ESOS-ENERGY
Energy efficient solutions

Energy Efficiency and Zero Carbon Advice

Cartmel Priory Church
2buy2 Church of England Audits

Author	Reviewer	Date	Version
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Contents

1. Executive Summary

An energy survey of Cartmel Priory 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.

Cartmel Priory Church is a large, fine, grade I listed church which dates back to 1188 and is a significant tourist attraction in the area. During the week it is open to visitors and has a shop and for a Sunday there are typically 4 services. There is both gas and electricity supplied to the site with the church being heated from two gas boiler based heating systems to a 12 degree background heating level.

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	13,102	£1,310	£1,500	1.14	List A (None)	2.36
Install an Air-to-Air Source Heat Pump to replace the existing heating system served from the Nave Boiler Room	121,706	£5,216	£89,100	17.08	Faculty	20.83
Change existing lighting for LED fittings	4,761	£1,428	£32,006	22.41	Consult DAC	1.00
Install electric pew heaters to nave pews and use heated seat cushions to town quire	60,347	£701	£40,004	57.04	List B	10.03
Install an Air-to-Water Source Heat Pump to replace existing heating system served from the Chancel Boiler	56,450	£1,129	£85,000	75.29	Faculty	9.46

In addition to the above, during the audit it was found that the frost stat for the nave boiler rooms was set at around 15 degrees, this was cause the whole heating system to run whenever the air temperature within the boiler room (which is located on an external wall and the room is vented to outside air) falls below this set point. With the agreement of the church, this was reset to around 3 degrees. This one adjustment should result in very significant savings to the gas bill and resolve the high consumption and billing issues reported. A revision to the warm up times may be required once the church has settled to this revised set point.

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

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

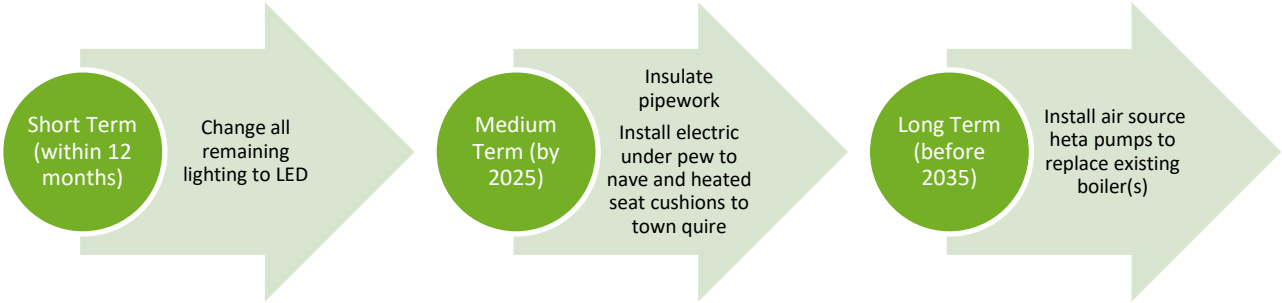
If all measures were implemented this would save the church £9,800 per year and reduce its carbon footprint by 44 tonnes (92%).

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 balance 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 2035 by undertaking the following steps:




SHOP
OPEN

3. Introduction

This report is provided to the PCC of Cartmel Priory 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 Cartmel Priory Church, Grange-over-Sands LA11 6PU, was completed on the 7th of December 2022 by Matt Fulford. Matt is a highly experienced energy auditor with over 15 years' experience in sustainability and energy matters in the built environment. He is a chartered surveyor with RICS and a CIBSE Low Carbon Energy Assessor. He is a Member of the DAC in the Diocese of Gloucester and advises hundreds of churches on energy matters.

Cartmel Priory Church	
Church Code	607243
Gross Internal Floor Area	1,374 m^2
Listed Status	Grade I

The church typically used for 45 hours per week for the following activities

Type of Use	Hours Per Week (Typical)
Services	9.5 hours per week
Meetings and Church Groups	0 hours per week
Community Use	36 hours per week

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 Cartmel Priory Church and have been reviewed against the current market rates for energy.

The current electricity rates are:

Day Rate	18.0065p/kWh
Night Rate	13.245p/kWh
Standing Charge	77p/day

Given the significant shifts in the energy market over recent months this rates are now very much lower than current market rates where the supported level until March 2023 is around 32p/kWh.

The current gas rates are:

Single / Blended Rate	1.9541p/kWh
Standing Charge	£5.22/day

Given the significant shifts in the energy market over recent months this rates are now also very much lower than current market rates where the supported level until March 2023 is around 7p/kWh.

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.

5. Energy Usage Details

Cartmel Priory Church uses 13,433 kWh/year of electricity, costing in the region of £4,000 per year, and 248,611 kWh/year of gas, costing £46,000. These costs are based on the current market costs and not the rates which have been paid on the existing contracts. The total carbon emissions associated with this energy use are 48 CO_2e tonnes/year.

This data has been taken from the annual energy invoices provided by the suppliers of the site. Cartmel Priory Church has one main electricity meter, serial number E09BG13702. There are two gas meters serving the site (one to each boiler room), serial number A0272416A6 and K0098516D6.

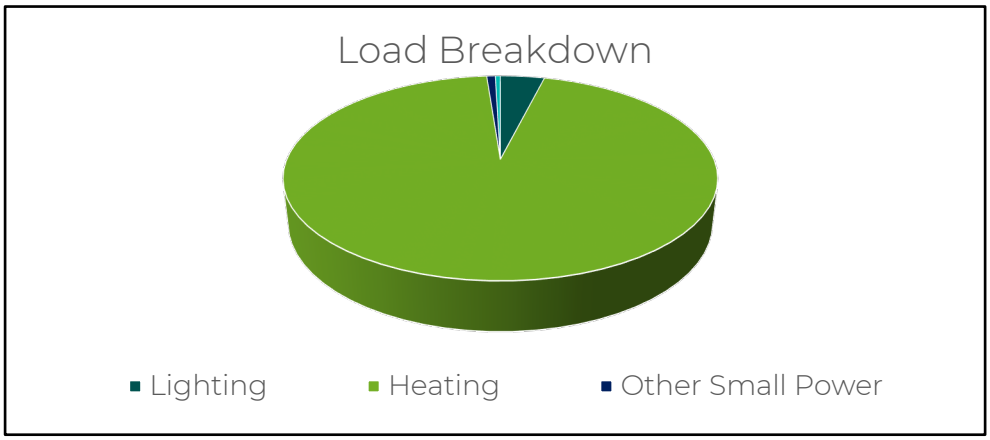
Utility	Meter Serial	Type	Pulsed output	Location
Electricity	E09BG13702	3 phase 100A	No but capable	North Side of nave

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	Estimated Proportion of Usage
Lighting	4%
Heating	95%
Other Small Power	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 Cartmel Priory Church uses 44% less electricity and 39% more heating energy than would be expected for a church of this size.

The high heating consumption is due to the background heating method used within this church and is also likely to be a result of the high setting of the frost stat to the nave boiler room.

	Size (m^2 GIA)	Annual Energy Usage (kWh)	Actual kWh/m^2	Benchmark kWh/m^2	Variance from Benchmark
Cartmel Priory Church (elec)	1,189	13,433	11.30	20.00	-44%
Cartmel Priory Church (gas)	1,189	248,611	209.09	150.00	39%
TOTAL	**1,189**	**262,045**	**220.39**	**170.00**	**30%**

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 has two heating systems, one for the nave which has two 100kW boilers which were installed in 2018 and a separate heating system for the chancel which has one 100kW boiler which was installed in 1991 and is now at the end of its serviceable life. Both heating systems server steel pipework feeding cast iron radiators around the church.

The nave boiler room still have around 15 years of life left in the boilers and therefore the replacement of these is not a priority. It is recommended that electric under-pew heaters are installed into the retained pews in the nave and north and south transepts so that the boilers can be used to maintain the background heating level of 12 degrees and the electric pew heaters can be used to provide the comfort boost required for services. This will provide a gentler

heating strategy for the fabric and allow for the potential for the flow temperature of the boiler to be reduced (to around say 60 degrees) which may help to improve the efficiency of the gas usage.

To the chancel boiler room, it is recommended that this system be replaced with an air to water source heat pump, possibly located on top of the flat roof area to the northeast corner of the church. This could then be connected to the existing radiator circuit through a heat exchanger to provide suitable separation and use a lower flow temperature form the heat pump to provide background heating levels only. Electric heated seat cushions could be used to provide comfort levels to congregations in the town quire area.

We therefore suggest the following decarbonisation plans are put into place.

6.1 Air to Water Source Heat Pumps

Air-to-Water Source Heat Pumps (AWSHPs) work by having an external unit which sucks air in and extracts the heat from it. It concentrates this heat and puts it directly into water that can then flow through the heating system. They work most efficiently when trying to produce water temperatures in the heating system between 40°C and 50°C. They tend to warm up slowly and steadily and are therefore well suited to situations where the heating is required for long periods of the day, and with heating systems that have a low temperature requirement such as underfloor heating systems. As they warm up spaces slowly, it is important that the warmth being slowly emitted is retained within the building so that the overall heat levels build up. This requires good levels of insulation and air tightness to ensure that the heat loss is lower than the heat being emitted. AWSHPs provide around 3 units of heat for every 1 unit of electricity used in the heat pump; they therefore have a Coefficient of Performance (CoP) of 3.

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

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

A case study of a church which has installed this solution is available at Heat pumps and fabric improvements make a rural church warm and well used : St Anne in Ings | The Church of England

6.2 Heated Pew / Seat Cushions

Most are now familiar with the concept of heated seats within cars; the same solution is also used in some outdoor venues such as alfresco dining and sports stadiums. These provide a heated cushion to sit on: the direct warmth from the contact areas provides a degree of comfort even when the surrounding space is cold. This can be a useful solution for churches which only have chairs (having removed pews) and/or for small congregations where there are few other alternatives.

There are a variety of heated seat cushions on the market. Some are directly plugged into a power socket (similar to an electric blanket). Others have battery packs, which can be charged and then connected to a seat pad. This makes them more flexible and avoids trailing leads. The more advanced products have a pressure sensor which means heat is only provided when someone is sitting on the cushion. Heated pads for 'benches' can also be used to heat a pew or could even be adapted to form a heated kneeler for the communion rail.

Area	Type/ Size	Length (mm)	Watts	Area Heated	Number required
Town Quire	Heated Pew Cushion	1000	85	Pew Only	30

A case study of a church using heated cushions is available at https://www.churchofengland.org/about/environment-and-climate-change/towards-net-zero-carbon-case-studies/marown-church-tries-new

6.3 Install Electric Under Pew Heaters

Electric under pew heaters provide a high level of thermal comfort to people sat in the pews. They are not installed to try and heat the entire air volume of the church, instead thermal comfort is achieved through a flow of warm air rising past the person in the pew. This means that the heaters should be installed under the entire length of all the pews that are likely to be used.

These heaters warm up almost instantly and a flow of warm air over the pew area is created within around 15 minutes of their being turned on. This significantly reduces the amount of preheating required before each use of the building and can make electric heating cost competitive with gas. It is important that this reduced 'on time' is properly reflected in any comparisons with other types of heating.

The 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.

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

Install BN Thermic Under Pew Heaters suspended from brackets from the underside of the pew seat as follows:

Area	Type/ Size	Length (mm)	Watts	Area Heated	Number required
Nave	Electric Under Pew 650W	948	650	Pew Only	52
South Transept	Electric Under Pew 650W	948	650	Pew Only	20
Nave	Electric Under Pew 450W	702	450	Pew Only	8
North Transept	Electric Under Pew 650W	948	650	Pew Only	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 both rows of pews. Each pew heater to be switched with a neon indicated fused spur located underneath the pew seat.

A case study of a church which has adopted this solution is available at https://www.churchofengland.org/about/environment-and-climate-change/st-andrews-chedworth-electric-heating

Photos of installations are shown below.

Brown BN Thermic 650W under pew heaters fixed to underside of pew seats for pews which have no solid backs.

Black 650W Norel under pew heaters fitted to solid pew backs.

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

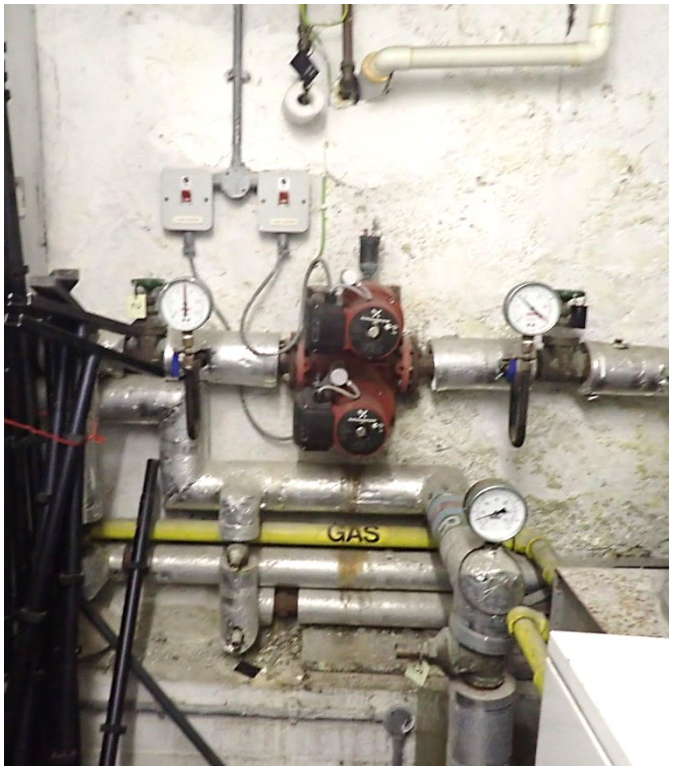
The lighting makes up a relatively small overall energy proportion of the electricity used within the church. There are some areas of the building which have had efficient LED lights installed but there still remains a large number of inefficient fluorescent and SON fittings within the vestry, nave, kitchen, south aisle, shop, and town quire.

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 £32,000. The annual cost saving would be £1,400 resulting in a payback of around 22 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/

7.2 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).

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	No – not sufficient demand, visible 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	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.

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.

9. Funding Sources

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

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 includes the installation of under pew heaters to pews which are made in or after 1850 and are not of historic interest.

All other works, including the like for like replacement of gas and oil boilers 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. This includes items such as solar 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 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
Vestry	2	2D LED 11W	£19	£118	6.07
Vestry	4	LED GLS	£38	£48	1.24
Upper Vestry	2	2D LED 11W	£19	£118	6.07
Lower Vestry	2	5ft Single LED	£60	£176	2.94
Piper Choir	2	PAR38 LED	£115	£34	0.30
Piper Choir	4	3 Spot Track lights	-£28	£4,000	-143.89
North Transept	2	3 Spot Track lights	£67	£2,000	29.98
North Aisle	4	PAR38 LED	£229	£68	0.30
Nave	7	3 Spot Track lights	£234	£7,000	29.98
Kitchen	2	4ft Single LED	£53	£143	2.69
South aisle	4	3 Spot Track lights	£133	£4,000	29.98
Shop	12	4ft Single LED	£122	£859	7.06
South Transept	2	3 Spot Track lights	£67	£2,000	29.98
Town Quire	7	3 Spot Track lights	£234	£7,000	29.98
Town Quire	2	AR111 LED	£67	£85	1.27