Energy Audit of St Lawrence, Warborough (II*)

February 2014

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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 Lawrence, Warborough.

The report was prepared following a site audit conducted by Marisa Maitland, Sustain on 4th February 2014. She was accompanied by Mike Powell.

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

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2.0 Church Details

St Lawrence in Warborough is the local parish church serving the community. It is located in South Oxfordshire and dates back to early 13th century.

2.1 Listed Status

St Lawrence 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 were supplied by the church warden and measured 143m^2.

From discussions on site during the audit it has been established that the typical usage of the church is for 90 hours per month.

	Description	Average Monthly Use
Church Use	2 or 3 services per week,	90 hours/month
Community Use	Children's group, Choir practise, Bell ringing	
Administration	n/a	
Catering and Events	Concerts	
TOTAL		**1100 hours/year**

The average congregation size is dependent on the service, and varies between 15 people at the 8am service, to 40 people at the 11 am service.

2.3 Current Energy Usage

Annual energy bills for the church have been provided and examined. These show that the current carbon footprint of the church is 9.8tCO_2e per year.

The annual energy consumption has been taken from the energy bills in 2013 and provided by Mike Powell.

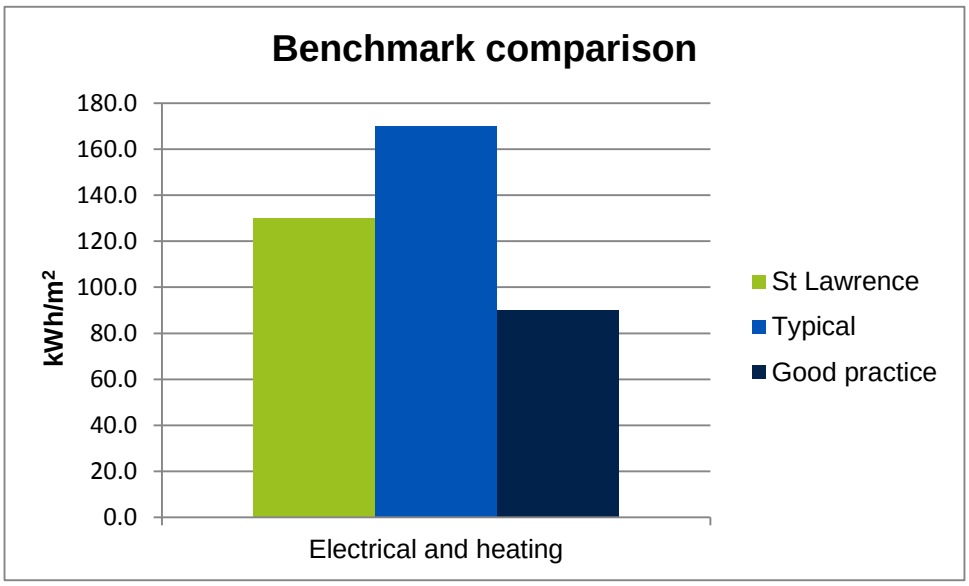
	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity	18,694	£0.1208	£2,258	9.81

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

In comparison with national benchmarks[1] St Lawrence consumes more electricity than is good practise for a church of this size. A focus on reducing the consumption is therefore advisable and the recommendations within this report should help to bring the church within the expected benchmarks.

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

	kWh/m^2 St Lawrence	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Electrical and heating	130	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.

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 or from the reduction in VAT 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.

Location	Existing Lamp Type	Recommended Lamp Type	Example Source
Church spot lights	Assumed 30W PAR38 lamp	7.5W LED PAR38	http://www.tlc-direct.co.uk/Products/LALED38WW.html?source=adwords&kw=&gclid=CNyrhoLYgL0CFaQfwwodXg0AQA

If all of the above lamps are changed we estimate this to **cost £450** but **save £80** per year therefore providing a payback in 5.5 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.

Internal lighting in the nave

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 switches located near the vestry. These are not labelled and 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. Also a simple use of red and green dots can be helpful to indicate which lights are required for general visiting.

Light switches

3.2 External Lighting

This church only has minor external lighting to the porch and the like. It is controlled by a manual switch and not used often.

The light for the church clock was reported to be on every night, but from the audit we were not able to establish what type of light bulb is used to light up the clock and if the light is left on all of the time or controlled by a timeclock or daylight sensor. We recommend that the church follow up on how this lamp is controlled.

4.0 Heating System Saving Recommendations

4.1 Electric heating system

The heating at the church is currently provided by electric bar heaters, which are located under the pews, below windows and up at ceiling level. The bar heaters ranger from 60-100W in output.

Electric bar heaters

The bar heaters are replaced as and when they fail and have individual fuses, however the wiring to the system is now at a stage where the electricity to the whole of the church trips when one of them does fail. They are deemed not to be too expensive to replace, however the overall running costs of this church is one of the highest for an electrically heated church when compared the other churches we have visited in Oxfordshire. This is also reflected in the resultant carbon emissions. The lighting in the church is fairly good, so the heating system will be a main contribution to this. Recommendations of changes to the heating system are below.

4.2 Control

The bar electric heaters are controlled by time switch, which turns the heaters on at 4am-12pm and 5pm-7.30pm on Sundays. Heating during the week was not discussed. The bell ringing chamber has electric radiant heaters which they control manually when they are practising and on a Sunday morning.

4.3 Heating recommendations

The use of some of the heating elements in the church, such as at the bottom of the windows and up at ceiling level seem excessive in terms of heating members of the congregation. During the services the heaters on the back of the pews should be providing enough heat to keep the congregation warm. We recommend that a trial is carried out to turn off the heaters at the windows and the ones at ceiling level to see if this makes any difference to the comfort levels in the church and determine if they are required. If they are not found to be necessary then this would lead to a saving of over £80 a year.

Another option for consideration is looking at renewable technology solutions. The type of solution would be dependent on the plans of the church to change the heating distribution system. The current system would only be supported by photovoltaic panels to generate electricity; however planning permission is currently unlikely to be given for these at this stage.

If the heating distribution system was changed to a wet underfloor system, then an air source heat pump would be a possible solution, or if it was just a wet system with radiators then a biomass boiler should be considered.

Please see further details in the renewable options for heating in section 6.0.

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 loft space in the roof in which to install any 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 both internally and externally no improvement recommendations have been made in this regard.

5.3 Floors

The floor was replaced 10-15 years ago, and it is a suspended timber floor underneath the pews. As there is a void these boards could be lifted, insulation added beneath them and then the boards replaced including sealing the joints to prevent cold draughts from rising up from the floor and would result in significant comfort improvements. Prior to doing this, you would need to consult with the inspecting architect to ensure that there will still be adequate ventilation under the boards to avoid wet and dry rot.

5.4 Windows

There were a few windows where there were gaps between the glazing and the abutments, such as in the vestry. Also the right hand window in the chapel appears to have dropped in causing it to buckle slightly at the bottom. This has also resulted in some gaps in the glazing at the bottom of the window. We recommend that the gaps are filled to reduce the draughts entering the building.

Window in vestry

5.5 Doors

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 door to the ringing chamber has a very large gap at the bottom which is going to be causing a significant draught into the church. From looking at the door, it appears that the gaps have been caused by the wearing down of the stone step. To eliminate this gap one solution would be to hang a heavy curtain over the door from the top to the bottom to eliminate all the gaps from the sides of the door as well, however as this door is frequently used this may not enable ease of access. The other solution would be to install a brush strip along the bottom of the door which could be cut to match the

West door to ringing chamber

specific shape of the gaps in the door. As the door is inward opening from the step, this should not cause any issues on opening the door. In addition to the strip along the bottom of the door, draught stripping should also be installed around the edges of the door where gaps can clearly be seen.

Another door that would benefit from draught proofing is the vestry door, and again, either draught stripping or a heavy curtain hung over the door would reduce draughts..

In addition to the above, an air curtain could be installed above the main South door. 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 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.

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 ideal location for the installation of PV at a church is on the south facing pitch of the roof, however as St Lawrence is Grade II* listed, the panels will be fully visible and at this time planning permission would not be granted.

An alterative solution would be to investigate installing PV panels on the roof of the tower, the area up there is approximately 4m x 4m, however the whole area would not be able to be covered as shading from the parapet would need to be taken into account.

Another option would be to find another suitable location in the church grounds, however this is likely to require the panels to be floor mounted, which might lead to the panels being damaged, either accidentally or deliberately. Also there would be shading issues from the trees within the churchyard and the DAC would need to be consulted to establish if this would be allowed.

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. They are suitable for use in urban areas which wind or hydro systems don't tend to be. 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.

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

An Air Source Heat Pump (ASHP) is worth the church considering as a renewable and cheaper source of heating if the church were to install underfloor heating. The most suitable type would be an air to water system which would provide the heat to the underfloor heating.

ASHP's work by extracting heat from the air and will operate at air temperatures down to -15deg C. The efficiency of air source heat pumps is known as the Coefficient of Performance (COP), which indicates for every kWh of electricity used by the system how much heat will be generated, a COP of 3 means the heat pump produces 3 units of heat energy for every 1 unit of electricity it consumes. The COP does reduce as the outside air temperature reduces. Within temperature ranges of -3°C to 10°C, the COP for many ASHPs is fairly stable at 3-3.5.

Most air source heat pumps have an electrical immersion heater that will cut in if the air source heat pump cannot cope with the heating load. ASHP are typically mounted outside, and may or may not require equipment inside the building. Poor design and specification can lead to the situation where an undersized heat pump system will use large amounts of electricity – essentially all the heating in extreme situation is electric water heating, so it is important to size the system correctly.

ASHP are also financially supported by the government run Renewable Heat Incentive, where you will receive a grant for renewable heat generation. The current tariff available for AHSP is 7.3p/kWh generated.

The Diocese of Oxford has a very informative fact sheet regarding ASHP which can be found here www.oxford.anglican.org/wp-content/uploads/2013/04/Your-Church-Heat-Pumps-Info-Sheet.pdf .

The installation of an ASHP at St Lawrence will reduce the carbon emissions for the church, and if used to heat at the current times and temperatures will reduce the cost, based on the premise that for every kWh of mains electricity used, 3kWh will be free. However, it would also mean that the church would also be able to heat the church for longer and not increase the cost to run the system.

If an ASHP was combined with PV panels on the tower this would result in a system that might be able to run for the some of the time from just renewable sources, but this would depend on the size of the PV array installed.

ASHP look similar to air conditioning units, so are not the most attractive feature to add to a church. There could be the possibility of installation the ASHP inside the tower to remove it from sight.

ASHP cost between £3,500 - £7,500 depending on the model and specification. The installation costs would also need to be taken into account and have not been included as these are specific to the church, the type of distribution system and the location of where the ASHP could be installed.

Advice would need to be sought from the DAC at an early stage to ensure they would support the installation.

6.7 Biomass

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.

This is alternative source of heating for the church; however it would require the installation of a new heating distribution system and a boiler room. If the church is seriously considering a new wet heating distribution system then biomass should definitely be considered as a source of fuel.

Biomass boilers 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.

The site appears to have suitable access for fuel deliveries. A new external boiler house and fuel store would need to be built adding to the cost. The boiler would require slightly more maintenance than a gas boiler so a service and maintenance contract should be put in place. The system would be eligible for the Renewable Heat Incentive which is currently 8.6p/kWh (small commercial biomass, tier 1).

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 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**	**To be actioned by**
Measure	£0	The savings depend on how much energy wastage there is currently. This saving is based on 3% of energy consumption a year saved ~£70	0.29 tCO_2e	
Calculate and monitor	£0			
Communicate	£0			
Housekeeping	£0			
Trial turn off of heaters in the windows	£0	£20	0.08	
Trial turn off of heaters at ceiling level	£0	£50	0.19	
Label light switches	£10	£23	0.1	
Add draught strip brush to bottom of West door.	£100	£25	0.1	
Install draught strip or heavy curtain to West door and vestry door.	£89	£45	0.2	

Medium Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £Saving per year**	**Estimated Carbon Savings per year**	**To be actioned by**
Replace spot lights with LED replacements	£446	£84	0.35	

Long Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £ Saving per year**	**Estimated Carbon Savings per year**	**To be actioned by**
Install an air curtain over the main South door	£1,400	£113	0.49	
ASHP with underfloor heating (recommend initial feasibility study)	ASHP cost a approx £3,500-£7,500 plus heating distribution system	Dependant on type of system	Dependant on type of system	
Biomass boiler with wet heating system (recommend initial feasibility study)	Approx £35,000 - £50,000 for boiler and new distribution system	Dependant on type of system	Dependant on type of system	

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