heat pumps

what are they?

A heat pump is simply a device for absorbing heat from one place and transporting it to another. Heat pumps can be used to remove unwanted heat (e.g. a fridge or air conditioning unit) or to transport heat to where it is needed.

A fridge is a good demonstration of how surplus heat (from cooling food) can be extracted and redistributed. In fact in a super-insulated home the heat from the back of a fridge or freezer can contribute significantly to space heating. Heat pumps, fridges and air conditioners work on the same principle. Air conditioners take heat from inside and dump it outside. A heat pump does the opposite. In fact if a heat pump is run in reverse it becomes an air conditioner.

Different sources can be used, depending on your property. The most easily installed is the air-source heat pump, which fits to the side of a building and draws in the heat from the air outside. A ground-source heat pump requires a system of pipes to be laid in the garden around a property, which means that it costs more, but is more efficient compared to air-source heat pumps. Water-source heat pumps are also available. In each case the system has 3 components: the heat pump itself, plus a collector (outside), and a distribution system (inside). Ground-source heat pumps (GSHPs) rely on heat from the sun warming the surrounding land. In the UK, soil maintains a relatively stable temperature of between 8-12°C at a depth of over a metre, even in winter.

The collector or ground loop is simply a closed circuit of pipe, containing a water / antifreeze mix, buried either in a horizontal trench at least 1.2m, but preferably 1.5-2m deep, or in a vertical bore-hole 15-150m deep. The liquid is pumped through the pipes, collecting heat from the surrounding soil, and into the heat pump, usually sited inside the building.

The heat pump itself has 3 parts:

- an evaporator absorbs heat from the liquid from the ground loop into a refrigerant, then...
- a compressor compresses to the required distribution temperature, then…
- a condenser releases that heat into a tank of water feeding the distribution system.

Since the heat pump will produce circulating temperatures of only 30-45°C, underfloor heating is best (or highly efficient low temperature radiators), with back-up heating if the system is used for domestic hot water.

what are the benefits?

Since the heat comes from a renewable source (the sun), heat pumps can help reduce fossil fuel consumption, CO_2 and other emissions. Remember though, that heat pumps require a reliable electricity supply which may itself come from a non-renewable source. Modern efficient heat pumps can produce about 3-4 kW of heat using 1kW of electricity for the pump and compressor. This is sometimes expressed as being 300-400% efficient, or having a coefficient of performance (CoP) of 3-4.

Running costs are therefore much lower than by direct electric heating. The Energy Saving Trust suggest savings of £1000 and 7 tonnes of CO_2 for 100% of space heating and 50% of hot water in a detached property using a 8-12 kW heat pump costing £6000-£12000 (excluding the distribution system).

Suggested savings over other fuels are £750 and 1.8T for oil, £350 and 6.5T for solid fuel, £410 and 1.2T for gas. This shows a relatively small financial benefit over gas, so that if a gas supply is available, the cost of installing a GSHP is much less attractive than an efficient gas-fired condensing boiler (at current gas prices). GSHP running costs are also subject to fluctuations in electricity prices. Using onsite PV or wind to pump the system would remove this risk and create a more eco-friendly system.

Other benefits are high reliability with low maintenance costs and long life expectancy (20-25 years for the pump and up to 50 for the ground loop). There is no local combustion or storage of fuel, and the pump unit only occupies the space of a large domestic fridge. It's quiet and requires no ventilation or flue because it produces no local pollution. Improvements in coolant and refrigerant technology have also reduced the wider impact of these components.

Air-source heat pump.

what can I do?

Look hard at your circumstances. A heat pump could be for you, particularly if:

- you are planning a new build or major refurbishment (underfloor pipes or high spec radiators essential).
- your property has a very high level of insulation throughout – remember, the heat is distributed at only 30-45°C – some older buildings may not be energy efficient enough.
- there is no mains gas supply (financial benefits are much less compared to gas).
- you have enough land for a horizontal collector trench – probably at least 2 trenches 300mm wide, 40-50m long and 1.8m deep (or shallower and wider) to take a coiled pipe.
- you are on a green electricity tariff (this enhances the environmental benefits).
- you can include onsite electricity generation (e.g. pv or wind) to power the pump.

On densely-built city sites with little land, vertical boreholes from mini-sized drilling rigs are the efficient solution. Vertical boreholes can be charged with heat from solar panels, pumping heat deep down for recovery in winter.

Get professional advice. System design is crucial for GSHPs. This is very project-specific as required output is calculated from the property's demand (heat loss, water use etc), and collector length matched to output. An oversized heat pump will cost more for no additional benefit, and possibly suffer reduced equipment life and operating efficiency due to frequent cycling. Under-capacity may require more top-up heating.

The heat pump itself is the size of a fridge-freezer, with a smaller buffer tank next to it.

Loopy collector pipe for a ground-source heat pump being laid in a trench.

It's hard to understand why heat pumps are not the default for new builds. It's much cheaper and easier to install than to retrofit, and provides a very low-maintenance way of generating heat from pure renewables. Using nearby parks or green spaces would be an ideal way of mixing natural space and renewable heating. If there isn't space for a horizontal underground collector system, the air source or vertical borehole options could be considered.

resources

- see lowimpact.org/heat-pumps for more info, training, products / services, links & books, including:
- Donal Blaise Lloyd, *Geo Power*
- John Cantor, *Heat Pumps for the Home*
- Billy C Langley, *Heat Pump Technology*
- renewableenergyhub.co.uk/search-installers – search for installers using your postcode
- gshp.org.uk – Ground-source Heat Pump Association
- heatpumps.org.uk – UK Heat Pump Assoc.
- heatpumps.co.uk – general information