CASE STUDY GROUND SOURCE HEAT PUMP WITH UNDERFLOOR HEATING

N.B. This case study considers only one possible approach, which will not be suitable for every church. Always seek professional advice.

Key Points

- A ground source heat pump (GSHP) is a low-carbon heating approach, suitable for regularly-used buildings. Acting like a fridge in reverse, it uses a compressor and heat exchanger to absorb heat from the ground and use it to warm water, which in this case runs through the underfloor heating pipes.
- As part of a major re-ordering, a GSHP has been successfully installed by St Mary the Virgin, Ashford, in their small mediaeval town-centre churchyard, using directionally drilled boreholes.
- In combination with underfloor heating, this system delivers constant low-level heat, suiting this church

1 The boreholes for the ground source heat pump were drilled into the churchyard.

2 Underfloor heating circuits circulate warm water at 40°C under the nave, aisles, foyer, café area and toilets.

3 This detail from a public information panel shows the plan and elevation views of the boreholes. All of the pipework is accessed from one master manhole, pictured top left.

The context

St Mary the Virgin is a Grade I listed church, located in the town centre of Ashford. It is a large mediaeval building, mostly constructed between the 13th and 15th centuries. Major changes in the 18th and 19th centuries saw balconies added to the north, south, and west sides of a widened nave. This gallery now provides additional seating for concerts.

The 2010 reordering included removing all the Victorian pews and platforms from the nave (allowing a flexible floor space for services, concerts and exhibitions) and the installation of underfloor heating. The church is a central arts venue for the town, Revelation St Mary, and is used around 2200 hours per year, plus around 70 event bookings per year (one per 5 days) pre-Covid.

For more information visit the church's entry on the Church Heritage Record and their website.

The need for change

The major reordering involved removing the pews and the radiators installed behind them, to create a clear, multi-use area. This called for a new approach to heating. A cost-effective method of heating a large space was needed, suitable for the usage pattern; there was too little use to justify constant gas space-heating, but too much use to make electric heating through panel heaters cost-effective.

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What were the options?

The church considered gas space heating, conventional electric heating, and both air–source and ground-source heat pumps.

- Gas-fuelled space heating, operated intermittently for 3 to 4 days per week, creates a "saw tooth" temperature profile. The hours of use are insufficient for constant gas heating: as well as services, there are c. 70 evening events annually plus a café open for 15 hours per week and a weekly toddler group.
- An electric space-heating method would cost around four times more than gas.
- Use of a heat pump (electric-powered) will deliver three to four times the amount of heat compared to the power consumed, which results in similar operating costs to gas (see note below). A heat pump driving underfloor heating delivers a relatively constant background temperature.
- Ground-source heat pumps are more efficient than air-source (since the average soil temperature is higher than the average air temperature), plus they do not have to be installed on an external façade.

Technical note on heat pumps

Heat pumps act like a fridge in reverse. They use electricity to run a pump, compressor and heat exchanger, which move heat from a low-grade source (the air, soil or water nearby) and "upgrade" it to provide warm water in the range 40-70°C, or sometimes warm air, which is then circulated around the building. The Coefficient of Performance (CoP) of a heat pump is the ratio of how much useful heat is obtained compared to the energy expended by the pump to "lift" the heat from the ground, air or water. For air-source heat pumps, this is usually in the range 2-3, for ground source heat pumps it is usually 3-4.

With a COP of 4, you receive 4 times more heat energy in kWh than you pay for in electricity. That makes them a low-carbon heat source, especially if the electricity is from 100% renewables. You have not broken any laws of physics! The "missing" heat has come from the air, ground or water, and ultimately from the sun.

What was done?

- The ground source pipes were installed in boreholes dug from one corner of the churchyard.
- The 24kW ground source heat pump is located in the existing boiler room, with a conventional boiler which heats the chancel. The pump delivers up to 96kW at a Coefficient of Performance (COP) of 4.
- The floor of the nave was excavated by 30cm to install the heating pipework, insulation and new floor surface. The underfloor heating system covers the whole of the floor of the church to the west of the central tower, i.e. nave, aisles, foyer, café area and toilets (with the exception of the central diagonally tiled walkway): an area of approximately 400m². The total floor area of the church is 880m².

How well does it work?

The system has been in use since 2011, with the underfloor system supplied with water at 40°C, and has met the church expectations of heating requirements.

There has been one period of several months when it was out of use, caused by an inability to source a replacement part. This was solved by sourcing another item of equal specification.

How much did it cost?

The installation cost approximately £400k, for the heat pump and the new underfloor heating over 400m² floor area. An EU grant of £275k was awarded toward the project.

Operating the heat pump and the circulation pump costs c.£4,100 p.a. in electricity costs.

Installing the new heating was a major investment, both of time and money, but has proven successful. The church is comfortable, the system is cost-effective, and it is good to know our carbon footprint is low. Church Representative, St Mary's