# *The Orangehouse Renewables Information Series:*
# AIR SOURCE HEAT PUMPS

## An introduction

Air source heat pumps (ASHP) are used instead of a conventional boiler to provide heating and hot water for buildings. ASHPs work by collecting thermal energy / heat from the air and concentrating it into usable heat for space and water heating. The heat pump uses the same technology as a fridge or freezer – ambient air is used as the heat source, which boils the liquid refrigerant into a gas (in the same way that water in a kettle becomes steam) which can then be compressed or concentrated by the compressor to give us usable heat. The harder we squeeze the hotter it gets! This is where the electricity is consumed to power the system. For every unit of electricity consumed we expect to produce up to 5 units of heat – making a heat pump 500% efficient. As a comparison, gas or oil boilers are around 90% efficient.

ASHPs are inverter driven, which means the compressor and fan speed can vary leading to several benefits:

- Output varies to match heat demand - this optimises efficiency through the year as the outdoor temperature and the building heat demand fluctuate
- As heat demand increases, the compressor runs faster and in warmer weather can run slower and more efficiently - reducing running costs
- The compressor starts slowly and then ramps up gradually, so there is less of a demand spike on the electricity grid allowing for a smaller fuse rating and lower power supply requirements
- Heat output and the flow temperature can be adjusted to follow outdoor temperatures - known as 'weather compensation'

## Suitability

ASHPs are ideal for many types of buildings and can be linked together to meet the increased demand of larger properties. New buildings are better insulated and therefore have a lower heat load and allow more flexibility for siting the outdoor unit.

Existing properties both modern or older can be effectively heated by ASHPs. Often buildings have had insulation or window upgrades reducing the heat demand, but the radiators may need upgrading to deliver the required heat output at lower (heat pump efficient) flow temperatures.

## Sizing and design

An ASHP system is sized in the same way as a gas or oil boiler. At Orangehouse Renewables, as required by the Microgeneration Certification Scheme consumer protection framework, we produce detailed room by room heat loss calculations to ensure that the heat pump will effectively heat your building. As the external air temperature drops there is less heat energy available in the air so we specify a system that maintains its output as the air temperature drops to -2°C, -4°C or colder.

Heat Pump flow temperatures are between 35°C - 55°C which works particularly well to:

- Deliver gentle background heating throughout the day rather than short bursts of heat morning and evening with a cool spell in the middle- especially helpful for homes or buildings occupied all day
- Ideal for underfloor heating systems
- Allow the heat pump to run efficiently with minimal running costs
- Deliver effective space heating through radiators or by working harder (compressor squeezes the gas more) deliver hot water for showering/washing up – 55°C is too hot to comfortably put your hand in! A legionella cycle is programmed to run to prevent bacterial contamination.

## Indoor plant

The indoor space required for the ASHP system is normally slightly more than a conventional system boiler with a hot water tank. There will be a hot water cylinder (usually 600mm in diameter), a buffer tank, a couple of expansion vessels, controller, circulating pumps, valves and pipework. The plant can be installed into a utility room, garage or generous storage cupboard - the average footprint for this equipment is around 1-1.5m$^2$. The hot water cylinder can also be located away from the rest of the system e.g. in an airing cupboard or loft.

*AN EXAMPLE OF A COMPACT PLANT ROOM WITHIN A CUPBOARD*

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We generally install a buffer tank with our systems. Although this costs more, we believe the efficiency, lifetime and performance benefits are worth the investment. This is because a buffer tank;

- ensures there is sufficient volume of water available to allow the heat pump to run efficiently,
- provides a supply of heat to the heating system while the heat pump is recharging the hot water cylinder,
- provides a supply of heat to facilitate the defrost cycle,
- reduces the number of compressor starts which prolongs compressor and ultimately heat pump lifetime,
- provides hydraulic separation between the heat pump and heating circuits.

## Outdoor unit

The outdoor unit needs a plentiful supply of fresh ambient air and a free metre or two in front of it to disperse the cooled air produced by heat extraction. The siting of the outdoor unit would preferably be in a south/south west facing location as this optimises the efficiency of the heat pump as the sun preheats the air and surroundings compared to a shadier spot. The heat pump can be located adjacent to the house or up to 30 or so metres away if required for aesthetic or practical considerations.

The other key consideration in siting the unit is minimising noise disturbance. Careful siting away from bedrooms and living rooms helps keep the peace! See the “noise” section.

*A LARGER CAPACITY UNIT*

*A CASCADE OF UNITS*

## Types

There are two types of air source heat pump - split and monobloc. As the name suggests a monobloc contains the compressor and heat exchanger in a single outdoor unit which produces warmed water. A split system is similar to an air conditioning system where there is an outdoor unit that generates the heat and an indoor heat exchanger which transfers it into the building. The indoor heat exchanger is generally a similar size and wall hung like a conventional boiler. These two components are linked by copper pipework carrying refrigerant gas. Installing or maintaining split systems requires an engineer with specialised refrigerant gas training and accreditation.

Split systems can be installed 30 or 50 metres away from the property and linked by relatively inexpensive refrigerant pipe. As monobloc units produce warmed water we need to use more expensive high specification pre-insulated pipe to ensure the produced heat is not lost during transfer to the building. We generally try and position monobloc units adjacent to the property.

## Pipework

Many homes have small bore central heating pipes. Historically it was cheaper and easier to install 8mm or 10mm pipes rather than standard 15mm for radiators. Heat pumps need a good flow of water to work efficiently and radiators need a good flow to provide effective heating at lower heat pump flow temperatures. To balance these two requirements, we always fit a buffer tank which allows both circuits to operate independently and ensures there is a plentiful volume of water available, even if the radiator valves have closed. This way we can effectively heat properties without having to pull up all the floors and walls.

## Defrost cycle to remove ice or frost

Great Britain is a warm wet island so we generally have warm wet air. Extracting heat from the air causes it to cool so the water vapour condenses on to the heat pump forming ice. Every so often the heat pump controller will run a defrost cycle to melt this ice which forms condensate water and needs to be effectively managed. We do not want this condensate to collect or pool near the heat pump where it can cause icing up and loss of heat pump efficiency or become a slip hazard for passing pedestrians. This is usually achieved by linking the heat pump slab into a drain, soakaway or by surrounding it with gravel.

## Cooling

A heat pump is a very honest machine that pumps heat - as one side gets hotter the other gets cooler. By running the heat pump backwards heat can be extracted from the building and pumped into the outside air. This differs from conventional air conditioning in that we are using chilled water instead of a refrigerant gas. Cooling can be delivered through underfloor heating pipework, wall mounted fan units (similar to air conditioning units) or even Mechanical Ventilation and Heat Recovery (MVHR) ductwork. Careful control is required to balance cooling and humidity to ensure no puddles or condensation issues occur.

## Noise

Air source heat pumps do make some noise but generally a correctly sized good quality heat pump “hums and purrs”! They are quieter than oil boilers and would not prevent a conversation in front of it. Air source heat pumps have undergone a transformation in recent years with fan blades, the evaporator and mountings re-designed to minimise noise.

In warmer weather where they are working less hard, they are quieter than in cold weather when they are working very hard (e.g. producing hot water). As a fan is needed to draw ambient air through the ASHP there is noise associated with this and there may be some noise from the compressor. This noise travels in the air stream emitted from the front of the heat pump so pointing this in a sensible direction minimises disturbance. Sound has two key properties – power and pressure. Sound power is the noise a unit produces if you’re standing next to it. Sound pressure is the noise you perceive which diminishes rapidly with distance. A modern good quality heat pump has a low sound power and so causes minimum disturbance.

## Hot water cylinders

High flow temperature gas and oil systems generally have a hot water cylinder with a 1m$^2$ heating coil. As the heat pump works at lower flow temperatures to effectively heat water effectively and deliver a quick reheat time, we need a coil with at least 3m$^2$ surface area. The legionella pasteurisation cycle uses an electric immersion to achieve a higher temperature.

*PLANT INCLUDING THE CYLINDER INSTALLED IN THE LOFT SPACE*

## Radiators/underfloor heating

Appropriately sized radiators are required as heat pump systems operate most efficiently at lower flow temperatures. To emit an equivalent amount of heat into a room at these lower flow temperatures, a larger surface area of radiator is required. Generally extra panels or fan assisted radiators can be specified.

Underfloor heating systems are increasingly a standard feature and complement heat pumps for the following reasons:

- With underfloor heating the large floor surface area acts as the radiator (rather than a smaller metal panel on the wall) delivering effective room heating at efficient low flow temperatures
- The lack of radiators allow for far more flexibility in room layout
- The floor can be heated up with low-cost electricity. This then acts as a thermal store, gently radiating heat during peak electricity times

*Example of 'snail shell' underfloor heating*

## Water pressure

Many older properties have two tanks in the loft. One is the cold-water header tank which relies on gravity using the height difference between the tank and tap to generate the pressure. The other is the feed and expansion tank for the heating system. This arrangement is not ideal. Generally, a shower pump is required to generate decent flow and pressure for a satisfactory shower and historically these have been noisy and unreliable. The heating system header tank can introduce air into the system leading to radiator sludge and a loss of performance. Normally when we install a heat pump system, we disconnect these tanks and switch to a sealed pressurised heating system with an unvented hot water cylinder. This means the higher-pressure mains water coming into the tank pushes the hot water out of the tap or shower for a more powerful and enjoyable showering experience.

## Controller

The system controller is generally placed somewhere visible or is part of the heat pump. The controller manages the heat pump, switches it between heating and hot water production, monitors system temperatures and pressures, records performance data as well as many other functions. Individual rooms or zones (e.g. ground floor and first floor) are generally controlled by room thermostats, programmers and radiator valves - exactly the same as a conventional system.

*A Nibe controller*

## Planning and other Permissions

A single air source heat pump qualifies for Permitted Development rights unless it is within the curtilage of a listed building or in a conservation area. Two or more heat pumps generally need planning permission. If in doubt, contact the local authority.

As heat pumps are electrically powered adequate electricity is crucial. Usually before a heat pump can be connected to the electricity grid permission has to be obtained from the owner of the power lines such as Western Power. The other factor to consider is the draw of the heat pump which needs to be compared to the electrical supply to your property and other demands such as induction cookers or electric vehicle chargers. The heat pump itself generally needs a 25 or 32-amp fuse and a single-phase electricity supply. Larger capacity heat pumps or cascades of several will need a three-phase supply.

## Smart Grid

As the country switches to wind and solar electricity generation the price of electricity and the way we manage it is changing. The introduction of smart meters is developing the old Economy 7 model of different costs or tariffs at different times of the day. During the night electricity is cheaper and at peak times, such as between 4pm to 7pm, it will be much more expensive. Newer heat pump controllers have the capacity to connect to the new Smart Grid to receive start and stop signals in line with electricity pricing. In the meantime, we can set schedules to utilise lower cost electricity and store it as heat in the buffer or hot water tank to bridge more expensive periods. Scheduling or cleverer controls also allow optimising of any on-site electricity generation from solar PV or similar systems.

## Environmental impact

Heat pumps need electricity to operate so if you run your heat pump on zero carbon or renewable electricity there are no carbon emissions. Generating electricity from an on-site solar PV array or wind turbine reduces running costs and environmental impacts. Burning fossil fuels, even the cleanest being mains gas produces carbon.

A good quality ASHP should last 12 to 15 years which may be the lifetime of two value engineered gas condensing boilers.
Heat pumps are charged with refrigerant gases which historically have had a serious impact. Modern heat pumps are changing to refrigerants with a far lower global warming potential which also provide better outputs, increasing efficiencies and higher flow temperatures.

## Running costs

As heat pumps use 1 unit of electricity to generate approximately 4 units of heat, they are the most efficient way to heat a building. Electricity at 14 pence per kilowatt hour equals 3.5 pence per kWh or unit of heat. Mains gas is typically around 4 pence, oil 5 pence and LPG slightly more expensive.

## Power supply

As heat pumps are electrically driven having your own solar PV or micro wind turbine installation will further reduce your running costs. Cleverer heat pumps can recognise or receive a signal when excess electricity is being produced and use the inverter to run the compressor slowly to convert this electricity into approximately 4 units of heat.

## Lifetime

We only install good quality ASHPs which should have a lifetime of around 12 to 15 years if regularly serviced and properly maintained. Manufacturers who are confident in the quality of their products are offering longer warranties, for example Nibe and Vaillant offer up to 7 or even 10 years.

## The Boiler Upgrade Scheme

The Boiler Upgrade Scheme (BUS) was launched on 1st April 2022 to replace the RHI grant scheme. It is designed to encourage the installation of heat pumps instead of gas or oil boilers. The BUS will pay £5,000 towards the cost of an air source heat pump and £6,000 towards the cost of a ground or water source heat pump.

## Servicing and maintenance

Like all machines with moving parts heat pumps need servicing to maintain optimal performance and operation. It is a condition of both the RHI grant scheme and manufacturer warranties that they are serviced annually – this will obviously extend the lifetime of the machine.


*REGULAR SERVICING ENSURES OPTIMAL PERFORMANCE AND EFFICIENCY OF YOUR HEAT PUMP - PICTURED HERE IS AN AIR SOURCE HEAT PUMP OUTDOOR UNIT*

*EXAMPLE OF A BLOCKED FILTER – THIS CAN BE AVOIDED BY REGULAR SERVICING OF YOUR HEAT PUMP*

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