**Checklist for Heat Pumps**

**GEAR@SME: G**enerate **E**nergy-efficient **A**cting and **R**esults at **S**mall and **M**edium-size **E**nterprises

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# Introduction

This is a checklist designed to support the procurement of energy efficient heat pump systems for space heating in buildings. It can be used both for individual SME or for a Trusted Partner in charge of procurement for a group of SMEs.

In this introduction reasons are given to consider applying a heat pump.

Then in the second chapter prerequisites for the successful implementation of heat pumps are presented.

In the third chapter the most relevant items on specification of a heat pump systems and its components are listed and described.

At the end of the document a glossary of relevant terminology is given.

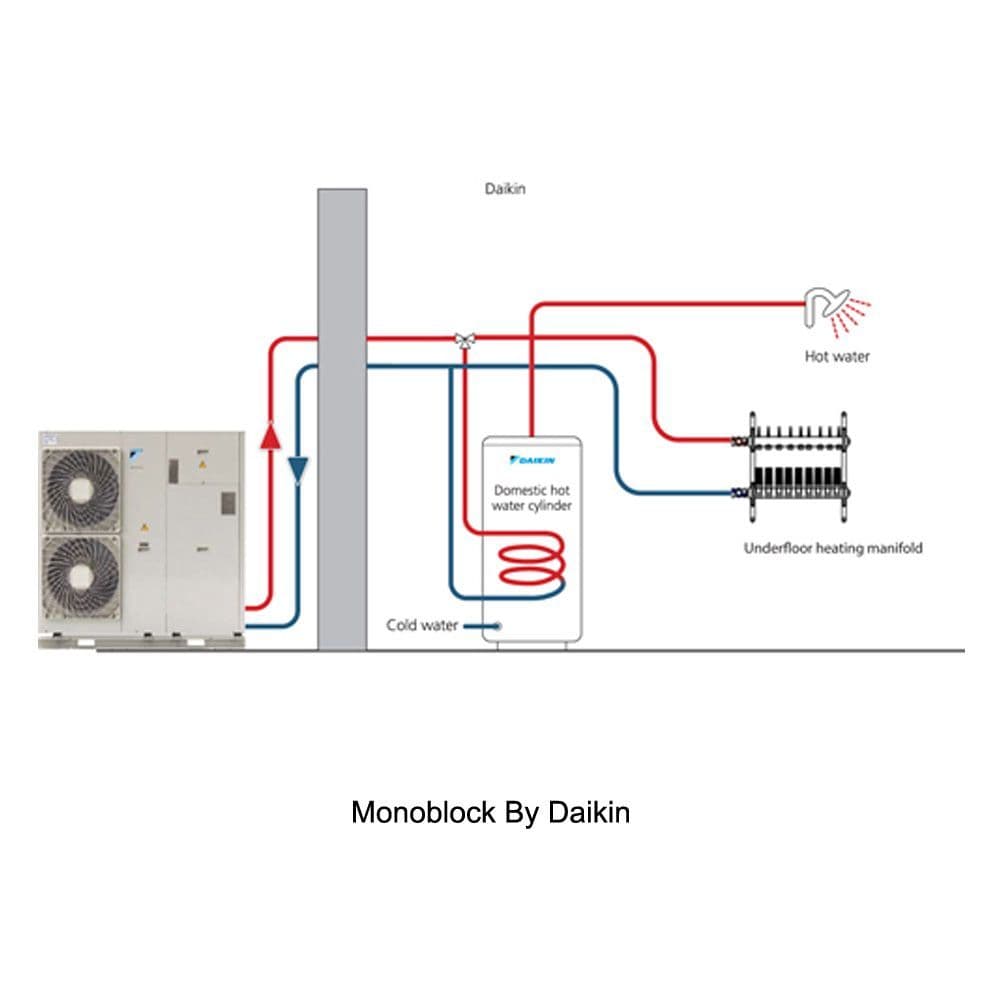
## Why consider a heat pump?

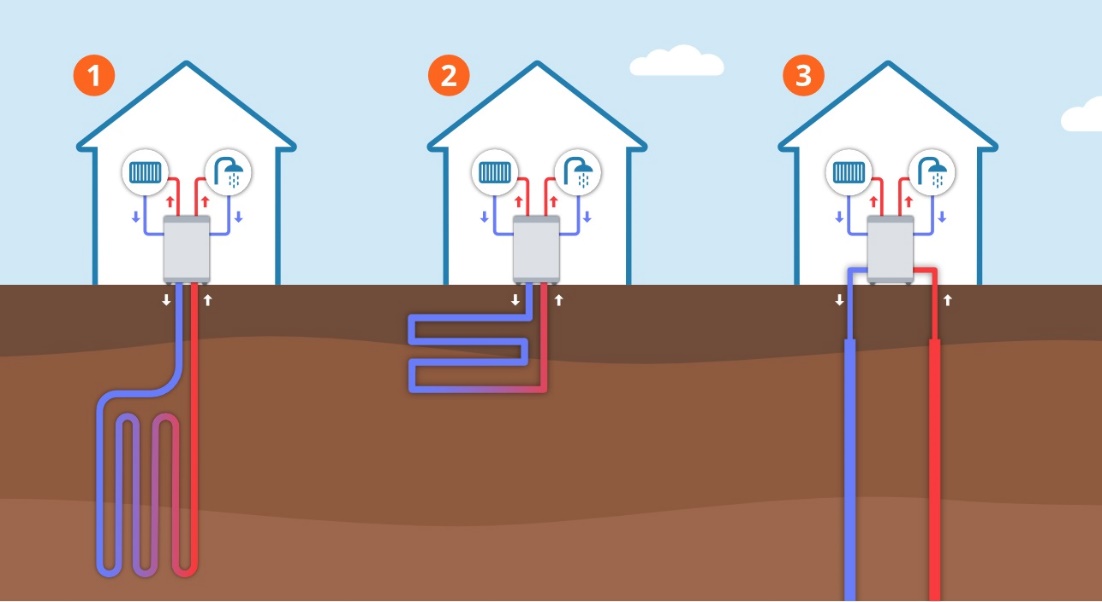
Heat pumps generally use electricity to raise the temperature of heat from low-temperature heat sources (e.g. in the surrounding air or ground or from waste heat streams from a manufacturing process) in order to heat a building or an industrial process. A heat pump uses energy from a heat source that would otherwise not be utilized. Electricity is used to upgrade this “free” heat to a useful level. With a heat pump the energy output is typically at least 2-5 times higher than the electricity input. This means that compared to direct electric heating, heating by means of heat pumps can reach a reduction in electricity to less than 50% of the electricity otherwise needed.

The energy efficiency of a heat pump is defined by its COP (Coefficient of Performance), which describes how much heat is supplied per unit of electricity. For a list of definitions related to heat pump systems, please refer to Section 4.

## Classification of heat pumps based on heat source

Air-source (most common)​: The air-based heat pumps use heat from the outside air. Normally cheaper than heat pumps based on other heat sources. Normally these heat pumps produce more noise due extra air movement. In cold periods the efficiency becomes lower due to the higher temperature difference that has to be attained. The Coefficient of Performance (COP) depends on the outside temperature.



Ground-source (alternatively water-source): ​   
As a heat source water from a piping system vertically (1) or horizontally (2) in the ground is used. This is sometimes referred to as geothermal heat pumps (not to be mixed up with geothermal energy using higher temperature heat from deeper sources). Another option here is to use the heat available in subsurface water layers. Ground-source heat pumps have a medium COP between 4 and 7. A ground-source heat pump is more efficient – with more stable performance seasonally – than an air-based heat pump, resulting in lower operational costs (lower electricity demand), but investment costs are higher due to the need for underground piping and possibly drilling. For ground-source heat pumps to be a good option, the ground needs to be suitable. This type of heat pump can also be used for energy efficient cooling of buildings.

A more detailed classification of heat pumps is provided in Section 4.

# Situation description

Heat pumps used for space heating in buildings are classified based on the heat source they use. If you know what type of heat pump you want, specify this in your request for offer. If this is yet to be decided, it may be appropriate to ask the supplier to suggest the best solution, including selection of heat pump type and distribution system.

For the supplier to be able to suggest an appropriate heat pump and estimate the required heat pump capacity, and electricity demand, you need to provide information about the current heating systems for each building included in the request for offers:

* Technology used (e.g. gas boiler or electric heating)
* Heat capacity of the technology used
* Internal heat distribution system (e.g. water-based radiators, floor heating, direct air heating)
* If there is information on current heat requirement then annual fuel or electricity demand for heating. Otherwise a calculation of the expected amount of heat needed via a heat loss calculation for the building.
* Heated space (e.g. total heated space area, number of floors)

Prerequisites for successful implementation

Proper insulation If a building is poorly insulated, insulation measures should preferably be implemented before the dimensioning and purchase of a heat pump. Otherwise, the cost of the heating system will be significantly higher. This is because the cost of a heat pump system investment increases with the amount of heating that is required.

Appropriate temperatures in heat distribution system The distribution system should be either low or medium temperature because heat pumps function with a better efficiency when the temperature difference between the source heat and the distributed heat is smaller.

Sufficient capacity of electric power connection Especially when larger buildings or poorly insulated buildings are switched from other heat sources to electricity the expected electric power demand for the heat pump should be verified with the capacity of the electricity connection. For example, you can specify the connection capacity in the request for offers, and ask the suppliers to include potential costs for extending the connection.

Suitability of the ground for ground-source heat pump Certain regulations may apply for ground-source heat pumps such as subsurface use regulations, regulations for drilling or groundwater regulations. Check which regulations apply in your local area. (For heat pump projects in the Netherlands, The internet tool <https://wkotool.nl> provided by the Dutch government can be used for this purpose)

Requirements for the heat pump system

For larger or more complex systems, it is important that you prepare a specification that can be included in the request for offer. Such a specification usually has to be done by a design engineer with experience of heat pumps. For smaller systems, it may be appropriate to rely on your supplier to complete the design. In this case, it is important to state clearly what you need the system to do for you when it is operating and what they should consider during installation.

Distribution system and temperatures. All heat pumps are dependent on the heat distribution system and the needed distribution temperature for those systems. Normally a floor or wall heating system can operate with water temperatures below 40 oC. Most systems with heat radiators have been designed to operate with a feeding temperature between 70 oC and 90 oC. The higher temperature needed for radiators negatively influences the COP value. For example, with an outside temperature of −7 oC and a distribution temperature of 40 oC the COP is 2.5 whereas with a distribution temperature of 55 oC the COP worsens to around 1.7). (see graph in Section 4).

Mode of operation Heat pump only, or a hybrid heat supply system? Will the heat pump cover the entire heating demand at all times, or is a hybrid system with complementary peak load capacity a possibility? Take care not to choose the heat pump capacity too high. A higher capacity implies higher investment. An extra electric or gas-based heating facility in a hybrid system is often an economical solution. The highly efficient heat pump can be used efficiently during most of the year. The extra investment in the hybrid extra capacity is relatively low. In some cases the existing heating system can be kept operational to be used in peak demand situations.

Monobloc or split-system for air-source heat pumps A so-called monobloc air-source heat pump module consist of an outdoor unit only. It is very easy to install, which reduces the time and cost for installation. A heat pump with split-system configuration has an outdoor unit with compressor, condenser and fan, which is connected to an indoor unit with the heat exchanger and control regulators through refrigerator piping. This has the advantage that freezing in the pipes and heat exchanger can be avoided when there are power outages. But it is typically a little more costly.

Heat pump for tap water/sanitary hot water Since hot tap water needs to be heated to a temperature of around 60°C due to legionella requirements, the temperature lift for a heat pump, which can heat tap water is higher than for a heat pump used only for room heating. Consequently, the COP for this process is relatively low. A system with added local electrical or gas heating for tap water is often economical compared to extra capacity in the heat pump with a relatively low COP.

Peak heat load and annual heating demand In order to reduce equipment costs and keep the offer cheaper, heat pumps are sometimes dimensioned smaller than the heating load calculation has shown. As a result, the operating costs of the heat pump will be disproportionately higher and out of proportion to the supposed savings in capital costs. To avoid this, make sure that the heat pump or hybrid heating system (see Mode of operation above) is dimensioned to cover the peak heat load and annual heating demand.

Location of the installation site The noise level of the fan of air-based heat pumps should be taken into account when selecting the location of the heat pump module. This point is important for both indoor and outdoor installation.

# Evaluation of the offer

Specific information regarding procurement of heat pumps is listed in this chapter. For general criteria for procurement of energy-efficient technology, please refer to [GEAR@SME Supplier selection tool].

## Technical criteria

This section presents technical specifications that could be included in the offers. You may want to include requirements for some of these criteria that are more important, or simply ask the suppliers to provide the specifications and use them in the scoring of different offers.

### Specifications for the heat pump module

Manufacturer and type Exact manufacturer and type designation. In some cases lists of heat pumps eligible for governmental subsidies have been made public.

Capacity Heating capacity in kW. There is a cost-optimum size for a heat pump. Larger heat pumps typically give better heat efficiency and less noise. But higher capacity heat pumps are more expensive, so if the larger capacity is not needed for a sufficient number of operating hours, a larger heat pump is not necessarily a cost efficient solution (see also “Mode of operation” in Section 2.2).

Compressor Select a heat pump with a variable speed compressor, usually denoted inverter compressor.

Quality label There are different quality labels for heat pumps in different countries.   
  
One such label is the EHPA Quality Label. This is a label that shows the end-consumer a quality heat pump unit or model range on the market. The heat pumps that receive the label need to undergo tests according to the international standard EN14511 and EN16147. These tests are executed by EN17025 accredited test centres. Currently, 12 countries are involved in the EHPA Quality Label scheme.

### Specification of other components of the heat pump system

Buffer or combination storage tank Exact manufacturer and type designation; Thermal insulation; Buffer capacity; Heat losses; possibility to give output at different temperature levels (for example high level for tap water and low level for the heating system).

Heat and refrigerant pipes Exact manufacturer and type designation; Material; Insulation including fire class.

Metering Heat meter and electricity meter possibly with connection to local network for reporting on the use of the system at regular intervals.

### Technical performance indicators for the heat pump system

COP value The COP of a heat pump describes how much useful heat is delivered per unit of primary electricity input. The COP depends on the temperature difference between the heat source and heat supply temperature, and therefore differs significantly between different types of heat pumps and systems (see also “Abbreviations and definitions”). If a heat pump is marked with a COP specification, this refers to the performance achieved under certain test conditions, and the true COP value under other conditions may differ.

Seasonal Performance Factor (SPF) (also referred to as Annual Performance Factor). Since the COP of a heat pump depends on the heat source temperature, the performance of an air-based heat pump will vary depending on weather conditions and outside temperature. (The temperature of the heat source for ground-source heat pumps using heat from the ground also varies, but not as much, and it will not drop as low in the winter). The SPF describes the annual performance of the system considering these variations. Especially in comparisons between air-based heat pumps and other heat pumps the SPF taking into account the local weather pattern should be used. The SPF factor can initially only be calculated by the specialist company as part of the planning. Pay attention to the value that is contractually guaranteed to you. In order to apply for specific subsidies, the SPF might need to be calculated according to specific criteria. (Example Germany : Jahresarbeitszahl must be calculated explicitly in accordance with VDI 4650-1 in order to be able to apply for Bafa subsidies).

Peak load value and Integrated value for COP The way the peak load value should be determined is specified in European norms EN14511-2-2018. However, for air-based heat pumps, when the outdoor temperature is between -2 °C and 5°C the condenser part outdoors could get frosted. The heat exchanger therefore needs regular defrosting. This defrosting process is taken into account of in the Integrated COP value.

### Specific requirements for ground-source heat pumps

The company responsible for the ground piping system should have necessary soil expertise. There may also be requirements that there is a groundwater analysis available for the area. Be aware that country-specific regulations may apply for drillling. And drilling itself normally implies significant costs.

Execution and handover

This section describes what the requested offers should include regarding installation and handover.

Assembly and installation work

* Exact breakdown of on-site services: Earthworks; development of the heat source (i.e., exact description of the services of the drilling company or well builder); installation of the refrigerant circuit, heat pump module, storage tank as well as connection to the heating circuit; wall and ceiling penetrations; electrical installation.
* Exact listing of all planning and executing companies including contact details, contact persons and responsibilities.

Other service in connection to handover

* Hydraulic balancing
* Arrangements for disposal of the old boiler
* Instruction in system operation
* Proposal for system maintenance

Technical documentation (data sheets) Technical documentation should be provided for: Heat pump module; Ground probes / ground collectors; Refrigerant pipes; Buffer or combination storage tank; Hydraulic scheme of the installation

Maintenance

Often a yearly maintenance visit is sufficient for the proper maintenance of a heat pump system. Some possible maintenance actions specific for heat pumps could be:

Tabel 1 : Example heat pump inspection checklist

|  |  |
| --- | --- |
| Check thermostat operation | Check the shape that the total system is in and advise customer of discrepancies |
| Check electric heaters with amp probe and voltage during heating inspection | Check condensate drain and pan then advise of any discrepancies |
| Check bearings & lubricate blower motor if needed | Check to make sure that the indoor & outdoor units turn on |
| Check electrical connections for tightness | Check condenser motor amp draw |
| Check blower belt, wear, tension & adjust as needed | Check voltage to unit |
| Check evaporator coil to determine if it needs cleaning | Check condenser motor bearings & lubricate if needed |
| Check blower motor amp draw | Perform visual inspection of ductwork and make notes regarding discrepancies |
| Check refrigerant (freon) level | Check crankcase heater if compressor has one installed |
| Check coil temperature | Replace the air filter or clean if reusable type (monthly) |
| Check reversing valve operation | Check defrost controls |
| Check compressor amp draw |  |

Cost

Total costs of ownership (TCO) or Life cycle costs (LCC)  Ideally, the tenderer shall provide a detailed calculation based on a total cost and/or life cycle cost approach, which includes the total investment costs (see below) but also the expected energy and maintenance costs over the lifetime of the heat pump. The projected lifetime for these analysis should be at least around 15 years

* Detailed equipment cost breakdown A full list of the costs for individual parts of the heat pump system should be provided.
* Detailed list of services provided Planning costs; labour hours for the installation; hourly rate; costs for the borehole and borehole heat exchanger; etc

Supplier selection & contract

For general criteria on supplier selection and on drafting a contract we refer to:

* [Gear@SME Supplier selection tool]
* [Gear@SME Example contract with supplier]

In addition to general contractual criteria regarding, liabilities, warranties etc, a heat pump contract could include the following elements:

* Contractual agreement on acceptable performance.
* Permission from the lower water authority for ground-source heat pumps.
* Attention to acceptable noise levels for air-source heat pumps.

# Abbreviations and terminology

*Glossary adapted from European Heat Pump Association (www.ehpa.org)*

**Air-based distribution system**

The heat distribution system using air to distribute the heat/cooling in the building – blown or forced air through ducts or grilles or wall hung a/c units.

**Air source (mono-bloc)**

Heat pump unit with the refrigeration cycle contained within one unit 'monobloc' which is then connected by piping to the heat distribution system. No refrigerant flows outside of the monobloc casing – just water, making installation possible by a plumber.

**Air source (bi-bloc or split)**

Heat pump unit with the entire refrigeration cycle being 'split' between separate outdoor and indoor units – which are connected using piping filled with refrigerant. Installation requires a refrigerant engineer.

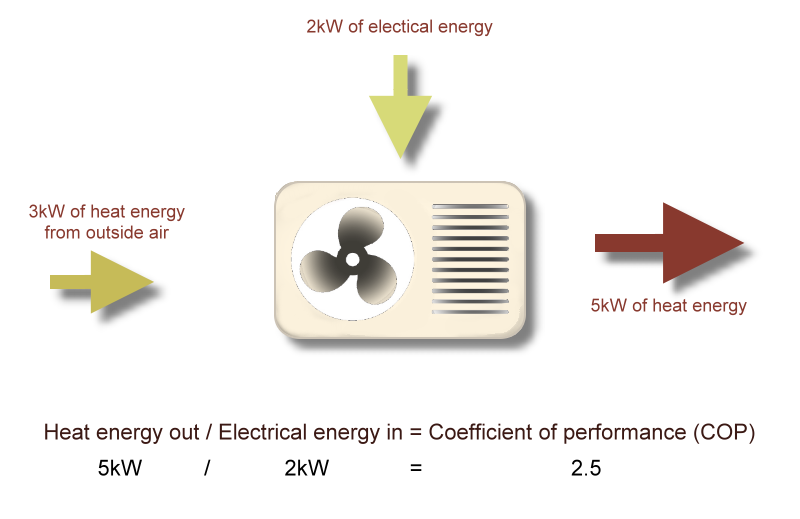
**Air-to-water heat pump (ASHP)**

Uses heat from the ambient air, they may be monobloc units or split. Air/water systems are always connected to a hydronic heat distribution by definition.

**Air-to-air / Reversible (AAHP)**

Air-to-air heat pumps use air for both the heat source and the heat sink. They are either developed from traditional air-conditioners extended to provide also heating functionality or they are optimized for heating and can then also be used for cooling. They are always split systems with a separate outdoor and indoor unit connected by pipes containing refrigerant. Generally these systems have to be installed by qualified refrigeration engineers and are sold through a cooling/refrigeration channel.

**Coefficient of Performance (COP)**

The COP is the ratio of useful heat produced to drive energy of the heat pump.

In the figure you can find a graphic illustration of the way the COP of a heat pump is calculated.

The COP of a heat pump depends on the temperature lift between the heat source and the heat delivered. The lower temperature lift, the better (higher) COP.

**Compressor (Fixed speed)**

A compressor that can only run with one speed and thus constant capacity. To vary the capacity over time, the compressor is switched on or off (on-off operation).

**Compressor (variable/modulating speed)**

The compressor speed can be controlled (varied) to change the heating capacity of the system. The main types used are inverter compressors, digital scroll compressors and multiple compressors:

**Inverter compressors**  control the speed by changing the frequency of the power input.

**Digital scroll compressors** technology operates on the principle of loading and unloading of scrolls i.e. the scrolls are engaged and disengaged periodically to get durations of “full capacity” and “no capacity”. Time average of the loading and unloading state results in variable capacity output to vary the compressor speed.

**Multiple compressors** can be used in to provide extended variable output. A stepwise capacity variation can be achieved by starting/stopping additional compressors.

**Exhaust air heat pump** Exhaust air heat pumps use energy from indoor air to provide heating, sanitary hot water. They can either use indoor air or be connected to a forced ventilation system. Most often, these systems are used for sanitary hot water preparation, not heating, due to limited heating capacity, but increasingly being marketed as a heating solution.

**Ground-to-x heat pump**, geothermal heat pump (GSHP, closed loop)

Uses heat from the ground, either via drillings (vertical) or via horizontal collector. Either pure water or brine (water-glycol mixture) is circulated in the heat exchanger. Naming variation depend on the medium used for energy dissemination including ground-to-water, or ground-to-air heat pumps. Direct expansion systems (DX) circulate a refrigerant in the collector. Direct expansion-water units use a hydronic heat distribution system.

**Hydraulic balancing**

**Hydraulic balancing is the final tuning of the heating system. It ensures that the pressure ratios of each radiator are optimally adjusted so that an optimum water supply can be guaranteed. By carrying out hydraulic balancing, heating costs can be significantly reduced and indor comfort is also increased.**

**Hydronic (water based) distribution system**

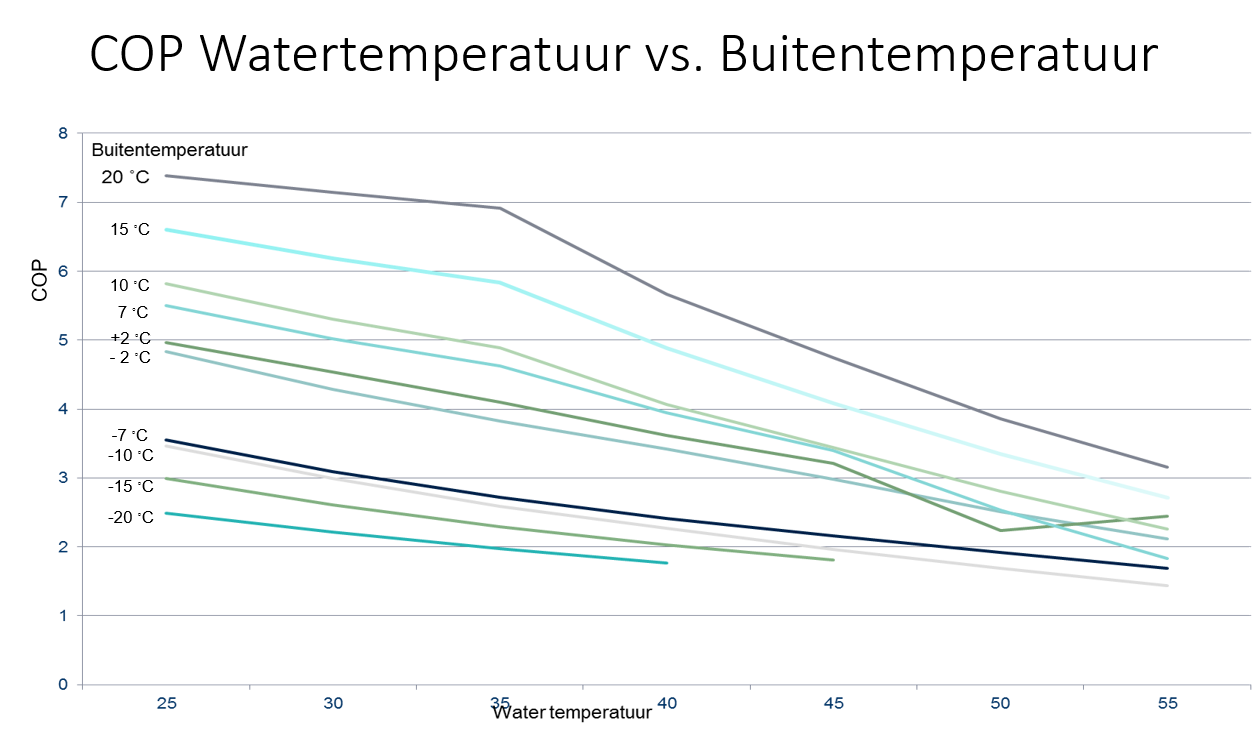
The heat distribution system is water based – e.g. the heat pump is connected to radiators, underfloor heating, fan convectors/fan coils.

**Sanitary hot water heat pump (SHW)**

Sanitary hot water heat pumps use mostly air to produce hot water (up to 65°C). They can use indoor or outdoor air to achieve this purpose. They are either built as compact units with an integrated tank or they are connected to an external hot water tank.  
Alternative name: Domestic hot water unit

**Seasonal Performance Factor (SPF)**

The SPF describes the annual performance of a heat pump system as the ratio of total annual heat output to the total annual electricity consumption. This value is dependent on the heat pump and the local seasonal temperature variation. The SPF for heating in colder countries will be lower than the SPF for the same heat pumps in warmer countries. The graph below gives an indication of the dependency between the COP of an air-based heat pump and the water temperature that is needed for heating a process or a building. The expected SPF can be calculated with the locally defined standard weather conditions.



**Thermally driven heat pump**

Heat pumps that come in different variations using gas as auxiliary energy. They can either use gas to run a gas motor (gas motor driven) and operate as conventional compression unit. They can also use a thermal process (adsorbtion or absorbtion) as an alternative to mechanical compression.

**VRF systems (multi-split)**

Air conditioning heating and cooling technology. One outdoor unit (condenser) connected to multiple indoor units, all of which may operate independently, i.e. providing heating and/or cooling at the same time. VRF systems are a more sophisticated version of the minisplit HVAC system used throughout the world. They distribute the refrigerant instead of piping hot water and chilled water to each fan coil unit (FCU) or air handling unit (AHU). By supplying different amounts of refrigerant to evaporators, the systems may provide simultaneous heating and cooling.

**Water-to-water heat pump (WHSP, open loop)**

Uses heat from a water source such as a well. Typically water is pumped from the source in an open system through the heat exchanger and returned to the source. In case of water-to-water heat pumps, they are often monobloc units with hydronic distribution.