# Heat Pumps Tipsheet 50p

Use heat pump technology to extract the heat energy stored in the ground, water or the air and apply it to your domestic or industrial heating and cooling needs.

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Heat pumps are designed to extract heat energy from a low temperature source and deliver it at a higher, more useful temperature. Some heat pumps reverse this flow of heat energy, as in the case of refrigerators and air conditioning systems.

Until now, plumbers, builders and architects in the UK have not utilised heat pump technology due to the availability of cheap conventional heating systems run on gas or other fossil fuels. The future of these fuels is uncertain, however, and as concern about climate change also grows the option of using heat pumps is becoming feasible and grants are available for some installations.

If you are looking to install a heat pump, the economic and environmental costs should be considered carefully. It might be the case that improving your insulation for better heat conservation will meet your heating needs more immediately.

**Common types of heat pump**

The reversible air conditioner (an air-to-air system which pumps cool or warm air) is the most common type of heat pump globally. Despite this wide use, air systems are not very efficient, as it is difficult to transfer heat energy using ambient air as a medium. The best source of heat energy is water, e.g. a river or stream, or the ground. Some heat pump applications can even use man-made sources of heat, such as domestic or industrial waste.

The most common heat pump in the UK is the fridge. Heat is extracted from the icebox and ejected through the grill at the back leaving the inside of the fridge cool and the air at the back warm. In this type of system the heat energy is not required for warmth and is expelled as waste.

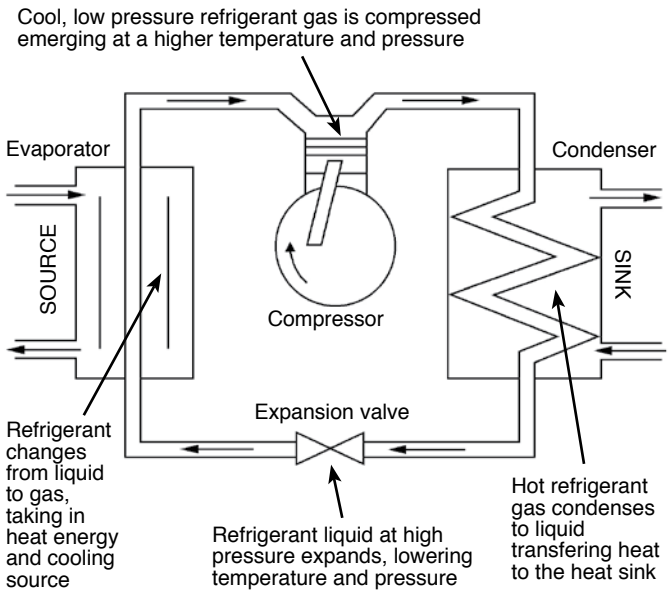
Another very common type of heat pump is the ground source unit, e.g. a floor standing unit (like a boiler) with connections running in from pipes in the ground and water connections running out to radiators or underfloor heating. Ground source systems like this are often called 'geothermal', though the heat extracted is actually from the Earth's surface rather than its centre. Pipes placed in trenches at a depth of around 2 metres, or in a borehole up to 100 metres deep, extract heat energy from the ground for use in domestic or industrial situations.

**Why choose a heat pump?**

- Heat pumps can be used for space heating, hot water heating or air conditioning.
- An electrical heat pump might need just 1 unit of energy to turn 2 units of heat from the surroundings into 3 units of useful heat.
- If the fuel for a conventional boiler were to be used to drive a heat pump about 35-50% less would be needed.
- A good heat pump installation will consume less primary energy than conventional heating systems, which means fewer carbon dioxide ($CO_2$), sulphur dioxide ($SO_2$) and nitrogen oxide (NOx) emissions.
- Heat pumps are a tried and tested technology – though they are not yet common in the UK, heat pumps are used in many established energy systems in countries like Germany.

Source: International Energy Agency Heat Pump Centre, Sweden

*Figure 1: Vapour compression heat pump operating principle*




**How do they work?**

But you might ask: how do heat pumps extract heat energy from a source that is cold? Confusion about this stems from our perception of heat rather than the heat pump technology itself: humans are very sensitive to changes in body temperature and it takes only a slight change in outside temperature to make us feel uncomfortable. But even when it is freezing (0°C), relative to Absolute Zero (-273°C) it is still warm and heat energy is available for extraction.

In the UK, a new heat pump installation is likely to consist of a ground source heat pump linked to radiators or underfloor space heaters (known as the heat sink, or emitter). The heat pump works by reversing the energy transfer that occurs naturally, i.e. heat naturally flows from warm to cool places. A system of pipes buried in the ground extracts the heat energy in the surrounding mass of earth and transfers it to a refrigerant. The refrigerant is passed through the compressor of the heat pump to raise its temperature further for use in radiators and so on. The compressor is usually powered by an electrical input. (Figure 1.) So, are heat pumps a form of renewable energy? While heat pumps do extract renewable heat energy from natural sources, an electric power source is required which is likely to be produced from non-renewable sources. The electrical input constitutes about 25% of the total energy input, which means heat pumps are not renewable in the same way as wind, solar or hydro – the 100% renewables.

**Want to install a heat pump?**

- Is the building properly insulated?
  Proper protection against draughts and heat loss is always the best way to cut your energy costs.
- What type of heat delivery system is it replacing?
  Direct combustion heating or direct electric heating systems do not use fuel efficiently – a heat pump with a good COP could be installed instead.
- Where is the heat source located?
  The feasibility of a heat pump installation usually depends on how accessible the heat source, for example a large garden, is in relation to the building.
- Are you eligible for a grant?
  The Government's Low Carbon Buildings programme provides grants for renewable energy installations including ground source heat pumps. (See Further information.)
- Are you paying a 'green' electricity tariff?
  Reduce the environmental impact of all your electrical energy needs by buying energy sourced from renewables.

## Are heat pumps energy efficient?

The measure of energy efficiency of a heat pump is called the Coefficient of Performance, or COP. It is the ratio of useful heat output to energy input, where:

**Useful Heat Output = Electrical Energy Input + Extracted Heat**

Thus the COP is the number of units of heat energy output by the pump per unit of electrical energy used to run the compressor. For example, a heat pump system with a 4kW output of heat energy per 1kW of electical energy input has a rating of COP 4. Each unit of electrical energy input used to drive the heat pump's compressor can generally deliver between 2 and 4 units of heat energy.

A heat pump in a heating system functions differently to a conventional boiler: the energy efficiency/COP of a heat pump depends on the temperature difference between the heat source and the heat emitters – the smaller the temperature lift the higher the energy efficiency and COP rating. This has implications for the design of the heating system; for instance, to keep the temperature lift in a ground source to radiator heating system at a minimum the radiators should be double the usual size. Alternatively, the radiators could be replaced by underfloor heating which works at lower water temperatures. (Heat pumps can also supply hot water of temperatures up to 55°C, but heating to these high temperatures will lower the energy efficiency.) A heat pump could (if big enough) provide full, year-round house heating, but most installations incorporate a smaller unit with a conventional boiler for back up use during colder spells. Weather compensation, which is used in most new heat pumps, also increases annual efficiency by dropping the emitter temperature in warmer weather.

## Other environmental factors

In the past, CFCs (chlorofluorocarbons) and HCFCs (hydrochlorofluorocarbons) have been commonly used as refrigerants in heat pumps. These are now banned and all standard heat pumps use 'ozone friendly' HFCs (hydrofluorocarbons). Unfortunately, this is not entirely desirable as HFCs are a potent greenhouse gas with the potential to cause damage to the environment if accidentally released into the atmosphere – for instance, a complete leak could cancel out the $CO_2$ gains from 1 to 4 years' use of a heat pump. However there is less danger of the refrigerant leaking during the lifetime of newer heat pumps due to the higher quality of manufactured units.

The danger of a refrigerant leak is further lessened when naturally occurring substances are used as refrigerants instead. Of these alternatives, hydrocarbons (HCs) are favoured since they have a near-zero environmental impact – an HC leak would release about the same amount of $CO_2$ as one person driving to work. However, it must be noted that HCs are flammable and should be used in accordance with strict safety regulations. Overall, if both a natural refrigerant and electricity from a sustainable source are used, heat pumps are environmentally benign and beneficial.

*Table 1*

| Heating system | Energy efficiency | $CO_2$ Emissions* |
|---|---|---|
| Oil | 85% | 0.32 kg/kWh |
| Gas | 90% | 0.21 kg/kWh |
| Heat pump | COP 4 | 0.12 kg/kWh |

*$CO_2$ emitted through primary energy use per kilowatt-hour of useful heat energy
Source: John Willoughby Energy Consultants

## Are heat pumps cost effective?

In nearly all applications heat pumps provide an overall energy saving – converting the energy input to a greater beneficial output while producing fewer $CO_2$ emissions (see Table 1). However, the saving is unlikely to automatically translate to your pocket as most heat pump systems use an electrical input, which is relatively expensive. When compared to a very good gas heating system a COP of 4 is necessary if the heat pump is to break even on the cost of using day-rate electricity. However, when there is no option of gas heating, e.g. when oil, LPG or electricity are the only available fuels, a heat pump system can make significant savings.

The installation costs for a heat pump are higher than a conventional boiler, but a heat pump will last longer than a boiler. So, if you are prepared to wait, a heat pump system will create significant savings over time. The wait can be lessened with help towards paying installation costs now available through the Government's Low Carbon Buildings programme, which provides grants for household or community renewable energy systems. Ground source heat pumps, where recognised products and an accredited installer are used, are included in this category. Remember, the first step towards reducing your energy needs and costs is always to make your home as energy efficient as possible by improving insulation, draughtproofing, and so on. This is likely to be the cheapest way of reducing your environmental impact, and will save you money. But, looking to the future, the use of more heat pumps nationwide, e.g. good underfloor heating systems with plenty of ground pipes, could significantly improve the UK's energy use and reduce our $CO_2$ emissions.

**Further information**

- Low Carbon Buildings Grants
  http://www.lowcarbonbuildings.org.uk/
  Tel: 0800 915 0990
  Department of Trade and Industry initiative providing grants for ground source heat pump installations in England, Wales and Northern Ireland.
- Energy Saving Trust
  www.est.org.uk
  Tel: 0845 727 7200; or local advice on: 0800 512 012
  Identifies, promotes and manages energy efficiency schemes in the UK. Runs grant schemes to assist installation of equipment.
- Heat Pump Association (HPA)
  www.feta.co.uk/hpa
- IEA Heat Pump Centre
  www.heatpumpcentre.org
  Detailed information on heat pumps.
- UK Heat Pump Network
  www.heatpumpnet.org.uk
  Provides information to help the UK heat pump market develop according to best practice on environmental and economic grounds.

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