ESOS-ENERGY
Energy efficient solutions

Energy Audit and Survey Report

St Clement's Church, Sandwich

PCC of St Clement's Church

Version Control

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1. Executive Summary

An energy survey of St Clement's Church, Sandwich 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 Clement's Church, Sandwich is a Grade I listed church with a Norman tower and architecture dating from the 13th and 14th centuries, with some Victorian additions. 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
Replacement of non-LED Floodlights and Spotlights	3500	£500	£1300 + fitting	2-3	List B / Faculty	0.89	£1,460.67
Draught proofing	2472	£115	£50	6 months	List A	0.45	£252.89
Purchase a temperature datalogger to optimise heating times	Potentially 5% of 50,000 = 2,500	£115	£50	6 months	None	0.46	£108.70
Contact suppliers to arrange for the meters to be changed to smart meters	None	None	Nil	N/A	None	-	-
Secondary double glazing in Attwood rooms	800	£35	high	long	Faculty	0.20	-

Radiant far infrared heating panel in vestry (if required)	Low as low use presently	0	£200-400	N/A	List B	-	-
Replace Attwood Rooms boiler with Air Source Heat pump OR	5000	£220	£1000	5	Faculty	0.92	£1,086.96
Replace Attwood Rooms boiler with electric heating	0	0	£2000	N/A	Faculty	-	-
Replace gas heating with electric underpew heating in the future	10000 from no preheating (25%)	None	£6,000	N/A	Faculty	1.8	£3,333.33
Consider a solar PV installation on	7800	£1,080	£14,000	13	Faculty	2.40	£5,842.68

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

Based on current contracted prices of 13.8554p/kWh and 4.3513p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church £2,065 per year in operating costs.

CO_2 factors for each type of fuel are obtained from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

2 Introduction

This report is provided to the PCC of St Clement's Church, Sandwich 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 Clement's Church, Sandwich was completed on the 2nd December 2019 by Paul Hamley. Paul is an energy auditor with experience of advising churches and small businesses. He is part of the Diocesan Environment Officers Energy Group developing advice for the Church of England and authored the 2018 "Assessing Energy Use in Churches" report for Historic England. He is a CIBSE Associate member and a Chartered Scientist, with experience of the faculty process gained from chairing the building committee of a Grade I listed church.

St Clement's Church, Sandwich	606168
Gross Internal Floor Area	775 m^2
Listed Status	Grade I
Typical Congregation Size	80

The church typically used for 10 hours per week for the following activities

Services	5 hours per week
Meetings and Church Groups	1 hours per week
Community Use	1.5 hour per week
Occasional Offices	6 weddings/ year 52 funerals / year

This gives an estimated annual use of 520 hours

Heating hours are estimated at 370 hours (main boiler – based on known 6 hours Sunday running time plus estimated other event use, and 270 hours for the Attwood Rooms boiler, based on 60 meetings per annum plus 3 hours weekly use over 30 weeks (e.g. for choir practice, flower arranging).

Annual footfall is estimated at 16,000

[Weekly service numbers 30+80+15x52, + PCC meetings + weekly meetings of various groups averaging 15 people + 6 weddings x 150 + 52 funerals x 100 = 14,300, + 1700 visitors]

The church is open daily from 10:00 to 16:00, April to September, 10 visitors estimated per day.

3 Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Clement's Church, Sandwich and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single / Blended Rate	13.8554p/kWh	In line with current market rates
Standing Charge	21p/day	N/A

The current gas rates are:

Single / Blended Rate	4.3513p/kWh	Above current market rates
Standing Charge	- p/day	N/A

The church has recently changed supplier to Parish Buying to take advantage of group purchasing discounts.

A review has also been carried out of the taxation and other levies which are being applied to the bills. These are:

VAT	5%	The correct VAT rate is being applied
CCL	not charged	The correct CCL rate is being applied.

The above review confirmed that the correct taxation and levy rates are being charged.

4 Energy Usage Details

St Clement's Church, Sandwich uses 6.100 kWh/year of electricity, costing in the region of £1,000 per year, and 49.500 kWh/year of gas, costing around £2,300.

This data has been taken from data provided by the church. St Clement's Church, Sandwich has one main electricity meter. There is one gas meter serving the site.

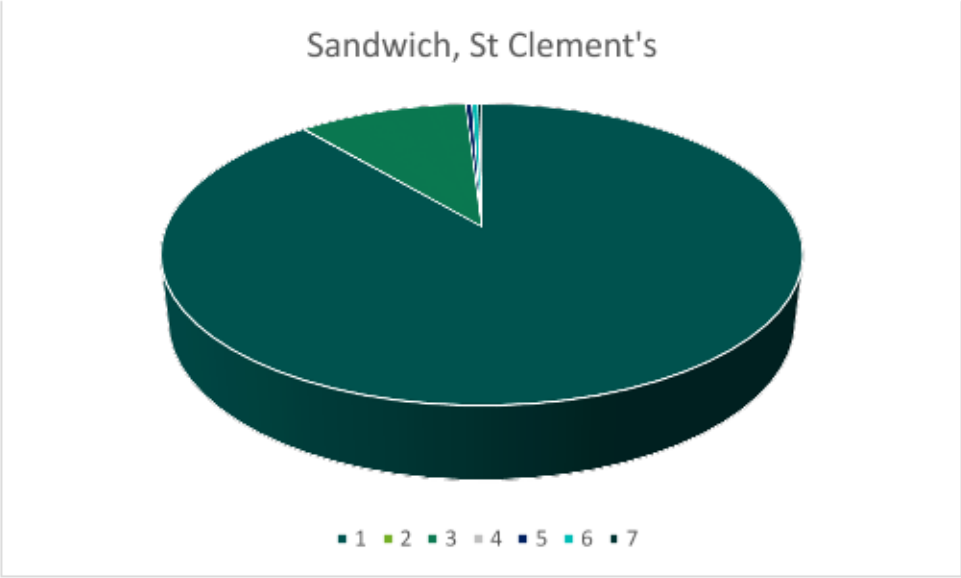
Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	K0110134	E43B3B-RH/8	no	Bone room, SE corner
Gas – Church	M016 K03526 13 D6	BK-G10M	no	Box in churchyard next to east yard wall

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.

4.1 Energy Profiling

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

Service	Description	Power	Annual Use/ kWh	Estimated Proportion of Usage
Lighting	See Lighting survey	11.5kW	5650	10.1%
Heating	Gas, Church, 111kW boiler 372 heating hours Gas, Attwood rooms, 30kW boiler 270 heating hours	111kW 30kW	41349 8100 TOTAL 49449	88.9%
Heating (electric)	Radiant bar heater in vestry (rarely used)	2kW	40	0.07%
Hot Water	Kettles, 2 x 2,5kW 20 boils of 3 minutes/ week x 52 weeks used Water heater in kitchen area 1/2hr per week	5kW 3kW	130 78	0.4%
Other Small Power	Microwave Oven Panasonic NN S 02715 Fridge	800W 200W	5 200	0.4%
Organ	Organ, pipe est 4h/ week Clavinova est 1h/week	500W 500W	100 26	0.2%



KEY 1 Gas heating 2 Electric heating (almost zero) 3 Lighting 4 External lighting (zero)

5 Hot water 6 Small power 7 Organ

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.

4.2 Energy Benchmarking

In comparison to national benchmarks[1] for Church energy use, St Clement's Church, Sandwich uses less electricity and heating energy than would be expected for a church of this size.

	Size (m^2 GIA)	St Clement's Church, Sandwich use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Clement's Church, Sandwich (elec)	775	7.9	20	10	39%
St Clement's Church, Sandwich (heating fuel)	775	63.8	150	80	42%
TOTAL	775	71.7	170	90	42%

St Clements records a low electricity use per area; the church has medium usage hours and little electricity use apart from lighting. Changing to all LED lighting (particularly the internal floodlights) will reduce this further. The church has a large boiler but is also a large church. 6 hours timed heating on a Sunday indicates the system is working well (many churches require 8-12 hours heating time).

[1] CofE Shrinking the Footprint – Energy

5 Energy Saving Recommendations (Electricity)

5.1 Lighting (fittings)

The lighting is the major contributor to electricity use. Appendix 1 lists lighting and estimates its energy consumption.

The known electricity use for 2018-19 of 6156kWh and estimated kitchen and small power use of 500kWh leads to a figure of 5656kWh for lighting. With an estimate of 520 annual use hours (a simplification as it implies main lighting is all on when the Attwood rooms are in use); this gives a total power of 11.5kW which agrees with observations of the number of bulbs and the assumptions made regarding the power ratings of bulbs and floodlights.

Many of the currently installed bulbs can be identified as CFL bulbs, although some may have been changed. The bulbs in the low level chandeliers can be changed by church staff and therefore cost much less than the supply and fit cost below. Replacement by LED will approximately half their electricity consumption, plus any new LED fittings would have a much longer life and hence reduce the need to replace the lamps in the ceiling.

The floodlights and spotlights are fixed at high level around the tower and the chancel would need to be changed by a lighting contractor. It is recommended that both bulb and their fittings (luminaires) of the spotlights are changed to ensure compatibility.

If all the floodlights were changed the total capital cost (supplied and fitted) would be around £2000. The annual cost saving would be around £500 resulting in a payback of around 4 years.

Parish Buying may offer an economic route to bulk buying of LED light bulbs.

Chandelier fitted with CFL bulbs

6 Energy Saving Recommendation (Heating)

6.1 Heating System and Strategy

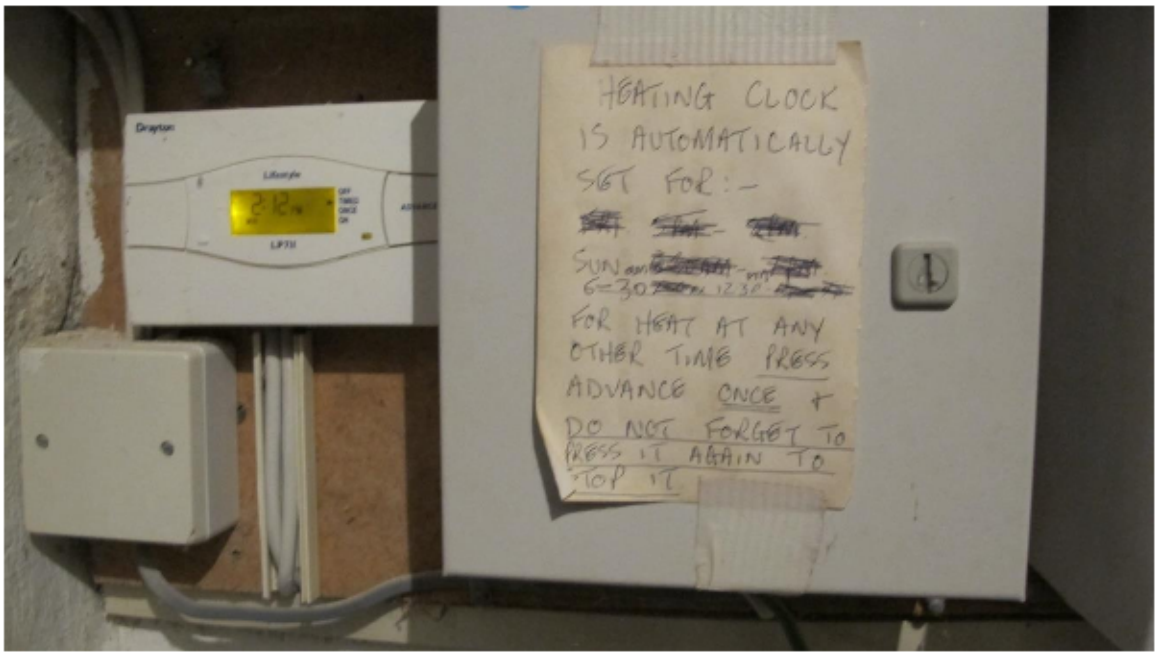
The church currently uses a gas boiler to heat the church. This is reported to work well and provides adequate thermal comfort into the church. Given that the system is successful and not overly wasteful of energy we would recommend that this system is continued with and consideration is given to the following improvements. The current heating timing regime of six hours on a Sunday is much shorter period than for many churches.

Under pew electric heating could be considered as an alternative future heating strategy.

A domestic, condensing gas boiler is used to heat the Attwood Rooms. It can be difficult to obtain spares for boilers over ten years old, so the church should consider its options which include electric heating (Section 6.7) or an Air Source Heat Pump (Section 8.2).

6.2 Boiler Timing Optimisation

The boiler timings for Sundays are reported to be ON 06:30, OFF 12:30. The church service at 10:30 finishes at 12:00 with people present until 13:00. Radiator systems with hot water remain hot for several hours after the boiler is switched off – experiments in the Diocese of Lichfield at over 50 churches have established that hot water radiator heating can be optimised by being switched off 45 minutes before the end of the service. As you have people present until 13:00 you could experiment with turning it off at 12:00, 30 minutes earlier.



6.3 Controls

Church boiler – Drayton LP111

Attwood Rooms boiler - Honeywell

The heater timer control is simple to operate, although one with an "Extra 1/2/3 hours" setting would remove the need to remember to turn it off. The Honeywell controller for the other boiler has this feature.

6.4 Space Temperature Set Point

It is unclear whether normal Sunday operation raises the temperature above 18°C at pew level – you may find that if the temperature is measured at the ceiling it is above 20°C.

It is worth the church logging how often the temperature falls below 9°C – if this is frequently but the minimum temperature is just below then it could be reset at a lower value.

The church use of gas appears to be efficient which suggests infrequent cold periods.

To assist in optimising and understanding the temperatures in the church, a datalogger such as an Easylog USB or Mindsets mini temperature datalogger could be purchased.

6.5 Boiler Maintenance: Clean / Flush Existing Heating System

To ensure longevity, the system should be periodically flushed and cleaned to remove any scale and corrosion. The church should have a record of when this was done last.

Neither boiler appears to be fitted with a magnetic particle filter. This apparatus catches any rust or metal particles and prevents them being deposited on the boiler heat exchanger. They should be installed if it is planned to continue using the water heating systems long term

Corrosion inhibitor should be added to the system when your boilers are serviced annually.

All these measures represent advice on good maintenance rather than energy saving.

6.6 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 in 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 self-installed.

6.7 Use of Electric Panels for Heating Specific Areas only

The heating within the vestry comprises of a small cast iron radiator and a small radiant bar heater. Should these provide insufficient heat; replacing the bar heater with a modern far infra-red panel would offer rapid heating to personnel. Slower acting forms of heating such as convector heaters are not worth it for a room in occasional use for short periods.

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.

6.8 Under Pew Heating

A future option is to install under pew electric heating. Although electricity is currently more expensive that gas per kWh, this form of heating requires little preheating time and delivers heat directly to the congregation. There are two sets of ten pews in the nave with some shorter pews in the south aisle.

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.

Two most popular under pew heaters within churches are BN Thermic PH65 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating.

7 Energy Saving Measures (Building Fabric)

7.1 Draught Proofing to Doors

There are a number of external doors in the building. These have the original historic timber doors on them, where these do not close tightly against the stone surround a large amount of cold can enter the church around the side and base of these doors.

Where a timber door closes against a timber frame it is recommended that draught proofing is fitted. 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. Note this cannot be used where the timber door closes directly against a stone surround.

Other simple measures such as using a small fridge magnet painted black over the large keyhole or the use of 'sausage dog' type draught excluders at the base of little used doors can prove to be very effective. Doors should be reviewed in daylight and gaps where the light shines through sealed or filled in whatever the most appropriate way is for the specific door.

The two holes in the lower panels of the external vestry door are clearly a source of draughts – are these holes part of the historic fabric, or were they made recently to control damp by increasing ventilation?

7.3 Windows

Consideration could be given to installing secondary double glazing inside the large windows of the first floor Attwood Room. This would clearly be an expensive proposition – it would be worthwhile if the upper level is used very regularly. With occasional use, the outlay would not be recouped from savings for a very long period.

If there are draughts caused by hopper windows (such as the bottom right four panels of the left window) not shutting correctly, a temporary solution is to use black plasticine to fill gaps.

8 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 – on south nave roof
Battery Storage	Yes – in conjunction with PV
Wind	No – no suitable land away from buildings
Micro-Hydro	No – no water course
Solar Thermal	No – insufficient hot water need
Ground Source Heat Pump	No – archaeology in ground and radiator system
Air Source Heat Pump	Investigate feasibility for Attwood Rooms
Biomass	No – not enough heating load as well as air quality issues

8.1 Solar PV potential

The government has advertised a "Smart Export Guarantee" to begin in 2020 which would pay for electricity generated and exported to the grid (the Feed in Tariff having ended). One of the issues for churches is that most lighting use is at periods when the electricity is not being generated, so any implementation of an PV system must wait until the SEG terms are guaranteed to assist financial viability.

For St Clement's church, the relatively flat nave roof offers a potential location – this would have to be confirmed with your architect as to suitability for extra weight and wind loading on the roof structure.

The south facing aisle roof is visible and therefore does not offer a location for solar panels.

The south facing chancel roof may offer a site, although it will often be shaded by the south aisle and the tower. The relatively flat nave roof offers an area of around 80m^2. This could generate 0.15kWpeak/m^2 giving a 12kWpeak system. A 1kWpeak system can generate 800kWh annually, although due to the proximity of the tower an over shading factor should be applied to give 650kWh per kW peak and a total annual generation of 7800kWh. This is in the same region as the church's annual electricity use (6150kWh) – although much of that use will be during the evening and night.

Options include covering the whole of the nave roof and installing a battery (so that all of the energy generated can be used) , or just covering half of the roof on the south side. It is assumed that panels would have to be laid directly onto the roof surface so they are not visible, i.e. not at

the optimum angle to the sun, which is around 30 degrees, so in fact any panels located on the north side would never generate to capacity.

The "bone room" which accommodates the two boilers does not appear to have space for the inverter or a battery; another nearby location would have to be identified.

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 substantial over the next 2 to 3 years therefore investment into this may be worth delaying at this stage.

The viability of a solar PV system would be increased if the heating system for the Attwood Rooms was to be changed to either a direct electrical system, or to a heat pump.

8.2 Heat Pumps

The large size of the church indicates that any heat pump system would also have to be large.

The age of the churchyard indicates significant burials, and lack of sufficient space for ground source heat pump coils.

Air source heat pumps require externally mounted units of similar appearance to air conditioning units. Given the size of the church, it is not considered that there is any location on the exterior of the building where these units could be accommodated. There may be an opportunity to install one ASHP to replace the gas boiler for the Attwood Rooms when it is due for renewal, if a suitable location can be identified to install it.

ASHPs consume electricity but deliver between 2.5 and 4 times the amount of heat in kWh that they consume. As St Clement's currently has relatively cheap electricity tariff but a more expensive gas tariff, this increases the viability of an ASHP for your building

If this is not possible then direct electric heating could be installed in these rooms in the future.

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-Jan-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
NAVE		Change to LED started, uncertain how many bulbs changed			
8 lamp chandeliers:					
4 x 9W CFL (up) = 36W					
4 x 25W CFL down 100W		40 large bulbs			
Total each set 136W	10 sets = 1360W				
4 lamp chandeliers:					
4 x 9W CFL (up) = 36W	1 = 36W	44 candle shaped bulbs			
Spotlights est 100W	8 = 800W	LED	Reduce to 200W total		
Floodlights small 250W	10 = 2500W	LED			
Floodlights large 500W	4 = 2000W	LED			
VESTRY					
Strip light 20W	1 = 20W				
Attwood Rooms 40 x GU 10 LED est 5W each	40 = 200W				
External Floodlights (estimate) 750W	6 = 4500W		Reduce floodlighting to 1800W total		
TOTAL estimate	11,500W		Load reduction 2kW by changing to LED, saving approximately £145 annually	Est. £2000 with fitting	14 years

With 520 annual use hours (a simplification as it implies main lighting is all on when the Attwood rooms are in use); this gives 5980kWh annual lighting use. The known use for 2018-19 of 6156kWh and estimated kitchen and small power use of 500kWh leads to a figure of 5656kWh for lighting, so the assumptions made regarding usage hours and power of floodlights above are reasonable.

Many of the currently installed bulbs can be identified as CFL bulbs, although some may have been changed. The bulbs in the low level chandeliers can be changed by church staff; replacement by LED will approximately half their electricity consumption.

The floodlights and spotlights are fixed at high level around the tower and the chancel would need to be changed by a lighting contractor. It is recommended that both bulb and their fittings (luminaires) of the spotlights are changed to ensure compatibility.

Parish Buying may offer an economic route to bulk buying of LED light bulbs.