ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

St Mary Magdalene
PCC of St Mary Magdalene Bridgnorth

Diocese of Hereford

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of St Mary Magdalene 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 Magdalene was built in 1792-1796. The renaissance style building is an unusual design by Thomas Telford. The outside is described as a 'regular Tuscan elevation' with high walls featuring six large clear glass windows. The roof angle is shallow and the building is orientated N-S rather than the usual E-W. Heating is provided by a gas boiler that has reached the end of its serviceable life distributed to panel radiators as well as via exposed pipework in floor trenches. 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)
Install SavaWatt devices on fridges and freezers	140	£43	£50	1.16	List A (None)	0.04
Fit timed fused spurs to hot water heaters	486	£149	£270	1.81	List A (None)	0.12
Change existing lighting for low energy lamps/fittings	5,699	£1,752	£3,922	2.24	Faculty	1.44
Install PIR motion sensors on selected lighting circuits	43	£13	£90	6.87	List B	0.01
Fit flow regulators onto existing taps	16	£1	£23	19.62	List A (None)	0.00
Replace heating system for electrical based heating solution	69,775	£2,046	£75,354	36.83	Faculty	12.06

The church should check any faculty requirements with the DAC Secretary at the Diocese before commencing any works. The electrical heating solution offers betterment (warmer church to occupants in all areas) of the church heating system and it may not be necessary to install pew heaters to all pews, therefore the capital cost may be higher than is necessary.

Based on current contracted and market prices of 30.75p/kWh and 7.00p/kWh for electricity and mains gas respectively. To allow a fair representation of pricing moving forwards, the current market gas price has been utilised but the contracted electricity prices at over 30p/kWh should be reviewed as these are high.

If all measures were implemented this would save the church £4,177 per year and reduce its carbon footprint by 14.12 tonnes (82%)

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 Magdalene 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 Magdalene, East Castle Street, Bridgnorth WV16 4AL was completed on the 14th September 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 Magdalene	
Church Code	618268
Gross Internal Floor Area	670 m^2
Listed Status	Grade II*

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

Type of Use	**Hours Per Week (Typical)**	**Average Number of Attendees**
Services	9 hours per week	60 (main eucharist), >10 other services
Meetings and Church Groups	4 hours per week	Variable
Community Use	6 hour per week	Variable

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

4. Energy Procurement Review

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

The current electricity rates are:

Single / Blended Rate	30.75 p/kWh	Well above current market rates
Standing Charge	49.281p/day	N/A

The current gas rates are:

Single / Blended Rate	3.81 p/kWh	Below current market rates in current volatile market (7p/kWh used in calculations)

The above review has highlighted that there are opportunities to gain cost savings from improved procurement of the energy supplies at this site. We would therefore recommend that the church obtains a quotation for its electricity supplies from the Diocese Supported parish buying scheme, http://www.parishbuying.org.uk/energy-basket. This scheme only offers 100% renewable energy and therefore it is an important part of the process of making churches more sustainable.

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

VAT	5% / 20% (mix of rates charged over annual bills)	The organisation is understood to be a charity and therefore should be benefiting from only be charged a 5% VAT rate. A VAT declaration should be sent to the supplier to adjust this.
CCL	Not charged	The correct CCL rate is being applied.

The above review has highlighted that VAT was being charged from the bills submitted. The church is a charity and therefore can claim VAT exemption status. As such the PCC of St Mary Magdalene should send the supplier at VAT declaration confirming this and check all supplies on other sites. VAT declarations are available from the suppliers' website and can usually be found by typing the suppliers name followed by "VAT Declaration Certificate" into most website search engines.

5. Energy Usage Details

St Mary Magdalene uses 8,203 kWh/year of electricity, costing in the region of £2,522 per year, and 81,724 kWh/year of gas, costing £3,114. The total carbon emissions associated with this energy use are 17 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site. St Mary Magdalene has one main electricity meter, serial number E14Z014248. There is one gas meter serving the site.

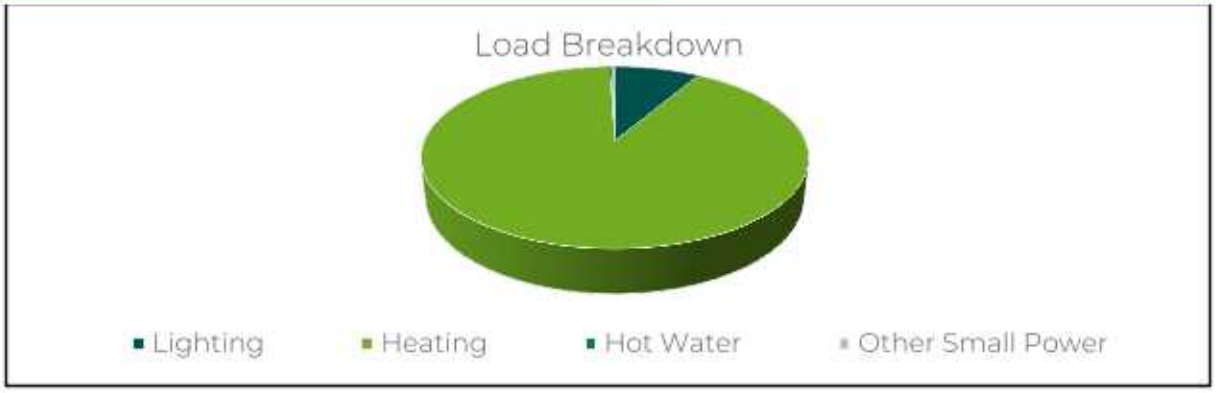
Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	E14Z014248	3 phase 100A	Yes but no AMR connectivity	Base of tower stairs

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	There is a mix of lighting within the church with halogen and metal halide spotlights as well as 2D bulkhead fittings and T8 fluorescent tubes as well as a move to LED	8%
Heating	A Clyde gas fired boiler (end of life) provides heating to panel radiators as well as through exposed oversized pipework in floor trenches in all aisles.	91%
Hot Water	Electric point of use water heaters provide hot water for the kitchen and WC.	<1%
Other Small Power	Heating pump, organ power, plug in heaters, kitchen appliances and other plug loads.	1%



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.

5.2 Energy Benchmarking

In comparison to national benchmarks for church energy use St Mary Magdalene uses 39% less electricity and 19% less 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 Magdalene (elec)	670	8,203	12.24	20.00	-39%
St Mary Magdalene (gas)	670	81,724	121.98	150.00	-19%
TOTAL	670	89,927	134.22	170.00	-21%

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 church currently does not have any fixed re-ordering plans and as such this report can only recommend what is currently in situ at the church. There are ongoing discussions, led by the most recent quinquennial report regarding the condition of the floor, and the possible removal of the pews. The PCC would like commentary on heating options if the pews were to be removed. However, the decision of retained or removing the pews should be taken for the benefit of the PCC and the church and the correct heating strategy can only be applied thereafter. During the discussion on the day, pew 'pruning' was suggested so that pews can be retained whilst allowing some flexible space to the rear of the church which would allow a more robust heating system to be considered. Should the PCC wish to remove the pews, the difficulty lies in siting heating emitters (i.e. radiators, electric panels) as there are no fixed points to locate

these. Removing the pews does make it more difficult to heat the church and underfloor heating is not typically recommended when the weekly occupancy is intermittent, as it is here. If the existing radiators and trench pipework were to be retained, a plate heat exchanger would be recommended and either a high temperature heat pump or a gas hybrid heat pump system would be recommended to replace the current gas boiler which has reached the end of its life. An air source heat pump would cost in the region of £40,000 whereas a gas hybrid heat pump system would require the addition of a new gas boiler, so costs are likely to be higher at around £50,000.

If the church remains as it currently is, with pews being retained, the recommended approach is to install under pew heaters which offer far greater flexibility and instantaneous heat which is delivered to exactly where it is needed – the users / congregation and not simply heating the space. Electric under pew heating provides the flexibility to switch on/off individual pews depending on the number of users in the church at any given time and is described in further detail below. The consideration of electric under pew heaters would be that the minimum number of heaters required at any given point would be used to heat the occupants, as opposed to all heaters needing to be on to heat the entire church.

6.1 Install Electric Under Pew Heaters

For replacement, 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. The pew heaters can be suspended from brackets from the underside of the choir stall seats.

We would therefore suggest that the following works could be considered:

Area	Type/ Size	Length (mm)	Watts	Number Required
Choir stalls	Electric Under Pew 650W	948	650	10
Main aisle pews (26)	Electric Under Pew 650W	948	650	130
Side aisle pews (20)	Electric Under Pew 650W	948	650	40
Balcony	Electric Under Pew 650W	948	650	20

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 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

As detailed above, it is recommended that the PCC consider installing electrical panel heaters in the following areas on a time delay switch and remove the existing radiators.

Area	Type/ Size	Length (mm)	Watts	Number Required
Under balcony	Electric Far IR Wall Panel 900W	1200	900	5
Vestry	Pulsar 1800W	-	1800	1
Kitchen (under plinth)	Near IR Overhead Heater 3kW	960	3000	1
WC	Electric Far IR Wall Panel 700W	1200	700	1
Chancel	Electric Far IR Wall Panel 700W	1200	700	2

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). As such these heaters tend to provide a relative instant sense of heat and comfort within the space and only need to be on for short periods of time.

The Pulsar heater for the vestry is a ceiling hung heater https://www.herschel-infrared.co.uk/product/pulsar/ which can be easily installed and offer responsive heating to a space which is not constantly utilised.

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. The altar flood lights are now efficient LED lights, but there still remains a large number of inefficient fluorescent and halogen fittings within most areas of 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/

If all the lights were changed on a simple "like for like" the total capital cost (supplied and fitted) would be £3,922. The annual cost saving would be £1,752 resulting in a payback of around 2.24 years (driven by the high unit rate paid for electricity). 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 GU10 spotlights, T12 and T8 fluorescent tubes 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 for longer than necessary in areas such as vestry, toilet areas and the like. Some of 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.

7.3 Refrigeration Controls

Within the church kitchen there is a domestic refrigeration unit. 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/. The installation does not cause any significant disruption to operations and can be undertaken during normal operating times.

7.4 Timers on Fuse Spurs to Water Heaters

There are a number of electric point of use water heater in the kitchen and WC to provide hot water for hand washing. This only needs to heat the water to the required temperature when the building is in occupation but at the moment this heater is directly wired in without any form of time control and therefore maintains it 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 and 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.

7.5 Draught Proof External Doors

There are a number of external doors in the church. These have the original historic timber doors on them, but these 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

For timber doors that close onto a stone surround more traditional solutions such 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 and keeping the door maintained in a good condition is important.

Simple measures such as having a 'sausage dog' style draught excluder laid along the base of a door, using plasticine of the right colour to fill gaps where daylight can be seen and putting painted fridge magnetic over large keyholes can all be simple DIY measures which are effective.

8. Saving Recommendations (Water)

8.1 Tap Flow Regulators

The taps to the wash hand basins within the building have been checked as part of the audit and the average flow rate within these has been measured to be 8l/min. The recommended flow rate for hand washing is 4.8l/min and therefore the taps are providing around double the amount of water that is necessary.

The over provision of water for hand washing is not only a source of excessive water use, but in the case of hot water, it is also a source of wasted energy in the heating that has to go into providing the hot water.

The flow rate of the taps can be easily regulated by fitting flow regulators within the taps. It is recommended that flow regulators such as those manufactured by neoperl (http://www.neoperl.net/en/) are fitted into all the viable hand wash basin taps to save on both water and heating of the hot water.

These regulators can be self-installed or by any good facilities staff.

9. 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	No – not sufficient demand, visible roof, previously dismissed
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	No – insufficient electricity supply
Ground Source Heat Pump	No – archaeology in ground and radiator system

Now that the Feed in Tariff scheme has come to an end the installation of solar PV panels in situations where there is not almost full usage of the electricity generated on site is not really viable. The church's electrical 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 only a very small number of panels (maximum of around 4) would be worth considering if at all.

However, 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.

10. 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 .

11. 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.

12. 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.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Bell ringers	1	5ft Single LED	£24	£88	3.68
Stairs	3	2D LED 11W	£21	£176	8.37
Under balcony	3	2D LED 11W	£21	£176	8.37
WC	1	2D LED 11W	£7	£59	8.37
Columns	12	GU10 LED	£206	£751	3.66
Chancel	8	AR111 LED	£178	£340	1.91
Altar	2	5ft Single LED	£48	£176	3.68
Vestry	1	5ft Single LED	£26	£88	3.37