Document Type: External

Heat Pumps

Author / Contact :

Julian Stringer
jules@teignenergycommunities.co.uk

Contents:

Section 1. Is this for me?

This guide is part of the E-Pack which is available to TECs members. We have made the guide available to everyone as it may also be of interest to others.

Heat pumps (**HPs**) like Photo Voltaic (**PV**) systems are all rage when looking for ways to reduce our greenhouse gas (**GHG**) emissions. The government's GHG reduction plans assume that 600,000 heat pumps a year will be installed by 2028. At the same time a target of 300,000 new builds per year has been announced. This sets an expectation that at least 300,000 existing buildings per year will be fitted with heat pumps. At the time of writing roughly 2% of new builds are being fitted with heat pumps.

You will probably have considered replacing your heating system with a HP, but have heard some conflicting information about them. You may even have gone as far as getting a quote and held back because of that or the price quoted. This guide gives you the information you need to make a more informed decision.

The guide explains the important concepts around HPs, a quick answer to whether you should consider fitting a HP and how to go about it as well as a detailed explanation of the following:

- How heat pumps work;
- Terminology you are likely to encounter;
- Typical performance parameters; and
- The design of a system.

Section 2. What is a heat pump?

A heat pump is a device which extracts heat from a heat source and transfers it to a heating medium which is used to transfer heat to emitters within a building.

A key feature of heat pumps is that the total heat output is more than the electrical energy needed to drive the heat pump.

A heat pump operates in a similar way to a refrigerator, but in reverse.

2.1 Types of heat pump

Heat pumps are categorised by heat source and heating medium. The following types are common:

- Air Source Heat Pump (**ASHP**), these are the most widely marketed form.
- Ground Source Heat Pump (**GSHP**), these are usually the most efficient and can be:
  - coils laid horizontally in trenches between 1 and 2 metres underground;
  - pipes in boreholes up to 100m deep; or
  - Shared ground loop (for multi-dwelling installations).
- Water Source Heat Pumps (**WSHP**), not common as they require a nearby body of water.
- Hybrid heat pumps which operate in conjunction with more traditional gas/oil systems.

2.2 Why do we need heat pumps?

It is likely that it will not be possible to buy a new oil boiler after 2028 or a new gas boiler after 2033. Alternative heating technologies are likely to become the norm in 5-10 years. We need to make sure our homes and buildings are ready for these changes.

Increasingly, new build houses will be designed to be heated by a HP which would be a cost effective alternative to a gas boiler, but this won't be enough. We need to consider which other buildings are suitable and how to make them suitable.

According to the energy saving trust heating accounted for 31% of household emissions in 2017. This needs to reduce by 95% if we are to have a chance of reaching net zero carbon.

As we decarbonise, we need to provide heat from low-emission sources. That means either electricity from low-emission sources, or alternatives such as green hydrogen, or burning biomass. An essential requirement of this strategy is plentiful renewable energy.

Section 3. The Quick Answer to Why and How I Should Get a HP

When installed with suitably sized radiators or underfloor heating a heat pump can save you money on energy, but a poor installation can lead to increased costs. Not every building is suitable, so you have to make sure yours is before you decide to have a HP installed.

A HP is one of many measures you can undertake to reduce your GHG emissions, improve comfort and possibly even pay less. TECs would strongly recommend that you take a more wholistic approach rather than opting for a measure which you've heard about, it may not be right for your objectives or circumstances.

Here are some basic steps which you should undertake to help you make that more informed decision:

- Decide what your aims and priorities are.
- Measure what and where your emissions, energy use and costs are.
- Get a whole building assessment done with a list of priced options and their effectiveness.
- Do the quickest and most effective measure first.
- Check if this worked as you expected before moving on to other measures.

Much of this you can do yourself using the TECs E-Pack for heating. You will probably need help when it comes to doing detailed heat-loss analysis. Much of this can be provided or signposted by TECs to its members.

Your approach should always be guided by the following Energy Hierarchy:

1. Reduce heat energy consumption by cutting out waste. This could be changing how/where you heat or simple measures to reduce heat loss with draught proofing or temporary insulation like curtains.
2. Reduce heat energy loss by improving the fabric of the building, i.e. insulation. This is where you need to follow the steps above to make sure that any measures are effective, but also take account of ventilation and condensation so as not to cause discomfort or damage the building fabric.
3. Only when you have managed to reduce your heat-energy consumption sufficiently, should you consider low-emission heating technologies such as HPs.

This makes sense because you'll get significant benefits from steps 1&2 regardless of whether you also do step 3.

Section 4. Outline of a central heating system

A simple central heating system consists of:

- A heat source (gas or oil boiler) which heats a heating medium – normally water or air.
- Pipework that allows the heating medium to flow to each room.
- Radiators in each room that deliver heat.

A traditional system using a gas or oil boiler might also have:

- One or more thermostats which determine when the boiler runs.
- Thermostats on radiators which control how much heat is delivered by the radiator.

4.1 Hot water

Central heating systems also deliver hot water, this may be at temperatures as high as 80C. For human comfort when washing a temperature above 40C is all that is needed. To protect against legionella the temperature should be raised above 60C from time to time. In most existing systems the hot is heated to 60C by default to guard against legionella. When a low temperature source, such as a heat pump is used then the temperature should be boosted to 60C periodically, this can be done with an immersion heater.

Legionella

Legionella bacteria can multiply in hot water systems, the conditions for this include:

- Water in some of the system being between 20 and 45C
- Organic material to feed the bacteria such a sludge
- Parts of the system that are stagnant

To guard against legionella it is recommended that:

- Hot Water is heated to 60C
- When a tap is turned on water should reach 50C within 1 minute
- Cold water is distributed below 20C

For further details see:

https://www.hse.gov.uk/healthservices/legionella.htm

Residential landlords and non-domestic building managers are legally responsible for the health and safety of building users, and so should perform a risk assessment that includes legionella. For more information see:

https://www.hse.gov.uk/legionnaires/legionella-landlords-responsibilities.htm

Legionionnaires' disease – A brief guide for duty holders

4.2 Radiators

Traditional radiators are designed to deliver a specified amount of heat (in Watts or BTUs). The heat output is specified at a delta T (difference between water temperature and room air temperature). Heat output is specified at a temperature difference between room and water (ΔT) of 50C and sometimes 60C. This means that in a conventional system the boiler will supply water at 80C to the radiator and it will return at 60C giving an average of 70C.

A radiator sized to work with a ΔT of 15 rather than 50 needs to have nearly 5 times the rated output. Commonly this means that it needs to have a much larger surface area, this can make the radiators impractically large, one way round this is to size for a higher flow temperature, but a higher flow temperature may not be achievable or cause the heating source to operate less efficiently.

Many radiator sellers and traditional plumbers use calculators for radiator sizing that typically take as input:

- Room type
- Room dimensions
- Type of windows

This is simple, but doesn't take account of building construction, so is likely to be inaccurate. This may not matter as a safety margin is built into the calculation, but they will also assume a water temperature of about 70C.

Strictly, these calculations must make assumptions about the heat source and room construction, so if either of these is not traditional then the result will be wrong. It is therefore advisable to get the calculations done by a qualified heating engineer familiar with all the different types of heating systems.

4.3 Underfloor Heating

While direct electrical underfloor heating is available, the explanation here is for water based central heating systems.

Underfloor heating provides a means of increasing the area of the heating surface without loosing any wall space. This should be the system of choice for a new build as it makes them future proof in terms of heating sources. It can also improve the level of comfort for occupants.

Installation in an existing building is extremely disruptive, as it requires the floor to be taken up and re laid. This should be considered if doing a deep retrofit.

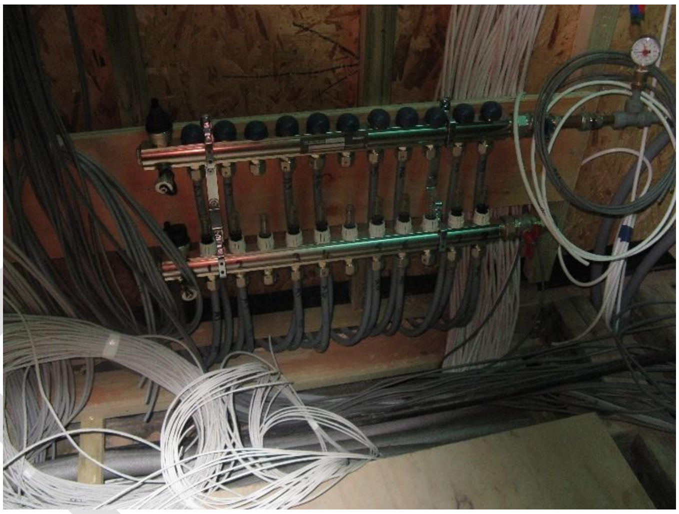
A typical underfloor heating installation consists of a circuit of pipe laid under the floor in a snake like fashion so that pipe is evenly spaced under the floor as shown in the photo above right (Oak house construction 10/4/2011)[i].

When installed at ground floor level pipes are typically laid over insulation and a vapour proof membrane. These are then clipped as shown in the photo above right. The pipes are then covered with a layer of screed about 75mm thick which provides thermal mass for limited heat storage capacity. The screed is then finished with a thermally massive material such as stone tiles. Note that it is not a good idea to finish the floor with carpet as this impedes the heat reaching the room.

For other floors pipes are laid on special panels (above left) over insulation between joists the pipes run in grooves routed into each panel. These are then covered with a layer of plywood and finally the floor finish.

Other options for floor constructions and finish (e.g. engineered wood) are also available.

4.4 Manifold



A water based underfloor heating system needs a means of regulating the flow of water to each room, this is done with a manifold, which consists of a set of electrically operated valves that are opened by thermostats in each room. The picture right shows a manifold during installation of a system in a new build.

4.5 Thermostats

Traditionally one thermostat for whole house, more recently thermostats per radiator. With underfloor heating there is no opportunity to put a thermostat on a radiator.

When underfloor heating is installed there are no radiators to put a thermostat on, so a thermostat in out in each zone to enable the amount of heat delivered to each room to be controlled accurately. These typically measure the air temperature in the room and signal to a controller for whole house systems or individual valves that the heating should be adjusted in the room. This is often achieved by actuating the associated valve.

Recently thermostats have become available that are Wifi enabled, these can be monitored using an App, which can also be used to control the heating.

4.6 Flow controller

All systems commonly have a flow controller, which is responsible for:

- Switching the heat source on and off
- Maintaining a set flow temperature in the space heating system
- Diverting flow to the hot water system
- Controlling any pumps in the system
- May also implement weather compensation

A flow controller will typically have a number of modes of operation:

- Boost Heating (targets higher flow temperature)
- ECO Heating (weather compensation)
- Hot Water
- Frost Protection – maintains just enough flow temperature to prevent pipes freezing.

The flow controlling may also take inputs from a number of temperature sensors.

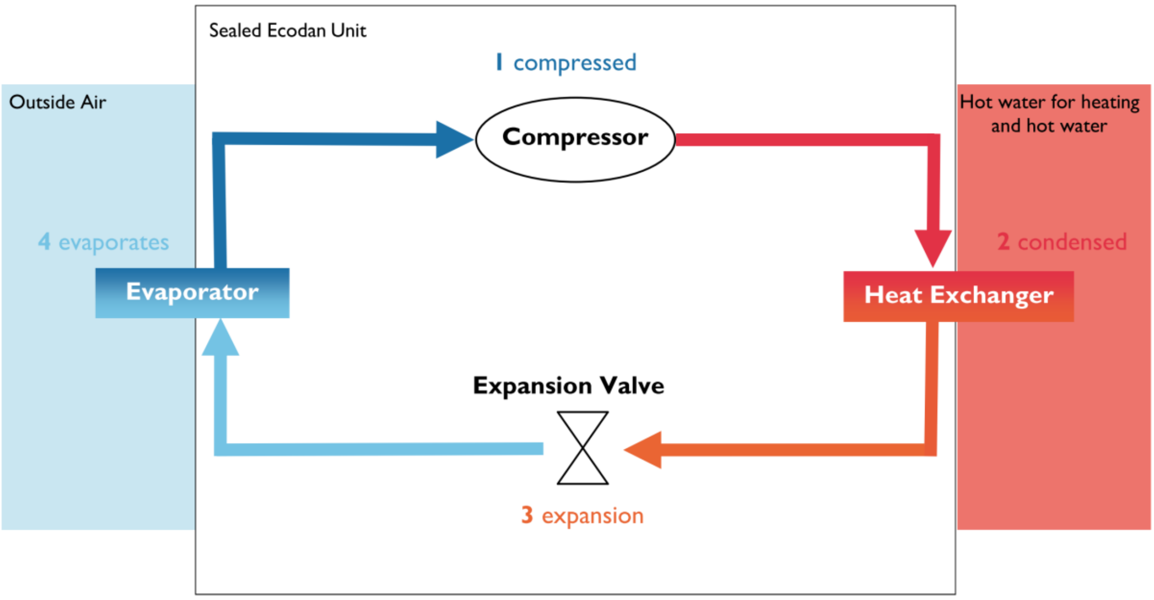
In some systems the flow controller will be integral with a boiler, but in others it is separate.

Section 5. Heat Pump specific components and types

the heat source in heat pump based system will differ from other heating systems. It will have a pump (compressor) and a heat exchange part which can be for air, ground or water.

The heat pump works by passing refrigerant though the heat source, then compressing the refrigerant to heat it up. The compressed refrigerant is passed through a heat exchanger to pass heat to the heating medium, then the refrigerant passes through an expansion valve to cool it again.

This cycle is shown in the diagram below[ii].



(From Mitsubishi FTC2 Installation manual)

The same principle applies to both air, ground and water source heat pumps.

Air Source Heat Pumps(ASHP)

An air source heat pump uses a fan to pass outside air over the evaporator, this slightly reduces the temperature of outside air surrounding the heat pump.

Ground Source Heat Pumps(GSHP)

A ground source heat pump passes a mixture of water and antifreeze through an array of pipes in the ground Heat is extracted from the water/antifreeze mix at the evaporator. This is the most common indirect closed loop system.

Other GSHP types include

- Direct – where the refrigerant is passed through the pipe array.
- Open loop where an existing water source is used.

As the ground temperature is more stable and higher in winter than air temperature, ground and water source heat pumps are more efficient, but are more difficult to install.

https://www.logic4training.co.uk/wp-content/uploads/2014/05/EST-CE82-DomesticGroundSourceHeatPumps.pdf

Water Source Heat Pumps

Water source heat pumps work in a similar way to ground source heat pumps, except that pipe array is placed in a water source, such as a lake of river.

5.1 High temperature heat pumps

High temperature heat pumps are designed to operate efficiently at higher flow temperatures.

Characteristics of this class of heat pump include:

- Capable of operating at flow temperatures 65°C and above.
- A7/W65 COP between 2.1 and 3.0.
- Cost 20 – 30% more than a standard heat pump.

For more details see: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/565239/Domestic_High_Temperature_HPs-_FINAL2.pdf

These can be used to reduce the increase needed in radiator surface area, that would be required in a normal installation.

Whilst a high temperature heat pump can operate at a higher flow temperature, it is less efficient than a normal heat pump, so more electrical energy will be required to generate heat.

As with any heat pump the output characteristics need to match those required by design calculations.

See also: https://www.icax.co.uk/High_Temperature_Heat_Pumps.html

5.2 Hybrid Heat Pumps

Hybrid systems use a conventional gas or oil boiler in conjunction with a heat pump and a suitable controller. This can be used in a number of ways:

- It can provide flexibility in when to use either system.
- The backup boiler provides heat when the heat pump does not have the capacity to produce sufficient heat efficiently.

For more information on a smart flexibility platform see https://www.passivsystems.com/case-studies/smart-hybrid-heat-pumps-provide-the-uks-pathway-of-choice-to-decarbonise-heat/

BEIS produced a report on hybrid heat pumps in 2017[iii]

This report includes the results of various studies that show a wide range (30% to 96%) of heat coming from the heat pump. Different heating schedules account for some of this variability, as heat pumps are more suited to maintaining a constant temperature.

We don't think these are a good option, except in exceptional cases.

Section 6. Technical terms for HPs

When investigating heat pumps you will undoubtedly encounter several terms all of which relate to performance. Figures quoted by heat pump manufacturers relate to precise definitions that do not necessarily reflect real conditions.

Most of the following terms will apply to all types of heating systems, but some are specific to HPs or have a specific meaning in such heating systems.

6.1 Emitter

An emitter is a surface which transfers heat from water heated by the heat source, and air in a room. Typically this is a conventional radiator or underfloor heating.

6.2 Flow Temperature

Flow temperature is the temperature of water flowing in the central heating system.

Typical values range from 30C to 75C. Temperatures above 60C are common with gas and oil boilers, but heat pumps work more efficiently if the difference between the source temperature and flow temperature is as small as possible. 55C is generally regarded as an upper limit for heat pumps.

6.3 ΔT (delta T)

Delta T or Δt refers to the difference in temperature between the water circulating throughout your central heating system and the room temperature. When replacing any radiators in your home it's important that you use the correct Delta T. This is because the same radiators can have different outputs at different water temperatures due to the heat source you are using. (See https://www.stelrad.com/news-events/blog/the-importance-of-delta-t-in-calculating-heating-output/)

Typically heat output of a radiator is quoted at ΔT=50

This means that to heat a room to 20C, the average flow temperature of water is 70C. Typically this means that the water entering radiators is at 80C and leaving the radiator is 60C.

6.4 ΔT correction factor

As heat pumps work better at lower flow temperatures, the temperature difference between room and radiator will be different from the quoted ΔT for the radiators used, so when calculating the heat output of radiators a correction factor needs to be applied.

Correction factors are given in the following table[iv]:

ΔT	Correction Factor
5	0.050
10	0.123
15	0.209
20	0.304
25	0.406
30	0.515
35	0.629

40	0.748
45	0.872
50	1.00

(https://www.buildingservicesindex.co.uk/entry/136540/AEL-Heating-Solutions-Ltd/How-to-calculate-the-delta-T-for-a-radiator/)

If the flow temperature is 55C rather than 70C, then to get an output of 100W you would need a radiator rated at 100 X 1.0 / 0.629 = 159W

If the flow temperature were instead to be 35C, then the radiator would need to be rated at 100 X 1.0/0.209 = 478W

6.5 Thermal Mass

Thermal mass states how much heat is required to change the temperature of a building or building element by a degree. In the context of a heating system thermal mass can be used to store heat. In an underfloor heating system a screed is sometimes used as thermal mass. Thermal mass determines how fast the system responds to heat applied. A system with high thermal mass will require more heat input to reach its target temperature, but will also loose temperature more slowly.

If the system has high thermal mass it is more efficient to try to maintain a constant temperature (or as near as possible given the precision of thermostats), whereas if a system has low thermal mass it is more efficient to heat only when heat is needed.

Which is more appropriate will depend on building occupancy and the building's heat-loss performance.

6.6 Weather Compensation

A heat pump works most efficiently at lower flow temperatures. Weather compensation sets the flow temperature at an appropriate level to just meet heating demand given the current weather conditions. This can be used when the system is already up to its working temperature.

6.7 Coefficient of Performance (COP)

COP is the ratio of heat output to electrical energy input under standard test conditions. A COP value of 4 means that you get 4kWh of heat out for 1kWh of electrical energy in.

For air to water pumps COP is typically quoted in terms of the air temperature (A) and flow temperature (W), this is codified as follows.

Aaa/Www

aa represents the air temperature

ww represents the water temperature

Example: A2W35 means air 2C, water 35C

Typical values are[v]:

Air temperaturee	Water Temperatures	Mirai COP[v]	Ecodan COP[vi]
7	35	4.51	4.26
7	45	3.64	

7	55	3.02	
2	35	3.83	3.11
2	45	3.05	
2	55	2.5	

(https://www.miralsrl.it/wp-content/uploads/2018/05/0dts000240em_00-mls.pdf , http://www.mitsubishitech.co.uk/Data/Ecodan/Air/Monoblock/Outdoor/PUHZ-W/2015/PUHZ-(H)W-VHA2(YHA2)_Databook.pdf)

It must be emphasised that these values are under test conditions they do not represent real world conditions. It can however be seen that the performance of any air source heat pump deteriorates as the temperature difference increases.

Similarly ground and water based HP manufacturers will quote a COP. Here the ground/water temperatures will be have a more limited range.

6.8 Seasonal Coefficient of Performance (SCOP)

In order to estimate annual performance, the European Union's Ecodesign regulations utilise a test and calculation standard (EN14825:2016) at a wide range of temperature conditions. These are used to calculate a Seasonal Coefficient of Performance (SCOP) for a heat pump, which is used to derive an energy label class (A++ to G) for comparison purposes.[vii]

https://www.bregroup.com/heatpumpefficiency/background

Unfortunately, the SCOP estimation of performance misses a number of important aspects that may affect the performance of a heat pump when installed in homes. These include:

1. Heat loss of the actual dwelling in which the heat pump is installed is ignored
2. It uses average European climate data
3. Hot water heating operation is ignored, including its impact on space heating operation
4. Heating hours
5. For inverter (modulating) heat pumps, the minimum heat output is not defined, meaning some heat pumps may cycle on/off more than others at identical temperature conditions
6. Weather compensation is always assumed to be present

Tables of SCOP values for specific heat pumps are available from the MCS certified product directory[viii], if you know the manufacturer or better product number for a heat pump you can look up its details, including SCOP values.

Here are SCOP values for Mitsubishi Ecodan PUHZ-HW140VHA2-BS

Flow Temperature	35	36	37	38	39	40	41	42	43	44
SCOP	3.87	3.83	3.79	3.75	3.71	3.68	3.64	3.6	3.56	3.52
Flow Temperature	45	46	47	48	49	50	51	52	53	54
SCOP	3.48	3.44	3.41	3.37	3.34	3.3	3.26	3.23	3.16	3.12

For this heat pump values above 55C are not given. This ASHP was certified in 2009, we should hope that more recent designs have better performance. It is included because the author has one!

Again you can see that SCOP deteriorates with flow temperature.

6.9 Seasonal Performance Factor (SPF)

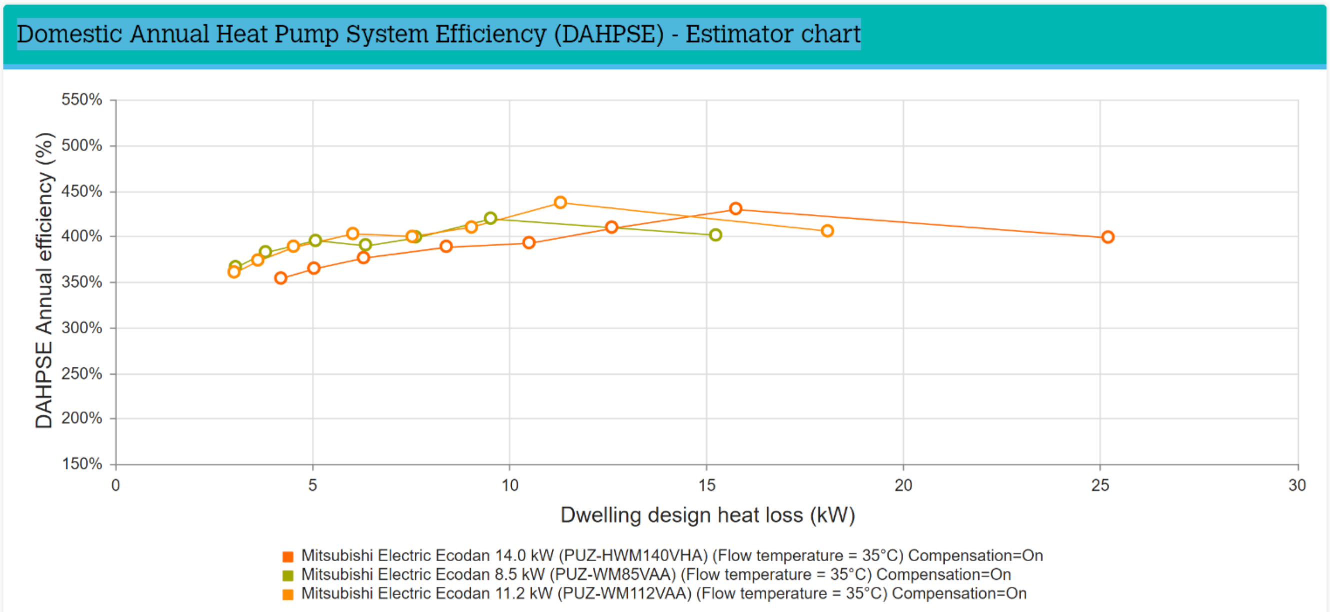
This standard was devised by BRE to get around the shortcomings of SCOP[vii].

https://www.bregroup.com/heatpumpefficiency/background

SPF estimates heat pump annual efficiency, an annual combined space and hot water heating duty cycle is used, which incorporates hourly space and hot water heat load and temperature assumptions, using average UK weather date (taken as City of Leeds). Heat pump test data satisfying Ecodesign regulation requirements (EN14825:2016) (SCOP) is used as an input to the calculation.

This provides a more likely and useful estimate of UK domestic heat pump performance.

BRE publish a tool called Domestic Annual Heat Pump System Efficiency (DAHPSE) which allows you to compare the UK performance of heat pumps in their database. It plots a graph of annual efficiency by design heat loss.



Section 7. System Design Process

This section outlines the process used to size a heat pump.

- For each room calculate:
  - heat loss at design interior and exterior temperatures
  - calculate flow temperature based on current radiators/emitters
  - if flow temperature is too high either:
    - Reduce heat loss
    - Change radiator to increase heat output
    - Repeat calculation until flow temperature is suitable for a heat pump
- Work out required flow temperature for building as is
- Reduce heat loss or increase emitter size until flow temperature is acceptable
- Find a suitable heat pump

7.1 Microgeneration Certification Scheme (MCS) Heat pump Calculator

MCS provides a heat pump calculator[ix] (macro enabled spreadsheet) which is commonly used to produce illustrations of system performance. The inputs to the calculator are:

- Design temperatures
- Assumed U Values for each element type and floor (ground, mid, upper) – a U Value calculator is included in the tool.
- Details of each room:
  - Heat loss
  - Energy usage
  - Design Temperature
  - Does the room have an Open Flue?
  - Air Changes per hour
  - Floor Area
  - Volume
  - W/m^2
- Details for each room are input on a separate sheet which includes all dimensions.

Outputs include:

- Sound output from the heat pump
- Ground loop sizing (for GSHP only)
- Radiator sizing
- Underfloor heating sizing
- Fuel price comparison, Annual running costs, CO_2 Emissions
- Compliance Certificate

Section 8. Requirements for installation

8.1 Insulation and ventilation

Emitters need to warm the air in each room. As emitter temperatures are lower with a heat pump installation, this takes longer than with a conventional radiator with a 50°C temperature difference. If the room is draughty then the air that has just been warmed will escape and its embodied heat will be lost. Likewise if the heat leaks out through the fabric of the building the heat pump will have to work harder to maintain target temperature.

8.2 Space considerations

Depending on the type of heat pump installed you need to have space for it both inside and outside.

Air Source Heat Pump Outside Space

The heat pump should be installed on a concrete base outside the building as close as possible to the interior parts of the system.

There should be sufficient ambient air around the heat pump.

The heat pump should be positioned so that it is easy to get at for occasional maintenance, so doesn't need scaffolding should it go wrong.

Avoid positioning it under a bedroom window as it will make some noise.

This yougen article gives further information.

Inside space for plant (plant room / large cupboard)

Inside the house you will need a large cupboard or plant room which might contain:

- Hot Water cylinder
- Expansion tanks
- Pumps, valves and other plumbing
- Flow controller
- Underfloor heating manifold if required

Ground Source Heat Pump Outside Space

As mentioned earlier there are 2 types of installation:

- Horizontal coils buried in trenches about 1 to 2 metres deep and a metre wide. This type of installation needs a sizeable lawn or field.
- Boreholes require less space. A house that requires 10kW of heating capacity will probably need 3 boreholes 80 to 110m deep. These should be 5 - 6m apart and 6m from any building. There needs to be sufficient access for a drilling rig. See the GreenMatch article for further information.

A GSHP will also need space in the plant room

This article gives an idea of the space requirements for a GSHP.

Solar Thermal

In some cases a heat pump is installed in combination with solar thermal system. This heats the bottom part of the hot water cylinder which pre-heats water to about 30°C so the heat pump only has to raise its temperature to about 50°C when the heat pump heats the top part of the tank.

Section 9. Comparison with conventional alternatives

We need to consider carbon emissions and running cost both now and in the future. Currently the national average carbon intensity for natural gas is 208g / kWh and for electricity 288g / kWh when scope 3 emissions are included. If we take efficiencies into account (say 93% for a gas boiler and 300% for an air source heat pump), then the following table shows emissions per kWh of heat:

Heat source	Energy carbon intensity (gCO_2e/kWh)	Energy to heat conversion efficiency %	Heat carbon intensity (gCO_2e/kWh)
Condensing gas boiler	208	93	224
Oil fired boiler	306	80	381
Air Source Heat Pump (ASHP) average	288	300	96
ASHP worst case	288	200	144
Ground Source HP (GSHP)	288	400	72

So even now a suitably installed ASHP would result in a reduction In CO_2 emissions for the same heat output. This uses the current average electricity grid intensity, in future this will change, hopefully it will get less.

A running cost comparison clearly depends on the relative prices of gas and electricity. (Forgive me I do not have gas so can only guess at its cost). The following table compares the cost of running an ASHP

Heat source	Energy cost p / kWh	Efficiency	Heat cost / kWh
Condensing gas boiler	4	93	4.3
Oil burner	6	80	7.5
ASHP low tariff	15	300	5
ASHP high tariff	20	300	6.7
GSHP low tariff	15	400	3.8
GSHP high tariff	20	400	5.0
ASHP break even tariff with **gas**	12.9	300	4.3
ASHP break even tariff with **oil**	22.5	300	7.5

The break even electricity rate for comparison with your current fuel source is given by:

Let

$R_{breakeven}$ = Break even rate for electricity

$E_{current}$ = Efficiency of existing heat source

$R_{current}$ = Current rate you pay for fuel

$E_{heatpump}$ = Efficiency of heatpump = SPF/100 (as SPF is expressed as a percentage)

Then

$R_{breakeven} = (R_{current} / E_{current}) \times E_{heatpump}$

If the rate you expect to pay for electricity is less than $R_{breakeven}$, then a heat pump should cost less to run.

Several electricity suppliers offer multiple rate tariffs. If your heat demand is low, so that room temperatures do not drop significantly during the day it can be cost effective to boost the heating a bit when electricity is cheap in order to ensure it isn't used when it is expensive.

According to homebuilding.co.uk an ASHP system costs between 11K and 20K, whereas a Combi-boiler costs between 2K and 4K.

The following section describes grants and subsidies that can help with financing a heat pump.

Section 10. Subsidies

There are a number of subsidy schemes which could apply to heat pumps:

- Domestic Renewable Heat Incentive (DRHI)
- Green Homes Grant
- Clean Heat Grant
- Energy Company Obligation (ECO)
- Local Authority Delivery scheme (LAD)

10.1 Domestic Renewable Heat Incentive (DRHI)

The additional cost can be offset by using the Renewable Heat Incentive, which has been extended to March 2022. For a new installation. Currently this pays 10.85p per kWh of heat generated for an ASHP and 21.16p for a GSHP.

under this scheme, you will receive payments based on the amount of heat you generate for 7 years. This scheme requires you to find the upfront capital cost.

In order for a heat pump to qualify some conditions must be met, the principal ones are:

- The Heat Pump must be MCS certified
- An MCS certificate must be issued
- Must be an air or ground source to water heat pump (the scheme does cover other technologies apart from heat pumps)
- The SPF of the heat pump must be at least 2.5
- From 2016 a heat meter needs to be installed, this is used as the basis for payment.
- The installer must provide Ofgem with details of the installation

The scheme covers single domestic dwellings.

You should be an owner-occupier, self builder, private landlord or registered provider of social housing.

If you fund your heat pump through green homes grant, then you must inform Ofgem, and any funding from this will be deducted from your RHI payment.

For more information see:

Energy Saving Trust – Renewable Heat Incentive

Ofgem – Renewable Heat Incentive

https://mcscertified.com/green-homes-grant-update-it-can-be-used-with-drhi/

OFGEM heat pump calculator

In order to qualify for renewable heat incentive (RHI), details of a heat pump need to be supplied to Ofgem. Another spreadsheet is provided to do this.

https://www.ofgem.gov.uk/publications-and-updates/heat-pump-seasonal-performance-factor-spf-calculation-template

This has to be filled in by an MCS installer and provides details of the design and supporting evidence. It provides evidence to calculate expected heat output to Ofgem.

Inputs to the calculation are:

- Design external temperature

- For each room heated by radiators:
  - Design internal temperature
  - Heat loss power (W)
  - Rated output of radiators at ΔT 50°C
  - Oversize factor (ΔT correction)
- For each room heated by underfloor heating
  - Design internal temperature
  - Specific heat loss power (W/m^2)
  - Underfloor heating type (Screed / Alu. Panel)
  - Floor covering (Tile / Wood / Carpet)
  - Pipe spacing band
- Temperature of water leaving heat pump at peak design conditions (Flow temperature)
- Heat pump energy star rating
- SPF of the heat pump calculated using BRE's DAHPSE tool covered in section 3.9

10.2 Green Homes Grant

This is a voucher scheme covering 2/3 of the cost of certain home improvements. The maximum government contribution is £5000.

If you, or someone in your household, qualify for certain benefits you may be eligible for a voucher covering 100% of the cost up to £10,000. This is administered through local councils.

The grant covers:

- primary measures
  - Insulation (roof, walls, floor)
  - Low carbon heat
- Secondary measures
  - Windows and doors
  - Heating Controls and insulation

You must install at least one primary measure.

You cannot apply for if:

- You have received a grant under ECO for the same measure
- You receive a grant under the local authority delivery scheme

All work must be completed by a Trustmark registered trader, and must meet PAS2030 and MCS standards.

For more information see:

https://www.gov.uk/guidance/apply-for-the-green-homes-grant-scheme

NOTE that using the Green Homes Grant to finance a heat pump means that the amount of the grant will be deducted from the DRHI payments you would receive, so it might make more sense to use the Grant for other heat saving measures.

10.3 Clean Heat Grant

The government ran a consultation on a replacement for RHI between April and July 2020, so the exact measures to be introduced are not finalised.

Details of the consultation are here:

https://www.gov.uk/government/consultations/future-support-for-low-carbon-heat

One of the proposals is a clean heat grant, which will support heat pumps through an upfront capital grant to overcome the barrier of upfront cost.

10.4 Energy Company Obligation (ECO)

Medium and larger energy suppliers are obligated to fund energy efficiency measures. Those eligible include:

- Core group customers of the Warm Homes Discount scheme (fuel-poor pensioners)
- Those in receipt of certain benefits

The scheme is administered by local organisations such as TDC.

For more information see:

https://www.ofgem.gov.uk/environmental-programmes/eco/support-improving-your-home

It is unlikely that funding would be available to an individual for a heat pump under ECO.

10.5 Local Authority Delivery scheme (LADS)

£500 million of the Green Homes Grant scheme is being administered by local authorities under the LADS. It is up to local authorities to bid for funds under this scheme.

This scheme aims to improve the homes of low income and low energy performance homes (EPC G,F,E)

This scheme is phased:

- Phase 1a must be completed by March 2021
- Phase 1b must be completed by September 2021, and also covers EPC D

Devon County Council (as lead) put a consortium bid on behalf of districts in Devon for funding under phase 1a of this scheme.

See https://www.gov.uk/government/publications/green-homes-grant-local-authority-delivery-successful-local-authorities

Section 11. Effect on the electricity network

Government proposes 600,000 HP installations a year. This will place significant additional demand on the electricity network, particularly if buildings are not suitable.

The following rough theoretical calculation shows that this could reasonably be achieved with reasonable increases in network capacity.

Average UK gas consumption is 13.5MWh per household. If this were to be replaced by a heat pump with SPF of 3, then that translates to electricity consumption of 4.5MWh per household. 600,000 heat pumps a year means an increase in electricity use of 2.7TWh per year, roughly 1% of UK electricity consumption. This will mainly be in winter months.

If the main heating season is assumed to be 100 days and each heat pump runs continuously, then that is a load of 1.875kW per heat pump, or 1.125GW from new heat pumps. This means that the electricity network capacity has to grow at 1.125GW annually for this to be feasible. If all heat pump use was a bit concentrated. In practice it will be worse because heat pumps don't run 24 hours a day and all days aren't the same, suppose we increase the peak load by 3 times to allow for that, then the increase would be about 3.4GW annually.

The current capacity is about 75GW, this in itself might not be a problem, but there will be other demands on the electricity network as we decarbonise. These will have to be planned for.

---

[i] Oak house construction 10/4/2011

[ii] Mitsubishi FTC2 Installation manual

[iii] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700572/Hybrid_heat_pumps_Final_report-.pdf

[iv] https://www.buildingservicesindex.co.uk/entry/136540/AEL-Heating-Solutions-Ltd/How-to-calculate-the-delta-T-for-a-radiator/

[v] MLS Mirai Air – Water heat pumps https://www.miralsrl.it/wp-content/uploads/2018/05/0dts000240em_00-mls.pdf

[vi] ECODAN PUHZ-HW140V/YHA2(BS) http://www.mitsubishitech.co.uk/Data/Ecodan/Air/Monoblock/Outdoor/PUHZ-W/2015/PUHZ-(H)W-VHA2(YHA2)_Databook.pdf

[vii] https://www.bregroup.com/heatpumpefficiency/background

[viii] https://mcscertified.com/product-directory/

[ix] https://mcscertified.com/wp-content/uploads/2019/08/MCS-Heat-Pump-Calculator.xlsm