Energy Efficiency and Zero Carbon Advice

St Alfege Church Hall, Greenwich
PCC of St Alfege Church

Author	Reviewer	Audit Date	Version
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1. Executive Summary

An energy survey of St Alfege Church Hall, Greenwich was undertaken by ESOS Energy to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use.

St Alfege Church Hall, Greenwich consists of four sections:

A central 19th century hall, (originally a school), with solid walls and large metal framed windows, a small house added to the north end now in use as offices, a triangular 1960's extension to the rear which mostly serves as kitchen and toilets, and a 1960's flat roof building to the south forming the nursery. There is also a two bedroom house on site which was not part of this audit.

The nursery is, and office will be in heavy use; investment in energy saving measures and more efficient heating is justified. The hall between is of lower priority but would be benefit from new windows to ensure that it can remain in full hireable use.

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						
On contract renewal, use a group purchasing scheme	N/A	5-15% 10% =	None	Immediate	None	
Disconnect fixed water heater in kitchen [replace with kettle]	390	£55	Kettle <£30	<1	None	0.10
Draughtproofing of doors	2% 800	£114	£200	2	List B	0.15
Fill void above internal window, Frank Smith room	1% 400	£57	£100	2	None	0.07
Install double glazing in office	15% 1,000	£143	£3,000	21	Faculty	0.18
Install presence detectors to control lighting in toilets and lobby areas.	400	£57	£330	6	None	0.10
MEDIUM TERM						
Install secondary or double glazing in hall	10% 4,000	£286	£6,600	23	Faculty	0.73
Investigate ceiling/loft insulation	10% 4,000	£286	£3.000	11	Faculty	0.73

Change hall lighting to LED	375	£53	£1,050	20		0.09
Install Air to water heat pump for office OR	7,000gas	£645 Without PV	£2,400	4	Faculty	1.29
Install Air to Air heat pump for office	7,000gas	£795 Without PV	£2,700	3.5	Faculty	1.29
Install Air to water heat pump for hall + nursery OR	40,000gas	£1,238 more Without PV	£13,200		Faculty	7.35
Install Air to air heat pump for hall + nursery	40,000gas	£382 more Without PV	£14,850		Faculty	7.35
LONG TERM						
Install solar panels	13,440	£1,918	£26,100	14	Faculty, Planning permission	3.40

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

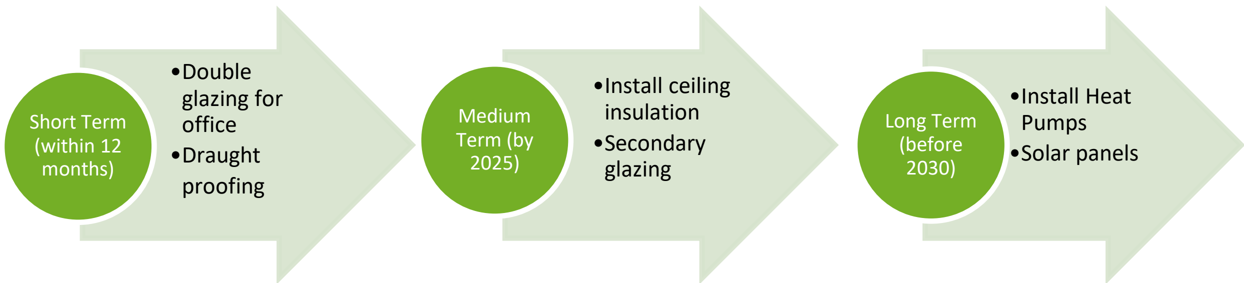
Based on current contracted prices of 14.27p/kWh and 7.159p/kWh (hall), 14.94p/kWh (offices) for electricity and mains gas respectively.

If all measures were implemented this would save around £2,500 per year in operating costs by removing gas charges and generating around 2/3 of electricity requirements (including heat pump use).

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 building has a clear route to become net zero by 2030 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Alfege Church Hall, Greenwich 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 Alfege Church Hall, Greenwich, SE10 9BJ was completed on the 20th July 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 Keith Ison and Malcolm Reid. Jack Edwards, Diocese of Southwark Environment Officer was also present for the audit.

St Alfege Church Hall, Greenwich	
Church Code	637228
Gross Internal Floor Area	360m^2
Volume	1,330m^3
Heat requirement	44kW [38kW + office 6kW]
Listed Status	Unlisted but within the Maritime Greenwich World Heritage Site Historic England Reference 1000096

The hall is typically used for 20 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Nursery building	50	20
Hall, Community Use	10	
Offices	40	4

Annual Occupancy Hours: 1,000

Estimated Footfall: 8,000

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Alfege Church Hall, Greenwich and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single Rate	14.27p/kWh	Below current market rates
Standing Charge	26.58p/day	N/A

Supplier Scottish Power

The current gas rates are:

Hall Single Rate	7.159p/kWh	Below current market rates
Standing Charge	25.923p/day	N/A

Supplier British Gas

Office Single Rate	14.94p/kWh	Around current market rates
Standing Charge	276p/day	N/A

Supplier: EOn

The above review has highlighted that when the current contracts expire, there will be opportunities to gain cost savings from improved procurement of the energy supplies at this site using a group purchasing scheme. The current rates are lower than the market rate and should be retained at present.

We would therefore recommend that the church looks into 100% renewable tariffs and obtains quotations for its gas and electricity supplies from group purchasing schemes such as the Big Church Switch scheme, 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. These are:

VAT	Electricity: 20% charged on some 2020 bills Gas: 5%	The organisation is understood to be a charity and therefore should be benefiting from only be charged a 5% VAT rate. A VAT declaration should be sent to the supplier to adjust this.
CCL	100% charged with 20% VAT rate	As the organisation is being charged the wrong VAT rate they are also being charged CCL which should not be applied as they are a charitable organisation. Sending the supplier a VAT declaration will remove this charge.

Whenever monthly electricity consumption exceeds 1,000kWh, or gas consumption exceeds 4,397kWh (52,000kWh per annum), 20% VAT is charged unless the customer has submitted a VAT declaration form. This should always be done when changing supplier.

The church is a charity and therefore can claim VAT exemption status.

Excess VAT paid can be reclaimed for the past three years.

VAT declarations are available from the suppliers website and can usually be found by typing the suppliers name followed by "VAT Declaration Certificate" into most website search engines.

A detailed explanation is available here: https:// perfect-clarity.com/vat-on-church-utility-bills/#:~:text=There%20is%20no%20VAT%20chargeable%20on%20Church%20water%20bills

5. Energy Usage Details

5.1 Annual Consumption

St Alfege Church Hall, Greenwich site used 6,630 kWh/year of electricity in the year from 2^{nd} June 2021 to 14^{th} June 2022 costing £1,365 (figures have been corrected to 365 days).

The hall and nursery used 39,723kWh of gas in the year from 1^{st} April 2021 to 2022, costing £1,758.

The office used 6,827kWh in the year to May 2022, costing £562.

This data has been taken from a list of electricity expenditure provided by the church.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity - Hall	L79A 43670	Three phase	No	
Gas – Hall	02612248	Schlumberger Cubic feet	No	Hall kitchen, cupboard at narrow end
Gas - Office	132075	Sensus Metric	No	

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

The office is fitted with a submeter, formerly used to bill tenants before it reverted to church use.

Left, hall gas meter, kitchen

Right, office gas meter

5.2 Energy Profiling

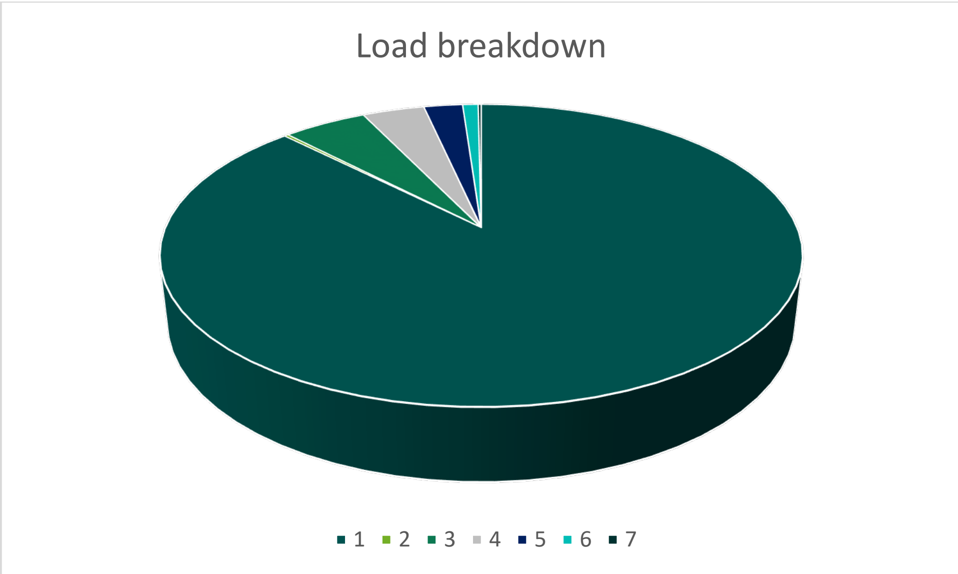
The main energy consuming plant can be summarised as follows:

	Equipment	Power kW	Annual Consumption kWh	Portion
Heating [Gas]	Hall: Worcester [1050 hours] Office: Viessmann Vitodens 100 [220 hours] 6 ring gas hob	38 ? 32 ?	40,000 7,000	 87.5%
Heating [Electric]	Boiler circulating pumps	0.2	130	0.24%
Lighting	Main Hall, 8 recessed panels of 4 x F30W fluorescent CFL 6 x 18W (entrance) Fluorescent 8 x F58W Bulkhead 6 x 40W LED 18 x 4W Nursery 4 x F58W Office	TOTAL 1888W 232W 100W	1900 600 200	5.0%
Hot Water	Kitchen: Lincat surface mounted fixed heater	3	600	

	Commercial dishwasher (1 hour to heat up, short cycles, used 3 x per week) Other areas Surface mounted fixed water heater	5 3	800 600	3.7%
Kitchen	Microwave oven 2 x large fridge Other areas Small fridge (almost empty)	1 2x 150W 100W	50 900 300	2.3%
Office	4 workstations	4x 100W	500	0.9%
Small Power	Vacuum cleaner	1.5	100	0.2%

Sum of estimates: 6,680kWh

Annual site electricity consumption, 2021: 6,630kWh



KEY *1 Gas heating* *2 electric heating* *3 Lighting*

4 Hot water *5 Kitchen* *6 Office* *7 Small power*

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 lighting and hot water.

5.3 Energy Benchmarking

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2
St Alfege Church Hall, Greenwich (elec)	360	6,630	18.4
St Alfege Church Hall, Greenwich (gas)	360	47,000	130
TOTAL	360	53,630	149

6. Efficient / Low Carbon Heating Strategy

6.1 Reducing Environmental Impact

The energy used for heating a traditionally constructed building 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

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 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.

6.3 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

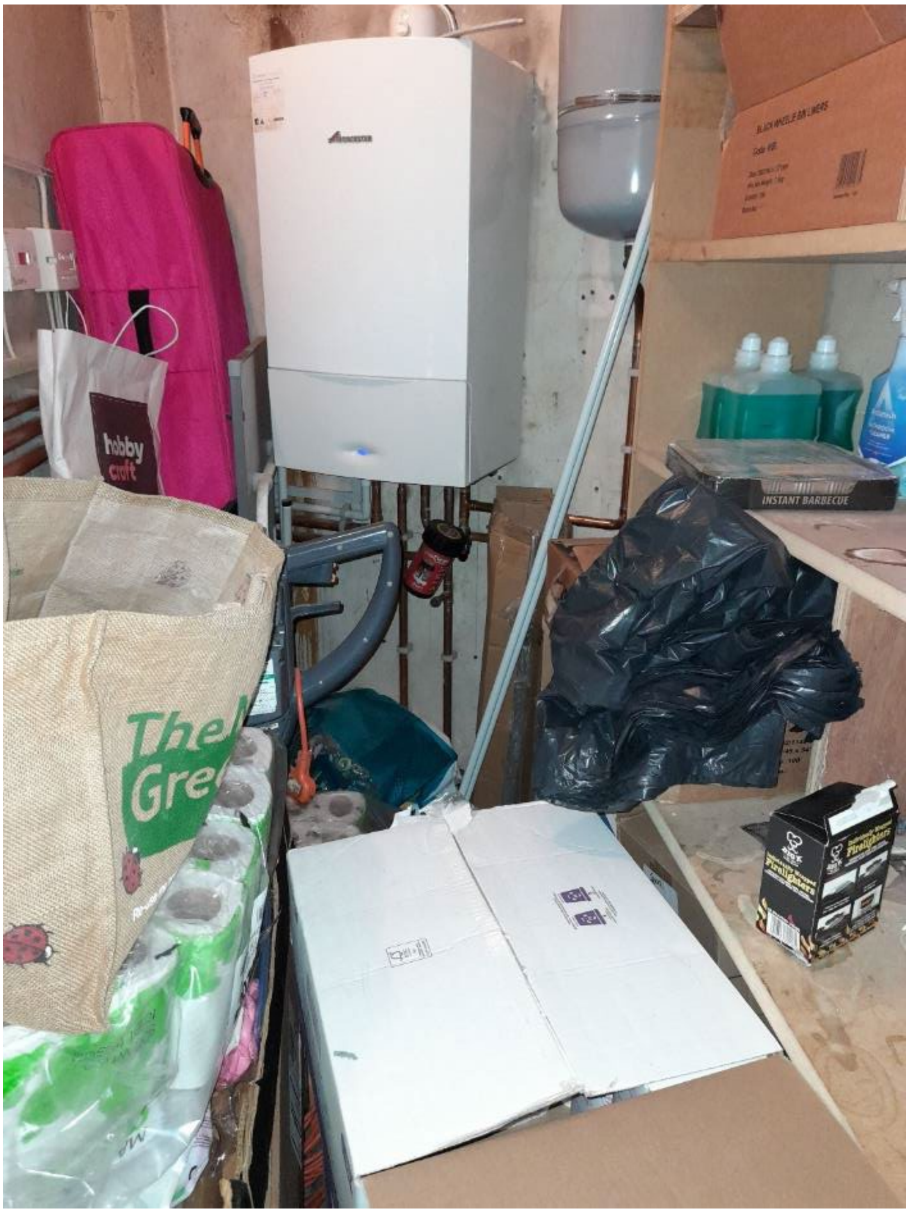
Condition	Factor kW/m^3
Poorly insulated with open or broken windows, draughty doors (add 5%)	0.034
Poorly insulated (assume no interventions)	0.033
Some insulating features	Estimate value
Well insulated	0.022
Insulated to 2010 regulations	0.013

Area	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Hall	1,330	0.033	44

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

6.4 Heating System

The main part of the hall plus the nursery is heated by a Worcester boiler of unknown type. Access to the boiler was not possible. It is probably in the 35-40kW range.



The office is heated by a Viessmann Vitodens 100 boiler, probably of 25-30kW and may be oversized.

Installation of or addition to ceiling insulation, and double or secondary glazing will reduce heat load.

The office could be fitted with an Air Source heat pump system; with external wall mounted units on the wall facing away from the church directly feeding the radiator network where the current boiler is.

Alternatively, and Air to Air system is feasible, with exterior units located on the external wall facing away from the church and supplying internal units directly inside. This would have lower operating costs. This would give the added benefit of providing cooling.

The rationale for using a heat pump to replace the gas boilers is:

i) Environmental – reducing dependency on fossil fuels

ii) Economic – a heat pump delivering 4 x the amount of heat in kWh which it consumes in electricity is clearly 4 x cheaper than “direct” electric heating (e.g. by under pew heater). This is important in a building with high use which is regularly visited and heated each day. The cost relative to gas depends on the ratio of the two rates (which can vary considerably at present). Systems delivering warm air at ground level require less heat input than radiator space heating system which heat the ceiling first. Heat Pump systems are considered to offer lower annual maintenance costs (no annual gas safety check).

iii) Heatwave relief - If the heat pump system installed also provides a cooling function as should be the case for AASHP

The main area could either be fitted with a large ASHP replacing the boiler and utilising the existing radiator network, or Air to Air system [AASHP] requiring either significant new plumbing for refrigerant, or a series of smaller exterior units directly supplying internal units. It may be difficult to obtain permission to fit external units on the side of the building facing the church which would mean the main hall would need to be supplied from the other side with a long refrigerant piping run. This may make an AASHP considerably more expensive to install than ASHP.

Detailed quotes should be sought from installers to select a system which is permissible and appropriate, and a boiler replacement plan developed before either boiler reaches the end of its life.

It is suggested that the west elevation at the rear of the office building in the recess could be a location for wall mounted heat pumps.

6.5 Heat Pump Overview

Heat Pumps are a low carbon method of creating heat.

As the hours if use of a building increase, so do heating costs.

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).

Refrigerant fluid is used to extract heat from large amounts of air, water or ground with a small temperature drop, and this is concentrated to produce a large (internal) temperature rise. An electric pump drives the refrigerant transferring the heat – less energy is required to drive the process than the amount of energy being moved.

Heat pumps are compatible with underfloor heating, which typically runs at fairly low water temperatures, but not with high temperature heating systems. 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).

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.

Heat pumps generally deliver water at around 55°C (although there are higher temperature ones on the market which require more energy to run); thus are compatible with a building which is regularly used and can be supplied with constant, medium heat, rather than a full power heat up on Sunday mornings.

Air Source (to water) systems deliver between 2.5 and 3 times the amount of heat in kWh to water that they consume.

Ground Source Heat Pumps supplying water at around 50°C are more efficient than their Air Source equivalent (since the average ground temperature is higher than the average air temperature), but require either a borehole, or extensive trench digging. CoP is 3 to 4.

Where a site has a daily requirement for heat (and thus high daily expenditure), the lower operating costs of a ground source pump outweigh the higher capital costs.

Air to Air systems deliver warm air through indoor fan units and have a CoP rating of between 4 and 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.

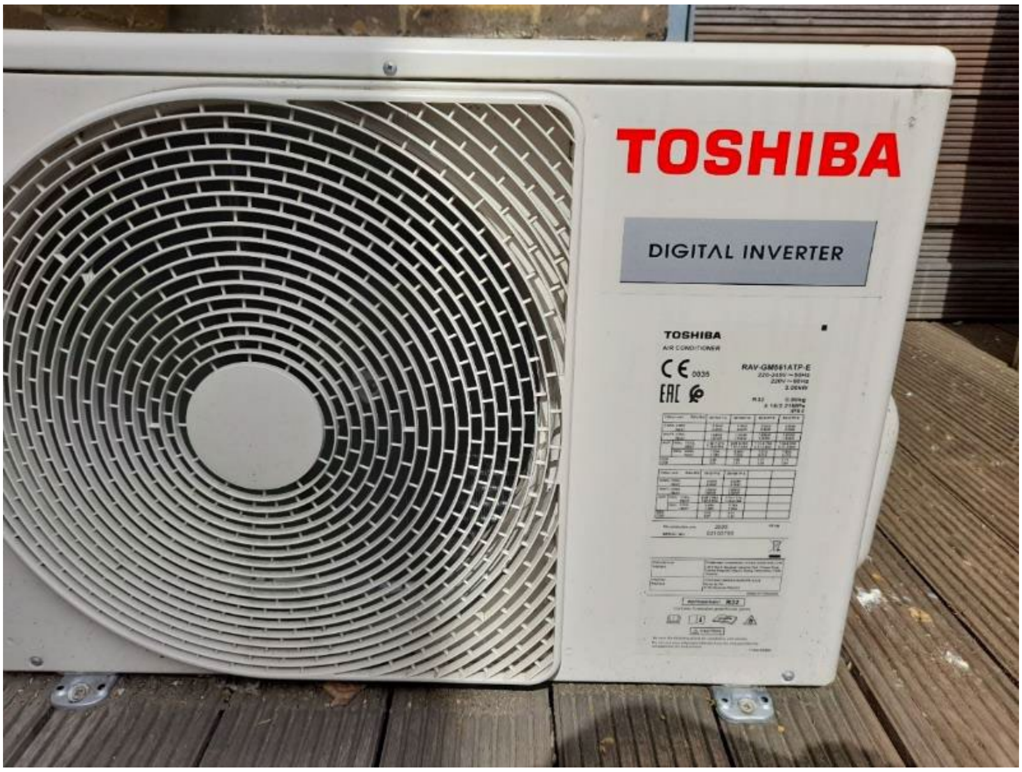
Some of the extra electricity required to run heat pumps could possibly be obtained from solar PV panels. Some types of heat pump can provide cooling – solar powered cooling in summer is very efficient.

6.6 Air to Air Source Heat Pumps

Air to Air Source heat pumps require internal fan units, blowing warm air, connected to external units – they do not require radiators. However, they require plumbing to circulate refrigerant. Systems provide summer cooling as well as winter heating and can deliver up to 4 to 5 times the amount of heat which they consume in electricity.

Four of the small units below supply one floor of an office of area 160m^2. These give a heating capacity of 21kW.

The CoP is between 3.2 and 3.9 depending on the type of internal unit chosen.



There are a wide variety of internal units for ceiling, high wall and low wall mounting.

6.7 Cost Comparison

Based on current utility prices.

Item	Power output kW	Power input kW	Operating cost	Capital Cost
Air to Water Heat Pump, Main area	33	13	40,000kWh £2,283	£13,200
Air to Air Heat Pump, Main area	33	8.2	40,000kWh £1,427	£14,850
Air to Water Heat Pump, Office	6	2.4	7,000kWh £400	£2,400
Air to Air Source Heat Pump Office	6	1.5	7,000kWh £250	£2,700

7. 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.

7.1 Fixed Water Heater:

It is recommended that the plumbed in fixed water heater in the kitchenette area is disconnected and replaced with a kettle.

The unit is being run every day just to make three cups of tea for nursery staff, but is turned on for around three hours daily.

Casing losses: The casing becomes too hot to hold; it is losing around 200W of heat. [200W x 3 hours x 5 days x 52 weeks = 156kW.].

Excess water heating losses: In addition to this it is boiling a volume of water, about 10 litres and maintaining this at temperature which wastes further energy as only about one litre of water is currently required.

<u>Calculation</u>

Specific heat capacity of water is 4.18J/g/ºC

4.18 x 10000g x 85ºC = 3,553,000J

Converting to kWh (divide by 3,600,000 = 0.98kWh.

As around a tenth of this water is required, so the excess energy used is 0.9kWh x 260 days annually = 234kWh.

Casing losses 156kW + excess water heated 234kW = 390kW.

390kWh x 14.27p/kWh = £55, so replacement by an inexpensive kettle will pay for itself within a small number of months.

7.2 Install Presence Detectors to Control Toilet and Lobby Lighting

There are several lights which appear to remain on all the time in areas such as the toilets and areas outside them. 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. There are also spaces which benefit from a good amount of natural daylight coming in through the windows where artificial lighting is not required for much of the year during the day.

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 considered 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.

7.3 Install LED Lighting in Main Hall

The main hall is currently lit by 8 panels inserted into the ceiling, each with four fluorescent tubes (probably of 30W each, giving a total load of 960W).

Replacement of the units by LED units (when the tubes are due for replacement) would cut consumption to about a quarter from around 500kWh to 125kWh; saving £53 annually on a 10 hour per week basis.

Capital costs estimated at £1,050 for 600mm square units would give a payback period of 20 years – this would reduce if hours of use increase.

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. Energy Saving Recommendations – Building Fabric

8.1 Draught Proof External Doors

It is recommended that the draughtproofing around doors is improved, particularly underneath where there is a large gap, and draught strips are added.

The door of the Frank Smith room has a large gap underneath.

For a non-listed building, simple and cheap interventions such as self-adhesive E or P cross section rubber strip can be used.

If there is a problem with water entering under a door, an upstand can be fitted.

Seldom used doors can have "sausage dog" draught excluders (filled with pea gravel or equivalent to stay in place).

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.

8.2 Fill Hole Between Frank Smith Room and Circulation Area

A double glazed window has been installed at the west end of the room. The space above, approx. 1m x 10cm has been left open, possibly as there are pipes present. This void allows air to flow in through the gap under the door and into the rest of the building. As this is an internal space it simply needs a thin panel. Consider whether there is a need for ventilation here – either use the door, or insert a closable vent in the above new panel.

8.3 Insulation to Roof

There may be potential for installing loft insulation, it was not inspected.

Adding insulation to an uninsulated ceiling can save 10% of heating bills, with a 5% saving where there is some existing insulation.

Ceiling insulation for an area of 320m^2 would cost approximately £3,040.

Cost £9.50/m^2

8.4 Replacement / Refurbished Windows

The three large original windows to the hall on the elevation facing the church are in a poor condition.

Several of the opening panels are broken, are not closed properly; frames are damaged and there is corrosion.

It is recommended that the inspecting architect is asked to cost a proposal to refurbish the existing windows (this may be necessary due to the building being in a World Heritage Site although it is unlisted) and also install secondary glazing, and compare this with the cost of new double glazing. The latter is likely to be considerable as bespoke construction will be required to fit.

In parallel, detailed costs should be obtained for replacement or refurbishment with secondary glazing of the kitchen and toilet windows at the rear of the property.

The large ground floor sash window in the office is a priority for work, as it appears insecure and could easily be entered. Replacement or secure secondary glazing is recommended.

9. Other Recommendations

9.1 Electric Vehicle Charging Points

The adjacent car parking area which serves the church and hall has potential for one or more EV charging points. In order to make a visible statement on the churches mission of stewardship and to facilitate more sustainable transport choices by those both visiting the church and using the hall, the church may wish to consider installing an electric vehicle charging point, probably on the side of the church hall to allow visitors to charge their electric car.

Installing a unit such as a Rolec Securi-Charge http://www.rolecserv.com/ev-charging/news/view/Robust-EV-Charging-With-Rolecs-SecuriCharge-EV-Wall-Unit-Coin-Token-PAYG would allow the organisation control over who is allowed to use the unit with a key operated system. Or given the type of use of the building and control over the usage of the car park as a whole a simple 32 amp type 2 wall pod type charger may be most suitable and these are widely available through many suppliers such as http://www.rolecserv.com/ev-charging/product/EV-Charging-Points-For-The-Home.

Because of the parish office within the building is a place of work and as such installation grants are available through the work place charging scheme https://www.gov.uk/government/publications/workplace-charging-scheme-guidance-for-applicants-installers-and-manufacturers which will fund 75% of the installation cost up to £500.

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	Yes
Ground Source Heat Pump	Too expensive
Air to Air Source Heat Pump	Yes

10.1 Solar Photovoltaic Panels

Solar panels could be placed on the west facing slope of the roof and also on the flat roof of the nursery building. These offer areas of around $80m^2$ and $40m^2$ respectively.

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
Hall	80	12	270 degrees / 30^0 0.8	0.9	8,640
Nursery	40	6	Optimum, using angled supports = 1	0.8	4,800

Total generation 13,440kWh, saving £1,918

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 hall's annual recent electricity use (6,630kWh). If no heat pumps are installed, the system should be sized appropriate for current electricity consumption.

If heat pumps were installed, this would require extra power. Using Air to water would require 19,000kWh to replace the existing heating system, so a total load of 25,600kWh. A maximum sized solar PV system would contribute to running heat pumps and supply summer cooling, but grid electricity would be required for much of the heating season.

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

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

Using average 2019 installation costs (£1,450 per kWpeak); a 18 kWpeak system would cost £26,100.

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.