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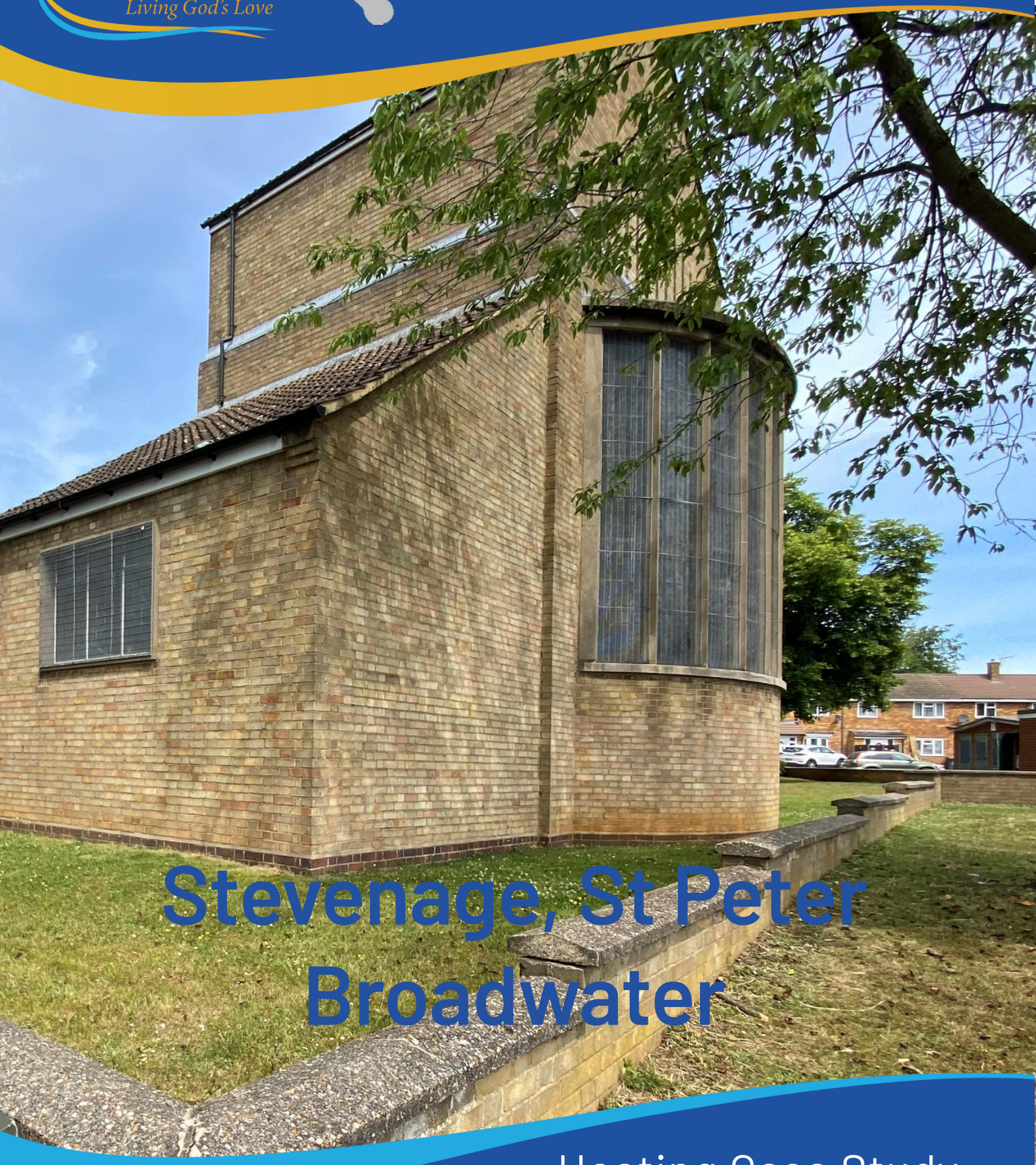


Stevenage, St Peter Broadwater

Heating Case Study

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

Context

St Peter's is within the Broadwater Conservation Area two miles to the south of Stevenage town centre. The area's overall character is that of the mid-20th century New Town development. The church sits on the north side of Broadwater Crescent which runs through the area from west to east. Nearby are houses, shops and garages.

St Peter's church is identified as a Building of Local Importance in the Conservation Area. It was designed by N.F. Cachemaille-Day and Partners and built in 1954. The walls are yellow brick and there is a tower and shallow apse at the east end. The hall uses the same brick and is linked to the church.

The church building has a footprint of 325 m which increases to 612 m^2 with the hall.

There are plans to extend and reorder the front porch and entrance to create a fully accessible approach and more welcoming entrance.

The church and hall are used extensively by the church and local community with up to 6 days per week usage although this tends to be in 2 hour slots. The hall is used on average 20-30 hours per week. There are plans to extend the usage with the addition of breakfast clubs and youth café.

About 80 people including children attend the Sunday morning worship, with 6-8 at Wednesday communion. There is a prayer service on Sunday evenings.

Worship is contemporary with use of speech reinforcement.

The space is flexible with chairs and it is used flexibly, with furniture regularly rearranged to suit the activity in the space. There is an office, kitchen, store and church hall.

Current Energy and Carbon Use

Fuel	Energy kWh	Carbon $kgCO_{2eq}$
Gas	68,299	12,567
Electricity	7,481	1,743
Total	75,780	14,310

Figures for 2019-2020, average reported carbon factors for the year

The current energy use (2021) is reported as approximately 20,000 kWh of gas per annum for the church, however figures were also been supplied for 2019 at 68,299kWh and this has been selected as the most representative as 2021 shows a significant reduced use due to lockdowns.

The church uses the Energy Footprint Tool to calculate their energy performance.

The church and hall energy uses are separately metered so footprint can be calculated for each.

The annual energy use for the church is 239kWh/m^2 per annum for gas and electricity.

The annual energy use for the hall is 79kWh/m^2 per annum for gas and electricity.

Somewhat surprisingly, given the higher use of the hall, this is much more efficient than the church having a lower energy use per m^2.

The church 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.

The usage is typical therefore it can be concluded that the current system and energy use is inefficient.

Current System

The current system comprises an atmospheric gas fired boiler, 77.5% efficient when new and likely to be less now, maybe around 70% efficient. Modern boilers are often 96% efficient as a means of comparison and up to 30% of the gas energy is therefore being wasted. **Just changing the boiler however will not address longer term carbon issues or the effectiveness of the heating.**

The boiler is over 40 years old serving single-pipe system with a few two-pipe additions to serve newer radiators. The radiators are generally older single steel panel type. It is reported that:

- The system needs 5-6 hours preheat
- It does not get up to temperature in very cold weather
- The radiators get very hot (which could be a safety issue given the mixed community use)

- The radiators need bleeding regularly which implies there is air ingress and/or water leakage from the system

The heating system including the boiler, pipework and radiators to the church overall was judged to be inadequate and in need of full replacement.

The electricity supply is 3-phase.

Future Plans

The parish planned an extension to the entrance/lobby of the church. The boiler house is on the same side as the proposed extension and relocating the plant could assist in opening up the frontage of the building. Other plans include the increased use of the church. The church needed flexible, responsive heating which can be easily controlled and heats up rapidly to respond to the current and projected usage.

Priorities of the church

The church's priorities were reported as:

- **Heating the church was the number one priority to ensure the church was usable in winter**
- **Addressing climate change**
- **Running costs due to limited funds**
- **Timescales for updating because the boiler could fail at any time**
- **Comfort - the plans for increased use are partially dependent on comfort**
- **Ability to control the system to respond to flexible usage**

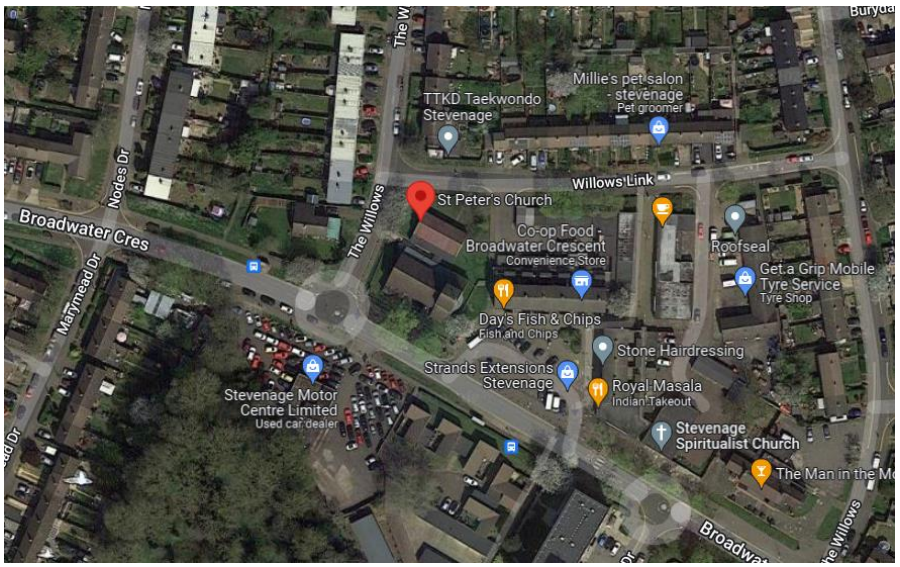
It was also important to keep the capital costs low because funds were limited but no figures were in mind. The congregation was, however, very capable and enthusiastic so there was the possibility of raising funds. There was the capacity to manage a project but skills and project management skills would have to be combined with the entrance area project.

Opportunities, barriers and special factors

Although the church is in a Conservation Area, **the lack of listing is an opportunity**. It should be possible to incorporate solar panels but they would be prominent on the road-facing elevation of the church because this is nearest to the south.

Funding is a barrier for the church but the church was encouraged to seek funding for a full replacement.

Another barrier was available land. Land is limited but it has not been used for burials. Nonetheless, the site was not considered particularly suitable for ground source heat pumps as there is limited land and nearby buildings, including the church, would be very close to any drilling rigs. There were no obvious plans for community or district heating available online.



Google Maps Satellite image of the church and hall (the red marker is over the hall)

What options were considered?

Direct Electric

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1. The current electric supply is three-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. Underpew heating not viable as there are no fixed pews 4. Electric source heating is not therefore considered suitable, apart from spot heating to specific small areas	1. Overhead: Radiant (black or red/gold). 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 appropriate for this church. 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. Not suitable as no pews therefore discount 5. Underpew heating –discount 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.	Not viable therefore not considered

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 although the space could be better used for the entrance project 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	1. Retention of the current emitters discounted as currently underheated and potentially leaking 2. Fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors would be suitable connected to a heat pump. They are safe touch temperature and fast response 3. Underfloor heating is 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 for the future as and when funding becomes available. The existing parquet floor would NOT be suitable for underfloor heating which is a negative factor. New flooring would be required. The current depth of the parquet could be investigated as this depth could be enough to accommodate underfloor heating without extensive level changes which is often an issue in existing buildings. This is a more positive factor 4. Pipework may have some leakage and replacement is advisable. 5. Other options would include low surface temperature radiators which are quiet but bulky and take up wall space.	1. If gas is retained the church would need to consider future cost risk 2. A simple domestic scale boiler could be installed for top up in tandem with a heat pump but the whole system needs replacing and ideally gas would be retained for top up only not as a main heat source. 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	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 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 £7,000 per annum for the church only current gas cost (12.53p/kWh) compared with £8,500 currently including additional capacity of 12kW therefore more comfortable 3. Capital costs would be incurred for a whole heating system and heat source -see below. Gas is not considered suitable in isolation as there are opportunities for lower carbon options, 4. Future capital may need to be put aside for the underfloor heating

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 pipes and cables between the indoor and outdoor units. 2. They would be possible to integrate into this church with care on routes 3. 3-phase electricity is available and would be required 4. Considered suitable for the church, and would be suitable for the church hall 5. Suitable locations were found for the outdoor units on the flat roof areas of the church and link to church hall although acoustic advice would be needed as there is housing in the vicinity and the outdoor units would need to meet residential noise limits. This was not seen as insurmountable.	1. Emitters are wall mounted air conditioning type units 2. They can be housed in casing, but this is not always necessary, depending on views of the DAC 3. The emitters blow warm air and are generally fairly quiet. 4. They are fast response and easy to control	1. Running costs would be reasonable as 2.5-3 times heat produced from 1 unit electricity. Savings assume 3. 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 – this is a major advantage where funding is limited 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 as well 7. Considered suitable	1. Capital Cost moderate and on a par or less than a conventional radiator systems but can be installed in phases unlike a "wet" radiator or fan convector system which would need full replacement in a single or at most 2 phases. 2. Estimated at £6,000 per annum for the church only compared with £8,500 currently including additional capacity of 12kW therefore more comfortable, based on current electrical cost of 34.7p/kWh 3. Running cost is less than a new gas boiler with 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 around the churchyard clear of graves however limited space and proximity of buildings along with very high capital cost limits suitability	1. Emitters suitable for lower water temperatures are required	1. Ground source heat pumps should attract Government Clean Heat or similar grant schemes depending on eligibility criteria 2. This option will require a full heating upgrade	1. The Ground source heat pump would be the most expensive solution in terms of capital cost

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		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.Viability is dependent on ground conditions and funding 5.Overall not likely to be viable.	therefore running costs not calculated

Air source heat pump (ASHP)

Suitability	Emitter options considered	Summary and observations	Running and Capital Cost
1.Suitable locations were found for the units on the flat roof areas of the church and link to church hall although acoustic advice would be needed as there is housing in the vicinity and the outdoor units would need to meet residential noise limits. This was not seen as insurmountable. 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.Considered suitable	1.Retention of the current emitters discounted as currently underheated and potentially leaking 2.Fan convectors suitable for lower temperature water e.g. SPC Belgravia fan convectors would be suitable connected to a heat pump. They are safe touch temperature and fast response 3.Underfloor heating is 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 for the future as and when funding becomes available. The existing parquet floor would NOT be suitable for underfloor heating which is a negative factor. New flooring would be required. The current depth of the parquet could be investigated as this depth could be enough to accommodate underfloor heating without extensive level changes which is often an issue in existing	1.Air source heat pumps should attract Government Clean Heat or similar grant schemes depending on eligibility criteria 2.Running costs would be reasonable as 2.5 -3 times heat produced from 1 unit electricity. Savings assume 2.5 as more typical. 3.This option will require a full heating upgrade 4.Overall, this combination is considered where budget and funding permits 5.Recommend using in tandem	1.The Air source heat pump would be the next most cost-effective solution after gas and air-air heat pumps in terms of capital cost 2.Estimated at £7,140 per annum for the church only compared with £8,500 currently including additional capacity of 12kW therefore more comfortable, based on current electrical cost of 34.7p/kWh 3.Gas would be in addition to this in extreme weather

	buildings. This is a more positive factor 4. Pipework may have some leakage and replacement is advisable. 5. Other options would include low surface temperature radiators which are quiet but bulky and take up wall space	with gas as top up in very cold 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 may be possible although consultation with local authority conservation officer will be needed. There is a significant south facing area available facing the main road which is unshaded. 4. The roof fixing should be reasonable straightforward as this is not a historic roof. 5. PV would be a significant contributor to offset carbon. 6. Considered suitable	1. As per the air to air heat pump options for the church AND/OR 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. 3. Battery storage could be included now, or in the future to extend the availability of electricity.	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 contributor and will reduce the running costs quoted for the heat pump options

LPG and Oil

Suitability	Emitter options considered	Summary and observations
Not considered as gas is available		

Biomass

Suitability	Emitter options considered	Summary and observations
Not considered due to proximity of housing and air quality issues		

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**
- **Hybrid of the above with gas boiler sources as supplementary source**
- **PV, subject to faculty and consultation**

The viable emitters were:

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

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

Conclusions

Of the options considered, **there are viable options for an air-to-air heat pump system, which uses refrigerant as the medium, and a "wet" system, that is radiators, underfloor heating and/or fan convectors fed by air source heat pumps**.

A straightforward **fan convector system connected to an air source heat pump possibly with gas back up would be one option.** The fan convectors would need to be heat pump compatible.

Of comparable or possibly slightly lower cost would be a number of air-air heat pump systems. The advantage of this approach is that they **could be installed in phases as funding permits whilst retaining the existing system (space permitting)**. The existing system could then be removed in its entirety.

If a wet system is preferred, **it is suggested that the entire heating is replaced as there is suspicion of leakage and it is ineffective**. The wet system could be fan convectors or, for a higher cost, include underfloor heating and/or low surface temperature radiators. If underfloor heating is considered, the flooring would need to be replaced and faster response heating is suggested in tandem to ensure flexibility and the ability to operate in the most cost effective mode. This is because underfloor heating is slow response and ideally runs at a low level continuously which can be expensive if the church is not used as much as expected.

There is 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, **PV panels either on the south roof of the church 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. Roof insulation is particularly recommended.

All options are, of course, subject to faculty and additional statutory and consultative body approvals.