

Air-to-Air Heat Pumps

Summary: Air-to-air heat pumps are well-known and extensively tested in modern buildings, this is an electric system that works like air conditioning but for heating. Suitable for churches with a medium-high usage pattern, and can work in uninsulated buildings if designed and sized correctly.



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



External units install in bell tower at St Andrews in the Wardrobe- Photo Credit - P Hamley, WCS Services

What are air-to-air heat pumps?

Air-to-air heat pumps (AAHPs) are essentially air conditioning units used in heating mode. They are exactly the same as an air conditioning system, it is just that the term 'air-to-air heat pump' tends to be used for when there are primarily installed for heating and 'air conditioning' is used for when they are primarily installed for cooling.

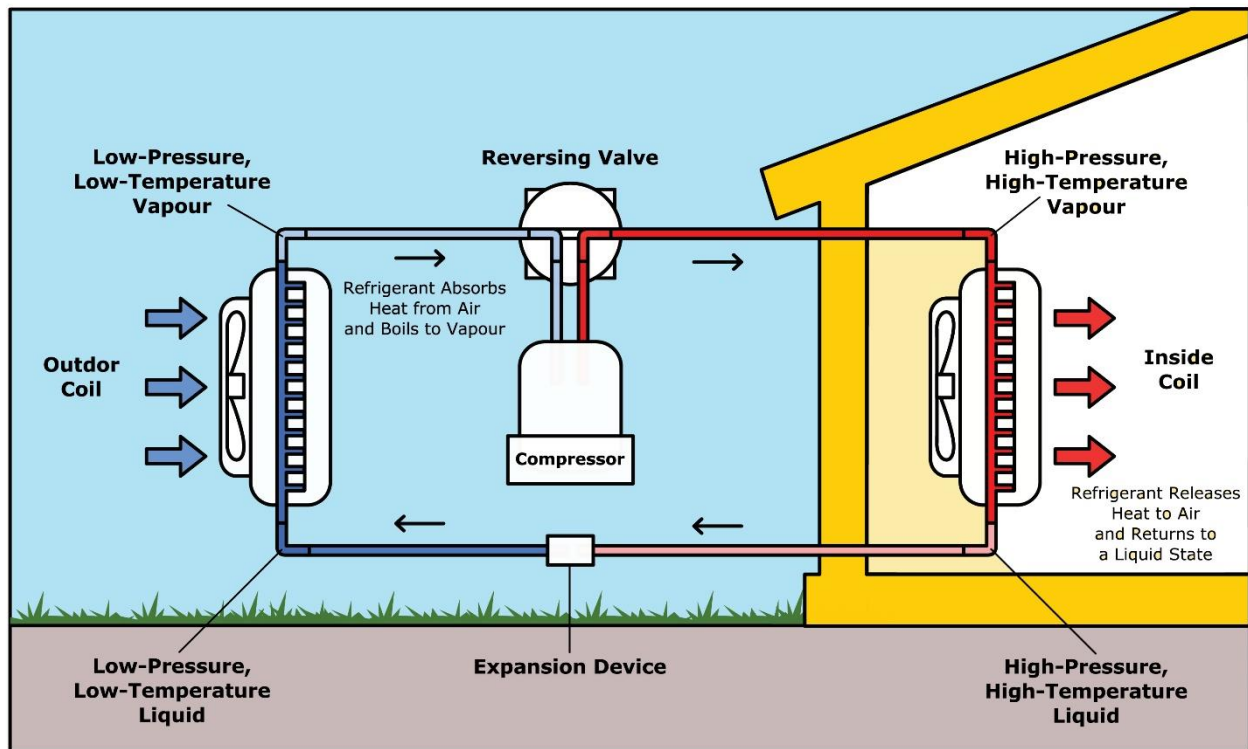
This solution is used extensively in retail, office and hotel environments and has been for many decades. Note – despite the similar name, they are different from heat pump solutions that heat water in heating systems, such as air-to-water heat pumps (the guidance note for air-to-water heat pumps can be found with the collection [here](#)).

The technical bit – how do they work?

AAHP systems work by having an external unit which sucks air in and extracts the heat from the air. The pump concentrates this heat and puts it into a refrigeration gas (in the same way as a fridge or freezer works)¹. This refrigeration gas is then piped inside the building through a small, insulated pipe where it is then allowed to expand in an internal unit with a fan. This heat is then blown out into the space. As warm air is blown into the building, this type of system can heat spaces from cold relatively quickly.

¹ Refrigerant gases do have some global warming potential (GWP) and work is ongoing to improve these within heat pumps; but overall a heat pump contributes significantly less carbon emissions than a traditional gas boiler, and is more energy efficient.

Air Source Heat Pumps Heating Cycle



How an air-to-air source heat pump works (image from Shutterstock)

AAHPs provide around 4 to 5 units of heat for every 1 unit of electricity used in the heat pump; they therefore have a Coefficient of Performance (CoP) of up to around 4.5. This is compared to around 3 for an air-to-water 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.

As a basic rule of thumb, the size of the heat pump required will depend on the volume of air inside the space being heated, as well as the insulation level of the space. For uninsulated churches, the approximate size of the heat pump (in kW) will be the air volume in cubic meters (length x width x height) multiplied by 0.04. For a building insulated to modern building regulations standards it will be the volume of the building multiplied by 0.015¹. An AAHP will work in uninsulated and large buildings (unlike air-to-water systems which can struggle), so long as it is sized correctly.

Installation of AAHPs

AAHPs require the installation of external units, which look like air conditioning modules, in well-ventilated external locations.



These external units will need an electricity supply and pipework running from them to the internal units. 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.

Air source heat pump external unit

Internal units come in a variety of styles. The most appropriate internal units for the majority of churches are floor-mounted units, which look very similar to a fan convactor heater.



Floor mounted unit



Ceiling mounted unit



Wall mounted unit for a more modern location



*Internal unit installed behind timber panelling at St Andrews in the Wardrobe, City of London –
Photo Credits: P Hamley, WCS Services*

The internal workings of the cassettes can be stripped down to remove their casings and installed behind bespoke timber boxings or the like. They require less space than the internal units for air-to-water heat pumps.

Noise levels – a bit of a myth!

All the internal units do have a fan element within them and therefore a small amount of fan noise is emitted. This tends to be less than a fan convactor heater on a boiler-based system and similar to the noise from a fridge or freezer. Air conditioning units are commonplace in hotel rooms, indicating that the noise is low enough even to be suitable for sleeping environments.

Suitable churches for AAHPs – are they for us?

AAHPs can be used in a wide range of churches and will remain efficient over a broad spectrum of usage profiles. They can therefore be appropriate for churches looking to increase their use over time, as they retain their effectiveness across changing use patterns.

For ‘Sunday-use churches’, under pew heating or direct infra-red heating is likely to remain the more appropriate choice. For those churches that have intermittent weekly usage and have no pews, or larger areas without pews, AAHPs could be a good consideration. In contrast, air-to-water heat pumps are mainly used for churches which need heating constantly, for example with underfloor heating.

AAHPs do work well in churches and historic environments and are a proven technology. They have been used to heat retail units, with single glazed shop fronts and the doors open in winter, for decades! This situation is not dissimilar to churches. The challenge is to be able to incorporate the necessary internal and external units - and pipework between them - sensitively into the historic building.

Pros and Cons

Pros	Cons
<p>Heats the whole air in the church to provide pleasant thermal comfort</p> <p>More efficient than direct electric heating systems, and the highest efficiency of any heat pump</p> <p>Correctly sized, will work in most buildings - even those without insulation</p> <p>The blown air element helps to warm buildings relatively quickly</p> <p>Around 80kW of heat output can be installed on a single phase 100A supply without needing an upgrade to a three-phase supply</p>	<p>Some minor fan noise internally</p> <p>Need to locate relatively bulky internal units appropriately within the church. Different formats are available.</p> <p>External units are visually unattractive and do produce some fan noise so need suitable locations</p> <p>Will take some time to warm up large volume churches, which will reduce their overall efficiency if used for short periods of time</p>

Links to local and national case studies, or relevant guidance

Case studies of churches which have installed such a solution are available at:

All Saints, Hethel

St Andrew by the Wardrobe, London

St Egelwin's, Scalford

Main product suppliers

There are a vast number of equipment suppliers and installers as AAHPs are a mature market. Listed below are the major manufacturers of equipment.

Mitsubishi Electric

Daikin

Panasonic

Toshiba

For installers, there are a large number of 'air conditioning installers' although few have extensive heritage experience. Electricians will need to be F-Gas registered in order to legally install the unit, so local electricians are unlikely to be qualified.

Estimated price brackets

Installing a simple, split AC unit to serve one small meeting room would cost around £2,500 to £3,500. A large, multi-split system to cover a whole church can be expected to cost in the region of £70,000.

They have an indicative life expectancy of 20 years.

What permissions are currently needed under the faculty jurisdiction rules?

The installation of AAHPs 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](#).