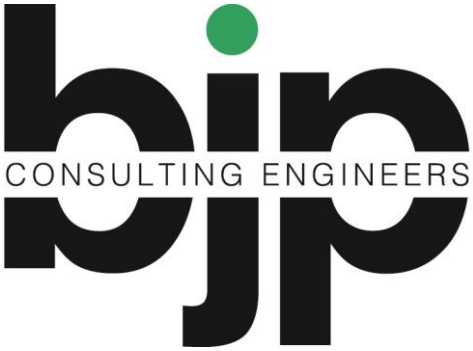

mechanical & electrical services

ST JOHN'S CHURCH, KEYNSHAM

HEATING OPTIONS APPRAISAL REPORT

MAY 2023

Revised 9th JUNE 2023

contents.

1.00 aim of the report.

Following reliability concerns with the heating boiler and in the light of a proposed reordering, this Report considers alternative and more sustainable heating options for the Church and the adjacent Church Hall.

In response, this Report will:

- Review the Age and Superficial Condition of the Existing Heating Systems
- Analyse the Existing Energy Consumption
- Create a Simple Thermal Model to Assess Impact of Options to Save Energy
- Assess Feasibility of Alternative Heat Sources
- Evaluate Capital Costs, Running Costs & Carbon Emissions for the Options
- Review the Feasibility for a PV Array

2.00 existing heating.

2.01 installation

The existing main Church heating system consists of a single Strebel gas fired boiler in a subterranean plant room serving an open vented system of radiators.

The heating circuit appears to operate at a weather compensated variable temperature with a control thermostat towards the front of the Church and a frost thermostat externally, the heating appears to be switched on and off via a simple optimum start controller/timeclock.

The duty of the boiler could not be ascertained but is anticipated to be around 100kW and is believed to be in excess of 25 years old.

The boiler has an open flue discharging at around 2m above ground level in the churchyard, with a balanced air inlet.

The Hall has a separate heating system with a more modern Atag 50kW wall hung gas boiler, again serving radiators in each room.

Domestic hot water to the toilets and kitchen is provided by local electric water heaters.

2.02 condition

The Church boiler is beyond its economic life, is inefficient by modern standards and in need of replacement.

The Church heating pipework, from a superficial visual inspection, appears to be sound, however it is understood that certain underground sections were recently replaced due to corrosion.

From a visual inspection, the Hall heating system appears to be in a good serviceable condition.

2.03 energy usage

The Church holds records of annual energy consumption for the Church and the Hall.

Using the data provided and interpolating the information, the like for like annual consumption for the previous two years has been created. This is then compared to a thermal model for assessing heat energy use:

	Annual Consumption (kWh)		
	2021/2022	**2022/2023**	**Thermal Model**
Hall Electricity	9,951	12,022	N/A
Church Electricity	8,640	8,513	
Hall Gas	50,391	36,995	40,931
Church Gas	67,738	42,041	64,896

Other than for Church electricity consumption, there is significant variance between the two years, beyond anticipated seasonal variation. Recent thermal improvements to the Hall may explain the reduction in gas consumption during 2022/2023, the increase in electricity consumption over the same period may be due to increased usage following the pandemic restrictions.

The reduced gas Church consumption in 2022/2023 cannot be immediately explained.

The modelling exercise indicates gas consumption is broadly as expected and assesses the peak winter heat demand of the Church to be 90 kW. It should be noted that to meet this peak demand, a system capacity in excess of 120 kW would be necessary.

The existing boiler appears to have a commensurate capacity; however the heat emitters are unlikely to be sufficient to satisfy this demand. As a result, in the colder months, it is likely that the Church will be underheated and will take an excessive time to reach a reasonably comfortable temperature.

The capacity of the Hall heating appears to be appropriate for the building heat demand.

2.04 carbon emissions and energy costs

The Report uses the following carbon emission factors from the UK Government January 2022 "Greenhouse Gas Reporting Conversion Factors":

Electricity	0.21016 kg of CO_2 per kWh
Mains Gas	0.18282 kg of CO_2 per kWh

It is understood that the Church purchases 100% renewable electricity and gas, therefore all energy usage might be deemed as carbon zero. For the purposes of this Report however, the assessment will be based on the published "Grid" carbon factor above.

The Church and Hall is currently contracted to a variable rate energy contract, it is understood that the tariff rates at the time of this Report were as follows:

Electricity 49.29p per kWh & 127.79p/Day Standing Charge

Gas 11.94p per kWh & 49.71p/Day Standing Charge

The above unit cost data, provided by the Church, excludes VAT.

The overall consumption and carbon emissions used in this Report are based on the thermal modelling exercise and as follows:

Energy Source & Building	Thermal Model	
	Cost	Carbon Emissions
		t CO_2
Hall Electricity	£6,392	2.53
Church Electricity	£4,662	1.79
Hall Gas	£5,931	8.80
Church Gas	£7,930	11.86
Hall Total	**£12,323**	**11.33**
Church Total	**£12,592**	**13.65**

The above costs exclude VAT.

The assessment assumes that the Church is occupied as follows:

Church Occupancy (Hours per Month)	
Sunday Mornings	14
Evensong	1
Funerals/Baptisms	8
Weddings	3
Schools	8
Total	**34**

In addition to the energy used for space heating when the Church is occupied for these 34 hours per month, background "conservation heating" is maintained throughout the heating season. It is estimated that around 45% of heating energy consumed is used when the Church is unoccupied.

The Hall is believed to be in daily use

Hall Occupancy (Hours per Month)	
9.00am to 6.00pm Daily	253.5

The proportion of the heat energy used when the Hall is unoccupied is estimated to be approximately 17%.

3.00 heating source options.

The following considers the heating source options available and examines their relative merits.

- Heat Pumps (Ground Source and Air Source)
- Low Temperature Hot Water Gas Boiler
- Direct Electric Heating

3.01 heat pumps

Using a refrigeration circuit, a heat pump is used to upgrade heat energy from the ground or air so that it may be usefully applied to heat the Building.

The benefit of a heat pump is that for every unit of electricity used to drive it, between 3 and 4 units of heat are produced.

To use heat from the ground, it would be necessary in this instance to bury either vertical boreholes or "Slinky" pipes. The cost of this installation would be prohibitive and impractical, given the location of the Church.

An analysis of the feasibility of an air source heat pump system has however been undertaken.

Based on six outdoor heat pump units, the units would each measure approximately 1500mm (height) x 1100mm x 400mm and would need to be in a location where there is good air flow. The units would need to be spaced a minimum of 1m apart and be provided with a concrete base and drain.

From the units, heating pipes would be taken underground into the existing boiler plant room which would house a buffer vessel, controls, pipes and pumps.

Each heat pump requires a 32A single phase electricity supply, which is likely to require a supply capacity upgrade.

A benefit of air source heat pumps over gas boilers is that there is no requirement for flues.

The disadvantage of the Heat Pump option is that the external plant would be obtrusive and may cause noise nuisance. A possible location may be adjacent to "The Park" however this would entail long underground heating mains connecting the Church. Locations closer to the Church would be more economic, however might give rise to disturbance to the Church, Hall or adjacent dwellings.

An air source heat pump works efficiently with a heating temperature range of 45-55ºC which would not provide sufficient heat through the already undersized existing radiators. Additional heat emitters would be necessary.

If this technology were extended to provide an alternative heat source for the Hall, there would be a need to increase the heat emitter capacities here too, possibly replacing the radiators with Fan and Coil units. The benefit of this change would be a reduction in Carbon emissions, but at a high capital cost.

3.02 gas boilers

The existing Church boiler is well beyond its economic operating life.

A like for like replacement of the gas boiler would offer a substantial improvement in system efficiency with limited visual and practical impact. It is important to note that many modern gas boilers are 'Hydrogen Ready' so would be future proofed, should this anticipated change in technology occur.

As the thermal analysis has revealed that the existing radiator installation may be undersized, it would be necessary to add further heat emitters if a gas fired solution was chosen.

3.03 electric heating

With an upgrade to the electrical infrastructure capacity, direct electric heating would offer a low cost solution for the Church, however it brings with it some loss of thermal comfort as well as visual impact.

It would be possible to install a series of suspended infrared chandelier heaters (typically 12) mounted at approximately 5m above the ground.

Electric heating would not be suitable for the Church Hall.

3.04 CO_2 emissions and energy costs

Based on the modelling data and occupation for an average of 34 hours per month, the performance of each option is assessed as follows:

Church Heat Source Replacement	Annual Energy Cost		Carbon Saving Over Existing	Cost Saving Over Existing
	Carbon Emissions t CO_2	Annual Energy Cost (Per Annum)		
Existing Gas Boiler	13.65	£12,592		
New Condensing Boiler	11.16	£10,961	18.29%	12.95%
Air Source Heat Pump	5.20	£12,659	61.92%	-0.53%
Electric IR Heating	5.49	£13,339	59.80%	-5.93%

Hall Heat Source Replacement	Annual Energy Cost		Carbon Saving Over Existing	Cost Saving Over Existing
	Carbon Emissions	Annual Energy Cost (Per Annum)		
	t CO_2			
Existing Gas Boiler	11.33	£12,323		
New Condensing Boiler	9.62	£11,203	29.57%	11.03%
Air Source Heat Pump	5.11	£12,444	62.59%	1.18%

3.05 capital costs

Heating System Budget Costs	Budget
New Church Boiler & Controls	£45,000.00
New Hall Boiler & Controls	£6,000.00
New Church & Hall Heat Pump with Additional Radiators	£205,000.00
New Church IR Heating	£133,000.00

Costs exclude Builder's Work, stripping out existing services pipework upgrades, additional heating (radiators), fees, Contractor Preliminaries, VAT etc. A cost allowance for a power supply upgrade is included where deemed necessary. It is assumed that the existing electrical installation is serviceable.

4.00 renewable energy.

A further means of carbon and cost reduction is by means of harvested renewable energy.

An assessment has been made of the impact of a 24m^2 PV array on the flat roof of the Hall and a larger 48m^2 array on the main south facing Church pitched roof.

It is noted that as the Church and the Hall are connected to separately metered supplies, an array on one building cannot effect an energy saving to the other.

It is noted that the relatively higher occupancy hours of the Hall compared to the Church means that a greater proportion of the electricity being harvested would be used, this will assist the economic case.

This can be further improved through the use of a battery system, which would time shift the harvested power from the time of it being harvested to perhaps an evening, when more might be used.

Photovoltaic Array	Annual Savings		Capital Cost	Simple Payback (Years)
	Carbon Emissions t CO_2	Energy Cost		
Church 48m2 Array	1.19	£1,283	£12,500	9.7
Church 48m2 Array + Battery	1.19	£1,942	£21,500	11.1
Hall 24m2 Array	0.56	£789	£9,000	11.4
Hall 24m2 Array + Battery	0.56	£1,092	£18,000	16.5

The costs assume a Smart Export Guarantee (SEG) payment of 5p/kWh where there is no battery and 12p/kWh with the battery.

The costs exclude any power supply changes that may be required.

The above is subject to a detailed feasibility assessment to check the structural integrity of the roof.

The scheme may be opposed on planning grounds.

The above budget costs exclude VAT, design costs, builders work and contractor costs.

5.00 reordering.

At the time of this Report, proposals were in development for the reordering of the Church.

The following options are briefly considered in relation to any heating system upgrade.

2107_SK23_St John's Keynsham Option 4B

2107_SK32_St John's Keynsham Option 7C

Each of these options create sub divided spaces withing the Nave.

It is anticipated that these new spaces will be occupied for a greater number of hours than the main Church. As a consequence, it is recommended that these areas are serviced with a dedicated heating solution.

If Option 7C is adopted, with the mezzanine, then the ground floor spaces would be linked with a common ceiling and the four spaces (Meeting Room, Welcome Area, Kitchen and Toilets). Using the common ceiling it would be possible to install a combined Air to Air heat pump system, offering a cost effective low carbon heating solution. It would be necessary to find a location externally to accommodate the outdoor unit.

For option 4B, local electric room heaters may be appropriate for the Toilets, Kitchen and Meeting Room. The Welcome Space, being open to the volume of the Nave, would be heated as part of the wider Church heating system.

It should be noted that the new kitchen and toilets would require ventilation systems, with ducts penetrating the external walls.

6.00 conclusion & recommendation.

The strategy adopted by the Church would depend on the balance between aesthetics, thermal comfort, capital costs, running costs and carbon emissions. If the Church deem that the existing gas and electricity supplies are zero carbon, the criteria becomes a cost/quality consideration.

The replacement of the existing Church boiler provides an economic means of achieving good levels of energy saving and carbon emission reduction, however the limitations of adequately heating the building remains. The system will also be reliant on the existing old pipes.

An air source heat pump is a costly option, both in terms of capital and running cost due to the very high electricity price at the time of this Report. This solution does however offer good levels of Carbon reduction, if this is deemed relevant in this instance.

Although more noticeable aesthetically and with compromised thermal comfort, the infrared chandeliers offer a good balance of energy saving and moderate capital cost.

In the Church Hall, the simple replacement of the existing boiler offers the most appropriate and cost effective solution. A new boiler should include weather compensation and optimum start control.