Heat Pumps

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What is a heat pump?

You'll almost certainly have a heat pump in your home already, as they are used to keep fridges cool - basically by 'pumping' heat out. Most air conditioning units are also heat pumps. Both of these are generally air-source systems.

A ground source heat pump will usually be the more efficient option for home heating – giving the lowest running costs. Air-source systems are cheaper to install, but their efficiency will drop as air temperatures drop (when you need heat most). Also, heat transfer from air is more difficult than from other sources. Water-source systems can be very efficient, but they're not common because you need a water source that will not freeze (such as a spring).

Are they environmentally friendly?

To be environmentally beneficial, the whole heating system must be properly specified and the house very well insulated (to a level above that specified by current UK Building Regulations). You can greatly improve the efficiency of most existing properties with simple energy conservation measures - see our *'Energy Conservation'* sheet for advice.

The efficiency of a heat pump is given by its 'coefficient of performance' (COP). At a COP of 3, it will give 3 units of heat energy for each unit of electricity used. The COP will vary as the source temperature changes.

However, the COP excludes factors such as any auxiliary electric heater or an immersion heater used to 'top-up' heating or hot water, or electricity for pumps and fans. It is more useful to look at overall system efficiency – total heat output compared to total electricity use across different weather conditions. A 'Seasonal Performance Factor' (SPF) can be used for this, so you may see this term quoted as well.

It is very important to get the SPF as high as possible, as most grid electricity is still generated from fossil fuels or nuclear power, at efficiencies of only 30 to 40%. A heat pump with poor seasonal efficiency can result in higher carbon dioxide emissions that a modern oil or LPG boiler. Electricity generation also causes other forms of pollution: sulphur & nitrogen oxides (that cause acid rain), particulates, mining impacts, and nuclear waste.

You can sign up for a 'green tariff', and have your electricity use allocated to renewable sources such as wind or hydro power. This is an excellent way to help promote the growth of the renewable energy industry, but it's not a green light to use loads of electricity! Doing so will increase overall electricity demand, and until more renewable energy technologies are ready, this will increase the use of fossil fuels and nuclear power.

An efficient heat pump gives most benefit (both financially and environmentally) when replacing oil, LPG or direct electric heating – as these are more expensive and polluting fuels. It will not give much saving (if any) against a modern mains gas boiler, so is mainly suitable for homes not on mains gas.

A heat pump contains about 2 kilograms of refrigerant - usually hydrofluorocarbons (HFCs). These are potent greenhouse gases (about 1600 times more powerful than carbon dioxide) and a leak during or after the unit's life will have a damaging impact. Some suppliers use hydrocarbon refrigerants such as R290 and R600a (propane & isobutane) or CO_2 (R744); these will have a much lower impact if accidentally leaked.

What other heating options do I have?

Modern wood pellet or 'batch' log boilers are very efficient, and some situations – particularly older houses - might be a better option than a heat pump. It's certainly worth investigating both to compare. See our *'Wood-fuelled Home'* sheet for advice.

Ground source heat pumps (GSHP)

These draw heat from under the ground using either a borehole or a series of pipes laid a few metres below the surface. This heat is mainly solar energy that has been

absorbed by the ground. Two metres down, the ground is protected from extremes of heat or cold - it stays at about 10°C all year. The heat pump 'boosts' this low-grade heat to the temperature needed to heat a home.

Air source heat pumps (ASHP)

This does the opposite of an air-conditioning unit. It takes heat from the outside air and boosts it to the level needed for heating. The COP gets lower as outside temperatures drop, because the ASHP then has to use more electricity to keep the house warm. Some ASHPs are air-to-air rather than air-to-water. Bear in mind that warm air heating systems are uncommon in the UK and hard to install into existing buildings because of the ductwork required. Make sure you've included the full costs of this

Comparing Efficiencies

The high COPs quoted in brochures may be rarely achieved. Low winter temperatures and domestic hot water demand can be factors. When comparing quoted COPs, check the source (inlet) and delivery temperatures they are for, as given here:

Temperature		Heat pump COP	
Inlet	**Delivery**	**7kW**	**9.5kW**
-7°C	35°C	2.3	2.5
2°C	35°C	3.0	3.3
7°C	35°C	3.4	3.8
7°C	45°C	2.8	3.0

Source: www.worcester-bosch.co.uk

Also, do they include hot water? - Ask the installer for the more useful Seasonal Performance Factor' (see last page) that a heat pump in your home could achieve

Specifying an efficient heat pump

A heat pump operates most efficiently when the temperature gap between the heat source and the heat demand is minimised. To reach a decent operating efficiency you must have a very well insulated house - usually a new-build or an extensive renovation. Heat pumps don't run efficiently when heating water to 75°C for standard radiators, so you'll need a low temperature system. Large radiators can be run on water at about 50°C, whilst underfloor heating can be run at only 35°C. Underfloor heating can be fitted under solid or suspended timber floors, but thick carpets should not be used – they'll stop the heat coming through.

So that a heat pump can work at maximum efficiency all year round it may be sized to meet about 90% of the heating demand, with some form of backup heating needed during very cold spells – perhaps a wood-fired room heater.

Heating domestic hot water to 60°C will also diminish efficiency - an immersion heater is often used to top-up hot water, and this means more electricity use and higher costs. Solar water heating is a good alternative for hot water and a good companion for a heat pump system - see our sheet on solar water heating for much more advice.

Actual performance in field trials

An Energy Saving Trust field trial of heat pumps in the UK found a wide variance in performance - only a few reached an acceptable system efficiency of 3 or more. The average for ground source systems was 2.3, while for air source heat pumps it was 1.8 (with none above 2.4).

In a second phase of this trial, various remedial measures were taken to improve the systems. After this, the average seasonal performance factor (SPF) for GSHPs increased to 2.8, and for ASHPs to 2.45. All but one of the GSHPs being monitored met the benchmark standard of 2.5, compared to 9 of the 15 ASHPs. Systems below this 2.5 benchark do not qualify for support under the Renewable Heat Incentive (see the box on next page).

To avoid a low COP, ensure that a home is well-insulated, has underfloor heating and good heating controls, and that the ground loop or air-source unit has been adequately sized. The best performing heat pumps in the field trial supplied underfloor heating

How much will a heat pump cost?

At current prices, a heat pump should be a cheaper option than oil, LPG (propane & butane), or direct electric heating (e.g. storage heaters). It will only be more cost effective than a modern gas boiler if the system can achieve very high efficiency.

Heat pumps are still a relatively rare option for central heating, so installation prices will vary a lot – the best thing to do is to compare quotes from a few installers.

As a rule of thumb, a ground-source system is likely to cost about £1000 per installed kilowatt (kW). The heat pump itself will be £400 to £600 per kW, with trenches £300 per kW or boreholes £500 per kW.

Installation costs for air-source heat pumps can vary from £5,000 to £9,000.

Putting in underfloor heating will cost about £2000. Existing homes will need insulation levels improved. Without these measures the running costs will be much higher.

The running costs (electricity use) depend on heat demand, system efficiency and electricity prices. To supply 12,000 kWh of heat per year, a heat pump with an SPF of 3 will use 4,000 units of electricity at a cost of £520 (when 13p per unit).

Heat pumps can receive support through the *Renewable Heat Incentive* (see below).

Guidelines for ground loop installation

Trenches should be at least two metres deep for a consistent year-round heat source. You will need 50-80 metres of pipe per kilowatt (kW), or 10 metres of 'slinky' coiled pipe per kW (7-8kW is a typical size). Boreholes will usually be 100-150 metres deep, with 20-50 metres of pipe per kW and 2-4 pipes per borehole (or more than one borehole). Pipe diameter should be 20 to 40mm for best performance: big enough to reduce pumping power but small enough to increase flow velocity and cause 'turbulent flow' (giving better heat transfer). Installers trying to reduce costs might skimp on the length or bore of pipe, or the depth of the trenches.

Are air-source heat pumps noisy?

There will be some noise - check technical literature on manufacturers' websites for figures. Worcester Bosch quote 65 decibels (db) for the noise level at 1 metre from their unit. By comparison, normal conversation may be at a noise level of 50db, a busy office about 60db, and a busy street about 70db. The external part of an ASHP is basically the same as an air conditioning unit, but they do vary a lot - so don't judge all ASHPs by the noisiest air conditioner.

Will I need planning permission?

Ground source heat pumps are usually a 'permitted development', as are air source heat pumps in England and Scotland (but not Wales) as long as certain standards are met. Check with your local planning office to make sure. In Northern Ireland planning permission will be needed.

Microgeneration Certification Scheme
Lists installers and equipment accredited for the proposed RHI. ☎ *020 7090 1082 www.microgenerationcertification.org*

Energy Saving Trust
Advice about energy conservation measures. ☎ *0300 123 1234; www.est.org.uk*

Heat Pumps and the Renewable Heat Incentive (RHI)

The UK Government's Renewable Heat Incentive (RHI) provides incentives to support the installation of heat pumps in domestic and non-domestic buildings.

Support for domestic buildings

All eligible systems are supported financially through tariff payments. Ground or water source heat pumps can currently get 19.64 pence per kWh of renewable heat, while air source heat pumps get 7.63 pence per kWh of renewable heat. These payments last for 7 years and increase with inflation.

The amount of 'renewable heat' is calculated by multiplying assessed heat demand by (1 - 1/SPF). For example: with an SPF of 3 we get (1 – 1/3) = 2/3, and so two-thirds of the heat demand is renewable and will be eligible for payments. See our website or contact us for more information.

Support for non-domestic buildings

Non-domestic buildings – from a B&B or a pub to a public building or factory – have a different tariff rate. For more information see our website or the Ofgem website. Non-Domestic RHI payments are for 20 years and increase with inflation.

For more information about the RHI, please visit ***http://info.cat.org.uk/rhi***

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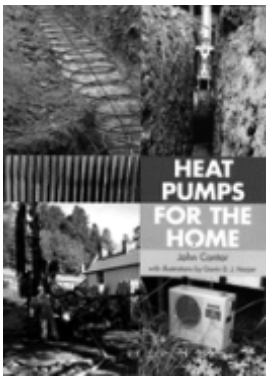

Heat Pumps for the Home
Written by a practising engineer with over 30 years relevant experience, attempts to give an easy-to-understand balanced view of a topic seemingly clouded with uncertainties. Providing all the information you need: how heat pumps work; are they appropriate for you; how to use them efficiently; sources of heat; distributing the heat; hot water production and environmental and financial issues. Dispels some common misconceptions and presents a number of case studies.
160pp hardback, £14.99

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