HEAT PUMPS – WHAT ARE THEY?

All heat pumps use a refrigeration cycle to extract low temperature – often referred to as low grade - heat from a source and reject high temperature heat to a heat emitter.
In building applications, the heat pump can be used as an alternative to a boiler for space heating and domestic hot water. This alternative will become increasingly in demand as the UK moves away from using fossil fuel as a primary heat source for space and domestic hot water heating.

The key characteristic of a heat pump compared to a boiler is that the amount of heat produced is greater than the energy used to drive the process, e.g. the electrical energy supplied to the compressor motor and fans or pumps. For this reason the cost of heat provided by a heat pump can be less than the cost of heat provided by a boiler, even though the cost of electricity is greater than alternative fuel sources.

The source can be air, ground water or the earth itself and the purpose of this guidance is to briefly explain these differences and how they can be applied in practice to significantly reduce our carbon footprint as a nation.

1. AIR TO AIR

Air to air heat pumps include the following types:

- "Split" Units
- Externally Mounted Air to Air Heat Pump Packaged Units
- Exhaust Air to Air Heat Pumps
- Reversible Air Conditioning systems including variable refrigerant flow (VRF/VRV) and Multi-split systems

Split unit heat pumps are similar to split unit air conditioning units but optimised for heating. The internal and external unit are linked together with refrigerant pipework. Where these systems are reversible air conditioning systems the indoor and outdoor units can act as the evaporator or the condenser depending on the operating conditions of the unit at any given time.

A VRF/VRV system may operate with some indoor units operating as condensers and others operating as evaporators simultaneously, providing very efficient heat recovery by providing some or all of the usable heat from other areas of a building that need to reject heat.

Externally mounted heat pump packages are located on a roof or adjacent to a wall with insulated ductwork transferring heated air into the building. Unlike split units there is provision for the variable introduction of fresh air directly.

Benefits:

Split type systems are more efficient than packaged ones due to the additional sub-cooling available in the pipe run. ***Typical efficiency is between 4 and 6kW of heat for every kW of power consumed.***

Quick response to changing outdoor conditions and heating requirements in the building.

Outside "fresh" air can be easily introduced in air supply systems, allowing filtering and air treatment to be embedded in the system design.

Drawbacks:

The split type units may require multi-trade involvement in the installation due to the refrigerant regulations requiring refrigerant pipework to be installed by a certified professional.

Air source heat pumps are subject to ice formation on the outdoor coil and require defrosting periodically (achieved automatically but sometimes with loss of output for short periods of time).

Efficiency drops off as the outdoor temperature drops below -5°C.

2. AIR TO WATER

The most common type of heat pump in use, predominantly used in the domestic market due to their similarity in design to the traditional gas/oil boilers in use in the UK housing market, air to water heat pumps include the following types:

- Air to water heat pump packages “monoblock” units
- Air to Water “split” systems
- Exhaust air to water heat pumps

Air to water heat pumps are usually provided as unitary packages for external mounting or as split units with only the evaporator unit mounted outside.

Indoor heating can be supplied by traditional radiators (although they need to be substantially larger than when using gas/oil boilers to heat the property) or by underfloor heating. They normally have to run at lower flow temperatures than traditional systems to achieve the energy efficiency levels published so are best suited to new-build, heavily insulated, homes. They are slow to react to fluctuating outdoor temperatures or indoor needs due to the lower flow temperatures.

Benefits:

Split type systems are more efficient than packaged ones due to the additional sub-cooling available in the pipe run. ***Typical efficiency is between 3.5 and 5kW for split type and 3 and 4.5kW for monoblock type for every kW of power consumed.***

Look like traditional heating systems so are more readily accepted by householders.

Drawbacks:

The split type units may require multi-trade involvement in the installation due to the refrigerant regulations requiring refrigerant pipework to be installed by a certified professional.

Air source heat pumps are subject to ice formation on the outdoor coil and require defrosting periodically (achieved automatically but sometimes with loss of output for short periods of time).

Slow response time when changing outdoor temperatures change the heating demand on a property.

Slow to heat from cold at start-up if heating has been switched off for a period of time.

Efficiency drops off as the outdoor temperature drops below -5^{o}C.

3. GROUND SOURCE / GEOTHERMAL

Ground source systems use one of two systems for heat extraction:

- Boreholes drilled into the ground at typical depths between 40 and 100m, with plastic tubes inserted into them to allow a flow and return of a water-based solution.
- Shallow trenches dug at around 1.2m deep into which a long looping plastic pipe, normally referred to as a “slinky”, is laid and buried.

The heat from the ground is absorbed by the water solution flowing through the pipes in both cases. They work on the principal that, in the UK, the ground temperature approximately 1m below ground is relatively stable all year round, regardless of the air temperature and weather conditions being experienced above ground. This enables a heat pump to work in stable conditions year round, enabling design to be optimised for those conditions.

Normally connected to a heat pump transferring heat via water into the building and delivering heat through underfloor heating circuits, or traditional style radiators in the same way that an air to water system described in section 2 does, they can also be connected to heat pumps delivering air heating in the same way as described in section 1 does.

Benefits:

Ground source systems do not normally need to have defrost cycles activated because they do not frost up the same way that air source systems do, and so do not have the periods of no heat being delivered.

Energy efficiency is maintained through colder outdoor temperature conditions. ***Typical efficiency is between 6 and 7kW for every kW of power consumed.***

Drawbacks:

Expensive to install compared to air source due to drilling or earth moving costs.

Boreholes may require permission from local authority to drill, and geological surveys may be necessary to determine suitability.

Shallow trenches for horizontal pipe laying require a large area of ground to be dug up and used so they are not really suitable for retrofit to existing properties without major disruption to landscaping.

4. OPEN LOOP WATER SOURCE

These heat pumps can extract heat from water stored in tanks, lakes, rivers or reservoirs; natural aquifers – layers of water occurring between layers of porous rock; or flooded disused mines.

They work in the same way a ground source system does but the water is directly extracted and pumped back into the larger body of water rather than in a closed loop. This use of naturally occurring water means the use of the water for heat extraction may require an abstraction and/or disposal licence from the Environment Agency and the quality of the water may require water treatment and filtration to make it safe for use.

Benefits:

Open loop water source systems do not normally need to have defrost cycles activated because they do not frost up the same way that air source systems do, and so do not have the periods of no heat being delivered.

Energy efficiency is maintained through colder outdoor temperature conditions. ***Typical efficiency is between 6 and 7kW for every kW of power consumed.***

Drawbacks:

Expensive to install compared to air source due to drilling or earth moving costs.

Boreholes may require permission from local authority to drill, and geological surveys may be necessary to determine suitability.

Water quality in aquifers and open water or in flooded mines will require fine filtration and may require water treatment with potentially high on-going maintenance costs.

For further reading and a more technical insight into how each type works and the pros and cons of each type see:

BESA TR30 Guide to Good Practice for Heat Pumps

CIBSE TM50 Ground Source Heat Pumps

CIBSE CP2 Surface Water Heat Pumps

CIBSE AM16 Heat Pumps for multi-unit residential buildings