Energy Efficiency and Zero Carbon Advice

All Saint's Church, Kempston
PCC of All Saint's Church

Author	Reviewer	Date	Version
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1. Executive Summary

An energy survey of All Saint's Church, Kempston 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.

All Saint's Church, Kempston is a limestone built Grade I listed church with origins dating to 1099, the majority of the construction is 15th century. [Historic England reference 1114281].

Only electricity is supplied to the site Heating is currently fuelled by oil.

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)
Draughtproofing works to doors	5% 800	40	400	10	List B	0.21
Install LED lighting where not already fitted	100	14	100	7	List A	0.06
Install PIR person sensors to control lighting	100	14	220	16	List B	0.06
Install Under Pew Heaters	16,000 oil	800	8 to 14k (or new boiler)	10-18	Faculty	4.30
Install solar photovoltaic panels on nave and south aisle roofs	All electricity 5,000 + oil replacement	1,600	16k	10	Faculty	1.3 electric 4.30 oil

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

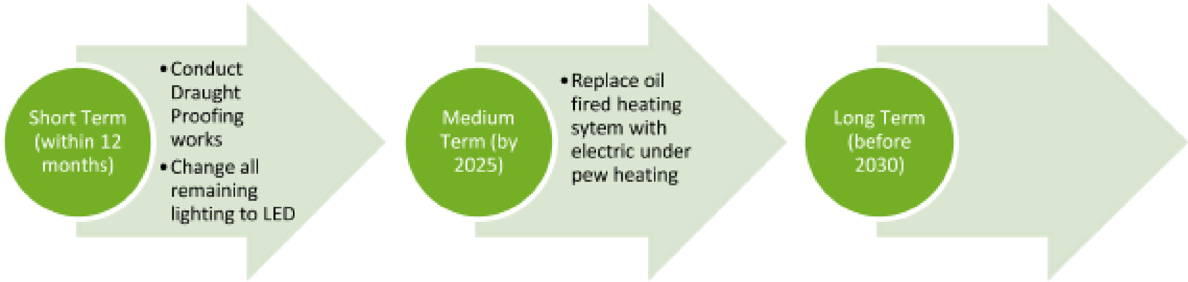
Based on current contracted prices of 13.8717p/kWh (day), 12.0238p/kWh (night) for electricity.

If all measures were implemented this would save the church around £2,400 per year in operating costs.

2. The Route to Net Zero Carbon

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

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



3. Introduction

This report is provided to the PCC of All Saint's Church, Kempston 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 All Saint's Church, Kempston, Church End, Bedford, MK43 8RH was completed on the 17th March 2021 by 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 Associate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church.

The church was represented by Mr Alan Lowe.

All Saint's Church, Kempston	
Church Code	**632286**
Gross Internal Floor Area	320 m^2
Listed Status	Grade I, List reference 1114281

The church typically used for 6 hours per week for the following activities

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	3 hours per week	30
Meetings and Church Groups	0 hours per week	
Community Use	0 hour per week	
Occasional Offices	8 Weddings p.a. 20 Funerals p.a.	100 100

Church annual use: 350 hours

Heating hours: Church: 220 hours

3.5hours per week x 30 = 105hours + 28 offices x 4 hours

(16,080kWh / 73kW average)

Estimated footfall: 4,500 people

4. Energy Procurement Review

Energy bills for oil and electricity have been supplied by All Saint's Church, Kempston and have been reviewed against the current market rates for energy.

The current electricity rates are:

Day Rate	13.8717p/kWh	Below current market rates
Night Rate	12.0238p/kWh	Below current market rates
Standing Charge	p/day	N/A

Recent oil consumption (2019) was 1500 litres, costing £763 (50.87p/litre).

Electricity is supplied by Total Gas & Power, through the Parish Buying Scheme.

The above review has highlighted that the current rates being paid are in line or below current market levels and the organisation can be confident it is receiving good rates and should continue with their current procurement practices.

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

All Saint's Church, Kempston used 4,841kWh/year of electricity from October 2019 to September 30th 2020, costing £800 per year, and 1500 Litres / 16,080kWh/year of oil, costing £763.

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

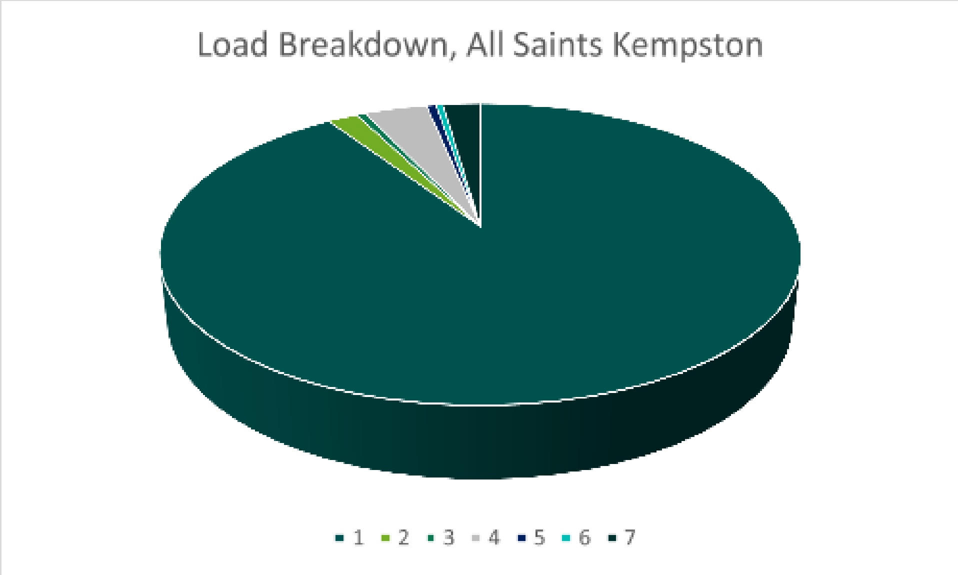
5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Annal Use kWh	Estimated Proportion of Usage
Heating (Oil)	Boiler: GAH Heating Thermecon Optic Approximately 90kW (6 hours weekly x 30 weeks)	16,080	90.6%
Heating (electric)	6 Radiator circulating fans c. 500W each 105 hours	320	1.8%
Hot Water	Wall mounted Point of Use water heater, 2kW Kettle, c. 10 boils per week, 2kW	25 75	0.6%
Lighting (internal)	Nave 6 chandeliers of 6 x 25W CFL = 900W Aisles 4 LED floodlights = 200W Chancel 2 LED floodlights = 100W 3 spotlights, Halogen 100W = 300W Tower 4 spotlights, Halogen 100W = 400W 350 hours use Total = 1.9kW	665	3.8%
Lighting (external)	PIR controlled security lights, total 500W	100	0.6%
Organ, music, PA	Organ blower, 1.5kW PA system, 500W total. 350 hours use	400	2.2%
Other Small Power	Vacuum cleaner, 1.5kW	75	0.4%
	Total from estimate	= 1,680kWh	

Church annual consumption, 10/2019 to 9/2020 = 4,841kWh.

The discrepancy between actual consumption for the past year (which will have involved less use than normal due to covid-19) might be explained by recent installation of CFL and LED light bulbs. The low hours of use of the church building and lack of electrical devices do not suggest many options. The tower was not investigated – if there is a ringing chamber which is used by bellringers, the church should investigate whether there is electric heating provided and the hours of use, which can be significant in some churches.



KEY 1 Oil Heating 2 Electric Heating 3 Hot Water 4 Lighting (internal)

5 Lighting (external) 6 Small power 7 Organ, P.A. system

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[1] for church energy use All Saint's Church, Kempston uses 21% less electricity and 66% less heating energy than would be expected for a church of this size.

This is due to low hours of use compared to many churches.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
All Saint's Church, Kempston (elec)	320	4841	15.1	19	-21%
All Saint's Church, Kempston (oil)	320	16,080	50.2	148	-66%
TOTAL	320	20,921	65.4	167	-61%

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

6.1 Building and Ministry Overview

The original church was constructed in 1099 (there is still a low Norman arch to the chancel); most of the building dates from the 15th century. The church has a small congregation of around 30. The moving of the original Saxon settlement and rural depopulation has resulted in a fairly isolated building (but with nearby car parking). It is located in a rural setting, with a few nearby detached houses, at the end of a lane with the river Great Ouse forming one boundary of the churchyard. Newly constructed housing the other side of the river is not connected. The low hours of use, basically Sunday mornings only except for weddings and funerals mean that electric heating is the best option for the future.

6.2 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 with little opportunity to decarbonise in the future. Electricity currently has 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 it remain 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 critical 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 for churches.

The church currently has an oil boiler which supplies a series of fan assisted radiators. The boiler will require replacement within the next decade.

The low hours of use of the building suggest that a new heating method which can rapidly deliver heat when it is required, rather than a system which provides heat slowly and therefore needs to run for many hours is appropriate. The existing fan assisted radiator network could be powered by a heat pump requiring electricity; however hours of use are too low for an Air Source Heat Pump to be successful, and there is no obvious location for a unit on the exterior of the Grade I listed building.

A Ground Source Heat Pump would require either ground pipework (unlikely there is enough suitable land due to burials), or trenching to the nearby river for a Water Source system (requiring Environment Agency permission): in both cases the large capital costs are not justified by the low hours of use of the building; one service per week plus weddings and funerals.

Therefore the most suitable heating method is to install under pew electric heating (6.3). Other, less suitable options are radiant heating from chandeliers (6.4) and radiant infra-red panels (6.5).

6.3 Install Electric Under Pew Heaters

The church is fitted with 26 forward facing pews plus a further three for the choir at right angles.

The aisle pews are 1.5m in length, the nave is seated with a mix of 2.1 and 3.0m length pews.

Under seat supports are fitted at various positions.

It is recommended that in order to heat a congregation of normally 30 people, only the nave pews need to be fitted and aisles could be fitted at a later stage if needed. If the church has sufficient capital, installation of heaters to all the pews at once would probably be cheaper.

Heaters should each be fitted with individual switches so they can be turned off if the people become too hot. They may also be controlled centrally, perhaps divided into zones (front, back, each aisle). All, or partial zones could be used dependent on the weather, and the amount of preheating before a service can also be varied as necessary.

The Inspecting Architect of All Saints is reported to attend a church with under pew heating plus some infra red panels. It is recommended that a group of church decision makers visit this church to understand how the system has been installed and how it is used.

The current boiler probably has a power of around 80kW. It is not necessary to provide 80kW of electric heating under the seats; the radiator space heating system warms air which firstly rises to the ceiling; eventually, somewhat less warm air arrives at pew level.

There are a variety of different length and power heaters; BN Thermic supply convection heaters whereas Cooltouch are flat panel radiant. The type chosen will depend on the spaces between pew supports which varies.

For replacement, two most popular under pew heaters within churches are BN Thermic PH65 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating.

The flat panels are from Cooltouch; https:// www.cooltouchheaters.co.uk/safe-heating

Different indicative installations would be:

A BN Thermic, all pews fitted

Aisles, Choir, (17 x 1.5m pews), 17 x BN45 units 702mm, 450W, £329 installed each = £5.593

Nave (4 x 2.1m pews), 8 x BN45 units 702mm, 450W, £329 installed each = £2,632

(8 x 3m pews), 16 x BN65 units 948mm, 650W, £341 installed each = £5,456

TOTAL £13,681

Total power 22.1kW. Used for current 220 heating hours = 4,862kWh

B BN Thermic, nave only TOTAL £8,088

Total power 14.0kW. Used for current 220 heating hours = 3,080kWh

C Cooltouch, all pews fitted

Aisles, Choir, (17 x 1.5m pews), 17 x 900mm units,250W, £330 + installation each= £5,610+inst

Nave (4 x 2.1m pews), 8 x 900mm units,250W, £330 + installation each= £2,640+inst

(8 x 3m pews), 16 x 1200mm units,320W,£360+ installation each=£5,760+inst

TOTAL £14,010+inst

Total power 11.4kW. Used for current 220 heating hours = 2,508kWh

D Cooltouch, nave only TOTAL £8,400+inst

Total power 7.1kW. Used for current 220 heating hours = 1,566kWh

Cable runs to the pew heaters should be in armoured cable or FP200 Gold when above ground.

Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

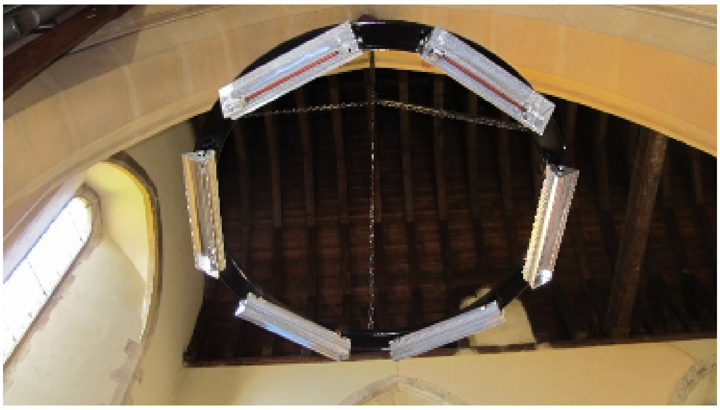
The under pew (see photo below) and panel heaters have been recently installed at St Andrews Church, Chedworth, Gloucestershire, GL54 4AJ. The church is open in daylight hours so can be viewed at any time.

The Cooltouch heaters below are installed at St Catherine's, Towersey, Oxfordshire.   The company is based in Kettering so there is probably a nearer church which is equipped.

6.4 Chandelier Mounted Overhead Radiant Heaters

Currently, the church is lit by six chandeliers suspended from the tops of the arches.

Radiant bar heaters could be similarly mounted on larger diameter chandeliers which also incorporate heating. As the nave is quite wide, this method may not effectively reach people at the centre of the nave or in the aisles next to the wall, whilst those sitting under the chandelier centre would become hot. Systems have been effectively installed in some churches where dimensions mean heating of the majority of the seating is feasible, e.g. at St Catherine's, Faversham, below.



6.5 Wall Mounted Electric Far Infra Red Heating

Wall mounted far IR panels are sometimes used to complement under pew heating.
At All Saints, Kempston, there are few suitable areas of wall; the nave walls above the columns are too high and there are limited areas of aisle wall available, which would not heat those seated in the nave.

6.6 Upgrade to 3 Phase Electricity Supply

To be able to have sufficient electrical power to supply enough energy into an electrical heating system the church will need to increase the electrical supply it current has coming in from the existing single phase supply to a 3 phase 100A supply.

The upgrade to the supply has to be carried out by the District Network Operator in the areas.

The DNO in your area is thought to be UK Power Networks - www.ukpowernetworks.co.uk; 0800 029 4282 (London, South East and Eastern England)

The cost of bringing in a new 3 phase supply can range from £300 to £30,000 but the DNO will provide a quotation for free so it is well worth obtain a quotation in the short term so that decisions can be made on a well informed basis.

6.7 Install an Overdoor Heater

In order to achieve the sense of a 'warm welcome' into the church an over door air heater could be provided. This would also help to provide warmth to the rear of the church. Such an over door unit should be sized to cover the whole width of the door and it is suggested the BN Thermic 860 model would be quite suitable. This has a 6kW output. The installation would therefore be:

Install a BN Thermic 860 Overdoor Fan heater above the main entrance door wired in with a BN Thermic CS-7 control switch. The unit requires single phase power, all new cabling to be run in FP200 Gold.

7. 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.

7.1 Completion of LED Lighting

Non LED lighting makes up a relatively large overall energy proportion of the electricity used within churches.

It is recommended that the remaining seven non LED spotlight bulbs in the chancel and tower are all changed for LED. 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/

Where the lighting is at low level and can be accessed by competent members of the churches internal team, this would be a cost effective List A item with no permission required. With no dimming required in the tower, replacement LED bulbs could be sources for under £100.

Higher level bulbs such as in the chancel ceiling would require access equipment.

7.2 Lighting Controls (Internal)

The church is understood to normally be open to the public for visiting in normal times.

It is recommended that a motion sensor is installed on certain lighting circuits so that some lights come on 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 could be a portion of the chandelier lighting with a detector at the entrance and another near the chancel.

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 Draught Proof External Doors

There are a number of external doors in the church. These are historic timber doors, many of which do not close tightly against the stone surround and hence a large amount of cold air will enter the church around the side and base of these doors during cold or windy weather.

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.

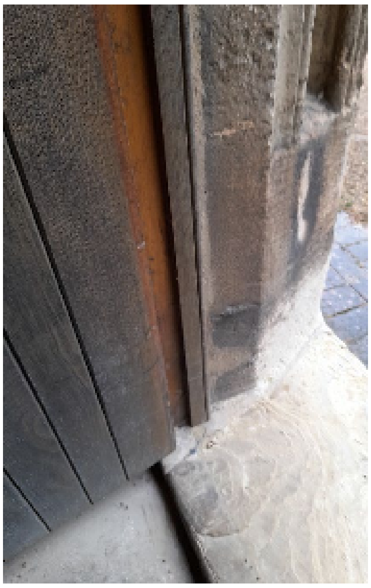
For timber doors that close onto a timber frame a product called QuattroSeal (see link below) is often used in heritage environments to provide appropriate draught proofing.
http://www.theenergysavers.co.uk/application/files/1714/7197/4194/National_Trust_Case_Study.pdf

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.


The church is entered visa a porch, so good draught proofing is possible here.





The tower door is wooden framed.   It has no draught exclusion device underneath.

The vent in the boiler room door should be sealed or removed when the boiler is removed.

8. 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 – on nave and south aisle roofs
Battery Storage	Yes – with 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 – no suitable location
Ground Source Heat Pump	No – archaeology in ground, insufficient hours of use.

Wind turbines require highly exposed sites and should be located 250m way from buildings as such this site is not suitable for a wind turbine to be installed.

Hydro electricity is a highly efficient source of renewable energy but requires a body of flowing water with a differential height which is not present on this site.

Solar thermal installations are best suited to heat water for use in washing up, hand washing and bathing. There is minimal hot water demand at this church so such an installation would not be viable.

There is potential for a solar photovoltaic array to be installed on the roof of the Nave and the roof of the South Aisle as both areas have a shallow pitched roof behind a parapet. Suitability of the roof structure would have to be confirmed with your architect as to suitability for extra weight and wind loading on the roof structure. If the roof is covered in lead sheet, the panels could be attached using a self weighted system.

The current arrangements around solar panels mean that to be financially viable the building on which they are mounted needs to consume the vast majority of the energy that they produce. The church's energy consumption is small and the consumption during the daytime when the sun is shining is likely to be very low indeed. However, this will increase if electric under pew heating is installed. Much of this use will occur on Sundays during autumn, winter and early spring; installing a battery of sufficient capacity to supply a significant portion of Sunday use (3 hours, 22 to 66 Wh depending on how many heaters are installed and used).

The roofs offer areas of around 150m^2 (nave 8 x 14m, south aisle 3 x 14m).

This could generate 0.15kWpeak/m^2 giving a 22.5kWpeak system. A 1kWpeak system at this locality can generate up to 950kWh annually, giving a total annual generation of around 20,000kWh. Orientation factor (roof slope and angle from south) is 0.93.

Annual Generation (kWh) = Area x 0.15kWp/m^2 x K factor x Orientation Factor x Overshading Factor

= 150m^2 x 0.15kWp/m^2 x 950kWh/kWp x 0.93 x 1

= 19,880kWh

This much larger than the church's annual recent electricity use (4,841kWh), and suspected use pre covid (over 5,000kWh). The estimate for electric heating is added ranges from 1,500kWh to above 5,000kWh depending on type of system, the percentage of pews fitted and hours of use. This totals to between 6,500kWh for the smallest pew heating system and above 10,000kWh.

The roof area is able to support a PV system large enough to provide enough annual generation in kWh to support electric under pew heating. A battery will extend the usefulness of the system (i.e. more of the generated electricity can be sued on site), but there will still be a need to export excess power in summer and buy grid electricity during winter evenings.

The Smart Export Guarantee pays about 5p/kWh for electricity generated and exported to the grid (the Feed in Tariff having ended). One of the issues for churches is that most lighting use is at periods when the electricity is not being generated, so installation of a battery to make maximum advantage is recommended. Using a battery will extend the usefulness of the power generated during the day into the evening, but some exporting of power to the grid in summer, and purchase from the grid for winter evenings will occur.

Using average 2019 installation costs (£1,450 per kWpeak); a 22.5kWpeak system would cost £32,625. This does not include cost of any battery.

A 11.3kWpeak system (75m^2) generating around 10,000kWh per annum would cost £16,385.

Sources: Tables H3 & H4, SAP 2009, http://www.bre.co.uk/filelibrary/SAP/2009/SAp-2009_9-90.pdf

Much of the surrounding ground has internments, so is unsuitable for subsurface Ground Source Heat Pump pipework, so a more expensive borehole would be required.

The river Great Ouse is about 50m from the building across the churchyard, so a Water Source Heat Pump is technically feasible, however, both these technologies are expensive (£1,000 per kW of heat required, so around £80k) and only suited to very well used buildings.

9. 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 .

10. 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.