Energy Efficiency and Zero Carbon Advice

St Paul's Church, Clapham
PCC of St Paul's Church

Author	Reviewer	Audit Date	Version
Paul Hamley	Tamsin Hockett	3rd November 2022	1.0

Contents

1. Executive Summary

An energy survey of St Paul's Church, Clapham was undertaken by ESOS Energy 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 Paul's Church, Clapham was constructed in 1815. The building is divided by walling at the nave/ chancel division. Most of the Romanesque style eastern end is the church hall and in use by a Montessori school during the week. The south transept is a chapel connected to the classical style church.

There is both gas and electricity supplied to the site.

The building 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)
Switch electricity (and gas) suppliers to ones which provide 100% renewable (or green gas) supplies	None	None	Nil	N/A	None	Offset 1.5 tonnes [church], 2.6 tonnes [hall]
CHURCH						
Draughtproofing works	2% 600	£17	£200	12	List B	0.1
Install reflective foil behind radiators	2% 600	£17	£30	2	List A	0.1
OFFICE						
Install reflective foil behind radiators	2% Included above	Included above	Included above	Included above	List A	Included above
Install secondary glazing	10% of office use 1,000	£40	£3,300	Not recovered	Faculty	0.2
Install ceiling insulation	10% of office use;	£40	£300	7.5	Faculty	0.2
Install Air to Air heat Pump	500	£240	£1,800	8	Faculty	0.09
FUTURE OPTION: Instal small solar photovoltaic system to supply heat pump	4,500	£2,200	£5,850		Faculty	0.95

CHANCEL AREA [HALL]						
Replace louvered windows with double glazed units	5% 2,150	£63	£500	8	Faculty	0.4
FUTURE OPTION: Replace heating system with air to air heat pump system	43,000 gas Replace by 11,000 electricity	Extra expense at current rates	£16,650		Faculty	5.4

The church has recently installed new gas boilers. The following options should be considered for implementation when the boilers require replacement in around a decade, or earlier should the gas price increase significantly compared to the electricity price.

Alternative Options	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/yr)
Install under pew heaters (half of pews)	30,000 gas 3,900 electric use	£700 extra, at current rates	£17,500		Faculty	4.6
Install chandelier mounted radiant heating	None, but electricity may be renewable	£6,000 extra, at current rates	£18,000		Faculty	2.4
Install Air to Air Heat Pumps	30,000 gas 7,500 electric use	£2,500 extra, at current rates	£31,500		Faculty	3.8

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

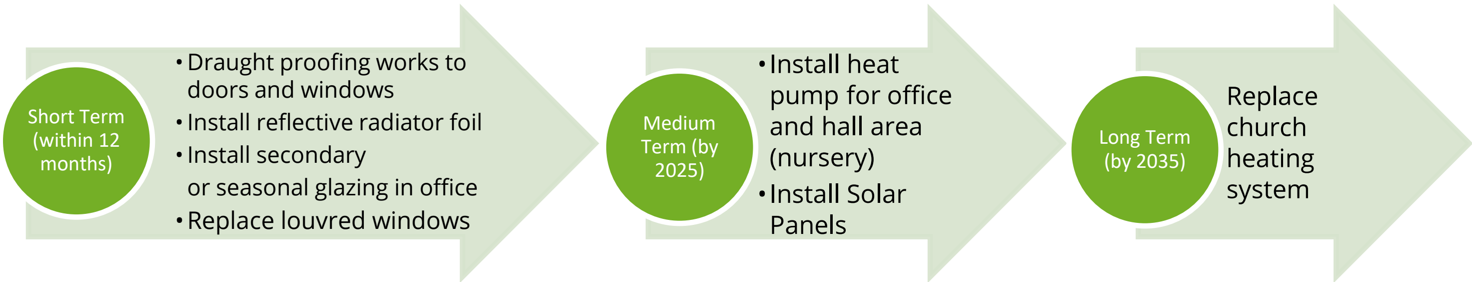
Based on current contracted prices of 49.77p/kWh and 2.93p/kWh for electricity and mains gas respectively.

If short term measures are implemented this would save the church around £420 per year in operating costs.

2. The Route to Net Zero Carbon

The General Synod of the Church of England has indicated that the Church of England should be Net Zero Carbon by 2030. Every church, cathedral, church school and vicarage will therefore need to convert to be a net zero building in the next 10 years.

This church has a clear route to become net zero by 2035 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Paul's Church, Clapham 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 Paul's Church, Clapham, Rectory Grove, SW4 0DZ was completed on the 3rd November 2022 by Dr. Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Church Energy Advisors Network developing advice for the Church of England and authored the "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE affiliate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church and has been an assessor for Eco Congregation.

The church was represented by Allison Clark, Administrator.

St Paul's Church, Clapham	CHURCH	HALL (Chancel)
Church Code	637032	637032
Gross Internal Floor Area	380m^2	145m^2
Volume	2,250m^3	1,120m^3
Heat requirement	74kW	37kW
Listed Status	Grade II	Grade II

The Church consists of the nave plus Lady Chapel in the south transept. The chancel and north transept are separated by a dividing wall and form the hall, used by a Montessori school.

The church is typically used for 12 hours per week and the hall for 53 hours per week for the following activities:

Type of Use	**Hours Per Week (Typical)**	**Average Number of Attendees**
Services	4 hours per week	60
Church Meetings and Groups	4 hours per week	
Community Use	4 hours per week	Monthly concerts Summer opera group
Occasional Offices	4 funerals	
Hall – Montessori school Evening and weekend hires	40 hours per week 13 hours	

Annual Occupancy Hours: Church 660 Hall 2,800 Office 1,000

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	49.77p/kWh
Standing Charge	168p/day

Supplier: British Gas

The current gas rates are:

Single / Blended Rate	2.93p/kWh
Standing Charge	70.29p/day

Supplier: Ecotricity. Contract end date 30/11/2022

The electricity is not purchased on a renewable tariff. 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. The gas supplier already provides a proportion of 'green' or 'carbon neutral' gas.

The above review has highlighted that when the current contracts expire, there will also be opportunities to gain cost savings from improved procurement of the energy supplies at this site using a group purchasing scheme.

We would therefore recommend that the church looks into 100% renewable tariffs and obtains quotations for its gas and electricity supplies from group purchasing schemes such as the Big Church Switch scheme, Charity Buying Group and the Parish Buying scheme, http://www.parishbuying.org.uk/energy-basket.

These scheme offers 100% renewable electricity and a proportion of renewable gas and therefore are an important part of the process of making churches more sustainable.

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

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

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

The hall has had 20% VAT levied on monthly winter electricity bills above 1,000kWh. This is correct if paid by a commercial nursery.

5. Energy Usage Details

5.1 Annual Consumption

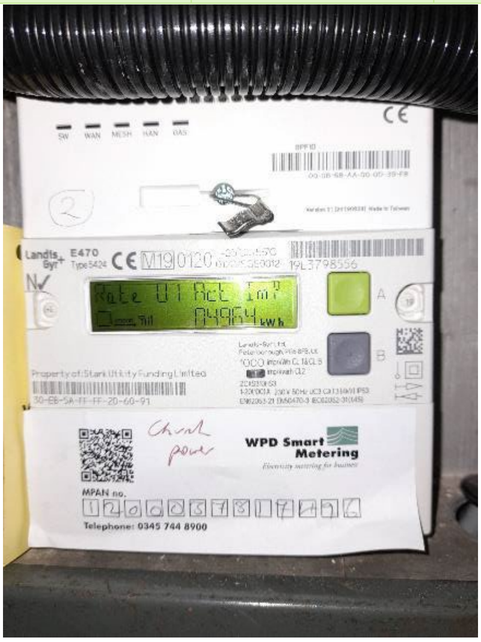
St Paul's Church, Clapham used 1,909kWh/year of electricity over the year from 8 January 2021 to January 2022, costing £467 for the year. 195kWh was for lighting and 1,714kWh was other power.

The hall (for which 5 months data were provided) used around 600kWh over 8 months of the year and 1,200 kWh over the winter months, November to February.   The estimated annual use is 10,000kWh.

Gas use for the church was around 29,708kWh for 2021, (377 days, data from supplier's total), costing £1,199.   Hall gas use was 42,860kWh, giving a site, and building total of around 73,000kWh

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

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Church Lights	19L3798548	Landis & Gyr 5424	Yes	Electrical cupboard inside entrance Right meter
Electricity – Church Power	19L3798556	Landis & Gyr 5424	Yes	As above Central meter
Electricity - Hall	19L3798569	Landis & Gyr 5424	Yes	As above Left meter
Gas – Church		Itron	Not fitted but port available	Above entrance doors
Gas - Hall	E016 K00356 19 D6	Honeywell BkG10E	Yes	East wall of N transept,



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

*The church gas meter (above right) is AMR capable, it is recommended to ask the supplier to add the AMR module; there appears to be an appropriate socket (bottom right of module).

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 Viessman Vitodens 100W of 30kW each [500 hours operation]	60	30,000	94%
Heating [Electric]	Boiler circulation pumps 2 x wall mounted convector heaters in Lady Chapel (use 2-3 hours weekly) Portable convector heater in office	200W 6 3	50 250 500 TOTAL 800	2.5%
Lighting [Internal]	CHURCH 660 hours use. All LED 18 LED lamps LADY CHAPEL 16 LED small + 2 spotlights	108W 120W		

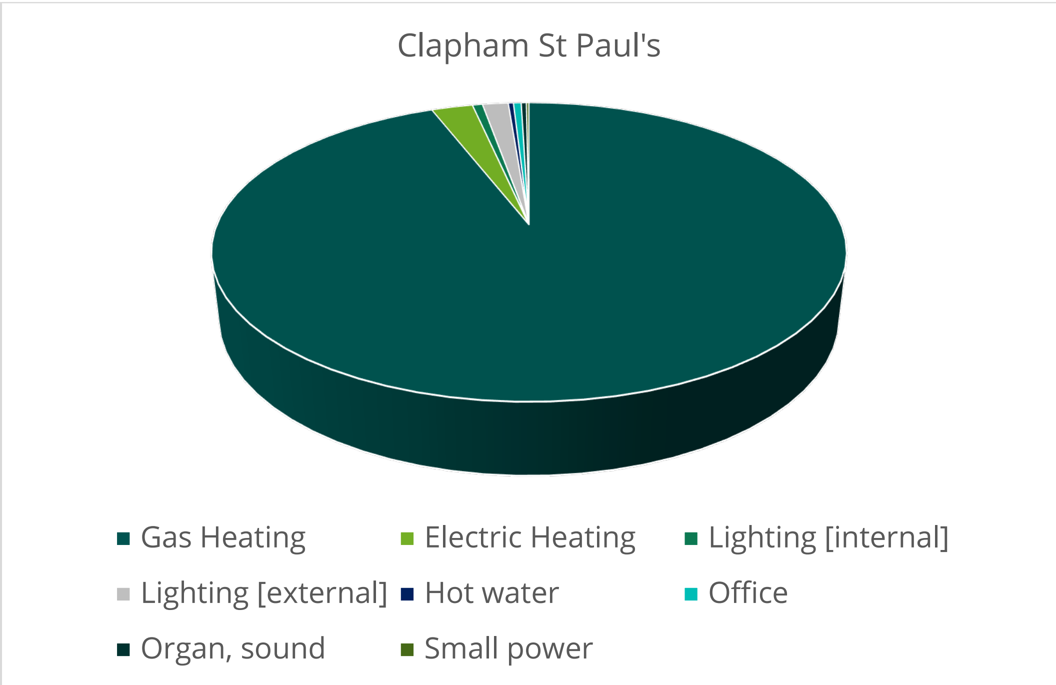
	OFFICE		195 (metered)	0.6%
Lighting [External]	4 Floodlights	400W	500	1.6%
Hot Water	Kettle	*3*	100	0.3%
Office	1 workstation, 20 hours per week Photocopier	150W 500W	100 50	0.5%
Sound, Music	Sound system Organ	0.2 0.5	30 70	0.3%
Small Power	Vacuum cleaner	1.5	50	0.2%

Sum of estimates: 1,900kWh

Annual church electricity consumption, 2021: 1,909kWh

The hall consumption is as follows:

HALL [Nursery use]	Equipment	Power kW	Annual Consumption kWh	Portion
Gas heating	Boiler		43,000	81%
Electricity	Lighting Washing machine Dishwasher kettle		10,000	19%



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 are electric heating and floodlighting.

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 body of the church is seated using pews. Heating is by two recently installed Viessmann boilers giving a 60kW input. This is delivered to four pressed steel and two fan assisted radiators in the nave, a further one at the rear, and one in the rear of nave room. The office has two pressed steel radiators which cannot be operated independently from the rest of the heating.

Installing independent heating and insulation for the office should be completed in the short term.

The church should develop a long term boiler replacement plan, by obtaining detailed quotations for the options presented in this report. Where electric heating can be obtained at similar or lower operating cost, this is recommended. Currently, the contracts involve a high electricity price and low gas price.

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

Area	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Church including Lady Chapel	2,130	0.033	70
Office, kitchen	120	0.033	4
Hall (Chancel, north transept)	1,120	0.033	37

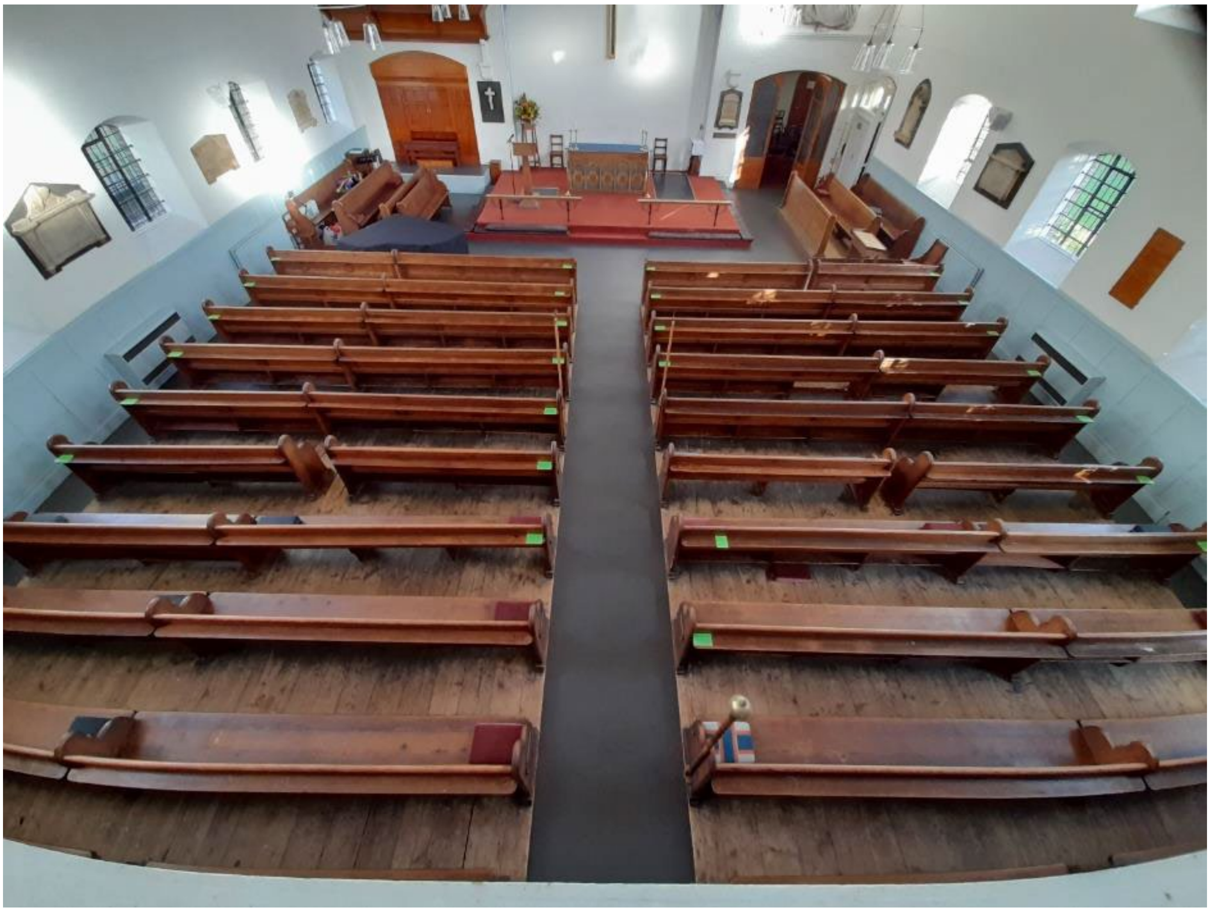
2 www.cse.org.uk/local-energy/download/estimating-the-heat-demand-of-a-hypothetical-community-building-79

6.4 Options Overview – use pattern and seating roof type, building width

The church is currently seated using pews in the nave. The low hours of use of the church itself at less than 12 hours per week is too low for technical success of an Air Source Heat Pump supplying radiators, and too low to justify the capital costs of a Ground Source Heat Pump.

It is recommended that the church develop plans for eventual boiler replacement (probably in a decade's time) and monitor the changing availability and prices of the various options:

- If pews are retained, fitting under pew convector heaters (a lower heat output is required than for space heating).
- Radiant overhead heating using chandelier mounted quartz tubes, or non glowing infra red heating rings.
- Air to Air Source Heat Pumps (70kW output for church).
  These give 4kW heat per 1kW electricity used, but are also a space heating method. Under pew heaters may therefore have cheaper operating costs (for low hours of use); whereas heat pumps are cheaper to operate for regular use.



6.5 Direct Electrical heating methods: 1kW of heat supplied per kW of electricity.

Electric under pew heaters provide a high level of thermal comfort to people sat in the pews. They are not installed to try and heat the entire air volume of the church, instead thermal comfort is achieved through a flow of warm air rising past the person in the pew. This means that the heaters should be installed under the entire length of all the pews that are likely to be used. 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.

These heaters warm up almost instantly and a flow of warm air over the pew area is created within around 15 minutes of their being turned on. This significantly reduces the amount of preheating required before each use of the building and can make electric heating cost competitive with gas. It is important that this reduced 'on time' is properly reflected in any comparisons with other types of heating.

We would therefore suggest that the following works could be considered:

Install under pew heaters, suspended from brackets from the underside of the pew seat as follows:

Full installation,

9 rows x 2 pews of 6m: 10 x 650W heaters in each row between uprights

90 heaters, 58.5kW output. Capital cost (2019 price) £31,500

Operating cost 4 hours x 30 Sundays = 120hours x 58.5 x 49.77p/kWh = £3,494

Partial installation sized to congregation of 60,

5 rows x 2 pews of 6m: 10 x 650W heaters in each row between uprights

50 heaters, 32.5kW output. Capital cost (2019 price) £17,500

Operating cost 4 hours x 30 Sundays = 120hours x 32.5 x 49.77p/kWh = £1,941

Cable runs to the pew heaters should run along the along the existing routes (all cabling should be in armoured cable or FP200 Gold when above ground) to both rows of pews. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

A case study of a church which has adopted this solution is available at https://www.churchofengland.org/about/environment-and-climate-change/st-andrews-chedworth-electric-heating

Photos of installations are shown below.

Brown BN Thermic 650W under pew heaters fixed to underside of pew seats for pews which have no solid backs.

Black 650W Norel under pew heaters fitted to solid pew backs.

6.6 Chandelier Mounted Radiant Infra Red Quartz Heaters

The church is lighted by six chandeliers which align well with the seated area.

Replacing these with larger hexagonal frames bearing heaters and lighting would be an option compatible with pews or loose seating. The visual glow from the elements can be considered unpleasant and there are localised hot spots if sitting under the centre of a heated chandelier. Unlike under pew convector heaters, these units will deliver very little heating of the air.

A recent product is a non-glowing IR ring heater which is a further option.

Capital costs (2019 data); approx. £500/kW. 6 x 6 1kW units; £18,000.

Operating costs are unlikely to be lower than for under pew heaters.

6.7 Heat Pumps: delivering 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).

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 operating cost than gas despite the higher cost of electricity per kWh.

Air Source to water– the low hours of use of the church, around 12 per week are insufficient for this technology. Also, a new installation of larger radiators would likely be required.

Ground source, as above, plus would require a borehole.

Air to Air Source Heat Pump – this requires an external unit (as do all heat pumps), and would be connected to a network of internal fan units which could provide heating or cooling. These could be located in place of the existing radiators.

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.

6.8 Air to Air Source Heat Pumps

Air-to-Air Source Heat Pumps (AASHP) work by having an external unit which sucks air in and extracts the heat from it. The pumps concentrate this heat and put 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 the heat is recovered 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; they therefore have a Coefficient of Performance (CoP) of 4.5.

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, which condenses and sometimes freezes 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.

Examples of external units for ASHP comprising of three smaller 3kW units with 10kW output each and two larger 10kW units with 37.5kW output each.

Internal units come in a variety of styles. The most appropriate internal units for most churches are floor mounted units which look 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 and similar to the noise from a fridge or freezer. Air conditioning units are commonplace in hotel rooms, indicating that the noise is low enough even 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

6.9 Air to Air Source Heat Pumps Costs

A small system to supply the office, with 4kW output would cost £1,800

Operating cost for 20 hours/ week x 25 weeks = 250 hours x 4kW x 49.77p/kWh = £498

The external unit could be located on the flat roof immediately above the office which is surrounded by a 40cm parapet.

Pumps to supply 70kW of heat for the church (with capital cost estimated at £450 per kW output): £31,500).

External units would probably be located on the north side of the building which is less visible.

4.5kW x 1,555 hours = 7,000kWh electricity used annually.

At current costs 49.77p/kWh, annual cost = £3,484 which is similar to a full size under pew installation.

If hours of use increase, the under pew option costs will rise faster.

Air to Air source heat pumps do not require water radiators. An external unit can be connected through the wall, using the existing flue ducts to internal fan units to directly replace the present gas heaters.

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 Radiator Reflective Panels

The church is heated by radiators served from the boiler. These radiators are located on the external, uninsulated walls and have no reflective or insulated surfaces directly behind them at present. They therefore loose much of their heat into the fabric of the wall behind the radiator rather than give out the heat into the body of the church.

In order to improve the insulation directly behind the radiators a reflective panel can be installed behind the four pressed steel radiators in the nave. 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 such as www.heatkeeper.co.uk.

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

8. Energy Saving Recommendations – Building Fabric

8.1 Draught Proof External Doors

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

The external door to the boiler room has a large gap underneath – if this is required to form an air intake for the boilers it will need to remain – though there are air intakes in the north facing wall (below). Otherwise, weighted "sausage dog" draught excluders are recommended.

The internal boiler room door has a draught strip round its edge – this should be replaced with a new strip which seals. “E” and “P” cross section rubber seals will be too thick for the small gap, self-adhesive foam strip may be suitable.

It is recommended that the draughtproofing around other doors are 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 as brush draught strips rebated into the edge of the door by a skilled joiner. Other traditional methods such as using hessian or felt pads tacked to the door could be used and keeping the door maintained in a good condition is important.

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

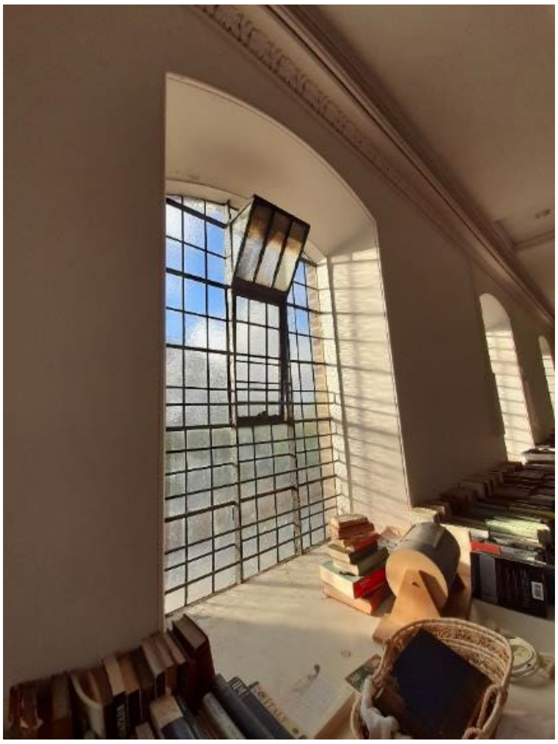
8.2 Windows

The north transept east facing windows in the hall (nursery) area have had hinged slat windows fitted, replacing the originals. These metal framed windows do not close properly and invasive ivy is growing through the windows as a result. It is very difficult to maintain an air tight seal with this type of window and a large amount of cold air will be entering the building as a result.

It is recommended that they are replaced as soon as possible by double glazed units.

The ground floor windows on the south side (above) include two with centre balanced opening sections and the other two with hinged hopper panels. Similar windows are fitted on the north side and the west, accessible from the gallery. The gallery windows (below) were found to be openable but unable to be shut without a gap (left window) / jammed shut with a gap (right window).

The opening frame of the right window below is seen to be corroded.



It is recommended that these are serviced to ensure that they shut properly (which may include removal of rust and excess paint). Corrosion will cause distortion of frames leading to further water ingress. In the short term, before repairs, black Plasticene can be used to fill gaps.

8.3 Secondary Glazing

This costs around £550/m^2, and is only viable where the building is regularly used.

The office and kitchen, used for 20 hours weekly has four windows of approximately 6m^2, so would cost around £3,300 to install and be relatively easy within the deep window reveals.

This cost would reduce long term energy spend on heating this area.

8.4 Seasonal Glazing

Single glazed windows can have temporary secondary glazing installed by use of inexpensive "seasonal" double glazing film. This is cheap, but a two person job to install. Many products seem to be available in 1m wide sheets, so care would be needed to select sheets wide enough for the office windows. Costs of under £50 are expected.

Since this is a temporary installation it should be permissible under List B.

8.5 Insulation to Roof

The ceiling/roof of a building is the largest contributing area to heat loss from a building as heat rises. It is worthwhile for regularly used rooms, in this case, the office. 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.

In this case, panel insulation material is envisaged to be installed from below

Ceiling insulation for an area of 30m^2 would cost approximately £300.

[Cost £9.50/m^2]

9. 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, small array on office roof only
Battery Storage	No
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 – hours too low
Ground Source Heat Pump	No – hours too low
Air to Air Source Heat Pump	Yes, currently for office. Future for church

12.1 Solar Photovoltaic Panels

Most of the roof is visible from the ground apart from the office roof which has a parapet.

This is around 40cm high, suitable to screen solar panels from view.

The office roof offers an area of around 30m^2. This could generate 0.15kWpeak/m^2 giving a 4.5kWpeak system. A 1kWpeak system can generate up to 1000kWh annually, panels could be optimally aligned.

The office annual electricity consumption is around 200kW for computer, photocopier and lighting. A heat pump used for 20 hours weekly x 25 weeks x 1 kW input (4kW output) requires 500kWh. The solar power potential from the office roof is greater than required for the office and potentially enough to contribute to a church sized heat pump system operation. However, most generation will occur when heating and lighting are not required.

It is recommended that funding is spent on other items first, and a solar PV system reconsidered in future if heat pumps are installed.

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
Office	30	4.5	180 degrees / 35^0 1.00	1	4,500

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 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 4.5 kWpeak system would cost £5,850.

10. 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 .

11. 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.