Low carbon equipment and building regulations – A guide to safe and sustainable construction

Air Source Heat Pumps

Mar 2010

This guidance document is intended to be read in conjunction with the general introduction to low carbon equipment.

The Scottish Government

Low carbon equipment and building regulations: A guide to safe and sustainable installation

This chapter is one of a series that provides a basic introduction to different low carbon technologies and describes their relationship to the building regulations in Scotland. It should be read alongside the general introduction to this guide.

Air source heat pumps

1 Introduction to air source heat pumps (ASHP)

Heat pumps work like refrigerators in reverse. They can take heat from an outdoor source and put into a building. Air source heat pumps upgrade low temperature heat from the air outside to a higher temperature that can be used for space or water heating, using electricity to power the process. Heat pumps use less electrical energy than other types of heating appliances which convert electrical energy to heat.

In a well designed, sized and installed system, up to four units of heat can be produced for every unit of electricity used to drive the heat pump, although the efficiency will be lower in very cold weather.

Like other types of heat pump, air source heat pumps exploit solar energy to limit the demand for electricity, but are generally less energy efficient than ground source heat pumps. However they do not require any groundwork, making them less expensive to install and more suitable for smaller sites.

Air source heat pumps can be used for space heating or domestic hot water and are suitable for new build or existing buildings. They are also used for space cooling in non-domestic buildings.

There are two types of air-source heat pump heating systems:

- air-to-air which supplies and circulates warm air to heat a building;
- air-to-water which supplies heat for space heating through radiators or an underfloor system, and may also supply hot water.

A typical air source heat pump works as follows:

- the fan draws air into the heat pump and passes it over the evaporator which contains refrigerant gas at a very low temperature;
- the refrigerant gas absorbs heat from the outside air;
- the compressor compresses the refrigerant gas, which raises its temperature;
- the condenser causes the refrigerant gas to condense to its liquid form, transferring the heat through a coil to the heating system;
- the liquid refrigerant is passed, through a drying filter to collect any excess moisture, to the expansion valve;
- the expansion valve lowers the refrigerant pressure and the refrigerant liquid returns to the evaporator.

The heat is transferred to the heating system through a coil within a thermal store (a hot water storage cylinder or buffer tank).

As well as being used to provide heating, some heat pumps can work in reverse to cool buildings, using fan coil units or the underfloor heating circuit.

Figure 1 illustrates the principle of operation of a heat pump.

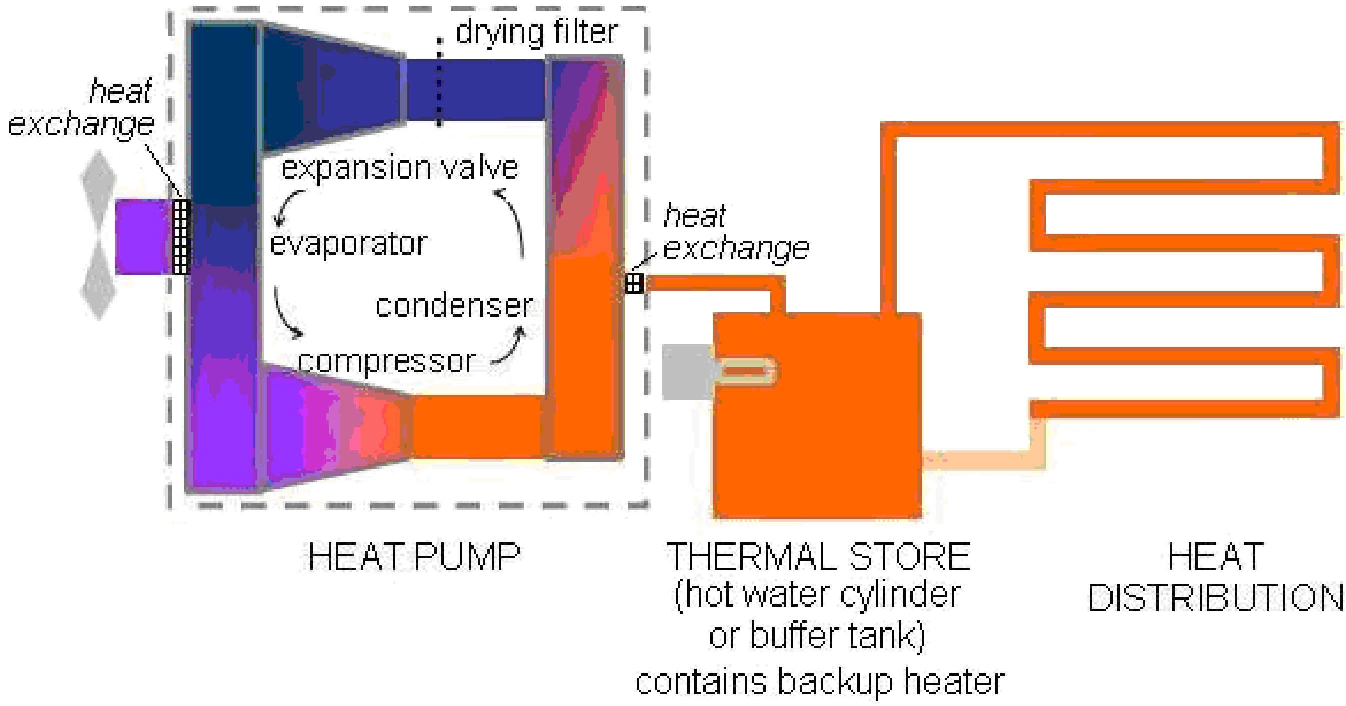


Figure 1: Schematic of an air source heat pump system

2 Components and types of ASHP systems

An air source heat pump system typically comprises the following components:

- air handling fan;
- heat pump - contains an evaporator, compressor, condenser, expansion valve, drying filter, controls;
- heat exchanger / hot water distribution unit to transfer heat to the distribution system;
- controller (to control heat pump, heating and hot water distribution pumps, mixer motor and supplementary heating sources);
- programmer;
- electricity supply to run the heat pump, heat distribution circulation pump, and any supplementary heating, and power management controls;
- distribution system (underfloor heating and / or low temperature radiators with heat distribution manifold, or fan units);

plus:

- hot water storage vessel (for air-to-water systems only);
- indoor fan unit (air-to-air systems only);
- buffer tank (optional);
- supplementary heating (optional);
- heat recovery unit (optional).

2.1 Air handling, heat pump, heat exchanger, controller, programmer

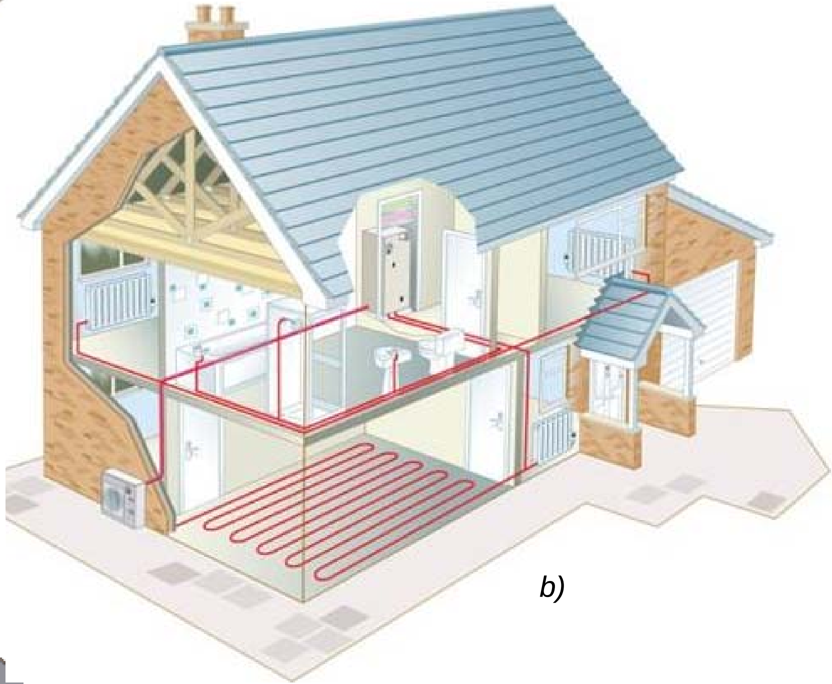
The terms used to describe components vary between suppliers. The arrangement of components also varies, for instance:

- an outdoor unit containing the air handling fan and heat pump + indoor hot water cylinder containing the heat exchanger + control unit;
- an outdoor unit containing the air handling fan and heat pump + an indoor thermal store with integral controls + hot water cylinder containing a second heat exchanger;
- an outdoor unit containing the air handling fan and heat pump + an indoor hot water storage vessel and integral controls;
- an outdoor air handling unit + indoor unit containing the heat pump, heat exchanger, controls and hot water storage vessel;
- an indoor unit combining the air handling fan, heat pump, heat exchanger, controls, and hot water storage vessel within a single unit.

The term ‘boiler’ is sometimes used, but this should not be confused with a conventional gas or oil fuelled central heating boiler. For instance, some manufacturers use the term ‘heat pump boiler’ to describe an outdoor unit that contains the heat pump.

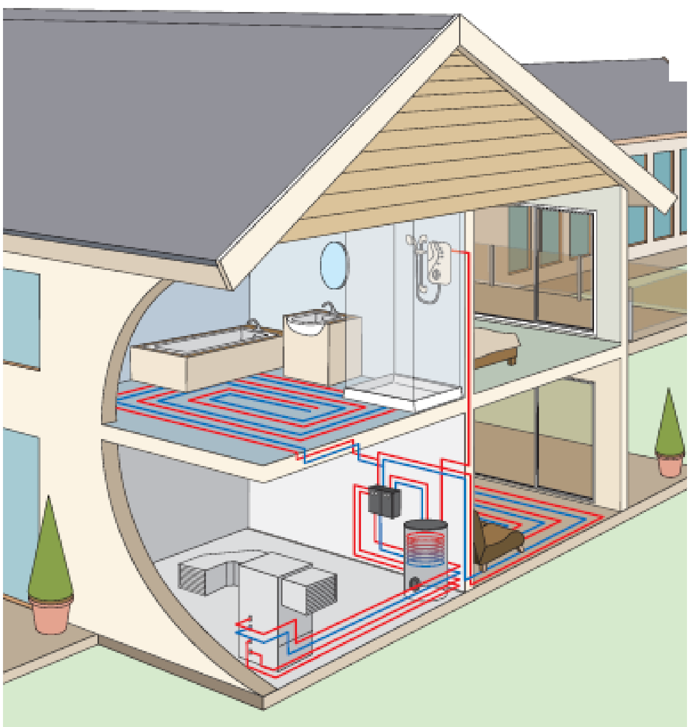
Air source heat pump units are designed either to be located outside or inside the building: an outdoor unit should not be used internally, and vice versa. Indoor units are either located against an external wall or within a roofspace with a duct to the outside air.

a)



b)

Figure 2: Examples of air source heat pump Systems.
Sources:
External units: a (above) Daikin Airconditioning Ltd.; b (right) Ecodan system by Mitsubishi Electric Europe B.V.
Indoor unit: c (below) Dimplex Ltd.



c)

Figure 3: Examples of components in air source heat pump systems (not to scale)

a) Indoor, self-contained systems
Sources: NIBE (provided by Ecoliving), Dimplex Ltd

b) Outdoor systems with indoor heat pumps
Sources: NIBE (provided by Ecoliving) Versan (with Daikin heat pump)

2.2 Electricity supply and power management

Electricity is required to run the heat pump and circulation pumps. The efficiency of the heat pump unit and the distribution system may limit demand for delivered energy and emissions of carbon dioxide (CO_2), but further savings can be achieved by combining the system with other low carbon technologies that generate electricity, such as solar photovoltaic panels or wind turbines. The amount they contribute will vary with size, with site conditions, with the seasons, and with the weather. It could be possible to have an autonomous system if there was space for sufficient on-site battery storage, but grid connection is more usual in the UK.

Some heat pump units incorporate an inverter which saves energy by reducing the number of times the heat pump will stop and start. When there is a demand for heating, the inverter-controlled compressor allows the heating capacity to be modulated, allowing the inverter to gradually increase its capacity, so that the desired temperature can be reached quickly. This reduces the start up time of the heat pump, using less power and making the heat pump system more energy efficient.

Inverter-controlled compressors start unloaded and do not require such a high starting current. The start current can be limited by a ‘soft start’. Compressors without an inverter may have a high starting load and it is advisable to seek permission from the electrical supplier before connecting to the supply.

2.3 Hot water storage vessel

A hot water storage vessel is required when the heat pump is used with a wet heating system and is used to supply domestic hot water (a cylinder is not required if the heat pump is only providing heating). It is important that the hot water storage vessel is sized correctly for the maximum heating capacity of the heat pump. Some companies offer matched systems, supplying the heat pump, vessel and controls from one source.

When used for heating domestic hot water, heat pumps usually heat the water to bring the temperature up to that needed at the taps. Sometimes they rely on another source of energy, such as a solar collector or an electric immersion element to boost temperatures. The energy efficiency of a heat pump reduces with higher supply temperatures but since the heat pump is still more efficient than an electric immersion heater, it is sensible to set the heat pump to produce the highest temperature it can reach.

2.4 Distribution system

Air source heat pumps are most commonly used in an air-to-water system, with a low pressure hot water distribution system for space heating.

The lower the required output temperature from a heat pump, the greater the system efficiency.

Traditional radiator systems are usually designed for high distribution temperatures, typically 60-80°C. But with heat pumps designed for a maximum operating temperatures of 45-55°C, either underfloor heating systems are often used as they only require temperatures of 30°-45°C, or systems designed to operate with lower surface temperature radiators of 45-55°C. Air-to-water systems can also be used to supply domestic hot water - see section 2.7 for typical air-to-water systems.

If existing radiators have been oversized at installation, they may be large enough for the lower flow temperatures from a heat pump to maintain room temperatures. It is advisable to check if existing radiators are suitable before looking to change them when fitting a heat pump in place of an existing boiler. At the same time as changing to a heat pump system, it may be worthwhile considering some simple improvements to the building fabric, such as improving loft insulation, that will reduce heat loss and increase the potential for the existing radiators to be retained.

Radiator and underfloor systems can be combined if an additional mixing valve is provided to adjust the supply temperature for the underfloor circuit.

Typically, the controller in the heat pump unit would be linked to a programmer-timer, to at least one room thermostat, and to thermostats on the hot water cylinder and buffer tank. Air source heat pump systems may achieve greatest efficiency when run continually, but thermostatic radiator valves in each room can be used to limit the amount of heat that can be delivered.

With an underfloor or zoned heating system, space is required for a manifold with motorised valves that control the flow around each distribution loop.

Alternatively, air source heat pumps can be used in an air-to-air system, with warmed air distributed through fan units. See section 2.8 for typical air-to-air systems.

2.5 Buffer tank

Some heat pump systems use a buffer tank to build a store of heat to cover fluctuations in demand for heat. It serves a similar function to an inverter, reducing the likelihood of the heat pump switching on and off unnecessarily and wasting energy. A buffer tank may not be necessary where the heat pump is fitted with an inverter.

As well as acting as a thermal store for space heating, a buffer tank may be used to supply hot water to the cylinder. Some systems incorporate a ‘tank in tank’ which combines the buffer tank and cylinder. This utilises the outer jacket as a buffer tank and provides hot water for heating and hot water. The requirement for the buffer tank is dictated by the volume of the heating distribution circuit, as the output of an air heat pump can change as the outdoor temperature increases.

A buffer tank would generally be required in buildings with several heating zones. Buffer tanks are often also used in housing to regulate the heating efficiently, but may not be needed in well-insulated homes that are built with high levels of thermal mass, as the relatively heavyweight building itself may act in effect as a buffer, moderating fluctuations in temperature. Buffer tanks are also required on some systems to ensure the defrost cycle can operate correctly.

2.6 Supplementary heating

An integral electric heater, sometimes termed a ‘boost,’ ‘back-up,’ or ‘emergency’ heater, may be provided to supply backup heating if prolonged periods of low external temperatures are anticipated. Some heat pump units can be linked to an existing electric, gas, or oil boiler, with special controls to allow switching between the heat pump and boiler.

When the external air temperature is low, the outdoor unit may need defrosting. Most heat pumps have a defrost cycle built in, where the heat pump runs in reverse cycle to allow defrosting to take place. Although this takes heat away from the indoor spaces, the defrost cycle should take only a few minutes and back-up space heating should be unnecessary.

Whilst back-up heating may be provided by an electric immersion heater at any time, demand for electricity could be reduced by a solar thermal system that can supply the system with hot water for much of the year. The heat pump should be set to operate if the solar cannot provide adequate water heating.

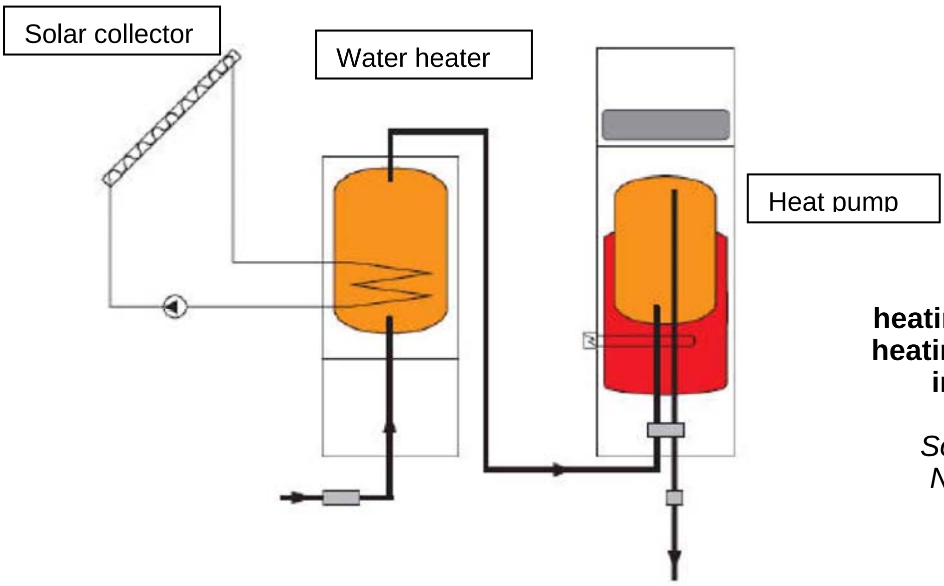
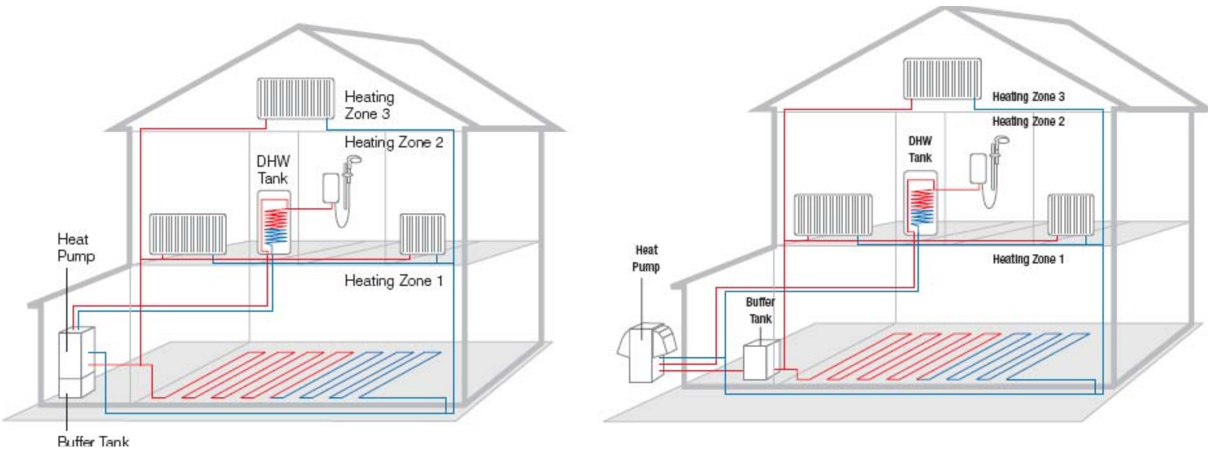


Figure 4: Solar water heating system supplementing heating by the heat pump, plus integral electric element to provide back up heating
Source: based on diagram by NIBE (provided by Ecoliving)

2.7 Types of system: Air-to-water

In an air-to-water system, the heat produced raises the water temperature in a storage tank that is circulated through underfloor heating or radiators. Air source heat pumps for air-to-water systems are designed to be located either outside or inside the building. An outdoor unit should not be used internally, and vice versa.

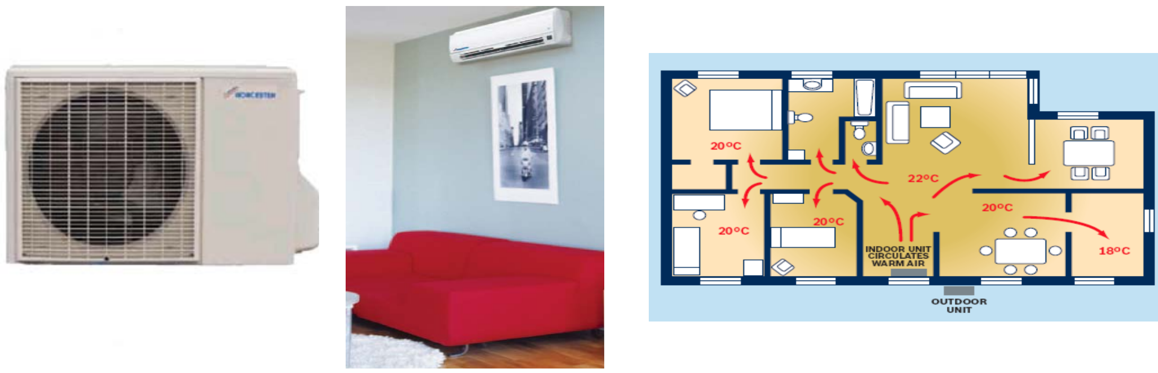


a) internal heat pump unit **b) external heat pump unit**

Figure 5: Examples of air-to-water systems with large surface, low temperature radiators on upper storeys underfloor heating at ground floor level
Source: Dimplex

2.8 Types of system: Air-to-air

There are two components in an air-to-air system: the heat pump which is normally located externally and an indoor fan which circulates the warm air produced by the heat pump (this is sometimes described as a split-system). In the example shown, a single fan provides warmed air throughout an open plan flat.



outdoor heat pump unit indoor fan coil unit layout

Figure 6: Typical air-to-air heat pump system
Source: Worcester-Bosch

2.9 Types of system: Whole house ventilation with heat recovery and air to water heat pump

Additional efficiency may be achieved by recovering heat from exhaust air, as part of a mechanical ventilation system.

An air-to-water system can form part of a whole house ventilation system with a fan that draws exhaust air from rooms along ductwork to the heat pump. The heat pump recovers the thermal energy from the exhaust air that has been gained from lighting, people, and domestic appliances, as well as any passive solar gain. The heat pump then supplies hot water and water for space heating. A fresh air supply needs to be introduced to balance the exhaust air.

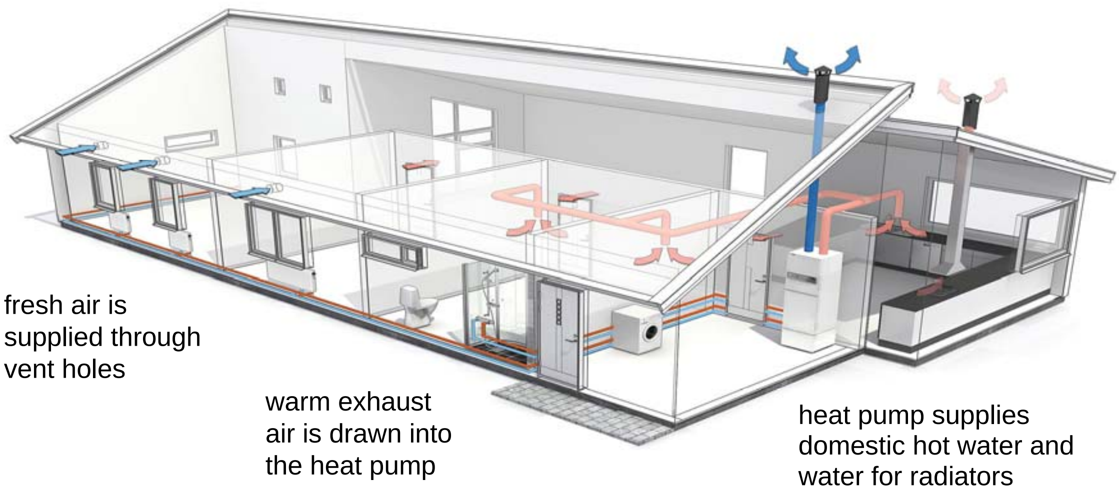


Figure 7: Whole house ventilation system with heat pump
Source: NIBE, provided by Ecoliving

3 Building regulations: ASHP systems

3.1 Building regulations and building warrants

All air source heat pump installations serving a building must comply with the requirements of the Building (Scotland) Regulations 2004, as amended, including the functional standards listed in Regulation 9, Schedule 5. However, it is not always necessary to apply for a building warrant to install an air source heat pump:

- for a new building, the air source heat pump should be covered by the building warrant.
- a building warrant is always required when a heat pump system is installed in or on an existing flat or a building containing flats, or for freestanding installations around flats.
- for existing houses, installations onto or within a building must comply with the building regulations and would normally require a building warrant. But if the installation is at least 1m from any boundary, some free-standing external installations of air source heat pump systems may not require a building warrant (see Regulation 5, Schedule 3). You should contact your local authority building standards office to check whether or not you need to apply for a building warrant, prior to works commencing on site.

Planning permission

Certain installations will need planning permission. Guidance is available in Planning Advice Note 45 Annex: Planning for Micro-renewables.

An independent study to examine the issues concerning permitted development rights for domestic microwind turbines and air source heat pumps has been published and is available at http://www.scotland.gov.uk/Publications/2009/12/16092021/0 An Order extending permitted development rights to those two technologies is required by section 70 of the Climate Change (Scotland) Act 2009.

Detailed consideration of planning requirements for non-domestic microgeneration equipment will follow. An Order for microgeneration in non-domestic buildings is required by section 71 of the Climate Change (Scotland) Act 2009.

3.2 Technical Handbooks

Guidance on complying with the building regulations is given in the Domestic and Non-domestic Technical Handbooks 2009.

This chapter highlights the issues in each section that should be considered when installing an air source heat pump system, but you should check the Technical Handbooks for any other standards and guidance that are relevant to the individual installation.

For any further advice on specific projects please contact your local authority's Building Standards office. Find them in your phone directory, the local authority website, or from the website of the Scottish Association of Building Standards Managers (SABSM).

3.2.1 Section 0 General

Section 0 gives an explanation of Regulations 1 to 17. It includes guidance on appropriate standards of durability, workmanship and fitness of materials.

For any air source heat pump system, sufficient space should be left around the components to enable access for maintenance or repair work (see Regulation 8).

If a heat pump system is used for cooling and has a total effective output of 12kW or more, it must be inspected at regular intervals and appropriate advice given to building users on reducing its energy consumption (see Regulation 17 on air-conditioning systems).

3.2.2 Section 1 Structure

Section 1 aims to ensure that the structure of a building does not pose a threat to the safety of people in or around buildings.

For air source heat pump systems, the following issues should be considered, to avoid damage to the structure of the building:

- the heat pump and associated hot water storage vessels are likely to change the loads imposed on the structure of the building and therefore, except for installations outside the building or on concrete ground floors, changes in loading should be assessed by a chartered engineer or other appropriately qualified person;
    - the supporting structure needs to be strong enough, or made strong enough, to resist the loads imposed by the heat pump, including the weight of water when the system is operating, and any vibrations generated;
    - for timber floor structures, loads should normally be shared across at least two joists and it may sometimes be necessary to add members to provide sufficient support;
    - units fitted on and supported by cavity walls should be fixed back to load-bearing structure, the outer leaf alone may not be sufficient, and additional reinforcement may be required.
- fixings must be suitable for the supporting structure and should be selected both to take the weight of the unit and to limit the effect of any vibrations, such as brackets that incorporate anti-vibration pads;
- the installation of pipework and ductwork should not detrimentally weaken the structure of timber roofs, floors, or walls:
    - notches and holes should not be cut in rafters, roof ties, collars or hangers;
    - lightweight trussed rafters should not be cut, trimmed, notched or drilled;
    - notches should not be cut in wall studs, cripple studs or lintels unless a full structural appraisal has been carried out by a chartered engineer or other appropriately qualified person;
    - Figure 8 shows the safe locations and sizes for notches and holes in floor joists and studs - if in doubt, ask a chartered engineer to check the proposed installation.

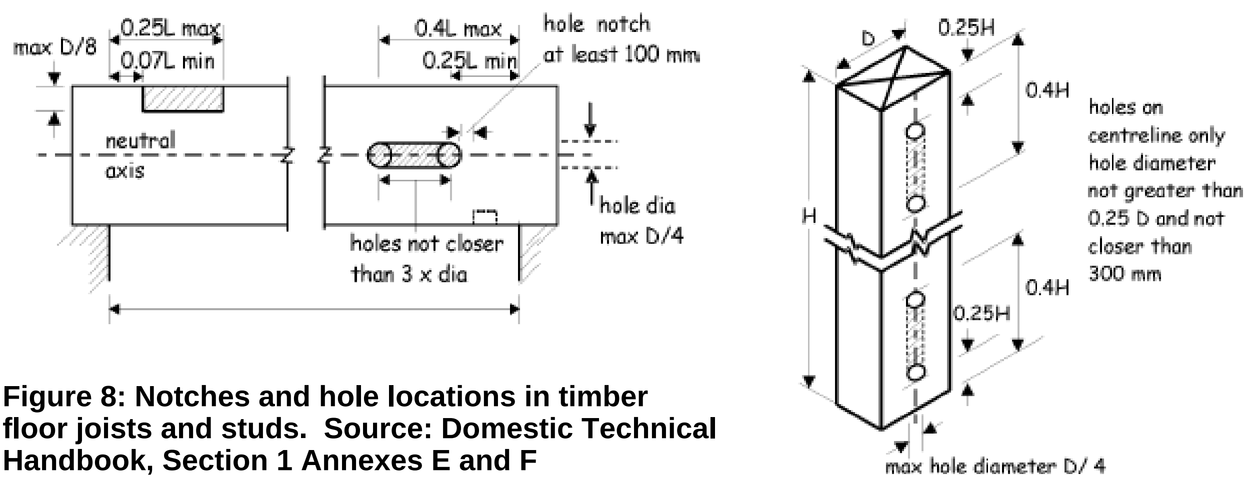


Figure 8: Notches and hole locations in timber floor joists and studs. Source: Domestic Technical Handbook, Section 1 Annexes E and F

3.2.3 Section 2 Fire

Section 2 aims to ensure that the risk of fire is reduced and if a fire does occur, there are measures in place to restrict growth and the spread of fire and smoke to enable the occupants to escape safely and fire-fighters to deal with fire safely and effectively.

Care should be taken to limit the risk of fire starting inside framed construction and to avoid the spread of fire through gaps in walls, floors, or ceilings, particularly within dwellings, between compartments, between cavities, and between cavities and any other room or space in the building.

- separating walls made of combustible materials should not contain any pipes or wiring, for instance timber frame separating walls, although pipes and ducts (other than a ventilating duct) can pass through such walls;
- cavity barriers should not be compromised by the ductwork or pipes associated with the heat pump unit or the distribution system – particular care should be taken not to disturb cavity barriers separating roof spaces in two dwellings, including boxed eaves, or at the head of a cavity wall;
- the heating system and any ventilation associated with the heat pump should have safeguards to avoid the spread of fire and smoke throughout the building: this may involve smoke detection to automatically operate in a fire control mode or alternatively shut down the system;
- casings to ductwork within a compartment should have the fire resistance duration of the compartment concerned. For example, a section of ductwork in different compartments should have the same fire resistance duration as required for each consecutive compartment that the ductwork passes through. Providing automatic smoke activated fire and smoke dampers is an alternative for ductwork that does not have a sufficient fire resistance duration where it passes through a ceiling wall, floor, cavity barrier, or through a protected route of escape. For penetrations other than ventilation ducts such measures are not required. These situations are listed in the Domestic and Non-Domestic Technical Handbook guidance;
- care should be taken to limit the size of any hole in a separating wall or floor, and to seal air gaps around pipes and ducts, for instance with intumescent mastic, to avoid reducing the fire resistance duration of the wall, floor, ceiling or cavity barriers;
- any penetrations through a protected escape route; or separating wall, floor, ceiling or cavity barrier; should not reduce the required fire resistance of the compartment.
- The risk of fire associated with electrical installations is covered in Section 4 Safety.

3.2.4 Section 3 Environment

Section 3 aims to ensure that buildings do not pose a threat to the environment, and that people in and around buildings are not placed at risk from various sources, including the effects of moisture in various forms.

For air source heating systems, particular care should be taken to avoid moisture damage to the building:

- pipes or fixings that penetrate the external walls should be properly weather protected to prevent the ingress of rainwater or dampness, for instance by caulking small gaps around pipes and in a way that any moisture collecting on a pipe in a cavity is shed to the outside of a wall;
- pipes or fixings that penetrate the walls should be installed in a way that does not adversely affect any existing damp proof, waterproof or breather membranes: if a membrane is damaged or disturbed, it should be reinstated;
- installations should not cause bridging of the damp proof course: for an outdoor unit installed close to an external wall at ground level, provision should be made to keep the gap beside the unit clear of debris, such as a lightweight protective cage;
- condensation produced by the heat pump should be disposed of to drainage systems:
    - for outdoor heat pumps, the condensate should be diverted to a mains drain or soakaway, through an insulated pipe to limit the risk of freezing;
    - for indoor units the condensate can be drained into the same drainage system as the sink or washing machine, or into an open tundish. The system should be protected by a trap to prevent unwanted smells.

Installations should not interfere with measures used to comply with the ventilation standard:

- if draught-proofing measures are used to limit the risk of frost damage to an indoor unit located in a garage, permanent ventilators should be installed to compensate for the loss of fortuitous air infiltration.

Care must also be taken not to interfere with the ventilation of any combustion appliances:

- If the heat pump is near a fixed combustion appliance, there must be adequate ventilation for both appliances and if the heat pump is near a boiler flue, the fan should not interfere with the safe removal of the products of combustion.

3.2.5 Section 4 Safety

Section 4 aims to ensure that the risk of harm to users of a building is limited to an acceptable level by identifying hazards in and around buildings.

For air source heating systems, particular care should be taken to avoid risks of burns and scalding, of legionella, and of electrocution and fire:

- unvented hot water systems are used to avoid the need for a cistern at high level and allow mains water to be supplied directly to the storage cylinder, but present risks of burns and scalds. So if an unvented system is used:
    - systems should incorporate appropriate safety devices and controls to regulate temperature and pressures within the system;
    - installations should be carried out by people with appropriate training and practical experience, usually members of a registration scheme operated by a recognised professional body such as the Scottish and Northern Ireland Plumbing Employers Federation (SNIPEF).
- to control the risk of legionella and similar pathogens, a secondary heat source, typically an immersion heater coil, is needed to raise the temperature of the stored water, once a week for a short time, to at least 60°C, in accordance with guidance to the Water Byelaws;
- as in any system where stored water is heated to control the risk of pathogens, provision must be made to prevent scalding, with a device such as a thermostatic mixing valve to limit the temperature of water delivered to a bath or bidet;
- to avoid the risk of electrocution and fire, the air source heat pump system should be installed in accordance with BS 7671, also known as the Institute of Electrical Engineers (IEE) Wiring Regulations 17th edition;

In addition, care should be taken so that an installation does not encroach on the requirements of accessibility in Standard 4.1, particularly outdoor units around entrances and the routes to entrances.

3.2.6 Section 5 Noise

Section 5 aims to limit the transmission of noise to a dwelling from another dwelling, other parts of the same building or an attached building, to a level that will not threaten the health of residents:

- the installation of heat pump and distribution pipe-work should not adversely affect the existing sound insulation of a separating wall or separating floor;
    - for instance, it is advisable not to mount units that incorporate a fan, pump. or compressor directly onto separating walls between flats or attached houses, or directly onto separating floors between flats;
    - care should be taken to limit the risk of flanking transmission from a unit mounted on a balcony to other parts of the building.

3.2.7 Section 6 Energy

Section 6 aims to ensure that effective measures for the conservation of fuel and power are incorporated into buildings, and that emissions of carbon dioxide are limited.

Installation of an air source heat pump and distribution system should not prejudice the energy performance of the building:

- if insulation within the walls, ground floor, or roof, and on pipe work is disrupted it should be reinstated;
- if membranes and seals that contribute to the airtightness of the building are disrupted, they should be repaired and the junctions around pipes or ductwork made airtight;
- gaps should be filled where any pipes or ducts penetrate external walls, incorporating insulating material to limit thermal bridging.

Various measures can help to ensure that the installation of the heat pump and distribution system is energy efficient:

- pipes and ducts within the system should be well insulated to minimise heat loss (see BS 5422: 2001 'Methods for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range – 40°C to + 700°C); for example a 22mm diameter copper pipe should be insulated with 23mm of insulation with a thermal conductivity of 0.035 W/mK;
- in addition to standard controls for a space or water heating system, heat pump unit controls should include:
  - control of water temperature for the distribution system,
  - control of water pumps (integral or otherwise),
  - protection for water flow failure,
  - protection for high water temperature,
  - protection for high refrigerant pressure, and
  - a weather compensating controller;
- further, ancillary controls are recommended:
  - timer to optimise operation of the heat pump;
  - room thermostats to regulate the space temperature, interlocked with the heat pump unit to ensure that the heat pump only operates when there is demand for heat,
  - zoning with thermostatic controls for heating systems in large buildings (with the floor area of each zone not exceeding 150 m^2) to limit unnecessary demand for heat;
- the whole system, including any supplementary heating or electricity generation, must be properly commissioned to achieve optimum energy efficiency:
  - there should be access to enable inspection, testing and commissioning;
  - commissioning should raise the system from a level of static completion to full working order and achieve the levels of energy efficiency that the component manufacturers expect from their products, at the same time with a view to ensuring safe operation.
- written information must be made available for the use of the occupier of the building on the operation and maintenance of the heating and hot water system,
  - information is intended to encourage the building user to optimise energy efficiency and the use of fuel;
  - a logbook should be provided for non-domestic buildings, with information presented in a manner similar to that recommended in CIBSE Technical Memorandum 31.

Although some heat pump systems can be used for cooling as well as heating, it is always preferable to adopt passive measures rather than using energy for cooling:

- buildings should incorporate passive measures that avoid or at least minimise the use of energy for cooling; measures might include:
    - designing the proportions and orientation of glazing to limit internal temperatures and adding external solar shading where appropriate, but taking account of the need for adequate daylighting;
    - very efficient lighting and daylight dimming controls to limit the generation of heat;
    - natural ventilation, including passive stack, cross-ventilation and night cooling;
    - incorporation of thermal mass in walls, floors, and ceilings;
    - passive chilled beams.
- In any new building or conversion, an assessment should be made of the risk of over-heating, using CIBSE Technical Memorandum 37 (TM37) for non-domestic buildings, or Appendix P to SAP 2005; this is also good practice whenever the use of mechanical cooling is contemplated.

4 Additional guidance

In addition to the issues covered by the Technical Handbooks, the following good practice guidance will optimise the performance of an air source heat pump system.

4.1 Location of units

In the placing of units internally or externally, manufacturers' design recommendations should be followed due to the weather resilience of the unit, its mounting requirements, the amount of air it handles and its provision for disposal of condensate.

Outdoor units

Buildings and sites may not offer ideal circumstances for the installation of an outdoor unit, but where possible, the following measures are recommended:

- shelter from high winds will limit the energy needed to run the fan, but sufficient space must be provided for airflow into the unit, and to prevent cold air re-circulation;
- sufficient space and easy access for regular cleaning to maintain performance;
- units on a south facing aspect will benefit from solar gains, so that there is more thermal energy in air drawn over the evaporator and therefore slightly less electricity is needed to reach the demand temperature;
- units should be raised off the ground to keep out rain water and surface water;
- fixings for units should be checked during servicing but it is advisable not to mount units above doorways, to limit the risk of injury in case the fixing fails;
- units should not be installed directly below or beside a window, to avoid noise nuisance;
- if outdoor units are located at ground level, a protective cage should be securely fitted to avoid vandalism or interference with the unit.

Indoor units

The building regulations cover noise transmission between parts of attached buildings by use of separating construction but do not control noise from services. However, any indoor installation of a unit that contains a fan, pump, or compressor, should take account of the potential impacts of noise and vibration. The following measures are recommended:

- do not fix units directly to the structure of the building, because it will transmit noise and vibration to other parts of the building;
- use anti-vibration pads or brackets that incorporate anti-vibration pads, to isolate the unit from the structure of the building;
- for ground-standing units, the heat pump should be installed on a firm, level and substantial base that will absorb vibrations.

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4.2 Pipework and fittings

Certain measures can limit the risks arising from pipework and fittings of damage due to condensation and nuisance due to noise or vibration:

- as well as insulating to maximise energy efficiency, it is good practice to insulate pipe-work and fittings to avoid condensation damage to the building;
- the heat pump can be fixed on anti-vibration mountings to limit the risk of transmitting noise or vibrations;
- pipe connections to the heat pump using flexible hoses can limit noise transmission through pipework.

5 Making the most of an air source heat pump

Manufacturers describe the efficiency of a heat pump as the Coefficient of Performance (COP). This is the ratio of the number of units of heat output for each unit of electricity input used to drive the heat pump. Sometimes the Heating Season Performance Factor (HSPF) is given, which is similar to COP, but is an average figure taken over the year, and is usually lower than the COP figures quoted

When an energy performance certificate (EPC) is produced using RdSAP, SAP or SBEM software, minimum COPs of 2 to 2.5 are ascribed to both air-to-air and air-to-water heat pumps. This assumes the use of underfloor heating, but the efficiency decreases where the system supplies all the domestic hot water or the radiators used have a low surface area, or where no compensation is made for the weather.

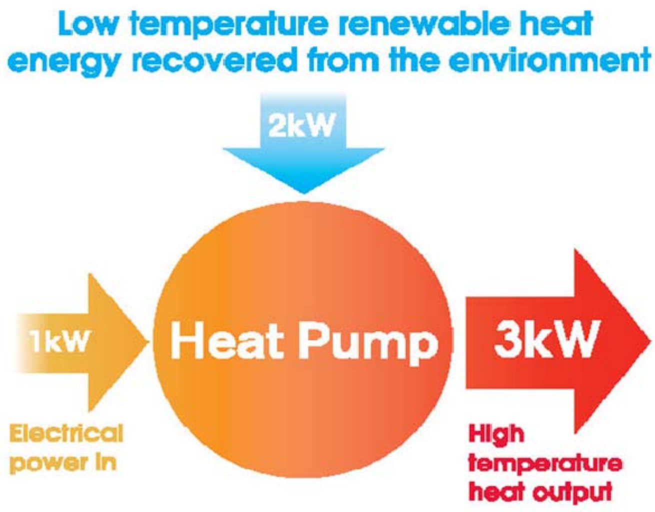

Figure 9: Example Coefficients of performance
Source: Mitsubishi Electric Europe B.V.

It may be possible to achieve much higher efficiencies in practice than is allowed for in EPC calculations, but this depends on the quality of the installation as well as the specification of the equipment and distribution system. The non-domestic calculation software allows for higher than default efficiencies to be input for a verifiable system design. This flexibility is currently being considered for SAP software too. At the same time, it is likely that the manufacturer's statement of the COP for the heat pump, which is based on test conditions, will be different from practice, which can be affected by a number of factors:

Using an Air Source Heat Pump	
more energy efficient	**less energy efficient**
✓ building has a high standard of insulation and airtightness	× building has poor insulation and unintentional air leakage
✓ extra insulation below underfloor heating with solid or screeded floors	× carpets, timber flooring above underfloor heating
✓ all pipes are well insulated	× heating pipes are uninsulated
✓ correctly sized heat pump	× over-sized heat pump
✓ underfloor heating or low temperature, large surface radiators	× standard radiators that operate at higher temperatures
✓ allowing the heat pump to run continuously over a long period – but some systems work well with thermostatic radiator valves (TRVs)	× stopping and starting the heat pump by setting controls incorrectly
✓ any ductwork is designed to take account of the fan power and bends are minimised.	× over-sized ductwork, bends in ductwork, or poorly formed junctions
✓ higher source temperature – unit is on a south-facing wall	× low source temperature – unit is on a north-facing wall
✓ adequate airflow available around unit	× insufficient space around unit so that it re-cycles cool exhaust air
✓ the occupants understand how to use the building and the heat pump system in an energy efficient way	× occupants leave windows open while the heating is on, set the controls so that the heat pumps keeps cycling, obstruct airflow with wheelie bins, garden equipment etc.

Fuel costs for an air source heat pump system will vary with the price of grid electricity, unless the electricity is generated on site. Some systems can partly operate on off-peak tariffs, for instance for heating water with an immersion heater.

6 Product standards

6.1 European and British Standards

There are a number of European and British Standards that are relevant to air source heat pump systems. These include those listed below, but this list should not be regarded as exhaustive.

Only those that **are** cited in the relevant section of 2009 Technical Handbooks have an asterisk by their number reference.

6.1.1 Standards for heat pumps

BS EN 378	Refrigerating systems and heat pumps. Safety and environmental requirements.
Part 1:2008	Basic requirements, definitions, classification and selection criteria
Part 2:2008	Design, construction, testing, marking and documentation
Part 3:2008	Installation site and personal protection
Part 4:2008	Operation, maintenance, repair and recovery
BS EN 14511	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling.
Part 1:2007	Terms and definitions
Part 2:2007	Test conditions
Part 3:2007	Test methods
Part 4:2007	Requirements

6.1.2 Standards for hot water storage vessels, buffer tanks, and associated fittings

BS 1566:	Copper indirect cylinders for domestic purposes –
Part 1: 2002 *	Open vented copper cylinders – Requirements and test methods
Part 2: 1984 (1990) *	Specification for single feed indirect cylinders.
BS 3198: 1981 *	Specification for copper hot water storage combination units for domestic purposes.
BS 5422: 2001 *	Methods for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating within the temperature range – 40°C to + 700°C
BS 6283: Part 2: 1991 *	Safety devices for use in hot water systems - Specification for temperature relief valves for pressures from 1 bar to 10 bar.
BS 7206: 1990 *	Specification for unvented hot water storage units and packages.
BS EN 1490: 2000 *	Building valves. Combined temperature and pressure relief valves, tests and requirements.
BS EN 1491: 2000	Building valves. Expansion valves. Tests and requirements.
BS EN 12102: 2008	Air conditioners, liquid chilling packages, heat pumps and dehumidifiers with electrically driven compressors for space heating

	and cooling. Measurement of airborne noise. Determination of the sound power level.

6.1.3 Standards for heating systems

BS 6700: 2006	Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages. (BS 6700: 1997 is cited in the Technical Handbook)
BS EN 15316-1	Heating systems in buildings. Method for calculation of system energy requirements and system efficiencies.
BS EN 15316-4-2:2008	Heating systems in buildings. Method for calculation of system energy requirements and system efficiencies. Space heating generation systems, heat pump systems.
BS EN 15450: 2007	Heating systems in buildings. Design of heat pump heating systems.

6.2 European eco label

A new EU Ecolabel can be awarded to those models of heat pump which are more energy efficient and which minimise their environmental impacts (see Decision 2007/742/EC[1]). It sets out various criteria, with testing to BS EN 14511:2004 . These include the minimum efficiency of the heat pump expressed as the coefficient of performance (COP) for specified inlet and outlet temperatures of the heat source and any wet distribution loop, as appropriate.

The label requires testing and display of the sound power levels (dB(A)) and does not allow the use of certain heavy metals and flame retardants. It requires suitable training to be available for installers, and spare parts to be available for 10 years from the date of sale. A maintenance, installation, and operation manual must be supplied that conforms to EN 378:2000.

Suppliers must also provide suitable tools, computer programs, appropriate climatic data and guidance so that competent installers are able to calculate the performance parameters, such as seasonal performance factor, seasonal energy efficiency ratio, primary energy ratio and annual emissions of carbon dioxide.

Information must be provided for installers and customers, available at points of sale. As well as giving information about the system, there must be advice on reducing heat loss and solar gain, probably starting with improving insulation but possibly also reducing solar gain. It requires that if retrofitting to existing heating systems, the heat pump should be selected to match the existing distribution system.

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[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:301:0014:0025:EN:PDF
Commission decision of 9 November 2007 establishing the ecological criteria for the award of the Community eco-label to electrically driven, gas driven or gas absorption heat pumps *(notified under document number C(2007) 5492)*

The Scottish Government