ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St George's Church, Bickley
PCC of St George's Church

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

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

St George's Church, Bickley is a Grade II listed Victorian church built in 1864. It sustained significant war damage; as a result, several windows were filled in, including all the clerestory windows; and the outer two lights of most of the three light lancets were replaced with stone. After a major fire in 1989 all of the roof and internal woodwork were replaced.

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.

Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission Required	CO_2 savings (tCO_2e/yr)
Purchase a temperature and humidity datalogger, and optimise heating start and stop times	5% 5,750	£119	£100	<1	None	1.0
Clean and flush heating system	10% 11,500	£238	£400	<2	List A	2.1
Install Endotherm heat transfer fluid	10% 11,500	£238	£50	<1	None	2.1
Install LED floodlights	1000	£125	£200 if just bulbs	2	None	(0.2)
Turn floodlights off at 23:00, 2 hours earlier	300 (if changed to LED, otherwise 600)	£38	zero	immediate	None	(0.1)
Draughtproofing, including vestry/ fire exit doors	5% 5,750		£150	1.5	List B	1.0
Install under pew heaters for chancel chapel seating	57,500 gas (use 2,200 electric)	£76	£1,450 + installation & cabling	1	Faculty	10.6
Install wall mounted infra-red panel heaters in Walsingham Chapel	8,000 gas	£119	£3,000	20	Faculty	With renewable electricity

Install under pew heaters for nave seating	57,500 gas (use 25,000 electric)	£916	£15,000 + installation and cabling	Avoids cost of new boiler and maintenance	Faculty	1.5

The above costs are based on current contracted prices of 12.5991p/kWh and 2.0759p/kWh for electricity and mains gas respectively. Estimates are based on each action being individual – i.e. installing under pew heaters in the chapel area will allow this area to be electrically heated, potentially cutting gas heating by half. Other efficiency measures will reduce the total and hence the size of this half.

The current carbon footprint of the energy use for church plus hall is 27.2t of CO_2, from gas use. The electricity supply is understood to be from renewable sources.

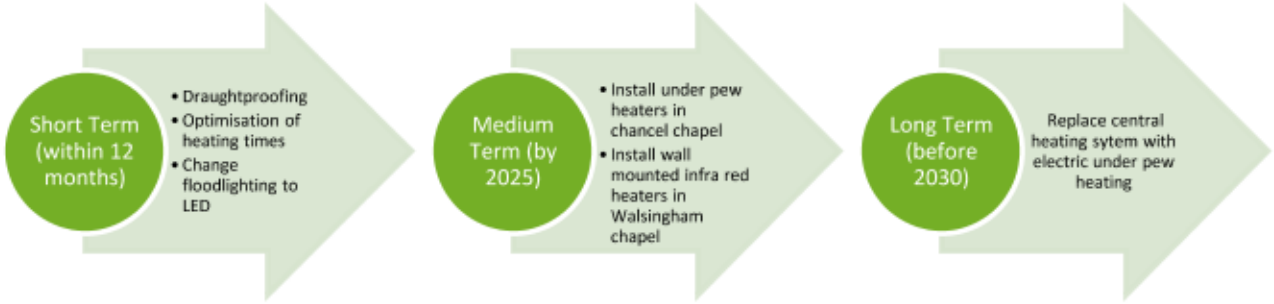
The Church should check any faculty requirements with the DAC Secretary at the Diocese before commencing any works.

If all measures were implemented this would save the church around £1,900 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 St George's Church, Bickley 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. 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 George's Church, Bickley Park Road was completed on the 14th September 2020 by 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 and has been an EcoChurch assessor.

St George's Church, Bickley	
Church Code	**631017**
Gross Internal Floor Area	655 m^2 (measured; includes vestry but not tower)
Listed Status	Grade II

The church typically used for 21 hours per week for the following activities

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	10 hours per week	115
Meetings and Church Groups	3 hours per week	30
Community Use	4 hours per week	Community choir, Plus 8 school carol services
Occasional Offices	10 Weddings 5 funerals 30 baptisms	150 100 100

Summing the data discussed gives the following figures:

Annual building Occupancy Hours: 1100

Annual Footfall: 28,000

Annual Heating Hours: 1000

Based on 26 hours heating per week x 30 weeks

Plus, semi continuous heating for four weeks in December.

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	12.5991p/kWh	Below current market rates
Standing Charge	39.0716p/day	N/A

The current gas rates are:

Single / Blended Rate	2.0759p/kWh	Below current market rates
Standing Charge	394p/day	N/A

The church obtains its gas and electricity supplies from the Diocese Supported parish buying scheme which offers 100% renewable energy. This means that the church's carbon footprint from electricity is zero.

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

VAT	5% current	20% was charged by the previous supplier between January and May, and October-November 2019. It is believed that this has been recovered.
CCL	Not charged	The correct CCL rate is being applied currently. CCL was charged during the above period.

The above review confirmed that the correct taxation and levy rates are being charged.

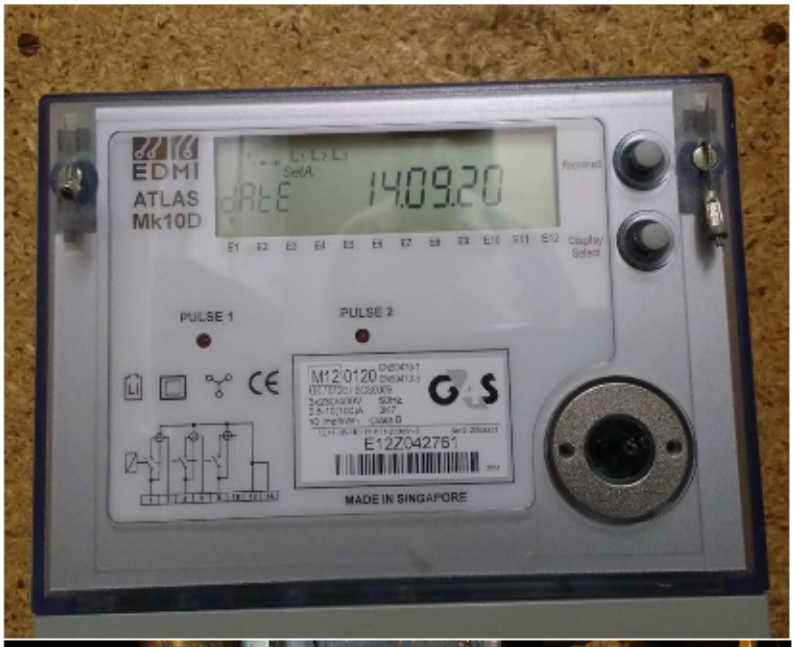
5. Energy Usage Details

St George's Church, Bickley uses around 8,800 kWh/year of electricity, costing in the region of £1,200 per year, and 148,000 kWh/year of gas, costing £4,750. Gas use is shared with the hall (Section 5.1).

This data has been taken from the annual energy invoices provided by the suppliers of the site. St George's Church, Bickley has a three phase electricity supply. The main gas meter serving the site is located externally. A meter is also located on the wall of the 1864 hall which appears to be connected to the gas pipe serving the church boiler – this meter appears to be obsolete.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E12Z042761	EDMI Atlas Mk10D	Yes	Flower room in tower
Gas – Church	M040 K00351 16 D6	BK - 625M	Yes	External gas meter cupboard, NW corner of car park

All the meters are AMR connected and as such energy profile for the entire energy usage should be possible to obtain from the supplier.



5.1 Church and Hall Gas use Estimation

One gas meter is thought to supply the site. The meter in the 1864 hall does not appear to be in use. An estimate has been made based on boiler size and reported hours of use for church and hall.

It is further assumed that (a) the church boiler is normally working at full power, heating a large space up from cool temperatures several times per week. 25h/week x 40 weeks

(b) the hall boiler is in use during the heating season when the building is open, 55 hours per week building use means the boiler may be operating for 8 or more hours on several days: it will not be at full power once the set temperature is reached. It is assumed the average is 1/3 power.

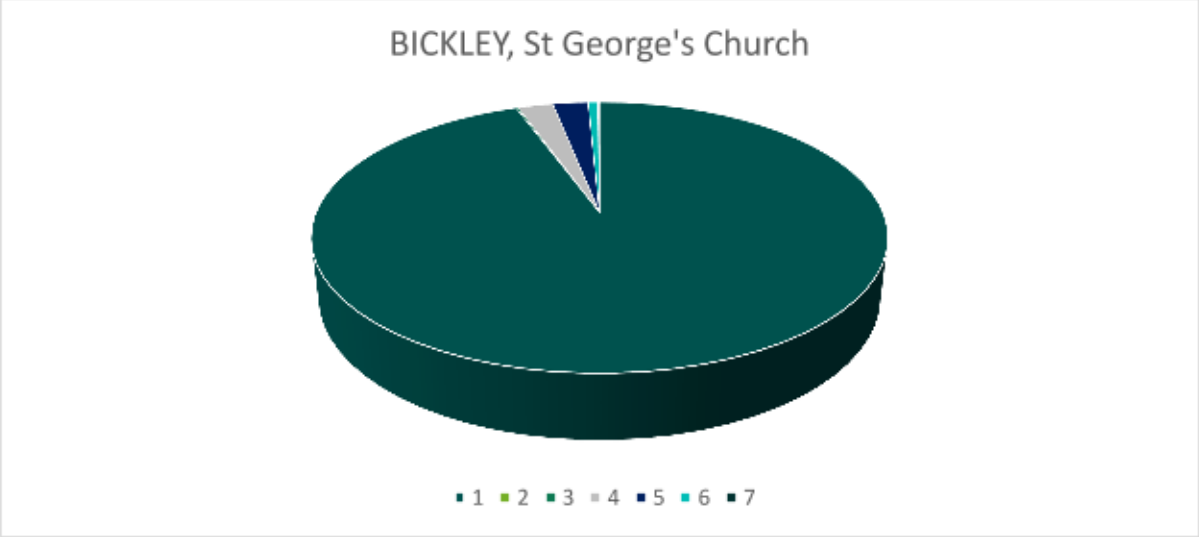
60h/week x 35 weeks

Building	Boiler Power/kW	Building use hours Per week	Building use hours annually	Heat hours annually	Annual use kWh
Church	115	21	1100	1000	115,000
Hall	46	55	2860	2100	33,000
Total					148,000

5.2 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Gas Heating		94%
Lighting	Internal and external lighting consumption is similar	4.7%
Other Small Power	Main component PA system	0.6%



KEY 1 Gas Heating 2 Electric Heating (zero) 3 Hot Water

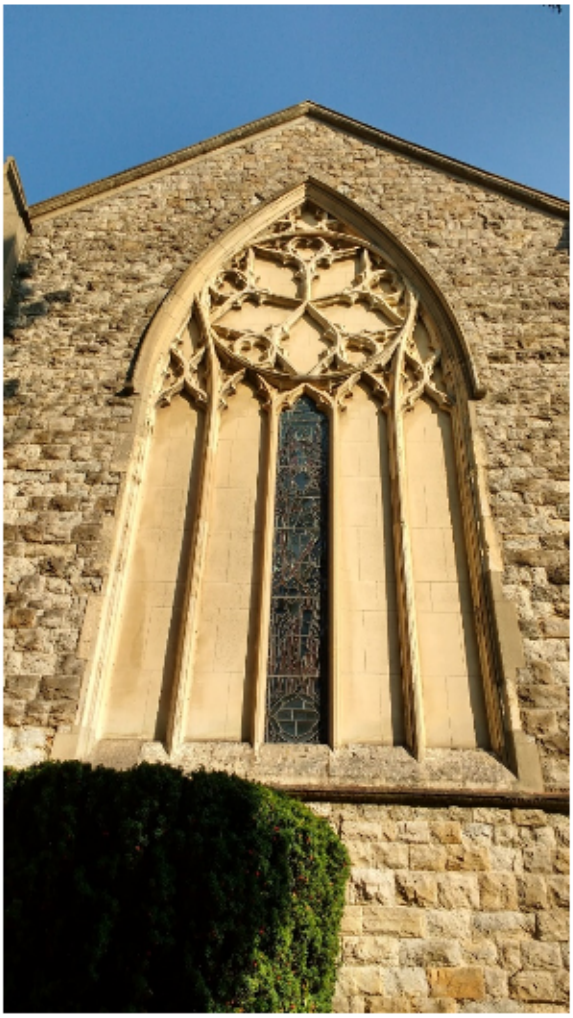
4 Internal Lighting 5 External Lighting 6 Small Power 7 Organ

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.

5.3 Energy Benchmarking

In comparison to national benchmarks for Church energy use St George's Church, Bickley uses only 67% of electricity expected but 50% more heating energy than an average church of this size.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
St George's Church, Bickley (elec)	655	13.4	20	10	67%
St George's Church, Bickley (gas)	655	226	150	80	150%
TOTAL	655	239	170	90	140%



South Transept window. Infilling of lights means that little heat is lost through the windows but will result in a higher need for lighting throughout the year.

6. Energy Saving Recommendations – Building Fabric

6.1 Draught Proof External Doors

Draughts can enter the building continuously, small draughts may be responsible for 5% of the total heating bill. It is recommended that the draughtproofing around external doors is improved where possible. This could be achieved in a number of ways.

For timber doors that close onto a timber frame, it is recommended that draught proofing is fitted to all external doors. 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 other doors which close onto a stone frame brush draught strips could be 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. For little used doors simple measures such as placing a 'sausage dog' draught excluder at the base of the door and/or using a fridge magnet painted black over the keyhole can be quite effective.

6.2 Door Closure Mechanism

The doors between the vestry and the 1864 hall is reported to often be left open during the service in winter. Fitting of an automatic door closer (hydraulic or sprung mechanism) to the top of the vestry door is not possible due to its shape, but installation of rising hinges would address the issue [NB they come in left and right hand options]. However, if this door is a fire exit this would fall foul of fire regulations (it also opens inwards which is the wrong way for a fire exit door).

The solution may be to fit a closer to the door of the 1864 hall, of rectangular shape. The external door to the lobby is in fact the fire exit (which should be provided with an emergency key). This door is also the one to be kept draught tight – some daylight can be glimpsed under it in the photo above.

7. Energy Saving Recommendations - Electricity

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 Lighting (fittings)

The lighting makes up a relatively large proportion of the electricity used within the church. This is partly because of the infilling of many windows, with the remainder having some lights infilled.

Fortunately, the church has already installed LED bulbs (50W) for all of the internal lighting.

7.2 Install PIR motion and daylight sensors on selected lighting circuits

Where lights are to be left on for visitors; these should be controlled by PIR motion sensing devices. Although LED lighting only uses a small amount of electricity, keeping lights on whilst the building is empty does not give a good message about stewardship or aiming at zero carbon.

It is recommended that a motion sensor is installed on certain 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. This should include the bookshelf light at the west end of the nave.

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 Floodlights

The four floodlights illuminating the tower use 250W sodium SON bulbs. These should be changed for lower power LED flood light units. The other floodlights use 150W bulbs and these would also benefit from being changed to new LED units.

Any external lighting needs to be IP65 rated (waterproof).

7.4 Lighting (timing for external lights)

The external flood lights are currently on from dusk until 01:00. Average dusk is around 19:30, so this corresponds to 5.5 hours per night. For efficient operation and to reduce light pollution and nuisance to neighbours it is generally recommended that external lighting is turned off between 11pm and 6am unless required for specific purposes. It is therefore recommended that the existing timer is adjusted to switch off the external lights at 11pm.

A timeclock with a time and day capacity is recommended over those that only have time of day capacity. Sangamo (http://sangamo.co.uk/) make a wide range of commonly used timeclocks which any qualified electrician can install.

Current tower floodlight and bulb. These are illuminated every night.

150W ground mounted floodlight – used occasionally

8. Energy Saving Recommendations – Current Heating System

8.1 Heating System Overview

A Remeha Quinta Pro 115kW condensing boiler is fitted. This serves two heating zones – the body of the church (nave) and the chapel area – the chancel. These areas are not separated in any way, so heat will circulate from one to the other. Each zone has an individual thermostat and timer, that for the chancel is located on the north side on the wall shared with the vestry. That for the nave is located in the vestry on the east wall, therefore it does not respond to temperature changes in the body of the church.

It is recommended that a temperature and humidity monitor is purchased. This will allow for optimum heating start and finish times to be determined. The device, (the size of a large memory stick), will record data (from hours to months); this can be used to view a temperature/ time graph which shows heating rate and temperature reached. Purchasing a device which also allows relative humidity to be recorded will help with organ care (see 8.6, 8.7)

8.2 Reflective Radiator Panels

The church is heated by radiators served from the boiler. These radiators are located on the external, uninsulated walls and have no reflective or insulated surfaces directly behind them at present. They therefore lose much of their heat into the masonry of the wall behind the radiator rather than give out the heat into the body of the church.

In order to improve the insulation directly behind the radiators a reflective panel can be installed, this helps to make sure more of the heat from the radiator goes into the space and requires less overall heating from the boiler to achieve the set point. There are a wide variety of reflective panels for installing behind radiators on the market such as www.heatkeeper.co.uk. It is recommended that these panels are installed behind all radiators within the building

The installation of radiator panels can be carried out by anybody competent in basic DIY and does not require the radiators to be removed.

8.3 Clean / Flush Existing Heating System

It is strongly recommended that the heating system is cleaned to remove sludge from the system, this is done by using a chemical clean and/or power flush procedure where cleaning chemicals are put into the system which is then turned 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 congregation in a cold church, or reduce gas use and carbon footprint where suitable temperatures are already reached.

8.4 Magnetic Particle Filter

It is recommended that a magnetic particle filter is fitted to the system to protect the boiler from sludge and debris from circulating, which will prolong the effectiveness of flushing. This would be fitted before the boiler input.

8.5 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.

8.6 Controls

The heating is controlled by a controller located on the vestry east wall.

The timings and settings on this were reviewed as part of the audit and there are opportunities to adjust these controls to provide more efficient energy usage of the building and to provide a more comfortable environment for the congregation.

The church is in regular daily use, with heating daily except Mondays. Only a couple of hours of preheating is necessary; regular use means that the church fabric will not cool very much between heating episodes.

- It is recommended that the heating is turned off 45 minutes before the end of the services. Extensive measurements within the Diocese of Lichfield show that radiators continue to export heat for around this period. Use of a temperature monitor will assist in optimising heating times.
- In addition, reduce the frost settings to 2°C as it is needed to prevent freezing pipes only.
- It is recommended that the church should not be heated at the end of the heating season. Given the recent hot summers in London, allowing the church to cool by not heating during April will prolong the period over which it will remain comfortable inside during the summer.

The adjustment of the heating system can be carried out by any member of the church who is competent at using the controls. It is recommended that the heating settings are recorded and a printed copy posted next to the control system, together with the name and phone number of who to contact if there is a problem.

8.7 Reduce / Discontinue Background Heating – Organ Protection

Providing constant background heating to the church building as a whole is excessive and wasteful of energy. Currently, the heating system is set to come on if the thermostat in the chapel registers less than 10°C, or that in the church less than 12°C. The heating is reported to often be on overnight in cold weather.

Most traditional churches were constructed without any form of heating. The modern addition 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. The only times when background heating may be required is if there are historic wall paintings or to for the preservation of large artefacts such as tapestries.

The organ (and other sensitive areas such as historic papers stored in the vestry) may require some local background heating specific to that area. Organs can be installed with a local background tube heater such as https://www.dimplex.co.uk/product/ecot-4ft-tubular-heater-thermostat within the organ casing in order to provide the heat where it is required. The fabric is often subject to the greatest damage by humidity (which is naturally higher when the air is warmer as warmer air has greater capacity for holding more moisture), as a result of large temperature swings (from central heating systems turning on and off).

The temperature and humidity monitor should be placed within the organ casing for a period to understand the differences experienced during an average winter week. This will inform whether a local heating device is needed for the organ itself. It may be that a specific organ heater will avoid having to heat the whole church for significant periods.

9. Efficient / Low Carbon Heating Strategy

9.1 Background

The energy used for heating a church typically makes up around 90% of the overall energy consumption. Heating often uses gas or oil as the primary fuel, fossil fuels with high carbon emissions and 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 the few remaining coal fired power stations. Mains gas does have some potential to reduce its carbon content through the use of biogas and hydrogen but these are less developed solutions and will be unable to deliver 'zero carbon mains gas'. Churches whose suppliers include a portion of bio gas typically have a reduction by around 20% of the gas carbon footprint.

The General Synod of the Church of England recently voted to put the church on the path to net zero carbon emissions by 2030. This is a deliberately bold step, aimed at encouraging churches to lead the way and set an example to society, viewing creation care and the fifth mark of mission as an important focus for effort and expenditure.

It is therefore important to set out a plan to make the future heating system more efficient and less carbon intensive. The current boiler is around a decade old. The church should develop a boiler replacement plan, as it will not last for ever. This report outlines options. 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 ideal solution would be one where the source of heat is carbon neutral – this could be electricity obtained from a fully renewable supplier, or possibly in the future, "green" gas from a mix of anaerobic digestion (of agricultural and food waste) and hydrogen [Parish Buying currently procures 20% gas from anaerobic digestion]. Adding hydrogen to the current mains gas can only be done up to a limit of around 20%, beyond which conversion of existing equipment will be required – in a similar way to which appliances nationwide were converted from town gas to North Sea gas in the 1970s. A changeover would be led by government working with the supply industry. A pilot scheme is underway, but it is very uncertain how much hydrogen will be produced, how and when. Achieving carbon neutral gas may take several decades.

Churches which are only heated once or twice weekly can replace gas central heating (requiring a considerable preheating period) with direct under pew (or radiant panel) heating. Although electricity is 3 to 4 times the price of gas per kWh, this is no more expensive due to the much shorter period of operation as it delivers the heat exactly where it is needed, rather than to the ceiling first. As the hours of use increase, this advantage diminishes. A constantly used church whose temperature is maintained fairly constantly during the week will have a heat input (from boiler or electrical devices) which matches heat loss through walls, windows and doors.

9.2 Recommendations

St George's church has a weekly use of around 20 hours, relatively new radiators and a boiler which will probably require replacement within the next decade.

The east end of the church is used for weekday services. This has a separate heating zone, but as it is open to the rest of the building, heating it alone has been found to be insufficient and the whole building needs to be heated. Addressing this will significantly cut energy use. The nave is estimated to be used for about 500 hours annually, with chapel based services and choir practice accounting for 600 hours.

Options for the whole building include:

- Installing another hydrogen ready boiler[1] and hoping that the gas supply transitions to lower carbon intensity. [This will not cut actual energy use].

- Keep the radiator network, replacing the boiler with a heat pump
  [This would incur greater operating costs with the same level of heating input. Installing localised "warm zones" can achieve greater savings]

- It is recommended that electric under pew heaters be installed under the chancel / chapel pews to create a "warm zone" which can be rapidly heated for smaller meetings without having to use the gas boiler to heat the whole church. This would significantly reduce gas use throughout the week by not having to heat the rest of the church; when this is the only area used. Initially, under pew heaters only would be fitted, retaining the existing system for insurance and use during the coldest periods. It is estimated that around half of the heating requirement is for services which are currently held in this zone. This will allow the need for space heating to be halved and it will significantly lower the church carbon footprint with renewably sourced electricity.

- As above, but with a heat pump supplying the rest of the church using the existing radiator network. As the heat pump is now only needed for 500 hours annually, its running costs are significantly reduced compared with supplying the whole building for 1300 hours.

- Install electric under pew heaters to the *whole* building, but retain the current gas boiler / radiator system to begin with as insurance. Under pew heaters to be gradually fitted in zones (perhaps three, one for each electric phase) in the nave, allowing experience of its use with space heating still in place and used for major festivals. No use of space heating in the "shoulder" months at each end of the heating season.
  As experience and confidence in the new system grows, the old system could be phased out.

- As above, plus remove all radiators, and add far infrared panels heaters in place of some to deliver heat to the aisle areas seated using chairs.

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[1] Some boiler manufacturers have already developed hydrogen ready boilers, but they are not mandatory. Boilers installed since 1996 are said to be able to allow up to 23% hydrogen

- The chapel area at the west end of the nave can be specifically heated using wall mounted far infrared panels. This area is seated using chairs.

- The organ to be monitored for temperature and humidity, an internal electric heater to be installed if necessary.

Recommendations

Phase 1

It is recommended that the church install under pew electric heaters in the chancel, allowing space heating to be discontinued for large periods.

Phase 2

Continue installation of under pew electric heaters in the nave, retaining space heating for insurance and large events whilst gaining confidence with the new system.

Phase 3

When boiler needs replacement, remove radiators. Add wall mounted far Infra-red panel heaters as required and specifically in the Walsingham Chapel at the west end.

10. Boiler Replacement Option Details

The current boiler was installed in 2011; thus, it is at the age where repairs or replacement can be anticipated to be needed during the next decade. Options for boiler replacement should be explored by the church, bearing in mind the General Synod's decision for the Church of England to aim at net zero carbon emissions by 2030.

10.1 Retention of wet radiator system – install an Air Source Heat Pump

Electricity is used to extract and upgrade heat from the air using refrigeration technology. ASHPs require a good air supply; so are usually located on roofs. This area of the church appears to have a flat roof so may offer a suitable location and is not viewable from any road. Neighbouring houses are at a distance.

An alternative option at St George's would be to locate the ASHP within the existing boiler room – using the old vent for the blown air heater. It would require a further duct to be installed for the outgoing air. However, this would turn the room into an "outside" area; it would require full insulation across the floor and south wall to isolate it from the church.

ASHPs work most efficiently providing warm water constantly / semi constantly (and most efficiently when the air is warmest). The use pattern of the church with services most days means that a heat pump could be envisaged as working regularly to maintain the temperature. A heat pump would have to work hard to heat the large space on cold days – it would be more expensive to run in winter. As discussed above, use of under pew heating in the chapel area would mean less need for ASHP use which would lower its operating cost.

Installation Cost Estimate (120kW) = £48,000

Approximate costs assuming an average Coefficient of Performance of 2.5

A] Assuming current 1300 hours of use:

Electricity requirement = 148000kWh/2.5 = 59,200kWh

Operating Cost (present prices) = £7,458

B] 500 hours: Sundays plus festival / concert/ wedding use etc; envisages midweek services and choir use separately heated chancel or church hall

Electricity requirement = 67,270kWh/2.5 = 26,900kWh

Operating Cost (present prices) = £3,390

The vestry and boiler room above are located behind the north transept, fence and trees and are relatively invisible, so addition of ASHP equipment could be easier than for most listed buildings.

The former air intake for the previous blown air heating system, on the north wall above the vestry.

10.2 Retention of wet radiator system – Ground Source Heat Pump

Ground Source Heat Pumps require less electricity to deliver the same heat as ASHPs over the long term, because the average ground temperature in the UK is higher than the average air temperature. The average Coefficient of Performance is around 3.5 rather than 2.5. This indicates how many kW of heat are produced for each kW of electricity. Installation costs are considerably higher than for ASHPs. Normally, churches with graveyards are unable to install the necessary underground coils required (which also require a large area to heat a large building). A borehole system may be feasible.

As GSHP installation incurs hight costs, this option should only be considered if the church plans to bring the nave into regular use of over 50 hours per week.

Installation Cost Estimate (120kW) = £120,000

Approximate costs Assuming an average Coefficient of Performance of 3.5

A] Assuming current 1300 hours of use:

Electricity requirement = 148,000kWh/3.5 = 42,285kWh

Operating Cost (at present prices) = £5,328

B] 500 hours: Sundays plus festival / concert/ wedding use etc; envisages midweek services and choir use separately heated chancel or church hall

Electricity requirement = 67,270kWh/3.5 = 19,220kWh

Operating Cost (present prices) = £2,420

10.3 Underfloor Heating

This should only be considered for a church with a building use of over 50 hours per week, i.e. regular use on most days. Underfloor systems take a long time to heat up (over a day) and deliver low grade heat over the area installed, which then gradually warms the surrounding fabric. They cannot deliver "on demand" heat and are extremely expensive to install, so should only be considered by churches who are able to guarantee regular daily use of their premises.

10.4 Under Pew Heaters

Under pew heating delivers heat to the congregation where and when required. This is recommended to create a "warm zone" using the chancel pews which can be used for small, midweek services – and for any occasional meetings with small numbers of people. Rapid heating can be provided without having to wait for hours for the whole building to heat.

Modern heaters are superior to the older style tube heaters (which have internal elements).

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.

We would therefore suggest that the following works could be considered:

Install BN Thermic Under Pew Heaters suspended from brackets from the underside of the pew seat as follows:

Chancel: 4 pews each with two under each pew – total 8 heaters.

Nave: 26 pews of 3.7m; each three BN65 heaters (948mm, 650W).

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.

Location	No. of pews	Number of heaters	Type	Heater cost	Operating Hours p.a.	Operating Cost p.a.
Chancel	4	8	PH45	£1,456	600	£272
Nave	26	78	PH65	£15,444	500	£3,194

Total power requirement 3.6 + 50.7kW = 54.3kW

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.

10.5 Electric Panel Heating

The Walsingham chapel area at the west end of the nave, seated using chairs, is used to host Saturday morning services with small numbers attending.

Central heating circulates warm air throughout the building; there is no physical separation possible here, so obtaining a warm chancel by space heating is at the cost of heating the whole church.

It will allow for more efficient heating of the Saturday services, but also for meetings to be held at short notice in the area as little preheating is required.

If the radiator network is removed in the long term; installation of radiant infrared panels in place of some radiators along the nave sides would allow the areas adjacent to the wall, which are provided with removable seating, to be heated.

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 cannot be left on accidently after use.

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). As such these heaters tend to provide a relative instant sense of heat and comfort within the space and only need to be on for short periods of time. 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 the building can rapidly be brought into use, economically, for short or unplanned meetings.

11. 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
Ground Source Heat Pump	Possibly, dependent on economics
Air Source Heat Pump	Possibly, dependent on economics
Biomass	No – maintenance and air quality issues

Biomass is an alternative boiler and fuel to oil or gas. It requires wood chips or pellets to be delivered on site, stored and then fed into a large boiler for burning. While the fuel is not a fossil fuel there are emissions from the burning of wood and these can be detrimental to local air quality particularly in more built up areas for all these reasons it is not considered a viable recommendation for this site.

Heat Pumps are a low carbon method of creating heat, there use and suitability for this church have been review in the section earlier on in this report in section 10, Boiler Replacement Option Details.

12. Other Recommendations

12.1 Electric Vehicle Charging Points

The church has a car park to the immediate north. In order to make a visible statement on the churches mission of stewardship and to facilitate more sustainable transport choices by those both visiting the church and using the hall, the church may wish to consider installing an electric vehicle charging point to allow visitors to charge their electric car.

Installing a unit such as a Rolec Securi-Charge http://www.rolecserv.com/ev-charging/news/view/Robust-EV-Charging-With-Rolecs-SecuriCharge-EV-Wall-Unit-Coin-Token-PAYG would allow the church to be able to sell tokens or have a coin operated device that would at least cover the costs of the electricity use and could make a small income. As the hall is a place of work for the pre-school users it may be able to benefit from a grant to part cover the installation costs of a charger from https://www.gov.uk/government/publications/workplace-charging-scheme-guidance-for-applicants-installers-and-manufacturers

13. 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-Jan-2019.pdf .

14. 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.