Air-to-Water Heat Pumps

Summary: Air-to-water heat pumps draw heat from the air and send it through a 'wet' system – i.e. through radiators or underfloor heating systems. They are more effective in well-insulated buildings and are best suited to daily use churches.

A monobloc air source heat pump at St Anne's Church, Ings, Cumbria - Photo credit - Historic England/Max Fordham LLP

What are air-to-water heat pumps?

Air-to-water heat pumps (AWHPs) are the main type of heat pump discussed in the media, as they are eligible for funding via the government's Boiler Upgrade Scheme[1]. Their attributes are very similar to ground source and water source heat pumps; the only difference is the source of the heat (i.e. the outside air, rather than the ground or a body of water). They are very different from air-to-air heat pumps, which do not heat water in a heating system but are air conditioning systems operated in heating mode, and should not be confused. The air-to-air heat pump guidance note can be found with the collection here. They also come in two different types, depending on the flow temperatures needed, and can be installed and configured with or without a thermal buffer tank, which is a store of hot water that can help to manage peak heat demands within a building.

> **Flow temperatures:** The flow temperature refers to the temperature of the water in the supply (flow) pipe in a heating system or separate part of a heating system.

[1] https://www.gov.uk/apply-boiler-upgrade-scheme at the time of writing – Feb 2024

The technical bit – how do they work?

AWHPs work by having an external unit which sucks in air and extracts the heat from the air[2]. It concentrates this heat and puts it directly into water that can then flow through the heating system. They work most efficiently when trying to produce water temperatures in the heating system of between 40°C and 50°C. AWHPs provide around 2.5 to 3.5 units of heat for every 1 unit of electricity used in the heat pump; they therefore have a Coefficient of Performance (CoP) of around 3 – compared to up to 4.5 for an air-to-air heat pump.

> **Coefficient of Performance (CoP)** is a number that describes the effectiveness of heat pumps, refrigerators or air conditioners. The higher the number, the more efficient the heat pump – i.e. the more heat is outputted per kWh of electricity inputted.

High temperature versions are available, these heat water for the heating system up to 70°C. These have a second heat pump cycle on them; the first extracts heat from the air into a tank of water, and then the second extracts the heat from the tank and concentrates this into higher temperature water for the heating system. The double process means these high temperature versions have lower efficiencies, with a CoP of around 2.

How well do AWHPs heat buildings?

The standard temperature versions tend to warm up buildings slowly and steadily ('low and slow') and are therefore well suited to situations where the heating is required for **long periods of the day,** and with heating systems that have a low temperature requirement such as underfloor heating systems. As they warm up spaces slowly, it is important that the warmth being slowly emitted is retained within the building, so that the overall heat levels build up. This requires **good levels of insulation** and air tightness to ensure that the heat loss is lower than the heat being emitted. The same principle is true for underfloor heating systems which also operate with a flow temperature of around 45°C in the system.

[2] There is latent heat in air down to -273°C and these units are still successful at providing heat when operating below zero. The Scandinavian countries have the highest proportion of heat pumps in their buildings in the whole of Europe.

Installation of AWHPs

AWHPs require the installation of external units which look like air conditioning modules in well-ventilated external locations. AWHP and air-to-air heat pump (AAHP) external units look almost identical.

Examples of air source heat pump external units, comprising of three smaller 3kW units and two larger 10kW units.

External unit location

These external units will need an electricity supply and insulated pipework running from them to the pipework of the heating system inside the building. They will also need a drain nearby as the back of the units can build up moisture, which condenses and sometimes freezes on the coils. The larger units do create some low-level noise and therefore the location and baffling of the units may need to be considered carefully.

Single phase or three phase electricity supply?

Most units run from a single phase electricity supply. A single phase 100A supply is likely to have spare capacity for heating of around 18kW. Given the CoP of around 3 for an AWHP, this would provide a heat output of just over 50kW from a single phase supply. This could be sufficient for a small church with roof and floor insulation, but larger churches are likely to require a larger, three phase, electricity supply.

Are our radiators sufficient for an AWHP?

For the standard temperature units, the internal radiators and other heat emitters will need to be reviewed to ensure that they will provide sufficient heat output at the lower temperatures. In many cases, radiators and fan convectors will need to be upgraded to work with the lower heat in the system; this often means changing radiators for similar size units, but which are deeper, with several sets of fins on the back of them. All underfloor heating systems work at around 40°C, so coordinate very well with heat pumps without need for much adaptation.

Note: single pipe systems (as opposed to ‘flow and return’) will not work well with any type of heat pump.

For your engineers – ensuring the right heat output

Heat pumps would normally need to be sized using heat loss calculations for the building, but for underfloor heating systems they should be sized on the output of the underfloor heating. This will be determined by the heated floor area. As underfloor heating systems have an output of around 100W[1] of heat per m^2, the approximate heat pump requirement (in kW output) can be found by measuring the heated floor area and multiplying by 0.1. Care should be taken when sizing AWHPs based on the existing boiler, as these have often been oversized and, in some cases, an additional boiler may have been installed as back-up.

Suitable churches – are they for us?

AWHPs are mainly applicable for those churches which already have underfloor heating that is used constantly throughout the heating season. AWHPs may also work well in other churches which heat their building 24/7. This therefore tends to be the larger, active and daily used churches.

AWHPs are only suitable for heritage buildings which are heated constantly (at least to a background level); they struggle to heat buildings from cold. Due to the lack of insulation and air tightness typically found within these buildings, an AWHP will not be very effective for intermittent heating and should not be considered as an alternative for a boiler which is programmed to come on and off for different times of use. They could also be considered for small, well insulated, heritage buildings which are able to retain some heat between uses but this type of building is very rare on the CofE estate.

Pros and Cons

Pros:	Cons:
Provide heating in a form that is similar in concept to a boiler-based system	External units are visually unattractive and do have some fan noise so need suitable locations
Work well with existing underfloor heating systems	May require the replacement of internal heat emitters and pipework
Do not require extensive ground works, unlike ground source heat pumps	Best used in well insulated buildings
More efficient than direct electric heating systems	

Links to local and national case studies, or relevant guidance

Heat Pumps in Historic Buildings, Historic England

Heat pumps and fabric improvements at St Anne in Ings

New heat pumps and lighting, as part of Newcastle Cathedral's major reordering

St Andrew's, Dean Court was rebuilt using an air-to-water heat pump

To compare St Andrew's, Sandford-on-Thames Ground Source Heat Pump and Underfloor heating Sandford case study

Main product suppliers

There are a vast number of equipment suppliers. Listed below are the major manufacturers of equipment.

Daikin	Mitsubishi
Vaillant	Clade (high temperature units)

For installers, there are an increasing number of heat pump installers although few have extensive heritage experience. One known installer that does is:

Cotswold Energy

Estimated price brackets

AWHP systems do tend to be expensive and costs can range from around £20,000 for a smaller domestic sized installation to several £100,000s for a larger scheme.

They have an indicative life expectancy of 15 years.

What permissions are currently needed under the faculty jurisdiction rules?

The installation of AWHPs will require a faculty, and for the external units, planning permission.

Contact details of the Diocese of Oxford Environment Team for further support and information

environment@oxford.anglican.org

Church House Oxford, Langford Locks, Kidlington, Oxfordshire, OX5 1GF

This is one of a collection of heating guidance notes available here.