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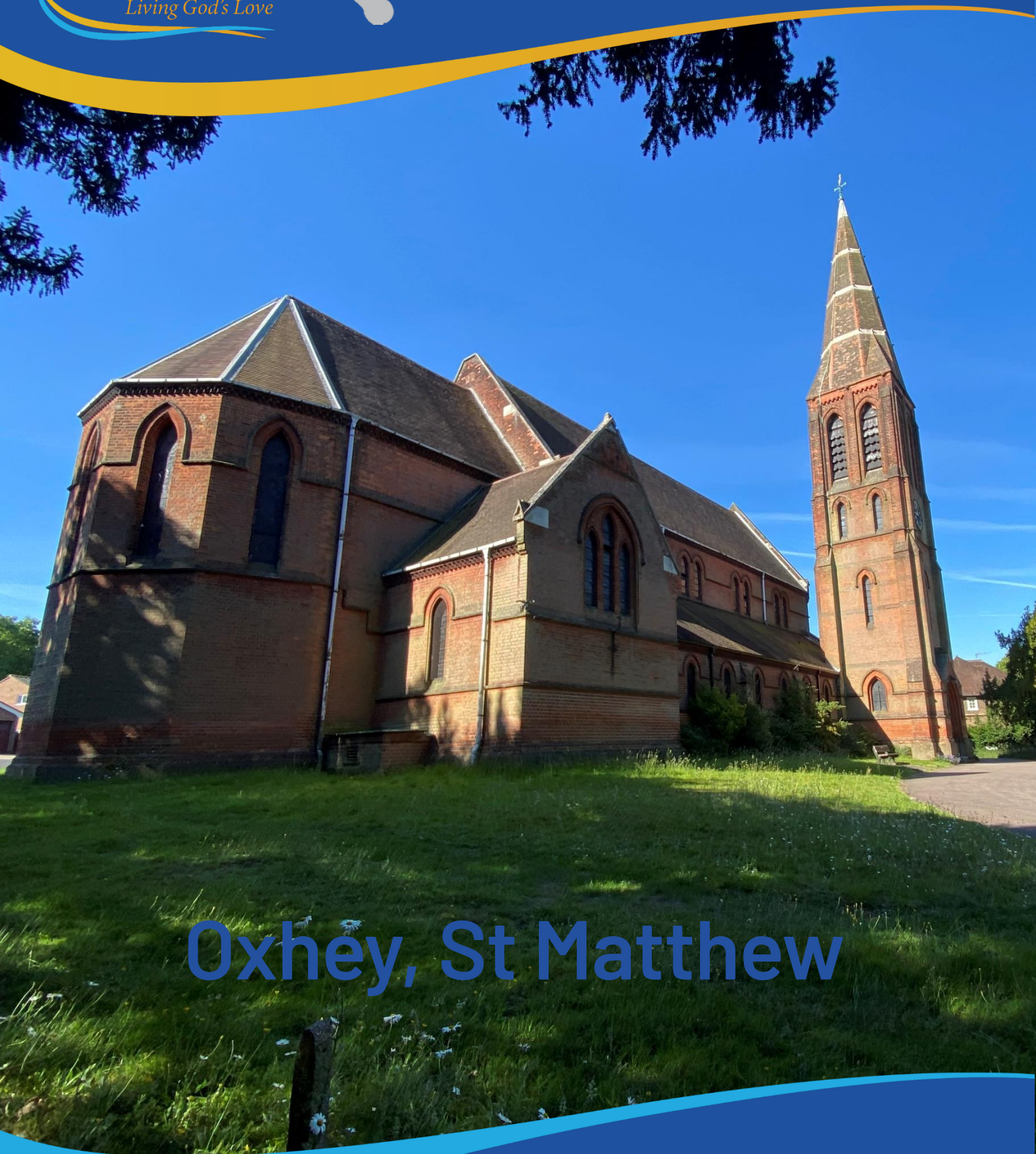

Oxhey, St Matthew

Heating Case Study

With thanks to Susan Logan MCIBSE C.Eng, Managing Director of Ecoteric who carried out the consultancy work

Context

Oxhey is a 19th and 20th century suburb to the south-east of the centre of Watford. St Matthew's church sits at the northern end of a tapering area of development. To the north-west is Eastbury Road, Oxhey Park and the River Colne. To the east is the railway and underground with a line curving north towards Bushey station.

St Matthew, Oxhey is a Grade II listed building.

The churchwarden described the general situation of the church in this way:

> *Our long-term aim is to be able to open up the church as a hub for the community but that is not possible with the current, erratic heating system. The area surrounding the church is not very large and we have 3 houses plus the Vicarage and a small parking area behind the church. The local population is a mix of retired, local workers and commuters and there is a railway link to London and bus links to central Watford and surroundings.*

The church building has a footprint of 592 m^2. In 2019 the average Sunday attendance was 33 with a midweek average of 3.

The heat energy source is mains gas.

Current Energy and Carbon Use

Fuel	Energy kWh	Carbon $kgCO_{2eq}$
Gas	65,000	11,960
Electricity	10,500	2,447
Total	75,500	14,406

Figures for 2021-22, average reported carbon factors for the year

The energy use is therefore 128 kWh/m² per annum. This is below average when compared with the results from the energy audit report Energy Audit Report 2012/13 - The Church of England where the average is 150 kWh/m² per annum, however the underheating is likely to account for this. The usage would likely be typical if the heating was adequate with the current system. The figures also are likely to include some periods when the church was not in full use due to covid restrictions.

Current System

The current system is a 115kw (maximum) Potterton Rapido pressure jet gas fired dating from 1993.

It is reported that it is difficult to get parts. At new, it would have been 90% efficient but is probably running below that, maybe 85%.

The boiler is located in an undercroft which is currently satisfactory, but modern electronics tend not to last for the full service life in subterranean environments which have an element of dampness.

Heating emitters are steel panel radiators probably dating from the 1970s and there is finned tube heating running in the ducts with cast iron grating.

The electricity supply is 3-phase, believed to be 60A per phase.

The church reports that they struggle to get to 18°C despite the heating being left on all the time in the heating season set at 13°C. The need to leave the heating on may become unaffordable and wastes energy and carbon. The congregation need to wear coats when seated.

The overall judgement is that the current heating system is undersized and needs at least partial replacement.

Priorities of the church

The church's main priorities were reported as:

- **Addressing climate change with net zero ambition. Although not yet an Eco Church, there is a desire to phase out gas**
- **Timescales for upgrading due to age of the boiler, although this was not as old as first thought**
- **Comfort because wearing coats was not considered acceptable for the mission and vision of this church**

The parish also wished to keep running costs low but were mainly concerned with efficiency of a system. There was also a desire to be able to control the system remotely by a select group, but this would need to be simple. Weather compensation and optimum start was not preferred owing to previous negative experience. There was some capital available for installation costs already available. There was enthusiasm from the PCC and high capability to enact recommendations. It was accepted that there may be a need for additional professional advice.

Opportunities, barriers and special factors

The church has a reasonable amount of land around the building. The church reports that there is no known archaeological importance associated with the land and it has not been used for burials. **This land offers high potential for low carbon solutions** such as a ground source heat pump (GSHP). A GSHP would probably need to be of the borehole type as horizontal collectors would require too much land to provide a meaningful heating output for the church.

There was housing in close proximity to the side of the church which is least obtrusive and, therefore, a possibility for siting an air source heat pump (ASHP). These can have a perceivable noise impact, especially if they run at night. Alternative locations are more visually obtrusive towards the side and front of the church but would be better from an acoustic point of view. Acoustic advice is recommended if ASHPs are proposed, along with the views of the DAC.

What options were considered?

Direct Electric

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. The current electric supply is 3-phase 2. The church is large and direct electric heating would be prohibitive in terms of running cost for this large church 3. Electric source heating is not therefore considered suitable, apart from spot heating to specific small areas	1. Overhead radiant (black or red/gold) Not preferred by church. On their own creates warm head cold feet. Needs additional heating. Discounted. 2. Chandelier radiant. On its own creates warm head cold feet. Needs additional heating. Not preferred. Discounted 3. Panel heaters – too expensive in running cost. Discount as a main heating source but could use in vestry. 4. Electric heated cushions. Not suitable as no pews therefore discount 5. Underpew heating –discount as no pews.	1. A three phase electric supply is available 2. Direct Electric heating would be expensive to run as the church is used extensively but heat pump solutions which provide between 2.8-4 times the output relative to the input would be possible – see next section 3. Local direct electric solutions may provide additional comfort in specific areas but direct electric heating is not a solution for the whole heating system.	1. For comfort level heating at current electricity costs, the estimated running costs with the Trust Electrical heating solution for which a quote was obtained would be around £30,000 not including VAT or CCL. 2. Radiant would be less in terms of running cost but is not considered satisfactory for the mission and vision of this church.

Gas

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. Gas is the current source 2. There is plant space available and a design for replacement boilers in the vestry – use of undercroft not preferred as	1. Retention of the current emitters is viable but noting that some the space is very underheated. 2. Could augment the current system with fan convectors on a separate new circuit e.g. SPC Belgravia fan convectors connected to a heat pump with potential top up from a boiler. This would be a mix of emitters in the same space. This would allow a phased approach which may be easier to fund Alternatively (and preferably) replace whole system with fan convectors and/or radiators.	1. If gas is retained the church would need to consider future cost risk however using it as top up only would balance risk between gas and electricity prices. 2. The boiler could be retained to provide top up heat in very cold weather.	1. Running cost would be proportionate to current costs – costs would rise in line with improvement of output of system. This would be offset to an extent if new fan convectors and smaller pipework was installed as pre heat time would be less. Improved boiler efficiency would significantly lower running costs.

electronics can fail. 3. As there are viable lower carbon options, not considered suitable on its own or as a long term solution but could be considered as top up alongside a lower carbon source	3. Could retain finned tube in ducts if cleaned and ducts insulated 4. If any pipework is retained, should upgrade heating pipework to remove all remaining cast iron, repair and flush out system thoroughly. 5. Underfloor heating not currently considered optimal as timber floor is not suitable for underfloor heating and would have to be replaced. This would make this a very expensive option and additional rapid response emitters in tandem such as fan convectors would be advisable.	3. Good controls would be needed to ensure the heat pump always works to capacity before the boiler fires. 4. Any proposed gas boiler should be suitable for conversion to Hydrogen 5. This option does not address climate change agenda on its own.	2. Estimated at £12,000 per annum all gas, including standing charge but excluding VAT and CCL 3. Capital costs would be around £70,000 based on Christopher Dunphy quote and allowing for inflation for full replacement although could be less with competitive tender

Air source heat pump - air-to-air

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. These have the appearance of commercial air conditioning units, need bulky pipes and cables between the indoor and outdoor units. 2. The systems would need to be multi split type given the size of the church. These systems link several "indoor" units (see emitters) to a single "outdoor" unit 3. See note in "opportunities, barriers and special factors" section above – a suitable location for outdoor units which have noise emissions needs to be found 4. Would be suitable for the vestry and church providing suitable locations found for the outdoor units	1. Emitters are wall mounted air conditioning type units 2. They can be mounted in casing (chassis type) if preferred by DAC/church	1. Running costs would be reasonable as 2.5-3 times heat produced from 1 unit electricity. 2. Electricity is an increasingly low carbon energy source. 3. 3-phase electricity needed. 4. Can be installed in phases whilst keeping existing system running and as funding permits 5. Can run several indoor units to a single outdoor unit but cable and pipework routes need to be planned sensitively. 6. Viable providing suitable locations can be agreed for the outdoor units	1. Capital Cost moderate and on a par or less than gas heating proposal although likely to be more than direct electric heating. However running costs much lower than direct electric. 2. Running cost £10,000-£11,000 based on current electrical cost of 34.7p/kWh including standing charge but excluding VAT and CCL 3. Running cost on a par with gas but carbon lower or nil on true green tariff

Ground source heat pump (GSHP)

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. There is an area in the churchyard at the front 2. 3-phase electrical supply available 3. Generates water at 40-50°C so needs low temperature system and/or top up from higher temperature source such as boiler 4. Ground investigation required by specialist contractor to confirm if soil type suitable. Reported to be heavy clay so not necessarily suitable and independent advice recommended 5. Considered potentially suitable with heating system upgrade. 6. Pipe route between churchyard and church possible 7. Vertical boreholes take up less land and would be more suitable than horizontal collectors	1. Emitters suitable for lower water temperatures are required 2. Underfloor heating not currently considered optimal as timber floor is not suitable for underfloor heating and would have to be replaced. This would make this a very expensive option and additional rapid response emitters in tandem such as fan convectors would be advisable. 3. Oversized radiators and fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors would be suitable 4. Ideally complete heating system replacement with this option	1. Ground source heat pumps should attract Government Clean Heat or similar grant schemes depending on eligibility criteria 2. This option will require at least a partial heating system upgrade 3. A GSHP has a more reliable performance which is steady across the year compared to air source heat pumps where the efficiency (COP) fluctuates dependent on the outside temperature 4. Overall, this combination is recommended where budget and funding permits 5. Viability is dependent on ground conditions 6. Recommend to use in tandem with gas as top up in very cold weather.	1. The Ground source heat pump would be the most expensive solution in terms of capital cost, in excess of £100,000 2. The costs are based on 4 times the electrical input as heat output, and would be about £8,000-£9,000 based on current electrical cost of 34.7p/kWh including standing charge but excluding VAT and CCL 3. Gas would be in addition to this in extreme weather 4. Carbon lower or nil on true green tariff

Air source heat pump (ASHP)

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. See note in "opportunities, barriers and special factors" section above - a suitable location for outdoor units which have noise	1. Emitters suitable for lower water temperatures are required 2. Underfloor heating not currently considered optimal as timber floor is not suitable for	1. Air source heat pumps should attract Government Clean Heat or similar grant schemes depending on eligibility criteria 2. This option will require at least a	1. The Air source heat pump system would be more than air-air, gas and electric system but less than GSHP

emissions needs to be found 2. 3-phase electrical supply available 3. Generates water at 40-50°C so needs low temperature system and/or top up from higher temperature source such as boiler 4. Has a noise level externally but could be located such that it would not cause nuisance. Acoustic advice recommended. Considered suitable	underfloor heating and would have to be replaced. This would make this a very expensive option and additional rapid response emitters in tandem such as fan convectors would be advisable. 3. Oversized radiators and fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors would be suitable 4. Ideally complete heating system replacement with this option	partial heating system upgrade 3. An ASHP has a less reliable performance than GSHP. Bills will therefore vary substantially as the efficiency (COP) fluctuates dependent on the outside temperature 4. Overall, this combination is also recommended where budget and funding permits 5. Viability is NOT dependent on ground conditions 6. Recommend to use in tandem with gas as top up in very cold weather.	2. The costs are based on 2.5 times the electrical input as heat output, and would be about £11,500-£12,500 based on current electrical cost of 34.7p/kWh including standing charge but excluding VAT and CCL 3. Gas would be in addition to this in extreme weather 4. Carbon lower or nil on true green tariff

Solar PV

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. Photovoltaic panels cannot provide the whole of the peak heating demand, although they could provide part. 2. The output (unless battery storage is provided at additional cost) is only available when daylight is available and as such is not suitable as a sole source. 3. Permissions for PV on will be difficult if roof mounted. Roof fixings would need the advice of a structural engineer. There is a significant south facing area available 4. Church hall may be demolished in the future although panels could be demounted and re-used so should not discount here. Need to check roof is strong enough. Has nearly flat roof although some is overshaded by trees	1. As per the air to air heat pump options for the church hall 2. As per the air and ground source options for the main church.	1. Part solution only and adds cost to installation 2. Overall, if affordable and permitted under faculty, PV would be a valuable contribution to the carbon footprint of the church and long term preservation of the fabric. Recommend if viable.	1. Capital cost is highly dependent on ease of access and fixing. Panels work out at around £200 -£300 per m^2 plus cabling and concrete base. One m^2 provides about £7-8 per annum of electricity. 2. Typically 11 years payback is quoted for PV but this is for applications where grid electricity is offset on a daily basis and the installation is straightforward. 3. There are no running costs- PV is a net

5. PV would be a significant contributor to offset carbon. 6. Considered suitable on the church hall where usage is higher, possibly viable on the south facing main church.		3. Battery storage could be included now, or in the future to extend the availability of electricity.	contributor and will reduce the running costs quoted for the heat pump options

LPG and Oil

Suitability	Emitter options considered	Summary and observations
A new boiler and tank would be required. Comparable with oil in terms of cost and carbon and therefore not considered further as no advantage		

Biomass

Suitability	Emitter options considered	Summary and observations
1. Biomass would require substantial plant and fuel storage space and an external plant space. 2. Not suitable in an urban area due to air quality emissions therefore discounted	Emitters are as described for gas boiler option.	Not suitable

Viable options

Based on the above and further discussions with the parish, the viable options for heat sources were:

- **Air-air heat pumps**
- **Air-water heat pumps**
- **Ground source heat pumps**
- **Hybrid of the above with gas boiler sources as supplementary source**
- **PV, subject to faculty and consultation**

This means that direct electric heating, LPG, oil and biomass were discounted as options and should not be explored further.

Conclusions

Of the options considered, there are viable options for a "wet" system, that is radiators, underfloor heating and fan convectors fed by air or ground source heat pumps.

The church needs to plan, in relatively short term, a replacement system. The existing system does not provide adequate comfort for the mission and vision of the is church.

Ideally the entire pipework circuit is replaced along with the emitters **but partial retention and a phased approach is possible depending on the option selected**.

To reduce the cost overall of low carbon solutions such as an air-water or ground source heat pump, it is suggested that gas could be retained to provide a top up in extreme weather.

A further option for this church would be air-air heat pumps which could be installed in phases which may help with funding. A partial system could be installed whilst retaining the existing system in the short term to improve comfort and further systems installed as funding permits.

There is a need to locate any external air source plant away from adjacent housing and in a sensitive location which is not obtrusive.

Correctly sized, these options would offer a high degree of comfort and flexibility for a range of uses.

If possible and acceptable under faculty and planning permission, PV panels either on the south roof of the church or church hall could provide a further layer of provision for mild weather and to keep the building and a steady if low temperature at no ongoing cost and with no carbon emissions.

All costs and carbon impact can be reduced if opportunity is taken to insulate and draught proof wherever possible, under the advice of the architect.