Energy Audit and Survey Report

St Michael and All Angels, Leafield

"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

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1 Executive Summary

An energy survey of St Michael and All Angels, Leafield 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 Michael and All Angels, Leafield is a Grade II* listed church dating from the 1858 with the tower dating from 1874, designed by Sir G.G. Scott

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 in conjunction with any plans to reorder spaces within the building.

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?
Replace four gas heaters with four radiant infrared panel heaters for occasional use when church is relatively full					List B	
Under pew heaters in defined small area of nave for regular use	The heat will be delivered where required, less will be needed	Comfort improved			List B / Faculty	

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?
Under pew heaters – increase number if required.		Reduces costs incurred by greater use during week			List B	
Construction of new area at west entrance to nave – Should be fully insulated.	N/A	N/A			Faculty	

Create a draught excluding lobby (internal doors – possibly glass to retain sight lines into nave) Heat with electric panel heaters. Possible underfloor heating.						

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 LED lights to replace CFL bulbs when due [3x lifetime, two purchases of bulbs avoided]	100 [low]	minimal	Same as LED	5 [Lifetime average 20 years]	List A	

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

Based on current contracted prices of 10.59p/kWh (electricity, evening & weekend), 12.59p/kWh (electricity, day) and 3.013p/kWh for mains gas respectively.

If all measures were implemented this would enable the church to increase the hours of use of the building without significant increase in energy costs. With group procurement of 100% clean electricity, the church could achieve both fossil fuel free status, reduction in electricity costs per kWh, and long-term reduction of maintenance costs with no gas equipment to service or maintain.

2 Introduction

This report is provided to the PCC of St Michael and All Angels, Leafield 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 it will be easier 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 Michael and All Angels, Leafield, OX15 4FT was completed on the 3rd October 2019 by Dr. 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 Michael and All Angels, Leafield	
Gross Internal Floor Area	455 m^2
Listed Status	Grade I I*
Typical Congregation Size	10 morning
Occasional events	150 schoolchildren

The church is typically used on average for 2.5 hours per week with an annual usage estimated at 130 hours for the following activities:

Activity	Activity Hours	Lighting hours per annum
Services	1 hour per week 2 hours heat per week in winter	100
Meetings and Church Groups	Occasionally in summer	40
Community Use	Occasional concerts, evening Monthly Saturday am coffee	20 36
Occasional Offices (Weddings, Funerals)	6 per annum (3 hours each) + preparation	30
		230h p.a. lighting total

3 Energy Procurement Review

Energy bills for gas and electricity have been supplied by St Michael and All Angels, Leafield and have been reviewed against the current market rates for energy. Current electricity rates are:

Weekday Rate	12.59p/kWh	Below current market rates
Evening / Weekend Rate [more relevant]	10.59p/kWh	Below current market rates
Standing Charge	18.11p/day	In line with current market rates

The current gas rates are:

Single / Blended Rate	3.013p/kWh	In line with current market rates
Standing Charge	39.946p/day	In line with current market rates

The above review has indicated that the procurement of energy at this church is good and obtaining competitive prices. We would recommend that when the current contracts come to an end 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 electricity (and currently 20% renewable gas) and therefore it is an important part of the process of making churches more sustainable. The exact rates are dependent on the market at the time of application and the number of churches in the "basket", but they will be less than for a single customer.

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

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

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

4 Energy Usage Details

St Michael and All Angels, Leafield used an estimated 747kWh of electricity over a 9-month period during 2018 plus approximately 600kWh for floodlighting over the same period (estimated from partial data). Gas use was 2,240 kWh over a 9-month period during 2018 (31/01/18 to 31/10/18,

estimated readings) costing £176.53. 12-month expenditures were provided. Note that as most of the readings were estimated it is possible that billing has not been correct.

The 9 month data has been taken from the annual energy invoices provided by the suppliers of the site.

Utility	9 months use 31/01/2018 – 30/10/2018	9-month Total including standing charges and VAT	Annual figures supplied [2018]
Gas	2,240kWh	£176.53	£237.71
Electricity	747kWh church 600kWh floodlighting	£142.88 £151.04	£190.30 £195.61

Utility	Meter Serial	Type	Pulsed output	Location
Electricity Church Left hand unit	L88C48325			Distribution board, vestry
Electricity Floodlights Right hand unit	K94C63309			Distribution board, vestry
Gas Church MPRN 4004 465 966	G4A01014651301	Unknown		External gas meter cupboard by lych gate, not accessible by church

All the meters are AMR connected and as such energy profile for the entire energy usage should be possible.

Figure 1 Electricity meters for church and floodlighting.

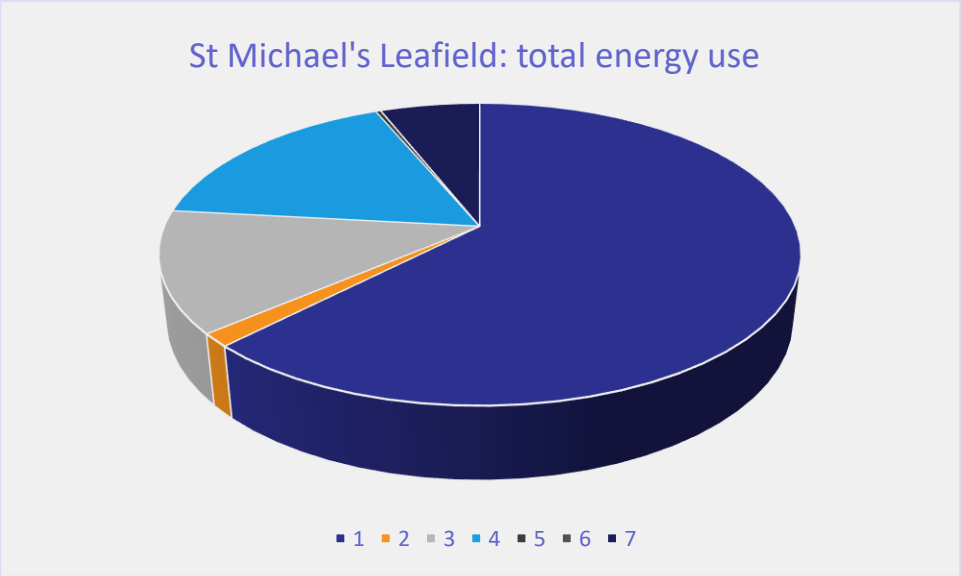
4.1 Energy Profiling

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

Gas	2,240kWh
Electricity annual consumption	747kWh (church)
	600kWh (floodlights)
Annual use hours	130 for activities
[4.5 per week]	230 when lights on (includes preparation, cleaning)

The church has a pipe organ of unknown power – a motor of around 15hp/11kW is possible

Service	Description	Estimated Proportion of Usage
Heating (gas)	Direct radiant heating 2240kWh	62.5%
Heating (electric)	3 portable electric heaters (occasional use) 2kW, 2kW, 1.6kW est 50kWh	1.4%
Lighting (internal)	Total est 2kW / 230 hr 460kWh	13%
Hot Water	Urn used very occasionally est 10kWh	0.3%
Other Small Power	Audio system 0.5kW/ 130hr 0.65kWh	0.02%
Organ	10kW / 20hr 200kWh	6%
Lighting (external)	Floodlights est 2kW / 300hr 600kWh	17%



Key 1: Gas 2: electric heating 3: lighting (internal)

4: lighting (external) 5: small power 6: hot water 7: organ

As can been seen from this data, the gas heating makes up by far the largest proportion of the energy usage on site. The other significant load is the lighting.

4.2 Energy Benchmarking

In comparison to national benchmarks for Church energy use St Michael and All Angels, Leafield uses considerably less energy than would be expected for a church of this size.

However, this is a factor arising from relatively low use of the building.

	Size (m^2 GIA)	St Michael and All Angels, Leafield use kWh/m^2	Typical Church use kWh/m^2	Efficient Church Use kWh/m^2	Variance from Typical
St Michael and All Angels, Leafield (electricity total including floodlighting)	455	2.96	20	10	15%
St Michael and All Angels, Leafield (electricity internal)	455	1.6	20	10	8%
St Michael and All Angels, Leafield (heating fuel)	455	4.9	150	80	3.2%
TOTAL	455	7.9	170	90	4.6%

The church consumption is very low; this is due to the small number of usage hours; a pattern of two morning and one evening service per month, and a small number of occasional offices gives around 130 hours usage per year – perhaps 230 hours when lights are on given extra time for preparation and cleaning.

Typical figures for comparison which are adjusted to reflect occupancy are not currently available. A church open for two Sunday services, a monthly midweek event, Friday evening events and occasional school visits gives 600 hours annual usage. A city centre church with events on weekdays, Saturday mornings and every night of the week will accrue around 5000 hours usage per year.

5 Energy Saving Recommendations

5.1 Lighting (fittings)

The lighting makes up 30% of the overall energy load.

The light levels were measured during daylight hours. Readings were as follows:

Location	Level (Lux)	Comments
Chancel	200 in centre	good
Chapel	90	adequate
Nave centre **Nave pews** Nave below lights	36 to 40 60 to 70 110	Low Just enough

Recommended lux levels are 200 in restaurants, 300 in classrooms. As people age they need more light to read. The church should ask its congregation if light levels are sufficient. If not, experiment with LED lights of high lumen output close to where people sit.

Most of the lamps in the nave appear to be compact Fluorescent lamps (CFLs), which in time should be replaced by LEDs. This will reduce power from around 15W per lamp to 10W, so a minimal saving on electricity but, on average give a longer lifetime. It is worth looking at Parish Buying to make a bulk order, rather than fitting piecemeal as CFLs come to the end of their life. When they begin to fail is the time to make a bulk order. Consider the colour temperature; a lower number gives a warm, yellow light (2700K), whilst higher numbers give a bright, white light (4000K, which can confusingly be referred to as “cool”) whereas daylight is 6500K. A level of around 3500K is often the most suitable for churches.

Figure 2

The chancel has four spotlights, and floodlights. If the floodlights are high power 250 or 500W bulbs they should be replaced by LED floodlights.

5.2 Lighting (control for internal lights)

When the church is re-ordered, there will be a requirement for local lighting in the new area – this should be carefully designed to create a comfortable and well-lit space and should have independent switching for each area. Recommended switches are person controlled but will switch off automatically if the room is left empty. The lighting should be designed to give Lux levels of 300 with dimming – much more than the church at present.

The church would benefit from a colour coded diagram correlating switches and lights to assist in switching the relevant groups of lights on to achieve various effects (e.g. low-level lighting for Christmas services, but full power for hymns).

5.3 Lighting (control for external lights)

It is suggested that the steeple floodlights are controlled by a timer and light meter so that they are only on from dusk, and the timer switches them off at a suitable time (no later than 11pm).

Gate lights should be controlled by a PIR detector, so they only come on when a person is detected. The time illuminated should be long enough for an elderly person to make their way into the church.

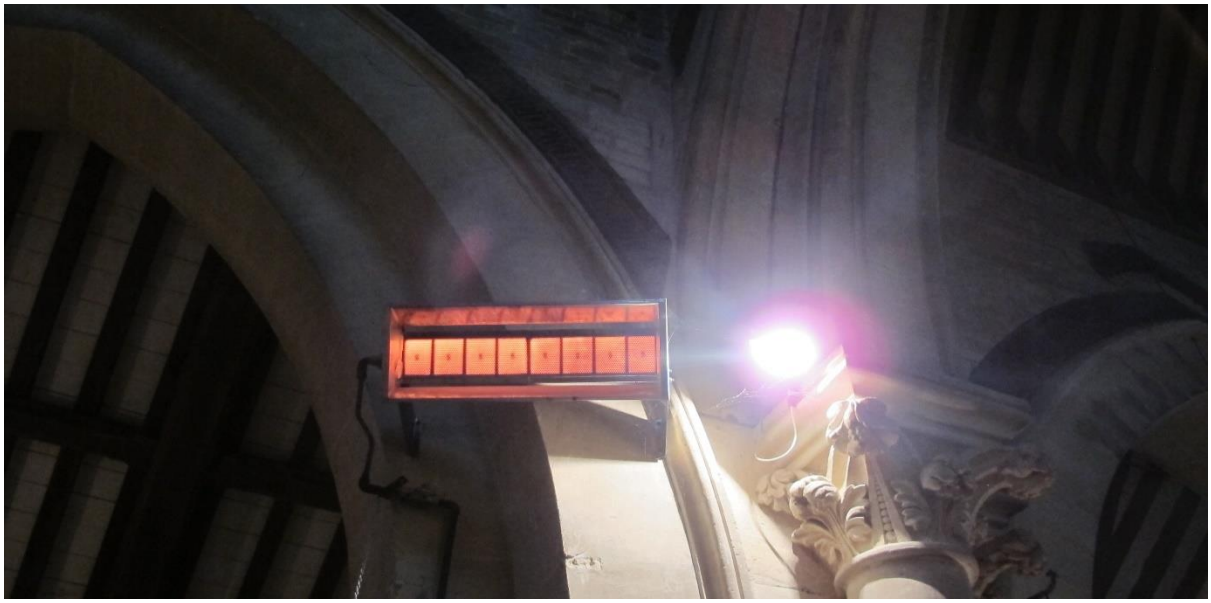
5.4 Heating Overview

As with most medieval churches, this church would have survived most of its life without any form of heating; the modern additional of heating is not needed to preserve the fabric but only to provide thermal comfort to occupants. The previous trend of 'conservation heating' for fabric issues is now largely considered to be unnecessary and is being avoided by the likes of National Trust and English Heritage.

Occupants comfort depends to an equal extent on air temperature and radiant surface temperature.

Adjacent cold surfaces such as pillars and walls, which readily accept radiant heat from bodies can be covered with soft furnishings (traditionally, tapestries were used for this purpose, and wooden panelling in some churches). At St Michael and All Angels, it appears that a small congregation can easily distribute themselves to sit away from the walls and pillars. The overhead radiant heaters are above the pillars; they are of the direct gas heating type where the exhaust gas and water vapour goes directly into the body of the church (and goes upwards!). The small number of usage hours of the church may contribute to the survival of the organ – if a system like this is used regularly then larger amounts of water vapour enter the building, and when the church is allowed to cool, the changes in relative humidity strongly affect organ pipes. The recommendation for relative humidity levels for conservation is between 40 and 70% RH, with 45-55% preferred.

Figure 3 Gas Radiant heater in chancel with ceramic plates.



The planned reordering of the church will create two different zones

1] The body of the church (main portion of the nave and chancel).

2] New room(s) at west end of nave

5.5 Nave – Under pew heaters

Continued use of the wall mounted gas heaters may be expected to lead to problems with humidity, especially if construction of the new room means that draughts through the west door are eliminated.

It is recommended that these heaters, along with their pipework and operating chains are removed

Instead, under pew electric heaters are recommended. St Michael's and All Angels have fixed pews; if this is to be maintained in most of the nave then this is compatible with underpew heaters. Due to the low normal occupancy, a small zone of pews could be fitted out with under pew heaters, rather than the whole nave. This area could also be given enhanced lighting. Further areas could be added later as necessary.

Modern under pew heaters can deliver heat where and when it is needed.

Two most popular under pew heaters within churches are BN Thermic PH30 heaters (http://www.bnthermic.co.uk/products/convection-heaters/ph/) or similar from http://www.electricheatingsolutions.co.uk/Content/PewHeating. Cable runs to the pew heaters could run to the adjacent vestry / organ area where there would be power, or alternatively to the new vestry area on the south side and incorporated with its redevelopment. (All cabling should be in armoured cable or FP200 Gold when above ground) to the both rows of pews quite easily).

Although, in the UK, electricity is currently around 4x the price of gas per kWh, annual service and safety certification costs will be removed (5 yearly Electrical Installation Certification Report instead). The system also only needs to be on when the church is occupied with no warm up beyond about 20mins needed so electric under pew systems are amongst the cheapest to run.

5.6 Nave - Electric Radiant Heating Panels

Electric radiant far infrared panels are an option to be used in addition to under pew heaters, located in areas where there are not pews such as near the font or behind the altar. Modern far IR heaters appear as flat panels, which can be coloured to blend in. They do not glow. [There are near IR heaters which glow pink, or the older incandescent bar radiators which are orange – these are not recommended]. These could be used to give more widespread heating for major services.

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.

5.7 Reordering – new room insertion

New rooms aimed at providing community facilities, kitchen, toilet, vestry, church office are planned to be installed at the west end of the nave; inserted under the first set of arches.

The heating planned should take account of the occupancy and use pattern which is intended and be designed to be independent of the main body of the church so these new facilities can be heated without heating the rest of the church.

The proposal for the successful heating system in this areas heavily depends upon its usage, if the space will be used for 8 hours a day, 5 days a week then a system which maintains a base temperature (e.g. around 10-12^{o}C) is compatible with this regular use (not so with a church which is only used once per week). Top up heat for weekday use would continue to be needed.

The planned flooring for this area will have an impact on the choice of heating. If a new floor is allowed, this allows for some sort of underfloor heating to be installed. Underfloor heating served from an air source heat pump may be possible and could be used to maintain a base temperature which could be supplemented by electric fan assisted convector heaters.

If underfloor heating is not possible, a mix of radiant far infrared panel and fan assisted convector heating is an option to discuss with the DAC and the architect.

Figure 4

Layout of rear of church, screened off area proposed for first bay. Useable radiant heaters to left and right. Four condemned (white) heaters on pillars and each side of doorway arch.

5.8 Quattro Seal

The external doorways have the original historic timber doors on them, where these do not close tightly against the stone surround a large amount of cold air will enter the church around the side and base of these doors.

It is recommended that draught proofing is fitted to all external doors. 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

Where there are large keyholes (south porch door?) these can be covered to prevent draughts.

6 Renewable Energy Potential

The potential for the generation of renewable energy on site has been reviewed and the viability noted.

Renewable Energy Type	Viable	Comments
Solar PV	Yes	Low priority
Battery Storage	Yes	Low priority
Wind	No	
Micro-Hydro	No	
Solar Thermal	No	
Ground Source Heat Pump	No	
Air Source Heat Pump	No	
Biomass	No	

There is potential for a small PV array on one of the low angled roofs as they do not appear to be visible from the road or other buildings. 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 churches electricity 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.

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. It would then be worth evaluating whether a solar PV array plus battery would provide electricity for existing or new infrared radiant heaters (and possible heat pump) more cost effectively than a 100% renewable electricity contract.

7 Funding Sources

This audit programme offers each participating church the chance to apply for a grant of up to £150 towards implementing some of the audit's recommendations. An application form is included with this report.

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 .

Trust for Oxfordshire's Environment (TOE) does have some funds available (over and above the small implementation grants of £150 available through this scheme) to support energy efficiency improvements in community facilities. If your church is used by the wider community, visit www.trustforoxfordshire.org.uk or contact admin@trustforoxfordshire.org.uk to find out if your project is eligible for a grant of up to about £5,000.

8 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.

9 Other Observations

There is a large churchyard which has potential for having a wildlife conservation area (e.g. wildflowers, bug hotel, nest boxes) and interpretation panels for visitors which could describe the wildlife, and church history. This might be another way of engaging with the primary school.

The church has a positive vision for using church as the centre for the community, which is missional through seeking to serve the community by hosting social activities and children's activities. The new construction planned for within the west end of the nave has the potential for being low energy and bring the building into greater use.

Disclaimer

Inspired Efficiency give no specific endorsement to any third parties products or advice mentioned in this document. The information is provided to illustrate technology which may be suitable; however, it is the PCC's responsibility to ensure that any new equipment is suitably specified and meets DAC approval requirements.

Appendix 1 – Schedule of Lighting to be Replaced or Upgraded

Room/Location	Number of Fittings	Recommended Upgrade	Annual Saving (£)	Total Cost (£)	Payback
Chancel floodlights	2	LED floodlights	£10	20-50	2-5y
Chapel floodlight	1	LED floodlights	£5	10-25	2-5y

Plan to replace all lighting with LEDs, using bulk buying such as Parish Buying to reduce costs.

Savings from replacing internal floodlights are low due to low usage hours at present.

New LED units cost £10-25 and consume ten times less electricity.