



mechanical & electrical services

ST ANDREW'S CHURCH, CHEDDAR

HEATING OPTIONS APPRAISAL REPORT

APRIL 2022

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1.00 aim of the report.

This Report is a response to a need to replace the existing unreliable boiler at the Church. Rather than opting for a simple like for like replacement, the PCC wish to consider alternative options, considering energy costs, capital costs and carbon emissions.

In response, this Report will:

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

2.00 existing heating.

2.01 installation

The existing heating system consists of a pressure jet gas fired boiler, the capacity of the boiler seems far in excess of the Church peak heat load, however this could not be confirmed given the age of the boiler and the lack of nameplate data.

The boiler serves a pumped and pressurised heating circuit which uses bare pipes as well as radiators to transfer the heat into the space.

The heating circuit appears to operate at a constant temperature with a control thermostat at the rear of the Church and a frost thermostat in the Boiler Room, the heating appears to be switched on and off manually.

2.02 condition

The boiler, pumps and associated control systems are all well beyond their economic life and in need of replacement.

The heating pipework is very old however appears from superficial visual inspection to be sound.

The electrical services installations supporting the heating are beyond their economic life and do not meet modern standards.

2.03 energy usage

A recent tender exercise undertaken on behalf of the Church by “Green Journey” includes, what is believed to be, representative consumption data. (Green Journey is an energy procurement scheme managed by Green Energy Consulting).

- Annual Electricity Consumption 1,682 kWh
- Annual Gas Consumption 27,054 kWh

A thermal modelling exercise has been undertaken and assesses the peak winter heat demand of the Church to be 81.6kW

From this information and a recent survey indicating that the Church is used for approximately 16 hours a week, the predicted gas consumption based on this profile is:

- Annual Gas Consumption 35,449 kWh

The 24% discrepancy between the “Green Journey” data and the modelling data (which assumes “typical” winter temperatures) could be due to the Green Journey consumption data being influenced by:

- Lower than Normal Occupation during the Pandemic
- Recent Mild Winters

For the purposes of this Report, the modelling data will be used.

The Report is based on carbon emission factors from the UK Government January 2022 “Greenhouse gas reporting: conversion factors” as follows:

- Electricity 0.21016 kg of CO₂ per kWh
- Mains Gas 0.18282 kg of CO₂ per kWh

The Report will also use the energy costs obtained by “Green Journey”

- Electricity 55.2 Pence per kWh
- Mains Gas 5.76 Pence per kWh

The overall consumption and carbon footprint used in this Report is:

Energy Source	Annual	
	Cost	Carbon Emissions
		t CO ₂
Gas	£2,041.86	6.48
Electricity	£928.46	0.35

It is important to note that the costs are the unit costs only and exclude standing charges

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 four outdoor heat pump units, located close to the Building, possibly adjacent to the existing Boiler Room, the installation would be as follows:

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 1 m apart and be provided with a concrete base and drain.

From the unit, 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 beyond the current supply capacity.

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. (Alternative locations may be possible, away from the building, however this would bring significant cost implications).

An air source heat pump works efficiently with a temperature range of 40-45°C and would not be suitable to be connected to the existing radiators.

3.02 gas boilers

The existing boiler is unreliable and well beyond its economic operating life, it is also understood that the flues are deficient.

A like for like replacement of the gas boiler would offer a substantial improvement in system efficiency with limited visual and practical impact.

It would however be necessary to find a route to discharge the flues, perhaps in a bespoke casing externally up the side of the building, this requires some guidance by a Gas Safe engineer. .

3.03 direct electric heating

With an upgrade to the electrical infrastructure capacity, direct electric heating would offer a simple replacement solution; however, it brings with it the greatest running cost and Carbon footprint.

3.04 CO₂ emissions and energy costs

Based on the modelling data, the performance of each option is assessed as follows:

Heat Source Replacement	Annual		Cost Saving Over Existing
	Carbon Emissions	Annual Energy Cost (Per Annum)	
	t CO ₂		
Existing Gas Boiler	6.5	£2,042	
New Condensing Boiler	5.1	£1,612	21%
Air Source Heat Pump	1.6	£4,193	-105%
Electric Heating	5.6	£14,676	-619%

4.00 heating systems.

There are a number of options for the heating systems used for the various spaces;

- (a) Radiators and Convective Heaters
- (b) Underfloor Heating
- (c) Fan and Coil Units
- (d) Radiant Heating

4.01 replacement radiator system

The Existing heating is a radiator system and believed to be very old and technically well beyond its economic life but may still be serviceable if treated carefully.

A radiator system offers a flexible, easily controlled and comfortable heating solution however it has the following disadvantages;

- Any new pipes would have a visual impact on the space (unless hidden under fixed pews)
- High surface temperatures of bare pipes and radiators are accessible to children and vulnerable people (unless larger low surface temperature heaters are used)
- If the existing system is removed then a considerable pipework installation would be necessary.

A limitation of this type of system is that it is not suited to a heat pump application.

To meet modern standards of heating, considerably more radiators would be needed in a replacement installation.

4.02 fan and coil units

As an alternative to the radiator solution, fan and coil units might be considered.

Fan and coil units can be connected to boilers, heat pumps or be direct electric. These units offer many of the advantages of radiators, while also having greater heat output, meaning fewer units are required.

The main disadvantages of this option are:

- Although there would be less of them, they are Physically larger than radiators
- The fans can be noisy, however offer a very quick thermal response
- The heat is delivered as convective heat only, a combination of radiant and convective is preferable

4.03 underfloor heating

While more costly than radiators or fan & coil units, underfloor heating offers a number of advantages;

- Even heat distribution
- An Improved Level of occupant comfort even at low temperatures
- Improved efficiency working with gas boilers and heat pumps

Even if the entire floor of the Church was dug up and underfloor heating laid, this would only account for 50% of the overall heat demand.

Underfloor heating could be used as a partial solution, however this would only be viable if there were other plans to remove pews and create open spaces.

4.04 radiant/infrared heaters

Electric infrared heaters would offer the lowest capital investment.

A limitation of this form of heating is the proximity of the heater to the occupants. They typically are mounted at 2.4m from the floor.

While these units offer “instant heat”, they do not control well and the levels of thermal comfort is poor.

4.05 capital costs

Heating System Budget Costs	Budget
Gas Boiler - Underfloor Heating & Radiators	£110,000
Gas Boiler - Fan and Coil Unit Heaters	£95,000
Air Source Heat Pump - Fan and Coil Heaters	£115,000
Electric High Level Infra Red Heaters	£35,000
Replacement Radiator Heating	£100,000
Replacement Boiler and Controls Only	£25,000

Costs exclude Builder’s Works, stripping out existing services, 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

The underfloor heating option excludes the new floor system, only the heating system.

5.00 renewable energy.

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

An assessment of the impact of some Solar PV array options have been made.

Each option is based on an array on the South Aisle roof.

It is noted that the relatively low occupancy hours of the Church means that only a small proportion of the electricity being harvested is being used at the same time therefore, the economic case is compromised.

This can be mitigated 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 it might be used.

Photovoltaic Array	Annual Savings		Capital Cost
	Carbon Emissions	Energy Cost	
	t CO ₂		
60m ² (10kW) Array	1.8	£573	£16,000
60m ² (10kW) Array + Battery	1.8	£1,132	£24,000
24m ² (4kW) Array	0.6	£355	£8,500
24m ² (4kW) Array + Battery	0.6	£888	£16,500

The most attractive economic solution is the 24m² (4kW) array with a battery, this provides a payback period of 19.6 years.

The 10kW array combines with a heat pump heating system would achieve a zero carbon solution for the Church.

The costs assume a Smart Export Guarantee (SEG) payment of 4.1p/kWh

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

6.00 conclusion.

The strategy adopted by the Church would depend on the balance between capital costs, running costs and carbon emissions.

If capital cost is the key driver, then a replacement gas boiler at approximately £25,000 would achieve approximately £430 per annum energy cost savings, however the imitations and risks of the existing heating remain.

A carbon zero solution could be achieved through heat pump heating and a solar PV array, however this attracts a capital cost of £131,000 and an increase in running coasts of nearly £1,600.00 per annum.

It is important to note that the energy costs were highly volatile at the time of this Report and so the running costs may significantly change over time.