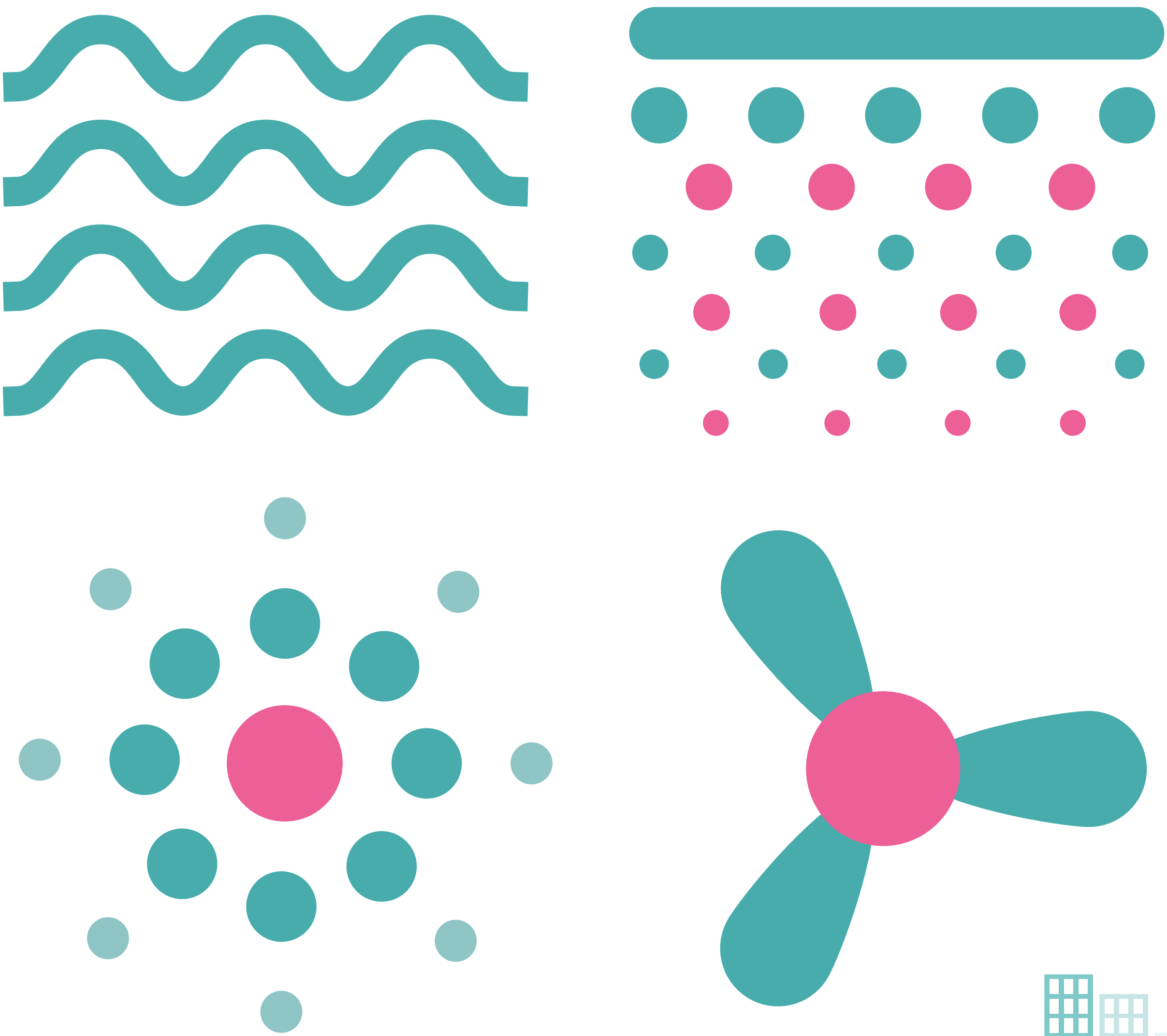
Department for Energy Security & Net Zero

Cabinet Office

Government Property Function

CATAPULT Energy Systems

Heat Pumps: Which one is right for your site and what else to consider alongside



Public Sector Decarbonisation Guidance

Disclaimer:

Contents

What is the purpose of this guide?

As part of a programme funded by the Department for Energy Security & Net Zero (DESNZ), the Energy Systems Catapult has produced guidance for the public sector to support them to decarbonise their built estate, with a particular focus on taking a whole building approach to decarbonising heat. These guides give an overview of all the activities required to successfully develop and deliver a decarbonisation programme.

This guide has been developed to give guidance on what heat pump types may be appropriate for a particular site or situations. It also provides insight into what complementary technologies and measures should be considered alongside a heat pump installation and some alternative electric heating solutions.

It is structured to provide high level information initially, then enables you to dive down into more detail in the later parts of the guide. References are signposted through the document to allow a reader to explore further detail.

This guide cannot possibly cover everything but, if there are areas where you as a reader are interested in finding out more, please contact us. We welcome your feedback on these resources, please email the Energy Systems Catapult at PSDecarbGuidance@es.catapult.org.uk

Why are heat pumps important for decarbonisation?

Heat pumps are an efficient way of providing heat that only uses electricity. Because electricity can be generated from renewable sources, heat pumps can provide heat without generating any carbon emissions.

Although, the electricity grid is not yet fully decarbonised, it will be over time[1]. More significantly, due to heat pump efficiencies and electricity carbon intensity, heat pumps already out perform gas boilers in terms of energy use, that is, for every unit of energy you put in, you get more heat out of a heat pump compared with a traditional gas boiler.

For some organisations it may currently be possible to power heat pumps from totally renewable sources for example on-site renewable generation or via certain Power Purchase Agreement (PPA) types, leading to an immediate and significant reduction in carbon emissions.

Heat pumps can be used for space/ central heating and domestic like hot water requirements but might not be suitable for every type of heat needed by an organisation. This guide focuses on large-scale heat pumps, whether they be for a campus style multi-building system or for a single larger building. This is because there is more publicly available guidance on single-building domestic scale heat pumps.

[1] https://www.gov.uk/government/news/plans-unveiled-to-decarbonise-uk-power-system-by-2035 (accessed 15/01/2024)

Where to use which heat pump?

This guide also gives you an idea of the complementary technologies which could be installed alongside heat pumps, to optimise the site's overall energy system. Use this first section to get an understanding of which type of heat pumps might suit your situation by using our **decision tree** and **site overview**:

DECISION TREE: that prompts you with questions around site requirements, opportunities and constraints to lead to technologies or measures to be considered.

SITE OVERVIEW: that from a birds-eye view of a sample site gives you a visual idea of how to identify potential requirements, opportunities and constraints.

Decision tree

Use this decision tree by starting at the Start arrow with "Are you heating an existing building?" and answering the questions it will give you a view of the types of systems which could be suitable for your site. Click on the technology blocks to take you to the relevant sections for more details.

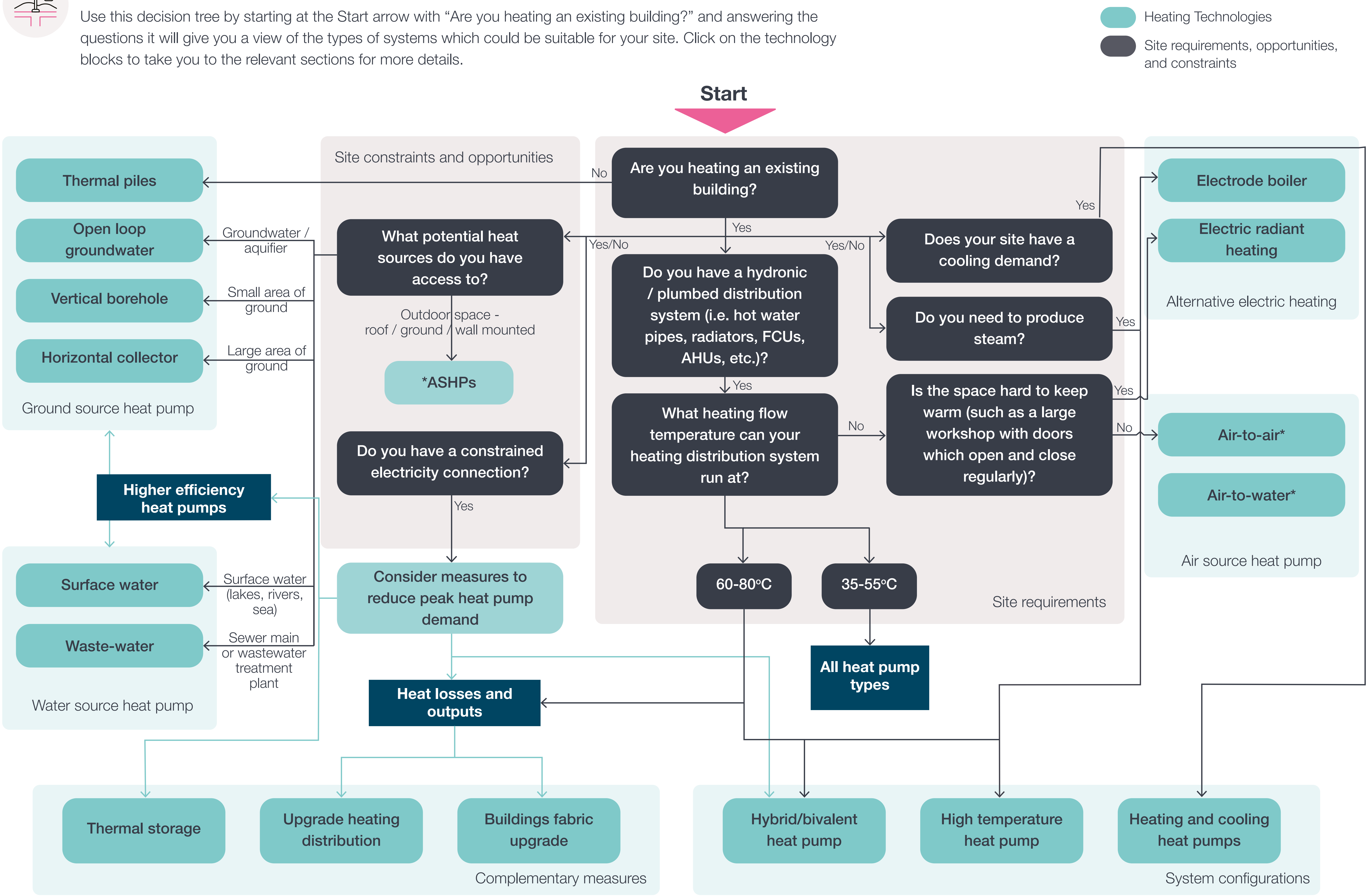


Figure 1 Decision tree to help guide users to solutions to be considered based on-site constraints, opportunities and requirements.

Site overview

This site view lays out the different things to look for which will help make decisions about which heating systems could be most appropriate as well as what might be installed with it.

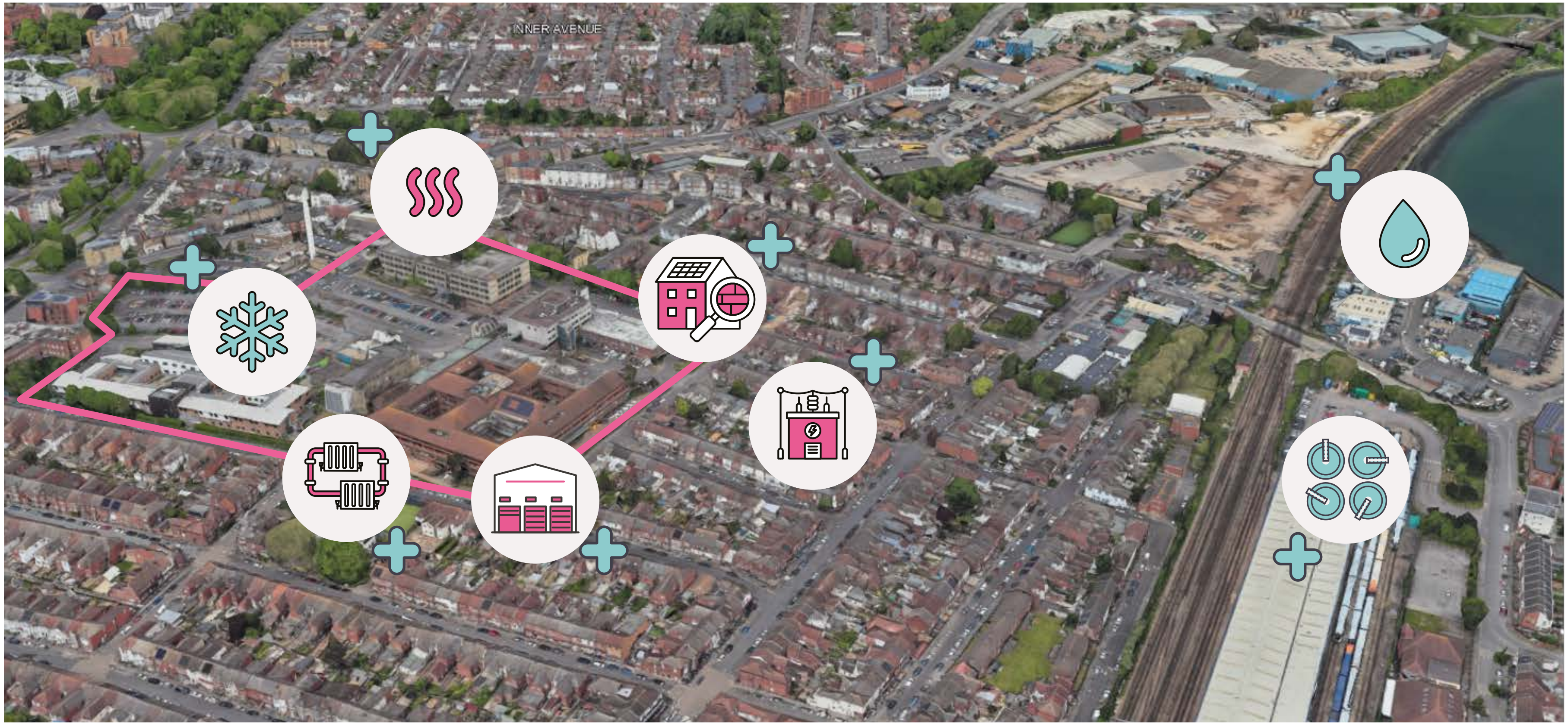


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Figure 2 Site requirements, opportunities and constraints (image of a hospital taken from Google Earth)

Heat pump types

This section explains the different types of heat pump available on the market and their applicability to different situations.

The concept

The concept of a heat pump is relatively simple. It takes low grade heat from a source such as the air, the ground, water, or even sewage and is able to (by adding some energy) turn it into higher-grade heat. It can provide this higher-grade heat by producing hot water (in what is called a hydronic system) or warm air. The Guardian have a really clear **visualised explanation** for further detail on how heat pumps do this. Figure 3 gives a view of the different types of heat pump. Heat pumps, unlike traditional gas boilers, often produce lower temperature outputs as shown in the diagram below. This means that there can be compatibility issue with an existing heating system, requiring extra work to make the heat pump viable.

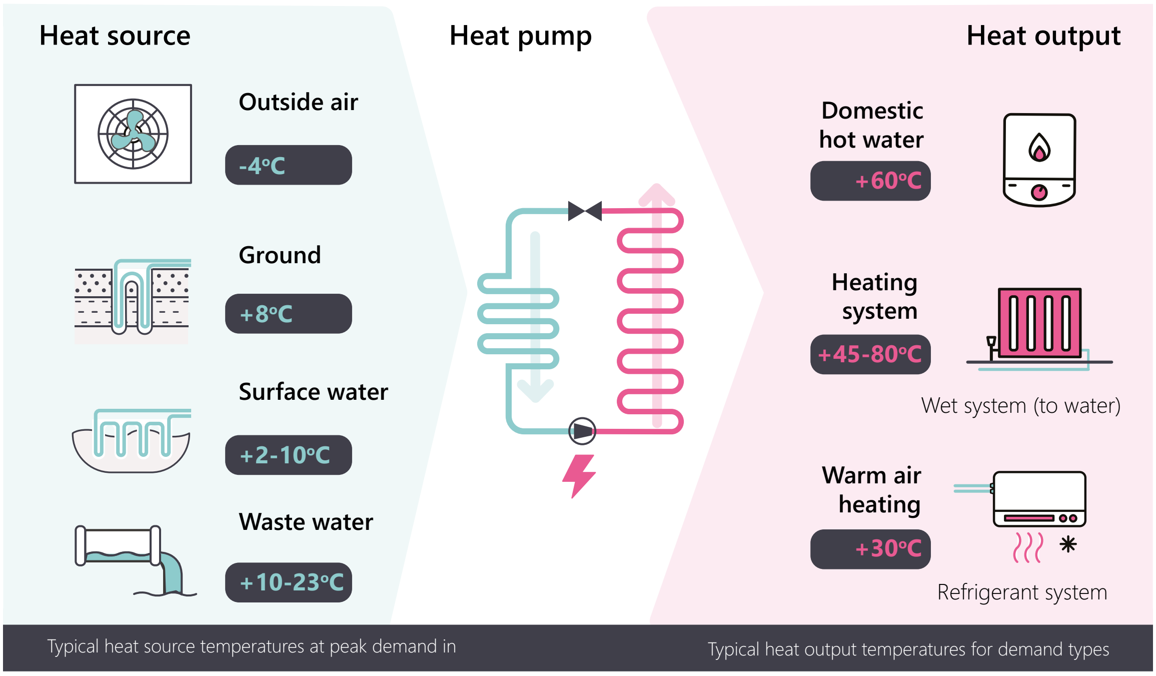

Figure 3. Typical temperatures for possible heat pump sources and required output temperatures[2,3] wet heating systems could include air handling units, fan coil units and other forms of heat emitter.

[2] **CIBSE AM17:2022** Heat pump installation for large non-domestic buildings (May 2022)
[3] Water source temperatures will vary significantly depending on the specific body of water in use. This range has been taken from case studies covering sea, river and canal captured in **CIBSE CP2 SWSHP CoP:2016** Surface water source heat pumps: Code of Practice for the UK

Decision tree
Site overview

Terminology

Systems are often explained by referring to where the heat is going from and to for example, air to air, air to water, water to water. There are also terms such as Air Source Heat Pump (ASHP which could be air-to-air or air-to-water) or Ground Source Heat Pump (GSHP) or Water Source Heat Pump (WSHP). When discussing options its worthwhile being clear on what you are discussing and ensure that the same terminology is being used by all.

The maths

When comparing options, understanding the efficiency of a system will help to know which one will potentially lead to lower energy bills. The heating efficiency of any heat pump is expressed through a Coefficient Of Performance (COP) and the cooling efficiency is expressed through an Energy Efficiency Ratio (EER). When a system performs simultaneous heating and cooling, this is expressed through a Total Efficiency Ratio (TER) where:

Typically, the closer the heat source temperature is to the heat output (what needs heating) the better the efficiency. For example, it will be more efficient for a heat pump to heat a room to 20°C if it is 8°C outside (where the air outside is the heat source) than if it was 0 degrees outside.

The efficiency number which gives the best view of how the heat pump will perform on a particular site is the Seasonal Coefficient of Performance (SCOP). This takes into account local weather conditions and how this affects the efficiency across the year.

From this you can see that the efficiency of the system is very much dependent on the heat requirement. The more heat required the more energy (electricity) is needed to produce the output. Therefore, the efficiency of any system is optimised by operating at a temperature closer to the heat source. For a heating system this would be lower heating water temperatures and for a heating system this would be higher cooling water temperatures.

$$\text{COP} = \frac{\textit{Heat Energy Transferred into Building}}{\textit{Electricity Supplied to Heat Pump}}$$

$$\text{EER} = \frac{\textit{Cooling Energy Transferred into Building}}{\textit{Electricity Supplied to Heat Pump}}$$

$$\text{TER} = \frac{\textit{Heating and Cooling Transferred into Building}}{\textit{Electricity Supplied to Heat Pump}}$$

Decision tree
Site overview

More detail on the different types of heat pump

The following sections provide more detail on each type of heat pump. Use this to click through to go straight to the one you are interested in:

Decision tree

Site overview

Air source heat pump

Air source heat pumps (ASHP) are the most commonly deployed heat pumps, and they fall into two broad categories, air-to-water systems and air-to-air systems.

The difference between these two common types is that if you had a wet heating system operating in your building (i.e. pipes and radiators with water running through them) you could connect the air-to-water heat pump direct to that system, whereas the air-to-air heat pump would provide you with an air output that could be used in an air conditioning system.

They both typically use a refrigerant circuit to move heat from outside a building to its inside, or vice versa when in cooling mode.

Decision tree
Site overview

Air-to-water

These are typically what are referred to when people talk about ASHPs. The units come with pre-charged refrigerant circuits which can connect into a wet heating distribution system within a building. These units can deliver hot water at flow temperatures of up to 55°C, referred to as low temperature heat pumps, with high temperature heat pumps able to achieve flow temperatures 80°C or higher. Typically, the lower the operating (flow) temperature the more effective the system and higher the COP.

If you had a system which was currently operating at a higher temperature like the traditional low temperature hot water system circulation of 82-71°C or even a medium temperature system, then you will need to think carefully about which system is most suitable for you (see section on **High temperature heat pumps**).

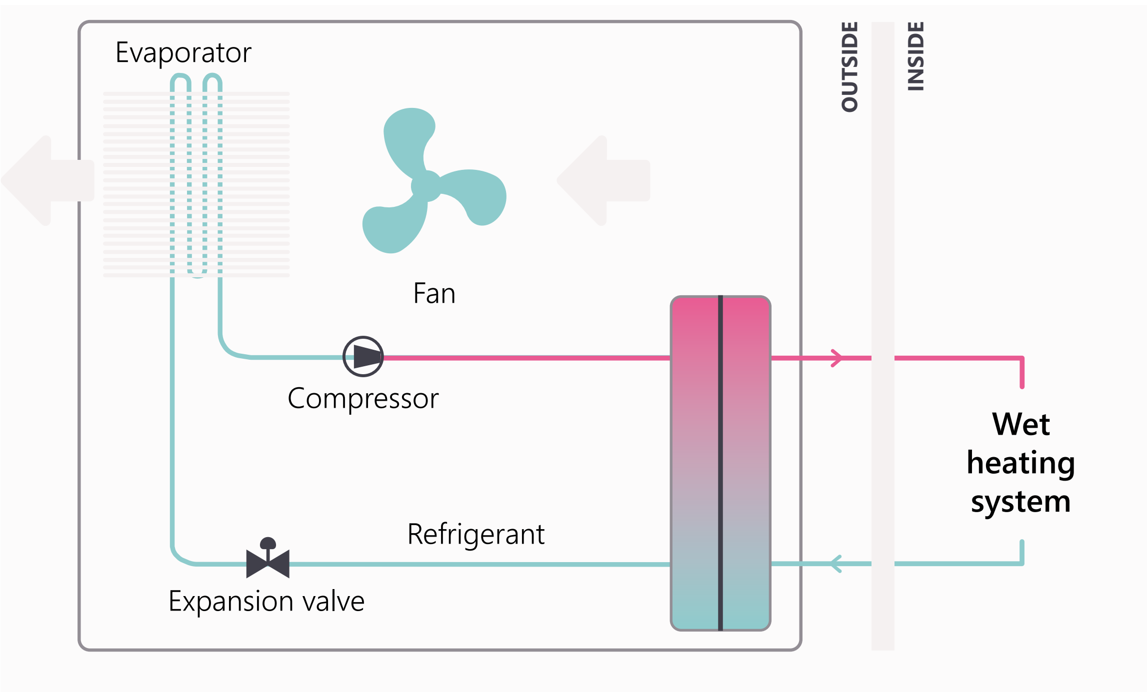

Figure 4 Air-to-water heat pump diagram

Decision tree
Site overview

Air-to-air

These systems exchange heat directly between the air inside and outside of a building. Therefore, as a part of these systems you would require an external unit, a refrigerant pipework distribution system and internal/terminal units within conditioned spaces. Types of air-to-air heat pumps include:

- **Direct Expansion (DX) systems – split and multi-split:** these are generally used for comfort or equipment cooling but can be run in reverse to provide heating.
- **Variable Refrigerant Flow/Volume (VRF/VRV) systems:** these work similarly to DX systems. However, they also provide the capability to recover heat around the building between internal units when there are simultaneous heating and cooling demands, thereby increasing the system's overall efficiency.

Both of these systems are very adaptable and can be installed almost anywhere. They can be installed relatively rapidly compared to ground source technologies and are also cheaper to purchase (though there may be a cost increase to a like for like replacement of a fossil fuel heat sourced VRF system) and therefore are often chosen as the preferred solution to ground source.

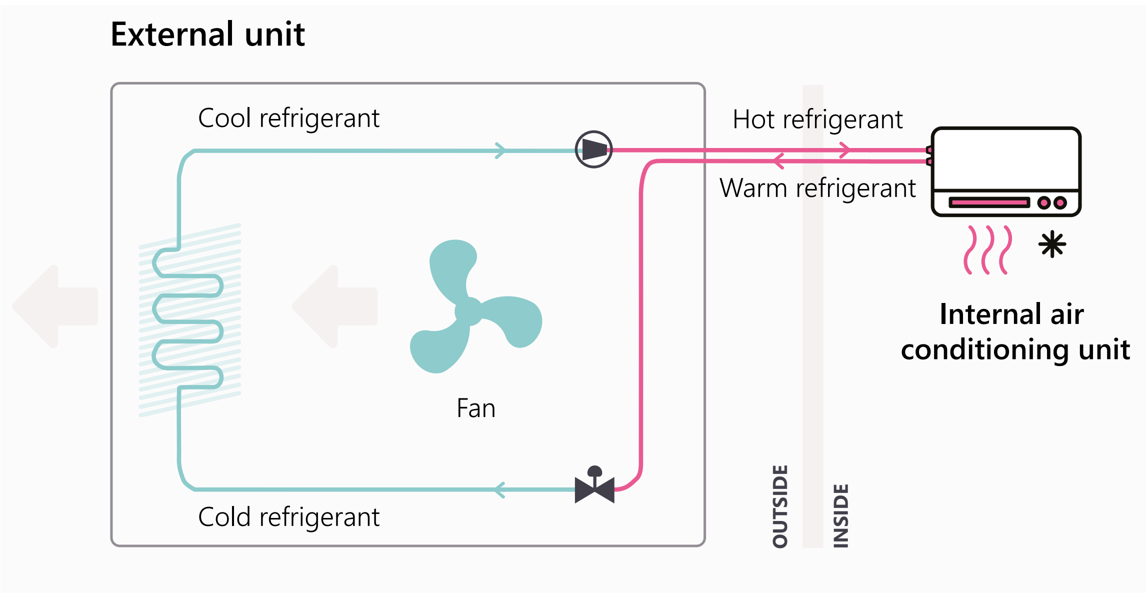

Figure 5 Air-to-air heat pump diagram

Decision tree
Site overview

Ground source heat pump

Ground source heat pumps benefit from more stable temperatures offered by the thermal mass of the ground. Below the depth of 10m ground temperatures remain effectively constant across the year at approximately the average of local air temperature across the year (between 10 and 14ºC in the UK depending on local geology and soil conditions). Additionally, GSHPs can store heating and cooling energy between seasons (this explored further in the Heating and cooling heat pumps section) further improving efficiencies.

As with air source, there are different configurations of ground source heat pumps falling under the categories of open loop or closed loop systems. Both require specialist input to understand the feasibility of the technology and to produce a suitable design on any site.

Closed loop

Closed loop systems, unlike open loop, do not exchange water with water in the ground. Instead, they rely on conduction from the ground through the pipes into the circulating fluid within the heat exchangers. There are two ways in which they can be installed.

Horizontal collectors

Horizontal collectors involve running a ground heat exchanger loop in trenches at a depth of 0.8 - 2.0m. It is relatively cheap to install but requires a large area (typically 10-40 W/m^2 of heat output[4]) of boulder-free soil which cannot be built over.

There is a risk of frost heave if the collectors are undersized. Frost heave is the upwards swelling of certain soil types during freezing conditions which could disturb and damage the collectors.

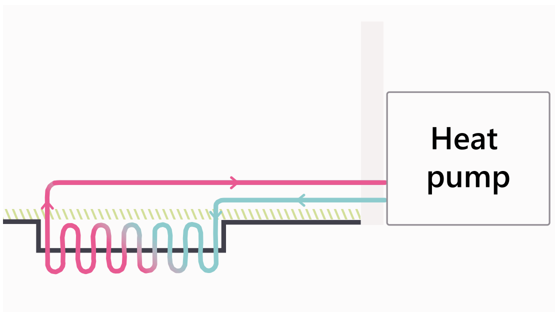

Figure 6 Horizontal collector ground source heat pump diagram

[4] CIBSE TM51: 2013 Ground Source Heat Pumps (February 2013)

Decision tree
Site overview

Horizontal collectors are cheaper to install than vertical boreholes, but the limiting factor is the amount of space that is required to achieve the required heat output. They are also very disruptive for the space and biodiversity. As a result, they are often not used for large developments.

Vertical boreholes

Vertical array heat exchangers, also known as vertical boreholes, are typically made of one or two U-tubes containing a circulation fluid which extend in a hole drilled between 50 to 200m deep[5]. Vertical boreholes require specialist design to determine feasibility and then install.

Boreholes deeper than 200m are considered ‘geothermal’ rather than a GSHP, though they follow the same principals and mean that you may be able to access higher grade heat.

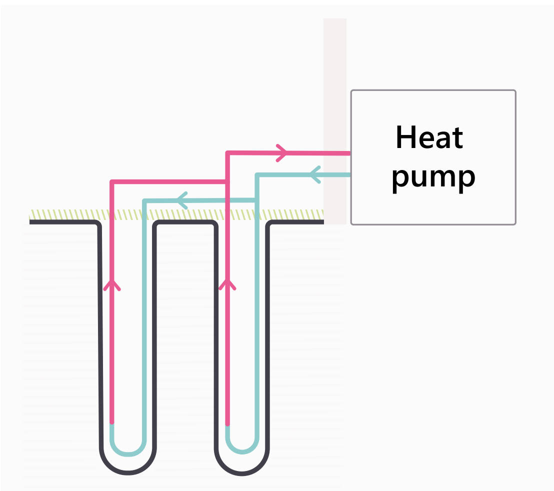

Figure 7 Vertical borehole ground source heat pump diagram

[5] CIBSE TM51: 2013 Ground Source Heat pumps (February 2013)

Often a test bore has to be drilled on site to establish the depth of borehole that is going to be required. This is because the specific geology of the location will impact on the actual depth required to provide the necessary heat. Once completed the test bore could be used as part of the main installation if it goes ahead.

Typically, for any installation more than one bore is drilled. A thermal response test (TRT) is used to assess the ground conditions of a borehole. A pulse of heat is injected into a closed loop borehole heat exchanger. By measuring key parameters, such as incoming and outgoing temperature and flowrate of the heat carrying fluid, the requirements for the installation can be established.

Thermal piles

Thermal piles are a particular type of vertical borehole which use the building’s substructure as a heat exchanger with the ground. Plastic pipes are connected to the steel reinforcement cage which is lowered into the hole prepared for the building structure and thermally enhanced concrete poured into the cage.

The benefit of this system is that it is typically less expensive than a vertical borehole system as the costs for drilling out the holes are already accounted for in the structure of the building. This is however, limited to new builds and if the heating and/or cooling capacity for thermal piles is insufficient to cover the building’s demands, additional collectors may be required.

Decision tree

Site overview

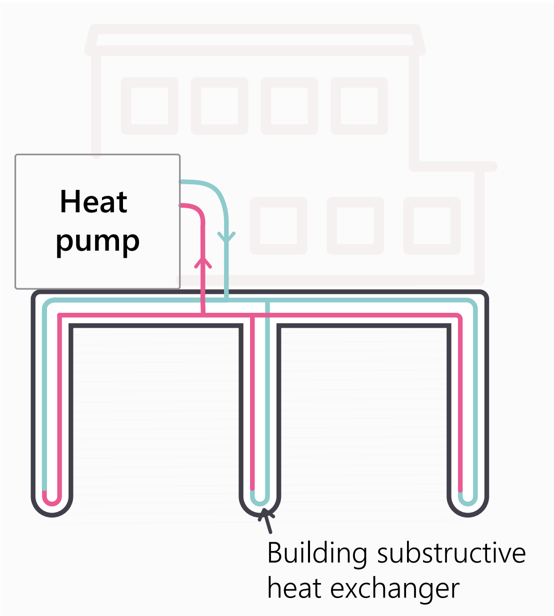

Figure 8 Thermal pile ground source heat pump diagram

Care should be taken in the design of the heat pump so that heating and cooling extracted from the ground establishes a sustainable temperature between the ground close to the pile and the ground further away. Reaching this stable temperature gradient can take several years. If it is not reached, this suggests that the heat is flowing to or away from the collector. This could affect the efficiency of the heat pump as the ground around the heat collector becomes cooler. In extreme cases this can result in destabilising the building structure. Operating heat pumps to deliver heating and cooling can help to balance this temperature drift (see **Heating and cooling heat pumps section** for more information).

Open loop groundwater

Open loop systems abstract (use) groundwater, passing it through a heat exchanger or directly through a heat pump.

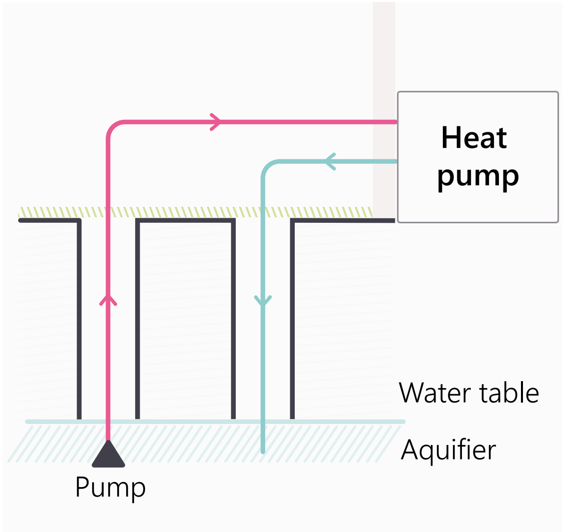

Figure 9 Open loop ground water heat pump diagram

Open loop systems can typically benefit from a lower installation cost due to the reduced size and complexity of the ground heat exchange system. This is because an open loop system directly extracts water from an aquifer whereas a closed loop system relies on, and is limited by, the conduction of heat through to the loops within the ground, therefore requiring a more significant ground heat exchange system.

However, open loop systems require investigations to ascertain feasible access to groundwater as well as environmental permits. These are detailed in **Figure 10**. As a result, open loop systems can take longer than other types of GSHP to install.

Decision tree
Site overview

Environmental permits for groundwater source heat pumps

Open loop heating or cooling schemes may require environmental permits Including, but not limited to:

- Groundwater investigation consent,
- Abstraction licence: for abstractions > $20m^3$/day.
- Discharge permit
- Flood risk activity permit

Under the Water Resources Act 1991 the British Geological Survey (BGS) needs to be notified of boreholes of depth >15m used for water abstraction (open loop).

Groundwater closed loop systems do not require environmental permits.

Figure 10 Environmental permits for open loop groundwater source heat pumps

Decision tree
Site overview

Water source heat pump

Water source heat pumps (WSHP) work on the same principle as GSHPs; however, they use water as a heat source or sink. Similarly, these can be open or closed loop systems.

Surface water

Surface water heat pumps work with local bodies of water (river, lake, sea, canal).

These systems require an understanding of the flow and temperature of the body of water, for example, the underwater terrain can be mapped using a bathymetric survey.

Approvals are needed for implementing a water source heat pump (particularly for open source). These may extend the timescales required to deliver such a scheme. See **Figure 12** for more detail on such approvals, the Environment Agency has more details[6, 7].

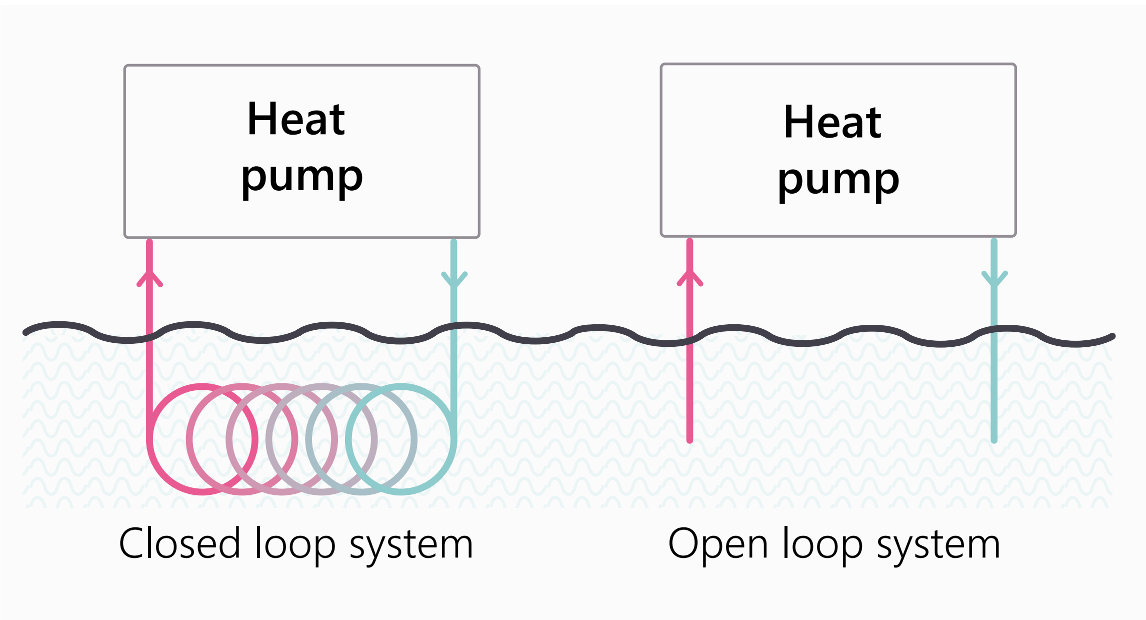

Figure 11 Open and closed loop surface water source heat pump diagram

Decision tree
Site overview

[6] https://www.gov.uk/government/organisations/environment-agency

[7] https://mail.gshp.org.uk/pdf/EA_GSHC_Good_Practice_Guide.pdf

Approvals required for open loop surface water source heat pumps

Open loop heating or cooling schemes may require environmental permits from the Environment Agency including, but not limited to:

- Abstraction licence: for abstractions > $20m^3$/day
- Discharge permit
- Flood risk activity permit

Approvals may also be required from:

- Landowners (if the water body is not on site and pipes need to cross through others' properties)
- Navigation authority if body of water is a navigable waterway (canal, river, port, etc.)

Figure 12 Possible approvals and agreements required for an open loop surface water source heat pump from the Environment Agency, landowners and navigation authority.

Decision tree

Site overview

Waste-water

Waste-water source heat pumps (WWSHP) recover heat from wastewater (sewage as well as industrial process water) using a heat pump. This solution can be employed in different contexts and along different parts of the wastewater treatment process.

Location of heat extraction	Approximate Temperature Range[8]	Considerations
Industrial	**60+ °C**	• High temperature water allowing high efficiencies of heat pump, • Depends on locality of industrial demand, • This could include wastewater from hospital sterilisation equipment.
On-site Building Drainage	**23 °C**	• No water company involvement, • Close to heat demand, • Relatively high temperature water and therefore CoP, • Unlikely to cover all of heat demand (~50% domestic hot water, ~15-30 space heating[9]) • Most pre-treatment required.
Sewer Main	**11-14 °C**	• Water company involvement required, • Less pre-treatment required due to mixing with rainwater run-off, • Still close to site, • But may also require crossing roads involving more stakeholders.
Wastewater Treatment Plant	**10-12 °C**	• Very little pre-treatment required, • Lowest temperature before returning to waterways, • Requires site to be in close proximity to a wastewater treatment plant.

[8] https://www.youtube.com/watch?v=B_pRlHrdR0I CIBSE: Waste Water Heat Recovery Technology Webinar (accessed 14/12/2023)
[9] https://www.youtube.com/watch?v=DKtSj3QAAEU CIBSE HNCE: Wastewater Heat Recovery Webinar (accessed 14/12/2023)

Decision tree
Site overview

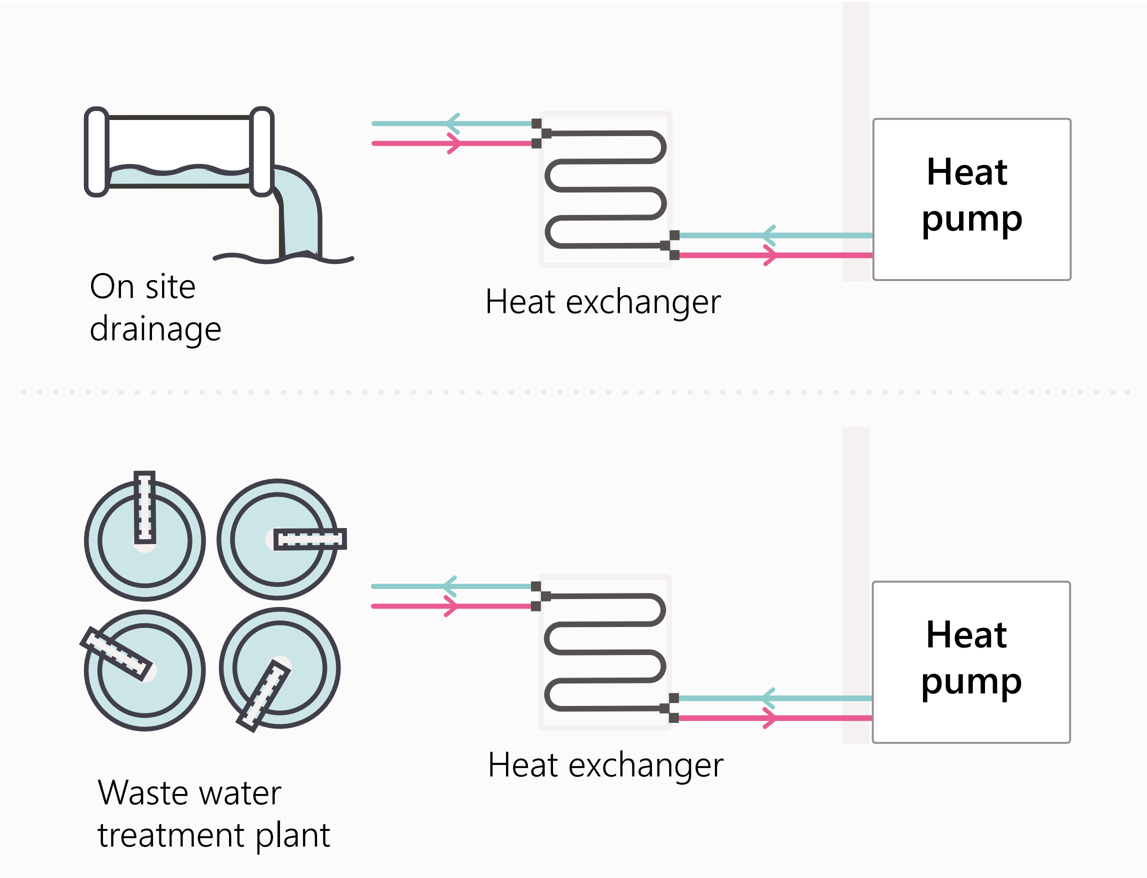

Figure 13 Wastewater heat pump diagram

Although not yet widely adopted in the UK, there are many wastewater heat pump schemes deployed across mainland Europe, in particular in Germany.

Case studies in the UK include:

- **Borders College** 800kW heat pump intercepting heat from a sewer main to deliver 1.9 GWh/yr. Heat at a COP of 4.8[10].
- **Aqualibrium Leisure Centre** 750kW heat pump recovering wastewater heat from Scottish Water's Kinloch Park Pumping Station[11].
- **Stirling Council** partnering with **Scottish Water** to extract heat from a wastewater treatment works and feed homes across the council district heat network[12].

[10] https://heatpumpingtechnologies.org/annex47/wp-content/uploads/sites/54/2019/07/borders-college.pdf (accessed 14/12/2023)

[11] https://www.waterindustryjournal.co.uk/innovative-leisure-centre-heat-project-to-make-a-splash (accessed 14/12/2023)

[12] https://heatsource.org/case-studies/stirling-district-heat-network (accessed 14/12/2023)

Decision tree
Site overview

Agreements and investigations required for wastewater source heat pumps

Data from the wastewater source will need to be collected to establish feasibility and heat capacity available. Properties such as water flow, depth and temperature will need to be measured across the seasons.

Upfront engagement and agreements with the water company should be put in place to establish a good working relationship.

This should consider technical aspects such as:

- Sewer connection design
- Maintenance

Commercial arrangements looking at how the value of the project will be shared across stakeholders considering options and aspects such as:

- Connection fee
- Heat generation fees
- Carbon reporting

Figure 14 Agreements and investigations required for wastewater source heat pumps[13]

Decision tree

Site overview

[13] https://www.youtube.com/watch?v=DKtSj3QAAEU CIBSE HNCE: Wastewater Heat Recovery Webinar (accessed 14/12/2023)

Thermally driven heat pump

Another less known type of heat pump are thermally driven heat pumps, which work in a similar way to the heat pumps described above but are powered using heat rather than electricity.

These heat sources could include:

- Natural gas
- Propane
- Solar hot water
- Geothermal hot water
- Waste process heat from industry
- Possible future options could include green hydrogen or bio-methane.

It is worth noting that several of these options only offer partial decarbonisation. Others would require you to have a site which is in proximity to reliable geothermal or waste heat.

The recent National Infrastructure Commission report also suggested that hydrogen should not be considered as an option for building heating. Therefore, the instances where these types of solutions should be considered carefully.

The most common heat source used is natural gas, so they are also referred to as gas-fired heat pumps.

The two main types of thermally driven heat pumps work on similar principles but are distinguished by:

- **Absorption heat pump:** these use an absorption cycle (into a fluid) to provide heating and cooling.
- **Adsorption heat pump:** these use an adsorption cycle (onto a solid surface) to provide heating and cooling.

Decision tree
Site overview

Heat pump selection considerations

You may find that a number of different types of heat pumps are technically suitable for your estate and can't quite settle on the most appropriate. Here are some of the other considerations which may help you consider which system might be optimal.

The tables cover considerations for installation and operation, both of which are important and then leads onto sections with additional detail.

Considerations for installation:

Factor	Consideration	Suitability
Disruption to the surrounding area	When selecting a type of heat pump, it is important to consider what the installation process will involve.	If a horizontal GSHP is chosen will there need to be large amounts of land equipment on site and that could be very disruptive to the site and local community. There might also be difficulties in accessing the site. Similar disruption may occur for a bore drill. It is worth considering noise disruption as well. For any installation you will need to think about any disruption caused to normal operational access for those using the buildings. If an ASHP to be placed on the roof, is there lifting equipment already positioned on the roof or will a crane be required?
Disruption to heat or cooling provision	Making sure that there is minimal disruption to occupants. This is no different to a normal plant replacement.	Typically heat plant replacements are carried out when not in the heating season. This would also apply to a heat pump installation. If cooling is required or air changes (ASHP), then a similar consideration should be made about the best time to do the installation to avoid disruption.
Sizing of plant	There are different options on how you size your heat pump to match your heat load.	There are several factors which could influence how you would size your heat pump. This would influence the cost of buying and installing the heat pump and potentially how you would operate the rest of the building. See more in Sizing of wet system heating plant

Factor	Consideration	Suitability
Speed and ease of installation	When installing the heat plant what is the optimum time period? Consider if there will be a long time period without heat?	It is possible that installing a heat pump will take longer as there may be the need to install ground source or water source pipework. There may also need to be more changes to the pipework configuration with the plantroom. There may also need to be new or upgraded controls or BMS installed.
Supply chain availability	Making sure that any plant or equipment is on order early in any installation is really important.	Particularly with Public Sector Decarbonisation Scheme (PSDS) grants, or other budgets that require spend within specific time periods, it's really important to make sure that any equipment is ordered and confirmed delivery dates received before commencing on any project. For some equipment it will be easier, standard product units like ASHPs, are likely to be available, however bespoke sizeable heat pumps delivery timelines should be confirmed with manufacturers.
Network capacity constraint concerns	Moving from fossil fuels to electricity driven heating systems are likely to demand additional capacity.	Being able to move to a heat pump which is electrically fed is dependent upon the capacity being available within your own electrical system and the local network. Early on in any project development it is essential to make sure that there is sufficient capacity to enable the connection to go ahead. If there isn't there may be a need to reinforcement, which could be costly. Alternatively implementing energy efficiency measures to manage electrical demand and reduce down this capacity need does make sense. See more in **Building fabric** section on how to approach this.
Cost	The capital cost for the different heat pumps is likely to vary.	As ASHPs are standalone units and do not require the installation of pipework either into the ground or a water source, they tend to be cheaper. They are also typically more standardised in size. It should be noted that this is the opposite when it comes to operational costs, so there is a counter balance between cost for installation and operational cost to consider.

Considerations for operation:

Factor	Consideration	Suitability
Heat temperature	The temperature of the heat is probably the most important element to consider. Understanding your internal temperature and if a wet system exists the requirements for that will help define the suitability of the different systems.	Being able to connect a heat pump to your existing heating system efficiently and provide the right level of heat is paramount to the success of any project. Making sure that the heat output is suitable is essential.
Existing system type	The type of heat generated (i.e. water or air) chosen is likely to be influenced by the system that is currently in place, as for retrofit there can be a substantial (financial and disruption) advantage in retaining the existing heating system (if it is in a good condition).	For example, if the building has an air conditioning system, then a replacement system which provides heating and cooling via air, i.e. replacing with a heat pump which integrates with this system, minimising retrofit requirement, would make sense. If there is a wet heating system, it is sensible to consider a system which is able to connect onto the existing circulation system.
Delivery of heat	It is worth understanding how heat pumps operate and the heat that they provide and how that matches the building, its occupancy patterns and operational needs.	Dependent upon the type of heat pump and the way in which it delivers heat to a building there will be differences in how quickly the internal temperature can be changed. ASHP, particularly Air-to-Air tend to be able to be more reactive to requests to change temperature, whereas GSHP's (particularly those operating at lower temperatures and dependent upon the type of emitter) are slower to react to requirement changes. See more in section on **Delivery of heat**.

Factor	Consideration	Suitability
Location and space requirements	One influencing factor may be the space requirement for the heat pump and where it can be located. For example, if in an urban environment then space may be limited, or plant equipment may need to be on a roof, however for some systems and refrigerants a separate boiler house may have advantages. See more in **Space requirements** section.	ASHPs are often suitable for an urban site where space is limited as they can be located on a roof or even wall mounted, (though noise levels need to be understood). It may be possible if there is a car park to install a bore hole, but it's unlikely to be able to accommodate horizontal GSHPs. WSHPs need to be close to a water source. Understanding the geology and the availability of an underground water source will help determine the potential viability of a ground source scheme.
Noise	Heat pumps make some noise, though not a huge amount.	Check out the noise levels of the product you are thinking about purchasing and consider if it might be worthwhile locating them away from areas of noise sensitivity, such as places of worship, recording studios or high-density occupancy.
Security	Heat pumps tend have some external parts.	Consider the location of the heat pump and if any protection is required to manage damage.
Equipment life	The lifespan of the different pieces of equipment that make up a heating system vary. It is worthwhile considering the age and lifespan of the different components and when you will need to replace them. For example, in a wet heating system a boiler may require replacing every 15-20 years. However, the heating network (pipes) and emitters (radiators) are expected to last a lot longer. The same variations apply to heat pumps.	A heat pump itself has an average lifespan of 20-25 years[14]. However, the lifetime of a ground source or water source loop is likely to be much longer. Heat network pipework is given an average lifetime of 50 years; however, we haven't had 50 years of the plastic pipework to test out if it will last longer. The heat network and building's lifetime are also worth considering, similar to considering the heat temperature and circulation needs.

[14] https://www.salixfinance.co.uk/schemesphase-3c-public-sector-decarbonisation-scheme/phase-3c-public-sector-decarbonisation-scheme (accessed 08/02/2024)

Factor	Consideration	Suitability
Operational maintenance	Maintenance of the equipment will vary dependent upon the type of installation. Overall heat pumps are likely to require similar amounts of maintenance to fossil fuel systems but different skills. It is important to consider who will be responsible for the heat pump installation and be confident that they have the right skills to operate the heat pump and carry out basic maintenance. It is likely that training will be required for anyone who has not operated a heat pump before and this should be factored in to your plan.	It is really important to make sure that the right supply chain is place to provide the right specialist maintenance on your equipment. Making sure that the installer or manufacturer offers a suitable service and will be able to react to any issues, and support planned maintenance is an essential requirement. The person/people who operate the heat pump on a day-to-day basis should make sure they are clear on who and how to contact the installer or manufacturer should any issues occur.
Operational cost	Heat pumps typically operate using electricity as their energy source.	Electricity prices are currently higher than that of fossil fuels. However, the COP of a heat pump means that not as much electricity is likely to be used as the energy typically needed for a boiler. Typically, as the COP is lower of an ASHP than a GSHP its likely that the operating cost will be lower. However, it is all dependent on the level of heat provided. When putting together a business case, estimates of the operational cost will need to be made against a COP for all the options.

The following section provides more detail on some of these considerations.

Heating the building

Traditionally many public sector buildings' heating systems were designed to work with Low Temperature Hot Water (LTHW) which operates at 82°C flow and 71°C return water temperatures. Until recently, this has been the industry standard equating to the old British legacy of 180/160°F. These higher temperatures allow for smaller radiators to be used. As building fabric performance has improved, due to a greater focus on energy use and the introduction of building regulations Approved Document Part L[15] in 1995 and its progressive improvements over the years, lower flow and return temperatures have become used more, particularly in new buildings.

Heat pumps operate most effectively in two different ways. These key differences are:

- The lower the temperature of the flow and return the more efficient the Coefficient of Performance is, typically below 50°C is ideal
- The system is more efficient with a wider flow and return temperature differential, a minimum of 20°C is ideal

Typically, a 50°C flow and 30°C return temperature is suggested as a starting point. It is possible to use higher temperature heat pumps, though the COP will be reduced (dependent upon the control system).

[15] https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l (accessed 15/01/2024)

This means that, when you are considering connecting a heat pump to an existing heating system, it is likely that the same level of heat will not be available to circulate around the system. This can present a challenge. However, it is not as black and white as it seems. Often a heat pump specialist may suggest testing out the operating temperature as the installation is completed, to confirm the actual COP achievable.

This is because there may be more capacity in the heating pipework network and distribution to be able to manage to transport heat and emit it than the originally design. The heating system (designed for a fossil fuel boiler) may well have been oversized for the spaces it serves (see next section on **delivery of heat**). This means that whilst the system is operating at a higher temperature it may well have capacity to deal with lower circulating temperature.

However, a challenge may occur when there is a switch on in cold weather which can be managed by suitable controls.

Traditionally a fossil fuel heating system in a non-domestic building would have optimiser controls for switch on in advance of the building being occupied. It then heats up the space over the time period in advance of the occupants arriving. However, with a heat pump operating at a lower temperature it is not possible to heat up the space as

Decision tree

Site overview

rapidly. Therefore the heat pump is more likely to need to be switched on earlier. This is one of the reasons why improving building fabric thermal performance properties are often recommended before the installation of a heat pump. As it means that the peak load size of the plant can be reduced.

The controls for a heat pump are likely to have different requirements to a traditional gas boiler, and it highlights the need to have good building fabric to retain as much heat as possible. An early start for a heat pump however could offer the potential benefit to low-cost electricity rates overnight to manage energy bills.

Domestic hot water

Domestic hot water (DHW) is the term used for hot water used for in sinks, showers and other applications which aren't space heating. Although the desired temperature of water from a hot water tap might be 30-40°C (i.e. for a shower head), DHW is often produced, stored and distributed at temperatures above 55-60°C. This is to avoid the risk of the DHW system being infected by legionella bacteria.

Legionella bacteria multiply where temperatures are between 20-45°C and nutrients are available. They are dormant below 20°C and do not survive above 60°C.

Current Health and Safety Executive (HSE) guidance therefore suggests that hot water storage cylinders should store water at 60°C and the hot water distributed at 50°C or higher[16]. There are other factors such as design of the pipework so that dead legs are minimised and thermostatic mixing valves are installed as close to point of use as possible. There is debate around this high temperature broad-brush approach of UK legislation[17]. However, with the lower temperature that heat pumps operate at more efficiently, it is important to have a strategy in place to mitigate against the risk of legionella growth. This may include measures such as an anti-legionella cycle boosting the temperature of the hot water storage cylinder to a minimum of 60°C for a limited period whilst running a de-stratification pump to ensure that the temperature of water is even across the whole cylinder.

[16] https://www.hse.gov.uk/healthservices/legionella.htm

[17] https://heatpumpingtechnologies.org/annex46/wp-content/uploads/sites/53/2020/10/hpt-an46-03-task-1-legionella-and-heat-pumps-1.pdf

Decision tree

Site overview

Getting the most out of a heat pump

High temperature hot water

As heat pumps are seen as the most likely way to decarbonise heating in buildings, it is important to be able to deliver higher temperature heat where required.

There are some options for this:

High temperature heat pumps

High temperature heat pumps are capable of producing hot water at high temperature (defined as flow temperatures > 60°C in the context of heat pumps). These can be used in heating systems designed to work with boilers and reduce any distribution upgrades (new/larger radiators, etc) and/or building fabric upgrades (insulation and draught proofing).

Some suppliers offer heat pumps which can achieve temperatures of up to 90°C by using other refrigerants such as propane or ammonia.
To serve industrial demands and steam generation needs some heat pumps have been designed to reach temperatures as high as 180ºC[18]. These are a specialist product and not as widely available as low temperature heat pumps.

[18] https://ammonia21.com/norwegian-researchers-develop-worlds-hottest-heat-pump/ (accessed 14/12/2023)

Decision tree
Site overview

Bivalent heat pump

Hybrid (also referred to as bivalent) heat pumps work with other heating technologies to deliver heat to a site (see section on Sizing of wet system heating plant). There are various reasons why you might choose a hybrid system which typically looks at optimising the lifecycle cost of a system, considering both running and capital costs. This could be installed in context of an overarching decarbonisation pathway. Combinations of technologies could include combining GSHP and/or WSHP with ASHP: a site may have insufficient access to ground or water sources to meet the full site's thermal demands. Therefore, combining this with an ASHP could be a solution to deliver a fully decarbonised heating system. Also, a hybrid system could be employed in order to balance the heating and cooling demand a GSHP system places on the ground.

The two sets of heating equipment in a hybrid system can be designed to work in different modes of operation including:

- **Parallel:** one heat pump takes the lead operating for the majority of the time with another heating equipment (whether it's fossil fuelled or another heat pump) works at the same time as the lead heat pump to top up at periods of high demand.
- **Change-over:** one heat pump takes the lead operating for the majority of the time with another heating equipment (whether it's fossil fuelled or another heat pump) taking over and delivering all of the heat at periods of high demand.

The right balance may be parallel or change-over and be chosen given the specific constraints and requirements of a particular site.

Decision tree
Site overview

Delivery of heat

Heat can be delivered to a building a few different ways. One of the first things to consider is how could a heat pump fit with your existing system. There may be multiple options, you will need to think about which match the existing system best so that operation is optimal.

Initial basic differentiators include is the existing heating provided by air through air conditioning or even a hot air heating system or a more traditional wet heating system. If an air conditioning or hot air system is in place the most likely solution is to replace with an air-to-air ASHP. This is likely to apply to many office spaces. Dependent upon their size and level of air conditioning.

If you have an existing wet system, then there are several things to think about. The first is the distribution or circulation network. The second is the emitters that are currently being used. The age and lifetime of the heating system should be considered too, if your system, or significant parts of it, are at the end of their life a different approach could be taken. However, if the heating system is still operational you are likely to be working with the following types of heat distribution networks and emitters.

Heat distribution systems

There are lots of different combinations of how a flow and return system can be installed, from a simple flow and return single pipe system to a reverse return, and all of these, dependent upon the size of the pipework will be suitable for a heat pump.

Typically, a heating system is a sealed system either with a compression/ expansion vessel or a header tank to pressurise it, there is then a circulation pump which makes sure that the water circulates to all parts of the system.

Some systems, for example in old Victorian buildings, were originally set up with a large pipework system that were gravity managed (the hot water circulated because it rose to higher points when warm). These systems with their large pipes would be suitable for the lower temperatures provided by a heat pump.

More modern systems are designed with smaller pipework and potentially could face issues with being able to distribute heat sufficiently. However, these systems tend to have commissioning valves throughout to make sure that the correct amount of water passes to different parts of the system, so there is potential to recommission a system making it suitable for a heat pump.

If heat is distributed to multiple buildings through ducts, then the insulation of the pipework or replacement with pre-insulated pipework would improve the efficiency of the system.

Decision tree

Site overview

Heat emitters

Heat emitter type	Typical application	Compatibility to heat pumps
Radiant panels (hot water fed – not direct fired) 	Radiant panels are typically deployed in spaces with high ceilings such as school or sports halls. They are designed to provide high temperature radiant heat to the occupants rather than heating the space.	Because radiant panels operate at a higher temperature and dependent upon what temperature your heating system is going to circulate at these may not be well matched to being supported by a heat pump.
Radiator 	Radiators come in many types of the traditional Victorian column radiators, panel radiators, and LST (low surface temperature radiators). Radiators (unlike their name) tend to provide most heat through convection not radiation.	Dependent upon the sizing of the radiators and their type will influence how compatible they are to a heat pump system. LST radiators often seen in classrooms, particularly of primary schools, are designed to provide heat at 43°C and therefore sized to be larger than typical panel radiators and will be more suited to heat pumps. Victorian radiators rely on hot temperatures as unlike panel radiators they don’t have the additional surface area to dissipate the heat. They may struggle to provide heat to a space unless they are oversized.
Low level radiant pipework 	Low level heating pipework tends to provide low grade heat to spaces that require heating and need wall space. This could include school classrooms, cloakrooms and hospitals. They are sometimes similar to LST radiators as they have the pipework covered.	This type of technology is typically very well suited to heat pumps due to the low temperature of hot water circulated for heating.
Underfloor heating 	Underfloor heating is designed to deliver low grade heat to a space over time. It is a technology that has been deployed over the past 20-30 years and seen in many more modern public sector buildings including libraries and schools.	This type of technology is typically very well suited to heat pumps. The large area of “emitter” for underfloor heating (the whole floor area) means that lower temperature of the circulating water is sufficient to heat the space.

Sizing of wet system heating plant

The sizing of heat pumps for a wet heating system can be approached in several ways.

1	The first is to consider that the plant installed needs to meet the full peak winter load (and if cooling required the summer load too) similar to how a traditional fossil fuel boiler would be sized. This would mean that the plant would operate partially the rest of the year.	Pros are that the system covers all eventualities and meets Net Zero.	Cons are that the system is larger than required for most of the year, potentially less efficient, costs more to install and costs more to run.
2	The heat pump is installed in parallel with a gas boiler which is used as a backup and operates only in the depths of winter when the heat pumps are not able to meet heat requirements. This could mean that a summer heating boiler (for hot water) is retained.	Pros are that the heat pump is smaller, it costs less, the heat pump is running at operational efficiency most of the time. This also enables the COP to be determined at lower risk as heat can still be delivered to the whole site.	Cons are the system is nearly, but not quite Net Zero, it doesn't qualify for PSDS funding.
3	A series of other actions are implemented at the same time or in advance of the heat pump transition to manage the heat demand, this could include improving building fabric. Then either of the above approaches is adopted.	Pros are that the heat demand is reduced and therefore the cost burden operationally reduced further.	Cons are that this may require a longer programme of works and could be costly.

These approaches are set in context in the guide **What could decarbonisation look like for you.**

Network capacity constraints

A common problem is making sure that there is the required additional electrical capacity available for the installation of a heat pump on the site and the local network.

It is essential that this is checked out early on in any feasibility studies, as it could limit the project very rapidly. This starts with understanding what your current electricity network capacity is, what your current peak electricity demand is and whether installing a heat pump would take the site demand over the existing capacity.

Our **Theme 7 guide on monitoring and evaluation** will help you understand existing electricity use while our Local distribution network operator capacity guide will help with understanding local constraints to the network.

Designing a heat pump system in a way which reduces the peak electricity demand will help to reduce its impact on network capacity constraints. This could include the following considerations:

- **Building fabric upgrades:** to reduce heat loss.
- **Hybrid systems:** which allow another system to deliver at times of peak heating.
- **Thermal storage:** which store hot water to deliver heating when heat demand is high.
- **Higher efficiency heat pumps:** in particular those which have more stable COP across the year, such as ground source heat pumps and waste-water source heat pumps.

Decision tree
Site overview

Space requirements

Each of the different systems has different space requirements which will influence the selection process.

Technology			Space requirement
Air source heat pump	Air-to-water		External ASHP units are typically located either on a rooftop plant area or at ground level, though sometimes they can be wall mounted. Sufficient space around them is required to allow good air flow and for the movement of heat to or from the unit. External units are a source of noise and sensitive placement is required to ensure this doesn't impact on building occupants or neighbouring buildings. Also, visibility of external units should be considered to reduce visual impact.
	Air-to-air		
Ground source heat pump	Open loop groundwater		Boreholes take up very little floor plan space as they extend downwards into the ground. Some internal plant space will be required for the refrigerant circuit equipment of the heat pump.
	Closed loop	Vertical boreholes	
		Horizontal collectors	Horizontal collectors require significant land area which is boulder-free and cannot be built on. Typically, 10-40W/m^2 of heat output[19] is required.
		Thermal piles	Like boreholes, thermal piles take up relatively small footprints. Even more so since thermal piles integrate with the space already required for building substructure.
Water source heat pump	Surface-water		Heat exchangers for surface water source heat pumps are located away from the building and submerged, therefore taking up very little footprint. However, depending on the location of body of water, significant pipe runs may be required to pump the fluid back to the heat pump it is serving.
	Waste-water		There are multiple configurations of WWSHP. In-line (heat exchanger in the sewer) require very little space on-site. Siphoning off waste-water to be macerated, filtered and heat extracted on-site will require more space. Agreements of where the equipment sits should be discussed with the relevant water authorities.

Table 1 Plant space requirements for different types of heat pump

[19] CIBSE TM51: 2013 Ground Source Heat Pumps (February 2013)

Decision tree
Site overview

Heating and cooling heat pumps

When designing a heat pump system, the cooling demands for the site should also be considered. There are different kinds and configurations of heat pumps which can offer heating and cooling:

- **Reversible heat pumps:** in the simplest case, these units can reverse the direction of the refrigerant cycle allowing to heat pump to switch between heating and cooling mode. This could allow overall installation costs to be reduced since heating and cooling can be provided by the same piece of equipment.

- **Simultaneous heating and cooling:** if you are likely to have rooms which have significant heat gains (such as IT server rooms, high occupancy rooms, high solar gains) it may be worthwhile to consider a heat pump which can heat and cool simultaneously. This can even be the case in the same room, for example in deep-plan offices where core areas have a cooling demand due to heat gains from IT equipment and people but a heating demand at the perimeter. This is possible through transferring heat from a chilled water system to a wet heating system rather than rejecting it to a sink (external air, water body or ground source). Therefore, this is compatible with ASHP, GSHP and WSHP technologies. Reject heat can also be used to pre-heat domestic hot water or swimming pools. It is also possible through a VRF system which has the ability to transfer heat from one thermal zone (this could be one room or a set of rooms) to another before calling upon more heating or cooling from the external unit. Much higher efficiencies can be achieved through this than by heating or cooling alone.

- **Independent heating and cooling:** it is highly likely that heating and cooling demands won't coincide and therefore, on a site with significant cooling loads, a system which can store thermal energy between seasons could be beneficial. GSHP systems lend themselves well to this through systems referred to as underground thermal energy storage (UTES). There are two main types of these:

  - **Borehole thermal energy storage (BTES):** these are closed loop systems and work by zoning the boreholes into a set of cool store and warm store boreholes. During the winter, return water is drawn through the cool store zones to reduce the temperature ready for the summer, then passed through the warm store zones to pick up heat before returning to the heat pump to be raised to the correct temperature. This increases the COP of the system by accessing this stored thermal energy. The same principles are applied in reverse for the summer cooling season.

Decision tree

Site overview

- **Aquifer thermal energy storage (ATES)**: this system works under a similar principle, but rather than transferring the thermal energy into the ground via conduction, it draws up water for heating from a 'warm' store aquifer and rejecting it into a 'cold' store in winter. In summer it reverses its flow. In a well-balanced ATES system, sufficient cooling can come from just running the circulating pumps (and not the heat pump refrigerant cycle); thus, achieving an EER of over 25[20] in summer.

[20] CIBSE TM51: 2013 Ground Source Heat Pumps (February 2013)

Complementary technologies

There are a number of technologies and measures which should be looked at alongside installing a heat pump system. These are explored in further detail in our **What could decarbonisation look like for you** and **How to treat technologies and what to ask for** guides. Some main considerations, as they relate to heat pumps are explored below.

Building fabric upgrades

For many years a 'fabric first' approach has been applied to the installation of heat pumps. This is because improving the thermal efficiency of your building (insulating and draught proofing) reduces the amount of heat required to maintain a building at a set temperature.

If you would like to explore the potential to improve your fabric, then try out our **building fabric intervention estimator**.

Insulation can have additional benefits such as reducing the potential for mould growth by making internal building surfaces warmer. However, any design to improve insulation should be carefully considered, especially with draught proofing measures, as this will decrease the fresh air that comes into a building, potentially introducing the need for additional ventilation.

On/near site renewables and electricity storage

As well as considering energy efficiency measures, another option is to generate electricity on or near a site to manage any electricity capacity constraints. This would provide additional electricity generation to support the heating system.

These could include PV arrays; roof mounted, solar carports or ground mounted or wind turbines. Consideration should be given to the generation seasonal and daily patterns versus the heating patterns. Energy storage could be considered so you can store and use electricity when required, financially benefiting the site.

Decision tree
Site overview

Thermal storage

Thermal storage is the storing of heat energy, typically by heating up a tank of hot water or (less widely adopted) by using a phase change material. As well as electricity/power storage there are number of reasons why you might want to consider installing a heat pump system with thermal storage. These could include:

- **System stability:** to reduce the frequency of cycling (turning on and off) a heat pump will do if it is working at part load.
- **Defrost:** using a thermal store to provide heat to defrost the external units which allows LTHW to be continuously produced whilst it's particularly cold outside.
- **Peak-lopping:** large thermal stores can be installed to cover the peak demand for a system and reduce the capacity of the heat pump which you would need to install. Thermal storage could be used to avoid having a gas boiler operating to cover peak load.
- **Resilience:** to provide back-up heating in case of heat pump failure.
- **Managing energy prices:** a thermal store, given appropriate controls, could allow a site to make use of dynamic (time-of-use) electricity tariffs. These tariffs typically make electricity prices cheaper when the grid has more available renewable electricity relative to demand. Our guides on Understanding energy utilities and pricing and Power Purchase Agreements might also be of interest.

Connecting multiple buildings together via a District Heat Network

If you are considering a large ground source heat pump, there may be potential to connect multiple buildings onto the same system. This could make the system more efficient. In the case of a public building such as a secondary school, often buildings are already connected on a network. However, there may be other public buildings close by which could also be connected for example a leisure centre. Consider these options:

- **Heat source** – there may be better heat sources a short distance away, for example a body of water or waste heat which can be used.
- **How the heat is circulated** – it can be better to circulate the heat at the ambient temperature (the temperature the heat is recovered at) and then connected to a heat pump at each building to provide heat. Similar to an approach that historically has been taken with the circulation of steam, which is then mixed as it arrives at a building. There are a few examples of developments where ambient circuits have been installed successfully[21].
- **Heat density** – the choice of deploying a heat network is likely to be a balance between the distance that a network must travel, and the losses associated with it, against the heat requirement of the buildings. As well as the cost of installing the heat network, versus installing separate heat pumps at each building or site.

[21] https://smartenergysystems.eu/wp-content/uploads/2019/09/17-3_PhilJonesSESAAU2019.pdf (accessed 15/01/2024)

Decision tree

Site overview

Supporting a ventilation system

If the building is ventilated by some mechanical equipment, such as air handling units (AHUs) or mechanical ventilation with heat recovery (MVHR), how the heating system integrates to decarbonise with the ventilation system should be considered.

Often, air is pre-heated within the ventilation system so that cold air is not blown into the building when fresh air is required. This is sometimes (though now necessitated through building regulations), combined with a heat recovery element such as a plate heat exchanger or thermal wheel within the ventilation unit which means less heat is lost out of the system.

There are various ways, depending on the existing ventilation system, this could be integrated into the design including but not limited to the following:

- **Heating coils:** Some AHUs have built-in coils of pipework with LTHW water running through to pre-heat the incoming air. How the potential change of LTHW flow temperature introduced with a heat pump should be assessed and heating coils may need to be replaced. Heat could be provided electrically either fully, or through additional heating of the lower temperature water as it reaches the ventilation system.
- **Exhaust Air Heat Pump (EAHP):** Similar to standard practice with waste heat extract systems, run-around coils, which are an application of air-to-air heat pumps, can be installed in the exhaust air to transfer this wasted heat to the incoming air at the AHUs. This can operate at very high efficiency due to the temperature of the exhaust air.
- **AHU with integral heat pump:** There are AHUs with built-in air-to-air heat pumps on the market. One side of the heat pump sits in the incoming air stream and the other in the exhaust air. This can be installed alongside a thermal wheel for heat recovery and achieve high efficiencies.

Miscellaneous

A less widely adopted measure is to install fans on existing radiators[22], a much cheaper solution although this introduces a source of noise in the room. If space for a larger radiator is a constraint, convector radiators can also be installed.

22 https://cambridgecarbonfootprint.org/wp-content/uploads/2021/09/DIY-Fanned-Radiator-Details.pdf (accessed 14/12/2023)

Decision tree
Site overview

Refrigerant choices

The fluorinated gas (F-gas) regulations are in place to enforce a phase out of the use and impact of fluorinated gas on global warming. Traditionally, many refrigerants used in heat pumps are high in global warming potential (GWP) meaning they are more damaging than CO_2 if they get into the atmosphere. This means it is important that existing heat pumps control leakage of refrigerant, as well as ensure that F-gases can be recovered during repair and decommissioning of heat pump systems.

To help the market address this regulation, manufacturers are producing heat pumps which run with low-GWP refrigerants, which include:

- Carbon dioxide,
- Ammonia,
- Hydrocarbons,
- Hydroflouroolefins (HFOs) such as R-1234yf R-1234ze and R1233zd,
- Hydroflourocarbons such as R32. Although all f-gas will be phased out in the long term.

Some of these technologies have additional design considerations (such as flammability of hydrocarbons) or additional capacities (such as higher temperatures being achievable with carbon dioxide or ammonia as a refrigerant).

Decision tree
Site overview

Other electric heating solutions

Electrode boilers

An electrode (jet or spray) boiler passes a current of electricity through streams of water to produce steam. The conductive resistive property of the water is used to heat the water. They can be sourced to significant capacities to meet large site demands. Relatively high boiler efficiencies (99%) are achievable with electrode boilers. However, this does not compare favourably against heat pump efficiencies which are typically greater than 200%[32] (COP > 2) in industrial applications. A typical economic life expectancy of an electrode boiler is 15 years[24].

Electric radiant heating

Electric radiant heating is a technology which passes electricity through resistive elements to produce heat. This heat is radiated to people's bodies through electromagnetic waves, rather than heating the air. This is a widely used form of heating seen on small scales in pub beer gardens to industrial warehouses. It can be particularly appropriate for spaces which are hard to keep well insulated or draught proof, such as loading bays, workshops and agricultural buildings. It is also applicable when the use of a space is unpredictable or for short periods of time and a heating system that is fast to react is beneficial.

[23] https://www.pollutionsolutions-online.com/news/green-energy/42/sbh4-gmbh/high-temperature-industrial-heat-pumps-for-energy-efficient-steam-generation/55811 (accessed 14/12/2023)

[24] CIBSE Guide M: Maintenance engineering and management, Second edition (November 14) with revised Appendix 12.A1 (October 2020)

Decision tree

Site overview

Grant funding considerations

There are a number of different grant schemes which support the installation of heat pumps. Please see our **Decarbonisation grants and funding sources** table for details.

Public Sector Decarbonisation Scheme

Salix's role is to support the UK government in driving the transition to a low carbon future and meet challenging net zero targets. Salix deliver and administer grant and loan funding on behalf of the Department for Energy Security and Net Zero, the Department for Education and the Scottish and Welsh governments. This is delivered across the public sector as well as housing.

The schemes we deliver provide funding for energy efficiency and heat decarbonisation projects for public sector buildings. Salix schemes are dedicated to reducing carbon emissions and supporting the government's ambitious net zero targets. These programmes include the Public Sector Decarbonisation Scheme, and the Low Carbon Skills Fund as well as Scotland's Public Sector Heat Decarbonisation Fund.

Guidance is published on the **Salix website** about the requirements to access funding. This may change between phases but the main themes and principles centre around:

- End of useful life: evidence that plant to be replaced has reached the end of its useful life.
- 'Whole building' approach: ensure that measures are not installed in isolation and therefore do not integrate into an overall cost-effective decarbonisation pathway.
- Applicant contribution: confirmation that sufficient financial reserves are available.
- Low carbon heating system sizing: evidence that sizing has been performed competently.
- Options appraisal: Evidence that all available options have been explored and appraised.

It should be noted that not all the different types of heat pumps covered in this guide are eligible for PSDS.

Decision tree
Site overview

What to look for when working with others

Construction is a complex process which requires expertise to deliver. Choosing the right designer, supplier or installer to partner with to deliver your heat pump system is an important decision.

This section is provided to give ways to check and reassure that you are engaging with competent installers and designers to deliver your heat pump system. This can be tested by compliance to standards and affiliations with professional bodies who ensure best practices are followed by their members.

Standards

The British Standards Institution (BSI) produce technical standards on a wide range of products and services including those that are related to building construction and manufacture of equipment.

The following British Standards (BS) relate in particular to the manufacture, design, installation, operation and maintenance of heat pumps and the systems they integrate with:

- Safety and environmental: BS EN 378-1 and BS EN 378-2
- Test requirements: BS EN 14511-1, BS EN 14511-2, BS EN 14511-3 and BS EN 14511-4
- Electrical installation: BS 7671
- Electrical safety for heat pumps, air-conditioners and dehumidifiers: BS EN 60335-2-40
- Domestic hot water installations: BS EN 806-3
- Ground investigations: BS 5930

Professional bodies

BESA

The Building Engineering Services Association (BESA) is a trade body which ensures the quality of its building engineering services specialist members through a number of lenses including regulation compliance, insurance cover, environmental awareness and recruitment and training. They regularly inspect their members who are required to perform according to criteria established by specifications and best practice guides. Their membership database can be searched by specialist type and location.

Decision tree
Site overview

CIBSE

The Chartered Institute of Building Services Engineers (CIBSE) is a professional body that exists to advance and promote and practice of building services engineering. Although they do not offer a membership database to browse affiliated members, they author and publish many guides which span all aspects of building services engineering, those specific to heat pumps include:

- AM16 Heat pump installations for multi-unit residential buildings (2021)
- AM17 Heat pump installations for large non-domestic buildings (2022)
- TM51 Ground source heat pumps (2013)
- CP2 Surface water source heat pumps: Code of Practice for the UK (2016)
- CP3 Open-loop groundwater source heat pumps: Code of Practice for the UK (2019)

Heat pump specific bodies

More specific to heat pumps, there are professional bodies which provide a focal point for the heat pump installation industry to come together:

- The Heat Pump Federation (HPF) https://www.hpf.org.uk/
- The Heat Pump Association (HPA) https://www.heatpumps.org.uk/
- The Ground Source Heat Pump Association (GSHPA) https://gshp.org.uk/

Members of these professional bodies have access to standards and codes of practice as well as the opportunity to access education and sharing of knowledge across the industry. These organisations also provide directories which are searchable for installers, designers and manufacturers. Due to the nature of organisations which would engage with these professional bodies, these are likely to provide a quality service.

The GSHPA, in particular, provides the following standards with detailed design, installation and materials requirements for GSHPs:

- Shallow Ground Source Standard
- Vertical Borehole Standard
- Thermal Pile Standard

As well as codes of practice for WSHPs which set minimum design, build, operation and maintenance requirements:

- SWSHP – Code of Practice
- GWSHP – Code of Practice

The GSHPA also set an expectation through a code of conduct such that members agree to abide by the standards they publish.

Decision tree

Site overview

What to ask for and expect back

Section 5.1 of the **How to treat technologies and what to ask for** guide covers a number of aspects to consider when engaging with designers and installers when decarbonising a heating system, such as:

- Actions and supporting information required for a technical assessment.
- What the output from an assessment should look like including detailing the expectations for:
  - design considerations,
  - cost breakdown,
  - and assessment documentation.

The following are additional or particular to heat pump installations:

- Retrofit enabling works:
- Upgrading distribution systems or heat emitters to enable lower heating water temperatures
- Structural improvements to support new plant
- Electrical infrastructure upgrades
- Permit costs (open loop GSHP and SWSHP)
- Abstraction charges (open loop GSHP and SWSHP)
- Site testing (vertical borehole and thermal pile GSHP)
- Water testing (SWSHP and WWSHP)

Decision tree
Site overview

Glossary

A glossary of terms and abbreviations in the context of a heat pump system. These may have different definitions when used in other contexts.

Term or abbreviation	Description
AHU	Air Handling Unit
ASHP	Air Source Heat Pump
BESA	The Building Engineering Services Association
Bivalent system	A heating system which combined a heat pump alongside a secondary heating technology to deliver the heat demand to a site. Another term used to describe this is a hybrid system.
BSI	British Standards Institute
CIBSE	Chartered Institute of Building Services Engineers
COP	Coefficient of Performance
DHW	Domestic Hot Water
DX	Direct Expansion
EA	Environment Agency
EER	Energy Efficiency Ratio
GSHP	Ground Source Heat Pump
GSHPA	The Ground Source Heat Pump Association
GWP	Global Warming Potential
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HPA	The Heat Pump Association
HPF	The Heat Pump Federation
HSE	Health and Safety Executive
HTHW	High Temperature Hot Water

Decision tree

Site overview

Term or abbreviation	Description
LTHW	Low Temperature Hot Water
MTHW	Medium Temperature Hot Water
PPA	Power Purchase Agreement
PSDS	Public Sector Decarbonisation Scheme
SCOP	Seasonal Coefficient of Performance
SWSHP	Surface Water Source Heat Pump
TER	Total Efficiency Ratio
VRF	Variable Refrigerant Flow
WSHP	Water Source Heat Pump
WWSHP	Waste-Water Source Heat Pump

Decision tree
Site overview

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Cabinet Office

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