Energy Audit of St Mary the Virgin, Great Milton

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 Mary the Virgin, Great Milton.

The report was prepared following a site audit conducted by Emily Guilding, Sustain on 29th January 2014. She was accompanied by church warden Jane Jefferies.

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 Mary the Virgin 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 Mary the Virgin is the local parish church serving the community. It is located in Great Milton, Oxfordshire and dates back to the11th century.

2.1 Listed Status

St Mary the Virgin 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 356m^2.

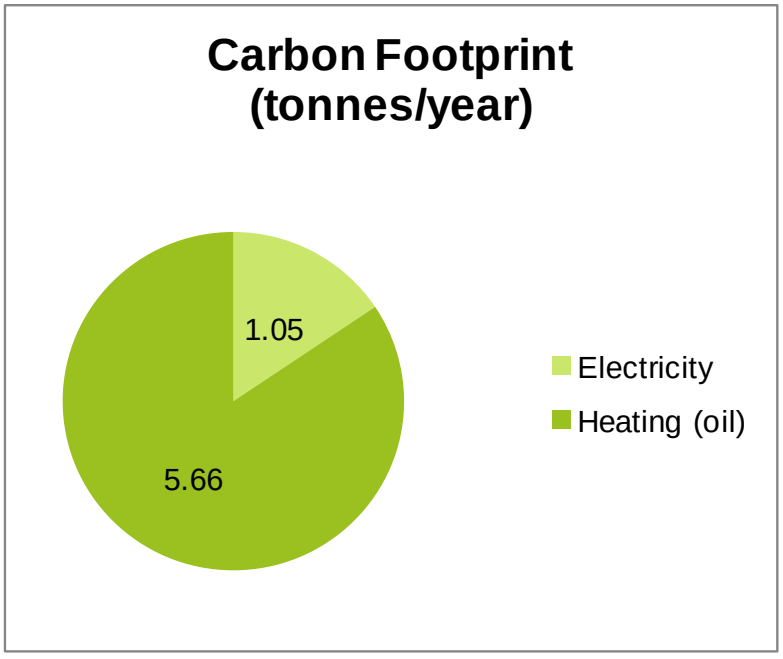
From discussions on site it has been established that the typical annual usage of the church is for 130 hours.

	Description	Average Use
Church Use	3 or 4 Sunday services per year	7 hours/month
Community Use	n/a	
Administration	n/a	
Catering and Events	Religious festivals, carol services, autumn concerts	46 hours/year
TOTAL		**130 hours/year**

The average congregation size varies between 15-20 people.

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 6.71tCO_2e per year.



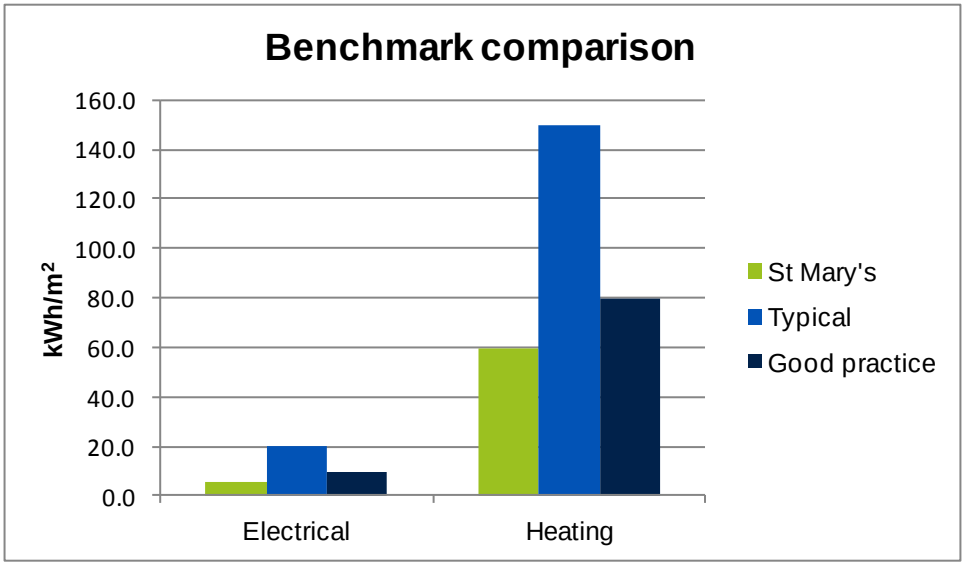
The annual energy consumption has been taken from the energy bills provided from October 2011 onwards. These may include the use of estimated readings where actual readings have not been taken.

	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity	2,000	13.73p	£275	1.05
Oil	21,070	5.61p	£1,181	5.66
TOTAL	**23,070**		**£1,456**	**6.71**

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

In comparison with national benchmarks[1] St Mary the Virgin consumes less heating fuel and electricity than would be expected for a church of this size. This is positive but there will certainly be room for improvement. The main limit to benchmarking is that it does not take into account occupancy hours. The recommendations within this report should help to bring the church further below the expected benchmarks.

	kWh/m^2 St Mary the Virgin	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Electricity	5.6	20	10
Heating	59.2	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 or tariff. The church is currently on a single rate electricity tariff. Dual tariffs have a cheaper off-peak rate which would likely reduce the electricity bills due to significant weekend use. 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 scheme 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. They should be replaced as the old lamps fail.

Location	Existing Lamp Type	Recommended Lamp Type	Example Source
All lights in nave, south aisle, north aisle, chancel and monument area (figure 1&2)	120W PAR38	20W Compact Reflector PAR38	http://www.tlc-direct.co.uk/Products/MGPAR3820ES.html http://www.tlc-direct.co.uk/Products/LALED38WW.html

Figures 1 and 2: Church lighting

If all of the above lamps are changed we estimate this to **cost £261** but **save £45** per year therefore providing a payback in 5.9 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.

The church could also consider replacing the lamps with LED lighting. This would likely require new light fittings and an electrician to do the work, LED are also more expensive so would be a bigger cost. However, at 7W each the LED lamps are even more energy efficient than the compact reflectors recommended and have a longer lifespan reducing maintenance costs.

When sourcing alternative bulbs it is important to consider the aspects listed below. Suppliers can provide advice and will often allow customers to trial lamps as long as they are returned in re-saleable condition. It is usually not recommended to mix lamp types within a fitting so it may be necessary to change all the lamps at once rather than as each fails.

- 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 lights are currently controlled by a bank of switches located in a cupboard in the monument area (figure 3). In order that those using the building only turn on the lights they need at that time it is advised that each switch is labelled to describe which light it switches on and off.

Figure 3: Light switches

3.2 External Lighting

This church only has minor external lighting to the porch controlled by a manual switch. This is appropriate for purpose and no changes are recommended.

4.0 Heating System Saving Recommendations

4.1 Boiler

The current heating system struggles to adequately heat the church and takes a long time to warm up for the regular Sunday service, which seems wasteful for such a small congregation for a couple of hours. Supplementary fan heaters sometimes have to be brought in for bigger events.

The church currently has an oil fired boiler which is serviced once a year. It was not possible to determine the age and size of the boiler but the church would like to know what the options are for when the time comes to replace it.

It is understood that there is mains gas in the village. It may be possible to run mains gas to the church and install a gas fired boiler. Gas is a cheaper and lower carbon fuel than oil. Alternatively the church could replace the existing oil boiler with a modern higher efficiency oil boiler. A further heating option is electric heating which is explored in section 4.4.

Initial calculations assume a 100kW boiler would be required costing approximately £5000 for a oil or gas fired condensing floor standing boiler (this does not include the cost of mains gas connection, controls or any upgrades that may be required to the distribution pipework).

When considering a boiler replacement it is worth taking into account the following;

- If the system is suitable for a condensing boiler. Condensing boilers are most efficient at lower flower temperatures, so if the heating system is not designed to work at a lower temperature the efficiency from a condensing boiler would not be noticeable. Also, if the current pipework is old and liable to have dirt in the system a non-condensing boiler would be better suited as the larger boiler pipework will be less susceptible to blockages.
- If a dual burner boiler is to be used, so in Spring and Autumn only half the boiler will fire
- If the existing boiler is over-sized and could it be reduced.
- Can the heating controls be up-graded to include weather and load compensation
- Can the existing distribution pipework be used or does it need replacing. Ensure pipework, valves and joins in external/non-heated areas are well lagged to reduce heat loss.
- Can the system be filled with an antifreeze based inhibitor such as X500 from Sentinel. This prevents the water in the system from freezing so boiler frost protection is not required.

  The church could also investigate a biomass boiler which is explored in further detail in section 6.7.

4.2 Pipework and Distribution

It was not possible to see the pipework in the boiler room due to difficult access. The lagging of the pipes, valves and other fittings should be checked. If these are not lagged then insulating these will save energy through reduced heat loss but will also provide better protection against burst pipes.

Within the body of the church the heating is distributed via 7 air fan convectors (figure 4). There are several actions that will ensure these are operating as efficiently as possible:

- Clean the fan convector air filters – these can be removed and gently tapped to remove most of the accumulated dust and either vacuumed clean or washed in lukewarm water with detergent. Rinse in clean water and allow to dry naturally before replacement.

- Bleed the system to check for corrosion and sludge. If any is present it is recommended that the system is emptied, power flushed and refilled with a suitable inhibitor. This will improve the performance of the boiler by reducing energy use and allow the building to be heated quicker and more effectively. It will also improve the performance of units with small hot water elements such as fan convector heaters.

Figure 4: Fan convector

- Check for air within the system. If there is any in the system this will be reducing the effectiveness of the heating system and it is recommended that the church undertakes regular bleeding of air from the system. This should be carried out when the boiler and circulating pump are on and should be scheduled in each year a few weeks after the heating has been turned on.

4.3 Controls

The boiler and fan convectors are controlled by two Sangamo timers which are normally set to come on 6am-12pm on Sunday's, allowing 1.5-2hours warm-up time before a service. There is also an override switch which is used when extra heat is required.

4.4 Electric heating

The size of the average congregation is relatively small for the size of the church so it seems wasteful to heat the whole church every Sunday. To avoid this the church may want to consider installing supplementary electrical heating in the form of pew mounted heaters. The idea is that these would be used for the small regular services when there are 15-20 people sat in one area of the church. When there are larger services, concerts, festivals, and community functions then the main boiler and central heating can be used to heat the whole church.

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 be fitted in the most frequently used pews, such as the 5 front pews on each side and only turned on when the pew is occupied.

Electricity is an expensive and high carbon fuel but the heaters would only be used to heat a small area and only for the duration of the service removing the need for the warm up time. Electrical heaters are easy to install and fairly low cost with minimal maintenance costs.

There are currently Dimplex electric heaters in the bell tower. These were on timers and should only be used as required.

See also renewable options for heating in section 6.7.

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

It is assumed there is no accessible roof void in which to install insulation. If the roof is replaced at a later date or if a roof void is found to be present, 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 raised timber platforms on top of solid stone floors therefore there is no opportunity to install floor insulation.

5.4 Windows

The windows are generally in good condition, with no broken window panes or gaps between the glass and the abutments witnessed.

5.5 Doors

A number of the church doors have gaps around them which will be creating draughts. It is estimated that up to 15% of heat generated can be lost through draughts and gaps in doors and windows, so it is a good idea for this to be reduced where possible and draught proofing doors is a simple and quick measure to install.

The doors that were noted to have gaps around the edges and underneath were the north and south aisle doors, tower and chancel door. Keyhole covers should also be fitted where there are open keyholes such as the north aisle door– a simple magnet can be used to do this where there is metal casing around the keyhole.

The edges of the doors can be sealed using the Quattro seal method which is suitable for historic buildings and is recommended (www.quattroseal.com) for your doors. The product is recognised by English Heritage for listed buildings as it is fully reversible which makes it ideal to be used in churches. The doors would benefit from a brush strip to be fitted at the base to reduce the draughts from under the doors.

We also recommend the installation of an air curtain above the south aisle door in order to reduce heat loss when the door is opened. An air curtain is a device used for separating two spaces from each other, usually at the exterior entrance. The most common configuration for air curtains is a downward-facing blower fan mounted over an opening, blowing air across the surface of the opening (figure 5). Air curtains can come with, or without heaters to heat the air. It helps keep out outside air, reducing infiltration though the opening. They can also be used to avoid cold draughts by mixing in warm air heated by the

air curtain. The fan must be powerful enough to generate a jet of air that can reach the floor.

This will help to reduce heat loss and cold air entering the building just prior to a service and reduce the need for longer warm up times. The air curtain must go across the full width of the door way to be effective. It is likely that the DAC will need to be consulted before installing this measure. There are many manufactures of air curtains, and Dimplex have a large range. You will need to employ an electrician to carry out the installation.

Figure 5: Example of an air curtain in a church

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 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, south aisle and chancel roof may be suitable for solar panels. As this is a Grade I listed building the solar panels would need to be hidden from view. The shallow pitch of the roof and parapet may hide part of the installation but more investigation is required into whether planning permission would be granted. It is worth making a request to the DAC to check this.

Ideally a solar PV system should face between south east and south west, and be free of shade. For best performance it should be angled at 30 to 40 degrees – although it 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.

Solar PV systems generate electricity from solar radiation from the sun, and any electricity that is generated can be used within the building or fed back to the National Grid. The installation would be eligible for Feed-in Tariff (FIT) 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

When the time comes to replace the existing oil boiler you may want to consider a biomass boiler. This would provide a heating system that would meet the church's requirements with an increased occupancy. Biomass is a lower carbon heating fuel than oil and at 4-6p/kWh would have similar or lower running costs.

Biomass boilers burn logs, wood chips, wood pellets or other forms of biomass. The most advanced boilers are fully automatic. They control the amount of fuel and air supplied to the combustion chamber. As a result they are highly efficient and emissions are low.

They are fed with wood chips or pellets from a large hopper sited nearby. If you've got space, manufacturers recommend a hopper that's big enough to hold a year's supply of fuel. This minimises transport and delivery costs for fuel, as well as work for the owner. The boiler would require slightly more maintenance than a gas boiler so a service and maintenance contract should be put in place. Ash will need to be removed about once a month.

A new external boiler house and fuel store would need to be built adjacent to the church in a style in-keeping with the church. Ideally this would be within 30 meters of the delivery truck to pneumatically delivery wood pellets. The means it would have to be sited to either the north or south side of the tower – neither of which are ideal. If it would be preferable to site it where the existing oil boiler is or on the north side of the chancel then the fuel would need to be bought in bags and hand loaded into the fuel store.

The system would likely be eligible for the Renewable Heat Incentive so the church would be paid for every kWh of heat produced; the rate is currently 8.6p/kWh (small commercial biomass, tier 1).

A biomass boiler can cost between £5,000 to £11,000 however the cost of the installation, distribution system, radiators and boiler room would all also need to be included. As these costs are specific to the church we are not able to provide an estimate as the parameters are wide ranging. The total cost of the installation would need to be obtained from installers due the specific requirements of the church and depends on whether the existing pipework and radiators can be used.

You also might find it useful to contact Oxfordshire Woodfuel Programme (setup by TOE2) who provide advice and support in this area www.oxonwoodfuel.org.uk.

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.

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 to help users 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. Also please take into consideration that the more the church is used, the greater the savings will be in the below table, as these are based on current usage times of the church.

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 indicative only based on our experience and are not specific to this church.

Short Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £ Saving per year**	**Estimated Carbon Savings per year (tonnes)**	**To be actioned by**
Measure	£0	£29	0.13	
Calculate and monitor	£0			
Communicate	£0			
Housekeeping	£0			
Label light switches	£0	£14	0.05	
Clean fan convector filters	£0	£24	0.11	

Medium Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £Saving per year**	**Estimated Carbon Savings per year (tonnes)**	**To be actioned by**
Replace lamps	£261	£45	0.17	
Draughtproof doors	£1000	£118	0.57	
Check heating system for corrosion, flush and add corrosion inhibitor if necessary	£500	£94	0.54	
Install air curtain	£500	£59	0.28	

Long Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £ Saving per year**	**Estimated Carbon Savings per year (tonnes)**	**To be actioned by**
Electric heaters	£850	Based on assumed number of heating hours - £687	3.77	
Gas boiler	£5000 (for boiler only)	Based on assumed number of heating hours - £800	4.03	
Oil boiler	£5000 (for boiler only)	Based on assumed number of heating hours - £700	3.30	
Biomass boiler	Biomass boiler approx £5,000 - £11,000 (boiler only)	Biomass running costs depends on fuel used. Based on assumed number of heating hours - £794	5.32	
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