# Energy Audit and Survey Report

# St John the Baptist Church, Little Missenden

*"There is a plan to reduce global carbon emissions to net zero by 2050. The plan will work. It involves all of us. We need to begin now, in our homes and workplaces and churches"*

*Revd Dr Stephen Croft, Bishop of Oxford*

Version Control

| Author | Reviewer | Date | Version |
|---|---|---|---|
| Paul Hamley | Matt Fulford | 20th October 2019 | 1.1 |

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# 1 Executive Summary

An energy survey of St John the Baptist Church, Little Missenden 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 John the Baptist Church, Little Missenden comprises a Saxon core with Norman aisles and later additions. It possesses nationally important 13th century wall paintings which dictate the heating regime. 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 | To be actioned by who / when? |
|---|---|---|---|---|---|---|
| Obtain Group Buying quotation from Parish Buying – both utilities | 0 | 10-30% of £3,200 maybe at lower end of range as you have a 7% electricity discount. | 0 | 0 | None | Treasurer<br><br>Deadline to inform current suppliers 23 Feb (G), 1 Mar (E) |
| Lag boiler room pipes | 5-10% | £100-200 | £50 | 0.1 | List A | Warden |
| Investigate heating timings, discuss with conservation consultant | Potential 10% if feasible | £220 | 0 | immediate | Conservation consultant | Warden |
| Curtain inside porch door (and / or other draught exclusion measures) | 5% | £100 | £100 | 1 | List B for curtain | Warden |
| Replace lighting in office | 440 | £60 | 60-80 | 1 | List A/B | Warden |

| Medium Term: Energy saving recommendation | Estimated Annual Energy Saving (kWh) | Estimated Annual Cost Saving (£) | Estimated capital cost (£) | Simple Payback (years) | Permission needed | To be actioned by who / when? |
|---|---|---|---|---|---|---|
| Investigate Air Source Heat Pump for when boiler replacement due (advice from conservation consultant) | 30,000+ | Higher running cost. Less maintenance | Similar to new boiler | | DAC | PCC<br><br>Create boiler replacement plan |

| Long Term: Energy saving recommendation | Estimated Annual Energy Saving (kWh) | Estimated Annual Cost Saving (£) | Estimated capital cost (£) | Simple Payback (years) | Permission needed | To be actioned by who / when? |
|---|---|---|---|---|---|---|
| Insulation of church office building when refurbished | Depends on future use | | | | | PCC Architect |

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

Based on current contracted prices of 13.73p/kWh and 3.891p/kWh for electricity and mains gas respectively.

**If all short term measures were implemented this would save the church £700+ per year**.

# 2 Introduction

This report is provided to the PCC of St John the Baptist Church, Little Missenden 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 John the Baptist Church, Little Missenden, was completed on the 17th October 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 John the Baptist Church, Little Missenden** | |
|---|---|
| Gross Internal Floor Area | 220 $m^2$ |
| Listed Status | Grade I, nave constructed c. 975 |
| Typical Congregation Size | 35 |

The church typically used for 8 hours per week for the following activities:

| | |
|---|---|
| Services | 0800-0830 congregation 10-12<br>1030-1115 35<br>1800-1900 12<br>3 hours per week |
| Meetings and Church Groups | 2 hours per week, evenings |
| Community Use | 1 hour per week for occasional concerts and lectures<br>2 hours/week av. From festival |
| Occasional Offices | 6 per annum<br>Av. 0.5 hours per week |

**Figure 1** At 220m$^2$ internal area, this is a small church.

The church is open for 7 hours per day and is receiving an increasing number of visitors.

**Figure 2** 13$^{th}$ century wall paintings in a Saxon nave are considered to be of national significance.

**Figure 3** A recent relighting scheme has been designed to illuminate specific areas to visitors

**Figure 4** The church hosts an annual music festival which sees ten days use (100 hours).

# 3 Energy Procurement Review

Energy bills for gas and electricity have been supplied by St John the Baptist Church, Little Missenden and have been reviewed against the current market rates for energy.

The current electricity rates are:

| | | |
|---|---|---|
| **Single Rate** | 13.73p/kWh | In line with current market rates [12.99 to 13.77p/kWh] |
| **Standing Charge** | 25.00p/day | N/A |
| **Availability Charge** | p/kVA | N/A |
| **Meter Charges** | p/day | N/A |

The current electricity contract ends on 31st March 2020; notice must be given by 1st March 2020.

A direct debit discount of 7% is currently offered, more than offsetting the 5% VAT.

The current gas rates are:

| | | |
|---|---|---|
| **Single Rate** | 3.891p/kWh | In line with current market rates |
| **Standing Charge** | 20.00p/day | N/A |
| **Availability Charge** | p/kVA | N/A |
| **Meter Charges** | p/day | N/A |

The current gas contract ends on 24th March 2020; notice must be given by 23rd February 2020.

The above review has highlighted that there are opportunities to gain cost savings from improved procurement of the energy supplies at this site. We would therefore recommend that the church obtains a quotation for its gas and electricity supplies from the Diocese Supported parish buying scheme, http://www.parishbuying.org.uk/energy-basket. This scheme only offers 100% renewable energy sourced electricity with 20% green gas and therefore it is an important part of the process of making churches more sustainable.

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

| | | |
|---|---|---|
| **VAT** | 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.

# 4 Energy Usage Details

St John the Baptist Church, Little Missenden uses approximately 7,400 kWh/year of electricity, costing in the region of £1,000 per year, and 57,000kWh/year of gas, costing £2,200.

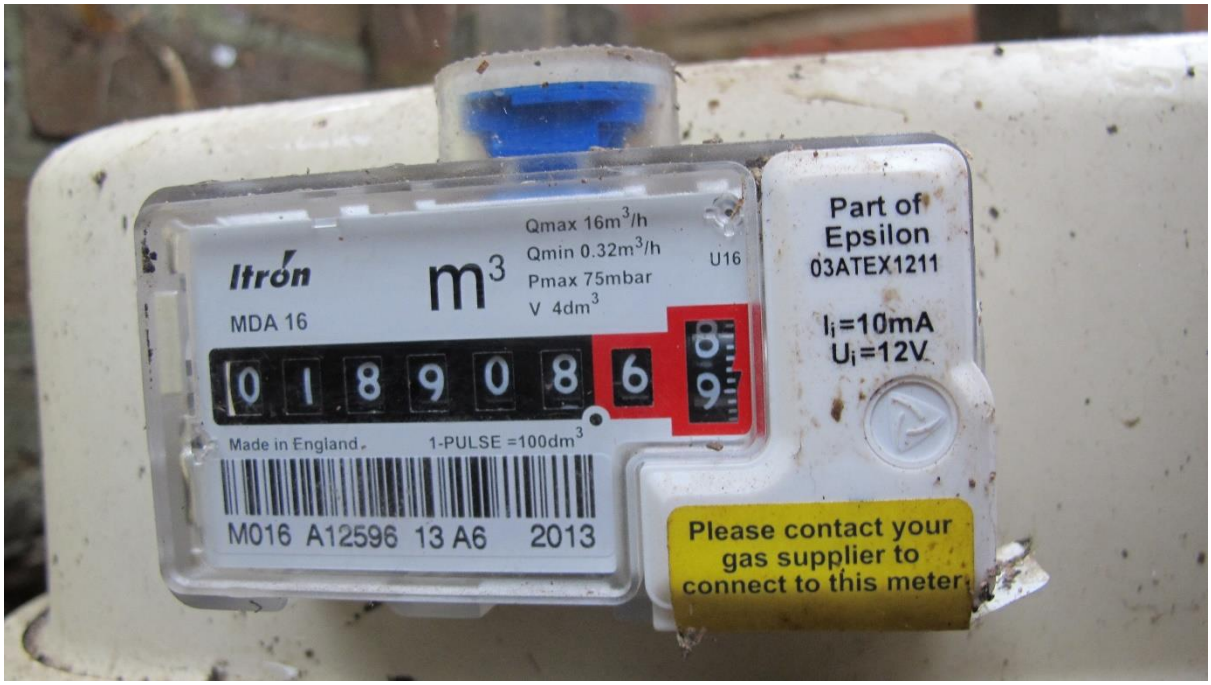
This data has been taken from the annual energy invoices provided, with 11 months of electricity data seen and gas costs only for 27 months. St John the Baptist Church, Little Missenden has one electricity meter, serial number D15B211593. There is one gas meter serving the site.

**Note that the reference numbers on the gas bill and the gas meter inspected differ. This means that either the meter has been changed and the gas provider has not been informed; or that the church is being billed for someone else's gas.**

| Utility | Meter Serial | Type | Pulsed output | Location |
|---|---|---|---|---|
| **Electricity – Church** | D15B211593 | Single phase E150, Type 5246C | | Office |
| **Gas – Church** | M016A1233713A6 Stated on bill<br><br>Meter inspected M016A1259613A6 | | | External gas meter cupboard next to churchyard boundary wall |

The meters are not AMR.

**Figure 5** Gas meter installed in box in churchyard



## 4.1 Energy Profiling

The main energy use within the church can be summarised as follows:

| Service | Description | Estimated Proportion of Usage |
|---|---|---|
| **Lighting - Church** | 50 spotlights at 30W each; 1560W<br>4 large cluster LED lights at 100W each; 400W<br>Church total estimate 2kw.<br>7 hours/ day + extra for festivals; 2700hrs/year<br>= 5400kWh | 8.3% |
| **Lighting – Office and Kitchen** | Office 4 halogen total 300W<br>Estimated on 40 hrs/week (2000h p.a.) = 600kWh<br>Kitchen and toilets 50kWh | 1.0% |
| **Heating** | Gas boiler supplying radiators 57,000kWh<br>Convector Heater Dimplex DA416, 1.5kW<br>Occasional use office days over winter 24 days = 36kWh | 89%<br>0.05% |
| **Hot Water** | Heatrae Sadia Express 7 (dishwashing)<br>3kW x 30 mins/week x 50 weeks = 75kWh<br>Urn (weekly use) 1kW x 3 hours x 50 weeks = 150kWh<br>Kettles, three, 2kW each<br>12 boils of 5 mins/week x 50 weeks (50 hrs) = 100kWh<br>Kitchen total estimate = 325kWh | 0.5% |
| **Other Small Power** | Microwave 0.9kW @ 10mins/week = 7.5kWh<br>Photocopier 500W – minimal consumption (1 to 7pence per day)<br>Printer 50W – minimal consumption<br>Computer Minimal consumption – 1 to 3p/day<br>Office in use 10 hours per week (2 days) at 5p/day cost 10p/week = £5.00 /year electricity cost @13.73p/kWh<br>Office total = 36 kWh<br>Organ | 0.05%<br>1% |

**Figure 6** Two types of lighting installed in the nave

**Figure 7** Electricity meter

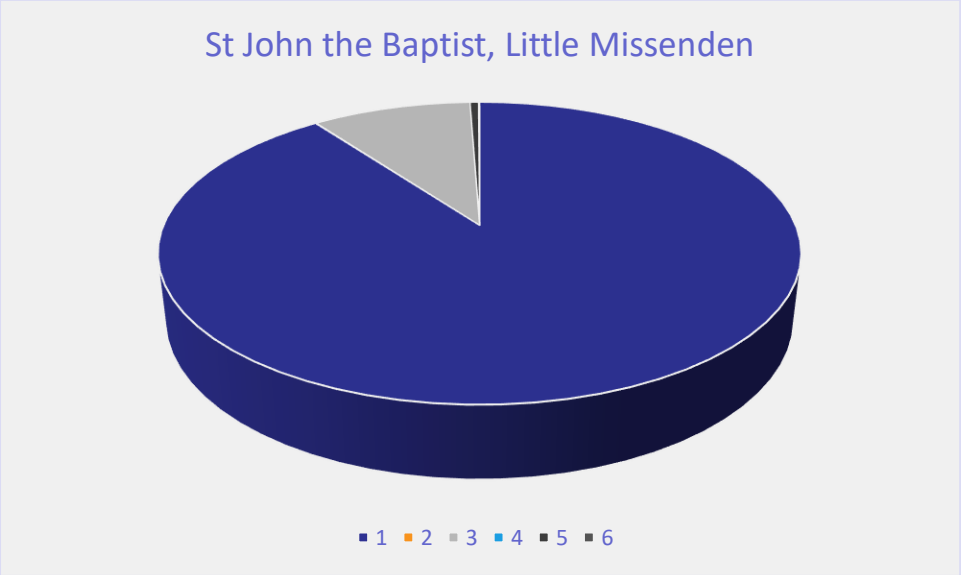



**Figure 8** **Load breakdown**

**Key** 1 Gas heating 2 Electric heating, office (negligible) 3 Lighting 4 External lighting (zero) 5 Hot water 6 Small power (negligible)

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.

## 4.2 Energy Benchmarking

In comparison to national benchmarks for Church energy use St John the Baptist Church, Little Missenden uses 68% more electricity and 73% more heating energy than would be expected for a church of this size. This is a consequence of having heating on 7 hours a day, driven by conservation requirements, and lighting being on for frequent visitors.

| | Size ($m^2$ GIA) | St John the Baptist Church, Little Missenden use kWh/$m^2$ | Typical Church use kWh/$m^2$ | Efficient Church Use kWh/$m^2$ | Variance from Typical |
|---|---|---|---|---|---|
| **St John the Baptist Church, Little Missenden (elec)** | 220 | 33.6 | 20 | 10 | 168% |
| **St John the Baptist Church, Little Missenden (heating fuel)** | 220 | 259 | 150 | 80 | 173% |
| **TOTAL** | 220 | 292.6 | 170 | 90 | 172% |

# 5 Energy Saving Recommendations

## 5.1 Lighting (fittings)

All the lights in the church were changed during a recent major refurbishment, overseen by a conservation consultant.

Any future lights installed will need to be checked to ensure that their spectrum does not contain harmful frequencies (any higher frequencies especially UV which promote scission of chemical bonds in paints and dyes).

The lights in the church office are currently four pendant bayonet B22 fittings contained within lampshades which results in a warm glow, which appeared to give rather dull lighting on the overcast day of the visit. They are positioned a long way from the office desk.

Currently, three 70W halogen and one 30W bulb are installed.

They should be replaced with LED lamps, but the type of luminaire/ lampshade should be discussed. The office staff should be asked if the lighting levels are sufficient at the desk – an LED desk lamp might be needed for very dull days. As well as lower energy consumption (about 20W each), LED lamps have a much longer lifetime; 15-20 years compared to 1-3 for halogen lamps, so there will be a small saving on bulbs (and installation effort!).

It was noted that there is a long term desire to redevelop the 1950s office building and move the office into what is now the roof space (see Section 7).

LED lamps are available in various configurations giving illumination angle between narrow (24°, spotlight) and wide (90°) which is probably more appropriate for lighting the office.

## 5.2 Lighting (control for internal lights)

This has recently been installed and is set up to provide suitable lighting options for services and to view the wall paintings.

## 5.3 Other Electrical Saving Measure – Voltage Reduction

The voltage was measured as 237.4V. This is higher than average within the range from 207 to 253V.

Many products destined for the European market are designed for 220V, operating at higher voltage can result in higher temperatures. Lighting, motors, fridges, transformers will benefit from lower energy consumption and longer lifetimes if run at lower voltages.

There will not be a saving from items such as kettles and heaters where heat is the only output – a kettle will take longer to boil at 220V than 250V as it will always require the same energy input.

[The trick to save money with a kettle is only to boil the amount of water which you need].

An explanation of voltage reduction can be found here: https://www.explainthatstuff.com/voltage-optimisation.html

Speak to your electricity supplier about voltage reduction (at the transformer).

## 5.4 Heating Overview

Heating of the church and adjoining office is provided by a gas boiler. The office has a 1.5kW portable electric heater for use as necessary.

The church received £400,000 in grant funding for restoration and conservation of the mediaeval wall paintings recently. This included scrutinization of the heating system and method of operation which was viewed to be in good health. However, the boiler is stated to be 15 years old; so a boiler replacement plan would be wise.

## 5.5 Boiler

The boiler is a Viesmann Vitrodens 200, dating from c. 2004, which provides both heating and hot water. It was fitted with a new control system in 2016. The boiler was set to deliver a flow temperature of 40°C (42°C was indicated at the boiler itself).

Radiator temperatures were measured at 34 to 35°C.

This system is able to achieve extra efficiency through operating in condensing mode.

It was noted that the annual service was due in October (R. Tomlin & Co.).

## 5.6 Boiler Controls

The boiler controls, stated to be a thermostat , are currently in the boiler room. A thermostat outside means that the heating is potentially going to fluctuate on and off with the weather more than necessary, and lose the buffering effect of the thermal mass of the building.

However, the boiler control panel itself has a day setting (currently 4/10) and a night setting (2/10)

The heating regime may be tuned as necessary if there is further information provided from temperature and humidity monitoring.

**Figure 9** Boiler control panel

## 5.8 Space Temperature Set Point

It is assumed that the set temperature has been agreed by the conservation consultant.

However, there is no monitoring of either temperature or relative humidity in place. Buying a simple datalogger would enable opportunities for energy savings to be made by identifying when the temperature is warmer than needed. Monitoring relative humidity and dew point will provide data to show if recommended conservation conditions are not met – and indicate when this is (i.e. cold periods of weather / overnight / services in wet weather with water evaporating from wet coats / large numbers of occupants for special events), and for how long. A suitable datalogger is the EL-USB-2 https://www.lascarelectronics.com/easylog-data-logger-el-usb-2/

## 5.9 Insulation of Pipework and Fittings

None of the pipework leaving the boiler is lagged (there is a two degree temperature drop in the short length of pipe from boiler to external temperature dial). The accessible pipework should be lagged. Where the pipes descend into a 50cm x 50cm hole; it is suggested that a cover be assembled to fit around the pipes and cover the hole. Thick polystyrene sheets (recycled from flat packed furniture – although you can buy it in DIY stores) and duct tape could be used.

**Figure 10** Unlagged pipework

The radiator temperatures were measured at 37,37,35,33°C. This is a three to five degree drop from the boiler exit pipe temperature, but a further two degrees are being lost due to lack of insulation. This suggests that a 5-10% improvement might be possible from lagging, which is considerable.

## 5.10 Clean / Flush Existing Heating System

If the system is fitted with a magnetic particle filter, this should be cleaned out annually when the boiler is inspected and safety certified. If not present, a suitable filter should be fitted. (The small red cylinder in figure 10 may be one). The system should be flushed periodically to remove any build up of sludge from inside the radiators.

An appropriate corrosion inhibitor should be used to refill the system.

## 5.11 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 is 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 consumption by over 10% and helps the building to heat up quicker.

## 5.12 Thermostatic Radiator Valves (TRVs)

Cast iron radiators are fitted which do not appear to have TRVs. This means that it is not possible to balance any areas of higher or lower temperature which occur in the church.

## 5.13 Boiler replacement Options

A] Condensing boiler, sized for frequent use, which maintains the church between certain levels defined for conservation (probably between 12 and 18°C). A larger boiler to allow for a 12 hour once a week heat up from 10°C to 20°C would not be needed. With the running of the boiler at lower flow temperatures the condensing function of modern boilers may never be enabled as for this to operate it does tend to need a higher flow temperature and a large difference in the flow and return temperatures.

However, this would still be reliant on fossil fuels – a green tariff should be sought, containing a proportion of “green gas” from anaerobic digestion (and allowing for hydrogen in the future).

B] Heat Pump.

The churchyard is closed to burials, therefore full. It is unlikely that permission would be granted for a ground source heat pump.

An air source heat pump could be accommodated within the existing boiler room building – it would probably need extra ventilation holes to be added. An ASHP delivering low grade heat fairly constantly would work well in providing the constant background heat required for the conservation

of the wall paintings but it would have to work as hard as a unit required to rapidly raise temperature from 10 to 20°C. Therefore, a mixed system may work best.

C] Underpew electric heaters

This would require more intervention to install than the above options. There would be no opportunity to install any high-level radiant heaters due to the presence of wall paintings. The use of underpew heaters could work well in being able to provide that rapid boost for services in a way that provides heat into the pew areas without causing major temperature fluctuations within the rest of the building that could be detrimental to the wall paintings.

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. All cabling should be in armoured cable or FP200 Gold when above ground.

The preferred option to consider would therefore be to have an air source heat pump providing the background heating and under pew electric panel heaters for raising the temperature for services.

## 5.14 Office Building: Use of Electric Panels for Heating Specific Areas only

Future conversion plans for the office area would see the office, which is used currently on two days per week, moved to a new first floor room.

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.

The ground floor area would become a multi use space. It could be heated by the main church system, options A or B above, or by underfloor electric heating, or electric convector heating. The system chosen will be influenced by the plans for use of the space, and the wall areas available (i.e., there does not appear to be much available wall space for wall mounted convector heaters at present).

## 5.15 Draught Exclusion: Quattro Seal

The hatch to the belfry was identified as a possible source of draughts. This should be checked in windy weather and draught proofed if necessary.

There are a number of external doors in the building. These should also be checked in windy conditions to ascertain if cold air is coming in to the church around the side and base of these doors.

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

# 6 Saving Recommendations (Water)

Any taps in toilets which have the potential for being left running or dripping by visitors during the week should be replaced by flow restricting push taps.

# 7 Other Recommendations

The church would like to convert the existing 1950s office building, which houses a kitchen and toilet, into a “useful space” at ground level, with the office function being moved to a new room located in the current roof space (probably requiring a lowered ceiling).

**Figure 11** Office and kitchen building

If permission was to be granted for this, the refurbishment is likely to require insulation being added under or between the roof rafters (with much of the roof space being needed to gain sufficient first floor height), and this new office room should be fitted out with full modern levels of insulation.

If the current two x 4 to 5 hours per week office use is to be continued, this would suggest a mix of underfloor (which could also be over ceiling) heating and radiant panels, which warm up quickly, rather than constantly heating the new office.

The space below is envisaged as having potential for various uses – perhaps an enlarged kitchen area. Currently, the small toilet is accessed from outside the kitchen, a cramped arrangement which probably does not meet regulations.

The rest of the space could be used for small church groups (likely evening use) – as could the office above; but also as a visitor centre during the day (perhaps giving space for displays or AV presentations with seating). This would increase energy consumption, mostly by lighting, although an LED lighting scheme would minimise this.

Mediaeval churches with relics became places of pilgrimage – there is potential at St John the Baptist for a modern interpretation of this and using the stories of St Christopher and St Catherine to engage visitors with the gospel.

# 8 Renewable Energy Potential

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

| Renewable Energy Type | Viable |
|---|---|
| **Solar PV** | Yes – on tower only |
| **Battery Storage** | No |
| **Wind** | No |
| **Micro-Hydro** | No |
| **Solar Thermal** | No |
| **Ground Source Heat Pump** | No |
| **Air Source Heat Pump** | Yes |
| **Biomass** | No |

There is potential for a small PV array on the roof of the tower. The current arrangements around solar panels mean that to be financially viable the building on which they are mounted needs to consume the vast majority of the energy that they produce. The churches energy consumption is already very small and the consumption during the daytime when the sun is shining is likely to be very low indeed, therefore while technically viable only a very small number of panels (maximum of around 4) would be worth considering if at all. This may change if an air source heat pump is installed as there will then we a constant draw of electricity which would be well suited to be met (in part) with solar panels on the tower.

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.

An air source heat pump system is a potential replacement for the current boiler, located in the current boiler building. Sizing and specifications should involve the churches conservation consultant.

# 9 Funding Sources

This audit programme offers each participating church the chance to apply for a grant of up to £150 towards implementing some of the audit's recommendations. An application form is included with this report.

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 .

As the church office is attached to the listed church, any future works would probably be eligible for the Listed Places of Worship VAT reduction Scheme. http://www.lpwscheme.org.uk/

Trust for Oxfordshire's Environment (TOE) does have some funds available (over and above the small implementation grants of £150 available through this scheme) to support energy efficiency improvements in community facilities. If your church is used by the wider community, visit www.trustforoxfordshire.org.uk or contact admin@trustforoxfordshire.org.uk to find out if your project is eligible for a grant of up to about £5,000.

# 10 Faculty Requirements

It must be noted that all works intended to be undertaken should be discussed with the DAC at the Diocese. Throughout this report we have indicated our view on what category of permission may be needed to undertake the work. This is for guidance only and must be checked prior to proceeding as views of different DACs can differ.

Under the new faculty rules;

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

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

All other works will be subject to a full faculty.

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

## Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

| Room/Location | Number of Fittings | Recommended Upgrade | Annual Saving (£) | Total Cost (£) | Payback |
|---|---|---|---|---|---|
| Office | 4 | LED<br>20W lamps | 440kWh<br>£60 | £60-80 | 1 year |
| Payback 1 year from operating cost, plus further savings from 15-20 year life compared to 3 year life of halogen. | | | | | |