Energy Audit of St John the Evangelist, Stoke Row (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 John the Evangelist, Stoke Row.

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

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 John 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 John in Stoke Row is the local parish church serving the community. It is located in south Oxfordshire and dates back to 1848.

2.1 Listed Status

St John 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

During the site visit the approximate internal area of the church was measured as 112m^2.

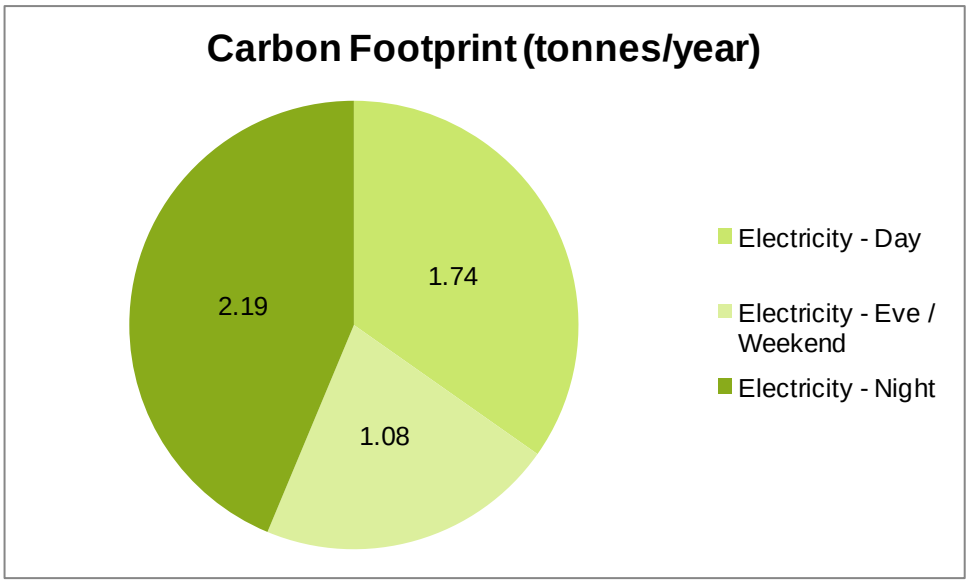
From discussions on site during the audit it has been established that the typical usage of the church is for 100 hours per month during school term time, and less during the holidays.

	Description	Average Monthly Use
Church Use	1 service per week	4 hours/month
Community Use	School use, as hall and gym. (Term time only)	96 hours/month
Administration	n/a	
Catering and Events	n/a	
TOTAL		**916 hours/year**

The average congregation size is dependent on the service, and varies between 10-15 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 5tCO_2e per year.



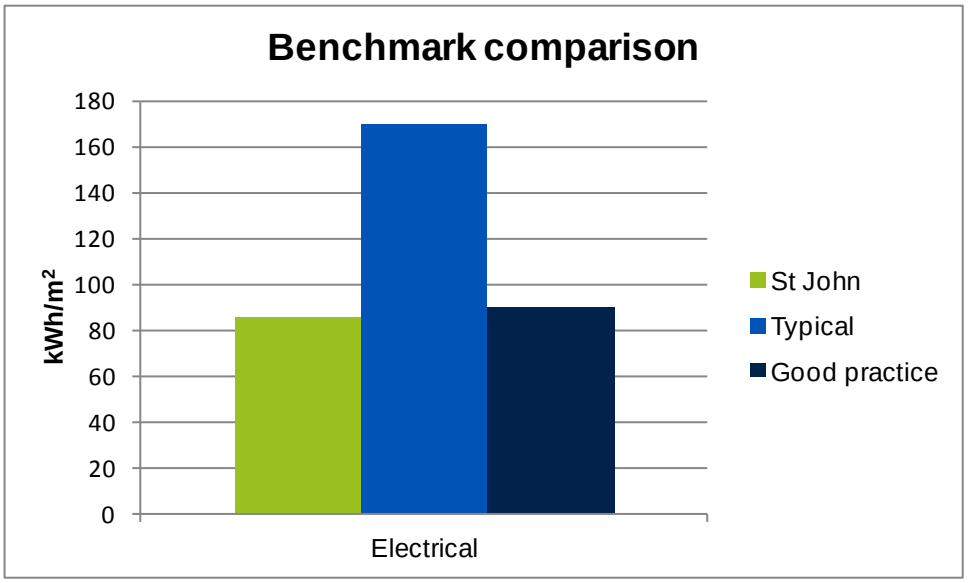
The annual energy consumption has been taken from the energy bills provided from November 2012 to November 2013. These may include the use of estimated readings where actual readings have not been taken.

	kWh/year	Cost/kWh	Total £	Total CO_2e (tonnes)
Electricity	9,544	£0.1164	£1,111	5.01

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

In comparison with national benchmarks[1] St Johns's consumes less electricity than would be expected for a church of this size. This is positive but there will still be room for improvement. The main limit to benchmarking is that it does not take into account occupancy hours.

	kWh/m^2 St John	kWh/m^2 benchmark (typical)	kWh/m^2 benchmark (good)
Electricity and heating	86	170	90



All energy bills should apply the VAT rate of 5% due to the charitable status of PCC's and this is being correctly applied at this church.

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

2.4 Energy purchasing

The church may benefit from obtaining reduced energy rates by switching energy suppliers. The church could also use the opportunity of switching suppliers to explore ‘green electricity’ options.

The Church of England has created the National Parish Buying scheme to provide churches access to negotiated schemes with energy providers and pool their energy to buy in bulk with an ‘energy basket’ – in the first instance this is a ‘brown energy’ basket, but a ‘green’ version will be available if enough churches express an interest, so please specifically register an interest in a ‘green option’ when contacting Parish Buying. By bulk buying energy it is anticipated that the costs will be 10% lower compared to buying alone.

Alternatively the Diocese of Oxford has negotiated green electricity schemes with both Good Energy and Ecotricity, who supply electricity from renewable energy sources at competitive prices.

For more details on all the above options visit: http://www.oxford.anglican.org/mission-ministry/environment/resources/switch-your-church-to-green-electricity/

It is further recommended that any cost savings obtained from improved rates through the purchasing scheme 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 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
Main body of the church, including nave and aisles	High bay flood lighting – assumed 300W	50W LED flood – warm white	http://www.deslamps.co.uk/50-watt-warm-white-led-flood-light-p-8954.html

If all of the above lamps are changed we estimate this to **cost £960** but **save £160** per year therefore providing a payback in 6 years. 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.

3.1.2 Controls

The lights are currently controlled by switches located adjacent to the entrance door at the back of the church. 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. 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 which is rarely used as Stoke Row is a ‘dark village’.

3.3 Small Power

During the site visit no electrical equipment was found to be left on.

4.0 Heating System Saving Recommendations

4.1 Electric Boiler

The heating at the church is currently provided by an electric boiler. This is 6 kW in size and was installed in the last 5 years.

The electric boiler heats water for the underfloor heating system, however it is expensive to run, so the use of the underfloor heating is now limited. The school pay for their use of electricity at the church, as due to the high cost they limit the use of the heating during the week.

Electric boiler for underfloor heating

4.2 Radiators and other heat emitters

The heating within the church is supplied via an underfloor heating system. This was newly installed in the church to provide a background level of heating. This was to enable the school to use the church on a regular basis during term time during the week and for the church to be adequately heated.

As previously mentioned, due to the cost of running the underfloor heating system, the amount it is used has been decreased, so for church services on Sunday mornings the church use additional heating from three electric fan heaters to supplement the heat provided by the underfloor heating system. These are 2.5kWh heaters which are put on at 7am and turned off at the start of the service at 9.30am. These are controlled by time switches and are used on Sunday mornings only.

Electric fan heaters

4.3 Controls

The heating system is controlled by a programmer by the cupboard adjacent to the vestry where the boiler and underfloor heating manifolds are located.

The programme is timed for the heating to reach set temperatures at set times, as follows for weekdays:
3am – 12^{o}C
9.30am – 10^{o}C
2pm – 12^{o}C
3.15pm – 9^{o}C

On Sundays the settings are:
2.30am - 12°C
9.30am – 10°C

These settings reflect the electricity usage shown in the breakdown of the electricity tariffs, with a high proportion being used during the night.

Heating programmer

We recommend that the church check if there is an optimised start incorporated into the heating programmer. If it has an optimised start, it will mean that the heating system will bring the room up to temperature for 3am, instead of coming on at 3am. There is some documentation produced by Rehau that does indicate that the CT2 programmer, such as the one used at St John's, might have an optimised start. What this means is that the system is likely to be coming on much earlier in the morning to heat the church to 12°C at 3am in the morning. This will be leading to energy wastage, and the programmer should be set for the temperature at the time is required, for example, 9am- 12°C.

4.4 Alternative forms of heating

It is clear that the current heating option is not being used at it was intended due to the high cost of running the system. Due to the running cost of the electric boiler, we recommend that the church investigate replacing the electric boiler with an air source heat pump. This is discussed further in section 6.6

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 has newly been replaced to install the underfloor heating system; as such there is no opportunity to install any insulation to the floor.

5.4 Windows

The windows are in good condition besides one missing pane which should be replaced as soon as possible.

5.5 Doors

The entrance doors at the West end of the church are not very well sealed. There is a large gap at the bottom, on the one side especially, and they do not join well in the middle either. There is a small porch which leads to a second set of double doors which open into the church. These inner doors also do not close well and leave a gap 2-3cm wide when closed. They are also not able to be closed from the inside due to a lack of door handles, following the direction of opening the doors was changed when the underfloor heating was installed.

Gap under West entrance door

The inner doors would benefit from being refurbished to make sure they are able to close fully and eliminate any draughts. It is estimated that up to 15% of heat generated can be lost through draughts and gaps in doors and windows, so it is a good idea for this to be reduced where possible and draught proofing doors is a simple and quick measure to install.

There was previously an air curtain in the church, but this was removed during the refurbishment. Air curtains however can be helpful in retaining heat in the church. It 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.

They are able to 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.

Example of an air curtain in a church

6.0 Renewable Energy Feasibility

The below reviews the viability of renewable technologies at your church and indicates if it would be possible for each of the technologies to be installed.

More details on the major technologies can be found by going to the following website www.oxford.anglican.org/mission-ministry/environment/resources

Also included in this website is a directory of installers who will be able to help you in providing 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 installation of solar photovoltaic's (PV) would complement the heating system at the church very well. The electricity generated by the PV panels could then be used to power the boiler for the underfloor heating system. The church has a large south facing roof which would be suitable for the installation of PV, however the panels would not be at all hidden from view and planning permission may not be granted for the installation. However if the church is interested, it would definitely be worth following this up with the DAC to gain their views.

Aerial view of church

Alternatively if the electric boiler is replaced with an air source heat pump (ASHP), the heating system then would be almost entirely from renewable energy, provided the electricity generated from the PV is enough to meet the requirements of the ASHP.

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.

An initial assessment indicates that there would be space for at least a 8kWp installation with a yield of approximately 6,900 kWh. The size of the installation could be reduced in line with the available church funds. The church will be able to use this electricity when it is occupied during the day, reducing the electricity bill. The installation would be eligible for Feed-in Tariff payments. This means the church will be paid for the electricity generated by the solar panels and the electricity that is not used and exported back to the National Grid. The export rate is currently 4.64p per kWh of electricity exported. The generation rate is dependent on the church's EPC rating. If this rating is A-D the higher FIT rate is applicable (currently 13.5p/kWh). If the rating is D-G, the lower rate is applicable (currently 6.85p/kWh). The calculation has assumed an EPC rating of E or below as it would be unlikely that the churches will gain an EPC band D, or be able to even with energy efficiency improvements.

The church could expect to pay off the initial investment within 12 years. However this would be variable depending on the exact make and model of the PV units being considered and the amount of electricity generated and exported.

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. 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 John's 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 this would result in a system that would be, for the majority of time, run from renewable sources.

Based on the assumption that 50% of the electricity used at the church is for heating, the ASHP has an average COP of 3 and that the RHI is 7.3p for every kWh generated, the cost saving per year for the church would be £580.

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 in 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 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.

If the church proceeds with the ambition of building an extension to include kitchen and toilet facilities, then further consideration could be given to a biomass boiler at that time. Biomass boilers would need a boiler room to be built and a fuel store, so a project such as this would combine well with an extension. The boiler could be used to heat the water for the underfloor heating system, and should have a similar running cost to an oil boiler, with fuel currently at a cost of 5p/kWh, which is half of the current cost of electricity.

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.

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 5% of energy consumption a year saved ~£45	0.25 tCO_2e	
Calculate and monitor	£0			
Communicate	£0			
Housekeeping	£0			
Label light switches	£10	£10	0.05 tCO_2e	
Draught proof entrance doors	£90	£15	0.10 tCO_2e	
Add draught brush strip to the bottom of the front door	£45	£8	0.04 tCO_2e	

Medium Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £Saving per year**	**Estimated Carbon Savings per year**	**To be actioned by**
Replace flood lamps with warm white LEDs	£960	£165	0.96 tCO_2e	
Consider installation of air curtain	£1,400	£70	0.40 tCO_2e	

Long Term Improvement Measures				
Description	**Estimated Cost**	**Estimated £ Saving per year**	**Estimated Carbon Savings per year**	**To be actioned by**
ASHP installation to replace electric boiler	£3,500-7,500 plus installation costs.	£580	1.88 tCO_2e	
Install PV panels on the roof	£12,250	£1,030	3.64 tCO_2e	
Consider installation of biomass boiler	Unknown – cost would be specific to the church	-	-	

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