MITSUBISHI ELECTRIC
AIR CONDITIONING SYSTEMS

Information Guide

Heat Pump Boilers

CPD CERTIFIED
Construction CPD Certification Service

Issue Ten

Heat Pump Boilers

Information Guide

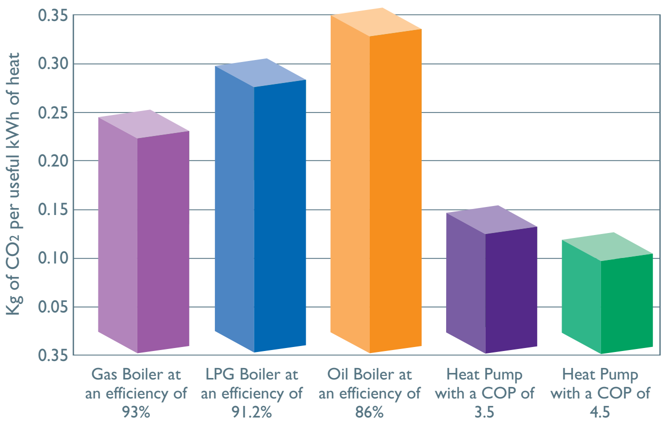
This is an independent guide produced by Mitsubishi Electric to enhance the knowledge of its customers and provide a view of the key issues facing our industry today. The guide accompanies a series of seminars, all of which are CPD accredited. The changing face of construction in the 21st Century demands that designers, specifiers and suppliers work as teams to create better buildings - for occupants and the environment. Mitsubishi Electric aims to be a part of this by encouraging employees and customers to work together to increase their knowledge of the latest technology, legislation and markets.

Contents

An introduction to heat pumps

Energy use in commercial and domestic buildings is already a hot topic in the UK. As both national and local government press forward with environmental legislation and as fossil fuel prices rise, the construction sector is looking for techniques and technologies which can help them meet new rules on cutting CO_2, reducing whole-life energy use and employing renewable energy sources.

CO_2 Emissions for various heating systems



There is **57% less carbon emissions** when comparing a gas boiler with a heat pump of a COP of 4.5.

Assumptions

CO_2 levels for per kWh for various fuels

	kg CO_2 per kWh
Oil	0.28
LPG	0.25
Gas	0.21
Electricity	0.43

This means that technologies which have not previously been considered, are now being looked at. Building heating and cooling are two of the main areas of energy use, so applications which offer more efficient ways of dealing with these challenges are of particular interest.

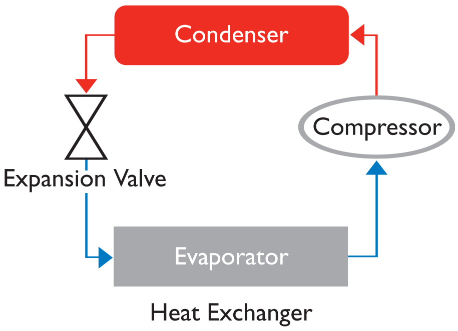
One technology which is benefiting from these market shifts is the heat pump. This technology is already well known in the air conditioning market, and has proved very efficient when used for cooling. However, in other countries, such as Sweden and Switzerland, heat pumps are also used for domestic heating and hot water. The heat pump is a very flexible technology, with excellent energy efficiency and CO_2 mitigation properties and the market is only just starting to tap into this potential. As illustrated in the graph there is 57% less carbon emissions when comparing a gas boiler with a heat pump of a COP of 4.5.

The term 'heat pump' refers to a variety of products which all work on the same principle. Heat pumps are usually categorised by the type of heat source and heat dissipation method they use (see page 4). What is common to all is that they provide a highly energy efficient method of heating space and hot water. Heat pumps can also provide cooling - an increasingly important feature as summer temperatures reach new highs, even in the UK.

Most heat pumps work on the same principle as a domestic refrigerator, using a vapour compression cycle. The main components in the heat pump are the compressor, the expansion valve and two heat exchangers (an evaporator and a condenser). The diagram opposite shows how the system works.

Coefficient of performance

The coefficient of performance, or COP, of a heat pump is the ratio of the heat delivered, divided by the power consumed. A modern heat pump, for example, will achieve a COP of 3 to 4.



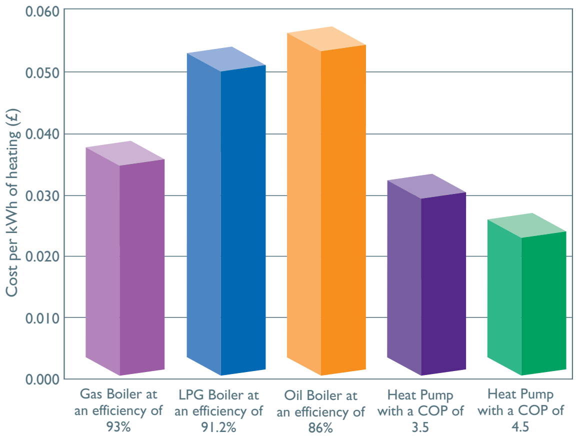
1. Refrigerant in the evaporator is colder than the heat source. This causes the heat to move from the heat source to the refrigerant, which then evaporates.
2. This vapour moves to the compressor and reaches a higher temperature and pressure.
3. The hot vapour now enters the condenser and gives off heat as it condenses.
4. The refrigerant then moves to the expansion valve; drops in temperature and pressure; and then returns to the evaporator.

A less common type is the absorption heat pump. These are thermally driven, using heat rather than mechanical energy to drive the cycle. Absorption systems use liquids or salts to absorb the vapour of the refrigerant. The liquids are used in pairs, most commonly water (refrigerant) and lithium bromide (absorbent); or ammonia (refrigerant) and water (absorbent). However, since these systems are used infrequently, this Guide will deal with vapour compression systems.

Heat pumps can transfer heat from natural sources (such as air, or water) to warm a building. In cooling mode, a heat pump will take heat extracted from a building and move it elsewhere (known as the 'heat sink'). This can be back into the surroundings, or the excess heat can be transferred to another part of the building.

External energy is required for the heat pump to move heat from source to sink. In theory, the heat delivered by the heat pump is equal to the heat extracted from the source, plus the amount of external energy. It is a very efficient equation, and electrically driven heat pumps for buildings can supply 100kWh of heat from 20 to 40kWh of electricity.

Running costs for various systems



There is a **34%** reduction in running costs when using a heat pump with a COP 4.5 when compared to a gas boiler

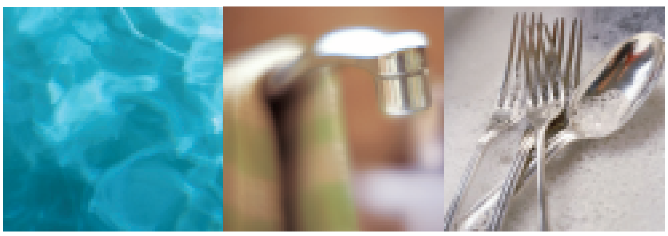
Assumptions Price of fuel per kWh

	Pence per kWh
Oil	0.037
LPG	0.046
Gas	0.03236
Electricity	0.10385

Heat pump systems achieve the highest efficiencies when they can access a heat source which is stable and relatively high. They also work best with heating systems which do not require very high input temperatures. For example, they are often linked to underfloor heating systems, rather than radiators. In domestic and smaller commercial applications, a heat pump system will also include a top-up boiler to meet any hot water needs.

The technology of heat pumps in action

Heat pumps are most often categorised by the type of heat source they use. One of the main benefits of heat pumps and the reason they are viewed as a sustainable technology, is that they utilise naturally occurring sources of heat.



The main sources are air, earth and water. To date, ambient air is the most common source for heat pump applications. Clearly, air is freely available, and means that installation of equipment is straightforward. A disadvantage of using the air as a heat source is that air temperatures change across the year. Also, as the temperature of the heat source drops, so does the efficiency of a heat pump. This means that at a time when heating is most required (when it's cold outside), the heat pump is at its least efficient.

Ground source heat pumps use the earth as a heat source. Pipes run from the building into the earth which provides a steady temperature all year round. Pipes can lie horizontally, or be placed in vertical boreholes. Excavation costs add to the capital costs of these systems, but the steady temperatures do result in high energy efficiencies.

Water is another stable heat source for heat pump systems. Like the ground source set up, pipes can run from a building into water underground (aquifers) or into a nearby lake or river. Again, there are costs associated with extraction and designers will also have to deal with local challenges such as the water table and local/national Environment Agency legislation. Care must also be taken with the expulsion of water from the system as this must not cause the water source temperature to rise.

Whatever source is used, one of the main advantages of heat pumps is their flexibility in application. For example, a heat pump using air as a heat source can simply supply water at 45°C to an underfloor heating system during the winter season. But the same heat pump can also be used to cool the building in summer using the same underfloor water piping as the heating system. Supplying hot water between 17ºC and 18ºC, can provide up to 40W/m^2 of cooling. Alternatively, normal air conditioning fan coils can be used. This gives a large advantage over a traditional boiler, which can only heat.

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Additionally, during the night, water can be heated to 45°C for domestic use the following day. With regard to Legionella contamination, the national recommendations for possible further heating should be followed.

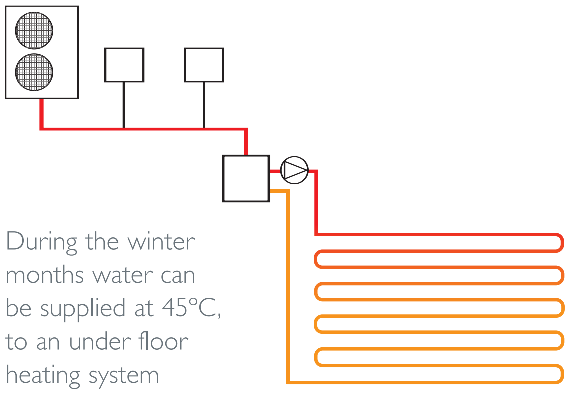
As a heating method, heat pumps are highly efficient. COP is between 4 and 4.5, which compares very favourably to a gas boiler which has a COP of around 0.95.

Further energy efficiencies can be gained from smart design with heat pumps. For example, during the cooling season, extracted heat from one area of a building can be used elsewhere. The system could work in a leisure centre, providing cooling to office space during the summer and year-round cooling to the cafeteria and gymnasium. This would create excess heat which can be utilised for heating a swimming pool year-round. Also, the heat extracted in the summer from cooled offices (and from restaurants and kitchens all year) could be used to heat the hot water for sanitary use and dish washing. Hence energy is saved by the efficiency of the heat pump and by using otherwise 'wasted' heat.

Heat pumps offer an alternative to traditional domestic and small commercial heating systems, with substantial savings in energy use and CO_2 emissions – both of which will be under scrutiny now that Part L of the Building Regulations is in force. One important point to note about heat pumps is that in order to fully realise their performance potential, good design and installation are vital. A number of factors affect the performance of heat pumps, including temperature levels of the heat source, and the type of heat distribution system. An experienced installer will be able to ensure these factors are taken into account.

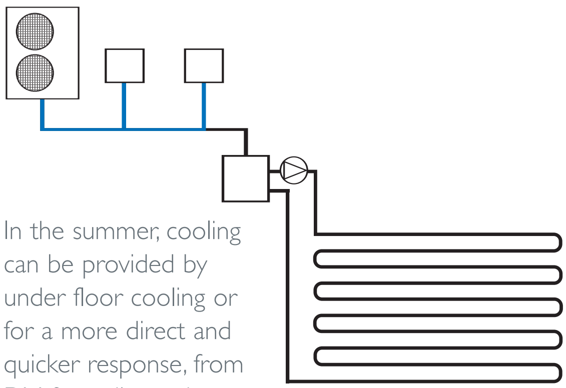
As the market for heat pumps in heating, as well as cooling grows, the European Union is working on a certification scheme to ensure that there are sufficient trained installers in the market place. There can be little doubt that in the UK we will see the number of applications for heat pumps grow as developers feel the pressure of rising fuel prices and the need to play their part in creating more environmentally friendly buildings.

Under Floor Heating (UFH) - Winter



During the winter months water can be supplied at 45°C, to an under floor heating system

AC Cooling - Summer



In the summer, cooling can be provided by under floor cooling or for a more direct and quicker response, from DX fan coils on the VRF system

Heat pumps at work

Heat pumps offer a flexible approach to cooling and heating. They can also be used very effectively to use heat which would otherwise be 'wasted'. In these kind of applications, heat pumps offer energy savings, running cost reductions and CO_2 emissions mitigation - an excellent combination for projects which are covered by Part L 2006 of the Building Regulations.

Although heat pumps in the UK are mainly used for air conditioning, there two recent projects where the technologies other properties have been utilised. In one recent example, a dwelling uses heat pump technology for cooling in summer. The house has a 9kW cooling load. Using heat recovery, the system can use the heat extracted from the house to warm the swimming pool to 30°C.

In winter, the house is warmed by a wet system supplied by the heat pump. During the winter the pool is covered and unused. Its heat load is very low, so excess heat from the house can be used to ensure that the water is maintained at a steady low temperature.

In a second project, heat pumps are combined with a R2 heat recovery system on a commercial building. In summer conditions, the air conditioning is on. Extracted heat is added to the heat pump boiler which supplies the building's domestic water requirements at 45°C, a boost heater is then used to heat the water for Legionella control. In cooler months, when the system is in heating mode, excess heat from the system can be diverted to increase the domestic water temperature. In this way, hot water is provided free all year round.

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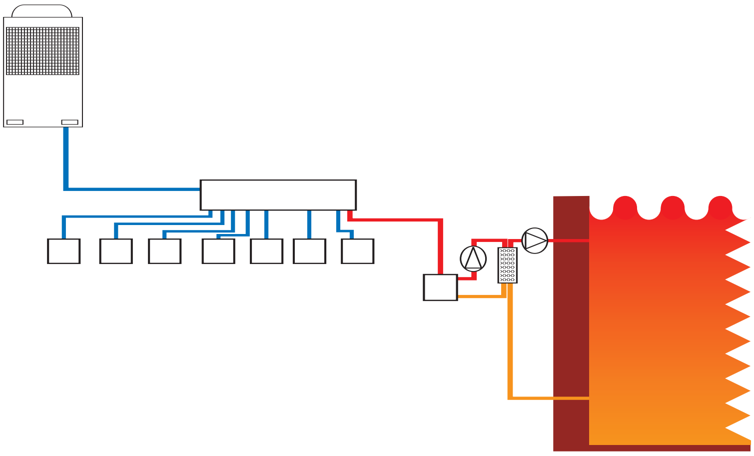
Swimming Pool Application

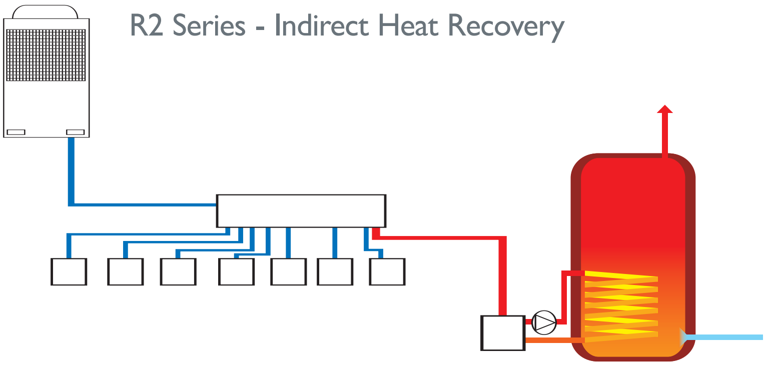


Throughout the year the system can either cool or heat the building as required.

A good example would be a leisure centre in summer, when cooling is required in areas such as the gym, cafeteria, offices or pool area. Rather than waste the heat taken from these areas by condensing the refrigerant outside, the heat can be utilised by transferring it to the water in the swimming pool.

Heat Recovery Systems

R2 Series - Indirect Heat Recovery

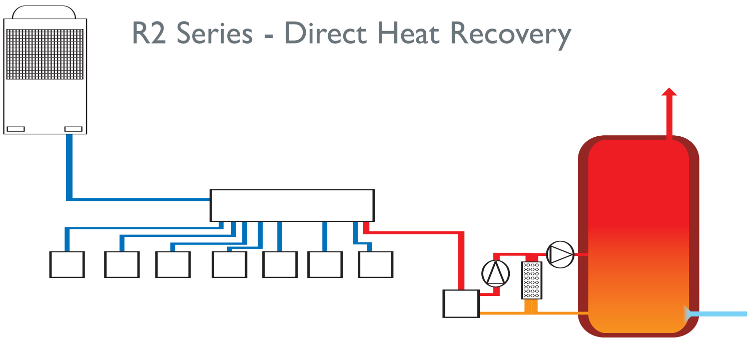


Throughout the year the system can either cool or heat the building as required.

In summer, when cooling is required throughout the building, rather than waste the heat by condensing the refrigerant outside, a percentage of the 'waste' heat can be utilised to heat water to 45°C for domestic type applications.

A good example would be a restaurant in summer. When the restaurant requires cooling, the heat taken from the building can be used to heat the water used to wash the dishes!

R2 Series - Direct Heat Recovery



Further information

For more information
on system running costs,
visit **www.calor.co.uk**
or **www.powergen.co.uk**

If you missed the CPD seminar on **Heat Pump Boilers**, you can call your Mitsubishi Electric Regional sales office to arrange an in-house presentation of this information.

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