ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary's Church, Ticehurst

PCC of St Mary's Church

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Mary's Church, Ticehurst was undertaken by Inspired Efficiency Ltd to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use.

St Mary's Church, Ticehurst is a mediaeval Grade II* listed church constructed of stone with a slate roof and shingled spire. It dates mostly from the 14th century, was restored in 1857, and has a 21st century room added to the south porch. [Historic England reference 1222324]. 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. 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)
Door and Window draught proofing measures	2% 400	£16	£5	<1	None	0.07
Install Endotherm heat transfer fluid	10% 2130	£81	£260	3	None	0.39
Change CFL lighting to LED	300	£63	£180	3	List A	0.07
Install under pew heating	21,000 gas Use 9,180 electric	Cost £1,115 extra	£32,000	Not recovered	Faculty	1.54 with grid electric 3.86 if 100% renewable electric

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

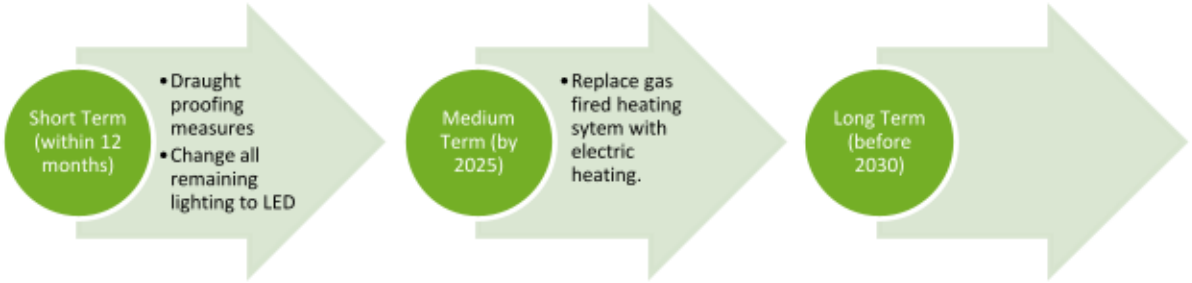
Based on recent contracted prices of 21p/kWh and 3.819p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church around £160 per year in operating costs. An electrical heating method will incur higher costs as solar power cannot be generated on site with a visible roof on a listed building.

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. Furthermore, the PCC of St Mary's Church have been awarded a Silver award by the ARocha EcoChurch scheme and are aiming for a gold award.

This church has a clear route to become net zero before 2030 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Mary's Church, Ticehurst to give them advice and guidance as to how the church can be improved to become more energy efficient. In doing so the church will also become more cost effective to run with potential 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 Mary's Church, Ticehurst, TN5 7AB was completed on the 26th May 2021 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 Judith Whiteman and Marianne.

St Mary's Church, Ticehurst	
Church Code	610489
Gross Internal Floor Area	460 m^2
Listed Status	Grade II*

The church is typically used for 11.5 hours per week for the following activities

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	5.5 hours per week Two Sunday services plus monthly evensong + Wednesday morning	80
Meetings and Church Groups	2 hours per week Regular Friday meeting	20
Community Use	1 hour per week Annual concert 3 school services	300
Occasional Offices	3 hours per week Average of 10 weddings, 10 baptisms, 12 funerals annually	100

Occupancy Hours	600
Heating Hours	300
Footfall	10,400

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	21.00p/kWh	Above current market rates
Standing Charge	30.00p/day	N/A

Supplier: EDF Energy, new contract from 21 April 2021. The rate increased significantly from 16.35p/kWh – was this negotiated or did the contract come to an end and the supplier moved the church to a higher rate? Is the church still tied to this supplier by contract?

The current gas rates are:

Single / Blended Rate	3.819p/kWh	Above current market rates
Standing Charge	49.49p/day	N/A

Supplier: British Gas, the contract end date was unreported.

The above review has highlighted that there are opportunities to gain significant cost savings from improved procurement of the energy supplies at this site. We would therefore recommend that the church looks into 100% renewable tariffs and obtains quotations for its gas and electricity supplies from the Big Church Switch scheme www.bigchurchswitch.org.uk

and the Diocese Supported parish buying scheme, http://www.parishbuying.org.uk/energy-basket.

These schemes offer 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% VAT included Gas 5%	The church is a charity and should be exempt from the 20% VAT rate.
CCL	Levied when 20% VAT is charged	As above

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. Charities are exempt, but VAT declarations need to be made when changing suppliers, and often when changing contract with the same supplier, as charity status is not automatically applied.

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.

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

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

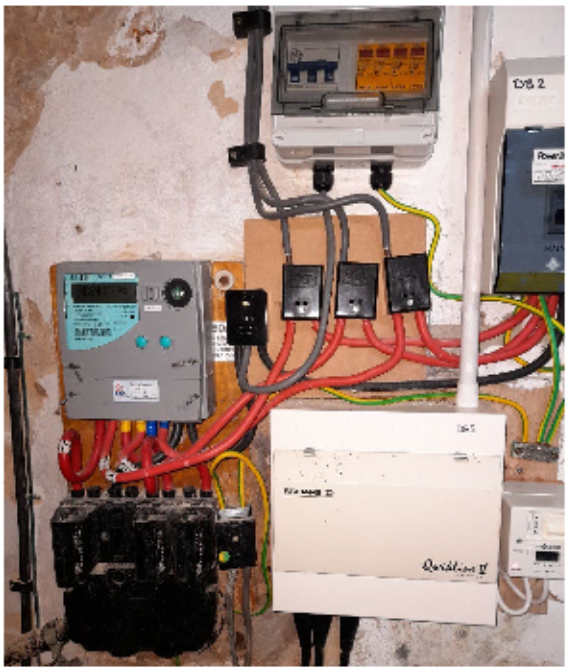
St Mary's Church, Ticehurst uses around 8,000 kWh/year of electricity, costing in the region of £1,300 per year, and 21,000 kWh/year of gas, costing in the region of £1,000.

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

St Mary's Church, Ticehurst has one main electricity meter, with three phases of power supplied.

There is one gas meter serving the site.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity	P07B 20345	Entity Sprint S3D410 3 phase	Yes	Under stair cupboard, adjacent to north porch
Gas	E016 K08065 16 D6	Elster Bk G10E	Yes	External cabinet adjacent to north boundary wall of churchyard



Utility	Annual use/ kWh	from	to	Cost
Electricity	8,189	08/02/2020	10/02/2021	£1,331 *
Gas	21.000	01/01/2019	31/12/2019	£1.043

*7% direct debit discount applied.

All the meters are AMR connected and as such energy profile for the entire energy usage should be possible. Monthly gas consumption data has been provided for this report which allows daily and weekly averages to be calculated; for instance; 12 hours per week in January 2019.

5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

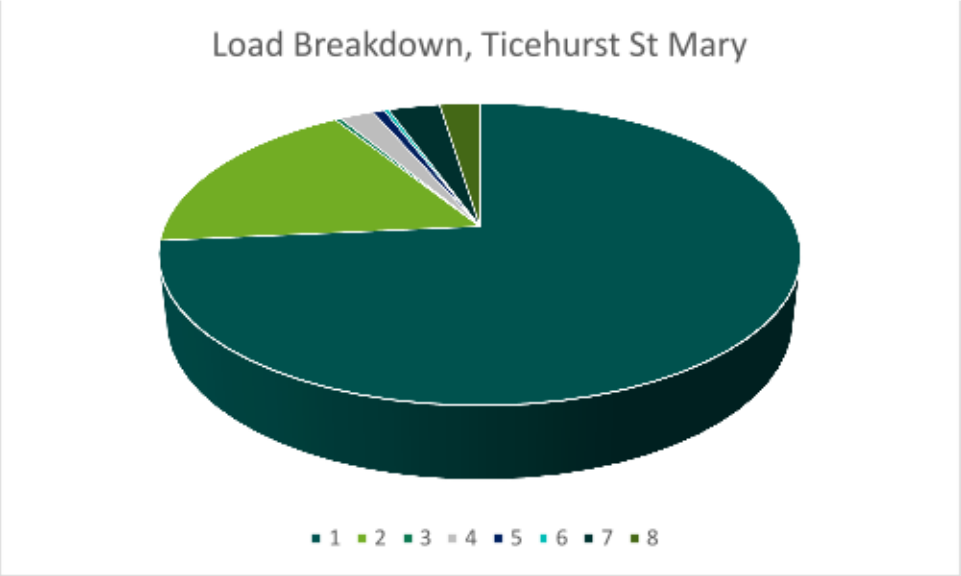
Service	Description	Power kW	Annual Use/ kWh
Heating [Oil]	Worcester GB 162.65/**80**/100 [300 hours use on full power]	80	**21,288**
Heating [Electric]	Boiler circulating pump Toilet hand dryer Underfloor heating (side room only)	0.15 3 Unknown	45 100 5,100
Lighting [Internal]	6 beam mounted floodlights @120W 12 pendant CFLs @ 18W 8 LED floodlights @10W Church 6 spotlights @80W 8 uplights @ 50W 5 bulkhead lights @40W St Mary's room TOTAL	 1016W 1080W 2.1kW	1,260
Lighting [External]	**3 floodlights (one LED)** 2 hours use on Sunday evenings + request use charged per evening **c. 200 hours use**	1	200
Hot Water	Kettle	3kW	100
Small Power	Vacuum cleaner	1.5kW	80
Organ, music, PA	Estimated 400 hours	1.5kW	600
Kitchen	Fridge Microwave oven Commercial dishwasher (low use) 2 ring electric hob	150W 1kW 5kW 3kW	440 20 200 40

Total Annual Consumption: 8,189kWh

The estimate of 5,100kWh for underfloor heating is based on a floor area of 50m^2; with an estimate of £1 per hour to run, which is 7kWh.

600 Occupancy hours => 400Heating hours for underfloor heating

5,100kWh / 7kW = 728 hours. October to April = 210 days. 728/210 = 3.5 hours per day



KEY 1 Gas heating 2 Electric heating 3 Hot water 4 Lighting internal
5 Lighting external 6 Small power 7 Organ, music, PA 8 Kitchen

As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site.

5.2 Energy Benchmarking

In comparison to national benchmarks for church energy[1] use St Mary's Church, Ticehurst uses 6% less electricity and around 70% less heating energy than would be expected for a church of this size. The gas data are from 2019, so representative of normal use, and a monthly breakdown of use by kWh has been provided by the supplier which conforms to the expected seasonal variation of use, with 3,857kWh used in January 2019. With the church in use on four Sundays, Wednesdays and Fridays; 12 heating events, this averages four hours heating per day at 80kW boiler output. The combination of a relatively new condensing boiler and timer settings result in efficient gas use compared to most churches.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
St Mary's Church, Ticehurst (electricity)	460	8,189	17.8	19	-6%
St Mary's Church, Ticehurst (gas)	460	21,288	46.3	148	-69%
TOTAL	460	29,477	64	167	-62%

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

[1] CofE Shrinking the Footprint – Energy Audit 2013

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 future. Electricity currently has a carbon emissions 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 by 2025.

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 unlikely to deliver 'zero carbon mains gas'. Whilst there are plans to add hydrogen to the network, and "green" gas from anerobic 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. Hydrogen at up to 20% of the gas mix is speculated (it is expensive to generate), and Anaerobic Digestion could account for a similar percentage. The economics of hydrogen production and the need to replace some pipework make full decarbonisation of gas unlikely. The total amount of gas use is expected to fall slowly from 2025 as new housing must be electrically heated.

If the gas boiler is retained 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.

It is therefore a critical element to review and set out a plan to make heating more efficient and less carbon intensive and one way to achieve this is to consider a transition to electrical heating where this also represents a more efficient and comfortable solution. The church is encouraged to obtain detailed quotes for electrical heating, whilst observing how the gas market evolves towards incorporation of H_2 and biogas.

The St Mary's Room, fitted with underfloor heating.

6.1 Fuel Supply

The boiler was run during the visit, giving the opportunity to inspect the radiators for efficient operation using a thermal imaging camera. The disconnected radiator was identified along with one which had been turned off inadvertently. No other issues were found. The hour's running also showed a boiler output temperature of 66ºC and return temperature of 52ºC. This is under the 55ºC limit necessary for recovery of heat by condensing exhaust steam and thus contributes to the very efficient low annual kWh use of gas for the church.

With an effective and efficient boiler, there are no financial incentives for the church to move to electrical heating – since electric costs per kWh are 5.5 times that of gas with the current supply contracts. Also, with a visible roof, there is no opportunity to install solar PV panels to generate electricity on site, so no reduction of the greater electricity use is possible.

A transition to electric heating can be made on the grounds of creation care, since it is possible to access 100% renewable electricity. The extra expense could then be considered as a mission cost.

The church should investigate options for boiler replacement, by obtaining detailed quotations.

The options include installation of under pew heating (relatively expensive due to the large number of pews), or overhead radiant heaters (either non glowing panels or chandelier mounted glowing bars) which are more visible. It is considered that obtaining permission for the latter options is unlikely, and the ceiling height reduces the viability of panels.

6.2 Under Pew heating

If pews are retained, under pew electric heating is recommended as this delivers heat exactly where it is required instantaneously, without having to heat the ceiling first. Although electricity is currently more expensive that gas per kWh, this form of heating requires little preheating time and delivers heat directly to the congregation, so overall savings are likely. There are two forms, convector heaters which are normally positioned under the seat, and radiant panels (fitted with a protective mesh so the surface is not hot) which can be fitted under the seat or to the back of the pew in front. Experience in some churches indicates that 300-350W convector heaters are suitable whereas 500W or more produce too much heat to be comfortable. Each heater should be provided with an individual switch for local control.

For replacement, two most popular under pew heaters within churches are BN Thermic PH30 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating. Cable runs to the pew heaters could run along the North and South walls (all cabling should be in armoured cable or FP200 Gold when above ground) to the both rows of pews quite easily.

The under pew (see photo below) and panel heaters have been recently installed at St Andrews Church, Chedworth, Gloucestershire, GL54 4AJ. The church is open in daylight hours so can be viewed at any time.

Radiant panel pew heaters, which may be fitted either underneath pews or to the back of the pew in front, are supplied by Cooltouch Heating Ltd. The heating elements are covered in material which prevents the surface becoming hot whilst allowing heat to radiate.

An example fitment is St Catherine's, Towersey, OX9 3QL.

Underpew installation, with individual switch to right.

	North Aisle	Nave North	Nave South	South Aisle	nave
Number	10	14	14	5	
Pew Lengths	2.46m	3.68m	2.89m	2.46m	2.78m
Space between supports	1.2m	1.2m	1.4m	1.2m	1.3m
Heaters per pew	2	3	3	2	2
Number of pews of this length	15	16	8	Included in north aisle total	4 in nave
Number of heaters for full installation	30	48	16		8

Equipment options for full equipping of all pews, requiring 102 heaters:

With many pews, equipping all fully with underpew heaters is an expensive option. Consideration should be given to only fitting these pews which are regularly used. Provision for peak periods, e.g. Christmas services would then involve running the heating for a longer preheating period. The convector type heaters would be more suited to this than the radiant variety. By contrast, overhead forms of radiant heating is independent of the number of pews. The amount required is dependent on the area of the church which is regularly used.

Manufacturer	Power each W	Length mm	Cost each £	Installed cost Each £	Total £
BN Thermic [Convector]	300	525	88	313	31,926
Cooltouch [Radiant]	250	900	330	Est 555	56,610

6.3 Cost Comparison

Method	Number of heaters	Total power [a] kW	Capital cost estimate	Estimated Annual load/kWh [c]	Annual operating cost [d]
Boiler, radiators	14	80	\	22,000	£813
Under pew convector	102	30.6	31,926	9,180	£1,928
Under pew radiant	102	25.5	56,610 [b]	7,650	£1.606

a) Note total power reflects that less power is required the closer the heating elements are to the congregation
b) Plus installation and cabling
c) Total kWh is reduced to reflect electric heat being provided to the congregation, rather than the ceiling, with 300 hours use as at present
d) Not including standing charge and VAT

7. Improve the Existing Heating System

A recently installed Worcester GB 162 boiler is fitted, with adequate pipework insulation

The expansion tank, right, is suffering from corrosion; this should be addressed, i.e. any roof leakage. In the short term, covering it with plastic sheet so that water does not drip onto it is advised.

The system appears to be set to deliver a return water temperature of below 55°C, which is required for efficient condensing operation. This should be checked after a long period of running. If it is above 55°C, the boiler output temperature should be decreased. Although this will require proportionally longer operating times to deliver the same amount of heat, some of it will be coming from the exhaust steam, so the system will be more efficient and cheaper to run.

Flow and return temperature gauges.

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 the following:

7.1 Endotherm Advanced Heating Fluid

In order to improve the efficiency of the heating system further it is recommended that an advanced heating fluid (http://www.endotherm.co.uk/) is added to the heating system.

This fluid in in addition to, and complements any existing inhibitors in the heating system and is added in a similar way. The fluid works to improve the ability of the boiler to transfer heat into the heating system and for the radiators and other heating elements to give out their heat into the rooms. It does this by reducing the surface tension of the water and increasing its capacity to transfer and hold heat. Case studies have demonstrated that the addition of this fluid into heating systems reduces heating energy consumptions by over 10% as well as helping the building heat up quicker.

Endotherm can be self-installed by any person competent to depressurise and repressurise the system.

Calculation:

80kW x 8 = estimated system volume = 640Litres. Divide by 100: 6.4litres = 13 x 500ml bottles @ £20ea. = £260

7.2 Magnetic Particle Filter

The boiler is not fitted with a magnetic particle filter. This apparatus catches any rust or metal particles and prevents them being deposited on the boiler heat exchanger and prevents blocking of radiator valves. One should be installed if it is planned to continue using the gas fired water heating system long term.

7.3 Reflective Radiator Panels

Wall mounted radiators will benefit from self installed reflective material placed between them and the wall.

8. Energy Saving Recommendations

In addition to having a revise heating strategy there are also a number of other measures that can be taken to reduce the amount of energy used within the church.

8.1 New LED Lighting

The lighting makes up a relatively small proportion of the electricity used within the church.

Replacing the eleven current compact fluorescent light (CFL) bulbs with LED units will approximately half the lighting electricity demand. This is not an urgent intervention, but suitable replacement LED bulbs should be sourced. If the lights are not dimmed, then "off the shelf" LED bulbs can be purchased. Where dimming is provided, compatible bulbs must be sourced which work with the expensive (c. £5k) semiconductor dimming equipment.

The six internal floodlights on beams in the nave should be changed for LEDs – these appear to be 80 or 100 Watt at present.

8.2 Lighting Controls (Internal)

The church is normally open to visitors. It is recommended that a motion sensor is installed on selected lighting circuits so that the lights come on only when movement is detected in the space and turn off approximately two to five minutes after the last movement has been detected (note that the duration of the time lag after which the light goes off needs to be consider alongside the type of light that is fitted. LED lights are much more suited to being switched off after only a short duration than some fluorescent lights). These movement sensors (commonly called PIRs) also have light sensors integrated into them so they can be used to make sure that the light does not come on if there is already sufficient daylight in the space. This prevents visitors inadvertently leaving lights on when they leave.

Areas such as the toilet 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.

Your existing electrician or any NICEIC registered electrical contractor can install PIR sensors onto existing lighting circuits. This can be carried out without significant disruption to the use of the space.

8.3 Draught Proof External Doors

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

For timber doors that close onto a stone surround more traditional solutions such brush draught strips rebated into the edge of the door by a skilled joiner. Other traditional methods such as using hessian or felt pads tacked to the door could be used and keeping the door maintained in a good condition is important.

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

8.4 Windows

Hopper windows can be draught proofed cheaply using black plasticene, which allows for summer opening.

9. Renewable Energy Potential

The potential for the generation of renewable energy on site has been reviewed and the viability noted.

Renewable Energy Type	Viable
Solar PV	No –visible roof
Battery Storage	No – no viable PV
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 hours of use
Ground Source Heat Pump	No – archaeology in ground and insufficient hours of use

Having reviewed the site it is not considered that there is good viability for any renewables and instead a good clear focus on reducing the energy demand of the building should continue with a targeted approach on reducing the heating energy.

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. Ground Source Heat Pumps require either large areas of ground for the pipework array, or boreholes.

Air Source Heat Pumps [ASHP] have temperature dependent efficiency values. They are least efficient when required to deliver large amounts of heat when the air is cold, so are incompatible with heating a church once a week from cold. They also require an external location which is often difficult to arrange on a listed building due to aesthetic considerations.

10. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available at www.parishresources.org.uk/resources-for-treasurers/funding/

This includes a 77 page guide to funders and their criteria:

https://www.parishresources.org.uk/wp-content/uploads/Charitable-Grants-for-Churches-Jan-2019.pdf .

11. Faculty Requirements

It must be noted that all works intended to be undertaken should be discussed with the DAC at the Diocese.

Throughout this report we have indicated our view on what category of permission may be needed to undertake the work. This is for guidance only and must be checked prior to proceeding as views of different DACs can differ.

Under the new faculty rules;

List A is for more minor work which can be undertaken without the need for consultation and would include changing of light bulbs within existing fittings, repair and maintenance works to heating and electrical systems and repairs to the building which do not affect the historic fabric.

List B is for works which can be undertaken without a faculty but must be consulted on with permission sought from the Archdeacon through the DAC. This includes works of adaptation (but not substantial addition or replacement) of heating and electrical systems and also the replacement of existing boilers so long at the same pipe work, fuel source and flues are used. It can also be used to replace heating controls.

All other works will be subject to a full faculty.

Works which affect the external appearance of the church will also require planning permission (but not listed building consent) from the local authority and this will be required for items such as PV installations.

12. Other Observations

12.1 Step safety

The bottom step in the boiler room is made of a slaty rock which is delaminating, and might further fail underfoot. This should be replaced, either with half a concrete paving slab, or turned over if the reverse face is in better condition.