DIOCESE OF ST ALBANS
Living God's Love

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Biggleswade, St Andrew

Heating Case Study

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

Context

Biggleswade was a stopping point on the old London Road while the A1 is a short distance to the west. St Andrew's church is set back from Shortmead Street and the church is a short walk from the historic market place and is a key building in the Biggleswade Conservation Area.

St Andrew is Grade II* listed (see the National Heritage List – Map Search - List Entry)

The parish church is a substantial and traditional medieval building and has been classified as a 'Major Parish Church' by the Church of England. It is mostly Perpendicular in style except for an 18th century west tower and the 19th century restoration of the east end by Butterfield. There is a linked chapter house and hall to the north dating from the 1970s.

The large church building has a footprint of 1,005 m^2. The average Sunday attendance was 158 in 2019 with 2 hours spent on average that day. The mid-week attendance in the same year was 26 with 1 hour as average time spent. (Environmental Footprint Tool data. 2020 figures were less due to Covid).

The wider use of the church by local schools and the community keeps it in use most days of the week. There was a DAC visit on 18 January 2022 which explored the background to the church's heating needs and plans for reordering.

The local authority maintains the surrounding churchyard, administered by Biggleswade Town Council on behalf of Central Bedfordshire. The churchyard is closed for burials.

Current Energy and Carbon Use

Fuel	Energy kWh	Carbon $kgCO_{2eq}$
Gas	180,940	45,159
Electricity	17,291	4,029
Total	198,231	49,188

Figures for 2019-20, average reported carbon factors for the year

The energy use is therefore based on usage per m^2 for gas which amounts to 180 kWh/m^2 per annum, based on a footprint of 1,005 m^2.

This is above 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/m^2 per annum but the relatively high usage is likely to account for the difference.

The church is attended by 90 currently, 120 pre-covid on average for the main Sunday service, and up to 20 for other services with peak services up to 350-400.

Most services are held in the main body of the church. Small services are sometimes held in the south aisle.

The services are mostly traditional with use of the organ although there are monthly more contemporary worship services. A wide range of users are catered for.

Future plans

The following is extracted from the visitation of January 2022 which sums up the plans:-

> *"A site visit in 2018 had discussed the needs of this town-centre church in the context of rapid expansion to the east of the town. Although the needs and potential uses of the church would continue to be reassessed following the pandemic, the uses for worship, performances and children's activities and for services involving the expanding church lower school (now on 2 sites) and church middle school were established, keeping the church in use on most days of the week. The proposals drawn up by the project architect in 2018 envisaged substantial re-seating and the replacement of the existing timber pew platforms with a solid stone floor. A substantial proportion of the estimated £0.25m budget was already available, so the project could be moved forward relatively quickly subject to consultation and permissions once the scope of the project had been reviewed and agreed."*

Current System

The current system is a gas-fired boiler dating from 1970s which has broken down. The casing and insulation have been removed but the boiler is not usable. **Action is therefore very urgent.** A design has been prepared for 2 new gas boilers.

Heating emitters are a mixture of cast iron radiators and fan convectors. The pipework is a mixture of large bore steel and some older cast iron pipework.

There is evidence of corrosion in places and the church reports that the system is losing water, potentially to leakage below ground. It is a 2 pipe system.

It is further reported that, in cold weather, the system is just adequate, the heating runs continuously in winter to maintain 12°C boosted to 18°C for services. This maintains the fabric and the organ, although this is clearly reflected in the energy consumption.

The electricity supply is 3-phase.

The hall has a 10-12 year old gas system independent of the church system. This comprises gas-fired flued heaters and, although currently not a priority, there are lower carbon and safer options available.

Priorities of the church

The church's main priorities were reported as:

- **Addressing climate change**
- **Timescales for upgrading because the boilers were not working, so action was very urgent**
- **Ability to control the system remotely, using a simple system**

The parish also wished to keep running costs low but were mainly concerned with efficiency of a system. Although it was preferable for the church to be warm, wearing coats in cold weather was considered acceptable. There was some capital available for installation costs and there was high capacity to be able to raise funds, including a Friends Group. Time and management skills were also available. It was accepted that there may be a need for additional professional advice and the parish had already sourced professional support and skills for existing proposals.

Opportunities, barriers and special factors

The church and hall should be considered together as this would lead to an integrated approach.

The church has a lot of land around the building. This land offers high potential for low carbon solutions but permissions from the local authority, faculty and archaeology would undoubtedly take time to put in place for a Ground Source Heat Pumps (GSHP). A GSHP would probably need to be borehole type as horizontal collectors would take up too much future burial space. This is considered in the option appraisal.

The church reports that they have a history of complaints from near neighbours regarding noise and light. **Any proposals would need to be handled sensitively and noise attenuation may be required** for air source heat pumps if progressed. Acoustic advice is recommended.

What options were considered?

Options already considered

A full design and specification had been drawn up by a consulting engineer to replace the current boilers. The boilers would remain in their current location.

The existing heating system had not been addressed and, with the funding available, it is recommended that full heating system replacement to the church is considered. This is included in the option appraisals.

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 and likely to be less comfortable than alternatives. 3. Reordering would limit direct heating options such as underpew 4. Electric source heating is not therefore considered suitable,	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 and night storage heaters – needs to be type with boost heater and fan, would need substantial load, difficult to find enough locations. Discount as a main heating source 4. Electric heated cushions. Provides comfort for seated congregation but must be fixed	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	1. Not viable therefore not considered

apart from spot heating to specific small areas	and to fixed electrical points. Must have additional heating to provide uplift in air temperature. Not suitable as pews may be removed therefore discount 5. Underpew heating –discount as pews may be removed.	comfort in specific areas but direct electric heating is not a solution for the whole heating system.	

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 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 and as a short term measure until a lower carbon source can be installed. 4. Could consider a time limited faculty?	1. Retention of the current emitters but noting that some the space is somewhat underheated. 2. Must however replace existing fan convectors with new fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors if and when connected to a heat pump 3. Underfloor heating as part of a reordering considered suitable but additional rapid response emitters in tandem such as fan convectors would be advisable. These could be installed now as part of a heating upgrade with a separate circuit connection left for underfloor heating. 4. Pipework may have some leakage and replacement is advisable. Some corrosion was observed. The plate heat exchanger in the current design could be omitted if this was undertaken.	1. If gas is retained the church would need to consider future cost risk 2. The current design could be simplified to a single boiler and new pipework circuit, reconnecting emitters and putting some new fan convectors in. 3. Provision for future reordering could be made as well as future connection of a heat pump (GSHP or ASHP see options below) 4. The boiler could be retained to provide top up heat in very cold weather. 5. Good controls would be needed to ensure the heat pump always works to capacity before the boiler fires. 6. Any proposed gas boiler should be suitable for conversion to Hydrogen	1. Running cost would be proportionate to current costs – costs would rise in line with hours of use and higher capacity 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. 2. Estimated at £21 per hour at current gas cost (12.53p/kWh) at full capacity, less at part load/ 3. Capital costs would be less than current proposals for a single boiler but then additional capital would be required for a new pipework system and additional fan convectors. 4. Future capital would need to be put aside for the underfloor heating and heat pump.

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. They would be difficult to integrate in this church 3. Not considered suitable for the church, but would be suitable for the church hall providing suitable locations found for the outdoor units	1. Emitters are wall mounted air conditioning type units	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. Plan for future installation to church hall	1. Capital Cost moderate and on a par with conventional radiator systems. 2. Running cost £10-£12 per hour as efficiency good (church hall only) based on current electrical cost of 34.7p/kWh 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 clear of current graves. 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 but considered suitable with heating system upgrade. 5. Pipe route between churchyard and	1. Emitters suitable for lower water temperatures are required 2. Underfloor heating is considered suitable as part of the reordering and would work well with this solution 3. Oversized radiators alone discounted due to lack of adequate wall space and difficulty in delivering heat to centre of church but could retain existing cast iron radiators	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	1. The Ground source heat pump would be the most expensive solution in terms of capital cost 2. The costs are based on 4 times the electrical input as heat output, and would be about £13 per hour at full capacity, less at part load. Based on 34.7p/kWh. 3. Gas would be in addition to this

church possible with archaeological advice 6. Vertical boreholes take up less land and would be more suitable than horizontal collectors 7. Considered suitable	4. Must however replace existing fan convectors with new fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors	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.	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. There is an area around the current boiler house which would be suitable for outdoor units. Space would need to be found for the indoor unit but this could be an external plant room. 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	1. Emitters suitable for lower water temperatures are required 2. Underfloor heating is considered suitable as part of the reordering and would work well with this solution 3. Oversized radiators alone discounted due to lack of adequate wall space and difficulty in delivering heat to centre of church but could retain existing cast iron radiators 4. Must however replace existing fan convectors with new fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors	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 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.	1. The Air source heat pump would be the next most cost-effective solution after gas in terms of capital cost 2. The costs are based on 2.5 times the electrical input as heat output, and would be about £20-22 per hour at full capacity, less at part load. 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.	1. As per the air to air heat pump	1. Part solution only and adds	1. Capital cost is highly dependent on ease of access

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. There is east and west facing unshaded roof in the valley of the church hall. Although less yield would be a much more straightforward option. Suitable for further investigation. 5. PV would be a significant contributor to offset carbon. 6. Considered suitable on the church hall where usage is higher, less suitable but possibly viable on the south facing main church.	options for the church hall 2. As per the air and ground source options for the main church.	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. 3. Battery storage could be included now, or in the future to extend the availability of electricity.	and fixing. Panels work out at around £200 -£300 per m2 plus cabling and concrete base. One m2 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 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	Running and Capital Cost
1. Biomass would require substantial plant and fuel storage space and an external plant space. 2. Space is limited in unobtrusive areas of the churchyard 3. The access for delivery is some distance from any suitable plant location and wood pellets are likely to be in sacks rather than blown, which need manual handling. 4. Although considered sustainable, this depends on the source of the wood pellet/chip. Emissions could be a local issue. Needs input from the congregation for ensuring the fuel is	1. Emitters are as described for gas boiler option.	1. High external impact visually 2. Highest maintenance option 3. After discussion, discounted as too high in risk, cost and reliability	1. Most expensive in terms of capital cost.

kept dry and circulated and to resolve any fuel blockages. 5. Would require excavation for pipework and archaeological watch. 6. May need to retain gas as back up in the event of failure.			

Viable options

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

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

Viable emitters were:

- **Fan convectors (low temperature type only)**
- **Radiators**
- **Underfloor heating (in tandem with fan convectors)**

This means that direct electric heating, LPG 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.

It is recognised that there is an urgency as the current boilers are not working and the suggestion of this report is to simplify the design that has been provided by a consulting engineer to a single boiler.

As well as this, it is suggested that the **entire pipework circuit is replaced as there is suspicion of leakage which would allow the plate heat exchanger to be omitted**. Some low temperature compatible fan convectors could then be added to improve comfort and **provide for a future heat pump**.

The provision for near-term connection of ideally a ground source, or failing that an air to water heat pump is suggested. A longer term installation of **underfloor heating** to take place during the proposed reordering is also suggested.

There is, therefore, the potential to retain some gas which would limit the size and cost of the heat pumps. If a suitable boiler is purchased, it could also be suitable for connection to hydrogen in the future.

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 east-west valley roofs of the 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. This would also offset and reduce carbon from grid electricity and fossil fuel.

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, and this is recommended.

A further option is an **air-based system in the form of air-air heat pumps to the church hall** only to replace the gas heaters which can be undertaken in phases as funding permits.