Inspired Efficiency

Energy Audit and Survey Report

St Luke's Church, Canning Crescent, Oxford

DIOCESE OF OXFORD

"There is a plan to reduce global carbon emissions to net zero by 2050. The plan will work. It involves all of us. We need to begin now, in our homes and workplaces and churches"

Revd Dr Stephen Croft, Bishop of Oxford

Version Control

Author	Reviewer	Date	Version
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1. Executive Summary

An energy survey of St Luke's Church, Canning Crescent, Oxford was undertaken by Inspired Efficiency 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.

St Luke's Church, Canning Crescent, Oxford was reconstructed in 2014 around an existing wooden frame dating from 1933. 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.

Short Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Obtain a temperature datalogger to optimise central heating	5% of gas 350	£15	£40	3	None	Warden

Medium Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Install solar panels, 15kWpeak system	2530	£370	£18,000	27	Faculty	PCC
Install battery storage	1000	£134	£2,000	15	With PV installation	PCC
Construct external draught lobby	5% 350	£15	£3,000	many	Faculty	PCC

Long Term: Energy saving recommendation	Estimated Annual Energy Saving (kWh)	Estimated Annual Cost Saving (£)	Estimated capital cost (£)	Simple Payback (years)	Permission needed	To be actioned by who / when?
Install Air Source Heat Pump	4,200	£560 with grid electric £780 if SPV	£10-15k	22 16	Faculty	PCC
OR						
Install far infra red electric heating panels	2,000	£267 £780 if SPV	£9,000	34 11.5	Faculty	PCC

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

Based on current contracted prices of 13.370p/kWh and 4.200p/kWh for electricity and mains gas respectively.

If all measures were implemented this would save the church over £1,300 per year in operating costs.

2. Introduction

This report is provided to the PCC of St Luke's Church, Canning Crescent, Oxford 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 Luke's Church, Canning Crescent, Oxford, was completed on the 21st November 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 "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 Luke's Church, Canning Crescent, Oxford	627225
Gross Internal Floor Area	255m^2
Listed Status	Unlisted
Typical Congregation Size	30

The church typically used for 25 hours per week for the following activities (estimated occupancy).

Services	4 hours per week am, (30 people) pm, (40 people)
Meetings and Church Groups	6 hours per week Youth group (20?) Bible study group (20?}
Community Use	15.5 hour per week Residents meetings 6 x (40?) Playgroup (50) Zumba (40) Narcotics anonymous (20) Coffee club (30) Party hire 26 x (60) Wedding reception 6 x (100) Music meetings 6 x (40)

Annual use = 1320 hours

Heating hours: estimated 230 hours based on annual gas bill.

Estimated footfall = 16,700 people

3. Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Luke's Church, Canning Crescent, Oxford and have been reviewed against the current market rates for energy.

The current electricity rates are:

Single / Blended Rate	13.370p/kWh	At lower range of current market rates
Standing Charge	29.610p/day	N/A

The current gas rates are:

Single / Blended Rate	4.200p/kWh	Above current market rates
Standing Charge	Zero p/day	N/A

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

4.1 Annual Consumption

St Luke's Church, Canning Crescent, Oxford uses 3,530 kWh/year of electricity, costing in the region of £370 per year, and 5,600kWh/10 months of gas (January – October), costing £780.

This data has been provided by the church with only one bill being viewed; the gas projection for the whole year is 7,000kWh, costing around £1,000. This is very low, especially given the regular use hours of the building; although this may indicate that the 2014 rebuild used optimum levels of insulation.

St Luke's Church, Canning Crescent, Oxford has one main electricity meter. There is one gas meter serving the site. The meters were not viewed. It is recommended that the church consider asking their suppliers to install smart meters, if not already installed, so that the usage can be monitored more closely and the patterns of usage reviewed against the times the building is used.

Utility	Meter Serial	Type	Pulsed output	Location
Electricity – Church	S02C49995			
Gas – Church	G4 K00033381301			

4.2 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	HALL 6 x T8 1.2m 5 LED downlighters OFFICE + KITCHENS + STORAGE 18 x T8 1.2m CHILLOUT ROOM 5 x LED floodlights 30W TOILETS 6 Ceiling mounted circular (assume CFL 20W) TOTAL	1162W	1534	
Heating Gas	Gas Central Heating Glow Worm Ultracom 30CXi	30kW	7000	
Cooking Gas	Gas hob weekly light use + 6 heavy uses per year = 75 bours use	?	150*	

Hot Water	Kitchen Lincat water heater (left on standby @40W) Plumbed in coffee machine (2 hrs per week) Dishwasher. Hobart Ecomax Kitchenette Coffee maker, Technivorm Thermo King @ 2 hours/week	 3kW 1.4kW 4.2kW 1200W	 400 140 730 120	
Other Small Power	Kitchen Fridge AEG Freezer ARCT 15 Extractor fan 1 hour/week Kitchenette Microwave Fridge AEG Santo Vacuum cleaner PA System Office Computer Printer	 150W 50W 500W 700W 150W 500W 300W 200W	 150 50 26 7 150 100 100 15 10	

Total Annual Electricity Consumption 2019: 3530kWh

Gas cooker use based on 1.5kWh for average domestic cooker use; this is a larger oven.

*One weekly light use at 2kWh x50 + 6 annual heavy uses at 8kWh = 150 kWh

4.3 Energy Benchmarking

In comparison to national benchmarks for Church energy use St Luke's Church, Canning Crescent, Oxford uses only 69% of the electricity and 18% of the heating energy that would be expected for a church of this size[1]. There is currently no benchmark data which takes hours of use and footfall into account.

	Size (m^2 GIA)	St Luke's Church, Canning Crescent, Oxford use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Luke's Church, Canning Crescent, Oxford (elec)	255	13.8	20	10	69%
St Luke's Church, Canning Crescent, Oxford (heating fuel)	255	27.5	150	80	18%
TOTAL	255	41.9	170	90	24.6%

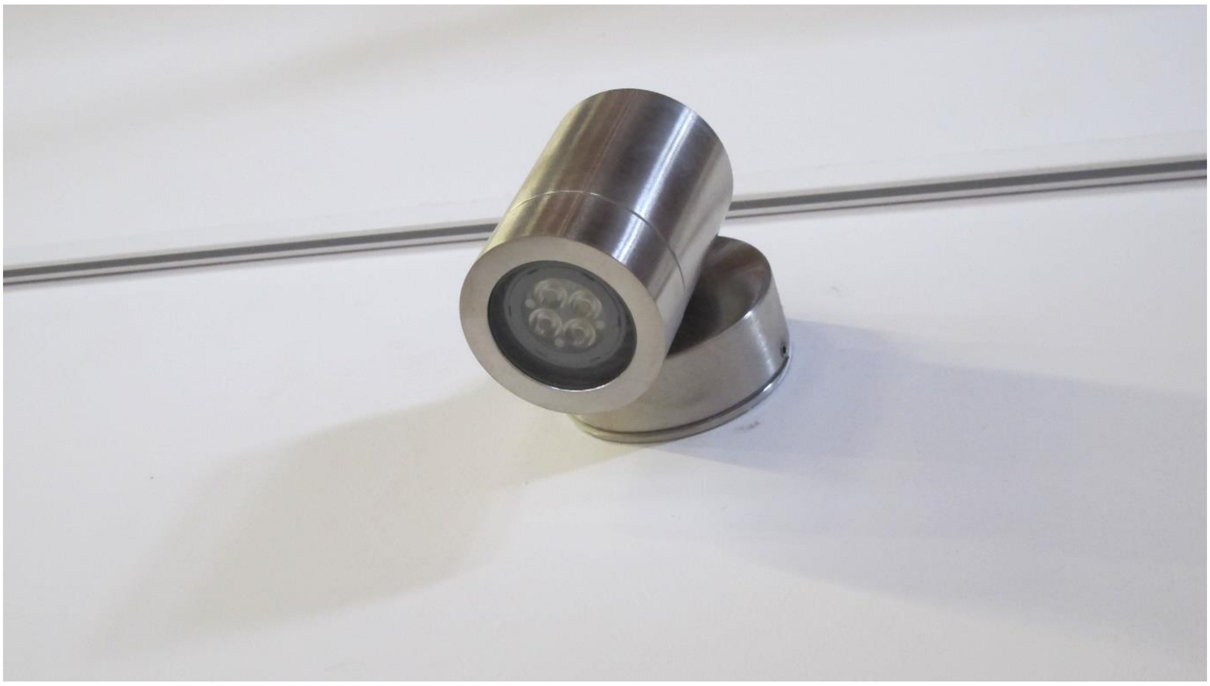
[1] CofE Shrinking the Footprint – Energy Audit 2013

5. Energy Saving Recommendations (Electricity)

5.1 Lighting (fittings)

The church is lit with a mix of fluorescent tubes and LED floodlights as described in Appendix 1.

Whenever the replacement of fluorescent tubes is required consideration should be given to replacing the fluorescent lighting with LED strip lighting which will use less energy and require much less maintenance.



5.2 Refrigeration controls

Install SavaWatt energy saving devices on fridges and freezers

Across the site there are various domestic and commercial refrigeration units such as fridges within staff breakout areas for storage of milk and staff food, and large commercial kitchen fridges and freezers within the restaurant kitchen. 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.

6. Energy Saving Recommendation (Heating)

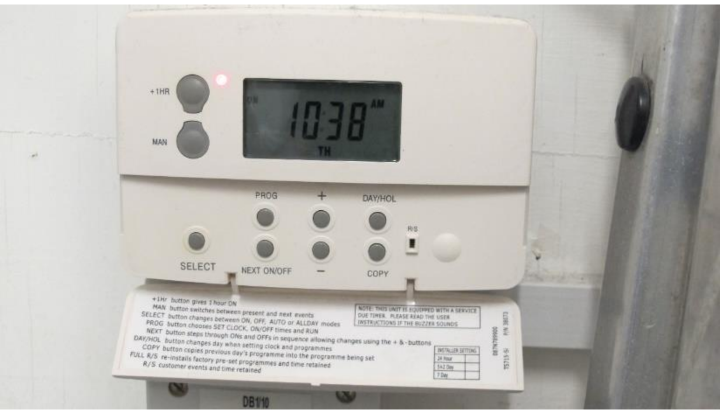
6.1 Heating System and Strategy

The church currently uses gas central heating 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 listed in section 6.

If the gas is to be used as the heating fuel in the long term, the boiler will need to be made hydrogen ready. Hydrogen is due to be added to the gas grid over the next five year period. If plans to decarbonise the gas grid are implemented; the hydrogen mix will eventually exceed 20% and a hydrogen compatible boiler (and piping) will be required. The transition will be overseen by the regulatory bodies in a similar way to that between town gas and north sea gas.

Given the churches usage profile we would suggest that a revised heating strategy for the church would provide a much more efficient use of energy and a more comfortable church.

6.2 Boiler Timing Optimisation



Studies of over 50 churches in the Diocese of Lichfield have shown that the optimum time for central heating to be turned off 45 minutes before the end of the service, as heat is still radiated from the hot radiators.

Purchasing of a temperature datalogger will allow the time for the church to heat (in different weather conditions) to be understood, as well as the time to switch off to be optimised. This would require someone with a computer to plug in the device and download the readings.

A suitable model retailing for around £40 is https://www.lascarelectronics.com/easylog-data-logger-el-usb-1/

6.3 Boiler Set Point

The heating is set to 75°C – this is too high for a condensing boiler to recover heat. Operating at a lower temperature for longer periods will allow the waste heat to be recovered from the flue and increase the efficiency. A second advantage is that the radiators surfaces will not be as hot, reducing risks to the elderly and small children – electric radiators for schools use have a 55°C surface temperature.

6.4 Thermostatic Radiator Valves (TRVs)

Radiators in the church (as below) did not appear to have TRVs fitted.

TRV's can be installed on the existing radiator and allow the users of the room to have some element of control over the temperature in the room and prevent over-heating which often leads to situations where the heating is on and the windows are open. It also allows un-used spaces to have the heating in them turned down.

It is recommended that TRVs are installed on all radiators and users advised as to the best way to operate these once they have been installed. TRV's can be supplied and installed by any good heating engineer.

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.

It is strongly recommended that the heating system is cleaned to remove sludge from the system, this is done by using a chemical clean and/or power flush procedure where cleaning chemicals are put into the system which is then turn on and run through a filter consisting of high power magnetics to remove the sludge.

The cleaning of a heating system can be carried out by any competent heating engineer and typically increases the efficiency of a system by between 10 to 15%. This can dramatically improve comfort for the occupants.

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.

7. Alternative Heating Systems

Alternatives to gas fired central heating would be to run the existing central heating system from an Air Source Heat Pump, or to use overhead radiant infrared heating panels.

In both cases this would increase electricity consumption. The church could install solar photovoltaic panels which would give "free" electricity (the capital cost would have to be paid off) and also benefit from any Smart Export Guarantee tariff for unused power generated.

A strategy could be:

1] Install solar power (once SEG terms are finalised). Reduce electricity expenditure and gain SEG income from excess generation.

2] Replace the current boiler when it is life expired with either:

A heat pump connected to the existing radiator system, or

Electrical heating (Radiant far infra-red panels and some convector heaters).

which would be run from the electricity generated.

Approximate costs for various sizes of solar photovoltaic system are presented in Section 8, together with capital and running costs for a heat pump to directly replace the boiler using the existing radiators, and finally replacement with direct electric heating.

7.1 Heat Pumps

Air source heat pumps are externally mounted units of similar appearance to air conditioning units, which could be installed either on the east side (directly outside where the current boiler is located) or on the north side of the building.

ASHPs consume electricity, delivering between 2.5 and 4 times the amount of heat in kWh that they consume [the Coefficient of Performance, COP]. They work most efficiently delivering low grade heat; so radiators at 40-50°C in frequently used buildings. They would be an inefficient method of heating a church used just once per week, but are suitable for a regularly used building.

Capital cost of a (small) 30kW heat pump; £10-15k.

Annual energy requirement; 1/3 of 7,000kWh; 2800kWh

7.2 Use of Electric Radiant Panels for Heating Specific Areas only

An advantage of radiant heating systems is that they allow small areas to be heated individually without having to heat up the entire building. To cover the hall area adequately, panels mounted on or suspended from the ceiling would be required.

The 10 month [January – October] gas use of 5,594kWh suggesting an annual use of 7,000kWh indicates a well insulated building (as would be expected if constructed to 2014 standards).

This is currently delivered by a 30kW boiler. Replacing this with a mix of mostly radiant overhead panels and some wall mounted electric convector heaters to deliver around 5,000kWh with less heat being used more effectively (without most of the heat going to the ceiling).

Replace boiler by 14kW of panels (12 kW in hall, 2kW in chillout room) + 16k of 2kW convector heaters near kitchen areas (four at north end and one in office and three in hall).

Capital cost 8 x £200 + 25 x £275 = £8,600

Annual energy requirement; 5000kWh

Suitable electric panel heaters would be far infrared panels such as these 550W panels retailing at £275: https://www.warm4less.com/infrared-heaters/ceiling-panels/ . 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.

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
Battery Storage	Yes
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 – not enough surrounding land
Air Source Heat Pump	Potential
Biomass	No – not enough heating load as well as air quality issues

8.1 Solar Photovoltaic 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 SPV system must wait until the SEG terms are guaranteed to assist financial viability.

For St Lukes church, the 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 west-south-west facing roof offers the best site, an area of around 100m^2. This could generate 0.15kWpeak/m^2 giving a 15kWpeak system. A 1kWpeak system oriented south can generate 800kWh annually, giving an annual generation of 12,000kWh. In this case the sub-optimal orientation would yield 85%, 10,200kWh^2. If the ENE facing roof was also used, giving another 100m^2 (a larger area but containing four skylights), this could generate 75% of 12,000kWh; 9,000kWh. At current installed costs of £1,200 per kWpeak, each 100m2 array would cost £18,000

The church's current annual electricity use is 3,530kWh, some of this use will be during the evening and night. Any extra electricity produced could be sold to the grid. The table below indicates approximate costings for different scenarios.

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 church will need to decide on the basis of the capital it can raise, and the plans it has for future hours of use of the building.

The viability of a solar PV system would be increased if a heat pump or electric heating was installed, as this would effectively run on free electricity.

Fully detailed PV design and calculations and quotation can be obtained from Batchelor Electrical, contact Stuart Patience on 01202 266212; 07793 256684; stuart@batchelor-electrical.co.uk.

Roof Area m^2	kWpeak kW	Annual Generation kWh	Installed cost £	Annual requirement from grid, for evenings and nights kWh	Annual cost of grid electricity at current rates £	Exported power and SEG income at 5.5p/ kWh	Sum Annual Grid cost £
	Current	**electricity**	**use**	3,530	370	-	370
	Estimations	**without**	**Heat**	**Pump**			
35 a	5.25	3,570	6,300	1000 b	134	1040kWh £55 c	48
100	15	10,200	18,000	1000 b	134	7670kWh £422	288 income
200	30	19,200	36,000	1000 b	134	16670kWh £2230	2095 income
	Estimations	**With**	**Heat**	**Pump d**			
	Heat Pump	**cost**	15,000	0 e			
100	15	10,200	18,000	1000	134	3870kWh £213	79 income j
200	30	19,200	36,000	1000	134	12870kWh £708	574 income
86 f	13	8,770	15,600	1000	134	2440kWh £134	Break even
	Estimation	with	Radiant	Panels			
100 h	15	10,200	18,000	1000	134	1670 £92	42

a A small system sized to match the building's current consumption

b LED lighting load 1.16kW, assume half of annual use (1320 hours) in dull or dark weather requiring grid electricity = 770kWh, plus other evening use totalling 1000kWh.

c With 1000kWh coming from the grid in the evenings and night, the use of solar generated electricity is 3530-1000 = 2530kWh; any extra generated over this is exported to the grid

d The heat pump replaces gas consumption, saving approximately £750 p.a. plus maintenance.

e 7000kWh of heat is provided by 2800kWh of electricity at a COP of 2.5. This would cost £375 at present grid prices, but would be supplied by SPV generation.

f Optimum sized system – minimum capital cost to run heat pump. However, there is no SEG income to offset the capital cost.

Current electricity use of 3530kWh + ASHP requirement of 2800kWh + enough exported to grid to offset cost of evening and night use (£134).

£134 income at predicted SEG rate of 5,5p/kWh is 2440kWh.

Total = 8770kWh

h For radiant panels, assume heat load 2/3 of GCH so replace 30kW boiler with 30kW of a combination of panels and convector heaters but with lower, perhaps 5000kWh annual use.

Requirement 3530 annual present electric use + 5000 electric heat + 1670 export to offset grid charges = 10,200; i.e. the largest system possible on the west side of the building.

J Annual income £79 + electricity saving £370 + no annual boiler maintenance £100 + 2x boiler replacement avoided over system lifetime, values at £100/year. £18,000/£650pa = 27 years payback period.

K Installation of a battery will add to capital cost but mean reduced grid electricity charges. Assume some grid electricity required in the winter.

9. Energy Saving Measures (Building Fabric)

9.1 Insulation

It is assumed that with the 2014 construction date, the building is insulated to or above current standards.

9.2 Draught Proofing to Doors

The main entry door to the building opens directly into the main space. If the area between the second set of pillars and the doorway was enclosed with further sets of doors, this would create a draught lobby and prevent ingress of lots of cold air every time the doors are opened. A cheaper alternative would be to construct a curtained off area inside to achieve the same effect although this would probably impinge on the use of the room.

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.

Other simple measures for dealing with draughts include using a small fridge magnet painted black over the large key hole 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 shins through sealed or filled in whatever the most appropriate way is for the specific door.

9.3 Closed Door Policy

The main entry doors should be kept closed in cold or windy weather and quickly closed behind the congregation by your friendly welcome team!

10. Saving Recommendations (Water)

10.1 Tap Flow Regulators

With regular groups using or hiring the church, consideration should be given to fitting tap flow regulators in the toilets.

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.

11. Funding Sources

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

12. 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.

12.1 Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Church	6 Fluorescent T12 x 4’ = 240W 5 LED downlights = 100W	none			
Office	3 fluorescent T8 = 108W	None			
Storage 1	0				
Storage 2	1 fluorescent = 36W	None			
Storage 3					
Storage 4					
Storage 5	1 fluorescent = 36W	None			
Kitchen	6 fluorescent T8= 216W	None			
Kitchenette	6 fluorescent T8 = 216W	None			
Toilets	6 fluorescent D shaped in circular diffusers = 120W	None			
Chillout Room	3 x 30W LED floodlights = 90W	None			
External Floodlights	None	None			
External path lights					
TOTAL estimate	**1162W**				

With 1320 annual use hours, this gives 1530kWh lighting use.