St Lawrence Church
LECHLADE-ON-THAMES

Project Inspire
Review of heating options

1. MTA Report

Martin Thomas Associates (MTA) has completed a feasibility report on mechanical and electrical services. An initial report was competed in September 2020 and, following our comments, a final report was submitted at the end of November 2020. The report covers heating, lighting and associated electrical and mechanical services. We have since been spending much time in reviewing the proposals, discussing with suppliers and obtaining a range of cost estimates.

2. Heating Options

We asked MTA to evaluate three heating options, namely:

- Option 1A: Retain existing gas boilers with new radiator and fan convector system;
- Option 1B: Retain existing gas boilers with underfloor heating, perimeter trench heating and central radiators/ fan;
- Option 2: New gas boiler(s) with underfloor heating, perimeter trench heaters and central radiators/ fan convectors;
- Option 3: New air source heat pump with underfloor heating and trench heaters;

MTA provided some broad cost estimates and, because this is a significant element of the project, we have been looking to compare cost estimates with other sources.

There are two components which we have considered: the energy source and the heat distribution system. While these are interlinked, it is useful to consider each in turn.

3. Key assumptions

We also considered key assumptions

(i) Utilisation: we need to make an assumption on the number of days use of the main church per week. This will be more critical for the winter months. A reasonable assumption would be three days per week although we need to discuss.

(ii) The minimum temperature to be maintained for building protection: MTA initially suggested 8°C although agreed that a lower 5°C could be applied as there is no evidence of condensation and damp in the building;

(iii) Temperature for occupant comfort: MTA has assumed a 17°C temperature uplift above a minimum external temperature of 2°C; that is to 19°C. MTA comments that while the external temperature may fall below 2°C, the large thermal lag in the building helps to reduce this; weather data suggests that the external temperature drops below a mean temperature of 1 to 2°C 15 times a year over a 24hr period. This assumption is used to size the heat emitters.

(iv) The two objectives of fabric protection and occupant comfort overlap depending on the frequency of use. Where the church is used once a week, the minimum temperature for building protection is around 5°C. Where it is used for three times a week, then the minimum ambient temperature increases to 9°C because of the thermal lag.

MTA estimated the maximum power requirement to be 80kW with boiler capacity slightly above this.

4. Energy source

The main factors to consider in the selection of an energy source are

(i) Total cost: capital cost with running costs for at least ten years;
(ii) Carbon reduction: the extent of reduction from each option;
(iii) Reliable technology: a tested technology;
(iv) Ease of operation and maintenance: we rely on ageing volunteers so this should not be onerous;
(v) Impact on heritage and significance.

We have applied these factors to the options above.

Options 1A and 1B: maintain the two existing gas boilers (75kW combined) with a top-up 20kW electric boiler to increase maximum output to 95kW.

This is the lowest cost option needing some modifications to the delivery pipework. There is a risk that because of their maintenance history that the boilers would need to be replaced in the short term. However, because of the embedded carbon in their manufacture we should look to maximise their use; hence the possible use in Option 3. When operating with underfloor heating there is a need to turn down the heat output to 55°C from 80°C normally used in conjunction with radiators. A new system control would be needed (rather than the on/off we have now), particularly in running an electric boiler in parallel.

The option offers no carbon reduction (other than on a green gas tariff and there are few of these). The technology is established although there could be a question on reliability in the medium term. We have a maintenance contract although if we continue to need call-outs then costs would increase. There is no material impact on heritage and significance.

Option 2: a replacement gas commercial boiler 100kW (or 2 x 50kW giving some contingency).

This option delivers a new more efficient gas boiler (or two boilers) located in the cellar as a like-for-like replacement of the existing boilers. While this will incur additional costs, of the order of £10k to £20k, reliability should be improved. This design would include modifications to the pipework and a new control system. The control would be complex as a lower temperature is needed for underfloor heating and higher for fast heat.

The option offers no carbon reduction (other than on a green gas tariff and there are few of these). The technology is established and new boilers would be more efficient and reliable.

For both options, the boilers would continue to be located within the existing boiler room although more effective ventilation will be needed to minimise rusting.

Option 3: Air source heat pump (ASHP) plus a booster source – either existing boilers or a 20kW electric boiler.

This option delivers a new technology which is started to be used in a few churches. The system operates like a reverse fridge, extracting air from the atmosphere and using heat exchangers to produce hot water. The output is around 55°C and suitable for operating with underfloor heating. The system is designed for continuous operation and provides a 'slow' heat. It needs to be supplemented with a 'fast' heat to increase the temperature when the church is occupied. This can be provided by the existing gas boilers or, when these reach the end of their lives, by an electric boiler.

This option significantly reduces power requirements and carbon emissions but is still dependent on the 'green' electricity tariff. The additional power for 'fast' heat is met in the long term by electric boilers although only likely to be required over the cold winter period.

The ASHP needs to be located outside the church and therefore would have an impact on heritage and significance. We propose a location immediately outside the south door and over the current difficult access to the cellar. This location would minimise pipework which could be routed directly into the cellar. We would need to discuss this with the DAC. A new access ladder would be required, possibly under the floor within the church. We need to work through the details.

Photovoltaic (PV) cells
The PV option, located on the south aisle roof, considers two sizes; own use (800 kWh/a) and export (3000kWh/a). It is not a 'stand-alone' option as a heating power source but could reduce the total energy needs in conjunction with other sources.

Ground source heat pump
A ground source heat pump option is not feasible because of the land requirements which we do not have.

5. Heat distribution

For the heat distribution options, we should consider

(i) Total cost;
(ii) Reliable technology;
(iii) Ease of operation;
(iv) Impact on heritage and significance;
(v) Impact on space and use of the building.

The main criteria we have applied are to

- provide an even distribution of heat, particularly in the centre aisle where most people sit;
- keep the internal walls clear of radiators wherever possible and minimise gratings in the floor;
- provide a slow heat to maintain a low ambient temperature to protect the fabric;
- enhance with fast heat to increase and maintain a higher ambient temperature during the winter period in advance of and during occupation of the church;

Option A: This is a combination of radiators and fan convection heaters. This is included to show the significant number and extent of radiators and convection heaters required, particularly where an ASHP is used. Because of the number and size of radiators, this is not a feasible option,

Option B: This is a combination of underfloor heating, trench heating and small convection heaters. The underfloor heating will be built into the new floor with pipework in zones – north aisle, Nave and south aisle. Trench heaters, providing 'fast' heat will be laid alongside the internal north and south walls so will be unobtrusive. Small column convectors will be located adjacent to columns to provide 'fast' heat to the central Nave. We need to discuss this location with the DAC. We plan to view a sample of these column convectors to see how we can limit their impact.

6. Capital Costs

We have obtained costs from a range of sources with varying scope so they are not directly comparable:

- St Lawrence Bourton on the Water bill of quantities
- St Mary's Church Puttenham – a church some 60% the size of ours
- Renelec, our current maintenance contractor
- J Davies – contractor for the St Lawrence B-o-W church
- MTA report – some approximate costs

The range of costs for each option are summarised below. Note that these are our best estimates at this stage and could change. Costs exclude building works which are in a separate part of the budget.

Option 1A: Retain existing gas boilers with new radiator and fan convector system:

Boiler – modify existing or new electric	£15k	
Radiators and Ecovectors	£40k	
Independent electric heating for smaller rooms	£10k	
Estimated total		**£65k**

Option 1B: Retain existing gas boilers with underfloor heating, perimeter trench heating and central radiators/ fan;

Boiler – modify existing plus new electric	£15k	
Underfloor heating	£20k	
Trench heating and Ecovectors	£20k	
Independent electric heating for smaller rooms	£10k	
Estimated total		**£65k**

Option 2: New gas boiler(s) with underfloor heating, perimeter trench heaters and central radiators/ fan convectors;

New Boiler	£30k	
Underfloor heating	£20k	
Trench heating and Ecovectors	£15k	
Independent electric heating for smaller rooms	£10k	
Estimated total		**£75k**

Option 3: New air source heat pump with underfloor heating and trench heaters:

ASHP and underfloor heating:	£60k	
Add for fast heat system used mainly in the winter months		
Boiler – modify existing or new electric	£15k	
Trench heating, Ecovectors	£15k	
Independent electric heating for smaller rooms	£10k	
Estimated total		**£100k**

The objectives of obtaining an even distribution of heat in the Nave, no gratings in the floor for flexibility and walls clear of radiators to return the walls to original leads us to Option 3 with the underfloor heating and ASHP as option. This also meets the carbon reduction objective with nearly 6 tonnes of operational carbon savings. There is potential to locate the ASHP just outside the south door and currently where the railings and existing stone steps to the cellar are located. We would need to discuss with the DAC as we see it as causing the least harm and enabling pipework to be close to the church.

7. Operating costs

Our current gas use in the church is an average 35,000 kWh when operating normally. Forecast power is likely to be greater than this to achieve better heat distribution and comfort although it is difficult to estimate and depends on the usage frequency of the church.

If the power requirements increased to 40,000kWh then the input from an ASHP would be about 16,000 kWh. Conversely the current green electricity tariff is around 16p/kWh compared with about 4p/kWh for Gas. However, we may in the future be able to negotiate night tariffs for electricity. We would save on the cottage heating costs, some £400/a which results in a small increase in electricity costs. We could also We would save about 6 tonnes of carbon emissions.

We could place a PV system on the south aisle roof at a cost of about £5k to deliver 3000kWh/a and saving nearly 1 tonne of carbon emissions although the overall benefits are marginal. If we could get grant funding for this then it would probably be worthwhile.

Nigel Jones
Chairman Project Inspire
15th April 2021