ESOS-ENERGY
Energy efficient solutions

Energy Audit and Survey Report

St Eustachius Church

PCC of St Eustachius, Tavistock

Version Control

Author	Reviewer	Date	Version
David Legge	Matt Fulford	30th January 2020	1.0

Contents

1. Executive Summary

An energy survey of St Eustachius Church was undertaken by ESOS Energy Ltd 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 Eustachius Church is located in the heart of Tavistock, South Devon and was consecrated in 1318. There have been later additions to the church and it holds Grade II* listed status. The church is very open with arches separating the aisles and seating consists of pews and central choir stalls. Heating is provided by a gas fired boiler to perimeter heaters as well as exposed pipework running under the mosaic floor and heat radiating through grilles. There is both gas and electricity supplied to the site.

The church has a number of ways in which is 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 is 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 (£)	Simple Payback (years)	Permission needed	CO2 saving (tonnes of CO2e/year)	£/tonne of CO2
Contact suppliers to arrange for the meters to be changed to smart meters	None	None	Nil	N/A	None	N/A	N/A
Switch electricity (and gas) suppliers to ones which provide 100% renewable (or green gas) supplies	None	None	Nil	N/A	None	N/A	N/A
Reduce background heating	24,804	£860	Nil	Immediate	None	4.56	N/A
Insulate exposed pipework and fittings in plantrooms	6,201	£215	£200	0.93	List A	1.14	£175.32

Install Endotherm advanced heating fluid into heating system(s)	12,402	£558	£1,200	2.15	List A	2.66	£451.12
Tune the boiler to more efficient combustion settings	6,201	£215	£500	2.32	List A	1.14	£438.31
Install electric heating to lady chapel and organ	18,603	£645	£2,500	3.87	List B	3.42	£730.51
Change existing lighting for low energy lamps/fittings	9,789	£1,233	£5,797	4.70	List B / Faculty	3.01	£2,333.53
Install PIR motion sensors on selected lighting circuits	28	£3	£87	25.16	List A	0.01	£10,321.17
Fit 270mm of insulation into the loft and block draughts	12,402	£430	£15,000	34.87	Faculty	2.28	£6,574.60

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

Based on current market prices of 12.6p/kWh and 3.468p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church £4,160 per year.

2. Introduction

This report is provided to the PCC of St Eustachius Church to provide them with 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 Eustachius Church, Plymouth Road, Tavistock, PL19 8AU was completed on the 27th January 2020 by David Legge. David is an experienced energy auditor with over 10 years' experience in sustainability and energy matters in the built environment. David is a fully qualified ESOS lead assessor with CIBSE and a CIBSE Low Carbon Consultant and a fully qualified ISO50001 lead auditor.

St Eustachius Church	**615599**
Gross Internal Floor Area	855 m^2
Listed Status	Grade II*
Typical Congregation Size	50

The church typically used for 19 hours per week for the following activities

Services	15 hours per week
Meetings and Church Groups	2 hours per week
Community Use	2 hours per week

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

3. Energy Usage Details

St Eustachius Church uses 22,029 kWh/year of electricity, costing in the region of £2,776 per year, and 124,022 kWh/year of gas, costing £4,301.

This data has been taken from a summary of consumption provided by the PCC. St Eustachius Church has one main electricity meter, serial number E14UP11909. There is one gas meter serving the site, serial number M025K03229 14 D6.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity	E14UP11909	3 phase 100A	Yes but no AMR connectivity	Cupboard under light switches, South aisle
Gas	M025K03229 14 D6	Elster BK-G16M	Yes but no AMR connectivity	Choir vestry

It is recommended that the church consider asking their suppliers to install smart meters so that the usage can be monitored more closely and the patterns of usage reviewed against the times the building is used.

3.1 Energy Profiling

The main energy use within the church can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	Predominantly SON uplighters, halogen spotlights and T8 fluorescent tube fittings.	13%
Heating	Provided by gas boiler with weather compensated control via perimeter radiators and underfloor pipes with grilles.	85%
Other Small Power	Organ power, sound system and other small plug loads.	2%

As can be 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.

3.2 Energy Benchmarking

In comparison to national benchmarks[1] for Church energy use, St Eustachius Church uses 29% more electricity and 3% less heating energy than would be expected for a church of this size. The electricity is likely to be higher due to the use of inefficient lighting and a number of fittings remaining on all day.

	Size (m^2 GIA)	St Eustachius Church use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Eustachius Church (elec)	855	25.76	20	10	29%
St Eustachius Church (heating fuel)	855	145.05	150	80	-3%
TOTAL	855	170.82	170	90	0%

[1] CofE Shrinking the Footprint – Energy

4. Energy Saving Recommendations (Electricity)

4.1 Lighting (fittings)

The lighting makes up a relatively large overall energy load within the building, and all areas are lit by inefficient fittings. The ceiling uplighters in the nave are high wattage SON fittings with integrated downlights, which appear also to be SON.

The spotlights in the nave, chancel and altar are a variety of halogen spotlights and floodlights. For these lights, the Megaman range of LED spot (reflector) lights https://www.megamanuk.com/products/led-lamps/reflector/ provides some very suitable substitutes to the current lamps.

It is recommended that all of the fittings are changed for LED. This could be undertaken in a direct like for like basis (as scheduled in Appendix 1) which is what has been costed for within this report, but the church may wish to consider using the opportunity to improve the lighting and consider a track lighting solution, fixed to the wall plate, which would provide greater flexibility and ability to create lighting effects. Track fittings such as https://www.sylvania-lighting.com/product/en-GB/products/2059568/ are regularly used to light churches such as this.

Like for like fittings are widely available on the market and it is suggested that the complete fitting (not just the lamp) is replaced. Any new LED fitting would have a much longer life and hence reduce the need to replace the lamps in the ceiling.

If all the lights were changed the total capital cost (supplied and fitted) would be £5,797. The annual cost saving would be £1,233 resulting in a payback of around 4.7 years. Many of the lights could be self-installed and therefore cost much less than the supply and fit cost above.

These costs do not include the external flood lighting or the clockface lighting within the tower, which is reported to be operated and paid for by the local Council. The capital cost to change these fittings would be £1,220 with a cost saving of £523 resulting in a payback of 2.3 years.

4.2 Lighting (control for internal lights)

There are several lights which currently remain on all the time in areas such as the vestry areas and vestry WC. These areas are only used occasionally and for a short amount of time and as such, 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 where artificial lighting is not required for much of the year during the day.

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 consider 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.

4.3 Lighting (control for external lights)

The external lighting is currently controlled by the Council but it was noted that the clocktower lights were on during the middle of the day. For efficient operation and to reduce light pollution and nuisance to neighbours it is generally recommended that external lighting is turned off between 11pm and 6am unless required for specific purposes and a photocell sensor is utilised during daylight hours to switch off lighting when there are sufficient daylight levels.

It is therefore recommended that either a combined photocell and timer is installed or that the existing timers are adjusted to switch off the external lights between 11pm and 6am daily and also over the weekend if not required. A timeclock with a time and day capacity is recommended over those that only have time of day capacity. Sangamo (http://sangamo.co.uk/) make a wide range of commonly used timeclocks which any qualified electrician can install.

As the Council operate these lights, the savings have not been included within the summary table.

5. Energy Saving Recommendation (Heating)

5.1 Heating System and Strategy

The church currently uses a weather compensating gas fired boiler to heat the church via perimeter convector heaters and underfloor exposed pipework and metal grilles. This is reported to work well and provides reasonable thermal comfort into the church. Given the churches usage profile we would suggest that a revised heating strategy for the church would provide a much more efficient use of energy and a more comfortable church.

5.2 Reduce / Discontinue Background Heating

As with most medieval churches, this church would have survived most of its life without any form of heating. The modern additional of heating is not needed to preserve the fabric but only to provide thermal comfort to occupants. The previous trend of 'conservation heating' for fabric issues is now largely considered to be unnecessary and is being avoided by the likes of National Trust and English Heritage. The only times when background heating may be required is if there are historic wall paintings or to for the preservation of large artefacts such as tapestries. The organ may require some local background heating specific to that area. In general, organs can be installed with a local background tube heater such as https://www.dimplex.co.uk/product/ecot-4ft-tubular-heater-thermostat within the organ casing in order to provide the heat where it is required. The fabric is often subject to the greatest damage by humidity (which is naturally higher when the air is warmer as warmer air has greater capacity for holding more moisture), as a result of large temperature swings (from central heating systems turning on and off) and from the excessive drying out/baking of timbers where high temperature heating units have been fixed to them (such as overhead heaters fixed to timber wall plates)

Providing constant background heating to the church building as a whole at a level of 15°C is excessive and wasteful of energy. At the very least we would recommend that this background level is reduced to a maximum of 12°C and ideally avoided all together.

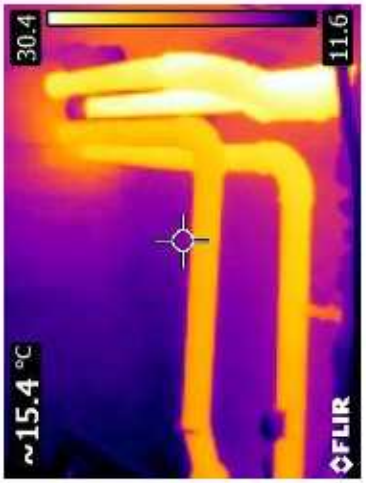
5.3 Endotherm Advanced Heating Fluid

In order to improve the efficiency of the heating system further it is recommended that an advanced heating fluid (http://www.endotherm.co.uk/) is added to the heating system.

This fluid is in addition to, and complements any existing inhibitors in the heating system and is added in a similar way. The fluid works to improve the ability of the boiler to transfer heat into the heating system and for the radiators and other heating elements to give out their heat into the rooms. It does this by reducing the surface tension of the water and increasing its capacity to transfer and hold heat. Case studies have demonstrated that the addition of this fluid into heating systems reduces heating energy consumptions by over 10% as well as helping the building heat up quicker.

Endotherm can be supplied and self-installed.

5.4 Insulation of Pipework and Fittings



The pipework within the plant room has the majority of its straight lengths insulated but the more complex shaped pipework fittings, such as valves, have been left uninsulated as well as some straight lengths of pipework downstream of the latest boiler installation works. These exposed areas of pipework contribute significantly to wasted heat loss from the system and make the plant room unnecessarily warm. The exposed hot surfaces also represent a health and safety risk of burns for those working in the area.

It is recommended that these areas of expose pipework and fittings are insulated with bespoke made flexible insulation jackets. These wrap around the various elements but can be removed and then replaced for any servicing activities.

A free survey and quotation for the supply and installation of insulation of pipework fittings can be arranges through ESOS Energy Ltd (contact Adrian Newton 0117 9309689, adrian@esos-energy.com).

5.5 Tune Boiler

The existing boilers on site are serviced at least annually during which time the flue gas is analysed and the results from this are displayed on the front of the boiler. The main purpose of this analysis is to make sure that the boiler is combusting the gas properly and not releasing too many toxic gases into the atmosphere. The flue gas analysis also provides an indication as to the efficiency of the boilers.

It was noted from the results of this flue gas analysis that while the flue gases are within the permitted limits there is more scope to adjust the burner to increase the efficiency of combustion. It is therefore recommended that the boiler engineer is requested to maximise the burner efficiencies during their next service visit, which is imminent.

5.6 Use of Electric Panels for Heating Specific Areas only

The heating within the Lady Chapel is currently not separate from the main church heating circuit and as such for the mid-week morning and evening prayer services (which typically means a congregation of up to 5 people), the whole church is heated to accommodate this. To avoid having to heat up the entire church building for these smaller mid-week services it is recommended that the PCC consider installing electrical panel heaters in this area on a time delay switch.

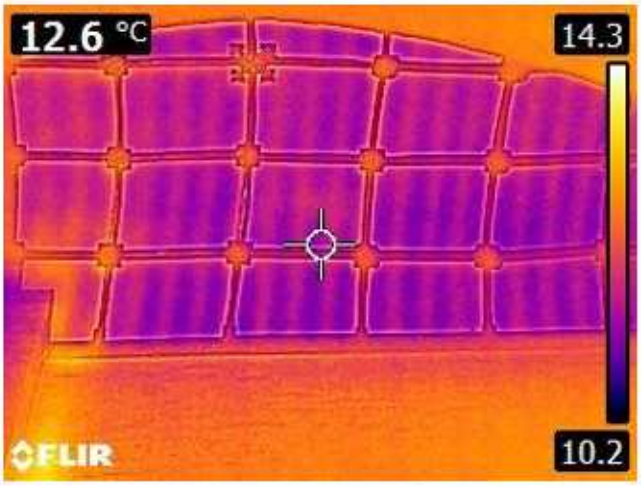
Suitable electric panel heaters would be far infrared panels such as https://www.warm4less.com/product/63/1200-watt-platinum-white- . These can be purchased widely and fitted by any competent electrician. It is recommended that they are fitted with a time delay switch such as https://www.danlers.co.uk/time-lag-switches/77-products/time-lag-switches/multi-selecta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

For choir practice on Friday evenings, consideration could be given to introducing under pew heating to the choir stalls, again to alleviate the need to heat the whole church for a small number of people. For replacement, two most popular under pew heaters within churches are BN Thermic PH30 heaters

(http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating. Cable runs to the pew heaters could run through the underfloor heating voids (all cabling should be in armoured cable or FP200 Gold when above ground) to the both rows of choir stalls quite easily.

6. Energy Saving Measures (Building Fabric)

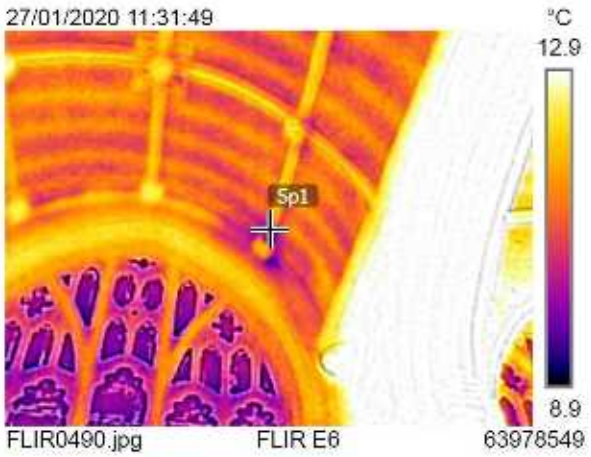
6.1 Roof Insulation



The church has a barrel-vaulted ceiling loft void above the ceiling was inspected as part of this audit and found to have little or no insulation present. In all cases where there is 100mm or less of insulation within accessible roof spaces it is recommended that insulation be added to prevent heat loss and create a more comfortable environment for the occupants of the building. Caution would need to be applied with any works to the ceiling due to its age and structural integrity; it is advisable for necessary risks to be addressed prior to any works starting.

The ceiling/roof of a building is the largest contributing area to heat loss from a building as heat rises. The insulation of such spaces can therefore have a dramatic impact on both the efficiency of the heating system and the temperature of the space below.

In addition to roof insulation, there were a number of draughts located, typically around the ceiling bosses. There was also a noticeable section missing above the chancel where cold air was drawn into the heated space. These draughts should be addressed and sealed to reduce air change rates between the heated space and the ceiling voids above.



A free survey and quotation for the supply and installation of insulation to the loft spaces can be arranged through ESOS Energy Ltd (contact Adrian Newton 0117 9309689, adrian@esos-energy.com).

7. Renewable Energy Potential

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

Renewable Energy Type	Viable
Solar PV	Yes – longer term measure if electric heating is introduced
Battery Storage	Yes – in the long term with PV
Wind	No – no suitable land away from buildings
Micro-Hydro	No – no water course
Solar Thermal	No – no current hot water need
Ground Source Heat Pump	No – archaeology in ground and radiator system
Air Source Heat Pump	No – insufficient electricity supply
Biomass	No – not enough heating load as well as air quality issues

There is potential for a PV array on the roof of the church as shading and listed building consent allows, but this would be suggested for the longer term. The current arrangements around solar panels mean that to be financially viable the building on which they are mounted needs to consume the vast majority of the energy that they produce. The churches energy consumption is already very small and the consumption during the daytime when the sun is shining is likely to be very low indeed, therefore while technically viable, this is only worth considering if and when a move to all electric heating is made and even then, battery storage technology would need to be considered or a very small array. It is more prudent to focus on the other recommendations made in the report to begin with.

Battery Storage is not strictly a renewable energy solution, but battery storage does however provide a means of storing energy generated from solar PV on site to be able to be used at peak times or later into the day when the PV is no longer generating. It therefore extends the usefulness of the existing PV system particularly in this sort of church. This is a new but fast-growing technology with prices expected to fall substantially over the coming years.

8. Other Observations

Within the bell ringers floor, there is a dehumidifier installed which is running 24/7 and has a maximum power rating of 650W. The unit has been installed to remove damp from the tower, which is evident on the walls. Whilst this is not tackling the root cause of the damp, which should be addressed during the next quinquennial inspection, the dehumidifier offers a solution to damp removal. To ensure that the unit is not running unnecessarily, the relative humidity within the space should be between 40-60% depending on the season. It would be sufficient to reduce RH to 40% during the winter and allow this to increase during the summer months.

Damp issues were pointed out by members of the PCC during the survey and thermal imaging highlighted these issues and are sent under separate cover to support the improvements to the building fabric.

9. Funding Sources

There are a variety of charitable grants for churches undertaking works and a comprehensive list of available grants is available at https://www.parishresources.org.uk/wp-content/uploads/Charitable-Grants-for-Churches-Nov-2019.pdf

10. 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.

11. Report Circulation

In addition to the PCC, this report is also sent to:

1. Your DAC secretary and your DEO, because
    - They maybe be able to offer you help and support with implementing your audit
    - They want to look across all the audits in your diocese to learn what the most common recommendations are.
2. Catherine Ross, the officer in the Cathedral and Church Buildings team centrally who leads on the environment, who wants to learn from all the audits across the country. She will be identifying cost-effective actions churches like yours might be able to make.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Choir vestry WC	1	2D LED 7W	£2.60	£54.55	20.95
Choir vestry	2	2D LED 11W	£5.21	£109.10	20.95
Vestry	3	5ft Single LED	£4.66	£281.10	60.31
Vestry	1	REMOVE	£3.97	£26.30	6.62
Nave uplighters (on all day)	7	50W LED Flood	£240.61	£639.10	2.66
Nave downlighters (on all day)	7	GU10 LED	£143.98	£82.60	0.57
Nave uplighters (service only)	27	50W LED Flood	£416.79	£2,465.10	5.91
Downlighters (service only)	27	GU10 LED	£249.40	£318.60	1.28
Chancel / nave spots	3	AR111 LED	£46.38	£133.62	2.88
Altar spots	11	AR111 LED	£90.65	£489.94	5.40
Aisle floods	1	AR111 LED	£8.24	£44.54	5.40
Tower	1	50W LED Flood	£15.44	£91.30	5.91
Bell Ringers floor	2	2D LED 11W	£5.35	£109.10	20.40

In addition to the lights scheduled above, the external lighting is also very inefficient but operated by the Council.

Both the ground mounted flood lights and tower clock face lights should be changed from inefficient SON fittings to LED equivalent.

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Ground floodlights	6	100W LED Flood	£313.71	£732.00	2.33
Clockface in tower	4	100W LED Flood	£209.14	£488.00	2.33