ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary's Church, Astbury

PCC of St Mary's

THE CHURCH OF ENGLAND
Diocese of Chester

Author	Reviewer	Date	Version
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1. Executive Summary

An energy survey of St Mary's Church 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 Mary's Church is a beautiful Grade I listed building and dates back to the 12th Century, with alterations and additions in the early 14th Century and again in the 15th Century. The church is currently heated from gas boilers to exposed large diameter pipework in the pews as well as radiators. The lighting is a mix of newer LED lamps in the nave and altar, but there are inefficient SON and halogen lamps in other areas. 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)
Insulate exposed pipework and fittings in plantrooms	5,760	£188	£250	1.33	List A (None)	1.06
Refurbish window ironmongery / draught seals	5,760	£188	£400	2.12	List A (None)	1.06
Install a Solar PV array to roof of building (assumed 100% of energy generated used in building)	21,871	£3,968	£43,165	10.88	Faculty	5.54
Install PIR motion sensors on selected lighting circuits	38	£7	£168	24.42	List B	0.01
Change existing lighting for low energy lamps/fittings	5,143	£933	£34,023	36.47	Faculty	1.30
Install Draughtproofing to External Doors	3,456	£113	£4,800	42.48	List B	0.64

Use electrical based heating solution for smaller services	41,364	-£429	£15,686	n/a	Faculty	6.52
Install an Air Source Heat Pump into the building to replace existing heating system	80,634	-£2,503	£80,000	n/a	Faculty	12.51

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

Based on current contracted prices of 18.14p/kWh and 3.27p/kWh for electricity and mains gas respectively.

If the move an air source heat pump is excluded, if all measures were implemented this would save the church £4,968 per year and reduce its carbon footprint by 16.13 tonnes (72%).

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 Mary's Church 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 Mary's Church, Astbury, Cheshire CW12 4RQ was completed on the 24th March 2021 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 Mary's Church	
Church Code	609223
Gross Internal Floor Area	700 m^2
Listed Status	Grade I

The church typically used for 14.5 hours per week for the following activities:

Type of Use	Hours Per Week (Typical)	Average Number of Attendees
Services	11 hours per week	40 (main eucharist), 20 (other services)
Weddings, funerals etc	3 hours per week	
Other- bank holidays	5 hours per week	

4. Energy Procurement Review

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

The current electricity rates are:

Single	13.98p/kWh	Below current market rates
Standing Charge	20p/day	N/A

The current gas rates are:

Single / Blended Rate	2.57p/kWh	Below current market rates
Standing Charge	240p/day	N/A

The above review has highlighted that the current rates being paid are in line or below current market levels and the organisation can be confident it is receiving good rates and should continue with their current procurement practices.

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	100% not charged	The correct CCL rate is being applied.

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

5. Energy Usage Details

St Mary's Church uses 4,823 kWh/year of electricity, costing in the region of £874 per year, and 115,192 kWh/year of gas, costing £3,766. The total carbon emissions associated with this energy use are 22.5 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site. St Mary's Church has one main electricity meter, serial number 216136955. There is one gas meter serving the site however this was not accessible during the site visit.

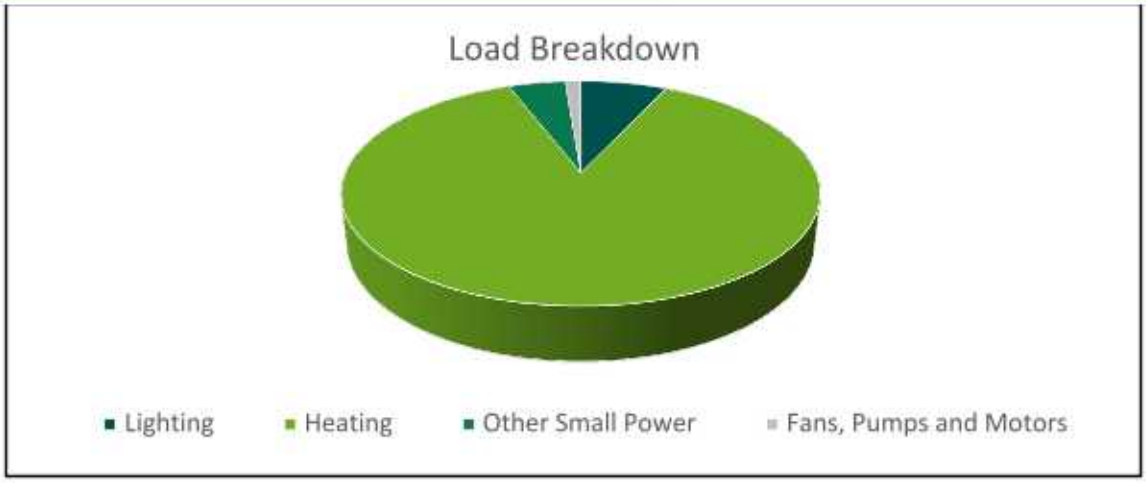
Utility	Meter Serial	Type	Pulsed output	Location
Electricity	216136955	EDMI Atlas Mk10D	Pulse output, no AMR connected	North West corner
Gas	Not accessible			

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.

5.1 Energy Profiling

The main energy consuming plant can be summarised as follows:

Service	Description	Estimated Proportion of Usage
Lighting	SON/halogen floodlights to many areas. Nave chandeliers and altar floodlights changed to LED	4%
Heating	Provided by 2no. Worcester Bosch gas fired boilers to exposed pipework in pews and perimeter and several radiators	94%
Other Small Power	Organ, sound system, kitchen appliances, plug-in loads, CCTV	1%
Fans, Pumps and Motors	Heating pump	1%



As can been seen from this data, the heating makes up by far the largest proportion of the energy usage on site.

5.2 Energy Benchmarking

In comparison to national benchmarks for church energy use St Mary's Church uses 66% less electricity and 10% more heating energy than would be expected for a church of this size.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
St Mary's Church (elec)	700	4,823	6.89	20.00	-66%
St Mary's Church (gas)	700	115,192	164.56	150.00	10%
TOTAL	700	120,015	171.45	170.00	1%

6. Efficient / Low Carbon Heating Strategy

The energy used for heating a church typically makes up around 80% to 90% of the overall energy consumption. Putting in place a heating strategy that is energy efficient and low carbon is, therefore, of the highest priority.

The Church of England is in the process of reviewing its heating guidelines. The process has already established some principles for heating that can help churches as they seek an acceptable combination of comfort, conservation, affordability, and environmental care. The principles can be found at https://www.churchofengland.org/sites/default/files/2020-04/CBC%20Heating%20guidance%20principles%20FINAL%20issued.pdf

As the principles make clear, every church's strategy will be unique to it, informed by many factors, including the nature of its usage, the system it's starting from, the conservation needs of the building, and the resources available. The strategies in this audit are designed specifically for your church.

Our recommendations on heating generally fall within three major areas. Firstly, for all churches we make recommendations that will help to reduce energy wastage and, as a starting point, to optimise the system that you already have.

Secondly, we recommend options for many churches that focus on heating people rather than the full volume of the church. Some of the changes that can help with this will be 'soft' changes – others will relate to the heating system itself.

Finally, we make recommendations about moving away from fossil fuels. Moves away from fossil fuels are key to cutting emissions. For most churches, this will involve moving from gas, oil or LPG to electricity. Electricity currently creates carbon emissions around the same level as mains gas, but the carbon emissions associated with it are reducing rapidly as the UK builds more renewable energy and decommissions its remaining oil and coal fired power stations. 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'. Some local areas may also be considering the option of district heating networks.

While moving away from fossil fuels may not always be possible, as the principles state, "churches should be expected to have at least carefully considered the option of moving away from fossil-fuel based heating (gas and oil boilers) towards electric-based heating." And if such options are not viable now, the churches "can try to be ready for a future retro-fit when technology and the grid has progressed."

The current gas boiler has been very recently installed and as such has a 20-25 year serviceable life that should therefore require replacement around 2042. At this stage, it is worth planning what to replace the gas boiler with and ensuring a clear strategy is in place for this eventuality. The most practical solution may be to install an air source heat pump (ASHP) using the existing heating system. Depending on the use of the church at this stage, this may be a high temperature heat pump or amendments may be required to the heating system coupled with a standard ASHP if usage is more frequent and the church is in continual use.

Prior to this, there are a number of areas to consider to make the church more energy efficient and to reduce gas consumption.

It is reported that for typical weekly services, congregation sizes range between 10-12 for the Wednesday service to 40 people for the main Sunday eucharist. At present, it is necessary to heat the whole church for these services. It is suggested that electric under pew heaters are introduced (see below) to a small number of pews as well as the lady chapel so that these services can take place without the need for the gas boilers to fire and attempt to heat the whole church. For larger services, the gas heating system can be utilised but it is suggested that this is closely controlled and switched off 30 minutes before the end of the service or event if the church is full.

Below is a table summarising the proposed electric heating replacement scheme. The top two lines detail the electric heating that could be introduced in the short term to reduce the high gas consumption.

Further details about the specific types of electric heating follow this.

Area	Type/ Size	Length (mm)	Watts	Number (or m) Required	Notes
The top two lines provide detail on an electric heating solution for the medium term.					
Nave	Electric Under Pew 650W	948	650	30	To accommodate 10 pews
Lady chapel - pews retained	Electric Under Pew 650W	948	650	16	All pews
The following heaters would be to consider once the gas boiler has reached end of life to supplement an air source heat pump.					
Vestry	Electric Far IR Wall Panel 1200W	1200	1200	3	Wall mounted
Choir vestry	Overhead Far IR Bar Heater 1.5kW	1580	1500	2	Fix to wooden ceiling below organ
Organ heater	Electric tubular heater	-	450	1	
Choir stalls	Electric Far IR Wall Panel 1200W	1200	1200	6	Either under pew if retaining or far IR panels on panel to E of rube screen and rear choir stalls (front mounted)
High altar	Electric Far IR Wall Panel 450W	800	450	2	On N and S walls of high altar
Lady chapel if pews removed	Electric Far IR Wall Panel 1200W	1200	1200	6	Wall mounted

6.1 Install Electric Under Pew Heaters

As detailed above, pew heating is a very suitable option for electric heating at this church. Two of the 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.

As per the table above we would therefore suggest that pew heaters to the nave and Lady Chapel be considered:

Cable runs to the pew heaters should run along the along the existing routes (all cabling should be in armoured cable or FP200 Gold when above ground) to the both rows of pews. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

The under pew (see photo below) and panel heaters have been recently installed at St Andrews Church, Chedworth, Gloucestershire, GL54 4AJ. The church is open in daylight hours so can be viewed at any time.

6.2 Install Electric Panel Heaters

At the end of the gas boilers serviceable life, it is recommended that the PCC consider installing electrical panel heaters in the vestry, choir vestry, choir stalls and high alter on a time delay switch to supplement the installation of an ASHP in a responsive heating strategy.

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 building can rapidly and economically be brought into used for short or unplanned meetings if needed.

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.

7. 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.

7.1 New LED Lighting

The lighting makes up a relatively large overall energy proportion of the electricity used within the church. There are some areas of the building which have had efficient LED lights installed but there still remains a large number of inefficient halogen and SON fittings within the church.

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/

The replacement recommendations of the lamps is not on a simple like-for-like basis, instead some areas, such as the high level lighting near the clerestory windows as well as the North and South aisles have been changed in design to allow for a more flexible 3 spot track lighting system. The benefit of this is to allow the church to be lit in a more flexible manner, which better suits the church's architecture as well as allowing the lighting to be more sensitive to the requirements of the church (e.g. predominantly up-lighting of the ceiling for more meditative services or Christingle). The total capital cost (supplied and fitted) would be £34,023. The annual cost saving would be £933 resulting in a payback of around 36 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/

There are some fittings such as the vestry where the existing fitting can be made more efficient by simply changing the bulb/lamp within the existing fitting to a new LED bulb/lamp. This could be carried out by competent members of the churches internal team, very cost effectively and would be a List A item so no permissions would be required.

7.2 Lighting Controls (Internal)

There are several lights which currently remain on all the time in areas such as the vestry, Lady Chapel, kitchen area 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.

7.3 Insulation of Pipework and Fittings

The pipework within the boiler room has the majority of its straight lengths insulated, but the more complex shaped pipework fittings, such as valves, have been left uninsulated. These exposed areas of pipework contribute significantly to 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 exposed pipework and fittings are insulated with bespoke 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 arranged through ESOS Energy Ltd (contact Adrian Newton 0117 9309689, adrian@esos-energy.com).

7.4 Draught Proof External Doors

There are a number of external doors in the church. The historic timber doors do 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

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.

7.5 Draught proof windows and repair ironmongery

The windows are in generally good repair, however there are a small number of gaps/breakages in the windows, allowing cold air into church. These gaps allow large quantities of cold air into the church whilst also allowing heat to escape. The main area of cold air ingress is through the original priests room which has a large opening to the outside and a smaller aperture to the church itself. These gaps should be addressed urgently to reduce the significant cold air ingress.

Gaps can temporarily be filled with black plasticine which will cause no damage and can be easily removed (as recommended by English Heritage). It is recommended that the masonry, mortar and frames are repaired to reduce these 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 – South aisle and south nave roof
Wind	No – no suitable land away from buildings
Battery Storage	No – no viable PV
Micro-Hydro	No – no water course
Solar Thermal	No – insufficient hot water need
Biomass	No – not enough heating load as well as air quality issues
Air Source Heat Pump	Yes – once gas boilers have reached end of life
Ground Source Heat Pump	No – archaeology in ground and radiator system

8.1 Solar PV

There is potential for a small PV array on the roof of the South Aisle ad South Nave. 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 church's energy consumption is already very small and the consumption during the daytime when the sun is shining is likely to be very low indeed, While technically viable, therefore, only a very small number of panels (maximum of around 4) would be worth considering. However, as electrical heating and ASHP are introduced, a larger array may be viable, particularly when combined with battery storage. The costs provided are for a relatively large 36kWp system, but this would not be required immediately and would require adjustment depending on the sizing of the heat pump and electrical heating (to be determined), but a small array is currently possible.

8.2 ASHP

The building is currently heated from a gas boiler which provides hot water into the heating system. The use of fossil fuels for heating means that it will not be possible for the building to become zero carbon without changing the heating system. A boiler also has heat and other efficiency losses within it, which means that the efficiency of a boiler in converting the gas into the heat is typically around 80 to 95% (depending on the age and type of boiler). Air source heat pumps use electricity to power the heat pump which takes heat from the air and puts this into water which can then go into the heating system. A heat pump can create around 3 units of heat for every one unit of electricity.

The existing boiler is approaching the end of its serviceable life and it is therefore recommended that the replacement of the existing boiler for an air source heat pump is considered.

A new air source heat pump is likely to need a heating capacity of around 200kW and could be located where the current boiler is located. As heat pumps operate on a low temperature basis some of the radiators and other heat emitters around the site may require upgrading. 3 phase

electrical power (currently installed as a 3 phase 60 A supply)may also be required to power the units.

Good local renewable companies can be contacted for further detailed assessment of heat pumps and quotes or contact www.yourfutureenergy.co.uk

There are currently government incentives available for installing air to water heat pumps but these are subject to future change and adaption so should be reviewed at the time of implementation.

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. 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 CO2 out of the atmosphere. These either involve locking up ('sequestrating') CO2 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.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Vestry	2	50W LED Flood	£34	£240	7.07
Vestry	4	GU10 LED	£28	£250	8.97
Lady chapel	2	R63 LED	£8	£43	5.09
Lady chapel	4	AR111 LED	£36	£170	4.69
Altar	2	AR111 LED	£18	£85	4.69
Clerestory lighting	17	3 Spot Track lights	-£48	£17,000	-351.46
North/South aisles	10	3 Spot Track lights	-£28	£10,000	-351.46
Kitchen/priests room	1	LED GLS	£8	£12	1.44
External	5	100W LED Flood	£721	£1,000	1.39
External	1	50W LED Flood	£95	£120	1.26
External	8	2D LED 11W	£61	£470	7.75