Energy Efficiency and Zero Carbon Advice

All Hallows Church, Whitchurch
PCC of All Hallows Church

Author	Reviewer	Audit Date	Version
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1. Executive Summary

An energy survey of All Hallows Church, Whitchurch 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.

All Hallows Church, Whitchurch is a mediaeval church, extensively restored in 1866 with windows from this date.

There is both gas and electricity supplied to the site.

The church has a number of ways in which it can become more energy efficient. Our key recommendations have been summarised in the table below and are described in more detail later in this report. It is recommended that this table is used as the action plan for the church in implementing these recommendations over the coming years.

Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)
SHORT TERM						
Install smart meters	None	None	None	N/A	None	None
Change porch floodlight lamp to LED	65	£10	£10	1	None	0.01
Draughtproofing	1%, 580	£19	£20	1	None	0.1
MEDIUM TERM						
Install radiant infra-red panels in Welcome Area	N/A	N/A	£2,240		Faculty	
Replace boiler with Air to Air heat pump	58,000 gas 14,500 electricity used	Currently £420 more at low gas cost rate	£43,200		Faculty	7.38
LONG TERM						
Install solar photovoltaic panels in roof valleys	6,300	£1,000	£11,600	12	Faculty	1.33

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

Based on current contracted prices of 16.9321p/kWh (day), 15.1781 (evening and weekends) for electricity and 1.779p/kWh for mains gas respectively.

If all measures were implemented this would save the church around £600 per year in operating costs (with current electricity and gas rates applying).

2. The Route to Net Zero Carbon

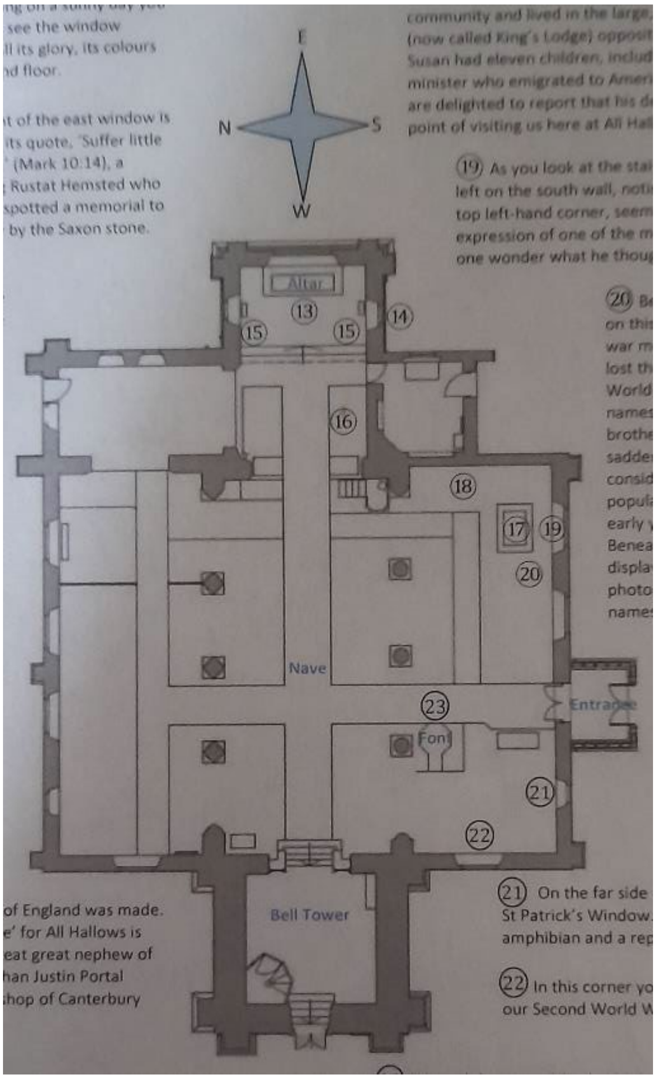
The General Synod of the Church of England has indicated that the Church of England should be Net Zero Carbon by 2030. Every church, cathedral, church school and vicarage will therefore need to convert to be a net zero building in the next 10 years.

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

Short Term (within 12 months)
- Complete LED lighting
- Draught proofing

Medium Term (by 2025)
- Install infra red panels for Welcome Area
- Install Heat Pumps

Long Term (before 2030)
Install Solar Panels



3. Introduction

This report is provided to the PCC of All Hallows Church, Whitchurch to give them advice and guidance as to how the church can be improved to be more energy efficient. In doing so the church will also become more cost effective to run with improvements in the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the All Hallows Church, Whitchurch, Church Street RG28 7AS was completed on the 21st October 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 John Mariner.

All Hallows Church, Whitchurch	CHURCH
Church Code	641160
Gross Internal Floor Area	375m^2
Volume	2,900m^3
Heat requirement	95W
Listed Status	Grade II*

The church is typically used for 11 hours per week for the following activities. A large proportion of use is from weddings and funerals.

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	3 hours per week	65
Community Use	4 hours per week	Growing use for concerts and events
Occasional Offices	20 weddings 10 funerals	100 100

Annual Occupancy Hours: Church 570

4. Energy Procurement Review

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

The current electricity rates are:

Day Rate	16.9321p/kWh
Evening & Weekend Rate	15.1781p/kWh
Standing Charge	77.3615p/day

Supplier: Total

The current gas rates are:

Single / Blended Rate	1.779p/kWh
Standing Charge	242p/day

Supplier: Total

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

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

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

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

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

5. Energy Usage Details

5.1 Annual Consumption

The reported electricity consumption for 2021 consisted of eight months of estimated bills, and one customer reading. This reading gave rise to a jump of 14,000kWh, around two years consumption at the supplier's estimate for each month, costing £2,040. [It suggests that the meter had not been read since before the pandemic]. It is recommended that the church read and report meter readings monthly. The meters appear to be Smart meters – it is possible that they are out of range and not connected to a network or the information is not being processed correctly by the supplier. [Another church has reported a similar problem, it is recommended that you report this to your supplier].

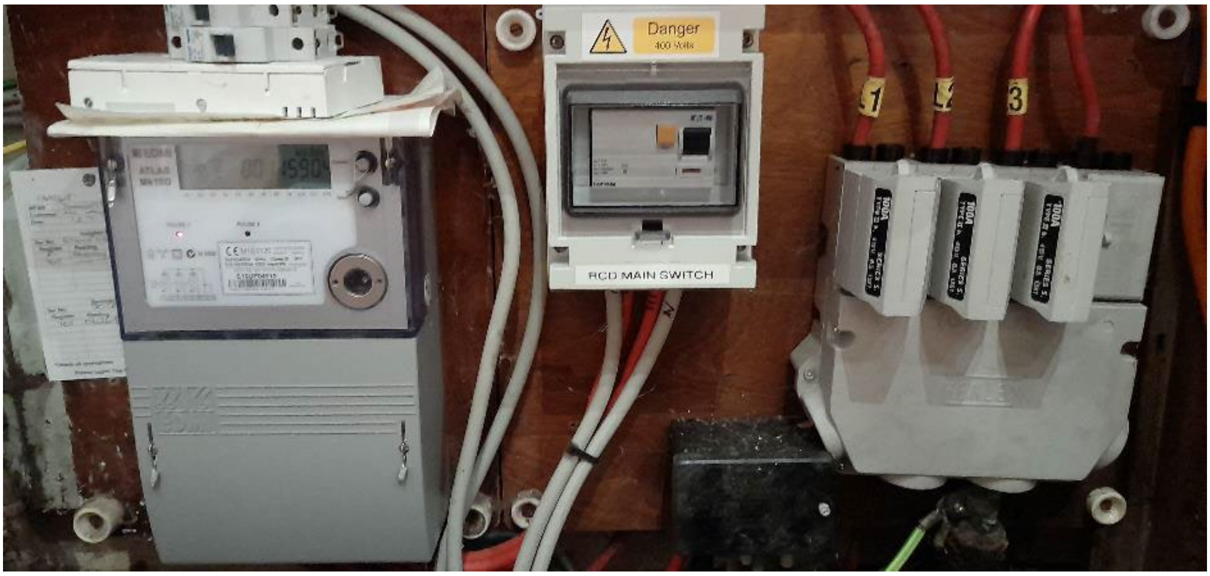
Based on the supplier's monthly estimates, All Hallows Church, Whitchurch uses 5,800kWh/year of electricity, costing in the region of £1,000 per year for the whole site including the hall and office.

58,000 kWh/year of gas is used, costing £1,900. The total carbon emissions associated with this energy use are 11.7 CO_2e tonnes/year.

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

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Church	E16UP 04915	EDMI Atlas Mk10D Three phase	Yes	Tower electrical cupboard
Gas – Church	K03867 14 D6	Bk-G10E Metric	Yes	Boiler room

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



5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

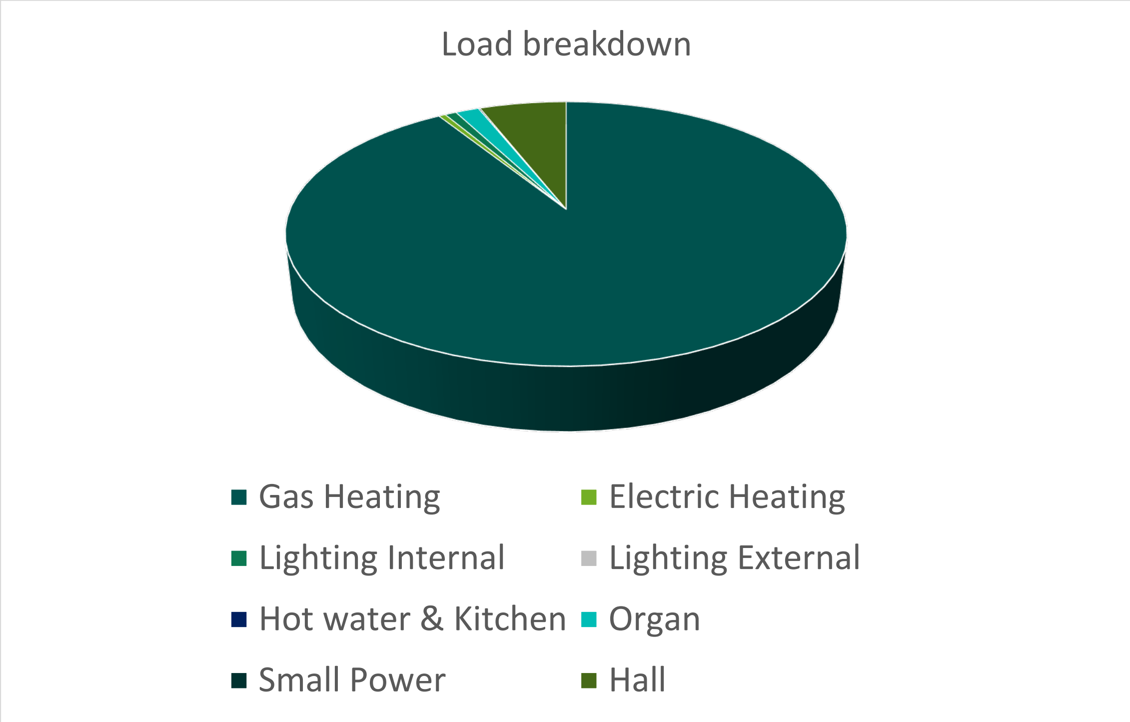
	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	Remeha Quinta Pro 65, 62kW output [890 hours operation]	65	58,000	91%
Heating [Electric]	Boiler circulation pumps	350W	300	0.5%
Lighting [Internal]	CHURCH 570 hours use 55 LED lamps, chandelier mounted 5 LED up lights, chancel windows 1 x PAR 38 spotlight (organist) 1 x R7S floodlight, porch	330W 140W 100W 250W	Subtotal 430 70 TOTAL 500	0.8%
Lighting [External]	None currently [security and path lighting recommended by QI]	0	0	0
Sound, Music	Sound system Organ – used for up to 20 hours per week for daily practice	0.2 1	30 1000	1.6%
Small Power	Vacuum cleaner	1.5	100	0.2%
Hall, Office	*Office used two mornings per week, one workstation plus lighting* *Hall lighting, nursery use 3 days per week*	*300* *Unknown*	*200* *3,600*	5.9%

Sum of electricity use estimates (church) : 2,000kWh

Hall useage: 3,800kWh

Annual site electricity consumption, 2020: 5,800kWh

It was not possible to visit the church hall and office complex which were in use by a nursery.



As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site. Hall electricity consumption provides the other significant load.

5.3 Energy Benchmarking

In comparison to national benchmarks[1] for church energy use, All Hallows Church, Whitchurch uses 19% less electricity and 4% more heating energy than is average for a church of this size.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
All Hallows Church, Whitchurch (elec)	375	5,800	15.4	19	-19%
All Hallows Church, Whitchurch (gas)	375	58,000	154	148	+4%
TOTAL	375	63,800	169	167	+1%

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

[1] CofE Shrinking the Footprint – Energy Audit 2013.

6. Efficient / Low Carbon Heating Strategy

6.1 Overview

All Hallows church is a mediaeval building, restored in the Victorian era, and is currently seated using pews. It is the largest public space in the town of Whitchurch (population 6,800). The church desires to increase community engagement and has already begun hosting concerts. It's vision is to re-order the building by removal of fixed seating in the body of the church, and in the chancel (to create performance space). The area to the rear (west) of the south aisle adjacent to the entrance porch is the Welcome Area; this is intended to be developed with further comfortable seating to provide a space for small impromptu meetings of up to 8 people.

The re-ordering is expected to occur in 3-5 years time.

The church is currently heated by a gas boiler which should be capable of providing heat until the re-ordering process.   It supplies only seven cast iron radiators, of which only one is located in the nave.

6.2 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.

6.3 Forward Planning

Whilst there are plans to add hydrogen to the network, and "green" gas from anaerobic digestion; some suppliers offering up to 20% "green gas" tariffs, the majority of the gas supply will continue to be fossil fuel for the next decade. The economics of hydrogen production and the need to replace some pipework make full decarbonisation of gas unlikely.

The church should develop a boiler replacement plan, by obtaining detailed quotations for the options presented in this report. Where electric heating can be obtained at similar or lower operating cost, this is recommended.

6.4 Strategy

The church building is currently used for 11 hours per week. This is considered insufficient to justify the expense of installing (at ~ £1,000/m^2) or operating an underfloor heating system which requires at least 12 hours to warm up.

Installing Radiant infra-red (non-glowing) panels on the walls of the Welcome Area would be an ideal way to provide heat for meetings of short duration, at short notice without having to heat the whole body of the church. This heating method has a range of about 4m, so would be insufficient to heat the centre of the nave, 12m from the walls, as well as being too expensive.

The Welcome Area, with porch entrance to the south aisle to left.

The cast iron radiators are of insufficient size to transfer enough heat from either a Ground to Water or Air to Water Heat Pump system (supplying water at 45 to 50ºC). Given the need to replace the radiators, and the desire of the church to move some radiators which are free standing, an Air to Air Heat Pump system is recommended.

This involves internal fan units which blow warm air horizontally at low level. External evaporator units will be required to be fitted in the least conspicuous locations.

The view of the north aisle from the road indicates that there is an area to the right (west) of the north aisle, where the boiler room is located, which could accommodate heat pump units without being visible.

The area between nave and tower could accommodate heat pump plant at the existing ground levels (providing the boiler room roof is of sufficient strength), or this could be removed and equipment sited at lower level.   It will require a well ventilated open air location.

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. The three radiators which are located on the external, uninsulated walls have no reflective or insulated surfaces directly behind them at present. These are situated at each end of the south aisle and on the north wall of the north aisle. 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.

8. Future Heating Options

8.1 Install Electric Panel Heaters

It is recommended that the PCC consider installing electrical panel heaters in the Welcome Area on a time delay switch. This would allow the area to be used for meetings of short duration without needing to heat the whole building. In the short term, if there is uncertainty about how much the area will be used, a portable electric heater could be used. If it is felt that the use of the area is enough to justify the expense of installing panels, this can be done as part of the re-ordering process.

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 accidently after use.

These heaters have a strong radiative effect (where heat is reflected to people from the surface) as well as a light convective effect (where air is warmed and moves around to heat the general space). As such these heaters tend to provide a relative instant sense of heat and comfort within the space and only need to be on for short periods of time.

There are several manufacturers. Four 900W panels with a guide price of £560 installed would cost £2,240.

8.2 Heat Pump Overview

As the hours of use of a building increase, so do heating costs. Heat Pumps are a low carbon method of creating heat. 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. This effect is increased if electricity is generated on site by solar power. 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.

Electrically operated heat pumps provide more heat in kW than they consume in electricity (The ratio is termed the Coefficient of Performance, CoP). When replacing gas boilers directly, sometimes larger radiators are required, or fan assisted radiators, or running the system for longer periods to achieve the same temperature (but at less power input).

Air to Air systems deliver warm air through indoor fan units, rather than radiators and have a higher CoP rating of up to 5 and they can also provide cooling. This system is suited where there are no radiators, or life expired / poorly sited units and spaces heated intermittently.

Some of the extra electricity required to run heat pumps can be obtained from solar PV panels. Some types of heat pump can provide cooling – solar powered cooling in summer is very efficient.

8.3 Install Air to Air Heat Pumps

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)

The Centre for Sustainable Energy model[1] can be used to estimate heat load for the building.

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

<u>Insulation Factors</u>

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

Area	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Church	2,900	0.033	96

Therefore a heat pump of 96 kW output would be required.

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.

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

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

At All Hallows Church, it is suggested that the external units be located in the area west of the north aisle, potentially on top of the current boiler room entrance area [which may require the current roof to be replaced if it is of insufficient strength], or otherwise nearby.

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]

8.4 Air to Air Heat Pumps Costs

Pumps to supply 96kW of heat (with capital cost estimated at £450 per kW output: £43,200) would deliver the same amount of heat annually, 58,000kWh, as the current system.

Operating at a Coefficient of Performance of 4, an 58,000kW output requires 14,500kWh of electricity.

At current costs (evening and weekend rate) of 15.1781p/kWh, annual cost = £2,200.

This is similar to the current gas cost of £1,900 annually. Note that the gas rate charged is currently very low and the likely increase of gas price will be much greater than that of electric which would then result in the above system being cheaper to run than gas.

9. Energy Saving Recommendations – Building Fabric

9.1 Draught Proof External Doors

The entrance is via a porch with two sets of doors creating a draught lobby. Both sets of doors have wooden frames. This is helpful to minimise draughts.

It is recommended 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

The vestry door appears to be little used and would benefit from having a 'sausage dog' style draught excluder laid along the base of a door – this should be filled with pea gravel or similar to be heavy enough to make a good seal. Also, 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.

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 – insufficient radiator network, low hours of use
Ground Source Heat Pump	No – insufficient radiator network
Air to Air Source Heat Pump	Yes

12.1 Solar Photovoltaic Panels

Solar panels could be installed in the valleys of the north aisle and the nave.

These offer lengths of 15m and 10m respectively (where the panels would not be visible from the ground), giving useable areas of around 30 and 23m².

This could generate 0.15kWpeak/m² giving an 8kWpeak 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
North Aisle	30	4.5	180 degrees / 40^0 0.99	0.8	6,560
Nave	23	3.5	180 degrees / 40º 0.99	0.8	2,770
Total	53	8			6,330

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 similar to the church centre's annual recent electricity use (5,800kWh in 2021). However, much generation is in summer daytime when the building is not in regular use. If no heat pumps are installed, the system should be sized appropriately for current electricity consumption – just one roof would suffice.

If heat pumps were installed, this would require extra power, estimated as 14,500kWh. There would still be reliance on grid electricity (which should be sourced from a 100% renewable supplier), the 8kW peak solar system would allow for summer cooling and provide for heating for periods during the autumn and spring.

It is recommended that Solar Panels are added after a heat pump system has been installed and its energy consumption pattern understood, so the solar system can be sized accordingly.

The system should be specified for future addition of a battery, when battery costs reduce as this would extend system usefulness into the evening.

Battery Storage is not strictly a renewable energy solution but provides a means of storing energy generated from solar PV on site to be able to be used at peak times or later into the day when the PV is no longer generating. It therefore extends the usefulness of the existing PV system. This is a new but fast-growing technology.

Using average 2019 installation costs (£1,450 per kWpeak for difficult access roofs); an 8 kWpeak system would cost £11,600.

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.