Hoval

FACTBOOK

Anergy networks and cold networks

Consulting manual

Hoval | Responsibility for energy and environment

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Anergy networks – cold networks

Cold local heating, also known as cold district heating, is a technical variant of a heating network that operates with low transmission temperatures in the vicinity of ambient temperature, and can therefore provide both heat and cold. The transfer temperatures are usually in the range of about 10 to 25 °C, which means that these systems operate at significantly lower temperatures than conventional district or local heating systems. This makes it possible for various consumers to heat and cool independently of one another, at the same time. In contrast to conventional heat networks, hot water production and building heating do not take place directly via heat exchangers, but via water/water heat pumps, which draw their heat energy from the heat network. Cooling can take place either directly via the cold heat network or, if necessary, indirectly via the heat pumps.

Cold local heating networks are also referred to as anergy networks.* The technical collective term in scientific terminology for such systems is 5th generation district heating and cooling. Due to the possibility of being operated fully by renewable energies, and at the same time contributing to compensating for fluctuations in generation by wind power and photovoltaic systems, cold local heating networks are considered a promising option for a sustainable, potentially greenhouse gas and emission-free heat supply. They are therefore considered the core technology of a heating transition.

*See the “Anergy and exergy” chapter.

Sources: Eawag Water Research Institute, technical article AQUAandGAS no. 6, Heat pumps in thermal networks in Switzerland, potential of district heating and cooling systems BFE-042.16-127/5, Thermal networks Lucerne University of Applied Sciences and Arts, News from heat pump research 2018 HTI Burgdorf.




Transformation of the heating sector

Only the interaction of demand reduction and increasing the share of renewables in the heating mix will enable the complete transformation of the heating sector.
The decarbonisation of the heating sector by 2050 is outlined in detail in a study by the Fraunhofer IWES Institute in Germany "Interaction of RES-E, Heat and Transport" and divided into the following three phases:

PHASE 1: Reduction of system temperatures (2012 - 2025)
PHASE 2: Increasing flexibility and heat pump expansion (2025 - 2035)
PHASE 3: Use of power-to-heat and sector coupling (2035 - 2050)

Reduction of system temperatures (2012 - 2025)

System temperatures will be reduced in district heating networks and buildings. The focus here is on reducing system temperatures to below 80 °C. In addition to energy refurbishment, the spread of low-temperature heating systems such as underfloor and wall heating is promoting the use of decentralised electric heat pumps, which is characterised by a low system temperature.

Increasing flexibility and heat pump expansion (2025 - 2035)

The second phase, "Increasing flexibility and heat pump expansion", focuses on increasing the flexibility of the electricity system by making heat storage a favourable flexibility option. Due to the expansion of renewable energies, flexibility options must be increasingly developed in the period from 2025 to 2035. This also includes heat storage tanks. However, the use of the building envelope as a heat storage system also plays an important role.

Use of power-to-heat and sector coupling (2035 - 2050)

The coupling of the energy sectors will dominate the third and final phase of the heat transformation. Especially in the period from 2035 to 2050, power surpluses due to wind and solar power will increase strongly. Due to the favourable possibility of storage in the heat sector, power-to-heat will be increasingly used both with heat pumps and heating elements in district heating.

Evolution of district/local heating networks

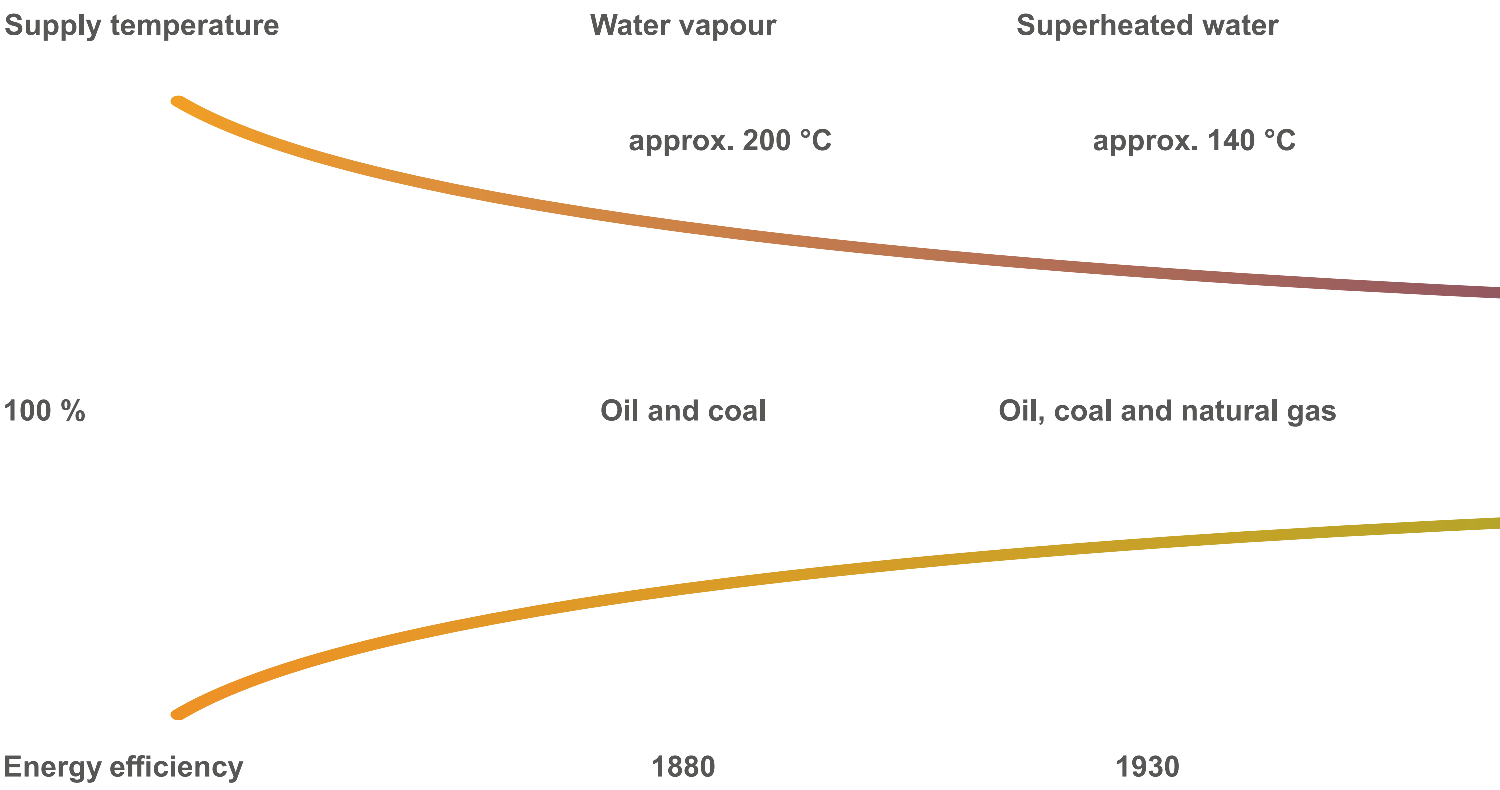
This chapter briefly describes the technological development of district heating networks over the last 100 years, and future developments. The appearance of district heating as we currently know it will change significantly in the future due to the need for decarbonisation.

1st generation

The first generation was introduced in the United States starting in the 1880s and subsequently spread to other parts of the world, such as Europe. These systems used hot, pressurised steam as the transmission medium, which was transported in steel pipes insulated on site. The steam was produced primarily in coal-fired central boilers and a few cogeneration power plants.

2nd generation

The second generation emerged around 1930 and was the predominant design in newly constructed district heating systems until the 1970s. These systems used pressurised water at temperatures usually above 100 °C as the heat transfer medium, transported in steel pipes insulated on site and conveyed through central pumping stations.



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3rd generation

The third generation emerged in the 1970s, and subsequently, starting in the 1980s, most district heating systems were built to this standard; many previous systems were converted to this standard. Since many manufacturers of components of such systems originate from Northern Europe, this generation is sometimes referred to as “Scandinavian District Heating Technology”,

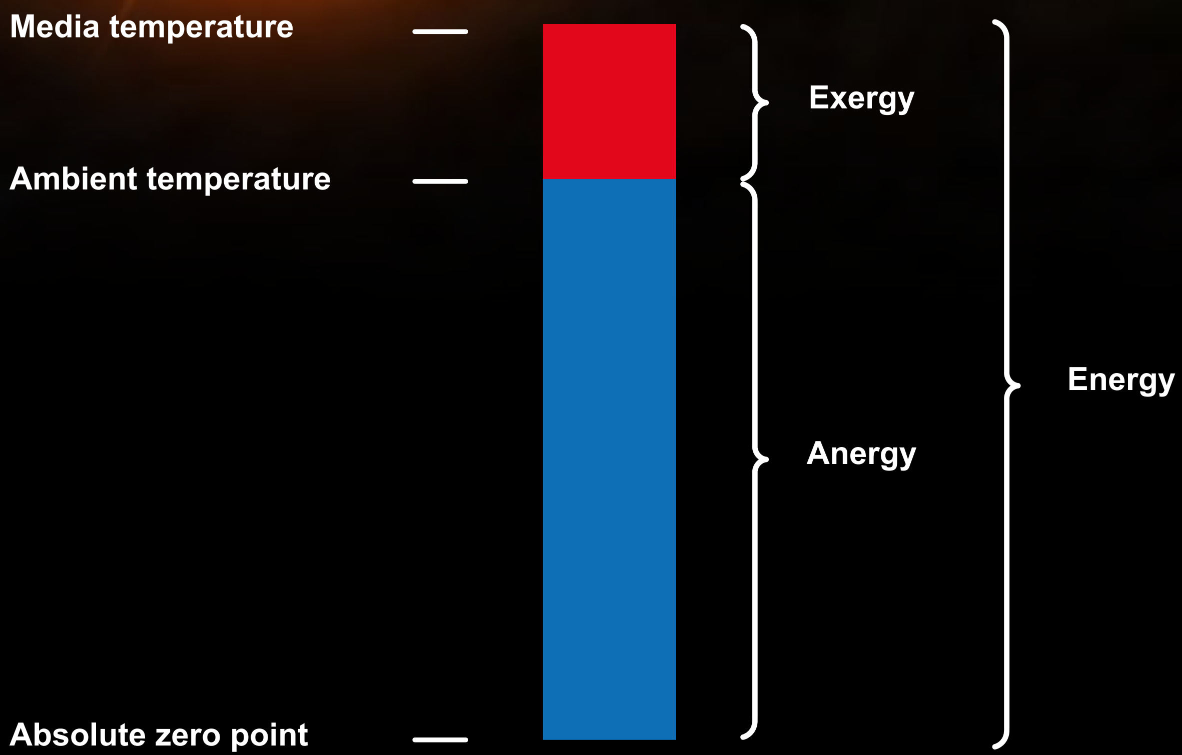
4th generation

The fourth generation (often referred to as Heat Networks 4.0, 4th Generation District Heating or 4GDH) has been implemented on a large scale since approximately 2020. This generation is mainly characterised by the requirements of climate change mitigation and sustainable energy production, and the associated energy transition to largely or fully renewable energy systems. In Denmark, the transition from third to fourth generation is already underway.

5th generation

The fifth generation (often also referred to as cold heat networks, anergy networks, low-ex heat networks, 5th Generation District Heating or 5GDH) is the next step in development. Since cold district heating networks provide not only heating but also cooling, thus creating a bidirectional energy flow between the building and the network, they are also referred to as bidirectional (low-temperature) heating networks. The system temperatures are reduced to the ambient temperature level.

1970	Today	2030
Hot water	Low temperature water	
approx. 90 °C	approx. 60 °C	
Oil, coal, natural gas and renewable energies	District heating systems, artificial intelligence, smart technologies, heat and power accumulator	New energy sources



Sulzer, Matthias & Hangartner, Diego. (2014). Fundamentals/theses on cold district heating (anergy networks)

Exergy and anergy

Excursus: meaning of the terms

Anergy is the non-working part of an energy. The magnitude of the anergy also depends on the thermal state of the respective environment.

The anergy indicates the maximum amount of mechanical work that could be obtained if a system in thermodynamic equilibrium with the existing environment were brought to a new equilibrium with an absolutely cold environment. Since this absolutely cold environment is not available, the anergy is not usable ("not able to work").
The opposite of anergy is exergy, which indicates the maximum amount of mechanical work that can be obtained with the participation of the environment when the system comes into thermodynamic equilibrium with the environment.

Thus, a system in equilibrium with the environment is not "without energy" but "without exergy" and still contains its anergy.

For systems that are above ambient temperature and pressure, it is usually stated in a simplified way:

Energy = Exergy + Anergy

It must be noted that both anergy and exergy are forms of energy. The distinction is made only on the basis of quality, i.e. ability to harness the energy.

The term Anergy

What does the physical term "anergy" actually mean?

The starting point is the familiar concept of energy. It is often described as the ability to do work. The 1st Law of Thermodynamics states that energy cannot be decreased or increased in a closed system, that is, without interaction with the environment. This is the law of conservation of energy for thermodynamic processes.

Exergy can be converted into any other energy. For us, of course, the convertibility into technical work is of particular interest. Electrical energy, for example, is pure exergy, if you will, because we can use it to power electric cars.

If we compare exergy with energy, we find that, unlike energy, exergy can indeed be reduced and even completely destroyed. Energy is known to be a conservation parameter, exergy is not.

Anergy is therefore the energy that has been completely destroyed and can no longer be converted into other energy. In a moving car, for example, this would be the friction between the tyres and the ground or the exhaust gas emitted from the exhaust pipe.

Anergy networks in combination with heat pumps

Definition of exergy and anergy in heating technology

Heating water with a temperature of 50 °C has a corresponding thermal energy, which can be used to heat a building, but only the heat with a temperature above room temperature. This usable proportion of heat is called exergy. Logically, the heat energy below room temperature cannot be used for heating the building. This unusable portion of the heat is referred to as anergy.

Energy is therefore always composed of a usable and unusable proportion of energy. Exergy is the usable portion of the energy with a temperature above the ambient temperature. Anergy, on the other hand, is the unusable part of the energy below the ambient temperature.

Energy
Invariable (constant)

=

Exergy
Variable (not constant)
Is converted into anergy

+

Anergy
Completely voided
No longer usable

Energy = Exergy + Anergy

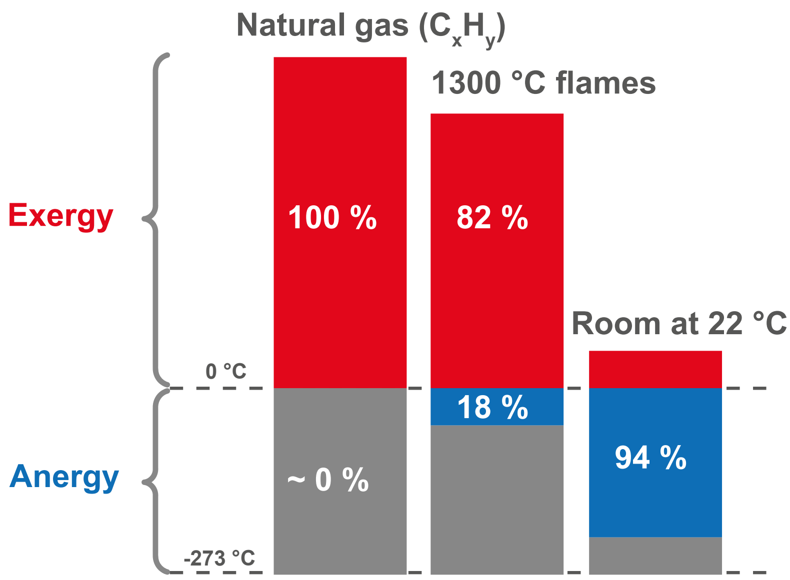
In contrast to energy, exergy is reduced during thermodynamic processes, and can even be completely destroyed. In heating technology, exergy is reduced or converted into anergy, for example, by heat losses, heat transfer in heat exchangers and mixing of heating and storage tank water in a buffer storage tank.

In principle, anergy cannot be converted into exergy.

Anergy ≠ Exergy

However, there is a technology in heating technology that does the trick of actually converting anergy into exergy:
The heat pump.

Heating with gas boiler



This means that 94 % of the exergy is lost! When using a gas boiler for building heating, natural gas is used as an energy source. This is a very high-value energy source with an energy content consisting of 100 % exergy. If natural gas is now burned in a gas boiler to generate heat, the combustion gas reaches temperatures of around 1300 °C. Part of the exergy is converted into anergy by heat losses (18 %). Finally, the heat of the combustion gas in the gas boiler is transferred to the heating water, and ultimately from the heating water to the room air. Overall, almost all of the exergy originally used is lost in this process (94 %). This is referred to as “exergy destruction”,

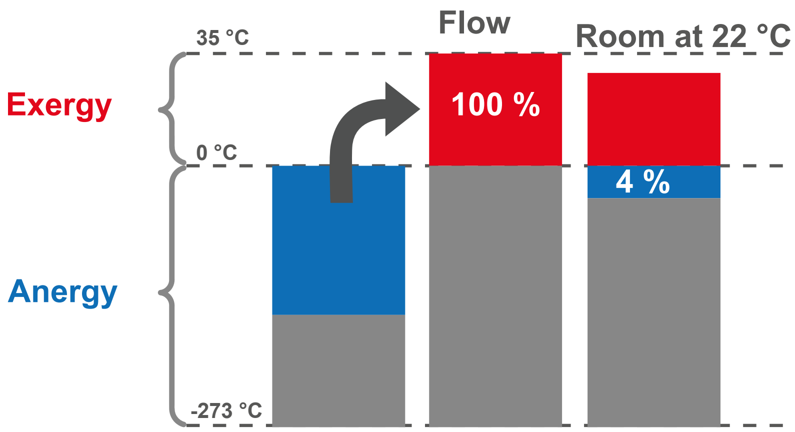
Heating with heat pump

Heat pump heaters (as well as other heat pump applications) take heat from a low temperature reservoir to produce usable heat at a higher temperature level. The low-temperature heat absorbed can be referred to as anergy.

Where only comparatively cold water is transported, heat losses are little or no problem.

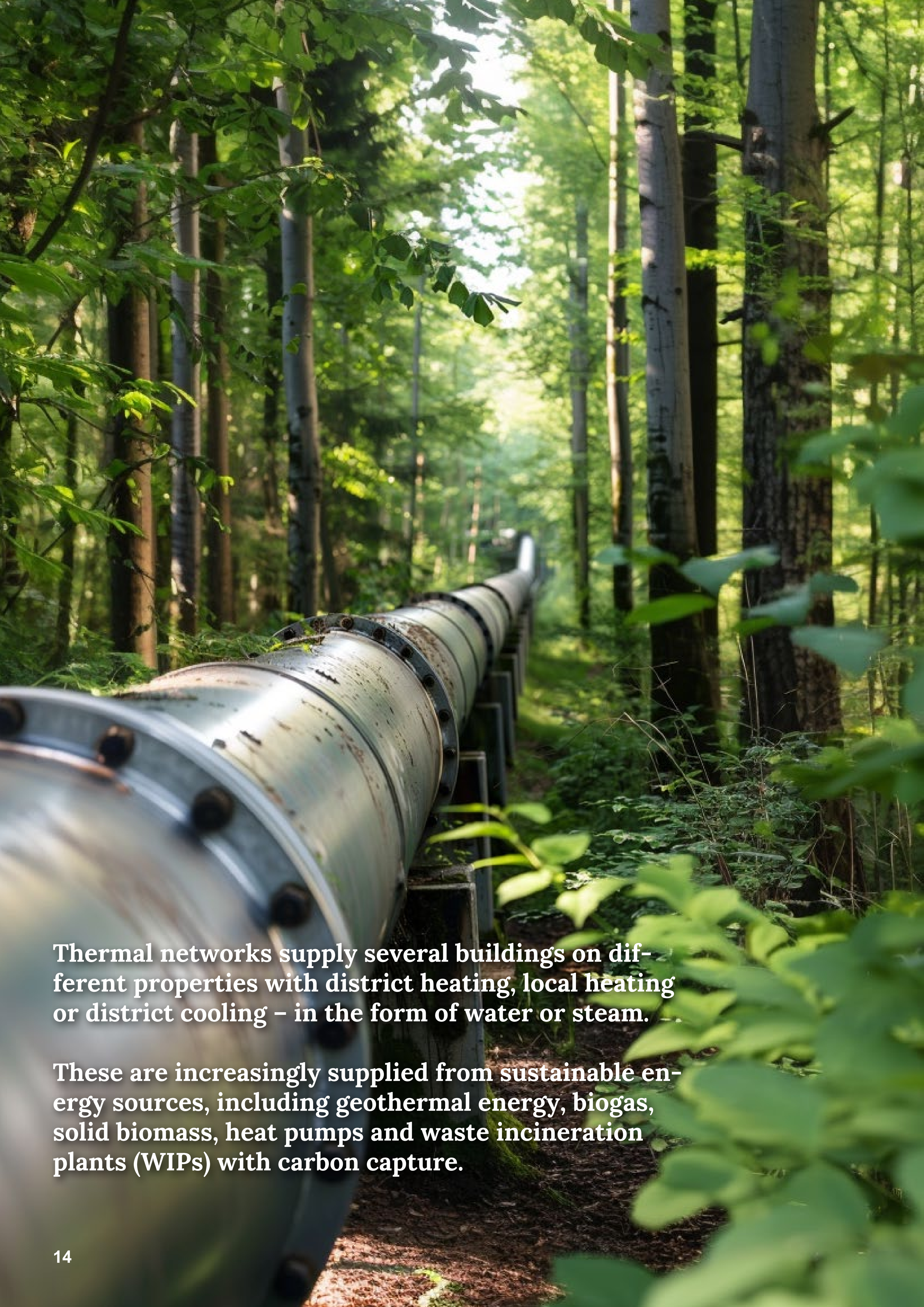
In small systems (without an anergy network), the anergy is taken from the environment in the immediate vicinity of the heat pump – for example, with the help of one or more geothermal probes or via an air/water heat exchanger from the fresh air.

In some cases, however, it makes sense to route the low-temperature heat through a network of pipes, usually covering only moderate distances of, say, a few hundred metres. Such a network of pipes is called an anergy network or cold local heating network. In principle, it works the same as a network for district heating or local heating, except that it is operated at a low temperature – not much different from ambient temperature: for example, at 10 to 15 °C. Consequently, the pipelines require little or no thermal insulation, which significantly reduces their cost; moreover, even longer lengths of pipelines are not a problem in this respect. On the other hand, due to the normally low temperature spread of such systems, a higher pipe cross-section tends to be required to achieve the high flow rate for a given output with a higher pump delivery. Frost protection must of course be ensured, for example by laying the pipes at a sufficient depth or by using a frost protection agent.



This means only 4 % of the exergy is lost!

As already mentioned, a heat pump can convert anergy into exergy. The heat pump uses heat energy from the environment and raises the temperature of this heat to a temperature level of the heating water of approx. 35 °C, which can be used for building heating. Finally, the heat from the heating water in the underfloor heating is transferred to the room air. 4 % of the exergy is lost or converted into anergy in this process. However, since no exergy was available at the beginning of the process, no exergy was destroyed overall.



Thermal networks supply several buildings on different properties with district heating, local heating or district cooling – in the form of water or steam.

These are increasingly supplied from sustainable energy sources, including geothermal energy, biogas, solid biomass, heat pumps and waste incineration plants (WIPs) with carbon capture.

Importance of thermal networks

Differences between heating networks and cold local heating

The main difference between classic heating networks and cold local heating networks is the operating temperature of the network: while classic heating networks are operated at flow temperatures of around 70 °C and more, the temperatures of cold local heating networks are around 5 to 35 °C. This means that the temperature level in cold local heating networks is not sufficient to transfer the heat from the network through heat exchangers into the building. Therefore, in cold local heating networks, a heat pump is installed in each building, which raises the temperature level of the heat. The different concepts are compared with one another above.

Anergy networks with geothermal power

In anergy networks, there is usually a lot of geothermal energy present. Such thermal networks offer interesting energy solutions for sustainable urban development.

Contrary to what the name suggests, anergy does not function "without energy", Rather, the principle is based on the recovery of the unusable portion of the energy into usable energy. In other words: the waste heat from one thing becomes the resource of something else. Anergy networks provide the ability to capture, store and redistribute energy. In most cases, a geothermal or other hydrothermal resource (sweet water, waste water cleaning system) is used.
The anergy network connects heating and cooling consumers. The concept allows simultaneous heat exchange between different consumers. Since they are connected to the same network, they have the opportunity to exchange their waste heat, which would otherwise go to waste. In anergy, the "energy losses" of one thing are converted into "energy gains" for something else. For example, an office building can be connected to nearby rental buildings. In summer, some of the heat given off by the offices can be fed into the network to meet some of the hot water requirements of the rental building. Likewise, the cold that is fed into the energy circuit in winter can be used to cool the server rooms in the administration building.

This type of recovery at the consumer level has actually been around for a long time. In old factories, water was taken from the mains to cool the parts being machined. The water discharged at 50 °C was then used for other industrial processes or to supply hot water for the employees' showers. The big change today is the development of the heating network infrastructure, which allows this potential to be exploited on a larger scale.

Which green energies have the most potential?

Lakes, rivers, groundwater and wastewater

Lakes, rivers, groundwater and wastewater offer the greatest potential for increasing renewable district heating production. Thermal networks are the only way to use these fixed and local energy sources.

They will be able to meet 30% of the heat demand in Switzerland with green energy by 2050, and thus avoid 10% of greenhouse gas emissions.

Geothermal

Medium-deep geothermal energy can also only be accessed via thermal networks, and not via individual solutions. The Swiss Association of Geothermal Energy estimates that this source can supply up to 8 TWh by 2050.

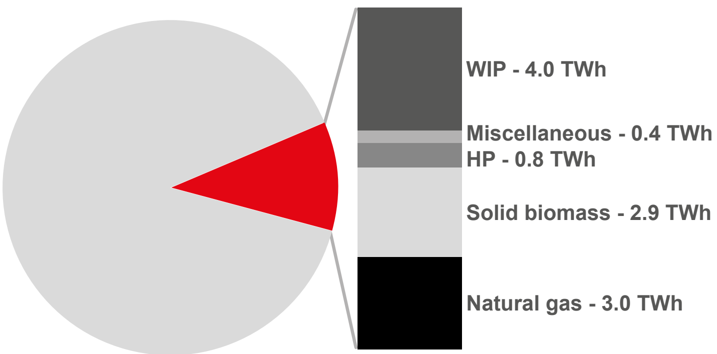
Waste incineration plants (WIPs)

One way to increase district heating production lies in making greater use of waste heat from waste incineration plants. The major importance of waste incineration plants can be seen in the energy mix of the thermal networks (see Figure 2): with 4 TWh per year, waste incineration plants now meet about 36% of district heating demand. Taking the most efficient Swiss waste incineration plant as a benchmark, the potential for usable waste heat from waste incineration plants is twice as high at 8 TWh per year. The increase in the heat potential does not come from an increase in the amount of waste – this is expected to remain constant over the next few years – but from an expansion of the heat networks and, associated with that, making better use of waste heat.

Heat demand 2021
104 TWh

Other heat sources

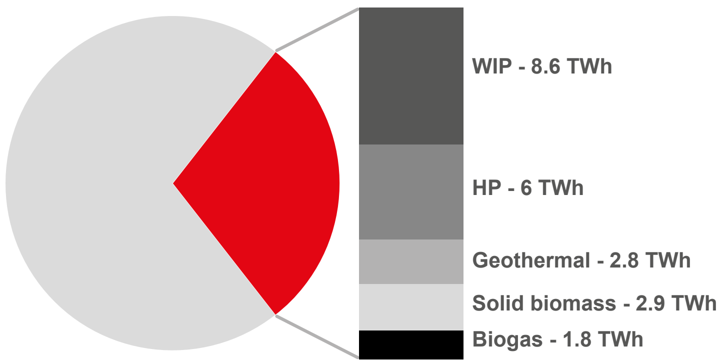
Thermal networks - 11.1 TWh/a



Heat demand 2050 (optimum scenario)
76 TWh

Other heat sources

Thermal networks - 22 TWh/a



Source:https://www.aquaetgas.ch/energie/fernw%C3%A4rme/20231003_ag10_wie-thermische-netze-zur-dekarbonisierung-der-schweiz-beitragen/

The four pillars of anergy

An anergy network includes one or more energy sources, the anergy circuit, heat pumps as well as intelligent control systems.

Energy source

In most cases, there is geothermal energy in the anergy network. But also sweet water from a lake or waste water can provide the heat.

Anergy network

The first step in creating an anergy circuit is to connect buildings together. This is done using two pipes through which the water circulates. Thus, all the buildings are connected to one another.

Heat pump

The anergy circuit is connected to heat pumps (water/water heat pumps) that use heat from the environment and make it possible to adjust the temperature level. It is therefore possible to connect one building with a temperature demand of 50 °C and another with a temperature demand of 30 °C to form an anergy circuit by adjusting the temperature setting of the heat pumps in each building.

Intelligent control systems

These enable the operation of an anergy network in the first place and are its brain.
One of the strengths of the anergy networks is the possibility of integrating different energy sources in the network. As long as the lines are connected, multiple resources can be fed in.
For example, in the anergy network there can be a geothermal centre that pumps water at a temperature of 50 °C, a waste water treatment plant that discharges purified water, and an industrial complex that discharges waste heat.
The network supports multiple sources of supply.

Another great advantage of anergy is the ability to control the different energy needs between buildings; this is not possible with a conventional heating network, which remains within the framework of centralised and unidirectional energy production. Each can benefit from the waste heat of the other. However, since the demand is not necessarily simultaneous, the geothermal resource can be used to store heat and cold. This is another advantage that should not be underestimated.

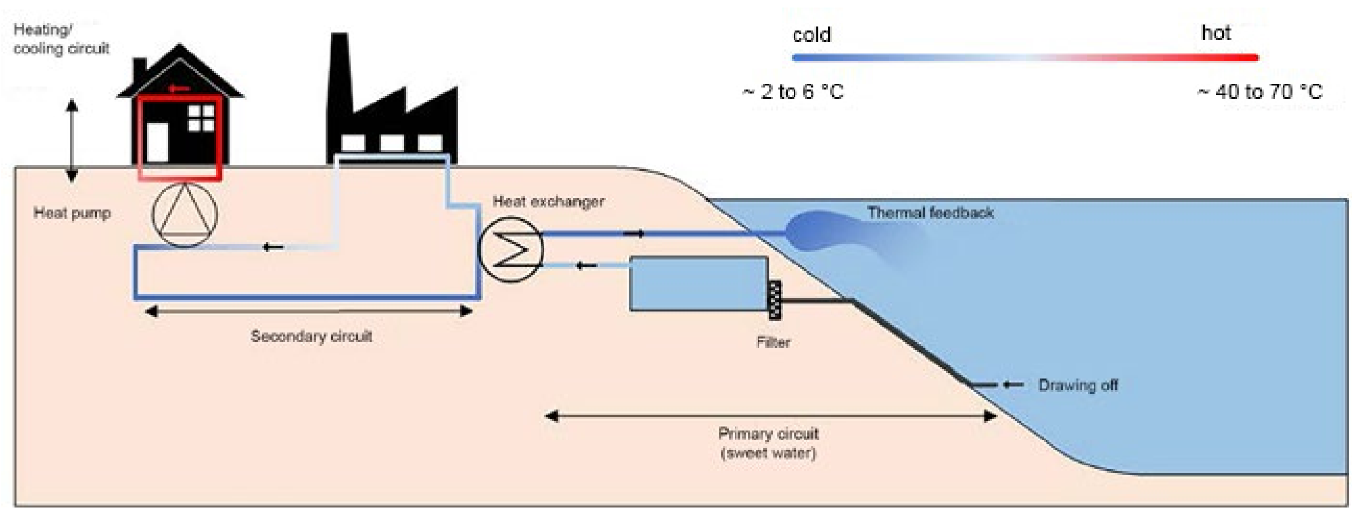
Relevant properties of lakes and flowing water

Mountain streams can be well suited for cooling use in summer due to their low temperatures. In winter, on the other hand, the temperature often drops below 3 °C, and their rate of flow is low. They are therefore not suitable for heat extraction in winter.

Lowland rivers are particularly suitable for heat extraction, as they also have a sufficient rate of flow in winter, and the temperatures hardly drop below 4 °C. They are less suitable for heat introduction in summer due to the high temperatures. In particular, below low-lying lakes or in slowly flowing rivers, the temperature in summer increasingly exceeds the legal limit value* for a use of 25 °C. This leads to limitations and reduced efficiency in the use of cooling.

The operation of a plant is impaired by growth of organisms such as algae, bacteria or crustaceans, and crust formation. This needs to be taken into account when designing a plant. The growth or organisms is promoted by warm, nutrient-rich water. This generally speaks against extracting water from the surface of lakes. Filters are usually necessary to limit growth and thus operating costs.

The surface layer of lakes is used for many purposes. They are more biologically active and have very variable temperatures. Therefore, as a rule, no water should be withdrawn from lakes at depths of less than 15 m. For cooling uses, it is advantageous to plan the extraction below 30 m. Depths of 50 to 70 m can be ideal for plants that require continuously low and stable temperatures. However, higher temperatures can occur temporarily in large lakes, even at such depths, as a result of autumn storms. This needs to be taken into account when planning a plant.
When selecting locations, existing water extraction and return points as well as other uses (e.g. protected areas) must be taken into account. Nearby thermal and sewage discharges could interfere with operation.



Based on source: Gaudard et. al (2018): Thermal use of lakes and rivers

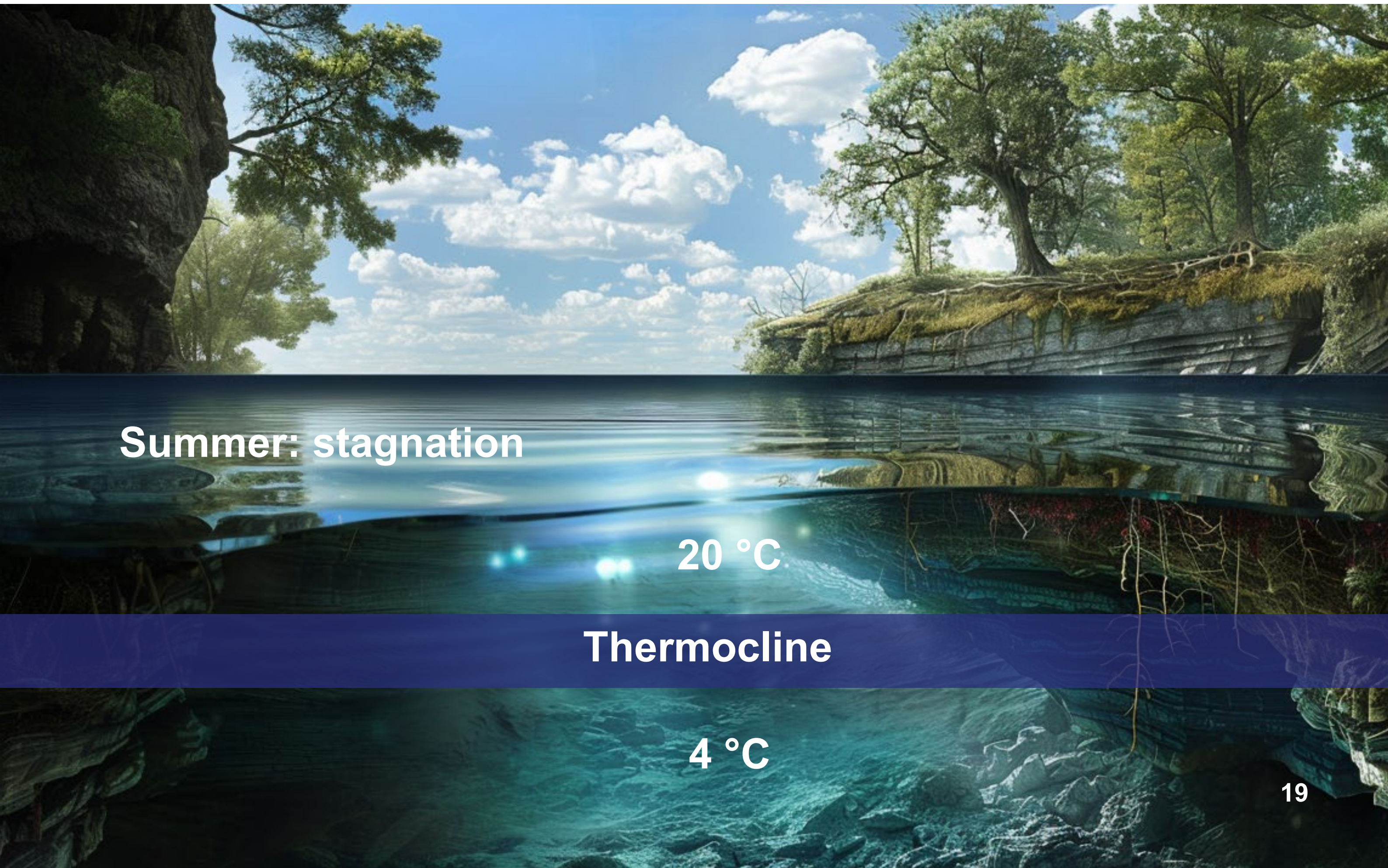
Thermal use of lakes and rivers

The extraction of heat or cold from a lake or river requires a water intake, a primary circuit in which the sweet/river water circulates, and usually a secondary circuit that brings the heat transfer fluid to the user. Heat pumps are used for heating, and the heating fluid normally circulates in a tertiary circuit which can be either central (a single circuit for all users) or decentralised (one circuit for each user). Heat exchangers allow heat transfer between the different circuits.

Thermal use is associated with the return of heated (when cooling) or cooled (when heating) water. This thermal return often takes place in the same body of water from which the water was previously taken. The temperature influences physical, chemical and biological processes in the water.

The image above shows a system for thermal use from a lake. In this example, sweet water is used to cool an industrial plant in a decentral-ised manner, and then to heat a house. Here, the heating is dominant and therefore the returned water is colder than the sweet water.

* In Switzerland



Importance of district cooling and anergy networks

In the context of global warming, the use of district cooling networks for cooling buildings has increased markedly, especially during the increasingly hot summer months. By extracting heat from the buildings with district cooling, the temperatures in the buildings decrease. Depending on the flow temperature of the district cooling network, the buildings are supplied either directly or with water additionally cooled by a heat pump. In industrial processes or in data centres, this type of cooling via district cooling or anergy networks is increasingly being used. In all these applications, the heat extracted from the buildings flows back into the district cooling network via a return line. There, this heat is either available for the heating needs of other connections, or it is recooled by a body of surface water (lake, river, ...).

Closed or open construction

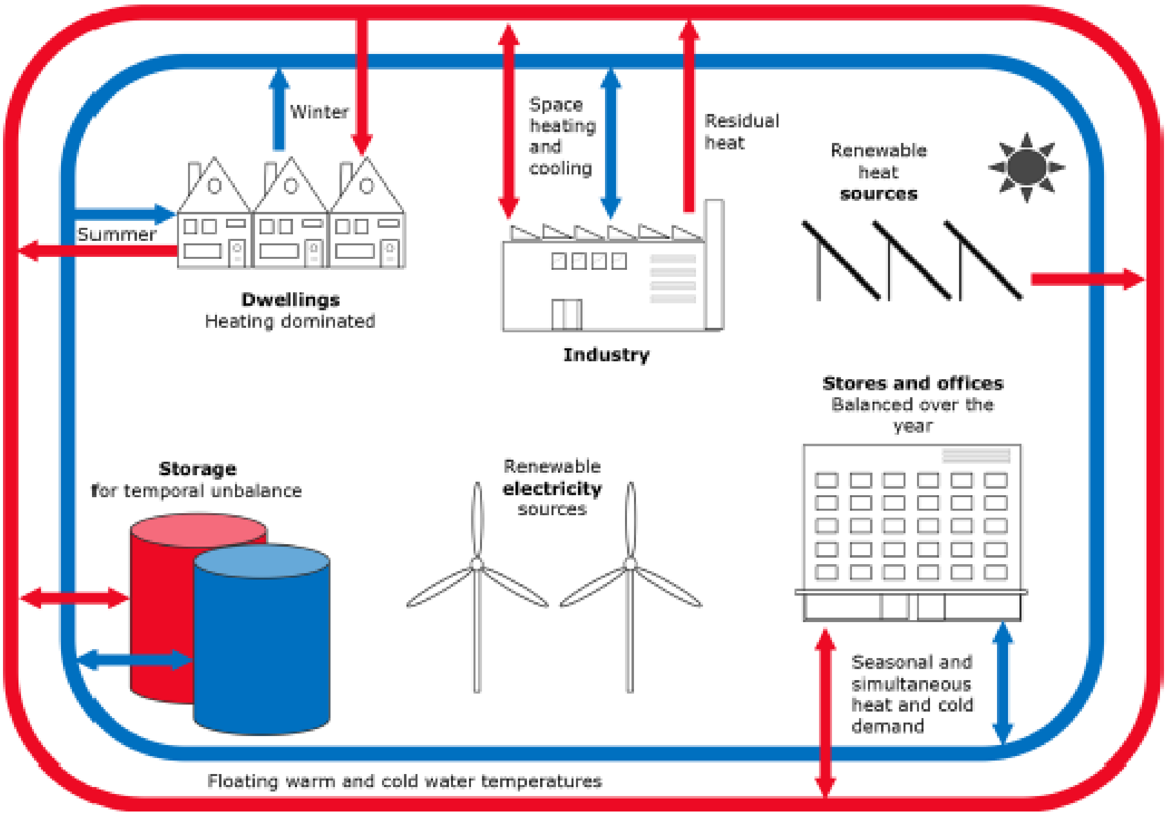
When it comes to using bodies of surface water for district cooling and anergy networks, a distinction is made between closed and open systems. In closed systems, the water extracted from bodies of water is returned to the environment at the same point after thermal use. In contrast, in open systems, water taken from the environment flows directly through large parts of the district cooling or anergy network. The place of return is often far from where it was collected.

Service life of infrastructure buildings

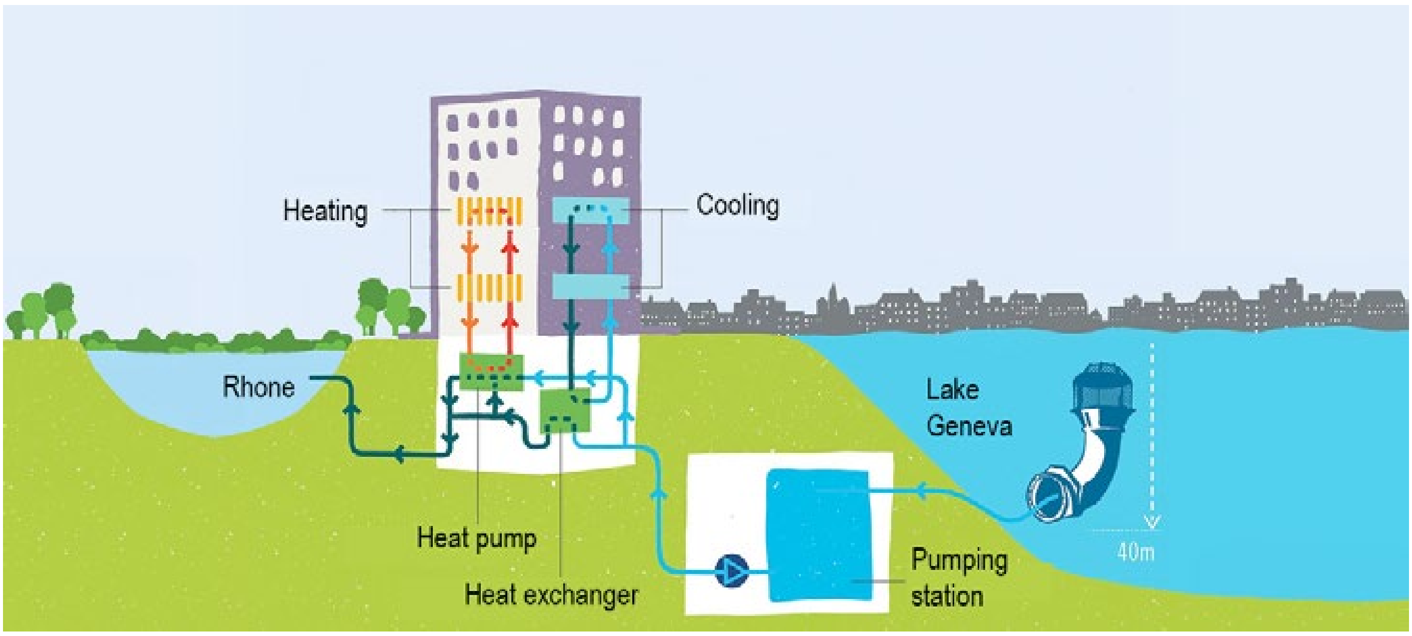
Due to the low temperatures in district cooling and anergy networks (< 30 °C), materials are often used that are also used in the drinking water supply, e.g. polyethylene pipes or ductile iron pipes.

District cooling and anergy networks are infrastructural structures with a long payback and service life. Decisions made by network owners and operators during the construction phase have an impact over the entire lifetime of the network: 40, 50 or sometimes even more years.

In order to ensure the long-term sustainable, reliable, safe and profitable operation of district cooling and anergy networks, important decisions are taken in the planning and construction phase: from the definition of the network topology and the operating parameters to the selection of materials, the technologies used and measures to ensure professional implementation. All this is done in compliance with budget, schedule and quality requirements, and in strict compliance with national and international standards.



By Stef Boesten, Wilfried Ivens, Stefan C. Dekker, Herman Eijdems - Stef Boesten, Wilfried Ivens, Stefan C. Dekker, Herman Eijdems: 5th generation district heating and cooling systems as a solution for renewable urban thermal energy supply. Adv. Geosci., 49, 129–136, 2019. https://doi.org/10.5194/adgeo-49-129-2019, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=92036189



https://www.swisscommunity.org/de/news-medien/schweizer-revue/artikel/auch-seen-werden-kuenftig-unsere-gebaeude-kuehlen-und-heizen

Structures of anergy networks

Network topology

There are also systems with more than two pipes that provide several different temperatures to serve plants with different ideal temperatures effectively.

1-pipe system

A 1-pipe system consists exclusively of a flow for media transport. The return, i.e. the return of the water to the environment, occurs in an open system, e.g. soakaway, body of surface water, storm drain.

2-pipe system

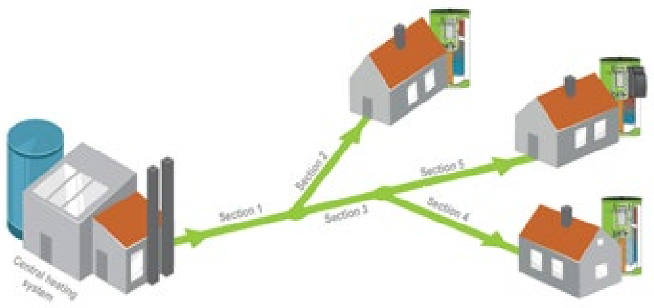
Most energy networks, or what are called “anergy networks", have 2 pipes, i.e. a supply and a return (closed system). In a heating application, the return has a lower temperature than the flow, while in a cooling application this is reversed.

3-pipe system

A 3-pipe system has an additional pipe with a different temperature level, e.g. above 35 °C. If there is a consumer, e.g. an underfloor heating system, at this temperature level, this heat can be used directly via a heat exchanger without using a heat pump. Analogous to heating, the 3-pipe system can also be designed for cooling purposes at a low temperature level.

4-pipe system

In a 4-pipe system, four pipes are operated at different temperatures. For one thing, this enables direct heating and cooling by means of heat exchangers and, for another, it supports the energy supply system with heat pumps / chillers. This network topology achieves the highest exergetic efficiency.



https://www.pressebox.de/pressemitteilung/enerpipe-gmbh/Waermenetze-im-Neubaugebiet-Auswirkungen-des-Primaerenergiefaktors/boxid/832371

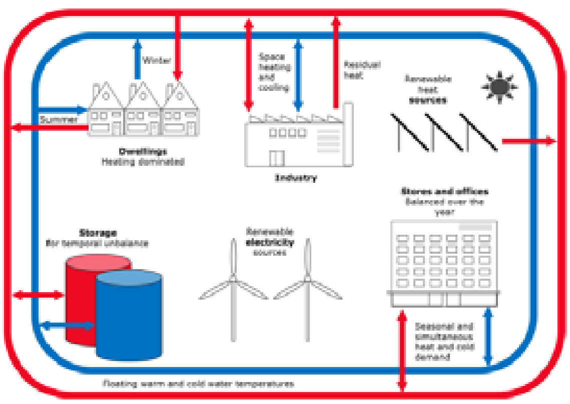
Mixed network forms

When networks are named with the terms unidirectional and bidirectional, we consider the energy flow in the respective network.
Depending on the usage characteristics of the consumers, an anergy network can function as a unidirectional network (only heat supply in winter) or as a bidirectional network (simultaneous room cooling and hot water supply in summer).

Unidirectional network

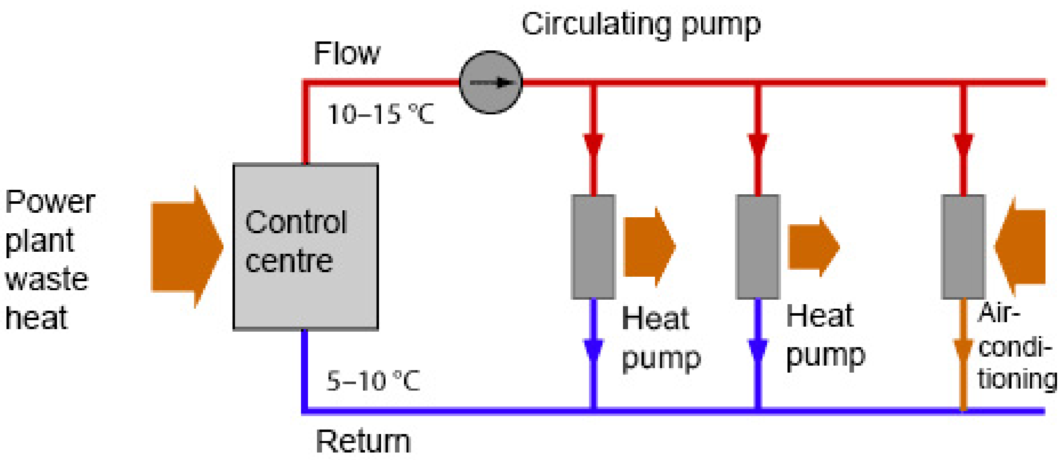
In relatively simple cases, a unidirectional network can be used (see figure). Here, a central station (heating centre) feeds a "warm pipe" with a temperature of between 10 and 15 °C, for example. The circulation is provided by a central pump. The individual heat consumers draw water from the flow line and discharge it cooled into the return line. Systems that supply heat, on the other hand, also draw water from the warm pipe, but discharge it at a higher temperature into the return line. The central station must ensure that the flow temperature remains within the designated range even if the withdrawals or feeds fluctuate. Heat meters are used for billing purposes.

Bidirectional network



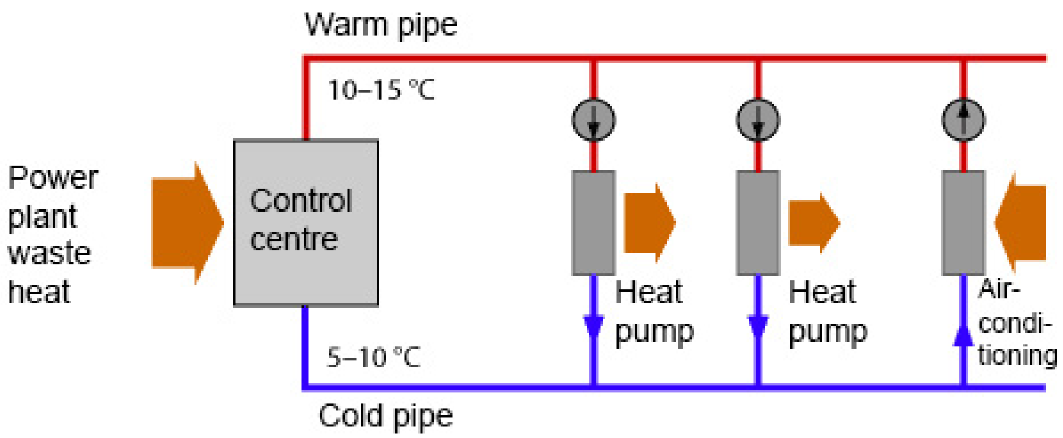
A bidirectional system (see figure) with a warm pipe (e.g. 12 to 18 °C) and a cold pipe (e.g. 8 to 16 °C) is suitable for an anergy network with several connected plants that extract or feed in heat, for example in an industrial area. (A system with ring lines can also be implemented, as a deviation from the figure). In this case, the heat consumers take water from the warm pipe and feed it cooled to the cold pipe, while feeders (e.g. cooling systems) take water from the cold pipe and feed it heated into the warm pipe – in each case with separate pumps. This approach provides a higher exergetic benefit, since the heat-emitting plants can be supplied with a significantly lower temperature than the heat-receiving ones. Again, the central plant must maintain the energy balance to keep the warm pipe and cold pipe temperatures within the designated ranges. After all, it is usually impossible to guarantee that the decentralised feed-ins and withdrawals of heat will balance one another out at all times. A large heat pump, for example, is suitable for this task. It can operate with a very high coefficient of performance due to the relatively low temperature difference.

Directed networks



In a directed network, a central main pump is installed to deliver the medium to the individual building control units. Placing the pump near the heat source or sink means that all consumers draw from the same pipe (flow). Every traditional district heating network is designed as a directed network according to the current rules of building technology, since the flow of energy and thus the flow of media always leads from the generating centre to the heat consumers.

Non-directed networks



In a non-directed network, a decentralised feed pump is installed at each consumer to deliver the medium to the respective building control unit. Here, the installation or switching of the pumps determines the media flow in the network. The direction is determined to the extent that the cold is drawn from the cold pipe and the heat is drawn correspondingly from the warm pipe. A non-directed flow of media occurs in the ring line due to the changing withdrawal points of the pumps.

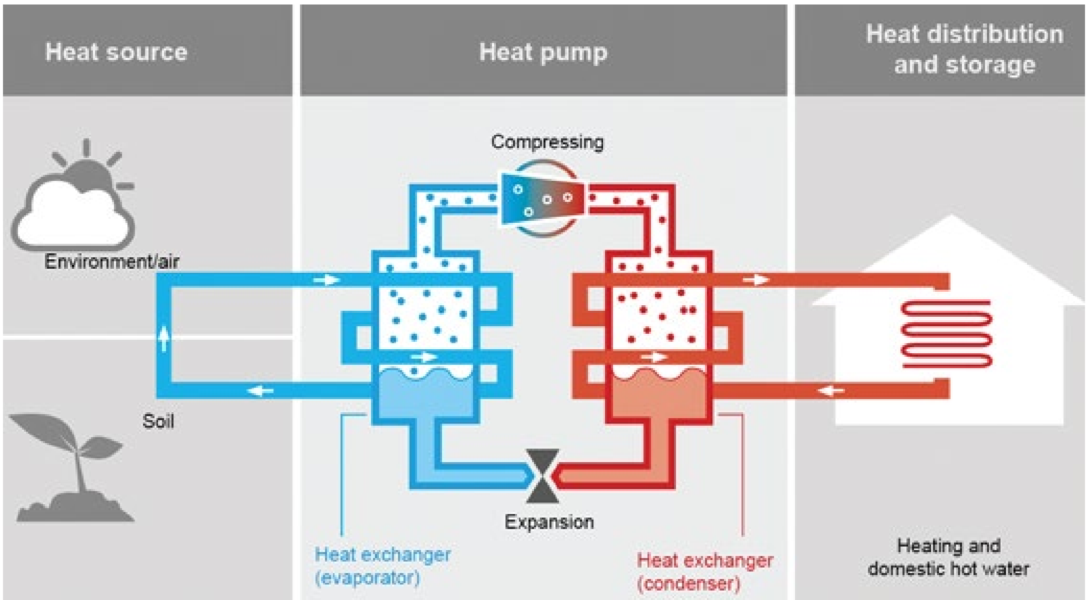
Maintaining the respective temperature ranges in the non-directed network of warm and cold pipes results in an exergetic advantage compared to a directed network. Mixing losses are reduced in the non-directed network.

Central/decentralised heat generation

In addition, it goes without saying that the higher the temperature of the distribution lines, the higher their energy losses, and thermally insulated lines are considerably more expensive. Waste heat feeds are also much more difficult to implement at higher temperatures. On the other hand, the investment costs for a central heat generator tend to be lower.
There are also solutions that represent a compromise between the two approaches. It is possible to run a heating network with a relatively low temperature of 30 °C from a central heating heat pump. The temperature is then sufficient only for heating purposes, and the higher temperatures needed for domestic hot water are provided by additional decentralised water/water heat pumps. This approach achieves efficient heat supply in combination with moderate heat losses in the (thermally insulated) distribution network.

Anergy networks with network operator

Like conventional heating networks, anergy networks do not necessarily have to be operated by the heat consumers; Instead, they may be operated more efficiently by a separate network operator that does not own the property and sells the provision of anergy to the individual consumers (at a cost per kilowatt-hour that is far lower than that for heat at higher temperatures). The decentralised heat pumps can either be installed and operated by the same grid operator or by the decentralised consumers. Certain operating conditions are agreed upon, especially concerning the temperatures of the flow and return, the flow rate and the permitted pressure drop. A fundamental question is also whether complete system separation with the aid of heat exchangers will be implemented in the interests of greater operational reliability.



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Possible alternative to central heat generation

Anergy networks offer some enormous advantages over conventional heat distribution networks. The additional costs for decentralised heat pumps can easily be compensated by savings elsewhere, and the often much lower operating costs.

Such a system stands in competition with a conventional system with centralised heat generation, and distribution of this heat at a higher temperature level. The advantages and disadvantages of these approaches must be sensibly weighed up against one another on a case-by-case basis. For example, one disadvantage of centralised heat generation is that the temperature must be sufficient for the consumer with the highest temperature requirements, but the other consumers are then supplied with an unnecessarily high temperature. This reduces the possible energy efficiency, especially when providing heat with a heat pump. In addition, the higher the temperature of the distribution lines, the higher their energy losses, and thermally insulated lines are considerably more expensive. Waste heat feeds are also much more difficult to implement at higher temperatures. On the other hand, the investment costs for a central heat generator tend to be lower.

There are also solutions that represent a compromise between the two approaches. It is possible to run a heating network with a low temperature of 30 °C from a central heating heat pump. The temperature is then sufficient only for heating purposes, and the higher temperatures needed for domestic hot water are provided by additional decentralised water/water heat pumps. This approach achieves efficient heat supply in combination with moderate heat losses in the (thermally insulated) distribution network.

There are old heat distribution networks with insufficient thermal insulation, which can subsequently be converted into low-temperature or energy networks, in which case decentralised heat pumps must be installed. The problem of heat losses in the pipes is thus eliminated, and the pipes remain usable in the long term. However, the transported power can decrease during the changeover due to the temperature spread usually being lower; this can be a problem in networks where the dimensions are tight.


Hoval

Advantages and disadvantages of anergy networks – cold networks

The potential benefits of using an anergy network depend on the particular circumstances:

In the simplest case, for example, a geothermal probe is located some distance from a heat pump, and a simple unidirectional pipe network with flow and return lines connects them. This makes it possible to use a slightly more distant heat source, for example, if for some reason a geothermal probe or ground water well can not be implemented directly at the location of the heat pump.

The cooling load can be evenly distributed among several geothermal probes.

It is also possible to use several geothermal probes, or also different heat sources, for example the use of ground water or waste water from industrial structures, other commercial buildings or even residential buildings. (In many places, substantial quantities of such waste water are available at a temperature level not far below 20 °C). In this case, the ability to distribute the cooling load evenly among several sources can be useful, regardless how the heat quantities extracted are distributed amongst the various heat pumps.

Decentralised heat pumps can supply individual consumers with the temperatures they need.

Several decentralised heat pumps, which may have different outputs and temperatures of useful heat, can be used. For example, heat pump heating systems can provide the majority of the heat with a relatively low flow temperature (e.g. 30 °C for underfloor heating), while smaller amounts of heat at a higher temperature level are required for water heating. Sharing, for example, a ground water well for multiple heat pumps can be significantly less expensive than constructing a well for each heat pump.

Waste heat from various sources can also be fed in decentrally.

Where there are sources of waste heat in the area of the network (e.g. decentralised power plants, air conditioning units, chillers or other industrial plants), these can feed the waste heat directly into the anergy network instead of releasing it into the air, e.g. with recoolers. For one thing, this can reduce the effort required to dissipate the heat (also improving the energy efficiency of chillers); for another, it can allow the heat to be reused elsewhere. Ideally, the various withdrawals and feeds of heat will roughly balance one another out on an annual average, so that only relatively small amounts of heat will have to be supplied from outside or discharged to it. Fields of geothermal probes, for example, are suitable for seasonal intermediate storage.

Air-conditioning systems may even get by without a chiller if the network temperature is sufficiently low – especially in the case of large-area temperature control, e.g. with cooling ceilings.

Solar thermal can help balance the seasonal heat load.

Solar thermal can also be used where there is a net heat demand. Because of the low temperature, low-cost and low-temperature solar collectors can provide very high annual yields. The at least temporary additional heat input from the collectors can prevent the temperature in geothermal probe arrays from dropping too much due to excessive heat extraction. At the same time, photovoltaics can generate part of the electrical energy for heat pumps and water pumps.

Compared to conventional heating networks with a central heat generator (e.g. a large oil-fired boiler), conversion to an anergy network often allows large energy savings and, above all, an enormous reduction in climate-damaging CO_2 emissions – in some cases by the factor of more than 10.

Advantages of cold local heating

- Cold local heating networks can provide both heating and cooling.
- Low-temperature waste heat sources, such as heat recovery from waste water or from cooling applications, can be utilised without raising the temperature further.
- Environmental heat can be used as a heat source. This includes ambient air or bodies of water such as lakes or rivers.
- Due to the low network temperatures, there is almost no heat loss from the pipe to the ground. In addition to distributing heat, uninsulated pipes also serve as ground collectors to extract heat from the surrounding soil.
- The use of decentralised heat pumps represents a strong coupling between the heat and power sectors, and increases flexibility with respect to the electrical power grid.
- Heating and cooling demands can be partially offset by a cold local heating network. This reduces the heat and cold input at the energy centre.
- The construction costs for the heating network are much lower when using uninsulated plastic pipes than with conventional heating networks.
- The laying of the heating network can be combined with other infrastructure (electrical and fibre-optic cables), which greatly reduces the cost of ground works.
- Installing a central probe field is more cost-effective than installing many decentralised probe fields.
- Due to simultaneity effects (peak load reduction in heating networks), the required number of geothermal probes and/or their depth is reduced.
- By using a heat pump in each building, the flow temperature of the cold local heating network (unlike conventional heating networks) is no longer dependent on the required flow temperatures of individual buildings (exergetic refinement of the heat at the consumer).
- Systematic monitoring of each heat pump can ensure high coefficients of performance (efficiencies).
- Purchasing decentralized heat pumps in bulk as well as a uniform installation scheme in all buildings leads to cost reductions.
- Consumers can be connected to the cold local heating network on an ongoing basis. Cold local heating networks are therefore easier to expand in a modular way.
- Consumption-dependent costs are incurred by the customer (electricity costs of the heat pump in the building).
- The electricity self-generated by PV systems can be used in the building to operate the heat pump.
- No local emissions (particulate matter, exhaust gas, noise) are generated.

- No storage space for fuel (heating oil, pellets or wood chips) is necessary.
- Heat supply is rendered more and more ecological with an increasing share of renewables in the power grid, and automatically reaches full sustainability together with the electrical power grid.

The advantage, however, is that plastic pipes are cheaper compared to plastic sheath pipes (PSP) made of steel. As a result, slightly larger pipe diameters can be selected for plastic pipes at the same cost. Since the pumping work decreases with the fifth power of the pipe diameter, cold local heating networks consequently do not have significantly larger pumping capacities than conventional heating networks.

Disadvantages of cold local heating

The system control of cold local heating networks is more demanding, since heat pumps (and possibly network pumps) are installed and operated on a decentralised basis in the buildings.

The mass and thus flow rates in cold local heating networks are higher compared to conventional heating networks. This is the result of the small temperature differences across the evaporators of the decentralised heat pumps and the associated smaller temperature differences between the warm and cold pipes of the network.

The heat transfer stations in the buildings are more expensive, as they include heat pumps.

Although a large number of cold district heating networks have already been built, there is often a lack of planning and operating experience.

By connecting to a heating network, customers are tied to the heating network infrastructure for the long term.

General planning aspects

Which heating network type for which area?

The choice of the right type of heating network depends on several factors: If the consumer buildings are to be supplied with heating and cooling, a cold local heating network is suitable, as this can be operated at such low temperatures that cooling requirements can also be covered.

A basic advantage of cold local heating networks is that in the event of simultaneous heating and cooling loads in the area, these demands can be partially offset by the network.

This can be particularly lucrative for operators, as they can sell cooling to cooling customers at the same time as selling the resulting waste heat to heat-consuming buildings.
Another important aspect for selecting the right type of heating network is the temperature level of the heat source. If only heat sources at ambient temperature (< 30 °C) are available, this means a cold local heating network should be favoured. Classical heating networks, on the other hand, are clearly preferable if heat sources with a high temperature level are available (> 50 °C), since in this case no further temperature increase (in decentralised or centralised heat pumps) is necessary.

For heat sources at ambient temperature, both types of heating networks can be useful in principle. The advantage of classical heating networks is that a large heat pump can be installed centrally, which is cheaper to implement than many small heat pumps.

However, the advantage of a cold local heating network is that there is hardly any heat loss in the pipe network due to the low temperatures (in some cases, heat gains can even be achieved if the surrounding soil has a higher temperature than the heating network). In addition, inexpensive (possibly even uninsulated) plastic pipes can be used for cold local heating networks.

This compensates for the additional costs of larger pipe diameters, which are necessary due to higher flow rates in cold local heating networks. The high flow rates result from the low temperature spread between the warm and cold pipes, which in turn are the result of a low temperature difference across the evaporator of the decentralised heat pumps.

What do these differences mean for planning?

The calculation for cold local heating networks is more complex than the calculation for ordinary heating networks. For one thing, the decentralised heat pumps in the buildings must also be considered. For another, the balancing effects of heating and cooling requirements in buildings and in the heating network must be considered. In particular, this means it is no longer sufficient for cold local heating networks to consider only peak loads and annual energy quantities. Rather, it is necessary to use annual profiles broken down into hourly units for the calculation, in order to properly represent the balancing effects.

Initial situation

Thermal networks make it possible to distribute heat over a large area and to use local renewable energies in a targeted manner.

The prerequisite for operating a thermal network profitably is sufficient heat dissipation in the supplied area or the presence of a very low-cost, high-quality energy source.
Until now, thermal networks have mainly been fed by energy sources such as waste heat from waste incineration plants, combustion of fossil fuels, and increased biomass. The potential of environmental heat such as ground water, sweet and river water as well as geothermal heat, or the potential of industrial waste heat and waste heat from refrigeration processes is still great, and it should be further expanded in the future.

The temperatures of these sources are often close to the ambient temperature. A corresponding temperature difference due a heat pump is required for the heating and treatment of domestic hot water.

Heat pumps are considered a key technology for future heat supply. Until now, most of them have been used to supply heat to single-family homes or blocks of flats. Due to the variety of available waste heat and environmental heat at different temperature levels, and the increased supply via thermal networks, there will be a variety of possible applications for heat pumps in the future, in different performance ranges, and for different temperature differences.
For example, heat pumps above 100 kW are required for very high temperature rises (> 60 K) or very low temperature reductions (< 4 K). The use of sources at relatively high temperatures will also be increasingly in demand.

Efficiency and cost effectiveness

Due to the ever higher structural engineering standards of buildings – better insulation and installation of underfloor heating – lower flow temperatures are required for the room heat, and accordingly the potential for sensible, economic and ecological integration of heat pumps in thermal networks increases; this is because the lower the flow temperatures, the higher the annual operating coefficient of the heat pump.
The efficiency or coefficient of performance (COP) of a heat pump is inversely proportional to the temperature difference between source and sink according to the Carnot efficiency.

For heating purposes, a temperature difference of around 25 K is often required with a water/water heat pump: a source such as ground water is at 10 °C and heat is generated at 35 °C (underfloor heating). The heat pumps then have a COP value of around 5.
As can be seen from the figure above, the lowest possible necessary flow temperatures should be selected for heat pump systems. Especially with temperature differences of less than around 50 K, a noticeable loss of efficiency is apparent per additional Kelvin of increase.

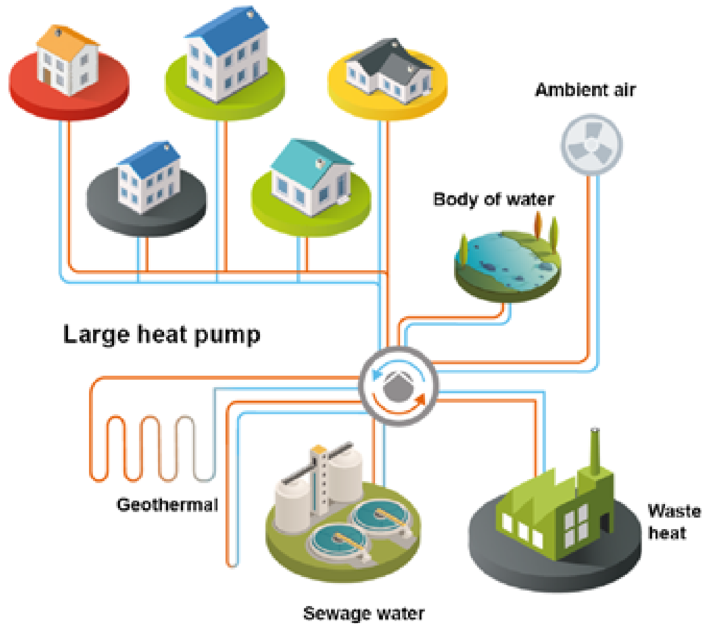
Energy generation	Fossil	Biomass	Heat pump
Investment	++	0	--
Operating and maintenance costs	+	+	++
Energy costs	++	+	+
CO_2 emissions	--	++	++
Efficiency	0	0	++

Tab. 1: Quality comparison between three heating systems (++) positive, (−) negative, (0) neutral properties

Table 1 shows that the biggest disadvantage of the heat pump is the initial investment, especially for brine/water or water/water heat pumps. On average, such a heat pump costs around three times more than a fossil-fuel boiler. Otherwise, the heat pump performs better or equivalent in all areas than fossil-fuel or biomass-fired heating systems, especially in terms of operating costs, efficiency and environmental impact.

Range of possible applications

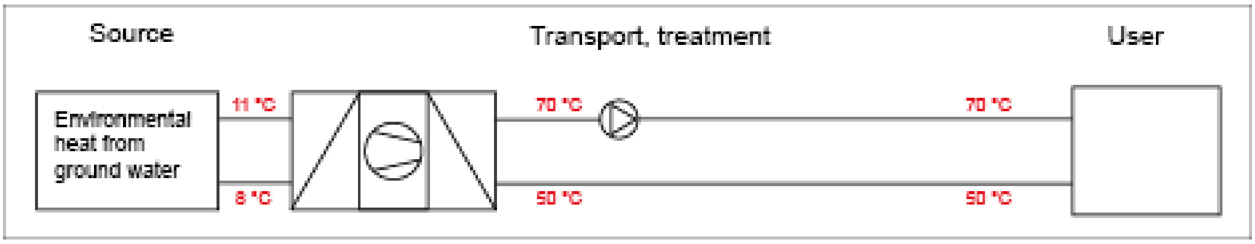
Heat pumps can be used in different ways in thermal networks, either centrally at the heat source or de-centrally at the customer. Possible applications are shown in simplified form below.



https://www.gruene-fernwaerme.de/gruene-fernwaerme/erneuerbare-energien/gross-waermepumpen

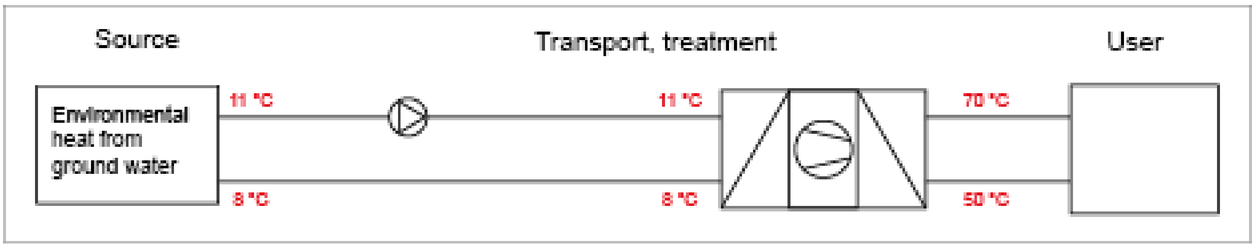
Central

In a high-temperature network, the heat pump is arranged centrally. It therefore provides the heat centrally at the required high temperature level.



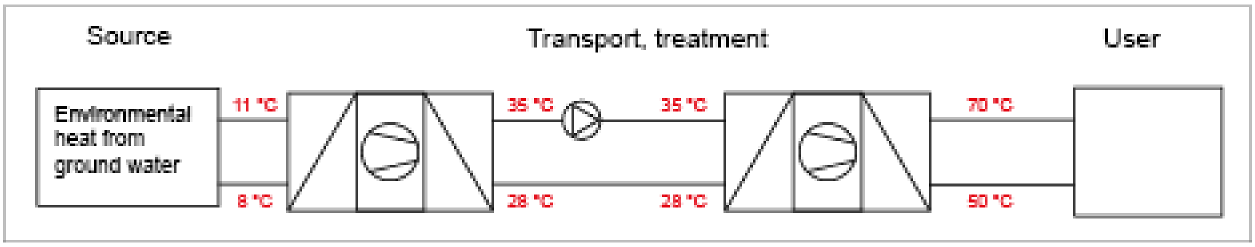
Decentralised

In a low-temperature network, the heat pumps are arranged decentrally. The individual heat pump is designed for one or a few users. From the point of view of the heat pump, the situation is comparable to a “normal” configuration for a building in which the network plays the role of the heat source.



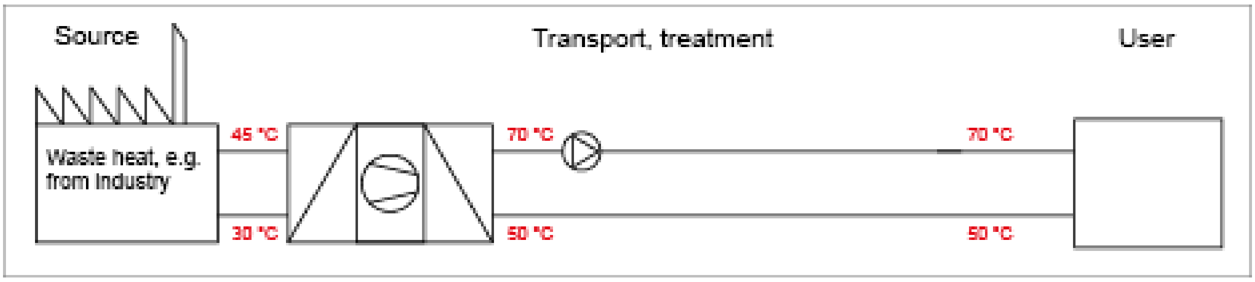
Centralised/decentralised (booster system)

A hybrid arrangement is also possible, in which a first heat pump centrally generates a difference of 35 °C for the building heating, while other heat pumps heat the domestic hot water decentrally.



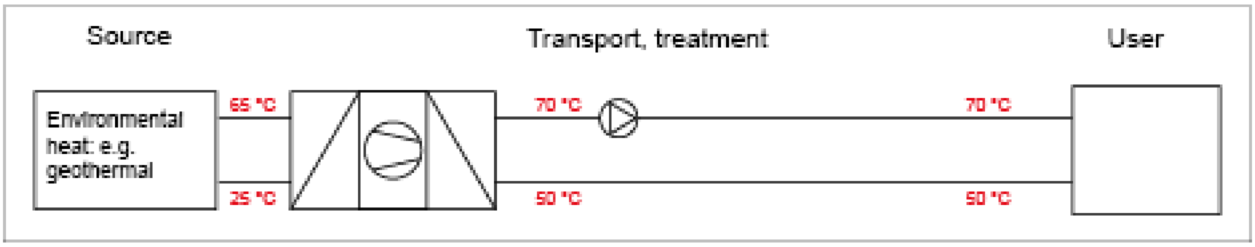
Waste heat utilisation

Heat production of industrial waste heat takes place at around 45 °C via a central heat pump.



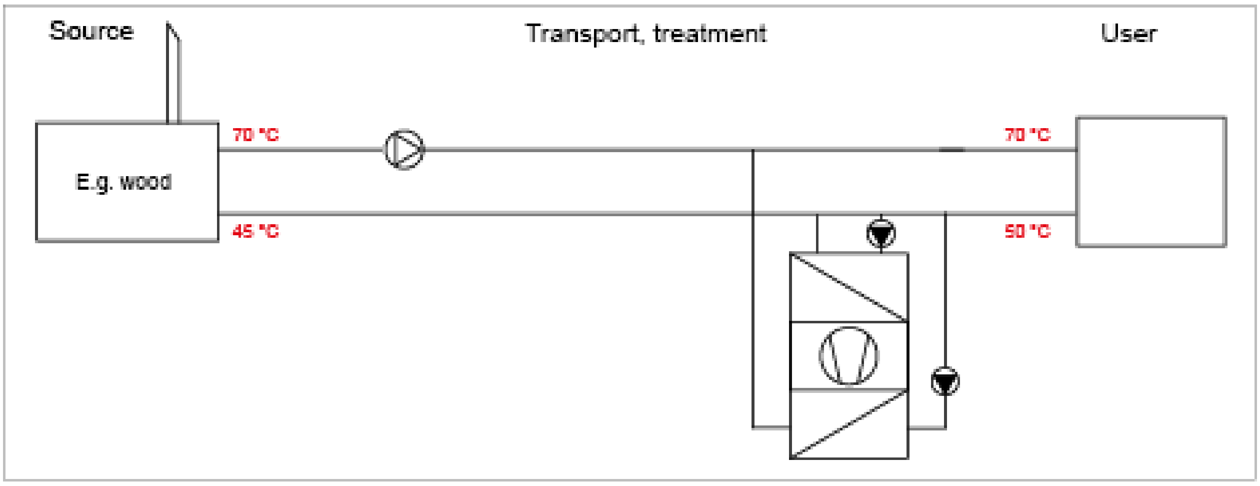
Temperature increase

Central temperature difference with an existing plant, so that the last customer still receives a temperature of a sufficient level at the end of the line. Possible applications, for example, in deep geothermal or solar thermal energy.



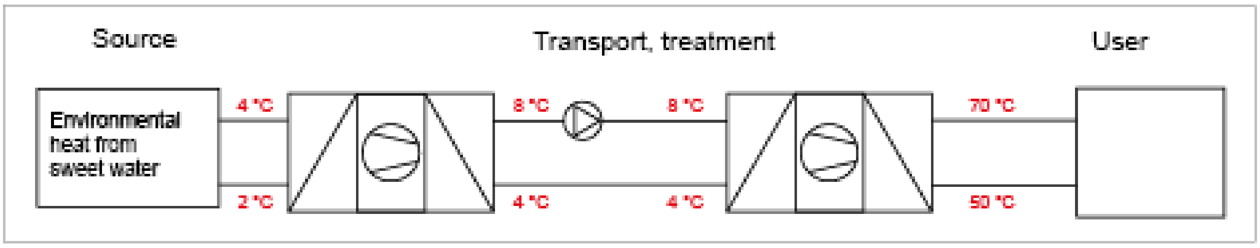
Capacity increase

The return temperature is lowered via a decentralised heat pump. This results in greater temperature spread and thus fewer distribution losses, as well as increasing the efficiency of the existing system (e.g. wood) thanks to better condensation of the flue gas.



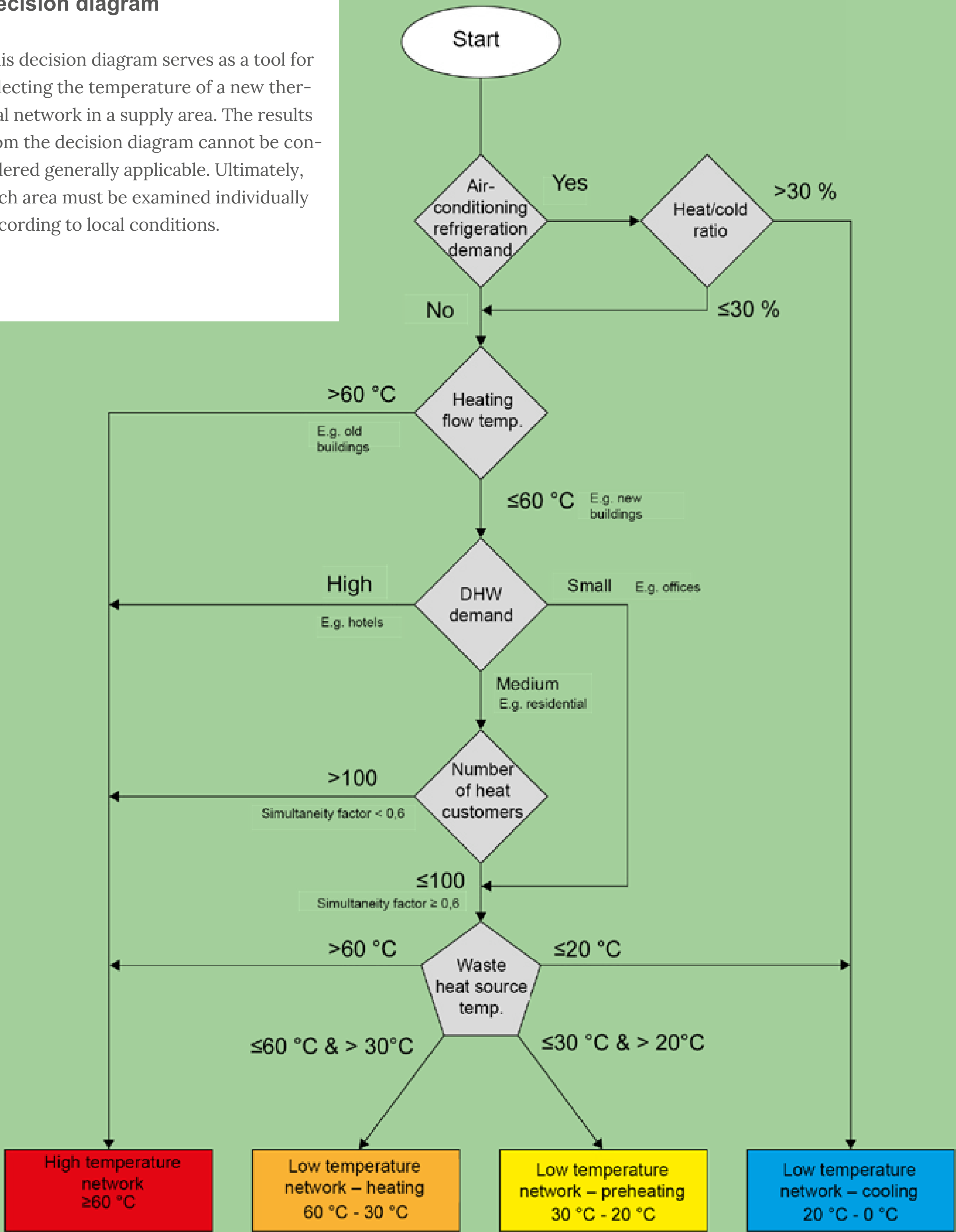
Frost protection

Temperature difference when using sweet water from 4 °C to 8 °C. Thus, cooling is still possible directly, and the risk of frost is eliminated.



Decision diagram

This decision diagram serves as a tool for selecting the temperature of a new thermal network in a supply area. The results from the decision diagram cannot be considered generally applicable. Ultimately, each area must be examined individually according to local conditions.



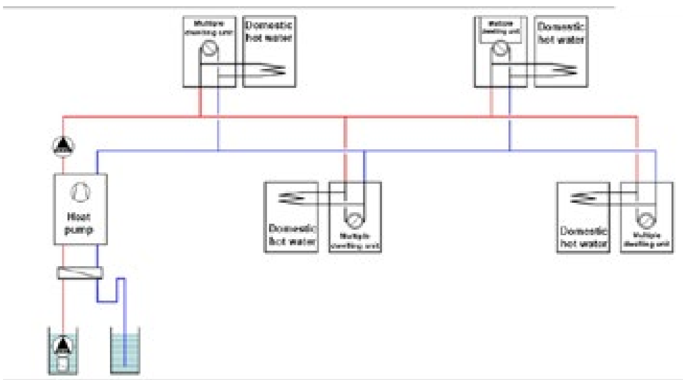
Forms of use

System 1

Networks with private use with low coverage. Use mostly in small to medium-sized developments

Features of small anergy networks

- Several single-family homes/multiple dwelling units with central heat source, distribution of anergy to the heat pumps in sub-stations
- Operator is the owner of the property/properties.
- Heat source is mostly ground water, other possibilities are waste heat or geothermal probes (depending on probe arrangement).
- The system decision has not necessarily been taken yet.
- System with anergy network competes with central heat generation with heat pump, distance pipe, and sub-station.

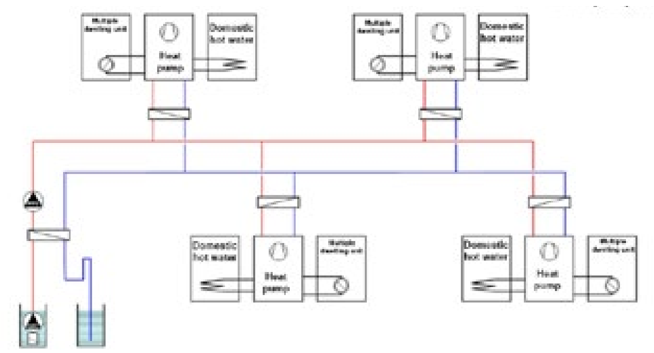


1. Networks with private use – system with central heat pump

- The following problems arise for central heat generation with regard to energy efficiency:
- Coverage of heat losses in the distribution lines
- Exceeding the flow temperatures in the centre beyond the required extent
  1. for coverage of heat losses in the distribution lines
  2. to ensure heat supply to the consumer with the highest flow temperature
- Unnecessary increase of the total system water content to the higher flow temperature for decentralised domestic hot water heating

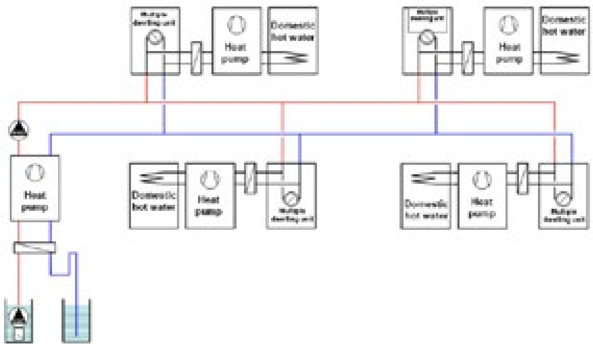
Heat losses during the summer months via the distribution line network (circulation losses, large modulation spectrum must be covered by the heat pump or also by the heat pump cascade)

2. Networks with private use – system with decentralised heat pump



Decentralised heat generation in the individual stations, in the case of brine/water or water/water heat pumps distribution of the source medium to the individual stations □ anergy network

3. Networks with private use – system with central heating heat pump, decentralised water/water heat pump for decentralised domestic water heating



- High efficiency for domestic water heating
- The central heat pump must generate the heat output and source energy for operating decentralised heat pumps.
- The central heat pump will have to provide about 85% of the total output.
- The connecting line must be an insulated district heating pipeline □ price!
- Decentralised domestic water heating with water/water heat pump is therefore the most expensive solution.

A solution with decentralised air/water heat pumps for domestic water heating is more cost-effective, but not as efficient.

To be noted for (small) anergy networks

Demand-based regulation of source energy, e.g. by regulating ground water pumps

Demand-based regulation of the network pumps

Ensure frost resistance with pure water in the anergy network

System separation by means of plate heat exchanger with low terminal temperature difference, depending on the source in the centre and in the sub-stations

If available, feed waste heat into the anergy network (observe the application limit of the heat pump!)

Develop alarm signalling concept

Advantages of (small) anergy networks

- The highest annual performance factors are achieved through anergy networks:
  1. No heat losses in the distribution lines
  2. No unnecessary increase in flow temperatures
  3. Decentralized drinking water heating without additional energy losses
- Anergy networks are no more expensive than systems with centralised heat generation.
- Anergy networks have the lowest operating costs due to their high efficiency.
- Anergy networks protect the environment.

System 2

Networks with commercial use and large reach

Features of anergy networks with network operator

- Network operator is not the owner of the property.
- Network operator sells anergy to owner/consumer.
- System decision has been taken.
- Network operator has certain connection conditions:
  1. Temperature (T_{FL}, T_{RT}, ΔT)
  2. Flow rate or pressure drop
  3. with/without system separation (increased safety with system separation)
  4. Medium in anergy network
- The source is often waste heat from industry, power plants or, for example, waste water treatment plants, but ground water, sweet water or river water is also possible.
- To be considered for networks with network operator

To be noted for sub-stations:

- Demand-based regulation of the source energy obtained
- Ensure frost resistance with pure water in the anergy network
- System separation prescribed (connection condition of grid operator)
- At elevated temperatures, observe the application limit of heat pumps

Product requirements

Transfer station consisting of:
- Balancing valve
- Plate heat exchanger
- Frost protection and flow monitoring
- Secondary pump (optional) cold water version
- Safety set with pressure monitor, expansion
- Sensors
- Activation of balancing valve
- Shut-off valves

Option: Can also be used in ground water systems (control of pump instead of valve)
Option: free cooling

Solutions

Ground water, sweet water systems and energy networks

Initial situation

Ground water systems are being implemented more and more frequently, as they are more favourable in terms of investment than geothermal probe systems at higher capacities. This leads to the emergence of more and more interconnected systems, by means of which several buildings can be supplied with the source medium □ anergy networks.

These networks can be designed as follows:

- Open systems; ground water, sweet water, etc. is directly conducted in the network □ system separation from heat pump required.
- Closed networks with water or brine
- Networks with sufficient upstream pressure without the need to install an additional circulating pump
- Networks with additional circulating pump for delivery to the recipient
- Central heat supply by renewable energy, heat recovery or by means of combustion

In principle, sourcing from these networks is subject to a charge for the system operator, and billing can be based on the volume or quantity of energy purchased. For cost reasons, therefore, attention must be paid to minimum water consumption, which leads to the aim of a maximum possible temperature difference during use (great advantage with volumetric billing, anergy network operators may prescribe maximum return temperature or speed control of the groundwater pump).

In contrast, water-operated networks require a minimum outlet temperature and the associated minimum required water quantity, which must be guaranteed at all times to ensure frost resistance.

Another advantage for operators of anergy networks is their use for cooling buildings in the summer months (Freecooling).

Our basic strategy of using 2-stage brine/water heat pumps of 15 kW or more enables the user to achieve minimum ground water consumption with maximum heat pump efficiency by adjusting the ground water flow. The same applies to cascades at higher outputs, of course.

Anergy networks

- More and more district heating networks are being built. However, anergy networks possesses the following advantages over them:
- Much lower temperature level in the range of ambient temperatures massively reduce thermal distribution losses.
- Use of renewable energy to provide heat (solar, geothermal, ground water) or heat recovery (industrial)
- Possibility of cooling in the summer months (only possible with geothermal and ground water systems)

Separation

- The following section deals with installations, which are designed as follows:
- 2-stage or multi-stage heat pumps or cascades up to 4 units
- 1 plate heat exchanger with intermediate circuit on the individual heat pumps
- Primary: open systems with ground water, surface water, sweet water or closed systems with water or brine
- Passive cooling mode (Freecooling option)
- Monitoring pressure difference via plate heat exchanger for indication of cleaning/maintenance (possibly monitoring by ΔT)

System requirements

The components in the primary circuit are controlled, the control/monitoring of the components in the secondary circuit is performed by the heat pump.

Heating operation

Opening cut-off ball valves

Start: switch-on command first stage/first heat pump, flow rate is driven to a defined value (0 – 10 V, e.g. default 5 V), the first stage/first heat pump starts with a time delay.

After a settling time of approx. 120 sec, control to:

- a defined temperature difference, e.g. 4 or 5 K or
- a defined outlet temperature, e.g. 4 °C and
- to a defined minimum temperature, e.g. 3 °C

When a stage/heat pump is switched on, immediate increase of the flow rate by a defined value, e.g. 30% above the current setpoint

After a settling time of approx. 120 sec, control to:

- a defined temperature difference, e.g. 4 or 5 K or
- a defined outlet temperature, e.g. 4 °C and
- to a defined minimum temperature, e.g. 3 °C

When steps are switched off, the temperature control remains in operation.

Frost protection function:

- If the outlet temperature falls below the defined minimum temperature, fault indication e.g. below 3 °C "Inadequate ground water coverage" (shutdown of stages or heat pumps in the cascade)
- If the outlet temperature falls below the frost protection temperature of 2 °C: heat pump fault shutdown (redundance sensor and thermostat required) "Temperature below minimum",

Interrogation of primary pump fault via flow monitor, leads to fault shutdown heat pump "Pump fault",

Stop: after-run time, switch-off actuators, close cut-off ball valve

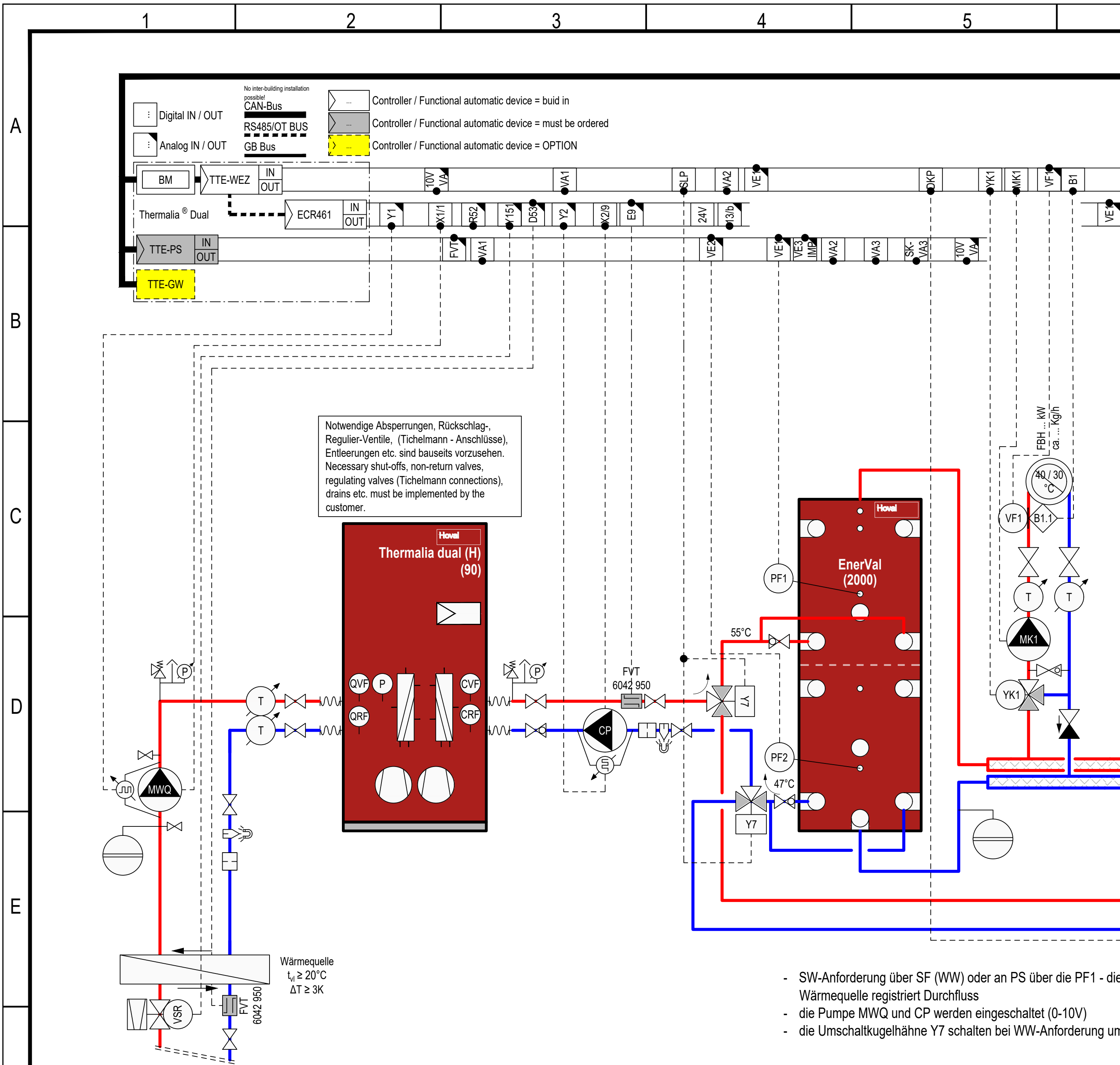
Cooling mode (passive cooling / Freecooling)

- Opening cut-off ball valve
- Start: Moving the control element up to a defined setpoint
- After a settling time of approx. 120 sec, control to:
  1. secondary-side setpoint
- Protection specifications of network operator:
- Compliance with a minimum primary-side temperature difference
- Compliance with a minimum primary-side return temperature

Stop: after-run time, switch-off actuators, close cut-off ball valve
The output signal to the control element is 0 – 10 V. Possible actuators are:

- central ground water pump with frequency converter (ground water systems)
- cold water pump
- 0 – 10 V through valve (adequate upstream pressure)
- additional motorised ball valve for shut-off open/close

Hoval system technology – customised complete solution



- SW-Anforderung über SF (WW) oder an PS über die PF1 - die
  Wärmequelle registriert Durchfluss
- die Pumpe MWQ und CP werden eingeschaltet (0-10V)
- die Umschaltkugelhähne Y7 schalten bei WW-Anforderung um

Thermalia® Dual (55)	Condeser side/ Kondensator-Seite (CP)		Evaporater side / Verdampfer-Seite (MWQ)	
Source /Quelle Temp. [°C]	7		7	
	I St.	II st.	I St.	II st.
Power/Leistung Qh [kW]	32	64	22.8	45.5
Flow/ Vorlauf Temp. [°C]	55		7	
Return / Rücklauftemp. [°C]	47		4	
Δ T [K]	8	8	3	3
m [l/h]	3439	6879	6520	13041
m [l/min]	57.3	114.6	108.7	217.3

Hydr. STS190034

Blatt: 1/8

Datum: 18.10.2019

Name: SCED

Version: 00

Datei: STS190034.dwg

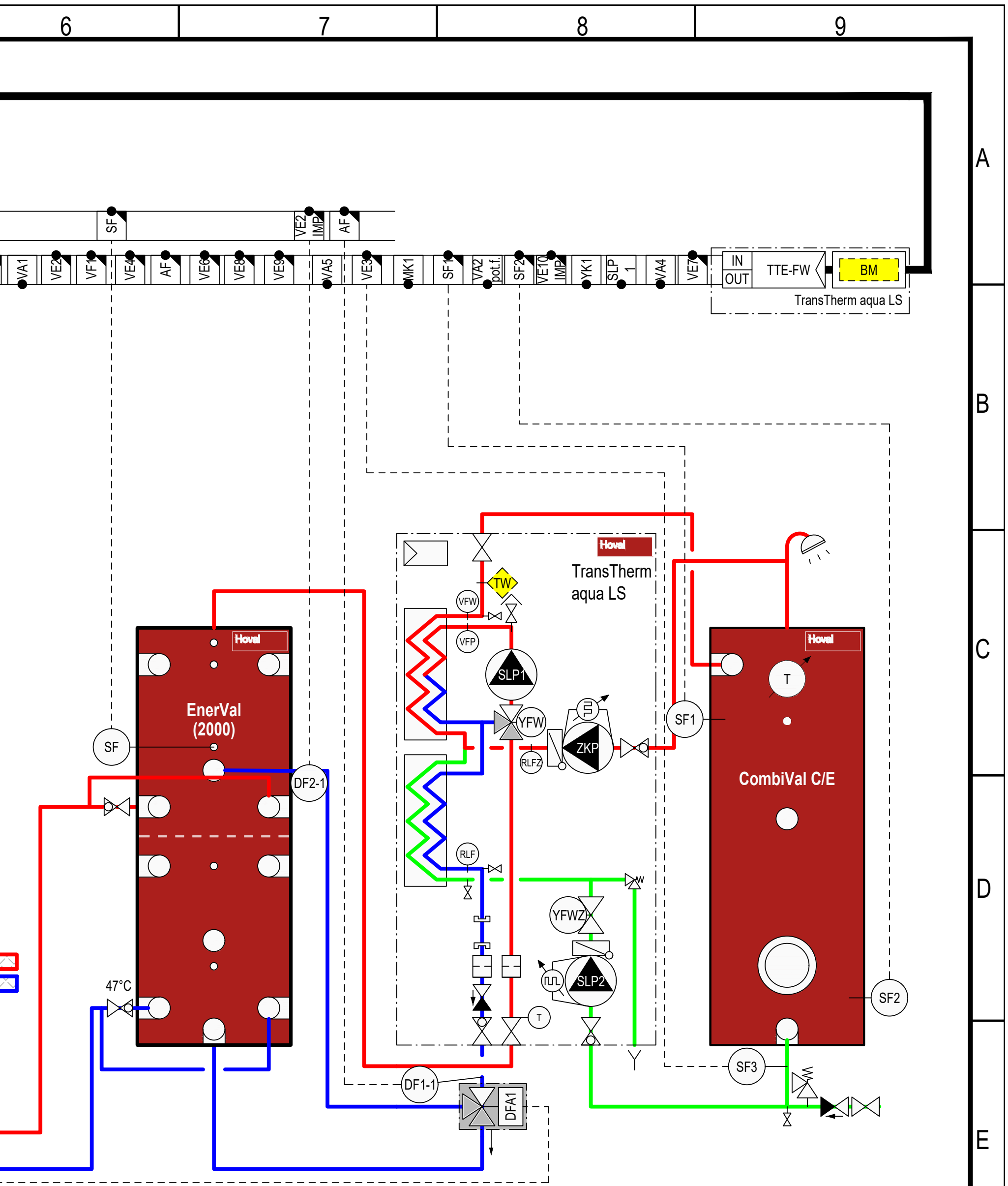
Verbindungshinweise / Notice / Nota / Remarque:

Achtung ! Für die Installa

Attention! This is just a sc

Attenzione! Per la messa

Attention! Pour la réalisat



e Wärmepumpe startet. Vorher wird VSR geöffnet , auf die gewünschte Wasermenge (Temperatur) geregelt und FVT auf der

n, oder bleiben stromlos im Heizungsfall

F

tion muss das anlagenbezogene Schema verwendet werden!
chematic. For installation please use the detail-plan!
in opera, utilizzare le schema dettagliato!
tion pratique de l'installation, il faut utiliser le schéma détaillé!

Hoval

6 7 8 9

Hoval

Hoval quality.
You can count on us.

Hoval is one of the leading international companies for heating and indoor climate solutions. Drawing on more than 75 years of experience and benefiting from a close-knit team culture, the Hoval Group delivers exciting solutions and develops technically superior products. This leadership role requires a sense of responsibility for energy and the environment, which is expressed in an intelligent combination of different heating technologies and customised indoor climate solutions.

Hoval also provides personal consultations and comprehensive customer service. With around 2500 employees in 15 companies around the world, Hoval sees itself not as a conglomerate, but as a large family that thinks and acts globally.
Hoval heating and indoor climate solutions are currently exported to more than 50 countries.

Responsibility
for energy and environment

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