ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Chad's Church and Hall
PCC of Chester

St Chad's HANDFORTH

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1. Executive Summary

An energy survey of St Chad's Church and Hall 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. This audit has been provided in conjunction with 2buy2, the Church of England's Parish Buying scheme provider and is subsidised from Total Gas & Power, the Parish Buying schemes principal energy suppliers.

St Chad's Church and Hall is a Victorian era church first opened in 1898. Over the years there have been alterations, with a small hall, kitchen and toilets erected in 1964 adjoining the southeast corner of the church, and further additions of the 'Old Church Hall' in 1969. In 1987 a new suite of rooms comprising a large lounge-type room, a kitchen, a toilet, and a Church Office were constructed down the northern side of the church. A new entrance formed a lobby to these 'New Church Rooms', which were opened on 27 January 1990. The main church building is constructed of solid brick with a plain pitched tiled roof, with the old church hall being a flat roof, and the new church rooms being pitched to match with the existing church building. There is both gas and electricity supplied to the site.

The church has a number of ways in which it can be more energy efficient and a clear path towards net zero carbon. 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 and the route to net zero carbon diagram below are used as the action plan for the church in implementing these recommendations over the coming years.

Energy and decarbonisation recommendations	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/yr)
Contact suppliers to arrange for the meters to be changed to smart meters	None	None	Nil	N/A	None	N/A
Switch electricity (and gas) suppliers to ones which provide 100% renewable (or green gas) supplies	None	None	Nil	N/A	None	1.89 (offset)
Improve pipework lagging and insulation on existing boiler	1,167	£350	£1,154	3.3	List A	0.21
Change existing lighting for low energy lamps/fittings	890	£267	£740	2.8	List B	0.17
Install PIR motion sensors on selected lighting circuits	28	£8	£480	57.1	List B	0.01
Timers on Fuse Spurs to Water Heaters	162	£49	£90	1.9	List A	0.03

Install Electric Under Pew Heaters (Church)	16,487	£1,195	£16,089	13.5	Faculty	2.96
Replace heating system for electrical based heating solution (Old Church Hall) (AASHPs)	12,127	£364	£44,850	123.3	Faculty	2.15
Replace heating system for electrical based heating solution (New Church Hall) (AASHPs)	10,419	£313	£38,443	123.0	Faculty	1.85
Install solar photovoltaic panels	6,405	£1,921	£13,200	6.9	Faculty	1.24
Electric Vehicle Charging Points	N/A	N/A	£2,500	N/A	List B	N/A
Consider registering for Eco Church	The Eco Church programme, which is recommended by the Church of England, helps congregations care for the environment in all aspects of church life. The programme is free; you can, however, make a donation to A Rocha UK towards its costs.					
Create a procurement policy for appliances (and other goods)	Commit to buying only appliances with the new energy efficiency ratings of A, B or C at the lowest when those you currently have reach the end of their useful life. (NB ovens, air conditioners and space or water heaters are still on the older rating scale, so for these, try for A+++.)					

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

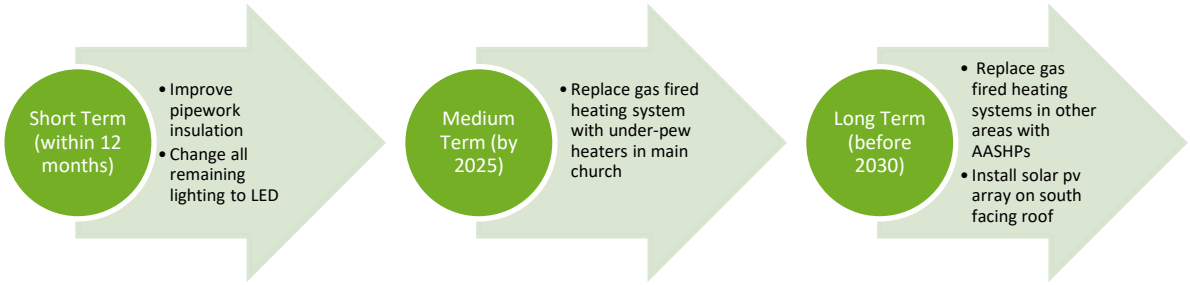
Figures in the table are based on current contracted/market prices of 30p/kWh and 10p/kWh for electricity and mains gas respectively. The carbon figures are based on the DEFRA 2022 carbon emission factors of 0.21107 for electricity, 0.18 for gas and 0.27 for oil. Do note that as energy prices increase, payback periods decrease.

2. The Route to Net Zero Carbon

Our Government has committed to move towards Net Zero Carbon – the point at which we have reduced emissions as much as we can and then balanced any residual emissions through removal of carbon from the atmosphere. They have done this as part of a worldwide agreement which aims to limit global warming to well under 2 degrees Celsius, with an aim of keeping it below 1.5 degrees Celsius. This will help protect all of us from the impacts of climate change.

In February 2020, the Church of England's General Synod set its own Net Zero Carbon target. The first stage of this target covers energy used by churches, cathedrals, schools, vicarages, other church buildings, as well as emissions caused by reimbursed transport. The target date is 2030.

This church 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 Chad's Church and Hall 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 and seek to improve the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Chad's Church and Hall, Wilmslow Rd, Handforth, Wilmslow SK9 3ES was completed on the 8th December 2022 by Nathan Tonkin. Nathan is an experienced energy auditor with over 4 years' experience in sustainability and energy matters in the built environment.

St Chad's Church and Hall	
Church Code	**609367**
Gross Internal Floor Area	640 m^2
Listed Status	Grade II
Average Congregation Size	70-80

The church typically used for 40 hours per week for the following activities:

Type of Use	**Hours Per Week (Typical)**
Services	8 hours per week
Meetings and Church Groups	10 hours per week
Community Use	22 hours per week

There is additional usage over and above these times for festivals, weddings, funerals and the like

4. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Chad's Church.

The current electricity rates are:

Day Rate	31.6044p/kWh
Night Rate	37.6296p/kWh
Standing Charge	98.1322p/day

The current gas rates are:

Single / Blended Rate	8.529p/kWh
Standing Charge	495p/day

The electricity is supplied by TotalEnergies and 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, and in some cases 'green' or 'carbon neutral' gas.

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

VAT	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

St Chad's Church and Hall uses 9,789 kWh/year of electricity, costing in the region of £2,936 per year, and 54,656 kWh/year of gas, costing £6,559. The total carbon emissions associated with this energy use are 11.87 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site. St Chad's Church and Hall has one main electricity meter, serial number 215022852. There is one gas meter serving the site, serial number A0930414A6.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	215022852	EDMI Atlas Mk7C 3 phase	Y	GF elec switch room
Gas – Church	A0930414A6		N	External boiler room

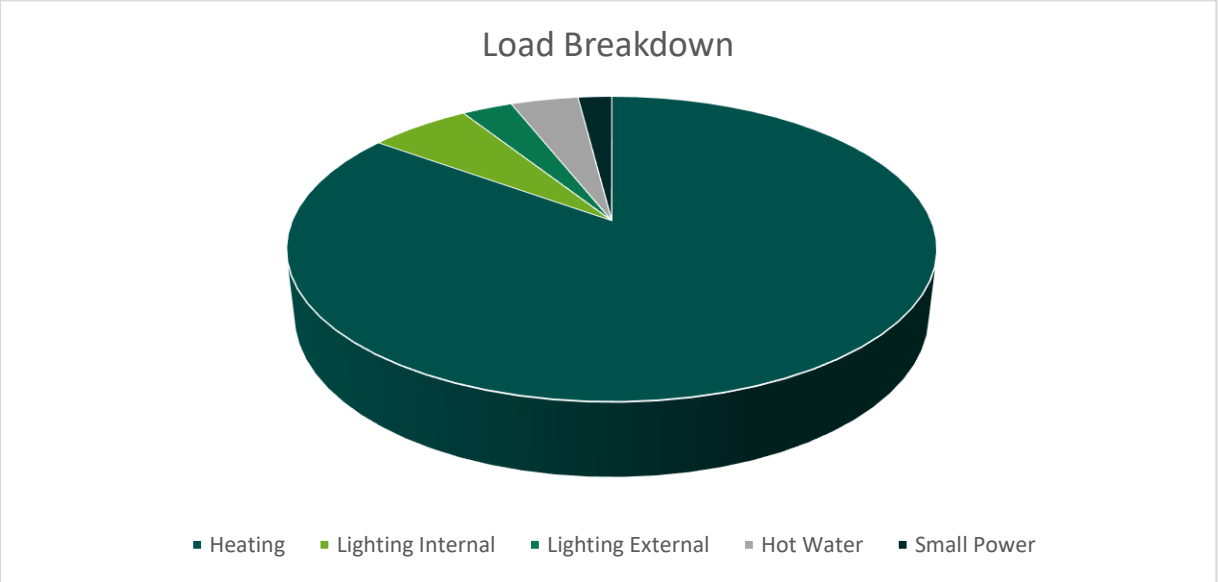
It is recommended that the church consider asking their suppliers to install smart meters so that the usage can be monitored more closely, and the patterns of usage reviewed against the times the building is used.

5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	**Main Church:** <40 lamps, all LED, spotlights and uplighters **Old Church Hall:** <20 lamps, majority LED, LED Strips and panels **New Church Hall:** <30 lamps, majority LED, LED panels	9%

Heating	**Main Church:** 1x Rehema Gas 350 boiler 130kW input **Old Church Hall:** 1x Vaillant ecoTEC pro 28 combi boiler 28kW input **New Church Hall:** 1x Veissmann 100-W combi boiler 32kW input	85%
Hot Water	Domestic hot water supplied to each hall by the corresponding combi boilers. Hydroboil fixed water heater, 30L, New Church Hall kitchen	4%
Other Small Power	Office equipment and other IT equipment	2%



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 load is lighting.

5.2 Energy Benchmarking

In comparison to national benchmarks for church energy use St Chad's Church and Hall uses 24% less electricity and 43% less heating energy than would be expected for a church of this size. It should be noted that the national benchmarks do not make any specific adjustment for the amount of time the church is used and the usage of this church will therefore affect how it performs against this benchmark.

This church is performing better than the national average due to the clever use of the additional halls, trying to move people away from the older church into modern extensions. With the addition of electric heating solutions, this efficiency will only improve.

	Size (m^2 GIA)	St Chad's Church and Hall use kWh	St Chad's Church and Hall use kWh/m^2	Typical Church Use kWh/m^2	Variance from Typical
Electricity	640	9,789	15.30	20	-23.53%
Heating Fuel	640	54,656	85.40	150	-43.07%
TOTAL	640	64,445	100.69	170	-40.77%

6. Efficient / Low Carbon Heating Strategy

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 near future. 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' in the foreseeable future

It is therefore important to review and set out a plan to make heating more efficient and less carbon intensive. One way to achieve this is to consider a transition to electrical heating where this also represents an efficient and comfortable solution for churches. 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 oil and coal-fired power stations.

The church is currently heated by a gas fired boiler which was installed in 2000 and is deemed to be at the end of its serviceable life and therefore should be looked at being replaced. The boilers provide heating to cast iron column radiators around the perimeter of the church, including to the altar and chancel. In addition, there is oversized and exposed pipework which contributes to the heating of the church.

The church makes use of fixed wooden pews in the nave and there are fixed choir stalls in the chancel.

The church is used a few times per week on a Sunday and midweek for services and the typical congregation size is 70-80. The heating is set to come on several hours earlier in the winter to ensure the church is warm for this service.

Each of the halls is served by a combi boiler each being installed between 2015-19. These have 10-15 years left of their serviceable life and solutions should be considered for replacement then. They supply hot water to radiators around the perimeter of the halls, supplementary rooms, and toilets. These are set on a separate timer schedule to the main church and are set to come on a few hours before the rooms are in use.

The various options for a decarbonised heating solution have been reviewed in the table below.

Decarbonisation Heating Solution	Viable
Air to Water Source Heat Pump	No – unsuited to current heating pipework and heat emitters
Air to Air Source Heat Pump	Yes – in old and new hall extensions
Water Source Heat Pump	No – no water source locally
Ground Source Heat Pump	No – significant archaeology
Under Pew Electric Heating Panels	Yes – fixed pews in church would be suitable
Electric Panel Heaters (to provide supplemental heating only)	Yes – to supplement under pew heaters in main church building
Over Door Air Heater (to provide a supplemental warm welcome at the door only)	No – not needed with current lobby design of the church

Overhead Infra-Red Heaters	No – visual intrusion to the church would do harm, least preferred heating source due to comfort
Heated Chair Cushions	No – other solutions preferred

The recommendation is therefore that the church consider electric under pew heaters. As described below.

6.1 Install Electric Under Pew Heaters

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.

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:

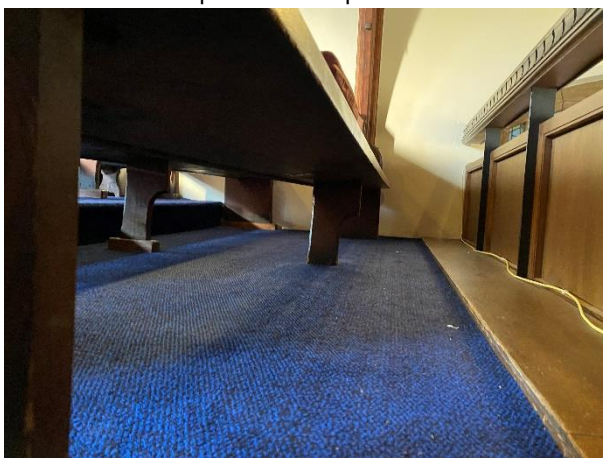
Install under pew heaters suspended from brackets from the underside of the pew seat as follows:

North side, 13 rows with three 450W heaters in each row between uprights

South side, 12 rows with three 450W heaters in each row between uprights

Balcony, 2x 3 rows with two 650W heaters in each row between uprights

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. In addition, several churches have recently installed such systems. If you would like to find out about churches whom you could ask about their experiences, please contact the diocese.

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.

6.2 Install Electric Panel Heaters

Electric panel heaters can provide additional heating to areas where there are no pews. Suitable electric panel heaters would be far-infrared panels. 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). For this reason, these heaters tend to provide a relatively instant sense of heat and comfort within a specific space and only need to be on for short periods of time. The heating effect spreads out from the panel by up to 3 meters, although this is reduced by people and furniture. This means that these heaters provide a useful source of supplementary heating or primary heating for some well-defined areas, but are not very well suited to providing a complete heating solution for a church without other forms of heating (such as under pew). As these heaters warm up almost instantly, this reduces the amount of preheating required before each use of the building and can make electric heating cost competitive with gas. It also means that areas using this form of heating can rapidly and economically be brought into used for short or unplanned meetings if needed.

It is recommended that the PCC consider installing supplementary electrical panel heaters in this area (on a time delay switch) allowing removal of the existing radiators.

These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch so they cannot be left on accidently after use.

If you would like to discuss panel heaters with a church in the diocese that already makes use of them, please contact the diocese.

Electric panel heater installed behind an altar

6.3 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 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. AASHPs 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 up to 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

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
Old Church Hall	639	0.033	21.1
New Church Hall	549	0.033	18.1

Therefore, a heat pump of 21 or 18 kW would be required in each area.

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.

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

Examples of external units for AASHP comprising of three smaller 3kW units and two larger 10kW units.

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.

FUA-A - Under ceiling cassette air conditioning unit

Unique under ceiling cassettes for high rooms with solid ceilings or false ceilings with a shallow void. Suitable for all types of commercial applications.

The FUA-A range provides comfortable heating and cooling even for rooms with high ceilings and has individual louvre control flexibility to suit every room layout.

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

7. Energy Saving Recommendations

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 New LED Lighting

The lighting makes up a relatively small overall energy proportion of the electricity used within the church. There are some areas of the building which have had efficient LED lights installed but there are still a few remaining inefficient fluorescent fittings around the church.

It is recommended that the fittings scheduled in Appendix 1 are all changed for LED fittings. There are a vast number of specifications of LED light fittings on the market, but it is recommended that any purchased should come with branded chips and drivers and offer a 5 year warranty. An example of such a range of fittings is available through Parish Buying.

If all the light fittings were changed on a simple "like for like" the total capital cost (supplied and fitted) would be £740. The annual cost saving would be £267 resulting in a payback of around 2.8 years. This estimate includes the supply of the lights, the labour to install them and the access required. It does not include any upgrade to the wiring or a new lighting design, both of which the church may wish to consider. Guidance on lighting, produced by Historic England for churches, can be found at: https://historicengland.org.uk/advice/caring-for-heritage/places-of-worship/making-changes-to-your-place-of-worship/advice-by-topic/lighting/

7.2 Lighting Controls (Internal)

There are several lights which currently remain on all the time in areas such as the entrance, toilet, and the like. Some of these areas are only used occasionally and for a short amount of time. The light, therefore, 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, such that artificial lighting is not required for much use during the year.

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 Insulation of Pipework and Fittings

The pipework within the boiler room has the majority of its straight lengths insulated, but the more complex-shaped pipework fittings, such as valves, have been left uninsulated. These exposed areas of pipework contribute significantly to heat loss from the system and make the plant room unnecessarily warm. The exposed hot surfaces also represent a health and safety risk of burns for those working in the area.

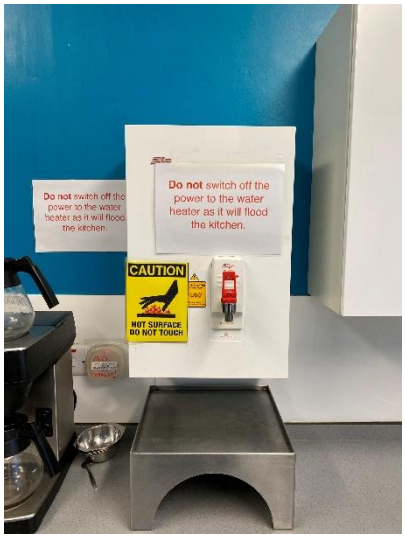
It is recommended that these areas of exposed pipework and fittings are insulated with bespoke flexible insulation jackets. These wrap around the various elements but can be removed and then replaced for any servicing activities.

7.4 Timers on Fuse Spurs to Water Heaters

There are various electric hot water heaters and water boilers (for tea-making and the like) located around the church. These only need to heat the water to the required temperature when the building is in occupation but at the moment these heaters are directly wired in without any form of time control and therefore maintain their set temperature 24/7.

It is recommended that the heaters are fitted with a 24 hour/7 day timeclock to replace the fused spur switch. They should be set up with times to match the times that the building is occupied. This will prevent the standing losses from the unit wasting energy during periods when the building is not occupied.

Such units can be purchased at any electrical wholesaler and fitted by your existing electrician or any NICEIC registered electrical contractor.



8. Other Recommendations

8.1 Electric Vehicle Charging Points

The church has a car park to the side of it which serves the church and also the frequently used church hall. In order to make a visible statement on the church's mission of stewardship and to facilitate more sustainable transport choices by those visiting the church and/or 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 cars.

Some units 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 without the need for a key may be most suitable. These are widely available through many suppliers.

Because of the office within the building, the church can be considered as a place of work and, as such, installation grants are available through the workplace 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.

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 Photo Voltaic (PV)	Yes – good south facing roof and enough demand
Battery Storage	No – unlikely to be worthwhile to extend the usage of the solar pv array

Now that the Feed in Tariff scheme has come to an end, the installation of solar PV panels in situations where there is not almost full usage of the electricity generated on site is not really viable.

There is potential for a small solar PV array on the roof of the tower or on the roof of the South Aisle. The church's energy consumption is already very small and the consumption during the daytime when the sun is shining is likely to be very low indeed, therefore while technically viable only a very small number of panels (maximum of around 4) would be worth considering if at all.

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

10. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available on this Parish Resources page:
https://www.parishresources.org.uk/resources-for-treasurers/funding/

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 includes the installation of under pew heaters to pews which are made in or after 1850 and are not of historic interest.

All other works, including the like for like replacement of gas and oil boilers 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. This includes items such as solar PV installations.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Narthex	2	1800mm LED Single	£64.90	£260	4.0
Prayer Room	1	1800mm LED Twin	£67.39	£160	2.4
Kitchen Hall	2	1800mm LED Twin	£134.78	£320	2.4