a potential location, but it would have to be open to the air for adequate ventilation.

One option might be to create a lowered space (by about two metres) running west, the width of the north transept, which would include the current boiler room steps area and then shield this from view by hedge planting.

8.5 Air to Air Source Heat Pumps Costs

Pumps to supply 200kW of heat would deliver the same amount of heat annually as the current system.

Operating at a Coefficient of Performance of 4, an 200kW heat output requires 50kW of electricity supply. A single phase can supply up to 23kW, so this is approaching the capacity limit. Given the regular hours of use of the building (especially in December), it may be possible to install plant of a lower power, lower capital cost and run it for longer periods.

This should be discussed with manufacturers / installers.

With the same annual heat requirement, 133,000kWh / CoP 4 = 33,250kWh.

At current cost of 15.363p/kWh = £5,108 which is similar to the current gas cost.

Capital Cost: £450 per kW output = £90,000.

8.6 Cost Comparison

Item	Power output kW	Power input kW	Operating cost	Capital Cost
Current gas boilers	Unknown	Unknown	£5,000	N/A
Under Pew Heaters (141 units)	91	91	Less than £20k (less preheating)	£49,350
Air to Air Source Heat Pump network	200	50	£5,100	£90,000

Heat Pump Heat Pump operating costs are between a quarter and a half of that of under pew heaters (depending on how much pre heating is used).

Capital costs are about double that of under pew heaters.

This suggests a 31 year payback. This would reduce if hours of use of the church increased.

Note that the operating cost of the electrical heating methods will go down with on site generation of solar electricity..

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.

It is expected that gas prices will rise faster than electricity in the short term. Electricity will always be more expensive per kWh, since it has to be generated, but the efficiency advantages of heat pumps generating 2.5 to 5 times the amount of heat in kW compared to the amount of electricity consumed can make the cost equivalent or less. This depends on the two utility tariffs and the CoP of the heat pump system chosen.

8.7 Future Replacement of Trinity Room and Kitchen Boiler

When this unit requires replacement (perhaps in 5 to 10 years), there are two options:

An Air Source heat pump (requiring a location for the external unit and using the existing radiators) – the best option if the area is to be used regularly.

Electric heating by means of infrared panels (better suited to sporadic use).

In both cases, hot water should become provided by an instantaneous point of use heater, not a fixed volume tank.

If the heating power is the same as the current boiler, a 30kW output Air Source Heat Pump operating at CoP 2.5 requires 12kW of electricity.

With the total number of heating hours for each section of the building uncertain, a comparison per hour will be used:

Current costs per hour for gas (assumes boiler operates at full power, which it will when warming the building from cold).

Gas boiler costs	30kW x 2.665p/kWh = 79.95p/hour
ASHP costs	12kW x 15.363p/kWh = 184p/hour

9. 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.

9.1 External Lighting Controls

The external flood lights are currently on from dusk (average around 18:00) until past midnight, possibly 01:00 . 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 the existing timer is adjusted 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 Draught Proof External Doors

The church is planning to add glass doors inside the normally used entrance.

This has the opportunity to create a "draught lobby" if the space is roofed (probably with glass), preventing escape of warm air.

Other doors can benefit from improved draught proofing.

The South West porch door has a visible gap under where the brush draught strip is about 1cm clear of the ground (which can allow leaves to be blown in). It should be refitted lower down or replaced with a longer item.

Little used doors can be draught proofed underneath using a "sausage dog" draught excluder containing some heavy material such as pea gravel.

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.

Using plasticine of the right colour to fill gaps where daylight can be seen and putting a painted fridge magnet over large keyholes can all be simple DIY measures which are effective.

10.2 Windows

Plasticene can also be used to (reversibly) fill gaps. Any rust or leaks should be addressed before more problems ensue.

10.3 Roof Insulation

As part of the planned works to replace the covering of the south aisle roof, it may be possible to install roof insulation, depending on levels and provision for rainwater goods. This should be discussed with your architect

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.

Ceiling insulation for this area of about 100m^2 would cost approximately £950.

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
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	Not for church, unsuitable radiator network
Ground Source Heat Pump	No, unsuitable radiator network, burials
Air to Air Source Heat Pump	Potentially for church

11.1 Solar Photovoltaic Panels

Most of the area of the roof is not visible from the ground apart from the chancel, which has the only pitched roof on the building.

The various sections of roof, offer areas of around 400m^2. This could generate 0.15kWpeak/m^2 giving a 60kWpeak system. A 1kWpeak system can generate up to 1000kWh annually.

The church has previously contacted a solar PV installer and obtained a quotation, identified a location for the inverter (in small first floor 3m x 4m store room). Cabling costs to the distribution board in the kitchen will be high. This board is inconveniently behind a panel which on opening hinges forward over the kitchen work surface. It is suggested that either the kitchen unit or some of the electrical equipment is moved.

The angle of the church roof is approximately 10.

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
Church	400	60	175 degrees / 10^0 0.93	1	55,800

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 (8,000kWh in 2019). If no heat pumps are installed, the system should be sized appropriate for current electricity consumption – just the aisle roof would suffice.

If heat pumps were installed, this would require extra power. With a current gas use of 133,000kWh, if heat pumps achieved an average of CoP 4 this would require 33,250kWh of electricity, so using the maximum possible roof area would oversupply. In practice, detailed installers calculations should optimise the system to generate only the amount which can be used – export to the grid is no longer cost effective.

The system should be specified for future addition of a battery, when battery costs reduce as this would extend system usefulness into the evening. A 40kW peak system is more suitable.

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 40 kWpeak system would cost £58,000.

12. Other Observations

The boiler room steps are hazardous due to a combination of leaf build up, and the urban location leading to the potential for hidden discarded needles, and on the occasion of the visit, a knife. The warden suggested that the council could assist in cleaning.

It is recommended that a waterproof plastic wallet is provided to house the boiler manual before it succumbs to further damp and becomes unreadable.

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.