ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Hilda's Church, Crofton Park
PCC of St Hilda's Church

Author	Reviewer	Audit Date	Version
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Contents

1. Executive Summary

An energy survey of St Hilda's Church, Crofton 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 Hilda's Church, Crofton Park is an Edwardian era church dating from 1908.

There is both gas and electricity supplied to the site, with the main body of the church being heated by oil.

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						
Switch electricity (and gas) suppliers to ones which provide 100% renewable (or green gas) supplies	None	None	Nil	N/A	None	Offset 0.4 tonnes
Door draughtproofing works	2% of oil 260	£47	£200	4	Faculty	0.17
Install reflective foil behind radiators	2% of oil 650	£47	£50	1	Consult DAC	0.17
Change lighting to LED	6,000	£1,973	£4,000	2	List B	1.3
MEDIUM TERM						
Replace Church oil boiler with Air to Air Source Heat Pump	13,000 oil	£447 Without solar power	£81,000		Faculty	3.5
LONG TERM						
Replace office and under croft boiler with Heat Pump	27,000 gas	Equal or greater costs	£16,100		Faculty	4.8
Install solar photovoltaic panels	Up to 43,000 electricity	2/3 of current consumption£1,300	£58.500 maximum sized array		Faculty	9.0

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

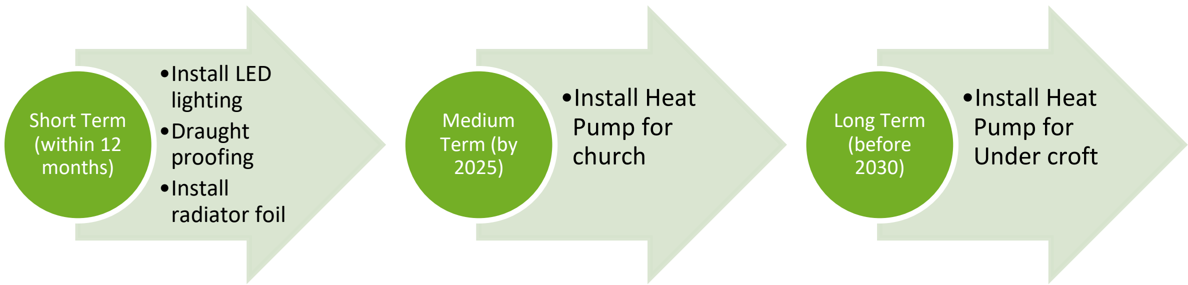
Based on current contracted prices of 32.88p/kWh and 3.02p/kWh for electricity and mains gas respectively.

If short and medium term measures were implemented this would save the church around £2,500 per year in operating costs based on current utility rates.

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 Hilda's Church, Crofton 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 Hilda's Church, Crofton Park, Brockley Road SE23 1PL was completed on the 12th September 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 Christopher Rainsford and attended by Duncan Gregory, Diocese Property Officer.

St Hilda's Church, Crofton Park	CHURCH	UNDERCROFT
Church Code	637267	
Gross Internal Floor Area	680m^2	160m^2
Volume	5,750m^3	700m^3
Heat requirement	190kW	21kW
Listed Status	Grade II	Grade II

The church is typically used for 14 hours per week and the hall for 16 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	6 hours per week	50
Community Use [Undercroft]	70 hours per week	
Occasional Offices	4 weddings 6 funerals	

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Hilda's Church, Crofton Park

The current electricity rates are:

Single Rate	32.88p/kWh
Standing Charge	46.48p/day

Supplier, SSE

The current gas rates are:

Single Rate	3.02p/kWh
Standing Charge	Zero

Supplier; Opus Energy

Going onto a renewable tariff is an important part of the process of taking churches towards net zero. The church is therefore encouraged to consider procuring its electricity from suppliers that offer 100% renewable electricity, and in some cases 'green' or 'carbon neutral' gas.

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

VAT	20% on electricity due to mobile phone installation	The correct VAT rate is being applied. Costs are believed to be recovered in billing the phone company
CCL	Charged with 20% VAT rate	The correct CCL rate is being applied.

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

5. Energy Usage Details

5.1 Annual Consumption

St Hilda's Church, Crofton Park [Church] site used 50,000kWh/year of electricity for the financial year 2021-2022, costing £7,722 for the year. 75% of this use is allocated to the mobile phone installation, so the Church's own consumption was 12,500kWh, costing £1,930.

Oil for church heating used 3,000 litres in 2021, delivering 32,000kWh and costing £2,370.

Gas use for the church was 25,515kWh during 2021, costing £714 for heating the office and under croft which is used daily.

This data has been taken from monthly electricity and gas bills provided by the church.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E12Z 111633	EDMI Atlas Mk10	Yes	image 1 below
Electricity – Crypt	S96D 03707	Single phase	No	image 2 below
Electricity – Mobile Phone installation	?	Iskra	Yes	Image 3 below
Gas – Church	K03524 16 D6		Yes	Boiler room

1 Church meter

2 Crypt meter

3 Mobile phone installation meter

5.2 Energy Profiling

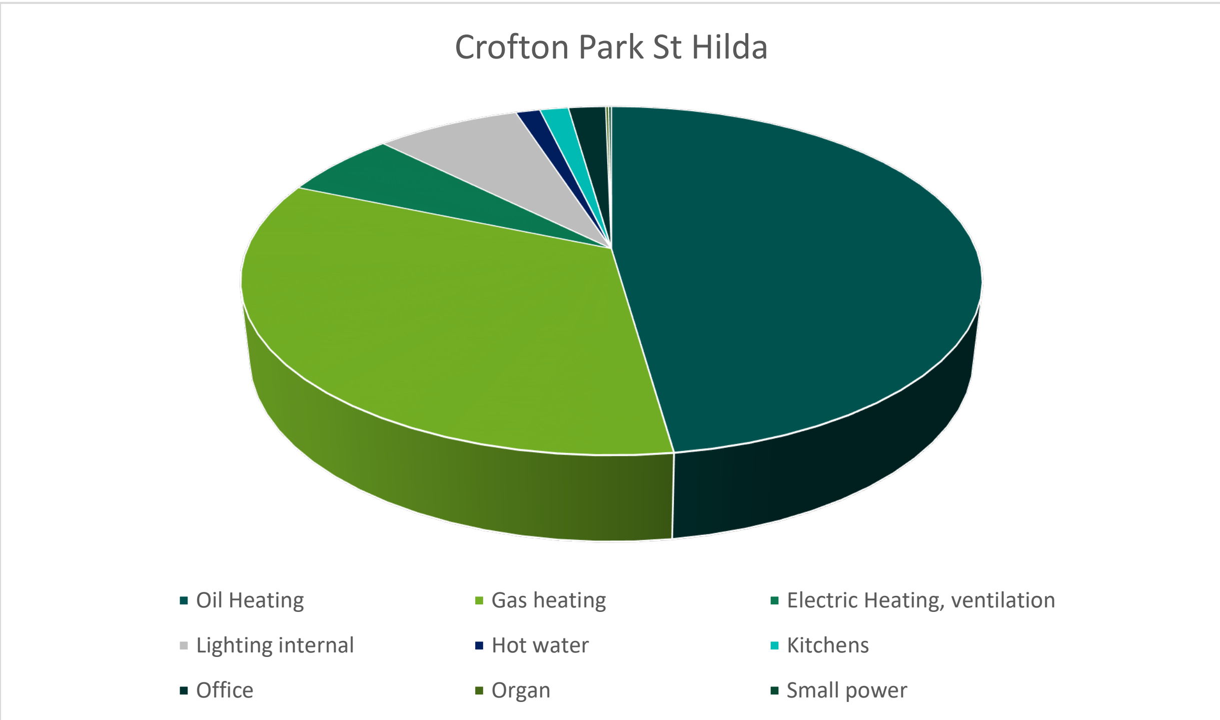
The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating - Church [Oil]	Buderus Sectional Cast Iron boiler 130 hours known use (5 hours per week October to March)	250	32,000	48%
Heating – Undercroft [Gas]	Vaillant EcoFit 830	25	22,500	33%
Heating & Ventilation [Electric]	Boiler circulation pumps Office fan, 15 hours/week in summer Undercroft radiant heaters	0.3 0.2 13	40 60 4,000 TOTAL 4,100	6%
Lighting [Internal]	Church (380 hours use) Kitchen Office Undercroft	8000W 120W 780W 750W	2,000 50 1,000 2,000	

			TOTAL 5,050	7,5%
Hot Water	Fixed water heater, over sink, Heatrae Sadia Kettle Dishwasher, weekly use	3 3 3	200 500 150 TOTAL 850	 1.3%
Kitchen	Microwave x2 Fridge x 2 (on constantly)	1 each 150W each	100 900 TOTAL 1,000	 1.5%
Office	Daily use 4 workstations Printer Server	 800W 500W 100W	 400 200 700 Total 1,300	 1.9%
Sound, Music	Organ	1	100	0.15%
Small Power	Vacuum cleaner	1.5	100	0.15%

Sum of estimates: 12,500kWh

Annual site electricity consumption, 2020: (church only): 12,500Wh (does not include the mobile phone installation).



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 loads arise from radiant electric heating, lighting and the server.

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

The office and under croft, which is used daily, are heated by a 25kW condensing gas boiler. This boiler has been installed relatively recently; when due for replacement a heat pump should be considered.

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 is heated by an oil boiler of considerable age (likely more than 40 years old). The flue pipe appears to have asbestos lining the joints and this material may well be present as insulation in the boiler itself. This boiler is unlikely to be repairable in the event of breakdown due to age and non-availability of spares (for instance, it has a Fahrenheit temperature gauge).

The church should develop a boiler replacement plan, by obtaining detailed quotations for the options recommended in this report.

Church boiler

Office and under croft boiler

The flue joints appear to be packed with a material which could be asbestos, with a length of asbestos (?) rope lying on the floor.

6.3 Site Heat Demand

The Centre for Sustainable Energy model[2] can be used to estimate heat load for the building.

Heat Load (kW) = Volume V (m^3) x Insulation Factor

Insulation Factors

Condition	Factor kW/m^3
Poorly insulated with open or broken windows, draughty doors (add 5%)	0.034
Poorly insulated (assume no interventions)	0.033
Some insulating features	Estimate value
Well insulated	0.022
Insulated to 2010 regulations	0.013

50mm roof insulation fitted = 5% saving on heating expenditure and footprint.

Location	Volume m^3	Insulation Factor kW/m^3	Notes	Heat Required (Space heating) kW
Church	5,750	0.031	Roof insulation	180
Under croft	470	0.028	Part underground	13
Office Vestry	230	0.033		8

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

Location	Heating energy kWh	Boiler power kW	Annual use hours
Church	32,000 oil	unknown	130
Under croft, office	22,500 gas	25	900

6.4 Future Heating Options [Church]

The following options were discussed:

- Underflloor heating

  This system takes many hours (12 to 24) to warm up, so is suitable for regularly used buildings rather than once per week used spaces. Costs are around £1,000/ square metre. Hours of use for the church are considered too low for this method.

- Ground Source Heat Pump [GSHP] using the existing radiator network

  There are four cast iron radiators on the aisle walls plus a further two in the north chapel and two 2.5m pressed steel radiators along the west end of the nave. Together these have insufficient surface area for the warm (about 50ºC), as opposed to hot water provided by a heat pump. GSHP are expensive and a borehole would be required.

- Air Source Heat Pump [ASHP] using the existing radiator network

  As above. ASHP systems need to be run for over around 20 hours per week for technical success (there needs to be enough heat energy in the building to run the pumps in reverse for the defrost cycle). The current use pattern of the main church indicates that a rapid heating system is preferrable to one which requires many hours to achieve a comfortable temperature through space heating.

- Air to Air Heat Pumps [AASHP] with new internal units

  All heat pumps deliver more kW of heat than the electricity they use, resulting in greater efficiencies than for “direct” electric heating methods. As hours of use increase, heat pump viability increases as they offer lower costs than direct electric methods such as convector heaters or radiant heaters by a factor of 2 to 4.

  This is the best option if the use of the main church area increases, offering lower operating costs than “direct” heating with around 4kWh of heat imported for every 1kW of electricity used.
  Internal fan units could be positioned where the current radiators are.

- Ceiling mounted radiant panels

  The ceiling is too high for this method to be effective.

- Wall mounted radiant panels

  Panels mounted on the aisle walls would be too far from the nave centre to be effective.

  This heating method is suitable for heating smaller rooms such as the North Lobby room, which could then be used for meetings of short duration, at short notice. 1kW of heat is provided by 1kW of electricity; this is not recommended for heating large spaces or for long periods.

- Chandelier mounted radiant heating

  Overhead heating units suspended from arch centres could be used to heat the majority of the seated area. There are two different technologies; radiant (glowing) quartz elements attached to hexagonal frames and radiant (non glowing) circular rings, which are black in colour and emit only heat.

  If eight chandeliers were installed each with 6 x 1kW elements this gives a 48kW system – this is lower than the current space heating provision, but the heat provided is immediate and focussed, rather than relying on warm air circulating upwards from radiators to the ceiling then down again.

  This is the best option for a low use building and gives the opportunity to heat for short periods at short notice. 1kW of heat is provided by 1kW of electricity; this is not recommended for heating for long periods.

- Summary

It is recommended that the church considers carefully the hours of use which the nave and aisles are predicted to have.

Radiant (overhead) heating will have a "direct" cost of around 48kW x electricity rate per hour.

Air to Air heat pumps will provide a space heating method requiring a preheating time, as at present. With a system of similar kW output (say 100kW), fan assisted heaters will speed heating time. Heating costs would be 180kW (space heating requirement) / CoP 4 = 45kW x electricity rate per hour with preheating time taken into account.

The midwinter preheating time for the current space heating was reported as around two hours – this is helped by the recent installation of insulation. Fan heaters will reduce this further.

Together with the lower cost per hour, this points towards a heat pump solution being the most favourable. It also offers less visual change.

7. Future Heating Options

7.1 Chandelier Mounted Quartz Radiant Heaters

Chandelier Mounted Radiant IR Quartz heaters – hexagonal frames supporting six 1kW heaters suspended from arch centres. These would align well over most of the current seating area apart from the rear of the nave.

Six units would be suspended from the six arches forming three bays covering the centre of the nave and the aisles.   The narrower rear section of the nave could either have two further chandeliers, or wall mounted far infra-red (not glowing) radiant panels installed.

The rear section is 7.3m wide,   Panels have a range of 3 to 4 metres so the seating areas would be covered. However, it should be noted that the seating positions closer to the panels would be warmer.

8 units x 6 elements of 1kW = 48kW.

Current operating costs are 48kW x 32.88p/kWh = £15.78 per hour

With 130 heating hours as at present (30 weeks of 4.3 hours) this would cost £2.051 saving £319 over the current oil expenditure.

Capital cost estimate at £580/kW x 48kW = £27,840

Air to Air Heat Pumps (below) offer lower operating costs and less visual intrusion so are the recommended option.

7.2 Replace Oil Boiler with an Air to Air Heat Pump System

As hours of use of the church increase, a heat pump system which delivers around 4kW of heat for every 1kW of electricity used becomes more favourable. [Coefficient of Performance, CoP = 4]

Internal units can be located in positions currently occupied by radiators.   These will be fan heaters which produce a small amount of noise.

External units could be located outside the north aisle wall, hidden behind buttresses.   There are ventilation ducts through the walls which could be used to introduce the necessary pipework.

The heat loss model estimates a 180kW heat load for the building. The power of the existing boiler is unknown, but its size suggests it may be around 100kW.   The currently low preheating time for the building – reported as around two hours, and the recent installation of roof insulation are in favour of heat pumps.   A lower power system with lower capital costs but operating for more hours may be preferrable.   For example, a 90Kw maximum output system would halve the capital cost.

<u>180kW system</u> [CoP 4]

Operating costs at current electricity cost rate are 45kW x 32.88p/kWh = £14.79 per hour

With 130 heating hours as at present (30 weeks of 4.3 hours), cost = £1.923 (saving £447 compared to oil).

Capital cost estimate at £450/kW x 180kw   = £81,000

<u>90kW system</u> [CoP 4]

Operating costs at current electricity cost rate are 22,5kW x 32.88p/kWh = £7.40 per hour x double time period = same cost as above, £1,923

Capital cost estimate at £450/kW x kw   = £40,500

7.3 Air to Air Source Heat Pump Details

Air to Air source heat pumps work by having an external unit which sucks air throughout it and extracts the heat from the air. It concentrates this heat and puts it into a refrigeration gas (in the same way as a fridge or freezer works). This refrigeration gas is then piped inside the building in a small pipe where is it then allowed to expand in an internal unit with a fan. This heat is then blown out into the space. This system is identical to an air conditioning system but it works in reverse to heat the space. As warm air is blown into the space this type of system can heat spaces from cold relatively quickly. Air to Air Source heat pumps provide around 4.5 units of heat for every 1 unit of electricity used in the heat pump (it therefore has a Coefficient of Performance (CoP) of 4.5)

Examples of external units for AASHP comprising of three smaller 3kW units (output 10kW each) and two larger 10kW units (output 37.5kW each).

AASHPs require the installation of external units which look like air conditioning modules in well ventilated external locations. These external units will need an electricity supply and pipework running from them to the heating system. They will also need a drain nearby as the back of the units can build up moisture, condensing and sometimes freezing on the coils. The larger units do create some low level noise and therefore the location and baffling of the units may need to be considered carefully.

Internal units come in a variety of styles. The most appropriate internal units for most churches are a floor mounted units which looks very similar to a fan convector heater.

FTXM-R - Wall mount air conditioning unit

Attractive, wall mounted design with perfect indoor air quality. 2 area motion detection sensor: air flow is sent to a zone other than where the person is located at that moment; if no people are detected, the unit will automatically switch over to the energy-efficient setting.

FVXM - Floor Mount Air Conditioning Unit

Designed to fit rooms of any size and shape, it blends well with the interior due to the new design which incorporates more flowing lines and softer edges. These units are ideal when it is not possible to fit a high level wall mount unit for aesthetic or practical reasons.

They are suitable for a wide range of applications including domestic, small to medium offices and commercial uses.

All these units do have a fan element within them and therefore a small amount of fan noise is emitted. This tends to be less than a fan convector heater on a boiler based system as is similar to the noise from a fridge or freezer. Air conditioning units are commonplace in hotel rooms so the noise is low enough to be suitable for sleeping environments.

A case study of a church which has installed such a solution is available at 5. Air-source heat pumps at Hethel Church - All Saints Church, Hethel - A Church Near You

7.4 Upgrade to 3 Phase Electricity Supply

To be able to have sufficient electrical power to supply enough energy into an electrical heating system the church will need a 3 phase 100A supply.

If an upgrade is necessary, this has to be carried out by the District Network Operator in the area.

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 New LED Lighting

The lighting makes up a relatively large overall energy proportion of the electricity used within the church, and large areas are lit by around 30 inefficient halogen 100W fittings across the body of the church. The church lighting is estimated to total 8000W – this could be cut by around 90% by changing to LED units.

The office is lit by twelve T12 fluorescent tubes of 65W each; these are an obsolete and higher power form of fluorescent tube. They could be replaced by LED strip lighting at around 20W per strip. It is recommended that the entire fitting is changed, not just the tube. The present 780W load could reduce to around 200W with LED units.

In both cases the scale of the work and height of fittings will probably require contractors.

In the under croft, most lighting appears to have been changed to LED but there are still some halogen bulbs (of around 70W each) which should be changed to LED and could be done by volunteers. This could be carried out by competent members of the churches internal team, very cost effectively and would be a List A item so no permissions would be required.

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 the under croft for example, which may remain on all the time such as the toilet and corridor areas. Some of these areas are only used occasionally and for a short amount of time and as such, the light does not need to remain on constantly.

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 Power Management Settings on Computers

The computers within the church are used by the staff within the parish office.

All computers can be shut down or put into a hibernate mode, it is recommended that all computer workstations are set to go into hibernate mode after a short period of time of not being used.

This can be set on the computers by going into the Power Options settings on the computers control panel and adjusting the times on the 'change when computer sleeps' option. It is recommended that computers should turn off their display after 2 minutes and put the computer to sleep after 5minutes. Putting the computer to sleep will not lose any unsaved work but will require the user to power up the computer again when returning to their desk. Having shorter hibernate modes not only helps to save energy but also improves security by reducing the time that computers are left on but unsupervised.

8.4 Reflective Radiator Foil

If significant time is likely to elapse before replacement of the current heating system, reflective radiator foil should be installed behind radiators.

The radiators are located on the external, uninsulated walls and have no reflective or insulated surfaces directly behind them at present. They therefore lose much of their heat into the masonry of the wall behind the radiator rather than giving it out into the body of the church.

In order to improve the insulation directly behind the radiators, a reflective panel can be installed. This helps to make sure more of the heat from the radiator goes into the space and requires less overall heating from the boiler to achieve the set point. There are a wide variety of reflective panels for installing behind radiators on the market. It is recommended that these panels are installed behind all radiators within the building

The installation of radiator panels can be carried out by anybody competent in basic DIY and does not require the radiators to be removed.

9. Energy Saving Recommendations – Building Fabric

9.1 Draught Proof External Doors

There are a number of external doors in the church. There are timber which 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 particularly the 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, completed 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.

This door in the basement was allowing traffic noise in so seems poorly seated in its frame – this may be addressed using "E" or "P" cross section rubber insulation seals.

9.2 Windows

Any opening sections should be kept maintained and any rust treated. Rust expands, causing distortion and allowing rainwater to enter and causing more damage. Plasticene can be used to fill gaps and stop draughts.

9.3 Secondary Glazing

Where a room is used regularly and is cold, secondary glazing can be considered. There are three levels of expenditure:

i) Seasonal glazing film, applied with double sided tape by two people.

ii) Polycarbonate sheet, cut to size with a craft knife to fit snugly in the window reveal. This can also be attached to a thin softwood frame if necessary.

Both of the above are temporary and reversible.

iii) Secondary double glazing, costing around £550/m^2. This would require faculty permission

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	No – existing radiators insufficient
Ground Source Heat Pump	No – existing radiators insufficient
Air to Air Source Heat Pump	Yes

10.1 Solar Photovoltaic Panels

The roof offers a length of about 30m and an area of around 300m^2. This could generate 0.15kWpeak/m^2 giving a 45kWpeak system. A 1kWpeak system can generate up to 1000kWh annually.

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	300	45	200 degrees / 40^0 0.97	1	43,650

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 (12,500kWh in 2021) and a maximum load of perhaps 15kW when the crypt radiant heaters are all in use. If no heat pumps are installed, the system should be sized appropriate for current electricity consumption. With regular daily use of the under croft and office, these electrical loads for lighting and office equipment could be met by solar power for much of the year, with a significant contribution towards heating (heat pumps could be run whenever the panels are generating excess power over that required for lights and computers, etc).

It is recommended that heat pumps are installed first; their electricity consumption pattern (especially hours of use in daylight) are understood, and then an appropriate sized solar system can be specified.

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 (£1,300 per kWpeak); a 45 kWpeak system would cost £58,500.

11. 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 .

12. 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.