sustain

Energy Audit of St Leonard's, Eynsham

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 Leonard's Church, Eynsham.

The report was prepared following a site audit conducted by Emily Guilding, Sustain on 15th January 2014. She was accompanied by Pete Brown, property 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 Leonard'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 Leonard's church is the local parish church serving the community. It is located in Eynsham, and dates back to the late 13th century.

2.1 Listed Status

St Leonard'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 437m^2.

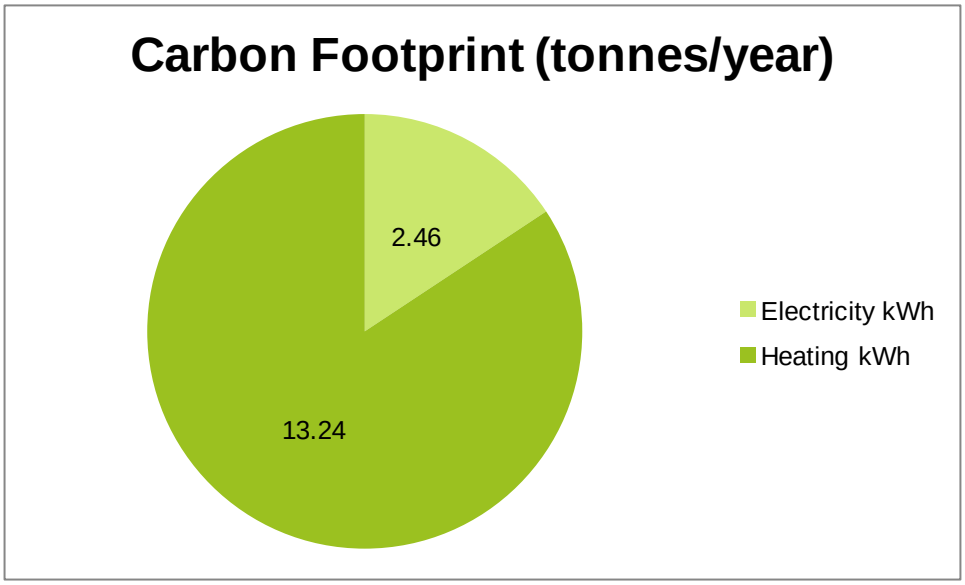
From discussions on site during the audit it has been established that the typical usage of the church is for 44.5 hours per month.

	Description	Average Monthly Use
Church Use	3 or 4 services per week, weddings, funerals and christenings	43 hours/month
Community Use	Children's groups	1.5 hours/month
Administration	n/a	
Catering and Events	Occasional concerts	
TOTAL		**534 hours/ year**

The average congregation size is approximately 200 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 15.7tCO_2e per year.



The annual energy consumption has been taken from the energy bills provided from December 2012 to November 2013. These may include the use of estimated readings where actual readings have not been taken.

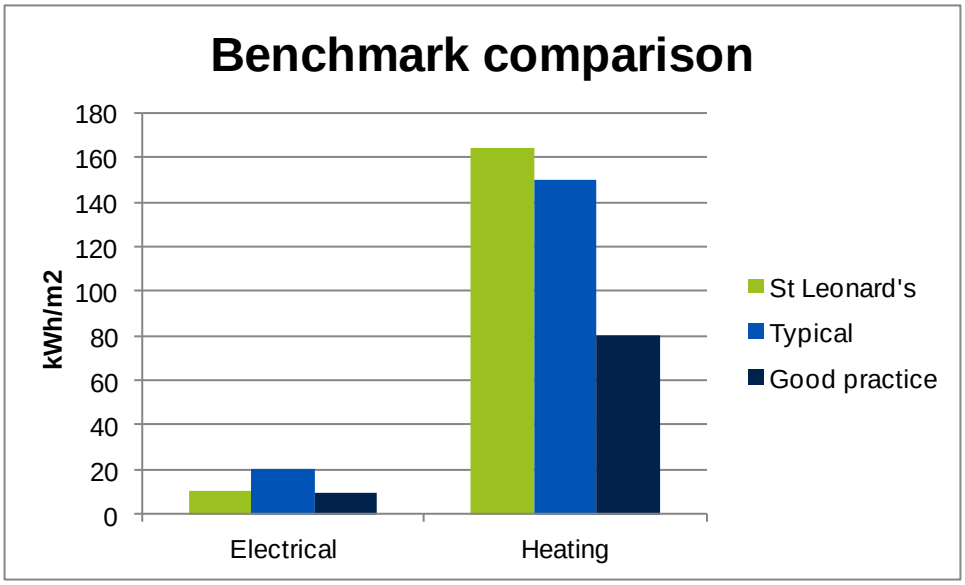
	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity	4,694	£0.0947	£444	2.46
Heating	71,949	£0.0284	£2,044	13.24
TOTAL	**76,643**		**£2,488**	15.70

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

The church is using sMeasure but the consumption data does not match the billed consumption. The meter at the church is an imperial meter (gas measured in cubic feet) but it appears that the cubic feet to cubic meters calculation has been missed when entering the data into sMeasure. To convert from imperial to metric – multiply number of units used by 2.83. This is approximately how much lower sMeasure consumption is than the billed data.

In comparison with national benchmarks[1] St Leonard's consumes more gas than would be expected for a church of this size and approximately the same amount of electricity. 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 Leonard's	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Electricity	11	20	10
Heating	165	150	80



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

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.

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 tariff. Dual tariffs have a cheaper off-peak rate which would likely reduce the electricity bills as the majority of the use is at weekends. 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 existing lamps fail.

Location	Existing Lamp Type	Recommended Lamp Type	Example Source
Alter platform spots x 2	500W Linear halogen R7s 117mm	400W ECO tungsten 117mm linear R7S	http://www.tlc-direct.co.uk/Products/LXTHE400.html
Tower room and stairs lighting	100W incandescent bulbs	20W Compact fluorescent lamp	http://www.screwfix.com/p/sylvania-spiral-bc-20w/50835
2 x halogens in porch	Estimate 50W MR16 GU5.3 halogen spots (should be checked)	5W MR16 LED	http://www.tlc-direct.co.uk/Products/LTMR9WW.html
North aisle x 4	100W PAR 38 spot lights	PAR 38 CFL Either Compact Reflector PAR38 20w ES (£7.50)	http://www.tlc-direct.co.uk/Products/LAPAR3820ESDL.html

If all of the above lamps are changed we estimate this to **cost £67** but **save £37** per year therefore providing a payback in less than 2 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.

3.1.2 Replace existing fittings with new low energy fittings

There are 9 150W high pressure sodium E40 flood lights installed at ceiling level in the chancel, nave and South aisle. These have a very poor colour rendering quality and take a while to reach full brightness. It is recommended that these are replaced with LED lamps, which would only need to be 40W equivalent to give a similar amount of light. These are likely to require new light fittings. The cost savings from reducing the overall wattage of the lamps would lead to a saving of £22 per year.

Changing the light fittings should be carried out by a qualified electrical contractor and advice on the requirement of a faculty should be sought.

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.

3.1.3 Controls

The lights are currently controlled by a bank of labelled switches (figure 1). These are deemed appropriate for purpose and no changes are recommended.

Figure 1. Labelled switches

3.1.4 External Lighting

This church only has minor external lighting to the porch (figure 2) controlled by a manual switch. This is appropriate for purpose and no changes are recommended.

Figure 2. Porch light

4.0 Heating System Saving Recommendations

4.1 Heating system

The heating at the church is currently provided by ceiling mounted gas radiant heaters (figure 3). This system is about 30 years old. There are four burners in the nave, 2 in the south aisle and 1 in the chancel.

The church is adequately heated by the existing system but due to its age the church is beginning to think about a replacement system and would like to advice on the most cost efficient and effective option (see section 4.3).

Figure 3. Radiant heaters

4.2 Controls and Frost Protection

The heating system is controlled by a Danfoss 852 programmer (figure 4) located near the vestry. The heaters in the nave are set to come on at 6:30am on Sunday's, giving 2 hours of warm up time before a service. The heater in the chancel is set to come on at 4am as it takes longer to warm up. The church have found that these warm up times ensure the church is sufficiently heated, but they could experiment with reducing the warm up time to see if adequate heat can be provided with less gas.

Figure 4. Heating programmer

There is supplementary electrical heating in the vestry. It is currently on at all times to keep the clergy robes dry. This will be using a significant amount of electricity as is an expensive way to heat a room. Reducing the heater setting and time it's on will reduce the church's electricity bills. The church could also look at installing a night storage heater in the vestry. This utilizes cheaper rate night time electricity so would only be of benefit if the church were to change to a dual electricity tariff.

There are also electric heaters in the tower room, crèche and toilet. Ensure these are only used as required.

4.3 Gas heating system upgrade

The existing heating system provides adequate heat, but the gas use is high for a church of this size which may be partly due to the system's inefficiencies. It was installed in the1980s so is nearly at the end of its useful life. Due to the church's listed status the installed reflectors had to have a matt finish meaning that less heat is reflected into the space compared to reflectors with a shiny finish.

Due to DAC guidelines it is unlikely that the system can be replaced with similar ceiling hung gas radiant heaters. If the church wanted to have mains gas fired heating a gas boiler and wet radiator system would be the most obvious option.

The church would require a gas boiler which could be located in the vestry or crèche and a wet distribution system via radiators around the church. Initial calculations assume a 150kW boiler would be required. An estimated cost for a high efficiency gas fired boiler, controls, distribution pipework is £50,000. Based on an assumed number of heating hours, it would cost approximately £1422 per year to heat the church.

The church should ensure that the system specification includes 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. Fan assisted convector radiators may well suited in order to distribute warmth around the space, although the noise levels of the fans should be checked.

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.
- If a dual burner boiler can be used, so in Spring and Autumn only half the boiler will fire
- Can the heating controls be up-graded to include weather and load compensation

See biomass heating option 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

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 floor is solid so there is no opportunity for insulation.

5.4 Windows

The windows are generally in good condition besides a few missing panes which should be replaced as soon as possible. The church has received a quote for this work.

5.5 Doors

An internal air curtain is fitted over the north door; the church reported this to be effective at reducing heat loss through the door.

The north door is particularly draughty. Fitting draught proofing strips will help stop this. Draught proofing using the Quattro seal method is suitable for historic buildings as it is reversible. A keyhole cover should also be fitted.

Both the chancel door and south aisle door are draughty and would benefit from 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.

Floor length curtains could also be fitted over these doors to reduce draughts.

6.0 Renewable Energy Feasibility

The below reviews the viability of renewable technologies at St Leonard's 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 and south aisle roofs could be suitable for solar panels. These need to be hidden from view on Grade II* listed buildings. The shallow pitch of the roof and parapet would hide part of the installation and there are no roads or houses on 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 grave yard has been used for burial it is not recommended that consideration is given to the feasibility of ground source heating.

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

As the church will be looking at replacing its heating system, it may wish to consider a biomass boiler and wet heating system option. 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 there is 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 will need to be cleaned and ash removed about once a month.

Biomass is a zero carbon fuel and depending on the fuel used costs about around 5p per kWh. The cost of the installation of the boiler would need to be obtained from specialist installers due the specific requirements of the church. 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. .

Access for fuel deliveries and location for a new external boiler house and fuel store is a key consideration. A new external boiler house and fuel store is likely to cost between £10,000-£20,000.

The system could be eligible for the Renewable Heat Incentive (depending on fuel used). This means the church will be paid for the energy generated by the boiler. The rate depends on size of boiler installed; for a small commercial biomass boiler it is currently 8.6p/kWh.

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 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. 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	£0	The savings depend on how much energy wastage there is currently. This saving is based on 2% of energy consumption a year saved - £44	0.8	
Calculate and monitor	£0			
Communicate	£0			
Housekeeping	£0			
Reduce vestry heating	£0	£311	1.72	
Replace alter platform lights	£4	£10	0.06	
Replace tower room and stair lights	£12	£6	0.03	
Replace porch lights	£22	£5	0.03	
Replace north aisle spot lights	£30	£16	0.09	

Medium Term Improvement Measures				
Description	**Estimated Cost**	**Estimated Saving per year**	**Estimated Carbon Savings per year (tCO2e)**	**To be actioned by**
Draught proofing of doors	£450	£61	0.4	

Replace high pressure sodium lamps and fittings	£576 for lamps plus fittings and installation costs	£22	0.12	
Replace missing window panes	£350	£10	0.07	

Long Term Improvement Measures				
Description	**Estimated Cost**	**Estimated Saving per year**	**Estimated Carbon Savings per year (tCO2e)**	**To be actioned by**
Gas boiler and central heating system	£50,000	£1,034	6.7	
Solar PV panels	Further investigation required	Further investigation required		
Investigate biomass boiler and central heating option	Biomass boiler approx £5,000 - £11,000 plus cost of installation, distribution system, radiators and boiler/fuel store.	Depending on fuel type used, biomass is marginally more expensive than gas		

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