

Heat Pumps

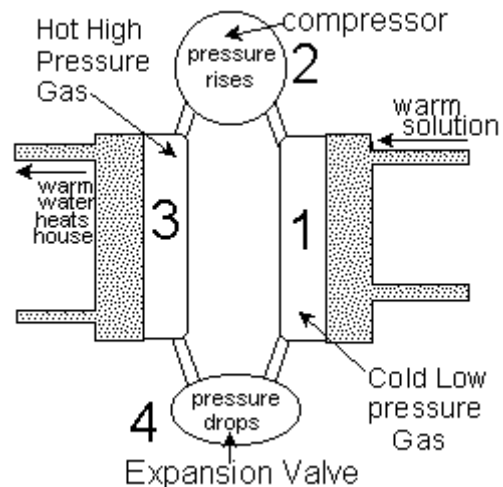
Heat pumps can be used to provide heat and cooling to buildings or rooms. Using this technology it is possible to recover heat from most sources (even those that have what appear to be very low temperatures) and pump that heat to another location e.g. removing heat from inside your fridge and dissipating it through the heat-exchanger grill at the back.

How do heat pumps work?

The vapour compression cycle (electric) heat pump is a closed system around which a refrigerant flows. A heat pump works by a fluid (gas or liquid) being passed through coils or matrix of the source, i.e. water, the ground or air (1). As this fluid is a couple of degrees cooler than the source, it will gradually warm up. The slightly warmer fluid is then passed through an evaporator and this slight temperature increase is transferred to a refrigerant in the internal system. The refrigerant boils at a lower temperature (around -40°C) so turns into a gas. It is then drawn into a compressor which increases the pressure and the temperature of the gas (2). In the condenser, the heat is then transferred to heating and water system (3). With the heat energy gone the refrigerant turns back into a liquid and passes through the expansion valve, reducing the temperature and pressure (4).

Because of their high efficiency, heat pumps use around a third less electricity for heating than other forms of electrical heating. This, in-turn, means two thirds less carbon dioxide emissions. But, unlike oil or gas, electrically-driven heat pumps can be made carbon dioxide-free by the purchase of electricity via a *green tariff* (See advice sheet No1) or the generation of electricity on-site by a

renewable technology such as wind or sun.



Ground-source systems

These are often referred to as geothermal heating or Ground Source Heat Pumps (GSHP) and can be used for heating residential and commercial buildings. Heat is extracted from pipes laid horizontally or vertically in the ground. Due to the extraction of heat from the ground, the ground temperature will fall slightly during the heating season. However, in summer the sun will raise the ground temperature back again. The offices of Cornwall Energy Efficiency Advice Centre at Tolvaddon Energy Park in Camborne are heated using a ground-source heat pump system.

Grants

From May 2007 the new UK Microgeneration Certification Scheme came into force replacing the existing Clear Skies accredited installer scheme. Therefore grants will now only be available to persons using both a BRE certified product and installer. Visit www.lowcarbonbuildings.org.uk for more information.

Costs for typical UK house heating

For every 3kW of heat provided, a heat pump will consume around 1kW of electricity. If the pump is run at night using off-peak electricity, the cost of space heating via a heat pump can be a little lower than using mains gas or oil. However, greater savings can be made if the heat pump can be employed for both heating and air conditioning. The initial purchase costs of a ground source heat pump system will be quite a lot more than conventional oil or gas fired boiler. But there are no fuel charges as the heat source is the ground. Costs for more conventional fuels are set to rise in the future. The cost of a heat pump system will vary according to the size and energy efficiency of the property but a typical domestic-sized ground-source system might be expected to cost in the region of £5,000 (not including trenching/borehole). VAT is payable at 5% not 17.5%.

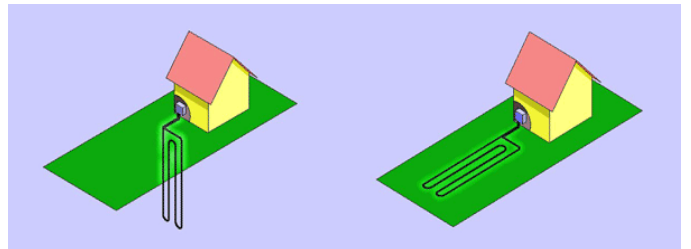
Size of System

The better insulated your house, the smaller the pump required - and the less money it will cost. The heating requirement for most UK homes is around 6 to 8 kW. A normal-sized home which

obtained building regulations approval after April 1st 2002 should only require around 4-5 kW.

Trenches/borehole

For an average home, you will need to connect the pump to either pipes in trenches (slinkies) or a borehole. Usually 2 trenches are needed and are typically 40 metres long by 1.5 metres deep and at least 5 metres apart. These trenches will contain several hundred metres of pipe. Costs will vary from a few hundred pounds for a single DIY trenched piping to £1,000+ for a commercially installed system.



Alternatively a borehole with single loop pipe could be used to extract heat from the ground. This requires a hole around 70m deep to be drilled and should cost around £1,000 - £3,000 (but this will depend upon the geology of your land).

Heat pump installation

Most heat pumps are easier to install than gas or oil boilers and can be installed by anyone who is reasonably competent at plumbing. Ground source systems are generally simple and straightforward while air source are more complex.

Domestic Hot Water (DHW)

It is possible to supply domestic hot water with a ground source heat pump. The water from the heat pump will be used for pre-heating and then an immersion heater to bring the temperature up.

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Underfloor, radiators or air heating

To obtain the maximum performance from a geothermal system you should ideally use an underfloor heating system. This is because a building can often be heated with water at a flow temperature of as little as 35 to 40° C. Lower temperatures save energy. Fossil fuel boilers, particularly oil, cannot run at these low temperatures and prefer as high a temperature as possible, hence the popularity of heat pumps with underfloor heating specialists.

Existing radiators can be used with a heat pump system but it is not ideal. The maximum flow temperature that most pumps provide is generally 50°C and so some rooms may need larger radiators than with a fossil fuel boiler. If you are planning to use radiators then you will need to select a pump with a higher output than that recommended for underfloor heating.

Ducted air is popular in North America, and can be used effectively in the UK, especially if cooling is required. However, it is not as efficient as underfloor heating although generally much better than using radiators.

Operating pumps overnight on the off-peak electricity tariff is the most cost-effective way of providing space heating from a heat pump. This is why underfloor piping set in the concrete floor slab is most economic (the concrete acts like a storage radiator). If pumps are run only on an 'on-peak' electricity tariff, the overall heating cost will be greater than an oil or gas-fired, condensing-boiler system. However, the drawback of floor-slab heating is that there can be a time

delay of 2 to 4 hours between switching the heat pump on and achieving the desired air temperature in the room.



Cooling

Being able to cool a building as well as heat it is one of the major assets of a heat pump. The additional installation costs are relatively low. It is possible to provide limited cooling using an underfloor heating system provided the piping is laid with double the density and a control system is installed to take account of the possibility of condensation. This method of cooling is usually regarded as unsuitable for houses because the floor area is too small and the response time too slow. We would also recommend the use of a buffer tank (around £450) if you are considering cooling with a floor. Cooling with radiators is not possible. Cooling with air using fan coils is ideal, and there are some hybrid systems which use underfloor heating in the winter and fan coil cooling in the summer connected to the same heat pump.

Buffer Tanks

A purpose-built buffer tank allows for a much wider range of temperatures to be achieved. Buffer tanks also prevent short cycling problems during periods of low heating or cooling demand - perhaps when only a small part of a building needs to be heated or cooled.

Environmental and energy efficiency benefits

Heat pumps, especially ground/water source, are a highly energy efficient method of heating buildings in the UK. There is generally no regular servicing requirement but occasional maintenance may be required. There are no local CO₂ emissions, no flammable fuels or tanks, no flue, no pilot light and no toxic exhaust gases. If electricity to drive the pump is purchased through a green tariff (See information sheet 1 –*Green Electricity*) your energy required for space heating should effectively be CO₂ emission-free.

Coefficient of Performance (COP)

Most GSHPs have a COP of about 3. This means that 1Kwh of electricity used to drive the pump will produce 3 Kwhs of heat.

Alternative Heat Sources

Air is free and widely available, and it is the most common heat source for heat pumps. Air-source heat pumps (ASHP), however, have a COP which varies considerably as the external air temperature varies. At 10°C the COP is similar to that of a GSHP, i.e. about 3. Above 10 °C the COP can reach 4 to 5, but at 0°C the COP will fall to about 2.

In mild and humid climates, frost will accumulate on the evaporator surface in the temperature range 0 to 6°C, leading

to reduced capacity and performance of the heat pump system. Coil defrosting is achieved by reversing the heat pump cycle or by other, less energy-efficient means. Energy consumption increases and the overall coefficient of performance (COP) of the heat pump drops with increasing de-frost frequency. Using demand de-frost control rather than time control can significantly improve overall efficiencies.

There is the possibility of corrosion of the ASHP when in close proximity to the sea so some manufacturers require the ASHP to be at least 1Km away from the coast.

Exhaust (ventilation) air is a common heat source for heat pumps in residential and commercial buildings. The heat pump recovers heat from the ventilation air, and provides water and/or space heating. Continuous operation of the ventilation system is required during the heating season or throughout the year. Some units are also designed to utilise both exhaust air and ambient air. For large buildings exhaust air heat pumps are often used in combination with air-to-air heat recovery units.

Ground water is available with stable temperatures (4-10°C) in many regions. Open or closed systems are used to tap into this heat source. In open systems the ground water is pumped up, cooled and then re-injected in a separate well or returned to surface water. Open systems should be carefully designed to avoid problems such as freezing, corrosion and fouling. Closed systems can either be direct expansion systems, with the working fluid evaporating in underground heat exchanger pipes, or brine loop systems. Due to the extra internal temperature difference, heat pump brine systems generally have a lower

performance, but are easier to maintain. A major disadvantage of ground water heat pumps is the cost of installing the heat source. Additionally, local regulations may impose severe constraints regarding interference with the water table and the possibility of soil pollution.

Rock (geothermal heat) can be used in regions with no or negligible occurrence of ground water. Typical borehole depth ranges from 100 to 200 metres. When large thermal capacity is needed the drilled holes are inclined to reach a large rock volume. This type of heat pump is always connected to a brine system with welded plastic pipes extracting heat from the rock. Some rock-coupled systems in commercial buildings use the rock for heat and cold storage. Because of the relatively high cost of the drilling operation, rock is seldom economically attractive for domestic use.

River and lake water is in principle a very good heat source, but has the major disadvantage of low temperature in winter (close to 0°C). Great care has to be taken in system design to avoid freezing of the evaporator.

Sea water is an excellent heat source under certain conditions, and is mainly used for medium-sized and large heat



pump installations. At a depth of 25-50 metres, the sea temperature is constant (5-8°C), and ice formation is generally no problem (freezing point -1°C to -2°C). Both direct expansion systems and brine systems can be used. It is important to use corrosion-resistant heat exchangers and pumps and to minimise organic fouling in sea water pipelines, heat exchangers and evaporators, etc.

Waste water and effluent are characterised by a relatively high and constant temperature throughout the year. Examples of possible heat sources in this category are effluent from sewers (treated and untreated sewage water), industrial effluent, and cooling water from industrial processes or electricity generation, condenser heat from refrigeration plants. The major constraints for use in residential and commercial buildings are, in general, the distance to the user, and the variable availability of the waste heat flow. However, waste water and effluent serve as an ideal heat source for industrial heat pumps to achieve energy savings in industry.

More Information

Permitted development rights

In England, changes to permitted development rights for renewable technologies introduced on 6th April 2008 have lifted the requirements for planning permission for most microgeneration technologies.

The General Permitted Development Order (GPDO) grants rights to carry out certain limited forms of development, without the need to apply for planning permission. The scope of the GPDO in England now extends to GSHPs and WSHPs but **not** ASHPs.

Installers

See 'Low Carbon Buildings Programme' approved installer list for grant-funded installations - call them on 0800 915 0990 or see www.lowcarbonbuildings.org.uk

It is advised that you seek more than one quote from an installer to achieve the best price. Some installers operating in Cornwall:

| Company | Telephone | Website |
|------------------|------------------------------|--|
| EarthEnergy Ltd | 01326 310650 | www.earthenergy.co.uk |
| Kensa Heat Pumps | 01872 862140 | www.kensaengineering.com |
| Microgeneration | 0845 4348084 | www.microgeneration.com |
| Eco Heat Pumps | 0114 2962227 01872 300200 | www.ecoheatpumps.co.uk |

We advise that you obtain at least 2 comparable written quotes from different installers and check the VAT discount for renewable technologies has been applied. For more information on VAT discounts, please see: <http://customs.hmrc.gov.uk>

Other Information

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|--|---------------|---|
| Cornwall Energy Efficiency Advice Centre | 0800 512012 | www.cep.org.uk |
| Energy Saving Trust | | www.energysavingtrust.org.uk |
| Navitron | | http://www.navitron.org.uk/heatpumps.htm |
| Ice Energy | 0845 310 5600 | www.iceenergy.co.uk |
| Calorex | 01621 856611 | http://www.calorex.com/ |
| Continental Underfloor Heating | 0845 1081204 | www.continental-ufh.com |
| Extensive installer list | | http://www.heatpumpnet.org.uk/ |

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