sustain

Energy Audit of St Mary's Church Headington, Oxford

November 2013

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1.0 Introduction

This report has been prepared to detail the energy saving measures and renewable energy generation potential that exist at St Mary's Church, Headington, Oxford.

The report was prepared following a site audit conducted by Marisa Maitland and Emily Guilding, Sustain on 25th November 2013. They were accompanied by Sheila Fulham, 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 Mary'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, Natalie Merry.

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 us at:
fionadanks@trustforoxfordshire.org.uk or www.trustforoxfordshire.org.uk

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2.0 Church Details

St Mary's is the local parish church serving the community. It is located in Headington, North West Oxford and was built in 1956.

2.1 Listed Status

St Mary's is not of listed status. This 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 416m^2.

From discussions on site during the audit it has been established that the typical usage of the church is for 42 hours per month.

	Description	Average Monthly Use
Church Use	1 service per week, church meetings	16 hours/month
Community Use	Choir practise, community groups	26 hours/month
Administration	n/a	
Catering and Events	n/a	
TOTAL		**42 hours/month**

The average congregation size is approximately 50. The neighbouring church hall is used for Guides, Brownies, dance classes, bingo nights etc. The hall is due for closure in July 2014 and some of these groups may use the church for their activities following the closure. The church is a well day-lit, airy space, leading itself well to a variety of community uses. It is however, a difficult building to heat effectively. This needs to be resolved in order to encourage greater use of the building.

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 11.61 tCO_2e per year.

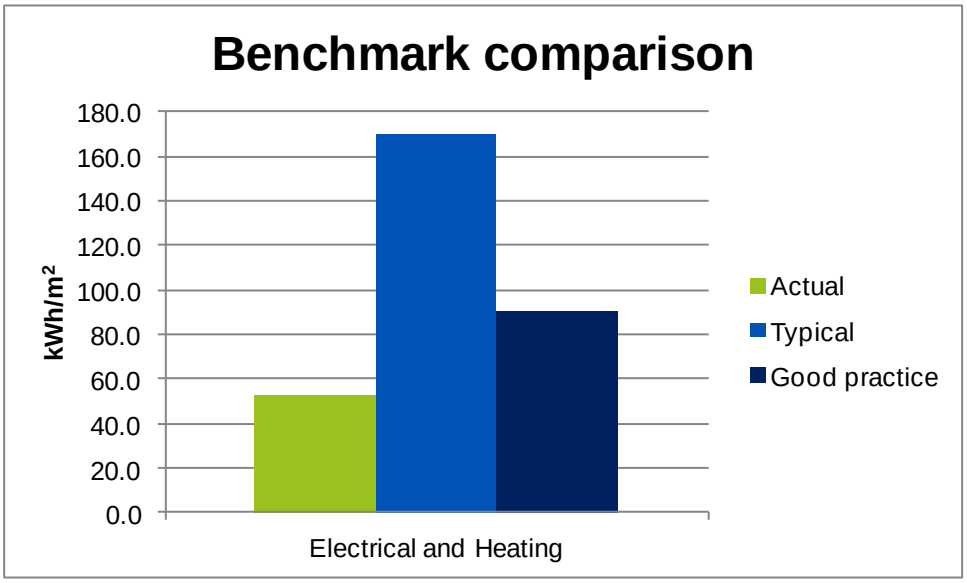
The annual energy consumption has been taken from the energy bills provided from 30 November 2012 to 30 September 2013 and pro-rated accordingly. These may include the use of estimated readings where actual readings have not been taken.

	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity	22,119	8.41p	£1,931	11.61
TOTAL	**22,119**		**£1,931**	**11.61**

Note: The above costs are for the energy only and do not include standing charges or VAT. The cost per kWh shown is the average off peak and peak cost over the year.

In comparison with national benchmarks[1] St Mary's consumes less energy than would be expected for a church of this size. Whilst this is very commendable, it is likely in part due to the low usage of the buildings and as the buildings usage is anticipated to increase the recommendations within this report should help to bring the church further below the expected benchmarks.

	kWh/m^2 actual	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Electricity and Heating	53	170	90



St Mary's has signed up to sMeasure which will help the church estimate its future costs of energy and report on its carbon. However the consumption data entered into sMeasure did not seem to match the energy bill data. This should be checked and updated accordingly.

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. 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

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

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 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 existing fittings with new low energy fittings

Due to the nature of the existing fittings the following lights would require the fitting to be replaced to create a low energy light source.

Location	Existing Fitting	Recommended New Fitting	Example Source
8 x internal uplighters	8ft T12 fluorescent tubes	T5 high frequency adaptor kits and T5 tubes	http://www.chalmor.co.uk/ReFit-T5
6 x wall mounted stage lighting, facing alter	Large stage lights	LED spot lights	

To upgrade the existing T12 fluorescent tubes the church has two options:

a) Retain the existing fittings and use a retrofit kit to convert the fitting to be able to use T5 or LED tubes, or;
b) Replace the entire fitting with a new high frequency unit.

To decide which the most appropriate option is the age and condition of the existing fittings need to be assessed. If they are more than 10 years old and/or in poor or damaged condition it is likely to be more cost-effective to completely renew the fittings rather than convert them.

If the T12 tubes are changed we estimate this to **cost £152** but **save £27** per year therefore providing a payback in 5.7 years.

If the 6 large stage spot lights are used regularly it would be worthwhile replacing them with low energy LED light. Alternatively the church could make it standard procedure that these lights are not used.

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

3.1.2 Controls

The lights are currently controlled by manual switches. These should be clearly labelled to ensure they are only used as required. A simple use of red and green dots can be helpful to indicate which lights are required for different use of the building.

3.2 External Lighting

This church only has minor external lighting, there was a timer present but it was unconfirmed whether this is used for the external lighting. If this timer has been bypassed and a manual switch is used, this is appropriate if it meets the needs of the church, as long as it is not left on when it is not required.

3.3 Small Power

During the site visit it was noted that small electrical appliances such as electric plug in radiators were present. These were switched off and this good energy practice should continue.

4.0 Heating System Saving Recommendations

4.1 Electric heating system

The heating at the church is currently provided by a range of electric heaters including 12 wall mounted radiant heaters, 4 night storage heaters and a couple of plug in electric heaters.

Electric heating provides heat almost instantly and can be a suitable heating solution for churches which are used intermittently. Care should be taken to limit the amount of time it is turned on to when it is required only. For the radiant heating this will only be when the main congregation are within the building and for the other electric heaters it need only be for an hour or so before the service.

The church has found that these heaters do not provide adequate heating for the building and with plans for additional community use, there is a need to provide a more comfortable, usable space. In order to do this considerable investment into upgrading the heating system is required. There are several options which could be appropriate at this church depending on the future usage, available funds, system suitability and DAC guidelines. These are: improve current electrical heating (section 4.2); install gas central heating system (section 4.3), install ground source heat pump (section 6.5) or install biomass boiler and heating system (section 6.7). A detailed feasibility study of the different heating options available to this church should be commissioned to allow the church to compare systems and costs.

4.1.1 Controls

The church finds that the night storage heaters perform very poorly. It is often the case with these heaters that users do not fully understand the controls and it can be very difficult to accurately judge how to set the thermostats. Setting them too low overnight can cause the heater to have no perceived effect while setting them at maximum will increase the cost of running them. The fact that the church is sporadically occupied makes it even more difficult to control them effectively as the settings need to be altered according to occupancy and weather.

The heaters were switched on on the day of the audit even though the building was not in use. It may be worthwhile fitting a 7 day programmer to the heaters so that they are only running when the church is in use. Alternatively, if all attempts to trial different settings have failed to provide better performance then the church may be better off not using these heaters altogether to avoid wasting money.

4.2 Improve electrical heating

Improving the electrical heating requires the lowest capital investment but has the highest carbon and fuel costs. This may be the best option if the church does not plan to increase its occupancy hours. Low level wall mounted electric convector heaters can be switched on individually as and when required and are thermostatically controlled. The convection action will distribute the air around the space at ground level helping to provide a warmer, more useable space in conjunction with the existing radiant heaters. Attention should be

given to the noise levels of convector heaters at the various operating speeds. The Dimplex Saletto range of heaters provide a low profile and discreet heating solution and cost around £150 per heater.

4.3 Install gas fired boiler and central heating system

Mains gas is a cheaper and lower carbon heating fuel than electricity. Installing a gas fired boiler and heating system would require significant investment but if occupancy hours are increased it could be a worthwhile upgrade.

Gas is not currently available at this site; the possibility of bringing it on site from a local connection would need to be explored and will add to the cost. A wet distribution system with radiators would need to be installed. The gas boiler could be located in the area next to the toilets.

St Frideswide's Church in Osney is an electrically heated church without mains gas. They have been quoted £50,000 to fit a gas boiler and wet heating system (not including the cost of connecting to mains gas). If St Mary's decides to go down this route the church should ensure that the system provides good controls and maximum efficiency with individually controlled radiators, well lagged pipework and connections and antifreeze based inhibitor put in the system which reduces the need for boiler frost protection.

See alternative 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 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 a loft hatch visible above the organ but it was not accessible and it is not known whether there is any loft insulation. This should be investigated and if suitable loft insulation fitted. The installation of insulation will reduce the heat lost from the building and improve the comfort levels.

5.2 Walls

The church is not listed and is of solid wall construction. Solid wall insulation may be an option to improve the thermal properties of the building. We advise that internal wall insulation would be preferable over external insulation if the external appearance of the building wishes to be retained. Internal wall insulation is more disruptive as it would require the internal walls to be redecorated, the skirting and electricity sockets to be moved to accommodate the additional depth of the wall on the inside of the building. Generally internal wall insulation is the cheaper option of the two, but is more disruptive.

The benefit of the wall insulation would be mean the church would require be a warmer building or the heating costs can be reduced if less heating is required to maintain current levels of heat in the building.

Further advice from the DAC would need to be sought as it would change the appearance of the church. The church is currently dealing with issues of water ingress which would need to be resolved before such work takes place.

5.3 Floors

As the floor is solid there is no opportunity for insulation. Fitting carpet will improve the thermal comfort of the space. There is a concern that carpet would be more difficult to keep clean than the current surface, however it is used successfully in schools and other spaces of high use.

5.4 Windows

Many of the lower windows have a top pane which has become jammed open. This is likely down to warping of the frame or a build up of paint on the frame. These open windows are leaking heat and should be repaired if the church wants to improve the effectiveness of its heating.

All of the windows in the church are single pane. It would be worth investigating secondary glazing for the upper windows. The height of these windows means they are less visible but the DAC will need to be consulted.

5.5 Doors

The main entrance door and the external door next to the toilet would benefit from draught proofing. Large gaps could be seen

around the door next to the toilet (pictured right). No gaps were visible around the main door but it was reported to be draughty. The Quattro seal method would be recommended (http://www.quattroseal.com/).

The church may also wish to consider the installation of a hot air curtain over the main entrance door to use when the door is open as the congregation enter for services. This will help to prevent large amounts of heat loss and cold air entering the building just prior to a service and reduce the need for longer warm up times.

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. 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 drafts 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.

Example of an air curtain in a church

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.

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 main nave roof is oriented due south west and as this is not a listed building a solar PV installation could prove to be viable option. The inverters could be located near the main electrical incomer. The availability of distribution board spare ways of a suitable capacity would need to be checked.

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 you will still catch a reasonable level of sunlight at angles of 20 – 50 degrees. Solar panels can be fairly heavy, so your 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.

A high level initial assessment indicates that there would be space for a 5kWp installation with a yield of approximately 4,250 kWh. 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 which are currently 13.5/6.85p/kWh (depending on the building's energy rating) for generated electricity and 4.64p/kWh for exported electricity. Depending on the amount of electricity generated and exported, the church could expect to pay off the initial investment within 18 years. However this would be variable depending on the exact make and model of the PV units being considered.

The buildings energy rating is established from an Energy Performance Certificate. The EPC will provide an energy rating for a building on a colour coded scale and range from A through to G, with A the best and G the worst. The EPC can be produced by a specifically trained *Non-Domestic Energy Assessor.* Such an assessor can be found by using this website www.ndepcregister.com/searchAssessor

6.2 Micro-Wind

Micro wind units require highly exposed sites and should be located 250m away from 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

A ground source heat pump could be a viable option at this site as it has surrounding unused grounds which could be used to lay piping. This heat source works best in conjunction with an underfloor heating system which could be installed in this church as the flooring is not of historical importance. The heat exchanger and manifolds could be located in the area next to the toilets. The system would be eligible for the Renewable Heat Incentive, meaning the church will be paid for the energy generated by the system. The rate is currently 4.8p/kWh.

Ground source heat pumps use pipes which are buried in the earth to extract heat from the ground. This heat can then be used to heat radiators, underfloor or warm air heating systems and hot water in your building.

A ground source heat pump circulates a mixture of water and antifreeze around a loop of pipe – called a ground loop – which is buried in the ground. Heat from the ground is absorbed into the fluid and then passes through a heat exchanger into the heat pump. The ground stays at a fairly constant temperature under the surface, so the heat pump can be used throughout the year even in the middle of winter. The pipes can either be buried in trenches or in bore hole if space is limited. Heat pumps also work best if the building is well insulated, so if a ground source heat pump is selected, additional insulation would be required.

The cost for the installation would need to be obtained as a specific quote from a heat pump installer to match the requirements of your church. Details of installers can be found following the link above at the start of this section.

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

A biomass heating solution could be viable at this church as there is good access for fuel deliveries. There is space for an external boiler house and fuel store to be built which would need to be built in-keeping with the adjacent church building. A wet heating system would need to be installed in the church.

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

A biomass boiler would provide low carbon heating at a similar running cost to a gas fired system. The boiler would require slightly more maintenance than a gas boiler so a boiler service and maintenance contract should be put in place. The system would be eligible for the Renewable Heat Incentive. 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.

Due to the construction of a new boiler house the DAC would need to be consulted to establish if this would be possible.

The cost of the installation of the boiler would need to be obtained from 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.

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

Short Term Improvement Measures			
Description	**Estimated Cost**	**Estimated Saving**	**To be actioned by**
Draught proof main entrance door and external door next to toilet	£89	£23/year and improved comfort	
Review control of night storage heaters, investigate 7 day programmers or stop using heaters	Dependent on outcome of review	Dependent on outcome of review	
Replace T12 fluorescent tubes	£152	£27/year	
Replace spot lights if required	Dependent on requirements	Dependent on usage	

Medium Term Improvement Measures			
Description	**Estimated Cost**	**Estimated Saving**	**To be actioned by**
Investigate loft insulation	£2800	£109/year	
Fix windows so that they can be closed	Further investigation required	£62/year and improved comfort	
Fit carpet	£6,000	Improved comfort	
Investigate secondary glazing to upper windows	Further investigation required	Improved comfort	
Fit air curtain above main entrance door	£500	£31/year and improved comfort	

Long Term Improvement Measures			
Description	**Estimated Cost**	**Estimated Saving**	**To be actioned by**
Solid wall insulation	To be determined at the time of the works. Approx £150-£200/m^2	£234/year	
Consider solar PV installation on the south facing slope of the nave roof	£10,000	Approximately £550/year. Payback of around 15-18 years.	
Commission options appraisal for a replacement heating system, looking at electric, gas, biomass and ground source heat pump options	To be determined at the time of the works	To be determined at the time of the works	

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