sustain

Energy Audit of St Michael's, Cumnor

January 2014

Table of Contents

1.0 Introduction

This report has been prepared to detail the energy saving measures and renewable energy generation potential that exist at St Michael's church, Cumnor.

The report was prepared following a site audit conducted by Emily Guilding, Sustain on 15th January 2014. She was accompanied by heating monitor, John Blackie

A summary of recommendations is made in Section 8.0 of this report.

The findings of this report in no way negate the PCC of St Michael's to petition for a faculty in order to conduct any works at the church. For further advice on the requirement for a faculty the church should seek advice from the DAC Secretary.

Further advice in planning and implementation of the recommendations may be sought from the Diocesan Advisory Committee (DAC).

"...churches aren't just places of wonder, encounter and community; they're also real buildings which make an impact on the natural world, and it's our responsibility to make sure that their carbon footprint is as small as possible. We have over 800 church buildings in our diocese, and with all the people who pass through them in a year, we can influence literally hundreds of thousands more buildings."

Bishop of Oxford

This energy audit has been carried out as part of a scheme to encourage and support church buildings in Oxfordshire to become more energy efficient. The scheme is being run by the Trust for Oxfordshire's Environment (TOE2) in partnership with the Diocese of Oxford, with Sustain as the delivery partner.

TOE2 is an environmental funder for Oxfordshire, supporting and developing projects which improve and benefit Oxfordshire's environment and local communities. TOE2 supports projects in 3 main areas: biodiversity, access to green spaces and energy efficiency and the sustainable use of resources.

This church energy audit scheme for Oxfordshire is being supported by TOE2 with funds from the Patsy Wood Trust, the Beatrice Laing Trust and Charlie Laing, with additional funding provided by the Bishop of Dorchester and the Diocese of Oxford.

For further information about TOE2 please contact: fionadanks@trustforoxfordshire.org.uk or www.trustforoxfordshire.org.uk .

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2.0 Church Details

St Michael's is the local parish church serving the community. It is located in Cumnor, Oxford and dates back to the 11th century.

2.1 Listed Status

St Michael's is of a Grade I listed status. This listing has been taken into account when determining the recommendations for energy saving measures and renewable energy within this building.

2.2 Size

During the site visit the approximate internal area of the church was measured as 270m^2.

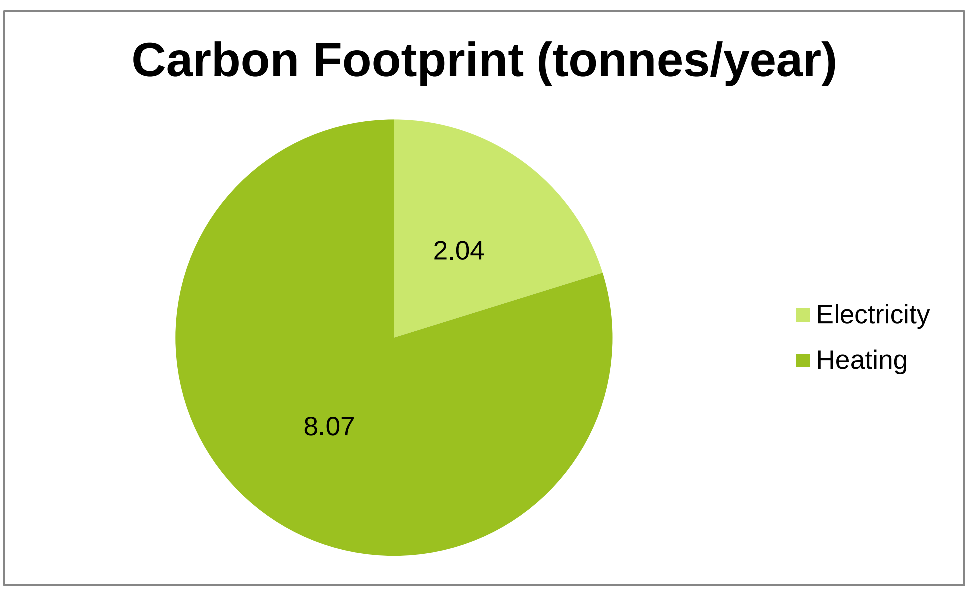
From discussions on site during the audit it has been established that the typical usage of the church is for 510 hours a year.

	Description	Average Monthly Use
Church Use	2 Sunday services a week. Bell ringing, choir practice, weddings, funerals, christenings.	44 hours/month
Community Use	n/a	0 hours/month
Administration	n/a	0 hours/month
Catering and Events	n/a	0 hours/month
TOTAL USE		**510 hours/year**

The average congregation size is dependent on the service, and varies between 7-25 people at the 8am service, to 90 people at the 11 am service.

2.3 Current Energy Usage

Annual energy bills for the church have been provided and examined. These show that the current carbon footprint of the church is 10.11tCO_2e per year.



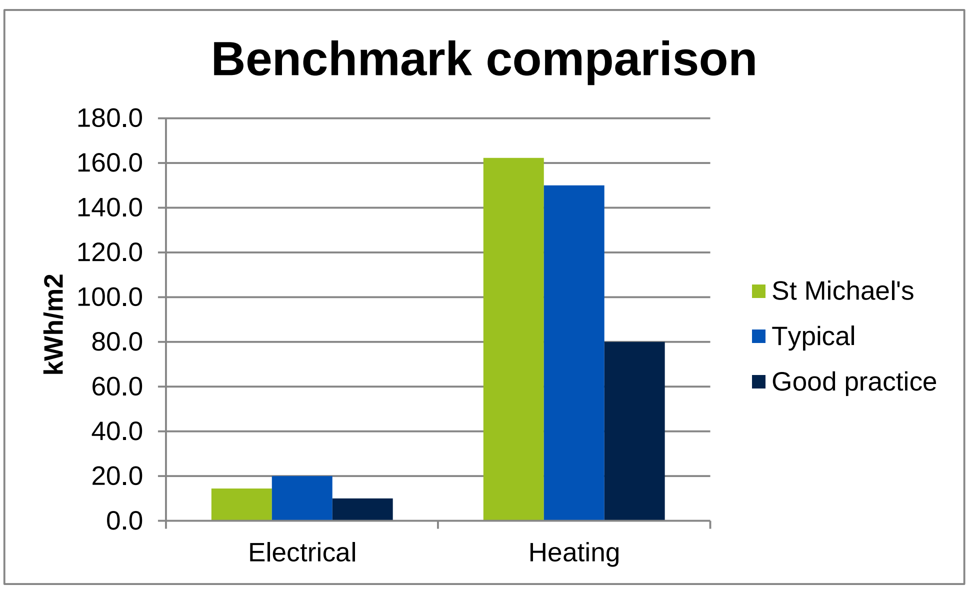
The annual energy consumption has been taken from the electricity bills provided from December 2012 – November 2013 and gas bills from October 2012 - September 2013. These may include the use of estimated readings where actual readings have not been taken and use pro-rated where there are gaps in the data.

	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity	3,888	£0.0987	£384	2.04
Heating	43,837	£0.0466	£2,044	8.07
TOTAL	**47,725**		**£2,428**	10.11

Note: The above costs are for the energy only and do not include standing charges, VAT etc

In comparison with national benchmarks[1] St Michael's consumes more gas but less electricity than a church typical of this size. A focus on reducing the gas consumption is therefore advisable and the recommendations within this report should help to bring the church within the expected benchmarks.

	kWh/m^2 St Michael's	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Electricity	14	20	10
Gas	162	150	80



All energy bills should apply the VAT rate of 5% due to the charitable status of PCC's and this is being correctly applied at this church.

[1] CIBSE (2012) *Guide F Energy Efficiency in Buildings*

2.4 Energy purchasing

The church may benefit from obtaining reduced energy rates by switching energy suppliers. The church could also use the opportunity of switching suppliers to explore ‘green electricity’ options.

The Church of England has created the National Parish Buying scheme to provide churches access to negotiated schemes with energy providers and pool their energy to buy in bulk with an ‘energy basket’ – in the first instance this is a ‘brown energy’ basket, but a ‘green’ version will be available if enough churches express an interest, so please specifically register an interest in a ‘green option’ when contacting Parish Buying. By bulk buying energy it is anticipated that the costs will be 10% lower compared to buying alone.

Alternatively the Diocese of Oxford has negotiated green electricity schemes with both Good Energy and Ecotricity, who supply electricity from renewable energy sources at competitive prices.

For more details on all the above options visit: http://www.oxford.anglican.org/mission-ministry/environment/resources/switch-your-church-to-green-electricity/.

It is further recommended that any cost savings obtained from improved rates through the purchasing are re-invested in the energy saving measures outlined within this report.

3.0 Electrical Saving Recommendations

3.1 Internal Lighting

The energy used for the internal lighting within churches typically makes up the largest use of electricity (except where all electric heating is installed) and therefore savings made to this area can result in significant overall reductions to energy usage.

The internal lighting within the church has been surveyed and it is recommended that the following improvements are made.

3.1.1 Replace bulbs/lamps within existing fittings

The following lights can simply have a new low energy bulb fitted to them to generate an energy saving. These should be changed as the old lamps fail.

Location	Existing Lamp Type	Recommended Lamp Type	Example Source
Bell tower	150W 118mm linear halogens	120W 118mm energy saving linear R7S halogen	http://www.lyco.co.uk/energy-saving-halogen-118mm-linear-r7s.html
North aisle spot lights x 3	75W PAR30 ES-E27	15W PAR30 spotlight	http://www.energysavingonline.co.uk/15wattpar30warmwhite

If all of the above lamps are changed we estimate this to **cost £23** but **save £12** per year therefore providing a payback in 1.9 years. We have assumed that the church can safely purchase and install the new lamps themselves without use of an external contractor. The changing of lamps within existing fittings will not require a faculty.

When sourcing alternative bulbs, LEDs are now worth investigation and when reviewing LEDs it is important to consider the aspects listed below:

- The lumen output of the light - a measure of how bright the light is, higher is better.
- Lamp efficacy measured in lumens/Watt - a measure of the lamp's energy efficiency. A good quality LED will now have over 70 lumens per watt output.
- Lamp life expectancy in hours - if a lamp has a short life expectancy, this will have an impact on your maintenance costs. One of the main secondary benefits of LEDs is that the maintenance time is vastly reduced due to the 20,000 - 50,000 hour lifespans.
- The time it takes to get to full brightness, LEDs are often instantly at full brightness, whereas even the best compact fluorescents often only start at 80%, and take a while to fully "warm up".
- Colour rendering quality and index (i.e. 100 - Excellent to 0 - Poor) - a measure of the accuracy with which colours can be seen.
- The beam angle/spread - think of a torch, the wider the beam the less the average illuminance (brightness) is, you get the same light out with a wide beam but it is spread more "thinly" over a wider area, compared to a narrow, bright spot for a "tight" beam.
- Colour temperature - a measure of the colour appearance of a light source ranging from "warm" light (for example, the light a candle produces) through to "cool" light (for

example, a bright white fluorescent light). This is measured in Kelvin (K). Lamps below 3,300K are classed as "warm" whilst those above 5,300K are "cold" or "daylight".

- If the light is suitable for use with dimmers.

3.1.2 Controls

The internal lights are controlled by a bank of labelled switches. This is deemed appropriate for purpose and no change is recommended

Figure 1. Labelled light switches

3.2 External Lighting

This church only has minor external lighting including one porch light and 2 flood lights controlled by a timer and daylight sensor (figure 2).

Figure 2. External lighting controller

4.0 Heating System Saving Recommendations

4.1 Boiler

The heating at the church is provided by an Ideal Concord CXA 120kW atmospheric gas boiler (figure 3). It was installed in 2006 and is serviced every 2 years. It would be worthwhile increasing this to an annual service. This will check for gas leaks and boiler and flue efficiency.

Figure 3: Ideal Concord CXA boiler

4.2 Pipework and Distribution

The pipework within the boiler room is generally well lagged except for 4 uninsulated threaded valves (figure 4). Insulating these valves will help to save energy through reduced heat loss and will provide better protection against burst pipes.

Figure 4: Uninsulated valve

Within the body of the church the heating is distributed via a number of radiators. There are a number of radiators on external walls which will benefit from radiator panels behind them. These panels reflect the heat from the radiator back into the room, rather than being absorbed into the stone wall. These are a low cost measure and simple to fit. The installation of the radiator panels will need to by checked with the DAC.

There are also 4 wall mounted 6kW radiant heaters in St Thomas' and 1 in the bell tower (figure 5). These radiant heaters should be used during choir and bell ringing practice rather than using the central heating. These will provide immediate warmth directly to the occupants rather than heating the whole church.

Figure 5: Radiant heater

4.3 Controls and Frost Protection

The heating system is controlled by a Dunphy's Church Warden 17 programmer located in the bell tower. The heating is set by the church warden according to the weekly schedule. The heating is closely and well controlled. The warm up time and the override boost button – which is used by groups using the church - has been reduced to a maximum of 2 hours.

The thermostat located in the nave is set to 18°C and the internal frost stat is set to 9°C. The system is regularly bled and contains an antifreeze additive to prevent the pipes from freezing. The concentration of the antifreeze should be checked and the frost stat turned down.

The heating system warms the church to about 14°C for the 8am Sunday service and gets to around 17°C for the 11am service. The system is well controlled and provides adequate heat to most of the church. The only exception to this is the congregation seating near the back of the church which suffers from a down-draught of cold air. Counteracting this effect is not easily rectified in a listed building. If this part of the church is in regular use, it may be worthwhile investing in a solution; there are two options that could be viable;

4.3.1 Install under pew heaters to boost temp in this part of the church

If there are specific pews which suffer from the cold down-draught the heating could be boosted by under pew heaters. Modern slim line electrical heaters such as the Dimplex 500W SCH5 could be fitted on the pews, either underneath (out of sight) or on the back of the pew in front. These provide direct heat to the person sitting in the pew. The heaters should be wired into individual switched fused spurs with a neon indicator so that the heater to each pew can be switched off individually. They should only be fitted in the pews which suffer from under heating and only turned on when the pew is occupied.

4.3.2 Install de-stratification fans

In buildings with high ceilings, warm air rises and heat is lost through the roof. Ceiling mounted de-stratification fans can be used to ensure warm air is kept at ground level so the benefits can be felt by church users. De-stratification fans blow warm air back to ground level where it's needed so improving the comfort of congregation and may mean that the heating use can be reduced.

Figure 6: Low velocity fan

There are two main types of de-stratification fans:
• Low-velocity' fan (figure 6)
• High-velocity axial fan (figure 7)

Both types can be thermostatically controlled so that they switch on when the temperature in the roof reaches the temperature needed at floor level. Their speed can also be controlled to vary air velocity. Low velocity fans are best for ceiling heights of between 5m and 10m, and axial fans for heights of 10m to 20m. Low-velocity fans don't usually cause a problem, but you do need to consider the noise from high-velocity fans for a quiet environments such as church. Custom painted ceiling mounted destratification fans for use in churches are available.

Figure 7: High velocity fan

5.0 Building Fabric

While it is acknowledged that the potential to undertake significant improvements to the traditional and protected fabric is limited, there are a number of areas noted below where improvements can be made which will result in a reduced amount of energy consumed and improved levels of comfort being achieved.

5.1 Roof

There is no accessible roof void in which to install insulation. If the roof is replaced at a later date then insulation should be seriously considered.

5.2 Walls

Given the listed and historic nature of the building and that the walls are exposed no improvement recommendations have been made in this regard.

5.3 Floors

The pews are on wooden floor boards which may have a void beneath them. If there is a void these boards could be lifted, insulation added beneath them and then the boards replaced including sealing the joints to prevent cold draughts from rising up from the floor and would result in significant comfort improvements. Prior to doing this, you would need to consult with the inspecting architect to ensure that there will still be adequate ventilation under the boards to avoid wet and dry rot.

5.4 Windows

The windows are generally in good condition, due to the listed and historic nature of the building there is not an opportunity to improve the insulation of the windows.

5.5 Doors

The North aisle door is draughty, there was a previous effort to fitting draught proofing on the door but this fell off. It would be worthwhile fitting draught proofing using the Quattro seal method - (www.quattroseal.com). This is recognised by English Heritage for use in listed buildings, as the installation is easily reversible if required. Fitting a curtain and keeping the porch door shut will also help reduce draughts.

The West door has a curtain and draught excluder which helps to reduce draughts but would also benefit from draught proofing using the Quattro seal method.

6.0 Renewable Energy Feasibility

The below reviews the viability of renewable technologies at your church and indicates if it would be possible for each of the technologies to be installed.

More details on the major technologies can be found by going to the following website www.oxford.anglican.org/mission-ministry/environment/resources .

Also included in this website is a directory of installers who will be able to help you in providing you with specific costs for either a feasibility study or installation at your church depending on what your requirements are.

6.1 Solar Photovoltaics

The south facing nave roof could be suitable for solar panels. These need to be hidden from view on a Grade I listed building. The shallow pitch of the roof and parapet would hide part of the installation and there are no roads or houses directly behind the south side of the church.

Ideally a solar PV system should face between south east and south west, and be free of shade. For best performance they should be angled at 30 to 40 degrees – although they will still catch a reasonable level of sunlight at angles of 20 – 50 degrees. Solar panels can be fairly heavy, so the roof must be strong enough to hold them; however Solar PV systems are easy to install, need virtually no maintenance and are estimated to last 40 years.

The solar PV systems generate electricity from the solar radiation from the sun, and any electricity that is being generated can be used within the building or fed back to the National Grid. The installation would be eligible for Feed-in Tariff payments. This means the church will be paid for the electricity generated by the solar panels and the electricity that is not used and exported back to the National Grid. The export rate is currently 4.64p per kWh of electricity exported. The generation rate is dependent on the church's EPC (Energy Performance Certificate) rating. If this rating is D or higher the higher FIT rate is applicable (currently 13.5p/kWh). If it is below D, the lower rate is applicable (currently 6.85p/kWh). Due to the historic nature of the church it is unlikely that it will gain an EPC band D even with energy efficiency improvements.

6.2 Micro-Wind

Micro wind units require highly exposed sites and should be located 250m away from buildings. They are not suitable to be located in the curtailage of listed buildings. Given these parameters it is concluded that micro wind generation is unsuitable at this site.

6.3 Micro-Hydro

Hydro electricity is a highly efficient source of renewable energy but requires a flowing body of water with a differential height, this is not present at this site and therefore such an installation would not be feasible.

6.4 Solar Thermal

Solar thermal installations are best suited to heat water for use in washing up, hand washing and bathing. The demand for hot water is very minimal within the church and therefore the use of renewable heat for such a small demand is not recommended.

6.5 Ground Source Heat Pump

Given the church yard has numerous archaeological features with graves and the like it is not recommended that any consideration is given to the feasibility of ground source heating within this building.

6.6 Air Source Heat Pump

Air source heat pumps are most effective in very well insulated buildings with long occupancy hours. They are also unlikely to be approved by the DAC therefore not deemed appropriate for this church.

6.7 Biomass

Biomass boilers burn logs, wood chips, wood pellets or other forms of biomass. As the church has a modern gas fired boiler it would not make economical sense to replace this with a biomass boiler at this time.

7.0 Energy Management

Energy savings can be achieved by simply keeping a closer eye on your church's energy use and communicating your carbon footprint to the congregation. Typical steps would be as follows.

7.1 Measure

- Nominate someone to have lead responsibility for energy management
- Take monthly meter readings and keep a record of these
- You could even take a meter reading at the start and end of when your church is used on a Sunday and use this to calculate the carbon footprint and costs of the service
- If you would like to establish how much it costs to run the church heating per hour you could take a meter reading at the beginning and end of an hour when only the heating is on (e.g. before a service if the heating is turned on more than an hour in advance).

7.2 Calculate and monitor

- Calculate the energy use using the meter readings and look for any stories behind the numbers e.g. how does this year compare with last? If it's greater, what are the reasons behind this? Is there anything that could be done to mitigate the increase?
- Calculate the church's carbon footprint.
- If you have not joined the scheme already, in order to provide more detailed review and measurement of the church's carbon footprint in the future, we recommend that the church join the CofE's national Shrinking the Footprint Energy Monitoring Scheme with sMeasure or a similar energy monitoring scheme. This will help the church estimate its future costs of energy and report on its carbon.
- For more information on the scheme please visit www.oxford.anglican.org/mission-ministry/environment/resources/energy-monitoring-scheme

7.3 Communicate

- Let the congregation know the carbon footprint of the church and the annual energy running cost
- Ask them to consider energy efficiency where it is under their control
- Ask for suggestions and ideas on how to reduce the church's carbon footprint
- Communicate to the congregation with a poster for example the latest carbon footprint figure each month / quarter and how it compares with the same period last year

7.4 Housekeeping

- Write up a procedure for energy efficiency in the church and associated buildings to help user of the building use the space more efficiently and effectively, and giving them the ability and know-how to make these changes.
- These procedures could include what to turn on (such as lighting and heating) when the building is being used for different functions, e.g. open for public during the day, services on a Sunday and midweek or larger public events such as flower displays.

8.0 Summary of Recommendations

This report has made numerous recommendations on improvements that can be carried out to reduce energy and carbon emissions from the operation and use of this church.

These have been summarised here in short, medium and long term measures taking into consideration the payback, capital investment and ease of carrying out each improvement.

These recommendations and this report should be presented to the next available PCC meeting and an action plan developed to implement as many of these actions as possible.

The costs below are based either on indicative quotations for this church specifically, previous similar quotes, or generic price information and include an allowance for labour unless stated otherwise. It is recommended that prior to engaging with any capital works, competitive quotations are obtained from suitably qualified contractors. We have not included a factor to account energy price rises or inflation which would make the payback periods more favourable. As the sequence of implementation of the measures is unknown the savings are independent rather than cumulative.

Short Term Improvement Measures				
Description	**Estimated Cost**	**Estimated Saving per year**	**Estimated Carbon Savings per year (tCO2e)**	**To be actioned by**
Measure Calculate and monitor Communicate Housekeeping	£0	£49	0.2	
Replace bell tower lamps	£4	£3	0.02	
Replace North aisle spot lights	£19	£9	0.05	
Use radiant heating for bell ringing and choir practice	£0	£291	0.82	
Boiler room valve insulation	£120	£28	0.11	
Reflective radiator panels	£100	£31	0.12	

Medium Term Improvement Measures				
Description	**Estimated Cost**	**Estimated Saving per year**	**Estimated Carbon Savings per year (tCO2e)**	**To be actioned by**
Draught proof North aisle and West door	£300	£61	0.24	

Long Term Improvement Measures				
Description	**Estimated Cost**	**Estimated Saving per year**	**Estimated Carbon Savings per year (tCO2e)**	**To be actioned by**
Pew heaters	Approx £50 per heater plus installation costs	Improved comfort		
Install destratification fans	Depending on ease of access and make/model of fan used, could be around £700	Improved comfort		
Solar PV installation	Further investigation required	Dependent on results of feasibility study		

9.0 Funding options

You may wish to consider seeking funds to implement the energy efficiency improvements recommended in this report. For further information please contact:

- **Diocese of Oxford** – for the latest funding advice for energy efficiency improvements that the diocese is aware of please contact the Diocesan Environment Officer using environment@oxford.anglican.org or 01865 208745.

- **TOE2** – can consider applications for up to £10,000 for works recommended in the Sustain report, usually supported with funds from Grundon Waste Management through the Landfill Communities Fund (LCF). www.trustforoxfordshire.org.uk

- **Other Landfill Community Funds** – the following organisations may consider applications from projects within 10 miles of the relevant landfill sites.
  WREN – www.wren.org.uk
  Viridor Credits – www.viridor-credits.org.uk
  Biffaward – www.biffa-award.org

- **Renewable Technologies** – Technologies that produce heat or electricity may be eligible for an on-going payment based on the amount of energy produced.
  - For heat generating technologies, such as biomass boilers, the Renewable Heat Incentive (RHI) might be applicable. For further information, please go to www.energysavingtrust.org.uk/Generating-energy/Getting-money-back/Renewable-Heat-Incentive-RHI
  - For electricity generating technologies, such as solar PV, the Feed In Tariff (FIT) will be applicable. For further information please go to www.energysavingtrust.org.uk/Generating-energy/Getting-money-back/Feed-In-Tariffs-scheme-FITs