Energy Efficiency and Zero Carbon Advice

St Mary's Church, Hadlow

PCC of St Mary's Church

Author	Reviewer	Date	Version
Paul Hamley	Matt Fulford	29th September 2020	2.0

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1. Executive Summary

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

St Mary's is a Grade II* listed church with pre Norman origins. It was extensively refurbished in the 19th century; the chancel dates from 1847, the north aisle from 1853.

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)
Clean and flush heating systems	10% 5,000	£105	£400	3.8	List A	0.9
Lag pipework and valves in boiler rooms	5% 600	£12	£500	41.6	List A	0.1
Draught exclusion strip around tower inner glass door	Included in above	Included in above	£50	-	-	
Install under pew heaters for chancel choir seating	limited gas if nave still gas heated	Nil if GCH retained	£2,632	N/A	Faculty	Nil if GCH retained
Install wall mounted far infra red panel heater in chapel	Savings included above	Savings included above	£560		Faculty	Savings included above
Install Endotherm heat transfer fluid	10% 5,000	£105	£360	3.5	None	0.9
Replace high level nave lighting with LED	3,182	£424	1,440	3.5	List A/B	0.8
Draughtproofing of tower door	5% 2,500	£52	£200	4	List B	0.46
Complete LED installation in chancel	2,220	£296	£1,440	5	None	0.56
Install solar photovoltaic panels on aisle roof	Generate 9,300 electric	Generates £1,238 worth electricity	£14,400	11.6	Faculty	

Install chandelier mounted overhead infra red heaters in nave (to also incorporate lighting)	50,000 gas (but some use of more electricity)	£1,055	£16,000 (approx. 450 per element x 36)	15	Faculty	9.2 with renewable electricity
Install wall mounted far infra red panels in upper room, kitchen and toilet	6,000 gas Use 4,000 electric	£126 gas Add £533 electric	£2,000	16	Faculty	1.1 with renewable electricity

The above costs are based on current contracted prices of 13.32p/kWh and 2.1101p/kWh for electricity and mains gas respectively. Payback periods do not include savings for lower maintenance costs from electric systems compared to gas.

The current carbon footprint of the energy use for church is 10.4 of CO_2, from gas use. Electricity would contribute 1.9t, but the supply is understood to be from renewable sources.

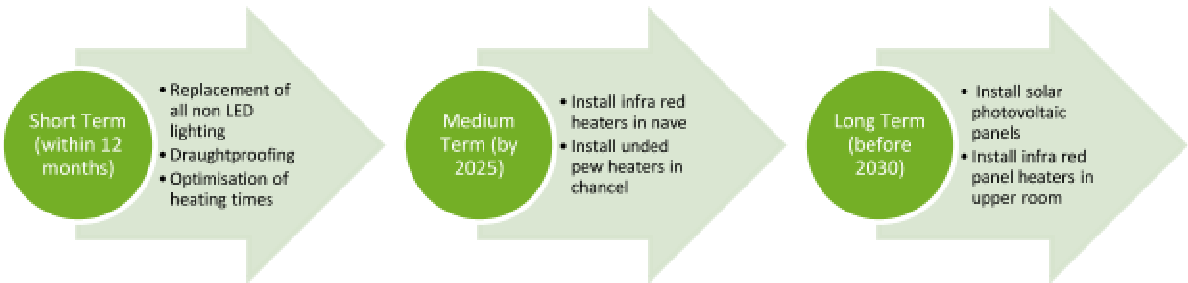
The Church should check any faculty requirements with the DAC Secretary at the Diocese before commencing any works.

If all measures were implemented this would save the church around £3,000 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 Mary's to give them advice and guidance as to how the church can be improved to be more energy efficient. In doing so the church will also become more cost effective to run and seek to improve the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Mary's, Church Street, Hadlow, TN11 0DB 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.

St Mary's	
Church Code	631232
Gross Internal Floor Area	460 m^2 floor plan 560 m^2 including first floor rooms
Listed Status	Grade II*

The church is typically used for 14 hours per week for the following activities.

Type of Use	**Hours Per Week (Typical)**	**Average Number of Attendees**
Services	Sunday 4 hours M, Tu, W, F Morning prayer 0930 Compline or evening prayer 6 hours total per week	70 4 4
Meetings and Church Groups	Choir Practice Friday 1915 2 hours per week	20
Community Use	Parent & toddler, Weds 1030-1200 Messy Church (6 p.a.) 1530-1730 Father's group, monthly, Sat Saturday coffee, monthy, Sat Average 3 hours per week	10 15 15 15
Occasional Offices	10 Weddings 10 funerals	100 100

Summing the data discussed gives the following figures:
Annual building Occupancy Hours: 740
Annual Footfall: 9,600

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	13.32 p/kWh	Below current market rates
Standing Charge	34.00p/day	N/A

The current gas rates are:

Single / Blended Rate	2.1101p/kWh	Below current market rates
Standing Charge	250p/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%	The correct VAT rate is being applied
CCL	not charged	The correct CCL rate is being applied

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

5. Energy Usage Details

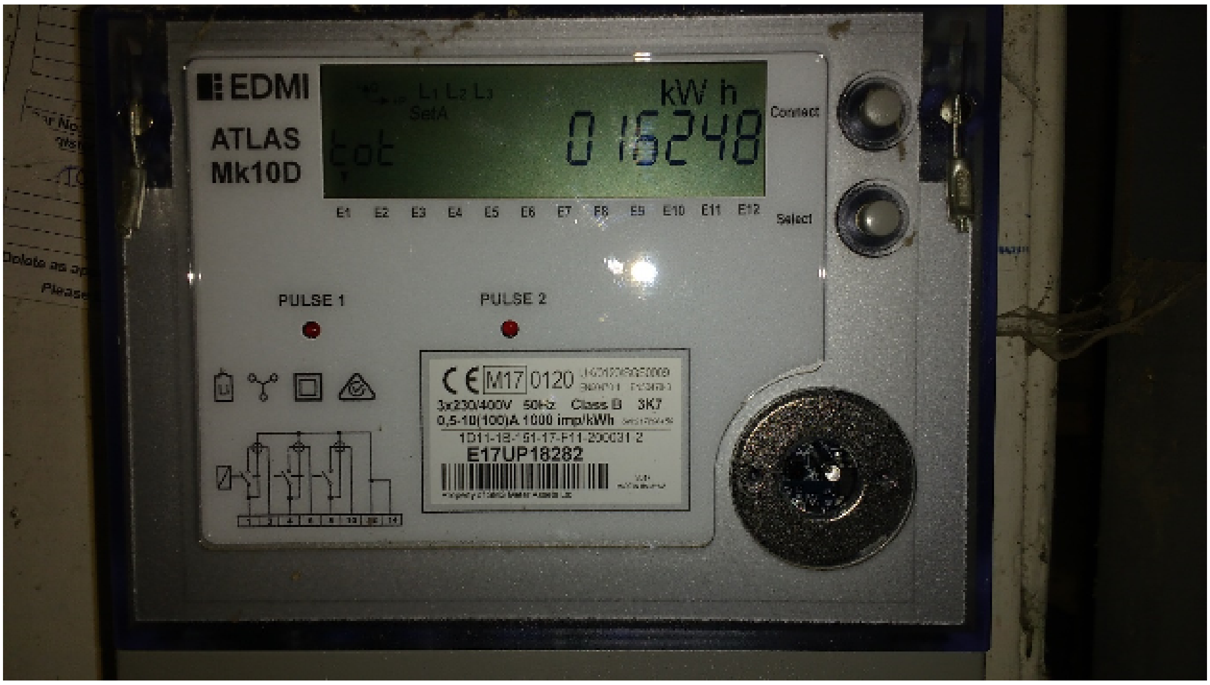
St Mary's uses around 7,700 kWh/year of electricity, costing in the region of £1,200 per year, and 56,000 kWh/year of gas, costing £2,350. Gas supplies separate boilers for the church and the upper meeting room.

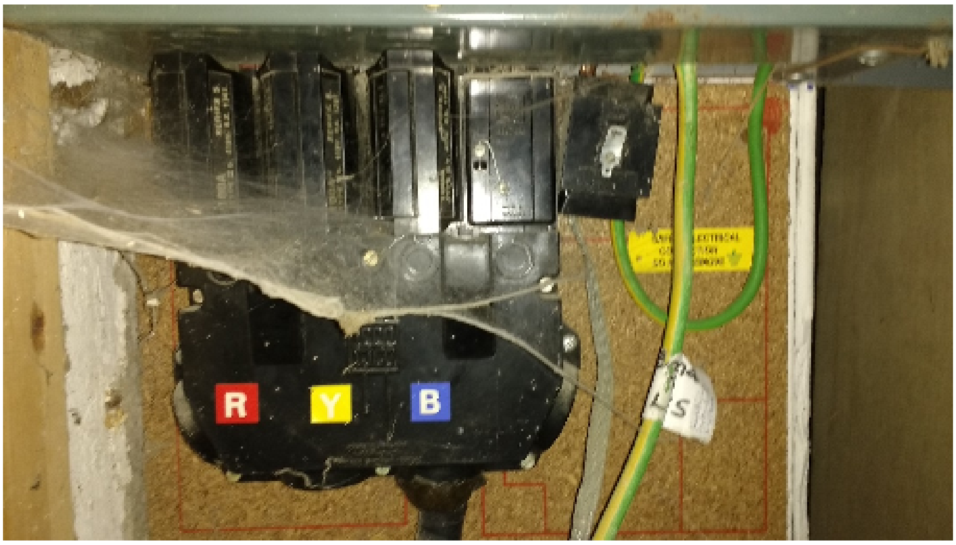
This data has been taken from the annual energy invoices provided by the suppliers of the site. St Mary's has a three phase electricity supply. The main gas meter serving the site is located externally.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E17UP 18252	EDMI Atlas Mk10D	Yes	Tower ground floor, north side cupboard
Gas – Church	M016 K02929 15 D6		Yes	External gas meter cupboard, NW corner of church yard

Three phases of electricity are supplied.

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

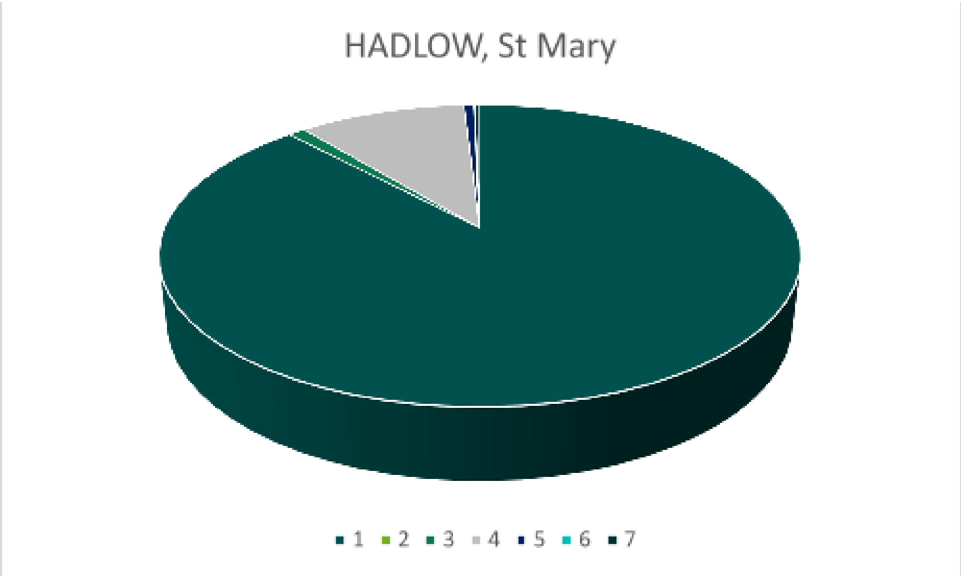




5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Gas Heating		88%
Lighting	Mostly Internal lighting	10.5%
Other Small Power	Hot water, kitchen, etc	1.5%



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

5.2 Energy Benchmarking

In comparison to national benchmarks for Church energy use St Mary's uses only 69% of the expected electricity and only 67% of the expected heating energy compared to an average church of this size. This is due to lower hours of use than many churches.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Tyical kWh/m^2	Efficienct kWh/m^2	Variance from Benchmark
St Mary's (elec)	560	13.7	20	10	69%
St Mary's (heating fuel)	560	100	150	80	67%
TOTAL	560	114	170	90	67%

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.

The tower door has a large asymmetric gap underneath, larger on the hinge side, plus another large gap at the top hinge. DAC and architect advice should be sought regarding this. The inner glass doors are thus important to keep draught tight.

6.2 Windows

Where small gaps in poorly fitting windows cause draughts, plasticine can be used to solve the problem with the window remaining openable. Any distortion of frames which allows water to penetrate, or existing rust should be treated professionally before further damage ensues.

6.3 Flooring

The nave floor is unsurfaced concrete platforms, raised by about 8cm above the walkways, probably dating from the 1936 alternations. Consideration should be given to a new floor covering with insulation underneath.

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.

Half of the lighting in the chancel has been changed to LED bulbs. The remaining 12 bulbs on the south side should be changed.

In the nave, pendant lighting is provided using 22W bulbs (five for each of the six fixtures). High level lighting is a mixture of 300W car headlight type bulbs and theatre spotlights. The church is quite dark, and high level lighting is a major consumer of electricity. This lighting should be replaced with LED lighting. If it is switched in three or four banks, there will be no need to install dimming controls, - avoiding dimming will significantly reduce cost.

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 lighting in the entrance and toilet areas, the upper meeting room and a selection of lighting in the nave (some of the pendant lights are suggested).

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 Lighting (timing for external lights)

The four external flood lights are LED devices. 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.

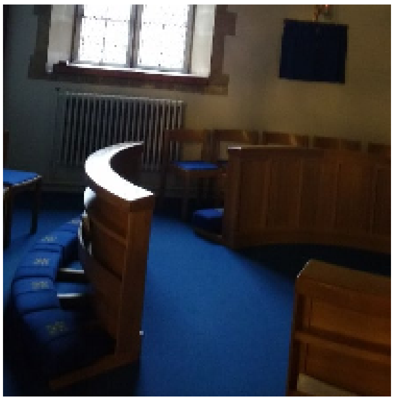
A timeclock with a time and day capacity is recommended over those that only have time of day capacity. Sangamo (http://sangamo.co.uk/) make a wide range of commonly used timeclocks which any qualified electrician can install.

8. Energy Saving Recommendations – Current Heating System

8.1 Heating System Overview

The current radiator based system has poorly spaced radiators; the north (left) side of the nave being served by three central free standing radiators, with three spaced along the south wall to the right. Others are located behind the lectern, in the chancel and in the chapel. Some heat is also emitted by the exposed piping, which presents a trip hazard.

While the current heating systems are still in use, there are several opportunities to save money and hence lower carbon dioxide output.



8.2 Boilers

Two boilers are fitted. The church boiler is a Remeha Quinta Pro condensing boiler, either 90 or 115kW (unstated). This serves the nave and chancel and is located in an exterior boiler shed. The church system is reported as having a leak of approximately 10 litres per month, the source has not been detected. This is most likely to be draining into the building foundations; finding and treating the problem could be expensive.

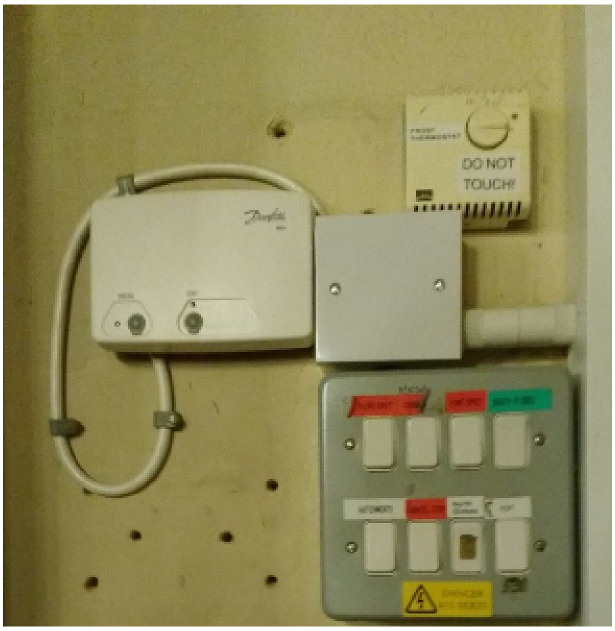
Pipework should be lagged further to prevent heat losses, including the valves. Plaster and debris from the boiler shed roof has been falling on the installation. It is recommended that a plastic box or waterproof pocket is provided for the boiler manual and other paperwork.

The frost thermostat and timer is located on the north side of the west nave wall next to the lighting controls. The control thermostat is located on the north east pillar.

A temperature monitor has been used to understand the heating system and optimise timings.

[It discovered that the frost stat, above, at the west end wall of the nave had been set to 18°C, so the heating had run constantly].

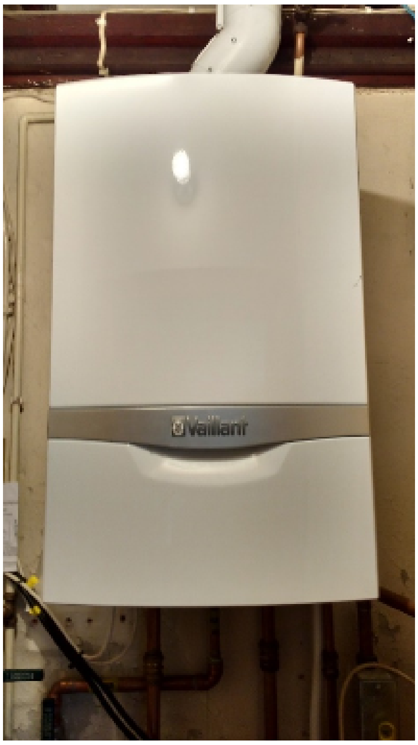
The temperature in church is normally raised to about 18°C for services.

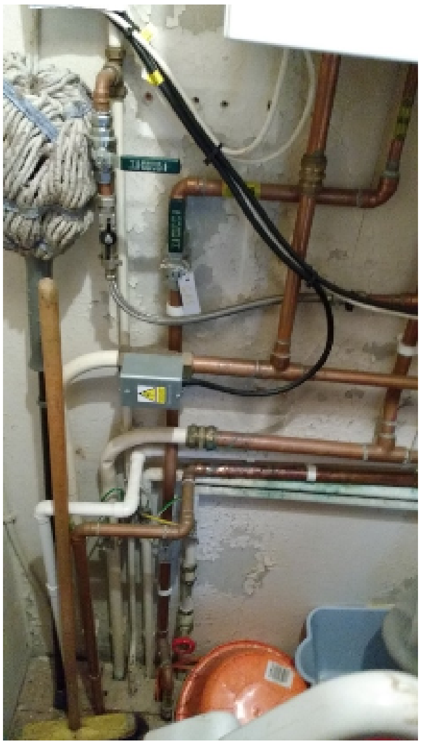


The boiler for the upper floor is located in a cupboard at the west end of the floor.

It is a Vaillant Eco Tec Plus 624 of 24kW. This boiler pipework would also benefit from lagging.

Timer controls are located adjacent to the boiler.





8.3 Reflective Radiator Panels

The church is heated by radiators served from the boiler. The nave has three radiators along the south wall, one behind the lectern, one next to the chancel arch and three free standing near the centre. Two are located in the chancel. All are cast iron.

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.

8.4 Clean / Flush Existing Heating System

It is strongly recommended that the heating systems are 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.

8.5 Magnetic Particle Filter

It is recommended that magnetic particle filters are fitted to both boilers from sludge and debris from circulating, which will prolong the effectiveness of flushing. This would be fitted before the boiler input.

8.6 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.

8.7 Control

- 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℃ 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, allowing the church to cool by not heating during April will prolong the period over which it will remain comfortable inside during the summer.
- Electronic controllers such as Hive or similar offer convenience but cannot change underlying inefficiencies.
- It is recommended that the heating settings are recorded and a printed copy posted next to the controls, with the name and phone number of who to contact if there is a problem.

8.8 Reduce / Discontinue Background Heating – Organ Protection

Providing constant background heating to the church building as a whole is wasteful of energy.

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 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 bio gas 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 boilers are approaching a decade old. The church should develop a boiler replacement plan, as they 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 infra red) 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 Mary's church has a weekly use of around 14 hours, old radiators and boilers which may require replacement within the next decade. In addition there is a persistent water leak from the church boiler circuit which is undetected, and therefore probably draining into the foundations. Addressing this expense will be needed for long term use of the boiler, it is a factor encouraging rapid electrification of the church heating.

If electric heating is installed quickly, then the various energy and cost saving interventions detailed in sections 8.2 to 8.6 should not be installed. However, if there is a to be a delay of more than a couple of years, they are worthwhile.

- Install chandelier mounted radiant infra red heaters in the nave.
- Install under pew heaters be under the chancel pews.
- The organ to be monitored for temperature and humidity, an internal electric heater to be installed if necessary.
- Install radiant infra red panel heaters in the upstairs meeting room. These will allow for quicker heating than a radiator based system, so that this room can rapidly be brought into use for short or occasional meetings.

10. Boiler Replacement Option Details

The current church boiler was installed in 2013; thus it is at the age where repairs or replacement can be anticipated to be needed during the next decade. The upper room boiler is of similar age. 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 NAVE: Electric Infra Red Heating – Chandelier mounted

In the nave, only the south wall can be fitted with wall mounted heating panels. There is no corresponding location on the north side, where the seating is next to the entrance area and a run of openable wooden panelling screening off a side room.

Suspended radiant bar heaters suspended from a chandelier ring of approximate 2m diameter could be hung in approximately the same positions as the current pendant lighting chandeliers. The chandeliers could also support lighting, interpolated between the heaters. At suitable height above floor (about 4m), the heat would spread out to warm the full area below. Mounting at lower levels would give problems with hot spots at the centres of each ring.

A system without lighting has been installed recently at St Catherine's, Faversham and there is another church nearby with has lighting plus heaters on chandeliers.

At St Mary's, the heater chandeliers would have to be hung from brackets mounted on the wall. The current brackets are probably not strong enough for the extra weight. The inspecting architect and/or a structural engineer will need to be consulted to ensure appropriately designed supports and fixings into the walls.

Costs are in the order of £1000 per heater; 6 rings of 6 = £36,000

Chandelier mounted radiant infra red heaters installed at St Catherine's, Faversham. They are suspended from the arch midpoints, which is not possible at St Mary's.

10.2 CHANCEL: Under Pew Heaters

Under pew heating can be used to deliver heat to the choir in the chancel and is only turned on when required. Rapid heating can be provided locally by pew heaters without having to wait for hours for the whole building to heat. This is recommended to create a "warm zone" using the chancel pews which could also be used for the midweek services – and for any occasional meetings with small numbers of people; although services may be held in the Lady Chapel and meetings in the smaller room upstairs which is easier to heat.

The church should decide on how this area will be used in the future, which will inform how many heaters should be installed. Should the space be used solely for the choir of around 20.

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

The under pew heaters shown to the righ 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 pew structure at St Mary's limits the length of heaters to below 80cm.

PH30 (300W), 525mm, PH45 (450W), 702mm. If heaters were installed in each space between pew legs this would require 23 heaters. Given the size of the choir it is suggested that just four rows be heated (thus the appearance of the front row of pews, visible from the body of the church will be unchanged). Using the larger heaters under alternate spaces is more cost effective.

4 Pews, Heaters in each space = 15 heaters : PH30 = 4.5kW

Cost including installation and cabling £313 each = £4,695

4 Pews, Heaters in alternate spaces = 8 heaters : PH45 = 3.6kW

Cost including installation and cabling £329 each = £2,632 *(used in estimations)*

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:

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 installed	Operating Hours p.a.	Operating Cost p.a.
Chancel	4 out of 6	8	PH45	£2,632	100	£48
	All 6					

10.3 CHAPEL & UPPER FLOOR: Electric Infra Red Panel Heating – Wall Mounted

If the radiator network is removed in the long term; installation of radiant infrared panels in place of radiators in the upstairs meeting room is recommended. This area is considered less of a priority than the body of the church.

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.

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 meetings.

Four 900W panels costing £560 each installed and smaller panels for kitchen, toilets and lobby areas would have a capital cost in the region of £3,000. Operating Cost (for 4,000kWh)= £533, less preheating is assumed compared to the current use of around 6,000kWh based on boiler size and hours.

10.4 UPPER FLOOR: Retain Radiators with Air Source Heat Pump option

Air Source Heat Pumps [ASHP] use electricity to extract and upgrade heat from the air using refrigeration technology. ASHPs require a good air supply; so are usually located on roofs.

An ASHP could be situated in the valley between the roofs, connected to the upper boiler room.

ASHPs work most efficiently providing warm water constantly / semi constantly (and most efficiently when the air is warmest). The use pattern of the church, Sundays plus occasional uses means that a heat pump could be envisaged as having to work hard to heat the space on cold days – it would be more expensive to run in winter. Preheating would still be required for the heat pump to bring firstly the radiators, then the room up to temperature; there would be no "less preheating" benefit which radiant heating provides.

Installation Cost Estimate (24kW peak output as at present) = £9,600

Approximate costs assuming an average Coefficient of Performance of 2.5

Assuming current 700 hours of use: Electricity requirement = 6000kWh/2.5 = 2,400kWh

Operating Cost (present prices) = £320

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	Yes
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
Air Source Heat Pump	Yes for upper floor, but higher capital cost and less benefits
Biomass	No –maintenance and air quality issues

11.1 Solar Photovoltaic Panels

The south facing north aisle roof, in the valley next to the nave roof offers a good location for solar photovoltaic panels. Your architect will need to conform suitability for the extra weight and wind loading on the roof structure.

The roof slopes at approximately 45 degrees to horizontal, the orientation is approximately 300degrees (south-south west), giving a solar yield factor of 91% of the maximum at this latitude.

The hours of hall use mean that most of the generated electricity could be used.

Furthermore, installation of a heat pump – which can run at any time, would ensure that no electricity generated is wasted

The roof offers an area of around 22m length x 4m = $88m^2$. Four small skylights are fitted. If the maximum available roof surface was used (access being from the valley gutter), this would give a usable area of around $80m^2$. There is shading from the nave roof at low sun angles which will reduce output. The roof orientation appears to be 15 degrees west of South.

This could generate $0.15kWpeak/m^2$ giving a 12.kWpeak system.

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

= $80m^2$ x $0.15kWp/m^2$ x 1000kWh/kWp x 0.97 x 0.8

= 9,300kWh

This is larger than the church's current annual electricity use (7,700kWh). Energy efficiency measures including replacement of the large installation of 300W light bulbs will reduce this. The excess can be used to part supply electric heating (heat pump or radiant).

Using costs for larger installations of £1,200 per kWpeak;; a 12kWpeak system would cost £14,400. This does not include cost of any battery.

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.

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

https://www.theecoexperts.co.uk/solar-panels/cost

https://www.exeoenergy.co.uk/solar-panels/solar-panel-output/#uk_rule_of_thumb

12. 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 .

13. 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.