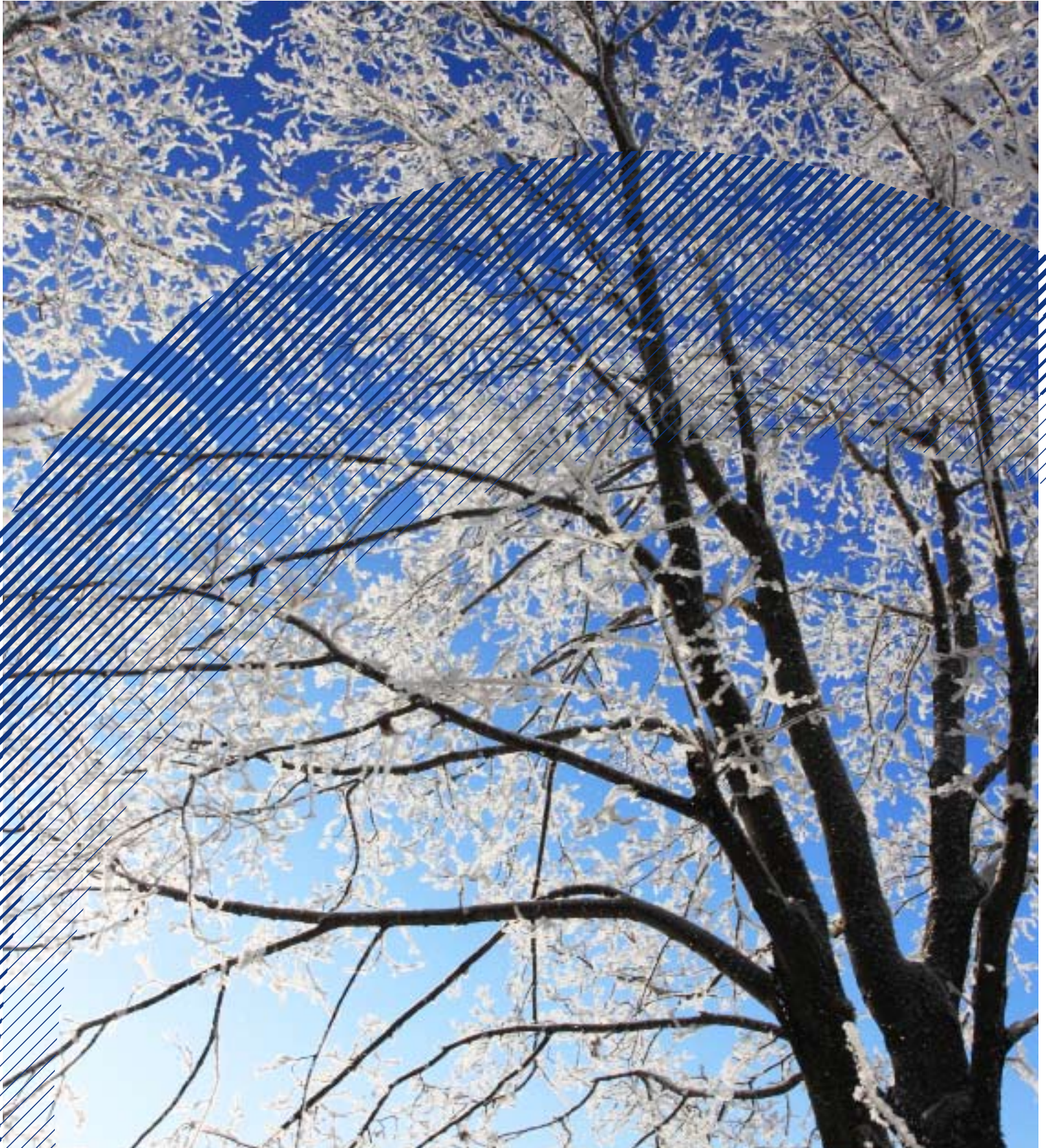


Best Practice Guide

Heat Pump Technologies



Objectives of this Guide:

Whether installing a heat pump in a new or existing dwelling, the initial capital investment will generally be greater than for a conventional boiler system. The concept of a heat pump might be relatively new to you, it is possible you have already gathered some very useful information with regard to specific products and systems.

The aim of this guide is to provide you with a fundamental knowledge of heat pump so that you can make more informed decisions in choosing the correct system and once installed how to operate the system efficiently.

The guide has been organised into the following sections:

- Introduction

- Section 1: Technology Overview

- Section 2: Feasibility and Design

- Section 3: Procurement and Purchase

- Section 4: Installation

Introduction

In the recent past, most Irish houses were heated by open fires with back boilers, oil / gas based central heating systems, or electrical storage heaters.

Today, home heating costs are one of the greatest budgetary concerns for any Irish household. In recent years, motivated by rising energy costs and the impacts of new legislation for the built environment Irish homeowners understand better that energy needed for heating homes and buildings can be reduced through reducing heat loss and improving the building fabric.

Houses with lower heat requirements allow a much wider choice in terms of a heating system. For this reason, heat pumps are proving an attractive alternative to fossil fuel boilers offering lower operating costs and reduced carbon emissions.

Technology Overview

Heat energy flows naturally from a hot place to a cold place. The main task of a heat pump is to move heat energy in the opposite direction i.e. from a cooler to a hotter place but energy is required to achieve this!

There is a lot of natural energy available in our surroundings which can be tapped into, but in order to do that, we need some way of collecting and moving it to where it's needed – that's the role of the heat pump.

There are two sides to a heat pump system: the heat source for example the ground, air or water and the heat sink where the heat is sent and used. In simple terms the heat pump is the machine which drives this cycle of heat collection and release.

A heat pump is similar to a fridge in the way it works. In a fridge, the heat is taken away from the storage section of the fridge and released at the rear. In a heat pump the process is opposite - the heat is taken from the air, ground and water and released into the building.

A heat pump uses an electric compressor which moves a fluid (called a refrigerant) around in a closed pipe circuit. A heat exchanger takes the heat from the surroundings, transfers it to the refrigerant circuit passing through the compressor, where its temperature is raised. The heat then passes through another heat exchanger, where it is transferred to the dwelling, and the cycle can start again. Electrically driven heat pumps are the most common type of heat pump available with electricity used to drive the compressor. The collector, the heat pump unit, the heat distribution system and the control system all make up the heat pump system.

The three main types of heat pump systems are:

- Air Source - energy is extracted from the external air
- Ground Source - energy in the soil is extracted either by transferring heat from a horizontal bed of pipes laid flat in the soil or by transferring heat from pipes laid in a vertical borehole
- Water Source - energy in the water is extracted directly, either from wells or from rivers, streams

Air source heat pumps

Air source heat pumps use the outside air as a heat source. Air temperatures vary seasonally and moisture content fluctuates also so an air source heat pump will always be at the mercy of the climate. The colder the air temperature, the harder the heat pump must work to lift the temperature up to what is required for heating. Also, as heat energy is taken out of the air, droplets of water can freeze on the heat pump heat exchanger which then means the heat pump must "defrost" so the cycle can begin again. For this reason, air source heat pumps are slightly less efficient than their ground and water source counterparts, however this slight loss of efficiency is reflected in costs – they are typically less expensive to install.

The most common type of air source heat pump used in dwellings is an air to water heat pump – the water referring to the method of heat distribution, i.e. through an under floor heating system (which uses water). Other types of air source heat pumps include exhaust air heat pumps, which are usually fitted to ventilation systems to provide hot water / hot water and heating, air to air heat pumps, which use the ventilation system instead of water systems such as under floor heating or radiators.

Figure 1: Air Source Heat Pumps



Air source heat pump installation [1]



Air source heat pump installation [2]

Ground Source Heat Pumps

Ground source heat pumps use the heat energy in the soil as a heat source. The soil provides a stable temperature all year round with minor fluctuations at depths of 1m or more. The energy available in the soil is often referred to as geothermal energy; however the vast majority of the energy available in the soil at the shallow depths used for heat pumps is solar heat (i.e. heat from the sun that has been soaked up by the soil). Collectors can be horizontal or vertical.

A horizontal collector usually takes the form of a series of plastic pipes buried in the soil approximately 1m below surface level and generally site space of between one and two times the heated area of the dwelling is required for this type of configuration.

The soil type has a bearing on the amount of collector area required. Some soil types have more heat available than others.

A vertical collector is not reliant on surface area, but rather depth. A vertical collector usually takes the form of one or more boreholes which accommodate a U-shaped plastic pipe configuration for collecting heat. Specialist drilling equipment is required to drill to the required depth, as well as special processes and materials (such as fusion welding and bentonite grouting). For this reason, a vertical collector system can be considerably more expensive than the horizontal collector.

With ground source heat pumps for every unit of electrical energy used, there are approximately four units of heat produced, i.e. the ratio of heat output (COP) is approximately four. To transfer the heat from the soil through the pipes and bring it to the heat pump, there needs to be a fluid passed around inside the pipes. This is usually a mixture of anti-freeze and water in a closed-loop circuit (i.e. it is the same fluid constantly being pumped around the pipes). Anti-freeze and water mixed together is known as brine. The whole system, including the heat pump and under floor heating / radiators is often referred to as a "brine-to-water" system. Note: Similar to an air to water system, brine to water refers to the heat carrier (brine) and the heat distributor indoors (water).

Figure 2 Ground source heat pumps



Horizontal ground source collector



Vertical ground source collector

Water Source Heat Pumps

Water source heat pumps use the heat energy available in water as a heat source. Water source heat pumps can be “open” or “closed” loop.

Open Loop - sometimes referred to as a “water to water” heat pump. Water to water heat pumps are open loop, which means that the water is passed directly through the heat pump, the heat is removed, and then the water is dumped back into a “discharge” well or other water source.

Closed Loop – in the case of a lake, river or stream collector, often a series of pipes are laid to extract heat from the water, but instead of taking the water directly into the heat pump as you would in an open loop water to water system, a mixture of anti-freeze and water in a closed pipe loop is used to extract the heat (similar to a ground source collector). In this way you extract the heat from the stream, river or lake, but do not use the water itself.

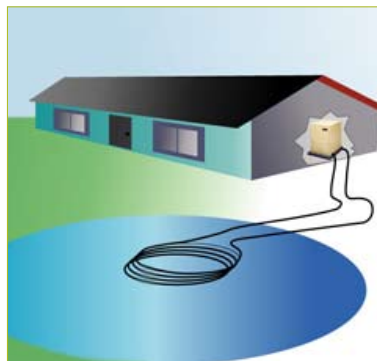
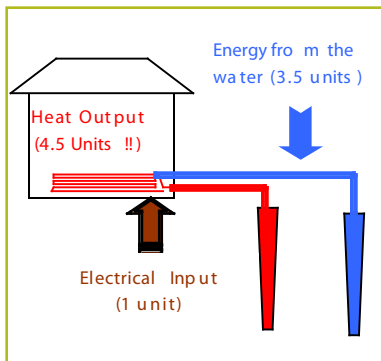
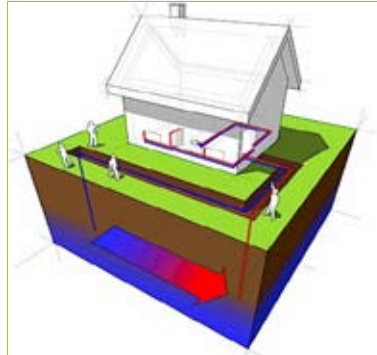
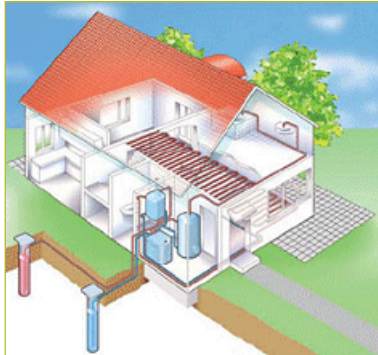
Ground water (i.e. the water in the water table) because of its temperature, is an ideal heat source for heat pumps, however it should be noted that water must be present in sufficient quantity so that drinking water resources are not affected. This would need to be verified using test boreholes and pumping tests. Also, when extracting from a well, the water must be re-injected downstream (of the groundwater flow) no less than 15m away from the extraction well. The water also passes directly through the heat exchanger of the heat pump in an open-loop system, therefore the water quality is an important consideration (hardness, corrosivity etc.)

The energy balance diagram shown in Figure 3 shows the average performance of a water source heat pump.

For every unit of electrical energy used, there are approximately five units of heat produced. Therefore, the ratio of heat output to electrical input (COP) is approximately five as per the energy balance diagram.

Surface water, such as a river, lake or the sea, can be used in either a closed or open loop system, however a closed loop system is likely to required much less maintenance. Protection against debris and physical damage and obtaining the necessary permissions from the Environmental Protection Agency and the planning authorities are also important considerations for surface water collectors.

Figure 3 Water Source Systems



Clockwise from top left: Twin-well water source heat pump (open loop); Heat flow: twin-well open loop system; Closed-Loop water source collector; Energy Balance: water source heat pump

Heat Pump Cycle - Introduction

We now know that heat pumps move heat energy from a cold place to a hot place, but how does it achieve this? See the stages of the cycle explained in terms of the components below, and in more detail in the following section.

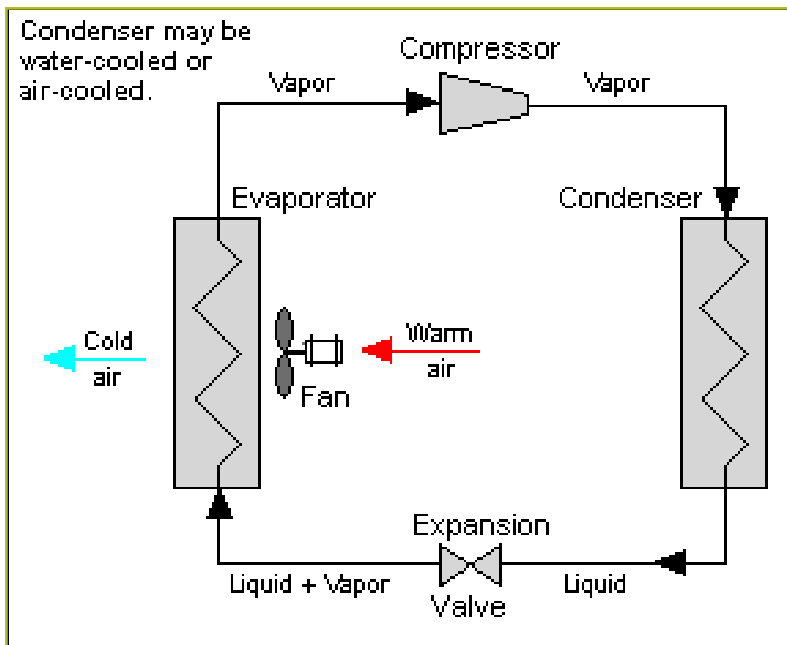


Figure 4 - The basic vapour-compression refrigeration cycle

Stage 1 - external heat exchanger picks up heat from the soil / air etc. and transfers it to the refrigerant passing through. The refrigerant, having picked up the heat from the heat exchanger, is evaporated and now enters the compressor. The heat from the soil / air alone is not enough to provide indoor heating in the building, that's why the compressor is needed.

Stage 2 – the compressor pressurises the refrigerant using a series of rotating scrolls, which significantly raises its temperature. The reason this happens is because, as you increase the pressure on a gas, the temperature increases. A similar effect can be felt when using a bicycle pump. As you pump, you pressurise the air close to the nozzle, and this air becomes hot before it is forced out under pressure, and eventually this heat can be felt on the pump itself. Now the refrigerant exits the compressor as a high pressure, high temperature gas, with sufficient heat energy for heating.

Stage 3 – the refrigerant gas now passes through the internal heat exchanger where it gives up its heat to the heating system (e.g. under floor heating) and the gas turns to a liquid (i.e. condenses, similar to the way that steam turns to water droplets on a window)

Stage 4 - in order to be able to start the cycle again, the refrigerant must be de-pressurised, and so it is passed through an expansion valve, where it returns to a low-pressure liquid / gas mix and the cycle can recommence.

Note: The net effect of the vapour-compression heat pump cycle is that for every unit of electrical energy used to power the compressor, there are between three and five units of heat energy produced. This is because a certain portion of the heat used is “free”, i.e. has been gathered from the soil / air etc.

Stage 4.1 - heat from the air / soil is transferred via the “outdoor side” heat exchanger to the refrigerant. The heat content of the refrigerant increases as it gathers heat from the exchanger, but there is no increase in pressure. It also turns into a gas where it crosses the black line.

Stage 4.2 – the refrigerant, having now absorbed the “environmental” heat, is compressed (by the compressor). This is the only part of the cycle where additional energy is required. The compressor increases the pressure of the refrigerant (as can be seen by the graph sloping upwards) and also its heat content.

Stage 4.3 - the refrigerant passes through the “indoor side” heat exchanger and gives up its heat to the under floor (or other) heating system, and turns back into a liquid from a gas (condenses). This can be seen on the graph above as a reduction in the heat content of the refrigerant as the line is followed towards point 3.

Stage 4.4 – the refrigerant is “de-pressurised” through an expansion valve, thus allowing it to return to point 4, where it can begin to absorb heat from the air/soil again as it moves towards point 1 (i.e. entry to the compressor).

The basic curve shape will not change, and work done by the compressor will always be less than heat released, therefore the efficiency will always be greater than 100%.

Feasibility and System Design

If you are considering installing a heat pump it is recommended you first carry out a feasibility study to determine the cost and technical perspectives. This does not need to be a complex process, details below will hopefully help.

If you decide to go ahead with a heat pump, make sure it's designed to integrate with other systems in the dwelling.

Whilst this might be the job of the installer / supplier, it helps to have a basic knowledge of how the process works, so that the design proposals for the system can be examined and informed decisions made as to whether or not the proposals follow good practice. It is also worth remembering that for new dwellings, the Building Regulations 2008 Part L requires a proportion of primary energy to be supplied by a renewable source. Heat pumps can help meet this minimum renewable energy requirement and influence the Building Energy Rating (BER) results for dwellings.

In this respect, it is worth mentioning again that the efficiency of a heat pump lies somewhere between 300% and 500% depending on the heat pump type.

General Considerations

Available budget - focus should always first be on reducing the heat demand of a building through low / medium / high cost – impact measures, for example improving the insulation, air tightness and glazing upgrades. Also strike a balance between efficiency and cost when looking at different heat pump types. It is recommended you get at least three quotes.

Space available on site – for example in urban / city areas, a ground source heat pump is not always feasible due to the space needed for the collector, or for reasons of restricted access for drilling / excavating machinery etc.

Dwelling suitability – first make sure you examine the energy performance of the dwelling (as outlined above) and ensure the existing heat distribution system can be used in conjunction with a heat pump.

Base case – for example compared to gas or oil

Heat requirement – establish annual consumption

Data availability – check out SEAI's online fuel cost comparison calculators and get quotes from supplier(s)

Simple payback – calculate how many years savings will be equivalent to the overall cost of the system

Fuel cost escalation – calculate adjusted payback as required

Factors which can influence the performance of a heat pump

System design and installation are crucial; at the design stage there are a number of items to get right.

The inherent efficiency of the heat pump itself. The correct design and installation of the collector system – for example, for a ground source heat pump system, it means that the piping is laid at the correct depth, and at the correct spacing, and that there is the optimum amount of piping installed to meet the heat needs of the dwelling.

The correct design and installation of the indoor heat distribution system – a badly designed or

installed under floor heating system might mean that the heat produced does not reach its intended destination efficiently. Negligence during the installation for example not fitting insulation under and to the sides of the heated floor slab, will lead to heat loss, and wasting the heat pump's energy.

The difference in temperature between the heat source and distribution - as the difference in temperature between the heat source and the heating flow increases, then the efficiency (or COP) of the heat pump reduces. This can either be due to a drop in source temperature (e.g. air temperature reduction in an air source heat pump) or due to an increase in the temperature required for the heating flow, or a combination of both.

Domestic hot water production considerations

A heat pump system can be designed to meet the entire space heating requirement of a dwelling, and some of the hot water requirements. The maximum temperature that a heat pump can produce is dependent on the properties of the refrigerant fluid being used. In order to heat water to the 60 degrees Celsius (C) recommended for storage, there usually needs to be a supplementary heating source. High temperature heat pump options are available that can offer a temporary boost up to approximately 60 degrees C, but for heat pumps without that option, some manufacturers offer an automatic built-in immersion heater, which will make up the shortfall in temperature. Electric immersion elements are expensive to run, so you should check this with the supplier or heat pump system designer.

Estimating annual heat requirement and likely running costs

Where a dwelling has a Building Energy Rating (BER) for example when built, sold or rented, the accompanying advisory report can provide some useful information on how to improve energy efficiency of the dwelling as the assessor should have included information on heating and hot water demand per year. Existing oil or gas bills can also be used to determine the energy requirements.

Example 1 - Calculating heat pump cost from existing oil bill

- Oil bill - shows that you use for example 2000 litres of oil per year for heating and hot water, which is costing you €1,700
- Energy content of oil = 10.55 kWh/litre, therefore - Total "oil" energy used = $10.55 \times 2000 = 21,100$ kWh per year
- Oil boiler efficiency = 80%, therefore actual dwelling heat requirement = $21,100 \times 0.8 = 16,880$ kWh
- Heat Pump efficiency (COP) = 4.0, therefore annual heat pump electricity input = $16,880 / 4 = 4,220$ kWh
- If heat pump is running at a 60 / 40% split of night rate to day rate electricity in terms of operation, then the average cost per unit is approximately €0.12, so the annual running cost would be $4,220\text{kWh} \times €0.12 = €506$

Note: Calculated using oil prices as of December 2011.

Note: Because heat pumps generally do not heat hot water up to 60 degrees C, an auxiliary heat source is required to do this, usually an electric immersion. An immersion might be 3kW, and it might run for one hour per day, at one hour per day, for 365 days in the year, that is $3 \text{ kW} \times 1 \text{ hour} \times 365 \text{ days} = 1095 \text{ kWh}$. At €0.12 per unit average, then this would amount to approximately €130 per year.

- So, a total estimated running cost for heating and hot water with a system similar to the above would be $€506 + €130 = €636.00$ per annum.

If you had a BER rating carried out, then you can read the actual dwelling heat requirement directly from this and carry out a similar calculation.

Note: The calculation above is intended to show the various steps in examining indicative running costs, there are many variables so this will differ in every situation. SEAI's online domestic heating cost and carbon comparison tool can be used to analyse the possible fuel consumption and running costs per year of different heating sources in a dwelling.

Note: A simple payback can be then calculated from the difference in running costs per year between the two systems for example €1,700 for oil against €636 for heat pump electricity, equating to an annual saving of €1064.

Divide the overall cost of the heat pump system by €1,064 to get a simple projected payback in years.

System Control

To reap the economic and environmental benefits from your heat pump, proper control of the system is important, and must be based on time and temperature information for different zones. Think of a zone as a particular area of a house, such as the living area, which might contain the hall, kitchen, living room etc. or a bedroom zone might be the landing, master bedroom and 2nd bedroom etc. Hot water can also be considered a separate zone.

The heat pump will usually read external temperature, return pipe temperature and different zone temperatures. The availability of time and temperature data allows the system to respond in the optimal way to either manual or programmed adjustments.

Times and temperatures are set by occupants to match living patterns for example rooms with low occupancy levels would not be fully heated, but rather kept at a "set-back" temperature. Rooms or zones which are frequently occupied are kept heated during occupancy times, and "set-back" at other times. An example of this would be the bedroom / living area exchange. When occupants move from the living zone (kitchen / living / dining rooms) to the bedroom at night, then the focus of the heating will switch from the living zone to the bedroom area, and therefore the same level of temperature is not required in the living zone, and can be "set-back". The bedroom temperature, having been "set-back" all day, now can be brought up to the level required by the occupants while they sleep.

The programming of times and temperature takes planning, an intelligent system will be able to compensate for the lag in the response to ensure heating temperature targets are met at the times required. Modern controllers can allow daily or weekly programmes to be used in this way.

The technical guidance document of Part L of the 2011 Building Regulations has some information on zoning of a dwelling. (www.environ.ie/en/tgd)

Heat Storage

Heat pumps are most suited to under floor heating. In under floor heating systems, the floor slab acts as a thermal storage facility, which is important for two reasons, firstly it minimises the on-off cycling of the heat pump, secondly as the area of heat release is very large, the required flow temperature of the water through the pipes is much less than that required by conventional radiator systems.

However, using low-temperature radiators (aluminium, larger surface area or fan-coil types usually) in conjunction with a buffer cylinder can provide an alternative design solution when planning heat pump installations that cannot use under floor heating. A buffer tank is usually incorporated into systems using radiators to provide the required thermal storage for efficient heat pump operation, it serves to mimic the storage effect of under floor heating, however it is not always required, for example where the heat pump can vary its heat output to match the heat requirement of the building.

Common Buffer Tank Configuration

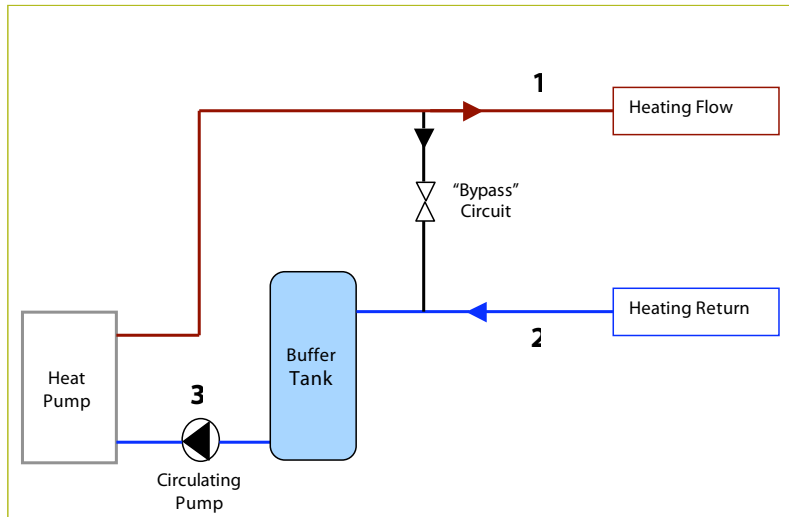


Figure 6 - Incorporating a buffer tank into a heat pump system

1. Hot water produced in the heat pump is pumped into the "heating flow", where it is distributed around the building for heating.
2. The cooler water returning from the heating distribution system is then fed into the buffer tank on the way back to the heat pump.
3. The water is then pumped from the buffer tank back to the heat pump to complete the circuit.

Over time, as the building comes up to the required temperature, the return temperature of the water from the heating system will approach that of the hot water flow coming from the heat pump, so will the overall temperature of the buffer cylinder. The buffer cylinder stores heat, which takes the pressure away from the heat pump to switch on and off frequently.

Note: The buffer tank is located on the return side of the heating distribution system and not on the hotter flow.

This configuration allows hot water from the heat pump to enter the heating system directly, ensuring a quicker response. In certain circumstances, the buffer is more appropriately placed on the "hot" side of the heating distribution system, for example in situations where domestic hot water production is also taking place in the buffer.

Note: There is a "bypass" circuit – this is a common feature of heating systems. Imagine a situation where, for example, there is a radiator system installed with thermostatic radiator valves. The water must always have a path back to the heat pump so that the pump does not pump up against a "dead-end", and this bypass is a common method of ensuring this is possible.

Procurement and Purchase

At this stage you will have decided which type of heat pump system suits your needs, and you will have a basic knowledge of how the system might be configured.

The process of sourcing and buying a system is the next step.

Heat Pump specifications

The heat pump should be assumed fit for the purposes (Building Regulations Part L 2008) and cross check the heat pump listing on SEAI's HARP database – for Building Energy Ratings. Heat pumps should have a minimum two year warranty and ask your supplier about the recommended maintenance.

Note: Heat pump performance – the efficiency of a heat pump lies somewhere between 300% and 500% depending on the type. We already know this is because the amount of electrical energy used to power the electrical compressor in the unit is less than the heat energy delivered to the dwelling. Because the efficiency is greater than 100%, it is not usually quoted as a percentage but as a figure greater than 1, for example 100% = 1, 200% = 2 etc.

Two terms are commonly used, but they are not interchangeable:

- *The Coefficient of Performance (or COP)* describes the ratio of electrical power used to heating power produced under fixed input and output conditions by the heat pump unit only. A COP is used for examining the performance of a heat pump unit at ideal test conditions, usually in a laboratory.
- *Seasonal Performance Factor (SPF)* describes the ratio of the amount of electrical energy used by all components associated with the heat pump system, to the amount of heat energy delivered to the heating system, over a long period of time (e.g. season or year). SPF is a better indicator of performance for the purposes of examining the “real-life” performance of a heat pump than COP.

What to Look for in a Best Practice System

Investment return - expected costs and paybacks will vary. Typical costs of heat pump and installation range from €10,000 to €15,000 depending on the heat pump type, size of the house and heat demand. Initial investment costs will be higher than for gas or oil systems but the running costs will generally be lower. Heat pumps compete especially well against oil and LPG systems where the fuel costs are high and costs continue to increase.

SEAI's online domestic heating cost and carbon comparison tool can be used to investigate the cost benefits of a heat pump system.

Agreeing cost – it is recommended that you agree a fixed cost for the supply and installation of the system with any perspective suppliers / installers before starting any works. Whilst this may be quite straightforward for a new house, you may need to accept variations in retro-fit installations where challenges may be uncovered once installation has started, for example connecting to an existing heat distribution system.

Similar to making any purchases you may have a preference to a particular system / supplier, however it is important to make a balanced judgment of the quality of the system and the features included. Other factors may come into play, for example familiarity with supplier / installer based on previous experiences and recommendations from trusted sources. Ensure that your preferred supplier / installer provides a good back up service at a reasonable cost and in a timely manner, also enquire how many installations they've previously carried out, ask for previous client's contact details to check out quality of work etc. Finally it is recommended that you get at least three quotes.

Contracts – do not rely on any word of mouth agreements, best practice dictates all agreements should be made in writing and signed. At the very least this can be used as a starting point for drafting a contract, basically an agreement between the two parties that is designed to avoid any misunderstandings at a later date.

Payment Terms and Project Milestones – agree a fixed price inclusive of VAT for all products and services, a start and completion date and payment plan perhaps on the basis of key project milestones. Ensure installer supplies a receipt for all payments made.

Installation

Insulation of pipe work - pipe runs can be a major source of heat loss so ensure all pipes and fittings are appropriately insulated.

A correctly designed system still needs to be installed in a way that allows the design to be fulfilled in practice. Engage a suitably qualified professional to carry out the work. Suitably qualified might mean that the installer has plumbing qualifications (completed an accredited heat pump installer course), training from the manufacturer and previous experience with a record of previous reference installations. Using one contractor for all the works can reduce potential future conflicts should any issues arise.

Obligations of the installer / supplier – your installer should carry out a survey of your home to ensure appropriate selection, design and sizing of the system (collector, heat pump and heating systems) and should ensure that the installation is carried out in accordance with recognised good practice, relevant national and European norms and regulations as well as the instructions of the manufacturer. Once the installation's completed, ensure your installer provides you with a signed commissioning certificate and all the system documentation, provides a schedule of required maintenance and demonstrates to you how the heating system operates.

The supplier / installer should also provide you with an operation manual in English that covers the operation and maintenance of the system.

Operation - familiarise yourself with manual and automatic controls and sensors for example thermostats. Set the controller to reflect your anticipated use and timer to adjust relevant zone temperatures at times when you desire space heating in the house. Remember to set heating times and temperatures for different space heating zones heating times and the times for heating the hot water to meet your demands and usage. (Electric immersion use can be expensive). Review and update automatic control settings three times during the heating season for example October, January and March. Set room thermostats to lowest level at which you feel comfortable – this may require some trial and error before getting it right. A 1 degree lower setting on the thermostat can provide significant energy savings. Typically, 20 – 21 degrees in the living areas and 18 degrees in sleeping areas are comfortable for the majority of people.

Heating System Control – maintaining comfortable conditions and at the same time running the heating system efficiently may require having an automatic temperature control in place. Thermostats are used to control the temperature of an area or space. Usually, a dwelling is zoned according to the use of that space, so living area would be one zone, bedrooms another, and hot water would be the third “zone” – it is possible to create as many zones as necessary for example a home office might be an extra zone. In most dwellings, not all areas are occupied at all times therefore; temperatures can be lowered and ramped up automatically as required. Thermostats with both time and temperature control are available and are best suited to this type of strategy. Some devices allow separate temperature and time programming for weekends, where the occupancy patterns are different.

Table 2 below highlights an efficient time and temperature strategy for Monday-Friday in a typical three zone dwelling. Note that actual comfort temperatures will vary from person to person.

	Living Area Zone (Kitchen, Living, Dining, Hall, WC)	Bedroom Zone (Master Bed, Landing, WC, Bed 1)	Hot Water Zone (Water heating only)
11pm-7am	Set back temperature to 16/17 °C	Heat to 18 °C	On after 12am if electrical immersion used, otherwise, comes on based on temperature demand.
7am-8.30am	Heat to 21 °C	Keep at 18 °C	
8.30am-6pm	Set back to 16/17 °C	Set back to 16/17 °C	
6pm-11pm	Heat to 21 °C	Set back to 16/17 °C	

Table 2 Sample Heating Control Strategy

Maintenance and after sales service – most reputable suppliers offer service contracts to ensure optimum operation and long life of the heat pump system. It is recommended that heat pumps should come with a very minimum warranty period of two years.

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