

Energy Efficiency Partnership for Homes

Hard to Treat Group

UK Heat Pump Guidance

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Introduction

Background

This brief guidance has been developed from a study commissioned by the Hard to Treat group of the Energy Efficiency Partnership for Homes. The purpose of this guidance is to help inform Local Authorities, Housing Associations, architects and developers about the use of heat pumps in the UK and includes an explanation of heat pumps, their advantages and disadvantages the different types of heat pumps and how and where they can be used most effectively. However the guidance is not designed to be a 'how to' guide for those who have already made the decision to specify heat pumps but there are a number of references, organisations and websites that can provide further information.

What is a Heat Pump?

A heat pump is a device that extracts heat from a low temperature source and transfers it to another location at a higher temperature. The technology is not new - it was invented in Victorian times – but it has never been extensively used to provide space heating in domestic properties in the UK.

The most common application of heat pump technology is in refrigerators, where a heat pump is used to extract heat from the interior of the refrigerator (thereby cooling it) and the heat generated is given out into the air adjacent to the appliance. This is also the means by which cooling of air is provided in air-conditioning systems, and there is a well established market for heat pumps that can provide cooling in summer and, by reversing their mode of operation, heating in winter in non-domestic buildings in the UK (and in domestic buildings in warmer climates).

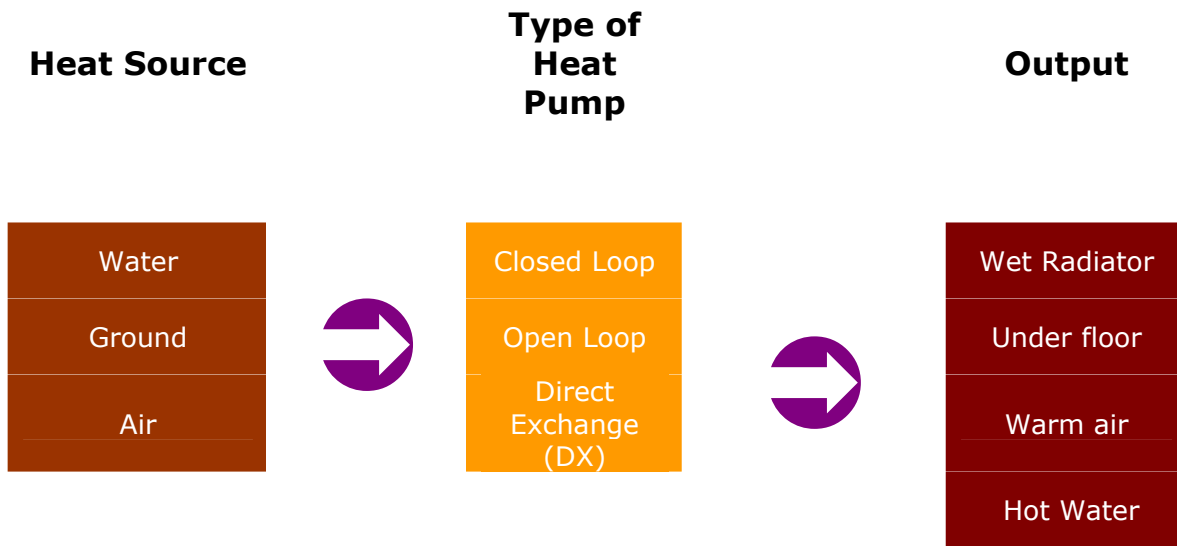
Heat pumps have become more popular in the UK in recent years but are still relatively rare when compared to more traditional heating systems. One of the reasons for this is their potential to provide high seasonal heating efficiencies of at least 250%. However their application is not entirely straightforward and the same critical assessment process undertaken for all heating and hot water systems should still be applied to heat pumps.

Advantages	Disadvantages
High Efficiencies	High relative capital cost
Low maintenance costs	Low temperature output
No Annual Safety check	Some noise and vibration
Wide range of applications	Developing industry
Long life expectancy	Specialist support required

The types of heat pump and their use

In simple terms there are three elements to any heat pump system – the heat source – whether that is ground, water or air, the type of heat pump itself which can be open or closed loop or DX and the system output and this can be traditional wet radiator, under floor or warm air. This is summarised below:

Fig 1 Heat Pumps Source, Type and Output Summary



A further option is the use of an internal source of heat, as in 'heat pump ventilation units' which extract heat from the exhaust air from mechanical ventilation systems.

Finally, there is the potential for 'hybrid' systems that combine heat pump technology with active solar thermal technology. In the case of solar hot water systems, a heat pump could be one option for the provision of top-up heat when there is insufficient solar energy available. However the match between these technologies is not ideal since the heat pump will also be least efficient in the coldest months when there is minimum solar energy available.

Heat Source – the input

In order to operate heat pumps simply need a temperature difference between their 'input' and their 'output' and they can find this heat source in the ground, from the air or from water. The way this is extracted has been often been the way heat pumps have been classified, for example, ground source heat pumps, air source heat pumps etc. However this is complicated by whether there is a direct exchange of heat between the source and the refrigerant in the heat pump ('DX' systems) or there is a secondary circuit or 'loop' that transfers heat from the source to the heat pump.

Despite this variation, by far the most common type of heat pump is the ground source heat pump.

Types of Heat pumps

<p>Ground (or water) source heat pump systems using closed loop water source heat pumps</p>	<p>The secondary circuit consists of a sealed loop of pipe containing a water/anti-freeze mixture that circulates through it, transferring heat from the source to a heat exchanger in the heat pump unit. The loop is then buried in either a horizontal trench or a vertical borehole (or submerged in a river or lake in the case of water source).</p>	<p>The majority of heating only heat pump systems currently being installed in the UK are ground source heat pumps using a closed loop water source.</p>
<p>Ground (or water) source heat pump systems using open loop water source heat pumps.</p>	<p>Open loop systems use natural groundwater as the means of transferring heat from the ground to the heat exchanger in the heat pump unit (or they can directly use the water from a river or lake). They are cheaper to install than closed loop systems, and until recently were the most widely used type.</p>	<p>Likely to be less efficient (since the temperature of the secondary circuit cannot be controlled) and potential sites where they can be used are becoming more scarce due to increasingly restrictive environmental regulations concerning the use of groundwater.</p>
<p>Ground source heat pump systems using DX heat pumps.</p>	<p>The ground loop contains the refrigerant from the heat pump rather than a secondary water-based circuit, so the heat is extracted directly from the ground into the refrigerant. DX systems are potentially easier and cheaper to install than systems with secondary loops.</p>	<p>There is a tendency for the soil around the loop to freeze, which can reduce the efficiency, and there may be concerns regarding the possible release of polluting refrigerants to the environment.</p> <p>Specialist refrigeration engineers may be needed to install the pipe work connections.</p>
<p>Air source heat pump systems</p>	<p>Air source heat pump systems operate by using fans to draw air across the evaporator element of the heat pump.</p> <p>Air source systems are technically also DX systems since heat is directly extracted from the ambient air into the refrigerant.</p> <p>Can potentially be used in any type of dwelling, including flats, subject to sufficient space being available.</p>	<p>The main advantages of air source heat pumps over ground source heat pumps are the relatively low capital cost, and the fact that they can be used for individual heating systems in blocks of flats.</p> <p>Less efficient than ground source heat pumps.</p>

Heating Systems - the outputs

As a result of heat pumps producing relatively low temperature of the heat, the distribution systems need to be designed to match this and operate at relatively low temperatures compared to those in boiler based systems. Below are the main options for heating and hot water systems. In addition the controls are also outlined.

Under floor heating

Under floor heating operates very effectively in the temperature range of 30-45°C, and therefore is the most effective means of supplying heat to a dwelling from a water output heat pump. In new build housing this is straightforward to install. However, it is expensive and disruptive to install in an existing property unless the floor needs to be replaced anyway.

Warm air heating

Warm air heating can be provided directly from an air output heat pump system and in this case the low output temperature makes this an effective method. Again a temperature range of 30-45°C can be used, although in this case the efficiency is slightly undermined by the need for higher air change rates at lower temperatures. Therefore it is not as efficient as under floor heating.

Radiator heating

Heat pumps can also be used to supply heat via radiators, but flow temperatures of 45-50°C are required as a minimum, reducing the efficiency of the system. Also, to operate effectively at these temperatures, relatively large radiators are needed to provide the same output as would be obtained from a boiler system (at least 30-40% greater surface area of emitter). Thus if new radiators are to be installed, they will need to be relatively large and/or designed to facilitate convection. Fan assistance would increase the heat output rate but would obviously add to the running costs.

Hot water supply

The supply of hot water potentially provides the greatest challenge for heat pump systems, since hot water has to be stored at least 55°C to avoid any risk of Legionnaires' Disease, and the output from a heat pump is not sufficient to provide an instantaneous hot water supply. Therefore modern systems are designed to achieve this, usually by giving priority to the hot water system when this is required, and sacrificing efficiency temporarily to provide the maximum output temperature possible.

Controls

From the householder's perspective, the heating and hot water control systems used with heat pump heating systems are generally no different from those used with boiler based systems, i.e. programmers, room thermostats, cylinder thermostats and, in the case of radiator based systems, TRVs.

Running Costs

The following table provides a comparison between a number of heating system options for a 'hard to treat' semi detached house with solid walls and a room in the roof, both with and without wall and roof insulation:

Heating system	Annual fuel cost (Standard occupancy)		SAP energy rating	
	No insulation	With insulation	No insulation	With insulation
Electric storage heating	£1,470	£883	13	44
Solid fuel heating	£1,122	£737	20	51
Oil fired central heating (condensing boiler)	£921	£632	37	66
Ground source heat pump (CoP 3.15, Economy 7 tariff)	£813	£582	41	68
Gas fired central heating (condensing boiler)	£801	£573	49	75

Fuel cost estimates produced by NHER Surveyor

This shows that the ground source heat pump system is only marginally more expensive to run than a mains gas condensing boiler system, and that converting from electric storage heaters to a ground source heat pump system would reduce the fuel running costs by a slightly greater amount than insulating the property. The issue is whether the capital cost is cost-effective compared to the alternatives, and the likelihood that this will be the case decreases as the size of system increases, since (unlike boiler-based heating systems) the capital cost of heat pump systems is proportional to the output required.

The application of Heat Pumps

It could be argued that any of the heat pump heating systems could be applied to any of the house types, if the option of supplying heat via a communal heating system in the case of blocks of flats was included.

The viability of heat pump systems is not especially constrained by the type of house as such. As detailed above, the constraints are space, access (in the case of ground source) and the availability of suitably sized heat pumps.

In practice, it comes down to a trade-off between capital costs and running costs, i.e. whether a heat pump system is installed or not will depend on the property owner's view regarding the benefits of lower fuel running costs (which in the case of rented properties, will not be of direct benefit to them).

An alternative matrix that also takes into account the existing heating system and access to mains gas, and whether or not the property is being fully refurbished or whether the heating system is to be replaced only is proposed on the next page. This additionally uses three colours to indicate where heat pumps are unlikely to be cost effective (red), where they may be worth appraising against other options (amber) and whether they should be actively considered (green).

Heat Pump Application Matrix – Indicative Use

	House/Bungalow				Flat Mid Rise				Flat High Rise			
	Full Refurb		Heating Only		Full Refurb		Heating Only		Full Refurb		Heating Only	
	Insuln Poss	Insuln Not Poss	Insuln Poss	Insuln Not Poss	Insuln Poss	Insuln Not Poss	Insuln Poss	Insuln Not Poss	Insuln Poss	Insuln Not Poss	Insuln Poss	Insuln Not Poss
Gas or Oil Central Heating Installed	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red	Red
No central heating but Mains Gas Available	Green	Yellow	Yellow	Yellow	Yellow	Red	Yellow	Red	Green	Yellow	Green	Yellow
No central heating Off Gas Network	Green	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green
Existing Electric Storage	Green	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Yellow

- Heat pumps are probably not worth considering
- Heat pumps may be considered equally with other options
- Heat pumps should be actively considered