Inspired Efficiency

Energy Audit and Survey Report

St Lawrence's Church, Hungerford

PCC of St Lawrence's Church

DIOCESE OF OXFORD

"There is a plan to reduce global carbon emissions to net zero by 2050. The plan will work. It involves all of us. We need to begin now, in our homes and workplaces and churches"

Revd Dr Stephen Croft, Bishop of Oxford

Version Control

Author	Reviewer	Date	Version
Paul Hamley	Matt Fulford	11th March 2020	2.0

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1. Executive Summary

An energy survey of St Lawrence's Church, Hungerford was undertaken by Inspired Efficiency 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 Lawrence's Church, Hungerford was constructed in 1814 to a Gothic style, with large windows, apse and a west tower. There is both gas and electricity supplied to the site.

The church has a number of ways in which is can be 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.

Short Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Purchase a temperature datalogger -Heating timing optimisation	5% 8400	£118	£50	<1	None	Warden
Draughtproofing measures	5% 8400	£118	£50	<1	List A	Warden
Replace remaining lighting and flood lights with LEDs	600	£84	£800	9.5	List B	PCC
Purchase a dehumidifier	N/A	0	£200	\	None	PCC

Medium Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Replace Oil boiler with under pew electric heating	50% + 80,000	Equal or higher	£10,000	\	Faculty	PCC
Heat Re-Ordered area using a Heat Pump	N/A	higher	£20,000 to £40,000	\	Faculty	PCC

Long Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Install solar PV panels	9600 for 12kWpeak system	£1,344	£14,400	11	Faculty	PCC

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

Based on the current contracted price of 13.9581p/kWh for electricity and 50p/litre for oil.

If all measures were implemented this would save the church £1500 operating costs per year.

2. Introduction

This report is provided to the PCC of St Lawrence's Church, Hungerford to provide them with advice and guidance as to how the church can be improved to be more energy efficient. In doing so the church will also become more cost effective to run and seek to improve the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Lawrence's Church, Hungerford, Parsonage Lane, RG17 0JB was completed on the 12th February 2020 by Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group developing advice for the Church of England and authored the "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE Associate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church and has been an assessor for EcoCongregation.

St Lawrence's Church, Hungerford	627417
Gross Internal Floor Area	430 m^2
Listed Status	Grade II*
Typical Congregation Size	70 for 10am service

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

Services	8 hours per week
Meetings and Church Groups	4 hours per week
Community Use	4.5 hours per week
Occasional Offices	10 Weddings 30 Funerals

Church annual use = 1200 hours

Heating hours: Church = 2295 hours.

Estimated footfall = 10,800 people to events + 18,250 visitors (door counter, 50 per day)

3. Energy Procurement Review

Energy bills for electricity and oil have been supplied by St Lawrence's Church, Hungerford and have been reviewed against the current market rates for energy.

The current electricity rates are:

Day Rate	13.9581p/kWh	Below current market rates
Night Rate	12.1565p/kWh	Below current market rates
Standing Charge	22.9873p/day	N/A

Currently the church obtains its electricity from the Parish Buying scheme, obtaining 100% green electricity.

The above review has highlighted that the current rates being paid are in line or below current market levels and the organisation can be confident it is receiving good rates and should continue with their current procurement practices.

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.

4. Energy Usage Details

4.1 Annual Consumption

St Lawrence's Church, Hungerford uses 6,500 kWh/year of electricity, costing in the region of £850 per year, and 4,700 litres [168,000kWh]/year of oil, costing around £2,350.

This data has been taken from information provided by St Lawrence's church.

There is one electricity meter, serial number L30C 30689. This is an older type of unit, possibly installed by SSE (it is labelled "Property of the North of Scotland Hydroelectricity board"!)

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

4.2 Energy Profiling

The main energy use within the church can be summarised as follows:

Service	Description	Power	Annual Use/ kWh	Estimated Proportion of Usage %
Oil heating	Firebird Enviromax C73 boiler, Approximately 2295 hours use annually if always operating at full power.	73kW	**168,000**	
Boiler pump	Assume 2500 hours use	200W	**500**	
Lighting	All lighting is reported to be LED. Calculations based on 1200 hours annual use.			
Nave	6 downlights, LED 40W (replaced 600W) 4 uplights, LED 20W 2 spotlights	240W 80W 50W	288 96 60	
	2 Stage lights (occasional use)	500W	10	
Feature lighting	3 x 25W LED, on 12h x 365	75W	328	
Rear	Circular CFL fittings One LED 15W	100W 15W	120 18	
Porch **Lych Gate**	Halogen (low use) Halogen (low use)	80W 80W	40 40	
Outside Floodlights	5 x 250W SON, used December – January, 8 hours per evening.	1250W	600	
	TOTAL		**1600**	
Heating [Electric]	One portable oil filled convector radiator – vestry, occasional use Tower – fan heater, 6 hours per week (x 30wks) **TOTAL**	2 3	60 540 **600**	%
Hot Water	2 kettles, 10 boils per week = 26 hrs p.a. Coffee machine 3 uses per week = ~ 156hrs p.a. Electric Immersion heater (2 hours operation when switch pressed), 3 uses per week **TOTAL**	3kW 3kW 3kW	78 468 936 **1482**	%
Other Small Power **Kitchen**	Sound system (600hours use) Vacuum cleaner (52 hours use) Electric Grille 3 uses per year Fridge AEG 2 toasters @ 1kW Microwave	1kW 1.5kW 3kW 200W 2kW 1kW	600 80 20 600 50 50	%

	TOTAL		**1400**	
Organ	Organ (8 hrs per week) Humidifier for Organ **TOTAL**	1kW 500W?	416 208 **624**	%

Sum of estimated uses: 6224kWh

Total Annual Consumption 2019: 6502kWh

(The difference may be greater use of heating, lighting, or use of power tools).

4.3 Energy Benchmarking

In comparison to national benchmarks[1] for Church energy use St Lawrence's Church, Hungerford uses only 76% of the electricity that would be expected but 2.6 times more heating energy than would be expected for a church of this size.

	Size (m^2 GIA)	St Lawrence's Church, Hungerford use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Lawrence's Church, Hungerford (elec)	430	15.1	20	10	76%
St Lawrence's Church, Hungerford (heating fuel)	430	390	150	80	260%
TOTAL	430	405	170	90	238%

There currently no benchmark data which takes hours of use and footfall into account.

[1] CofE Shrinking the Footprint – Energy Audit 2013

5. Energy Saving Recommendations (Electricity)

5.1 Lighting (fittings)

The lighting is reported to have been changed to LED bulbs for all of the main lighting, which therefore makes up a relatively small overall energy load within the building. The small number of subsidiary lights should be changed to LED and this lighting method used for the re-ordered area.

5.2 Lighting (control for internal lights)

The church is very well lit in daylight, with relatively large main and clerestory windows, therefore the number of lights used to light the church during summer could be reduced by experimentation.

When the church is open for visitors, motion sensors should be used for certain 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 building use.

5.3 Floodlighting

The five floodlights are each sodium SON bulbs of 250W. These could be replaced by LED bulbs of around 100W each, which would cut the current use from 600 to 240kWh.

6. Energy Saving Recommendation (Heating)

6.1 Heating System and Strategy, Carbon Footprint and Costs

The church currently uses oil fired central heating to heat the church. The building records the highest level of 390kWh/m^2 for heating from oil fired churches surveyed by this auditor, which is likely to be due to the large windows.

The kWh/m^2 index does not take occupancy hours into consideration – thus high use churches will be expected to have a higher value. Dividing the figure by occupancy hours gives the average power per area, of 325W/m^2. The range for oil fired churches surveyed is 110 to 510W/m^2.

An important question to be considered is if the use of the main church is intended to increase after re-ordering (in which case it needs a "regular use" heating system), or if non-service activities are to be concentrated in the re-ordered (and thermally separated?) west end, with the church "cold" except for services. The church also needs to consider the implications of the Fifth Mark of Mission; will it consider investment in heating capital and operating costs as a missional activity?

6.2 Oil

The church has experienced difficulties with oil deliveries which can only be made by mini tanker which needs to fit under the entrance gate and drive along the church path to the rear of the building. Oil has the highest carbon footprint of any heating method. The only way of reducing this is to optimise heating timings to reduce consumption. Purchase of a temperature datalogger will allow optimum heating times to be discerned – experiments in the Diocese of Lichfield have shown that the heating system should be turned off 45 minutes before the end of the service to optimise use (the radiators remain warm and continue to radiate heat).

Current Carbon Footprint: 167,576kWh oil x 0.26782kgCO_2/kWh = 44.9 tons CO_2 p.a.

6.3 Gas

There is gas in the village but connection would require around 100m of pipe to be laid at considerable expense across consecrated ground.

Change to gas (and remaining at the same kWh per year) would lower the church's carbon footprint at present by:

- 32% (on a "brown" tariff) as the footprint of gas is less than oil (0.18385kg CO2/kWh) 30.8t CO_2 p.a.
- 45% if a "green" gas tariff was procured (such as available from Parish Buying or Ecotricity which offer 20% renewable gas from anaerobic digestion). 24.6t CO_2 p.a.
- Potentially 60% after introduction of 20% hydrogen into the gas grid (from 2025?). 18.5t CO_2 p.a. only if this technology is introduced.

The above figures may reduce by between 10-20% on reordering if the area at the west of the church is thermally separated, so reducing the volume to be heated. High heat losses from windows and flat roof may mean this is a smaller reduction.

6.4 Space Heating Inefficiency

Thermal Imaging camera image of a convector radiator heating mostly the ceiling. Warm air firstly displaces cold air downwards before eventually arriving at head level. Low level placement of radiators means that radiant heat is blocked by the first row of chairs.

6.5 Direct electric heating

Direct electric heating, ideally by under pew heaters, delivers heat immediately to the congregation.

Will this offer a cut in kWh needed to heat the church?

Not necessarily. For churches which are heated a few times per week and then allowed to cool, It will offer a cut in the number of kWh required, as less preheating is required from electric systems which deliver heat directly to the congregation, whereas central space heating systems begin by warming air which rises to the ceiling, displacing cold air, so several hours of circulation are necessary for warmth to reach the seating level. For such churches, the reduction in kWhours can mean costs are similar or not much more (electricity being about 2.8 x the cost of oil per kWh), with a fall of 50% or more in heating kWh and hence a reduced carbon footprint. Electric heating also allows for individual switching of pew heaters according to demand, or temperature.

But it takes about 24 hours for a church to fall from 20^{o}C to 12^{o}C (less if there are large draughts). So direct electric heating for a constantly / regularly used church where there is less than 24 hours between each heating period will not save kWhours – the church will be at fairly constant temperature where heat in = heat losses. There will no longer be a benefit from avoiding preheating if the church is used often enough that it doesn't cool fully. Hence, because of the higher cost of electricity, with a similar number of kWh required, electric heating will be more expensive than gas.

What could this church expect with a change to direct electric heating (see Section 7 for equipment details):

Energy Consumption and Carbon Footprint

A 40 kW system (PEW AREA ONLY) used for 600 to 2400 heating hours could require 24,000 to 96,000 kWh.

[Currently: 1200 annual church use hours, 800 in heating season. ~ 416 hours annual services.

168,000 kWh oil used; actual heat input at 85% efficiency ~ 143,000kWh

Estimates below are for the entire system to be on, heating under each pew.

Lower use, 600 heat hrs, 24,000kWh: 6.1t CO_2 p.a. (brown tariff), Zero on 100% renewable tariff

Medium use, 1200 heat hrs, 48,000kWh: 12.2t CO_2 p.a.(brown tariff), Zero on 100% renewable tariff

Higher use, 2400 heat hrs, 96,000kWh: 24.4t CO_2 p.a. (brown tariff), Zero on 100% renewable tariff

– The higher use scenario is a similar CO_2 footprint to that achieved by direct conversion to gas when using a "green" gas tariff (estimated at 24.6t CO_2 p.a.) and uses a similar amount of heating hours as at present. Heating hours are *expected* to be less, as there is less requirement to preheat, with heat delivered directly to the person in the pew without being sent to the ceiling first. With 800 hours use in the heating season, adding an extra 50% of hours for preheating this gives the medium use scenario. Churches with electric only heating report between one and two hours preheating, less in the shoulders of the heating season, this might indicate 1000 heat hours. It is not possible to be more specific because there are so many different variables.

The estimates above suggests that direct electric heating for the body of the church is likely to lead to a lower carbon footprint, even with a "brown" tariff. The present "brown" electricity value of 0.25kg CO_2 per kWh will continue to fall as the final 7% of coal in the fuel mix is reduced to zero by 2025; thus electric heating will offer a cleaner and less energy intensive solution than gas or oil. When electricity is procured from a "green" tariff the church will have obtained significant environmental and missional benefits.

Operating Costs

Operating costs of electricity (11 to 18p/kWh, currently <14p/kWh for St Lawrence's) are clearly greater than for gas (2 to 4p/kWh) or oil (4 to 5p/kWh). A reduction in the number of kWh to heat the whole church, as above can be further reduced by only heating occupied pews – this is easily possible with control of each heater at a distribution board and with individual switches under the pews themselves. An example is All Saint's, Hollingbourne, who normally only heat half of their pews.

Estimate	Heat Hours	kWh	Cost, all pews heated At 14p/kWh	Cost, half pews heated At 14p/kWh
Low	600	24000	£3360	£1680
Medium	1200	48000	£6720	£3360
High	2400 (same as Current space heating	96000	£13440	£6720
OIL	2295	167576	£2350 at 50p/litre	Not possible

The west end re-ordered area is *not* considered above and will require separate heating.

6.6 Re-Ordered Area

It is recommended that the re-ordered area at the west end of the church is thermally separated from the body of the church by either a glass or composite glass and wood (with insulated core?) screen, and where there is an opportunity to insulate, this should be taken, to provide a space which can be used frequently. Use of a heat pump will allow the area to be maintained at a warmer temperature than the body of the church. Heat pump running on solar power generated on site during the day, with top up radiant heating to allow for the meeting room area to be warmed rapidly.

It has been noted that there is condensation on the windows in this area. If they are not to be double glazed with internal secondary double glazing, which would be worthwhile in the long term for a space to be used and heated regularly, then a dehumidifier should be used.

6.7 Heat Pumps

Heat pumps work with the existing central heating radiator system, and also with underfloor systems. Therefore, the system will still be space heating, requiring preheating if used irregularly.

The capital cost of a heat pump itself would be of similar order to a boiler but compared to a gas boiler there would be no pipe installation cost. Pumps are most efficient delivering low grade heat (40-50°C) constantly, and inefficient when asked to heat up a large space from cold (as with heating a church once a week). Heat pumps deliver between 2 and 4 times the amount of heat for the electricity which they consume. Heat pumps can become more economic if powered by solar power generated on site.

If the proposal for re-ordering the rear of the church is compatible with a space which can be heated semi constantly, a heat pump / underfloor system or heat pump / large low temperature radiator system is recommended. This could bring the space up to a "middle" temperature of say 15-16°C, with top up radiant electric panels installed in the meeting areas for use just when people are present.

For the main church, a heat pump would have to work very hard to raise temperature from cold to 18°C for a service. Achieving this would require a large heat pump (capital expense) and is unlikely to be justified.

The area immediately outside the space in the church to be re-ordered contains the boiler room. This offers a location for a heat pump.

Air An Air Source Heat Pump (ASHP) could be located within the existing boiler room envelope – it would need to be well ventilated with grilles rather than solid doors provided. An advantage over GSHPs is there is no underground circuit to leak.

Ground Ground Source Heat Pumps (GSHP) are more efficient than ASHP as the average temperature of the ground is higher than that of the air. The capital cost is greater due to the need to install coils or drill a borehole. This part of the churchyard does not have any marked graves, so a GSHP installation may be possible here.

Water The churchyard is immediately adjacent to the Kennet and Avon Canal; offering the potential for a Water Source Heat Pump, an efficient method which has been employed by the NT near Anglesey and the University of Nottingham (Sir Colin Campbell Building). This would involve pipework crossing the land of another owner to reach the canal property so would be complex to organise. The depth of the canal probably precludes installation of a pipework grid, so the system would probably have to abstract water from and return it to the canal. Currently, a section of the canal near Bedwyn has been drained for maintenance. Taken together with the other issues, there are too many issues out of the church's control for this to be viable.

Heat Pump Running Costs

Total space heating use at present; 168,000kWh (2300 heating hours, 1200 use hours)

Rear quarter of church, estimate = 42,000kWh.

Re-ordered area, 6.5 hours use per day = 2400 hours annually. If space heated as at present, this would require ~4800 heating hours or double; 84,000kWh (uninsulated).

With some insulation (limited due to solid walls and listed building environment): 75,000kWh

Air Source Heat Pump at COP of 2.5 requires 75,000kWh/2.5 = 30,000kWh

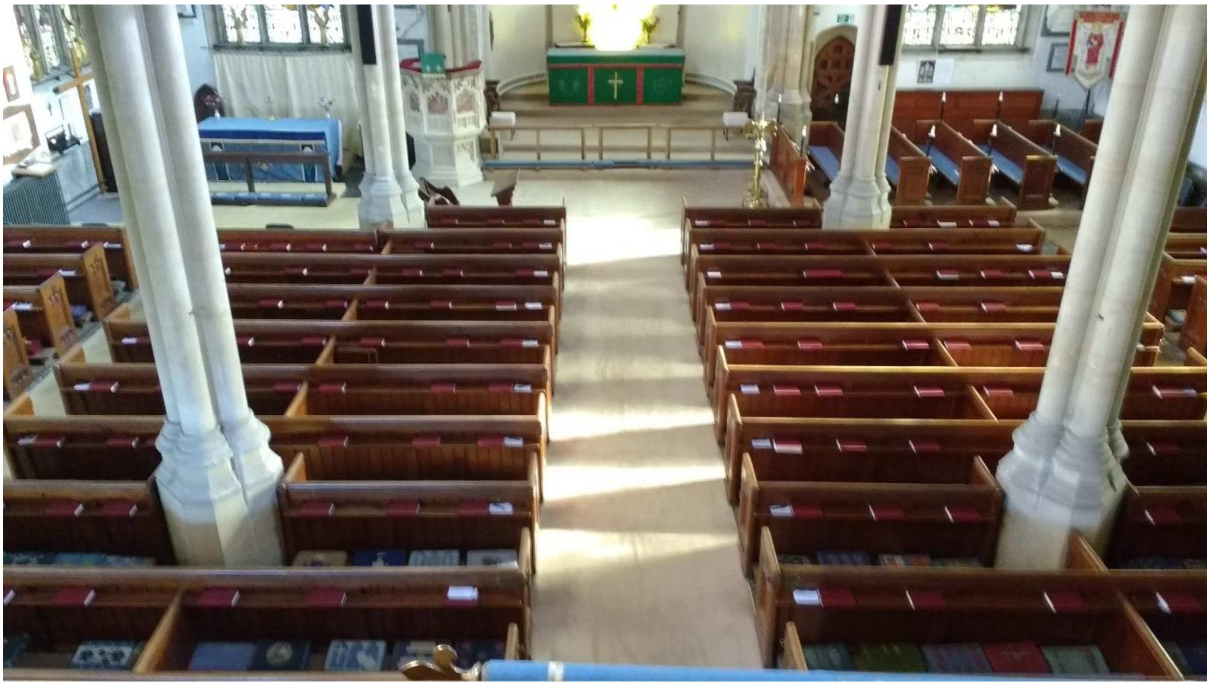
Grid electricity @ 14p/kWh = £4,200 operating cost.

7. Alternative Heating Systems

A church with low hours of use per week will always fall back to "base" temperature between heating events (it may take around 24 hours for the temperature to fall). A system which can heat rapidly, without sending most of the heat to the ceiling first, and in addition can be configured to heat small areas independently for small services or midweek meetings will be more efficient than one which seeks to heat up the whole volume.

7.1 Under Pew heating

It is recommended that under pew electric heating is installed. Although electricity is currently more expensive that gas per kWh, this form of heating requires little preheating time and delivers heat directly to the congregation. From north aisle (left) to south aisle (right), there are 8/10/10/9 pews with a further 6 in the south east corner.



If one heater each is placed under the aisle and corner pews, and on under each of the two sections of the nave pews, this requires 8+19+20+9+6 = 64 heaters.

Heaters with an output of 300-400W seem to be more suitable than 500W models according to reports from different churches.

This would give a heat output of 25.6kW.

There are two types of under pew heater to choose from, convector heaters and radiant heaters.

Heater costs are in the region of £160 per installed heater, giving a cost in the region of £10,240.

Currently, some of the pews benefit from underpew heating from the central heating pipes.

For replacement, two most popular under pew heaters within churches are BN Thermic PH30 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating. Cable runs to the pew heaters could run under the raised wooden platform. All cabling should be in armoured cable or FP200 Gold when above ground.

The under pew convector heaters (see photo below) together with IR 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.

Another option is under pew radiant heaters. The example below is at St Catherine's, Towersey.

https://www.cooltouchheaters.co.uk/about-our-heaters

7.2 Use of Electric Radiant Panels for Heating Specific Areas only

Under pew heating will cover the majority of the nave, but the rear circulating area may benefit from far infra-red radiant panels for use in the coldest periods.   These could be planned for future installation on the nave side of the re-ordered area dividing surface, but not installed unless it is found that the extra heat is needed.

Radiant panels are also recommended as a method of rapidly heating space in the re-ordered area (with a heat pump providing background heating).

Suitable electric panel heaters would be far infrared panels such as https://www.warm4less.com/product/63/1200-watt-platinum-white- . These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch such as https://www.danlers.co.uk/time-lag-switches/77-products/time-lag-switches/multi-selectable-time-lag-switch/159-tlsw-ms so they cannot be left on accidentally.

7.3 Overdoor Air Heaters

In order to achieve the sense of a 'warm welcome' into the church an over door air heater could be provided. This would also help to provide warmth to the rear of the church and supplement the proposed under pew heating.   This would form part of the proposal to create a new entrance lobby.

Such an over door unit should be sized to cover the whole width of the door and it is suggested the BN Thermic 860 model would be suitable. This has a 6kW output.

7.4 Under Floor heating

The church is considering installation of underfloor heating for the re-ordered area, the rear bay of four.

Costs are reported in the region of £1000/m^2, so this option should only be taken for a regularly used building with high footfall.

Visual inspection suggests that this is viable – the floor has an existing wooden pew platform which requires replacement. Underfloor heating requires a vertical space of 150-200mm, which may be accommodated within space under the existing pew platform.

Installing underfloor heating at the rear of the nave (the second bay of four) is questionable as the body of the church will (probably) not incur a much greater period of use. It would be a greater capital expense and double the surface area and running cost. However, if the area, (cleared with the removal of the rear row of pews), was intended for uses such as a toddler group during the week, it would be more viable. It is recommended that the two areas are installed as separate circuits, so the church and reordered rooms areas can be individually heated dependent on the use pattern.

8. Optimising Existing Heating System

8.1 Reduce / Discontinue Background 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.

8.2 Boiler Timing Optimisation

Radiator systems with hot water remain hot for several hours after the boiler is switched off – experiments in the Diocese of Lichfield at over 50 churches have established that hot water radiator heating can be optimised by being switched off 45 minutes before the end of the service

Purchasing of a temperature datalogger will allow the time for the church to heat (in different weather conditions) to be understood, as well as the time to switch off to be optimised. This would require someone with a computer to plug in the device and download the readings.

A suitable model retailing for around £40 is https://www.lascarelectronics.com/easylog-data-logger-el-usb-1/

8.3 Space Temperature Set Point

Use of a datalogger will allow the temperature in the pews to be understood. Aim for 18°C (some churches struggle to reach this with central heating systems, which is one advantage of under pew heating systems. You may find that if the temperature is measured at the ceiling it is above 20°C.

8.4 Boiler Maintenance; Clean / Flush Existing Heating System

To ensure longevity, the system should be periodically flushed and cleaned to remove any scale and corrosion. The church should have a record of when this was done last.

It is strongly recommended that the heating system is cleaned to remove sludge from the system, this is done by using a chemical clean and/or power flush procedure where cleaning chemicals are put into the system which is then turn on and run through a filter consisting of high power magnetics to remove the sludge.

The cleaning of a heating system can be carried out by any competent heating engineer and typically increases the efficiency of a system by between 10 to 15%. This can dramatically improve comfort for the occupants.

8.5 Magnetic Particle Filter

The boiler is not fitted with a magnetic particle filter such as illustrated below. This apparatus catches any rust or metal particles and prevents them being deposited on the boiler heat exchanger. One should be installed if it is planned to continue using the water heating systems long term. Corrosion Inhibitor should also be added to the system when your boilers are serviced annually.

8.6 Endotherm Advanced Heating Fluid

In order to improve the efficiency of the heating system further it is recommended that an advanced heating fluid (http://www.endotherm.co.uk/) is added to the heating system.

This fluid in in addition to, and complements any existing inhibitors in the heating system and is added in a similar way. The fluid works to improve the ability of the boiler to transfer heat into the heating system and for the radiators and other heating elements to give out their heat into the rooms. It does this by reducing the surface tension of the water and increasing its capacity to transfer and hold heat. Case studies have demonstrated that the addition of this fluid into heating systems reduces heating energy consumptions by over 10% as well as helping the building heat up quicker.

Endotherm can be self-installed.

8.7 Insulation of Pipework and Fittings

The boiler pipework is unlagged.

The exposed areas of pipework contribute significantly to wasted heat loss from the system. The exposed hot surfaces also represent a health and safety risk of burns for those working in the area.

It is recommended that the areas of exposed pipework and fittings are insulated with standard pipe lagging for the straight lengths and bespoke made flexible insulation jackets for the valves. These wrap around the various elements but can be removed and then replaced for any servicing activities.

A free survey and quotation for the supply and installation of insulation of pipework fittings can be arranged through ESOS Energy Ltd (contact Adrian Newton 0117 9309689, adrian@esos-energy.com).

9. Energy Saving Measures (Building Fabric)

9.1 Draught Proofing to Doors

There are currently two pairs of doors into the building, creating a draught lobby. The inner doors have a felt covering which offers a good potential to eliminate draughts.

It is planned to create a further draught lobby inside using electrically operated doors. It should be ensured that a draughtproof design is selected.

Draught proofing measures for heritage doors include 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. Note this cannot be used where the timber door closes directly against a stone surround.

Other simple measures such as using a small fridge magnet painted black over the large keyhole or the use of 'sausage dog' type draught excluders at the base of little used doors can prove to be very effective. Doors should be reviewed in daylight and gaps where the light shines through sealed or filled in whatever the most appropriate way is for the specific door.

9.2 Closed Door Policy

The main entry doors should be kept closed in cold or windy weather and quickly closed behind the congregation by your friendly welcome team! An extra draught lobby will solve this issue.

9.3 Windows

If there are draughts caused by opening sections of windows such as hopper windows not shutting correctly, a temporary solution is to use black plasticine to fill gaps.

9.4 Dehumidification

The windows in the north west corner were covered in condensation. A dehumidifier will assist in addressing this issue. It will work more effectively in the smaller space created when this area is re-ordered. Heating will not solve a condensation problem – warm air will absorb moisture and deposit it somewhere else on the coldest surface.

10. Saving Recommendations (Water)

10.1 Tap Flow Regulators

Where there is public access to the toilets in an open church, consideration should be given to fitting tap flow regulators. This is also relevant where children are regularly using toilets.

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

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

11. 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, but fixing issues identified
Battery Storage	Yes, with SPV
Wind	No – no suitable land away from buildings
Micro-Hydro	No
Solar Thermal	No – insufficient hot water need
Ground Source Heat Pump	Maybe
Air Source Heat Pump	Yes
Biomass	No – not enough heating load as well as air quality issues

11.1 Solar PV potential

There is potential for a PV array the almost flat roof of the aisle which is hidden by a parapet.

This offers an area of about80m2. The church has previously considered solar PV, but a fixing solution was not found. Both an initial plan to clamp onto the lead folds, and a proposal to drill into the lead were rejected. Self weighted systems are available and could provide a suitable solution on a near flat roof. A self weighted system on a low pitched roof was used at St Michael's, Withington.

If a heat pump is used then there will be a requirement for around 30,000kWh of electricity annually, an SPV system would provide some of this and make the whole system cheaper to operate in the long term.

The government has advertised a "Smart Export Guarantee" to begin in 2020 which would pay for electricity generated and exported to the grid (the Feed in Tariff having ended). SEG generation payment rates appear to be 5.5p/kWh or less – a third of electricity costs from the grid. Thus, it is advisable that a church should consume all of the solar electricity it generates, rather than exporting.

The relatively flat aisle roof offers an area of around 80m^2. This could generate 0.15kWpeak/m^2 giving a 12kWpeak system. A 1kWpeak system can generate 800kWh annually, giving a total annual generation of 9600kWh. This is greater than the church's annual electricity use (6500kWh) – although some of that use will be during the evening and night. A heat pump will require in the region of 30,000kWh.

If it were also possible to cover half the nave roof (although it appears to be visible), this would give a maximum of around 150m^2 generating 18,000kWh.

Using average 2018 installation costs for larger systems (£1,200 per kWpeak); a 12kWpeak system would cost £14,400, including access at height and cabling. This does not include cost of any battery.

Battery Storage is not strictly a renewable energy solution, but battery storage does however provide a means of storing energy generated from solar PV on site to be able to be used at peak times or later into the day when the PV is no longer generating. It therefore extends the usefulness of the existing PV system particularly in this sort of church. This is a new but fast-growing technology with prices expected to fall substantial over the next 2 to 3 years therefore investment into this may be worth delaying at this stage. (This should not delay investment into PV panels).

Fully detailed PV design and calculations and quotation can be obtained from Batchelor Electrical, contact Stuart Patience on 01202 266212; 07793 256684; stuart@batchelor-electrical.co.uk.

12. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available at https://www.parishresources.org.uk/wp-content/uploads/Charitable-Grants-for-Churches-Nov-2019.pdf

Trust for Oxfordshire's Environment (TOE) does have some funds available (over and above the small implementation grants of £150 available through this scheme) to support energy efficiency improvements in community facilities. If your church is used by the wider community, visit www.trustforoxfordshire.org.uk or contact admin@trustforoxfordshire.org.uk to find out if your project is eligible for a grant of up to about £5,000.

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.

14. Report Circulation

In addition to the PCC, this report is also sent to:

1. Your DAC secretary and your DEO, because
    - They maybe be able to offer you help and support with implementing your audit
    - They want to look across all the audits in your diocese to learn what the most common recommendations are.
2. Catherine Ross and team, the officer in the Cathedral and Church Buildings team centrally who leads on the environment, who wants to learn from all the audits across the country. She will be identifying cost-effective actions churches like yours might be able to make.