AIR SOURCE HEAT PUMPS  
– Getting heat out of thin air

Last month we looked at the heat pumps which harvest free, renewable heat from the ground. Others get heat from nothing more substantial than thin air, either the ambient air outside the house, or the exhaust air from within. This month we look at Air Source Heat Pumps (ASHP’s), which take their heat from the ambient air outside.

ASHP’s

Although selfbuilders have generally preferred Ground Source Heat Pumps (GSHP’s), nationwide many more ASHP’s have been installed – mostly for shops, offices, etc. The reader may have noticed the blandly-coloured steel boxes on the outside of commercial buildings. (Many heat pumps can cool as well as heat, a feature often wanted for commercial premises.)

ASHP’s are a well proven technology, and, being mass produced, their prices are low. (Trianco’s Activair ‘5kW’ ASHP costs about the same as a gas boiler, at only £850.) However, an ASHP has a shorter life expectancy (15 – 20 years) than a GSHP (20 – 25 years) – it has more moving parts and is usually more exposed to the weather. It will, though, out-last a condensing gas boiler (10 – 12 years).

Our mild winter climate is well suited to ASHP’s, and the cost and upheaval of installing the ground collector for a GSHP is avoided. So an ASHP system might well be a sensible way to heat your low energy home, especially if mains gas is not available. But some supplementary form of heating will probably be required – see later.

There are two types of ASHP: air-to-water, and air-to-air.

Air-to-water heat pumps

Air-to-water heat pumps supply heat for space heating and/or for Domestic Hot Water (DHW).

Most air-to-water ASHP’s are designed to be installed outdoors, with insulated pipework conveying the ‘brine’ to and from the heat pump. The units are heavy (eg, 140 kg), and a concrete base, or similar, is required. In use, water condenses on the evaporator (maybe 25 litres/day), and pipework is required to allow this to run away to a drain or soakaway. Due to its fan, an ASHP is somewhat noisier than a GSHP, so place it well away from bedroom windows and close neighbours.

Other ASHP’s are designed to be installed indoors, eg, in a utility room, garage, or basement. In this case, two air ducts are required through the wall, one for the inlet and the other for the outlet. If the utility room is situated at a corner of the house, a neat configuration is to install the heat pump in the corner. Take the air in through a duct in one wall, and out through a duct in the other – the incoming and outgoing air are kept well separated.

A third type is a split heat pump, with only the (silent) evaporator outside. The compressor is inside the house, connected to the evaporator by a pair of insulated refrigerant pipes.

A potential problem of ASHP’s is that the air grill may become blocked by snow. (Some designs have downward facing cowlings which keep out snow, rain and leaves, and which also reduce noise.) Worse is that the heat pumps stop working if the

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outside temperature is too low – some have a ‘stop temperature’ set to –7°C, for example. That might be OK in the balmy South, but the loss of the heat pump when the outside temperature is below –7°C might be unacceptable in Northern Britain. (Some other ASHP’s can work down to a temperature as low as –20°C.) Both the efficiency and the output of an ASHP fall appreciably as its lower temperature limit is approached.

Like a GSHP, an air-to-water ASHP acts as a small boiler and is best coupled with Under Floor Heating.

**Air-to-air heat pumps**

In contrast to the above heat pumps, air-to-air ASHP’s are self-contained heating systems.

The heat pump (40 kg, maybe) is often mounted on brackets on an outside wall. Inside the house, one or more fan units (10 kg, maybe) are fixed high up on a wall. The heat from the pump is conveyed to a fan unit by brine in insulated pipework. (Sometimes refrigerant is used instead, in which case the installer should be F-gas registered.)

These split systems form a simple, and relatively low cost, space heating system. Many of them come with a bonus: the option of cooling in summertime. A few of them come with another bonus: the option of ‘purifying’ the air by ionic technology. For example, in the ‘plasmacluster’ technology used by Worcester Bosch, water molecules in the air are split into negative and positive ions, and these attack bacteria, viruses, allergens and odours in the air. (But don’t install a heat pump just for this feature. Ionic air purifiers are available as separate appliances.)

**Defrosting**

An early pioneer of heat pumps in the UK was Murray Armor, who was the original author of the best selling book, ‘Building Your Own Home’. He installed an Air Source Heat Pump in his selfbuild way back in the Seventies. But when I visited him some years later, he had to admit it was not working properly. If I remember correctly, it frosted over in cold weather. (A less well known book by Murray was ‘Heat Pumps and Houses’, published in 1981.)

Even with the outside air temperature above zero, the refrigerant in the evaporator may be below zero. So when the outside temperature is below about 5°C, frost forms on the evaporator, fan and grill, and this impedes both heat transfer and air flow. Modern ASHP’s have overcome the problem by incorporating defrost cycles. Three methods are in use:

- **Reverse cycle**
  Diverting valves reverse the direction of flow of refrigerant around the heat pump – the evaporator becomes the condenser, and vice-versa. In short, the pump goes temporarily into cooling mode. The defrost time is short, maybe 4 minutes. (Heat pumps which can be used for summer cooling use this method.) A buffer tank is desirable to supply the heat for defrosting.

- **Hot gas bypass**
  Most of the hot gas from the compressor is made to flow directly into the evaporator, bypassing the condenser. The manufacturing cost is lower for this
method, but longer defrost times result. (During the defrost period, a small portion of the hot gas from the compressor is directed to the condenser, so some heating is still provided. But a buffer tank may be desirable, nonetheless.)

- *Electrical resistance heating*
  This simple, cheap method is mostly used for air-to-air heat pumps.

Frosting is likely to be most severe at ambient temperatures around 2ºC. (At lower temperatures, the amount of moisture that the air can carry is reduced.) The need for defrosting in cold weather obviously has an adverse effect on efficiency. The COP in those conditions may be reduced by about 10%, and this need for defrosting is one of the reasons why ASHP’s have lower overall COP’s than GSHP’s.

**Coefficient of Performance**

The draft version of SAP2009 gives the overall Coefficient of Performance (COP) for an ASHP as 2.5. Some manufacturers and suppliers are claiming COP’s of more than 3. Indeed, some even claim more than 4 – though the small print shows this is only for A7/W35. (See my article two months ago for the meaning of the nomenclature).

There is little empirical evidence available at the time of writing for actual COP’s in real life. But the results of one notable study have been published, for some field trials lasting two years in the Black Forest region of Germany. (See Further Info.)

For ASHP’s coupled with UFH, the average COP was 2.8 (or 2.4 for the whole system, including buffer tank etc.) The best had a COP of 3.0 for the whole system.

However, the UK has a milder, moister winter climate than the Black Forest, and ASHP’s can be expected to perform better here. How much better? We await a report by the Energy Saving Trust for their year-long field trials.

The high humidity of our maritime climate has a benign effect on the COP. Water vapour that condenses on the evaporator gives up its latent heat to the heat pump.

How much heat is released? The latent heat of vaporization of water is 2.5 megajoules/kg. We saw earlier that 25 litres (ie, 25 kg) of water may condense in a day. That would release 62.5 MJ of heat (62.5 = 2.5 x 25). Since 1 kWh = 3.6 MJ, we see that, in more familiar units, water condensing out of the air may release 17.4 kWh of heat in a day – a considerable amount of heat.

By way of illustration, the energy content of the air in London, averaged over the winter period, has 64% more energy available than the air in Berlin:

<table>
<thead>
<tr>
<th>Enthalpy (kiloJoules/kg)</th>
<th>London</th>
<th>Berlin</th>
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<tbody>
<tr>
<td>London</td>
<td>16.2</td>
<td>9.9</td>
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(Enthalpy is the sum of the ‘sensible’ heat available relative to 0ºC, and the latent heat. In winter, London air is warmer and moister than Berlin air.)

**Comparing ASHP’s**
Comparing the laboratory COP’s of air-to-water ASHP’s is complicated by the fact that different manufacturers quote figures for different temperature lifts. Most quote a figure for the water temperature of 35ºC, but the air temperature may be 0ºC, 2ºC, or 7ºC. Fortunately, the figure most commonly quoted is for 2ºC, a temperature which is likely to be near the average air temperature at those times when the heat pump is required to operate (ie, mostly in cold weather). For this temperature lift (A2/W35), most ASHP’s have a COP in the range 3.1 to 3.6 – though Vokèra claim an amazing COP (A0/W35) of 3.9 for their Aria 6.8.

Another factor to consider is noise level, which varies appreciably between models. Most manufacturers give the sound pressure level at a distance of 1m from the pump. The figures cover a wide range, 45 – 60 db(A). (‘db’= decibels, the lower the better. The ‘A’ indicates that the figure relates to perceived loudness – the physical sound levels have been weighted according to the perceived loudness of different frequencies.). Other manufacturers give the figure for a distance of 10m. A few quote figures for both distances. (The figure for 10m is about two thirds of that for 1m.)

Several manufacturers offer variable fan speeds. Besides saving electricity, this allows the noise level to be reduced when full heating is not required, eg, at night-time or during the summer.

**Supplementary heating**

A big disadvantage of ASHP’s is that their performance deteriorates as outside temperatures fall. Their COP is reduced; but worse than that – their output is reduced, too. When there is the greatest need for heat, an ASHP provides less of it, and less efficiently. Indeed, when it is extremely cold, some ASHP’s simply switch themselves off.

We saw last month that a common strategy is to undersize a GSHP, so that some supplementary form of heating is required to meet a very heavy demand for heat.

For ASHP’s, under-sizing is almost standard practice, and is, indeed, regarded as desirable in order to reduce on-off cycling. If the ASHP is sized to provide 80% of the heat on the coldest day, it will, in fact, provide about 95% of the heat required over the year. Even so, a supplementary method of heating is almost a necessity.

The supplementary heating may simply be electrical resistance heating, either integrated with the pump unit, or separate. With Under Floor Heating in a screed, off-peak electrical heating of the UFH water may be used to supplement the ASHP. Or the supplementary heating may be a more carbon-light method, such as a separate wood or pellet stove.

**ASHP’s and off-peak electricity**

The main off-peak period is during the night, when air temperatures, and hence the COP, are likely to be lower. So though it may still make financial sense to use an ASHP with cheap night-time electricity, performance suffers – in contrast to a GSHP whose efficiency is unaffected by the time of day.

**Next month:** Exhaust Air Heat Pumps.

**FURTHER INFO:**

AIR SOURCE HEAT PUMPS 4 FEBRUARY 2010.
Black Forest heat pump trials
www.agenda-energie-lahr.de.
For a translation:

**Dimplex**
www.dimplex.co.uk.

**Earthcare Products**
Environmentally friendly air-to-air ASHP’s.
www.earthcareproducts.co.uk.

**Keston**
UK manufacturer of Airgen ASHP’s.
www.keston.co.uk.

**Mitsubishi**
Ecodan ASHP’s.
www.mitsubishi-heating.co.uk.

**Nibe**
www.nibe.co.uk.

**Trianco**
UK manufacturer of Activair ASHP’s.
www.trianco.co.uk.

**Vaillant ClimaVAIR**
Air-to-air ASHP with up to 4 indoor fans.
www.vaillant.co.uk

**Veissman**
ASHP’s for internal or external installation.

**Vokèra**
www.vokera.co.uk.

**Worcester Bosch**
www.worcester-bosch.co.uk.

**Nu-Heat Underfloor and Renewables**
Yutaki ASHP, with COP (A7/W35) of 4.3.
www.nu-heat.co.uk.

**ICS Heat Pumps**
DeLonghi ASHP’s have modulating fans. ‘Floating set-points’ make a buffer tank unnecessary.
www.icsheatpumps.co.uk.

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