ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Paul's, Tiverton
PCC of St Paul's

DIOCESE OF EXETER
THE CHURCH OF ENGLAND IN DEVON

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Paul's was undertaken by ESOS Energy to provide advice to the church on how it can be more energy efficient and provide a sustainable and comfortable environment to support its continued use. This audit has been provided in conjunction with 2buy2, the Church of England's Parish Buying scheme provider and is subsidised from Total Gas & Power, the Parish Buying schemes principal energy suppliers.

St Paul's is a Grade II Victorian church with a large congregation. The church building is solid stone with a pitched slate roof. There are church offices on site which are used daily. The church is heated from a gas boiler to fan convectors heaters in the church itself, the church offices have electric panel heaters. The lighting is predominantly SON lamps, with some fluorescent lamps. The church has a sophisticated sound and visual display set up in the church used for their services. There is both gas and electricity supplied to the site.

The church has a number of ways in which it can be more energy efficient. Our key recommendations have been summarised in the table below and are described in more detail later in this report. It is recommended that this table and the route to net zero carbon are used as the action plan for the church in implementing these recommendations over the coming years.

Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)
Replace heating system in side chapel for electrical based heating solution	34,008	£3,322	£1,527	0.46	Faculty	6.11
Install SavaWatt devices on fridges and freezers	140	£42	£50	1.19	List A (None)	0.03
Add or Replace draught strips to external doors	2,293	£229	£300	1.31	Consult DAC	0.41
Fit timed fused spurs to hot water heaters	324	£97	£180	1.85	List A (None)	0.07
Change existing lighting for low energy lamps/fittings	4,327	£1,298	£5,555	4.28	Consult DAC	0.91
Install PIR motion sensors on selected lighting circuits	132	£40	£242	6.09	List B	0.03
Install an Air-to-Air Source Heat Pump to replace the existing heating system served from	42,668	£1,829	£115,200	63.00	Faculty	7.30

the Main Boiler Room						
Upgrade incoming electrical supply capacity to power decarbonised heat solution	0	£-	TBC by DNO	N/A	Faculty	-

The church should check any faculty requirements with the DAC Secretary at the Diocese before commencing any works.

Based on current market prices of 30p/kWh and 10p/kWh for electricity and mains gas respectively.

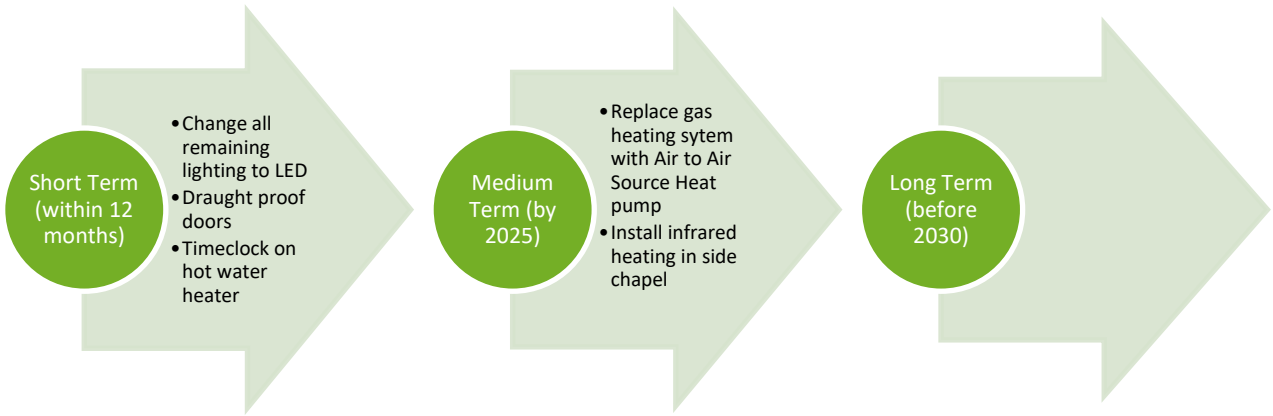
If all measures were implemented this would save the church £6,800 per year and reduce its carbon footprint by 14.8 tonnes (64%).

2. The Route to Net Zero Carbon

Our Government has committed to move towards Net Zero Carbon – the point at which we have reduced emissions as much as we can and then balanced any residual emissions through removal of carbon from the atmosphere. They have done this as part of a worldwide agreement which aims to limit global warming to well under 2 degrees Celsius, with an aim of keeping it below 1.5 degrees Celsius. This will help protect all of us from the impacts of climate change.

In February 2020, the Church of England's General Synod set its own Net Zero Carbon target. The first stage of this target covers energy used by churches, cathedrals, schools, vicarages, other church buildings, as well as emissions caused by reimbursed transport. The target date is 2030.

This church has a clear route to become net zero by 2030 by undertaking the following steps:



3. Introduction

This report is provided to the PCC of St Paul's to give them advice and guidance as to how the church can be improved to be more energy efficient. In doing so the church will also become more cost effective to run and seek to improve the levels of comfort. Where future church development and reordering plans are known, the recommendations in this report have been aligned with them.

An energy survey of the St Paul's, St Paul's Square, Tiverton EX16 5HU was completed on the 4th October 2022 by Marisa Maitland. Marisa is an experienced energy auditor with over 10 years' experience in sustainability and energy matters in the built environment and a CIBSE Low Carbon Energy Assessor

St Paul's	
Church Code	615220
Gross Internal Floor Area	741 m^2
Listed Status	Grade II
Average Congregation Size	50 people at 9am 150 people at 10.45am

The church typically used for 12 hours per week for the following activities, with the church office occupied everyday from 8am to 12pm.

Type of Use	Hours Per Week (Typical)
Services	8 hours per week
Meetings and Church Groups	1.5 hours per week
Community Use	2 hour per week
Weddings and funerals	Approx. 1 hour per week

The average congregation size is 50 people at the 9.30am Sunday morning service, 150 people at the 10.45am Sunday morning service and 20 people at the Sunday evening and Thursday morning services.

There is additional usage over and above these times for festivals, weddings, funerals and the like

4. Energy Usage Details

St Paul's energy data that was supplied covered the period from January 2021 to December 2021, part of which was during the COVID lockdown periods, therefore the consumption levels reported are likely to be lower than use at 'normal' times.

Based on this period of data the church uses 12,171 kWh/year of electricity, costing in the region of £3,650 per year based on current market rates, and 114,670 kWh/year of gas, costing £11,500 based on current market rates. The total carbon emissions associated with this energy use are 23 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site. St Paul's has one main electricity meter, serial number SL1CBNCBFBBBG-B. There is one gas meter serving the site, serial number M016A0109503A62003.

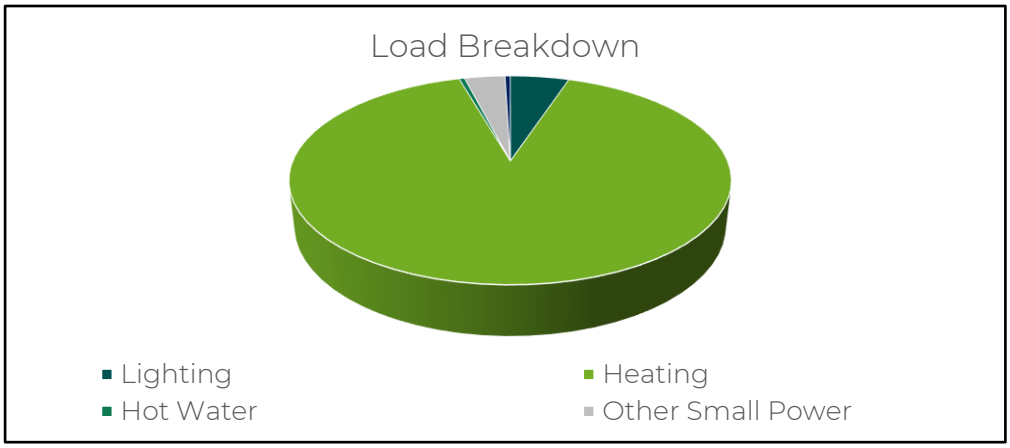
Utility	Meter Serial	Type	Pulsed output	Location
Electricity	SL1CBNCBFBBBG-B	Single phase, 100A	Yes	Outside church office
Gas	M016A0109503A62003	Actaris R5	Yes	External meter cupboard

The meters are AMR connected and as such energy profile for the entire energy usage should be possible. Half hour meter data has been provided for the purpose of this report and this has been used to verify the data.

4.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	Mainly SONs with some fluorescents	5.1%
Heating	Gas boiler to fan convector heaters	90.4%
Hot Water	Electric point of use water heater for WCs and kitchen	0.5%
Other Small Power	Electric panel heaters in the office, office computers, sound system equipment	3.5%
Fans, pumps, motors	Heating pump	0.5%



As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site. The other significant load is lighting.

5. Efficient / Low Carbon Heating Strategy

The energy used for heating a church typically makes up around 80% to 90% of the overall energy consumption. Heating also often uses gas or oil as its primary fuel. These are fossil fuels with high carbon emissions and little opportunity to decarbonise in the future. Mains gas does have some potential to reduce its carbon content through the use of bio gas and hydrogen but these are less developed solutions and will be unable to deliver 'zero carbon mains gas'.

It is therefore important to review and set out a plan to make energy use more efficient and less carbon intensive. One way to achieve this is to consider a transition to electrical heating where this also represents a more efficient and comfortable solution for churches.

Electricity currently has carbon emissions of around the same level as mains gas but the carbon emissions associated with electricity are reducing rapidly as the UK builds more renewable energy and decommissions its remaining oil and coal fired power stations.

The church is currently being heated from a gas boiler which provides heating to the fan convector heaters in the nave and side chapel. The boiler is nearly 20 years old and the church requires a 3 hour warm up period before being used in the winter time and it reported losses heat rapidly when the doors are opened despite a draught lobby and overdoor heaters. The church office is heated from electric panel heaters.

The various options for a decarbonised heating solution have been reviewed in the table below.

Decarbonisation Heating Solution	Viable
Air to Water Source Heat Pump	No – unsuited to current heating pipework and heat emitters
Air to Air Source Heat Pump	Yes - Air to Air source heat pump in the main church and office
Water Source Heat Pump	No – no water source locally
Ground Source Heat Pump	No – significant archaeology
Under Pew Electric Heating Panels	No – no fixed pews
Electric Panel Heaters (to provide supplemental heating only)	No – not required
Over door air heater (to provide supplemental heat only to provide a warm welcome at the door)	No – Already in place in main entrance
Overhead Infra-Red Heaters	Yes – Ideal in the side chapel to provide localised heating for small services with no warm up time required
Heated chair cushions	No – other solutions preferred and very large congregation

The recommendation is therefore that as the boiler is coming towards the end of its life the church consider replacing it with an Air to Air source heat pump system, which can be installed in the office for daily use and the main church on Sundays for the main services. Alongside this, it is recommended that the side chapel is installed with infrared panel heaters which can then be used to provide heating into this space for the smaller Sunday evening and Thursday morning services. The infrared heaters will provide heating to the people, rather than trying to warm up the whole of the church, so will be more effective. These are described in more detail below.

5.1 Air to Air Source Heat Pumps

Air to Air source heat pumps work by having an external unit which sucks air throughout it and extracts the heat from the air. It concentrates this heat and puts it into a refrigeration gas (in the same way as a fridge or freezer works). This refrigeration gas is then piped inside the building in a small pipe where is it then allowed to expand in an internal unit with a fan. This heat is then blown out into the space. This system is identical to an air conditioning system but it works in reverse to heat the space. As warm air is blown into the space this type of system can heat spaces from cold relatively quickly. Air to Air Source heat pumps provide around 4.5 units of heat for every 1 unit of electricity used in the heat pump (it therefore has a Coefficient of Performance (CoP) of 4.5)

The Centre for Sustainable Energy model[1] can be used to estimate heat load for the building.

Heat Load (kW) = Volume V (m^3) x Insulation Factor

Insulation Factors

Condition	Factor kW/m^3
Poorly insulated (assume no interventions)	0.033

Area	Volume m^3	Insulation Factor kW/m^3	Heat Required (Space heating) kW
Church	6,080	0.033	200
Church office	25	0.028	1

Therefore a heat pump of 205kW would be required.

ASHPs require the installation of external units which look like air conditioning modules in well ventilated external locations. These external units will need an electricity supply and pipework running from them to the heating system. They will also need a drain nearby as the back of the units can build up moisture condensing and sometimes freezing on the coils. The larger units do create some low level noise and therefore the location and baffling of the units may need to be considered carefully.

[1] www.cse.org.uk/local-energy/download/estimating-the-heat-demand-of-a-hypothetical-community-building-79

Examples of external units for ASHP comprising of there smaller 3kW units and two larger 10kW units.

Internal units come in a variety of styles. The most appropriate internal units for most churches are a floor mounted units which looks very similar to a fan convector heater.

FUA-A - Under ceiling cassette air conditioning unit

Unique under ceiling cassettes for high rooms with solid ceilings or false ceilings with a shallow void. Suitable for all types of commercial applications.

The FUA-A range provides comfortable heating and cooling even for rooms with high ceilings and has individual louvre control flexibility to suit every room layout.

FTXM-R - Wall mount air conditioning unit

Attractive, wall mounted design with perfect indoor air quality. 2 area motion detection sensor: air flow is sent to a zone other than where the person is located at that moment; if no people are detected, the unit will automatically switch over to the energy-efficient setting.

FVXM - Floor Mount Air Conditioning Unit

Designed to fit rooms of any size and shape, it blends well with the interior due to the new design which incorporates more flowing lines and softer edges. These units are ideal when it is not possible to fit a high level wall mount unit for aesthetic or practical reasons.

They are suitable for a wide range of applications including domestic, small to medium offices and commercial uses.

All these units do have a fan element within them and therefore a small amount of fan noise is emitted. This tends to be less than a fan convector heater on a boiler based system as is similar to the noise from a fridge or freezer. Air conditioning units are commonplace in hotel rooms so the noise is low enough to be suitable for sleeping environments.

A case study of a church which has installed such a solution is available at [5. Air-source heat pumps at Hethel Church - All Saints Church, Hethel - A Church Near You]

5.2 Install Electric Panel Heaters

As the church is used for smaller services on a Sunday evening and Thursday morning, it seems wasteful to heat the whole church for a congregation of 15-20 people. Therefore it is recommended that the PCC consider installing electrical panel heaters in the side chapel on a time delay switch and remove the existing radiators.

Suitable electric panel heaters would be far infrared panels such as https://www.warm4less.com/product/63/1200-watt-platinum-white- . These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch such as https://www.danlers.co.uk/time-lag-switches/77-products/time-lag-switches/multi-selectable-time-lag-switch/159-tlsw-ms so they cannot be left on accidently after use.

These heaters have a strong radiative effect (where heat is reflected to people from the surface) as well as a light convective effect (where air is warmed and moves around to heat the general space). For this reason, these heaters tend to provide a relatively instant sense of heat and comfort within the space and only need to be on for short periods of time. This reduces the amount of preheating required before each use of the building and can make electric heating cost competitive with gas. It also means that the space can rapidly and economically be brought into used for short or unplanned meetings if needed.

5.3 Upgrade to 3 Phase Electricity Supply

To be able to have sufficient electrical power to supply enough energy into an electrical heating system the church is likely to need to increase the existing electrical supply from single phase 100A supply to a 3 phase 100A supply.

The upgrade to the supply has to be carried out by the District Network Operator in the areas.

The DNO in your area is thought to be Western Power Distribution - www.westernpower.co.uk; 0800 0963080 (East Midlands, West Midlands, South Wales & South West England)

The cost of bringing in a new 3 phase supply can range from £300 to £30,000 but the DNO will provide a quotation for free so it is well worth obtain a quotation in the short term so that decisions can be made on a well-informed basis.

6. Energy Saving Recommendations

In addition to having a revise heating strategy there are also a number of other measures that can be taken to reduce the amount of energy used within the church.

6.1 New LED Lighting

The lighting makes up a relatively large overall energy proportion of the electricity used within the church. There is a small area of the church which have had efficient LED lights installed but there remains a large number of inefficient SON fittings within the nave, alter, side chapel and church office. The church have had the lighting reviewed and have an application in with Faculty for a proposed up-grade.

It is recommended that the fittings scheduled in Appendix 1 are all changed for LED. There are a vast number of specifications of LED lights on the market but it is recommended that any LED light should come with branded chips and drivers and offer a 5 year warranty. An example of such a range of fittings is available from http://www.qvisled.com/

If all the lights were changed on a simple “like for like” the total capital cost (supplied and fitted) would be £5,555. The annual cost saving would be £1,298 resulting in a payback of around 4 years. This estimate includes for the supply of the lights, the labour to install them and the access required. It does not include for any upgrade to the wiring or a new lighting design both of which the church may wish to consider. Guidance on lighting, produced by Historic England for churches, can be found at https://historicengland.org.uk/advice/caring-for-heritage/places-of-worship/making-changes-to-your-place-of-worship/advice-by-topic/lighting/

6.2 Lighting Controls (Internal)

There are several lights which currently remain on all the time in areas such as toilet and some office areas and the like. Some of these areas are only used occasionally and for a short amount

of time so that, in actuality, the light does not need to remain on constantly. There are also spaces which benefit from a good amount of natural daylight coming in through the windows, such that artificial lighting is not required for much use during the year.

It is recommended that a motion sensor is installed on these specific lighting circuits so that the lights come on only when movement is detected in the space and turn off approximately two to five minutes after the last movement has been detected (note that the duration of the time lag after which the light goes off needs to be considered alongside the type of light that is fitted. LED lights are much more suited to being switched off after only a short duration than some fluorescent lights). These movement sensors, commonly called PIRs, also have light sensors integrated into them so they can be used to make sure that the light does not come on if there is already sufficient daylight in the space.

Your existing electrician or any NICEIC registered electrical contractor can install PIR sensors onto existing lighting circuits. This can be carried out without significant disruption to the use of the space.

6.3 Refrigeration Controls

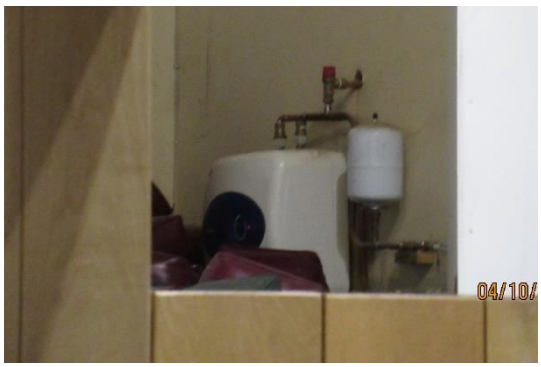
Within the church there are various domestic fridges within the kitchen and office area. These units run 24/7 and contribute to the baseload electrical consumption of the building.

To reduce the electrical consumption of these appliances, it is recommended that they are all fitted with a SavaWatt unit. These units work by automatically detecting the load of the compressor and turning down the power when it is not in full load. This reduces the energy consumption of the refrigeration unit by around 18% while maintaining the cooling of the appliance. It does this by reducing the voltage delivered to the unit when it is idling but allowing the full energy to the unit when it is required.

Supply and installation and further details can be undertaken by SavaWatt directly http://savawatt.com/. (Note the self installed SavaPlug has been discontinued, butthe professionally installed Savacontrol option is available) The installation does not cause any significant disruption to operations and can be undertaken during normal operating times.

6.4 Timers on Fuse Spurs to Water Heaters

There is an electric hot water heater located on the wall above the WCs in the church to provide hot water to the hand basins and kitchen. This only need to heat the water to the required temperature when the building is in occupation but at the moment these heaters are directly wired in without any form of time control and therefore maintain their set temperature 24/7.



It is recommended that the heaters are fitted with a 24 hour/7 day timeclock to replace the fused spur switch. An example of such a unit would be a TimeGuard FST77. They should be set up with times to match the times that the building is occupied . This will prevent the standing losses from the unit wasting energy during periods when the building is not occupied.

Such units can be purchased at any electrical wholesaler and fitted by your existing electrician or any NICEIC registered electrical contractor.

6.5 Draught Proof External Doors

There are a number of external doors in the church. The historic timber doors, and for example the bellringing chamber door does not close tightly against the stone surround and hence a large amount of cold air is coming into the church around the side and base of these doors.

It is recommended that the draughtproofing around the door is improved and draught strips are added. This could be achieved in a number of ways:

For timber doors that close onto a timber frame a product called QuattroSeal (see link below) is often used in heritage environments to provide appropriate draught proofing.
http://www.theenergysavers.co.uk/application/files/1714/7197/4194/National_Trust_Case_Study.pdf

Or for timber doors that close onto a stone surround more traditional solutions such as brush draught strips rebated into the edge of the door by a skilled joiner. Other traditional methods such as using hessian or felt pads tacked to the door could be used. Keeping the door maintained in a good condition is also important.

Simple measures such as having a ‘sausage dog’ style draught excluder laid along the base of a door (it needs to be sufficiently heavy to stay in place), using plasticine of the right colour to fill gaps where daylight can be seen, and putting painted fridge magnets over large keyholes can all be simple DIY measures which are effective.

7. Photo Voltaic Electricity Generation Potential

The potential for the generation of renewable energy on site has been reviewed and the viability noted.

Renewable Energy Type	Viable
Solar PV	No – shading from south tower and little demand
Battery Storage	No – no viable PV

Having reviewed the site it is not considered that there is good viability for any renewables and instead a good clear focus on reducing the energy demand of the building should continue with a targeted approach on reducing the heating energy.

8. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available on this Parish Resources page:
https://www.parishresources.org.uk/resources-for-treasurers/funding/

9. Faculty Requirements

It must be noted that all works intended to be undertaken should be discussed with the DAC at the Diocese.

Throughout this report we have indicated our view on what category of permission may be needed to undertake the work. This is for guidance only and must be checked prior to proceeding as views of different DACs can differ.

Under the new faculty rules;

List A is for more minor work which can be undertaken without the need for consultation and would include changing of light bulbs within existing fittings, repair and maintenance works to heating and electrical systems and repairs to the building which do not affect the historic fabric.

List B is for works which can be undertaken without a faculty but must be consulted on with permission sought from the Archdeacon through the DAC. This includes works of adaptation (but not substantial addition or replacement) of heating and electrical systems and also the replacement of existing boilers so long at the same pipe work, fuel source and flues are used. It can also be used to replace heating controls.

All other works will be subject to a full faculty.

Works which affect the external appearance of the church will also require planning permission (but not listed building consent) from the local authority and this will be required for items such as PV installations.

10. Offsetting

As you take action to reduce your emissions, you may also wish to offset those that you cannot yet reduce. If you would like to engage in offsetting, it is important to use a reputable scheme. The Church of England recommends Climate Stewards, which has a simple calculator that can help you to work out how much you would need to offset. https://www.climatestewards.org/

Climate Stewards encourages people to 'reduce what you can and offset the rest' as part of your journey to Net Zero carbon emissions. They provide training and resources to help you understand climate change and its impacts, and to calculate the carbon footprint from your activities including travel, energy, expenditure, and food. Their online carbon calculators for individuals and smaller organisations are free to use, and they provide bespoke carbon footprint audits for larger organisations.

Having reduced as much of your organisation's carbon footprint as you can, there will always be unavoidable emissions from your work and travel. Carbon offsetting allows you to compensate for the negative impact of your carbon emissions by funding projects which take an equivalent amount of CO_2 out of the atmosphere. These either involve locking up ('sequestrating') CO_2 as trees grow, or reducing emissions by using low-carbon technology such as fuel-efficient cookstoves or water filters.

Climate Stewards has a close relationship with all their project partners in Ghana, Uganda, Kenya, Tanzania, Nepal and Peru. They work closely with them to design, develop, implement and monitor projects which will not only mitigate carbon, but also bring tangible benefits to the local community - including improved health, savings in time and money previously spent on buying or collecting fuel, and improvements in local biodiversity. Each project is assessed using their Seal of Approval protocol which enables us to assess and monitor carbon mitigation and ensure robust, sustainable and transparent partnerships.

11. Other Observations

11.1 Bat's Managements in Churches

The Bat Conservation Trust has a project with the Church Buildings Council Natural England, the Church of England, Historic England and the Churches Conservation Trust to address bat problems issues: *www.churchofengland.org/resources/churchcare/advice-and-guidance-church-buildings/bats-churches*

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Wcs	4	2D LED 11W	£48	£235	4.86
Small room	8	NO CHANGE			
Kitchen	4	4ft Single LED	£25	£286	11.55
Nave	17	100W LED Flood	£869	£3,400	3.91
Nave	4	R63 LED	£33	£86	2.59
Side chapel	1	AR111 LED	£19	£43	2.19
Side chapel	1	50W LED Flood	£8	£120	14.29
Alter	2	PAR38 LED	£67	£34	0.51
Alter	2	GU10 LED	£27	£125	4.56
Alter	2	LED GLS	£33	£24	0.73
Alter diffusers lamps	6	LED GLS	£33	£71	2.14
Office	2	5ft Single LED	£52	£176	3.40
Office side room	1	5ft Single LED	£26	£88	3.40
Upstairs office	1	5ft Single LED	£57	£88	1.54