ESOS-ENERGY
Energy efficient solutions

Energy Audit and Survey Report

St Peter's Church, Boughton Monchelsea

PCC of St Peter's Church

Version Control

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Peter's Church, Boughton Monchelsea was undertaken by ESOS Energy Ltd to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use. 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 Peter's Church, Boughton Monchelsea has Norman origins in the early 1100s with the tower at the south transept surviving. The nave was rebuilt following a fire in 1832, with an extra bay, south aisle and vestry added in 1874. There is both gas and electricity supplied to the site.

The church has a number of ways in which is 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.

Short Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)	£/tonne of CO2
Switch electricity supplier to one which provides 100% renewable supply	Nil	5-15% savings likely	Nil	immediate	None	N/A	N/A
Draughtproofing maintenance	3,000	£180	£50	0.28	List A	0.64	£77.71
Replace 400W floodlights with 150W LED floodlights	2,000	£270	£800	2.96	List B	0.61	£1,302.08
Install solar photovoltaic panels on south aisle roof	7,650	1,000	£11,700	11.33	Faculty	2.35	£4,978.55
Install electric under pew heaters and some radiant heaters	Save 70,000 kWh of oil, Use 15,600kWh of electricity instead	£2,094	£15,800	7.55	Faculty	10.22	£1,545.99

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

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Based on current market prices of 13.5 p/kWh for electricity and 6p/kWh for oil.

If all measures were implemented this would save the church more than £1,400 in operating expenditure per year.

Operating costs of electric heating are equivalent to those of oil fired central heating, since less preheating is required.

2. Introduction

This report is provided to the PCC of St Peter's Church, Boughton Monchelsea to provide them with 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 Peter's Church, Boughton Monchelsea, ME17 4BU was completed on the 18th November 2019 by Dr. Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group 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.

St Peter's Church, Boughton Monchelsea	606317
Gross Internal Floor Area	495 m^2
Listed Status	Grade II*
Typical Congregation Size	75

The church typically used for 13 hours per week for the following activities

Services	4 hours per week
Meetings and Church Groups	4 hours per week
Community Use	4 hour per week
Occasional Offices	1 hour (10 weddings)

Church annual use = 675 hours

Heating hours: Church = 700 hours

Estimated footfall = 10,500 people

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3. Energy Procurement Review

Annual consumption and costs for oil use, and annual costs for electricity for St Peter's Church, Boughton Monchelsea have been supplied by the church. Electricity bills have not been provided and rates are unknown.

The current electricity rates are unknown.

We would usually recommend that the church obtains a quotation for electricity supply from the Diocese Supported parish buying scheme, http://www.parishbuying.org.uk/energy-basket. This scheme only offers 100% renewable energy sourced energy and therefore it is an important part of the process of making churches more sustainable.

It is unclear what VAT rate and CCL are being charged.

If 20% and/or CCL are being charged the PCC of St Peter's Church, Boughton Monchelsea should send the supplier at VAT declaration confirming the organisation is a charity and has VAT exemption status.

Possibly the oldest Lych Gate in England – 15th century. (uninsulated)

4. Energy Usage Details

4.1 Annual Consumption

St Peter's Church, Boughton Monchelsea uses £1,170 worth of electricity per year (in 2019), estimated at 7,555 kWh/year of electricity using average charges of 13.5p/kWh, 25p/day standing charge and 5% VAT. This data has been taken from a summary of the last three years annual electricity expenditure provided by the chruch. It has not been possible to view the utility bills to see the rates charged.

Annual oil consumption for the past 5 years averaged 6,574 litres [For the heating years from October to September from 2014: 5,452L, 5,947L, 6,968L, 7,741L, 6,761L] The costs are variable; £3,500 in 2018-19. This represents an average annual use of 70,470kWh for space heating.

Meter Details

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	D0094216	General Electric SGC1311	Yes	Cabinet in North west corner of church near door

Energy Usage Details

Utility	Annual use/ kWh	from	to	Cost
Electricity - Church	7,555 Calculated from bill using average cost rates	October 2018	September 2019	£1,170
Oil – Church	70,471 kWh	October 2018	September 2019	£3,502

The electricity meter is AMR connected and as such energy profile for the entire energy usage should be possible.

4.2 Energy Profiling

The main energy use within the hall can be estimated as follows:

Service	Description	Power	Annual Use/ kWh	Estimated Proportion of Usage %
Gas heating	Ideal Viceroy boiler Estimated 700 heating hours	100kW estimate	70,000	90.3%
Boiler pump		100W	70	0.1%
Lighting	All LED fittings in church total 675 hours	1kW	675	
Floodlights	Crompton Darksky metal halide	each 400W	3,840	5.8%
Heating [Electric]	North Porch over door fan	1kW	30	
	Unspecified radiators		2,445	3.2%
Hot Water	Fixed water heater (Supreme) hour/ week	3kW	156	0.2%
Other Small Power	Vacuum cleaner 1/2 hour per week	1.5kW	39	
	PA System	1kW	150	0.2%
Organ		1kW	150	0.2%

Total Annual Consumption 2019: 7,555kWh

4.3 Energy Benchmarking

In comparison to national benchmarks for Church energy use St Peter's Church, Boughton Monchelsea uses 76% electricity and 95% heating energy than the average for a church of this size.

	Size (m^2 GIA)	St Peter's Church, Boughton Monchelsea use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Peter's Church, Boughton Monchelsea (elec)	495	15.2	20	10	76%
St Peter's Church, Boughton Monchelsea (heating fuel)	495	142	150	80	95%
TOTAL	495	157	170	90	93%

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

[1] CofE Shrinking the Footprint – Energy Audit 2013

5. Energy Saving Recommendations (Electricity)

5.1 Lighting (fittings)

Internal lights are thought to be all LED

5.2 Lighting (control for internal lights)

The church is well lit in daylight, with relatively large south facing windows, therefore the number of lights used to light the church during summer could be reduced with some experimentation.

The existing lighting control panel is well labelled.

5.3 External Lighting

400W metal halide floodlights are in use. These could be replaced by lower energy models such as the 150W LED illustrated below. This will save considerable amounts of electricity consumption.

6. Energy Saving Recommendation (Heating)

6.1 Heating System and Strategy

The church currently uses an Ideal Viceroy oil fired central heating boiler, dating from October 1989 to heat the church. This is reported to work well and provides adequate thermal comfort into the church, but requires long heat up times. However, the boiler is old and oil has been stolen from the tank. The annual heat use is around 70,000kWh.

Direct electric heating by under pew heaters with some radiant heating would give more flexibility and allow the church to be zoned. As less heat is being circulated to the ceiling, the annual use is likely to be 30-40,000kWh. Further details are in Section 7.

An overdoor electric fan heater is positioned over the north porch entrance, below.

chemicals are put into the system which is then turn on and run through a filter consisting of high power magnetics to remove the sludge.

The cleaning of a heating system can be carried out by any competent heating engineer and typically increases the efficiency of a system by between 10 to 15%. This can dramatically improve comfort for the occupants.

7. Alternative Heating Systems

A church with low hours of use per week will always fall back to "base" temperature between heating events (it will take around 24 hours for the temperature to fall from 20 to 12°C). A system which can heat rapidly, without sending most of the heat to the ceiling first, and in addition can be configured to heat small areas independently for small services or midweek meetings will be more efficient than one which seeks to heat up the whole volume.

As with most medieval churches, this church would have survived most of its life without any form of heating the modern additional of heating is not needed to preserve the fabric but only to provide thermal comfort to occupants. The previous trend of 'conservation heating' for fabric issues is now largely considered to be unnecessary and is being avoided by the likes of National Trust and English Heritage.

Electric heating systems offer rapid heating (i.e. without the hours of preheating necessary to raise a cold church from 10 degrees) so offer advantages in churches heated once or twice per week.

Electric heating becomes more viable when a church is able to generate electricity on site; installing solar panels would help viability.

7.1 Under Pew Heating

The most likely option is to install under pew electric heating. 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. There are four rows of ten pews. Those in the nave would require two heaters each and those in the aisles one, giving a total requirement of 60.

Heaters with an output of 300-400W seem to be more suitable than 500W models according to reports from different churches.

60 x 400W =24kW. Cost at £140-180 per heater installed = £8,400 to £10,800.

The church is used for 675 hours a year, assuming two thirds of this use requires heating (the other third being in summertime) this would mean there is 450hours of use when heating is required. Electric under pew heating needs only 30min warm up time so adding this on would mean the electrical heating would be on for around 650hours a year. 24kW x 650 hours = 15,600kWh per year compare with the 70,000kWh per year of oil

An advantage of under pew heating is that each heater can be switched individually to fit with congregation size. All Saints, Hollingbourne is an example of a church heated entirely by under pew heating.

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.

7.2 Use of Electric Radiant Heating

For areas of the church without pews which still need heating; the rear circulation area, the chancel, chapels; heat can be provided either by electric convector heaters (which lose heat to the ceiling), or electric radiant heating. This may be delivered using ceramic bar heaters, which emit some visible radiation as a red glow, or rectangular far infrared heaters which emit only heat.

Far infrared panels come in three types, low surface temperature designed for ground level installation and safe for schools (55°C) and hospitals (42°C), medium temperature, and high temperature at 150°C designed for installation under high ceilings. In churches they have been successfully installed under ceilings, often in aisles between the beams. Normally available in white, they can be sourced in other colours including marching to stonework or brickwork or decorated. https://www.suryaheating.co.uk/custom-image-heating-panels.html

Suitable electric panel heaters would be far infrared panels such as https://www.warm4less.com/product/63/1200-watt-platinum-white- . These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch such as https://www.danlers.co.uk/time-lag-switches/77-products/time-lag-switches/multi-selectable-time-lag-switch/159-tlsw-ms so they can not be left on accidently after use.

Costs are £350-500 wall mounted and £500-700 ceiling mounted.

Another option would be to use radiant (glowing) heating elements – these normally look unsightly when hung from ceilings or attached to walls but have been successfully deployed in churches hung from chandeliers, where they can be combined with lighting if desired.

The image below is from St Catherine's, Faversham, which is heated solely by chandelier mounted radiant heaters suspended from arch centres. Costs are approximately £500 per 1kW element.

7.3 Under Floor heating

The possibility of installation of underfloor heating to the body of the church was mentioned.

This would require removal of pews and lifting of the tiled floor. It is not believed that there is a vault underneath. Underfloor heating would raise the floor level by 150-200mm (unless suitable excavation is performed).

Churches with underfloor heating installed have a regular use pattern, such as St Mary the Virgin, Ashford which hosts an arts venue and St Mary the Virgin, Willesborough, Ashford which hosts a café every morning. Systems take a long time to warm up and have higher energy uses (c. 100,000kWh + p.a.).

The current use hours and very rural location of the church do not suggest it is a suitable location for underfloor heating.

7.4 Heat Pumps

The relatively low hours of use for the church, 13 per week, mostly Sunday – Tuesday mean that the church will be intermittently heated. Any system has to raise temperature from the base temperature it has dropped back to (churches take about 24 hours to cool from 20 to 12°C and continue to cool if the weather is cold enough). A heat pump would have to work very hard to raise temperature rapidly in a large space, thus consuming lots of electricity. For optimum efficiency, they deliver low grade heat (warm water) at a constant rate, so are suited to regularly / constantly used buildings where the temperature is maintained.

ASHPs consume electricity but deliver between 2.5 and 4 times the amount of heat in kWh that they consume. Heat pumps work by circulating refrigeration fluid and taking heat from a

reservoir (the air or ground) and upgrading it (the fluid gets hot when compressed – in the building. When it evaporates it cools, and warms up again in contact with the external heat supply, air or ground. The Coefficient of Performance (COP) relates the amount of heat energy delivered to the electricity used. It is normally between 2 and 4. There are issues with trying to use an air source heat pump for intermittent heating in a building with very poor thermal qualities such as a church.

ASHP systems are often less efficient than this when the air temperature is cold and when they are heating a building from cold. A move to ASHP powered central heating would allow for 100% renewable heating if electricity is procured from a 100% renewable source (including Parish Buying), or from onsite generation. For St Peter's, with oil fired heating delivering 70,000kWh of heat annually, a COP of 3 would require 23,333kWh; 28,000kWh at COP 2.5.

This needs to be compared with the estimate for direct electric heating of 15,600kWh – requiring less preheating than space heating and (for under pew heaters) delivering heat close to where it is needed. Direct heating also allows for specific zones to be heated – ASHP driven central heating will still heat the whole building with heat rising to the ceiling.

Costs of a heat pump in the 50kW range are about £40,000. The pump, looking like an air conditioning unit requires a well ventilated location, possibly in the boiler room with extra ventilation ducts or louvres.

8. Energy Saving Measures (Building Fabric)

8.1 Draught Proofing to Doors

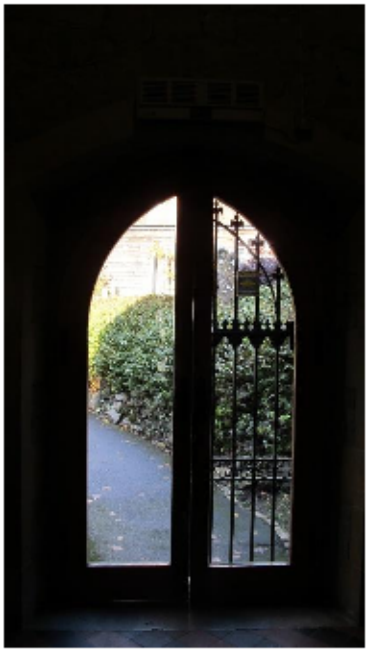
There are a number of external doors to the building. These are timber doors, which will benefit from maintenance and draughtproofing to prevent large amounts of cold air is coming into the church around the side and base of these doors.

Where a timber door closes against a timber frame it is recommended that draught proofing is fitted. 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. Note this cannot be used where the timber door closes directly against a stone surround.

Other simple measures such as using a small fridge magnet painted black over the large keyhole or the use of 'sausage dog' type draught excluders at the base of little used doors can prove to be very effective. Doors should be reviewed in daylight and gaps where the light shines through sealed or filled in whatever the most appropriate way is for the specific door.

8.2 Closed Door Policy

The main entry doors in the north porch should be kept closed in cold or windy weather and quickly closed behind the congregation by your friendly welcome team!



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	Yes, south aisle roof hidden by parapet
Battery Storage	Yes
Wind	No – no suitable land away from buildings
Micro-Hydro	No – no water course
Solar Thermal	No – insufficient hot water need
Ground Source Heat Pump	No – archaeology in ground and radiator system
Air Source Heat Pump	Potential
Biomass	No – not enough heating load as well as air quality issues

9.1 Solar PV potential

The roof of the south aisle and the lower portion of the nave roof which is hidden by the parapet offers a location for solar panels. The area has been inspected from above and it appears viable. Seven of the 21 rows of slates can be seen in the image above the parapet. Taking visibility through the gaps in the crenellations into account this means approximately half of the

roof area of the nave, plus some of the aisle roof is available, potentially 19m x (2m + 1m above aisle) = 57m2. A discussion with the DAC had occurred before the audit visit.

The suitability of the location would have to be confirmed with your architect regarding extra weight and wind loading on the roof structure.

A 57m^2 area generating 0.15kWpeak/m^2 giving an 8.5kWpeak system. A 1kWpeak system facing south at the optimum angle can generate 1000kWh annually in Kent, although due to the proximity of the tower an overshading factor should be applied to give 900kWh per kW peak and a total annual generation of 7650kWh. This is in the same region as the church's annual electricity use (estimated at 7,500kWh) – most of the use occurs be during the day, except for Tuesday evenings and occasional PCC meetings.

Options include installing a battery (so that all of the energy generated can be used. It is assumed that panels would have to be laid directly onto the roof surface.

Using recent costs for large installations of £1,200 per kWPeak including scaffolding, the system cost is £10,200. This does not include cost of any battery which a small unit may add £1,500. [Average 2018 domestic installation costs were £1,667 per kWpeak].

Battery Storage is not strictly a renewable energy solution, but battery storage does however 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 PV is no longer generating. It therefore extends the usefulness of the existing PV system particularly in this sort of church. This is a new but fast-growing technology with prices expected to fall substantial over the next 2 to 3 years therefore investment into this may be worth delaying at this stage. Most of the electricity generated by solar PV should be useable on site, especially if a battery is included.

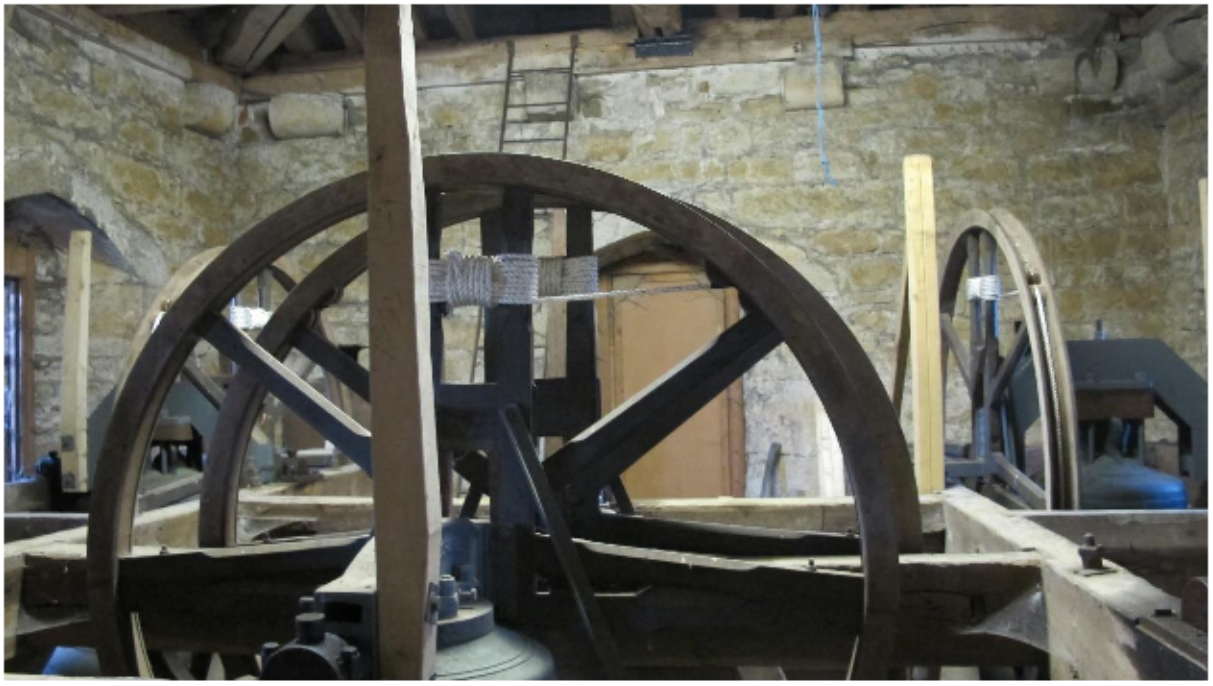
The government has advertised a "Smart Export Guarantee" to begin in 2020 which would pay for electricity generated and exported to the grid (the Feed in Tariff having ended). The rates are determined by individual purchasing utility companies and are low (up to 5.5p/kWh).

10. Maintenance Issues - Tower

The tower roof was visited in order to inspect the south aisle roof for solar PV potential.

It was noted that the lead gutter was cracked in the north west corner of the tower (above the top left in the photo below). Note also there is a large crack running along the centre of the main beam from this corner.

It is recommended that a rope (or handrail) be fitted across the bell frame to assist the warden or other persons who have to access the belfry or tower roof, as the existing route to the ladder involves walking across the bell frame, right of photo, and avoiding tripping on the large protruding bolt. All handholds can move! Crossing the bell frame should not be undertaken except in good light.



11. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available at https://www.parishresources.org.uk/wp-content/uploads/Charitable-Grants-for-Churches-Nov-2019.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.

13. Report Circulation

In addition to the PCC, this report is also sent to:

1. Your DAC secretary and your DEO, because
    - They maybe be able to offer you help and support with implementing your audit
    - They want to look across all the audits in your diocese to learn what the most common recommendations are.
2. Catherine Ross, the officer in the Cathedral and Church Buildings team centrally who leads on the environment, who wants to learn from all the audits across the country. She will be identifying cost-effective actions churches like yours might be able to make.