Energy Audit of St Peter's, Marsh Baldon

December 2013

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 Peter's, Marsh Baldon.

The report was prepared following a site audit conducted by Emily Guilding, Sustain on 12th December 2013. She was accompanied by Debbie Dance the church warden.

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 Peter'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

2.0 Church Details

St Peter's is the local parish church serving the community. It is located in Marsh Baldon, Oxfordshire and dates back to the 14th century.

2.1 Listed Status

St Peter's is of a Grade II 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

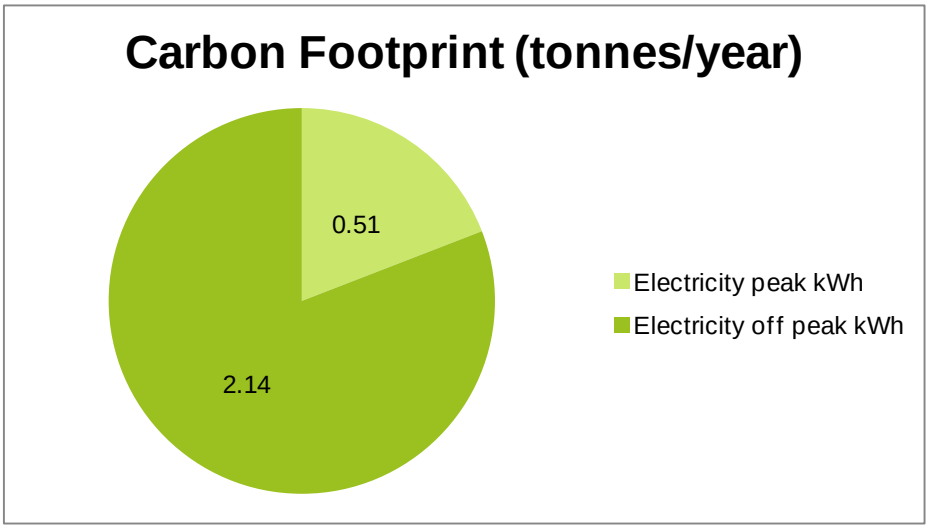
The approximate internal area of the church was measured as 210m^2.

From discussions on site during the audit it has been established that the typical usage of the church is for 40 hours per month.

	Description	Average Use
Church Use	2 services per month	5 hours/month
Community Use	n/a	0 hours/month
Administration	n/a	0 hours/month
Catering and Events	Concerts, talks, school services	14 hours/year
TOTAL USE		**94 hours/year**

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 2.64tCO_2e per year.



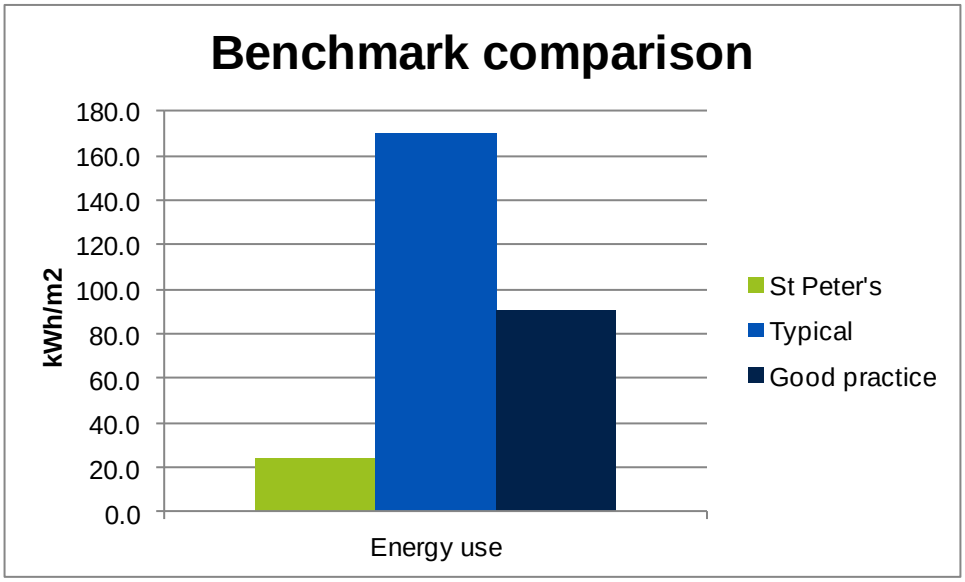
The annual energy consumption has been taken from the energy bills provided from 31st October 2012 – 31st Octorber 2013. These may include the use of estimated readings where actual readings have not been taken.

	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity peak	962	£0.13	£130	0.51
Electricity off peak	4,072	£0.06	£272	2.14
TOTAL	**5,034**		**£402**	2.64

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

Typical and good practice energy benchmarks[1] exist for non heating electricity use and gas use for churches with gas heating. It is difficult to compare a church with electric heating to these as we do not know the proportion of electricity that is used for heating. We have therefore presented just the overall picture below. This shows St Peter's is consuming less electricity than would be expected for a church of the same 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 Peter's	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Energy used	24	170	90



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 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 electrically heated churches typically makes up the second largest use of electricity (after heating) 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 bulbs fitted to them to generate an energy saving. This should be done as the old lamps fail.

Location	Existing Lamp Type	Recommended Lamp Type	Example Source
10 brackets of 3 lamps around edge of church (figure 1)	50w MR16 GU5.3 halogen spots	5w MR16 LED	http://www.tlc-direct.co.uk/Products/LTMR9WW.html
Main aisle 2 x spot lights and 2 x spot lights lighting the north aisle painting	120w flood ES PAR38	Either Compact Reflector PAR38 20w ES (£7.50) or LED PAR38 ES Reflector Lamp 7.5w (£16.50)	http://www.tlc-direct.co.uk/Products/LAPAR3820ESDL.html http://www.tlc-direct.co.uk/Products/LALED38WW.html

Figure 1. Bracket with 3 halogen lamps

If all of the above lamps are changed we estimate this to **cost £360** but **save £13** per year therefore providing a payback in 28 years. If the occupancy of the church increases, the payback will shorten. 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 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 labelled switches (figure 2) located next to the West door.

Figure 2. Labelled light switches

4.0 Heating System Saving Recommendations

4.1 Current heating

The church heating is provided by 5 wall mounted radiant heaters. These are thought to be 15-20 years old and each estimated to be 3kW (figure 3).

Radiant heating is often the most appropriate heating method in a low occupancy church. Radiant heaters are turned on as required and provide instant heat. They heat the occupants rather than attempting to heat the whole space.

The heaters are individually controlled with manual switches. They are currently switched on the night before a service to warm up the church. However this should not be necessary as radiant heat passes through the air and heats solid objects, for example people, rather than the air. It also might be considered a potential fire risk leaving these on overnight in an unattended church. The church should try turning the heaters on just before a service. If all the heaters are turned on 11 hours before a service this costs the church approximately £13 per service so not doing this over the course of a year could save around £158, which is over a third of the total cost of electricity a year. In addition, only the heaters under which people are sat should be turned on, rather than all of them.

There is also an electric radiant heater and plug-in convector heater in the vestry. Care should be taken that these are only used as required.

If the church wishes to increase the internal temperature of the church this is ultimately going to use more energy and will require investment. There are several options that are available to achieve this: increase the electrical heating (section 4.2); install a gas boiler and heating system (section 4.3) and; install a biomass pellet stove (section 6.7.2). The advantages and disadvantages of each option is covered in the sections below, the church will need to use this information to decide which the best option is.

Figure 3. Radiant heater

4.2 Increase electrical heating

At the church's current electricity rate of 7p/13p (off-peak/peak) per kWh, electricity is an expensive and high carbon fuel. However, electrical heaters are easy to install and fairly low cost with minimal maintenance costs. It should be noted that wall mounted radiant heaters are not currently favoured by the DAC.

The current radiant heaters warm the congregation sat in the direct line of the heaters. Additional wall mounted radiant heaters such as the Dimplex Quartz 3kW heater could be

installed to heat more occupants, filling the gaps in-between the existing heaters in the north and main aisle. Care should be taken that only the heaters where people are sitting are turned on.

Alternatively, 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 and only turned on when the pew is occupied.

4.3 Install gas boiler and central heating system

At approximately 4p per kWh gas is a cheaper and lower carbon (although not carbon free) heating fuel than electricity but the capital required to install a boiler and wet heating system is greater and would be a more intrusive installation. It would also depend on getting a connection to mains gas which is thought to be along the village road, approximately 40 meters away. A gas central heating system will require several hours of warm up time before a service. The system would be low maintenance, requiring only an annual service.

The church would require a gas boiler which could be located in the vestry and a wet distribution system via radiators around the church. To give an idea of the cost of such a system, a similar sized church was quoted approximately £38,000 exVAT for a low-pressure hot water system with a 80 kW wall-mounted, gas-fired boiler serving a total of 14 radiators (this does not include the cost of connecting the church to a mains gas supply). The church should ensure that the system specification provides good controls and maximum efficiency with individually controlled radiators, well lagged pipework and connections and an antifreeze based inhibitor put in the system which reduces the need for boiler frost protection.

See also renewable options for heating in section **Error! Reference source not found.**.

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

The main aisle appears to have a void between the external pitched roof and the internal barrelled ceiling of this area (figure 4). It is unknown whether access to this space is possible, if it is this could be insulated without affecting the appearance of the church interior. Care should be taken in the installation of the insulation to maintain good levels of ventilation to the timber in the roof by using a breathable insulating material and not a foil backed material. Options include mineral wool, dry cellulose (recycled newspapers) or sheep wool. Ensure the material is treated with vermin repellent.

Figure 4. Barrelled main aisle ceiling

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

Laying strips of carpet on the floor in-between the rows of pews which will help improve thermal comfort. Carpet should be hessian (not rubber) backed and if fixed in place, tacks should be used rather than glue.

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 west door is currently used as the main entrance. There is a visible gap at the bottom of the door which will allow warmer air in the church to escape and cold draughts to enter when the wind is blowing in the direction of the door. A brush seal on each door leaf could

be fitted to the bottom of the door to stop this. The church could also install a curtain and sausage dog draught excluder to help combat this problem.

The south door may become the main entrance in the future. Draughts could be felt around the edge of the door. Fitting draught proofing strips will help stop this. Draught proofing using the Quattro seal method suitable for historic buildings is recommended (www.quattroseal.com).

6.0 Renewable Energy Feasibility

The below reviews the viability of renewable technologies at the 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 provide specific costs for either a feasibility study or installation at the church depending on what the requirements are.

6.1 Solar Photovoltaics

The south facing north aisle roof would make a suitable location for a solar photovoltaic (PV) array. The panels would have to be located in the valley between the north and main aisle to keep the visibility of the panels to a minimum. Shading from surrounding trees may be an issue and these may need pruning to reduce it (figure 5). The cable routes could run down the tower to the distribution board located in the base of the tower, where there is space for an inverter if required. It is likely the distribution board would need updating, which would be an additional cost

Figure 5. Aerial view of 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.

An initial assessment indicates that there would be space for a 6kWp installation with a yield of approximately 5,100 kWh at St Peter's. The church will be able to use this electricity when it is occupied during the day, reducing the electricity bill. 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.

Depending on the amount of electricity generated and exported and assuming the church would receive the lower generation rate, the church could expect to pay off the initial investment within 20 years. However this would be variable depending on the exact make and model of the PV units being considered.

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 grave yard has been used for burial it is not recommended that consideration is given to the feasibility of ground source heating. Ground source heat pumps often work most effectively with an under floor heating system in a well insulated building; therefore are not recommended for this site

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 site.

6.7 Biomass

6.7.1 Biomass boiler and central heating system

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. The boiler works in conjunction with a wet heating distribution system, such as traditional radiators, similar to a gas boiler.

The boiler is 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. Maintenance is minimal – although you will need to clean it and remove the ash about once a month.

This site does not appear to have suitable delivery access or fuel store and boiler house location. Therefore we would not recommend this type of heating system for this church.

6.7.2 Biomass wood pellet stove

A biomass wood pellet stove located in the main body of the church would be a direct source of renewable heat to that area suitable for small congregations. It would not require installing a distribution system but would need a flue to be run up through the roof (probably with a black enamel finish). Stoves can fire automatically and have up to a 12kW output. For further details contact suppliers such as http://woodpelletstove.co.uk/ . The stoves utilise pellets, a biomass product made of renewable substances, generally recycled waste wood and sawdust and also short rotation coppice wood.

This type of biomass stove is not eligible for the Renewable Heat Incentive.

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
- 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 a number of 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 indicative only based on our experience and are not specific to this church. The savings are based on the occupancy hours given therefore may change depending on occupancy and heating hours of the church.

Short Term Improvement Measures			
Description	**Estimated Cost**	**Estimated Saving**	**To be actioned by**
Measure	£0	Low for this church but there will be a small saving	
Calculate and monitor	£0		
Communicate	£0		
Housekeeping	£0		
Reduce heating warm up time by turning on heaters on Sunday mornings.	£0	£158	
Replace MR16 spot lights	£330	£10	
Replace PAR 38 lights	£30	£3	

Medium Term Improvement Measures			
Description	**Estimated Cost**	**Estimated Saving**	**To be actioned by**
Insulate main aisle roof space	Depends on type of insulation used but likely to be in the region of £1,400	£30/year and improved comfort	
Pew carpet strips	Approx £9 m^2	Improved comfort	
Draught proof west and south doors	£250	£9/year and improved comfort	

Long Term Improvement Measures			
Description	**Estimated Cost**	**Estimated Saving**	**To be actioned by**
Increase electrical heating	Approximately £50 per pew heater and £350 per Quartz radiant heater plus installation costs	Improved comfort	

Consider gas boiler and central heating system	Circa £40,000 plus mains gas connection cost	Difficult to quantify as depends on increasing the use of building. Gas heating per kWh is lower cost than electrical	
Consider biomass pellet stove	Depends on model chosen, around £4,000	Improved comfort	
Consider solar PV installation on the south facing slope of the north aisle roof	Approximately £12,000	Approximately £612/year. Payback of around 20 years.	

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