



13th IEA Heat Pump Conference
April 26-29, 2021 Jeju, Korea

Range of application of heat pumps - Implementation of heat pumps with different heat sources

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Abstract

Through the increasing use of heat pumps, the number of potentially usable low-temperature heat sources and associated heat exchangers on the market is increasing, too. Planners often do not have a sufficient overview of the available technologies and boundary conditions of the individual systems and components. Based on the current results and experiences together with the development of the pre-dimensioning program, further key aspects for the integration and use of heat pumps and various associated components will arise, which will be dealt with in the project "future:heatpump_II". The following topics will be addressed in this article:

- compatibility of different heat pump technologies, such as absorption, adsorption or power-controlled heat pumps with different low-temperature heat sources and systems.
- consideration of a bivalent operating mode of two heat generators (e.g. heat pump and gas boiler). This is relevant, among other things, for concepts in multi-family and office buildings.
- integration of solar thermal energy for the regeneration of ground-coupled heat pumps.
- energy concepts and their planning with regard to the supply of buildings and districts by heat pumps.

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Selection and/or peer-review under responsibility of the organizers of the 13th IEA Heat Pump Conference 2020.

Keywords: heat pump; low temperature heat source and heat exchanger system; system design; usage

1. Introduction

Heat pumps are an increasingly applied technology in the energy supply of buildings. This is also reflected in the sales figures and the variety of heat pumps available on the market. In order to maximize the potential of the entire energy supply system, the choice of the low-temperature heat source and the associated heat transfer system and the connection to the building is of crucial importance. In this context, the pre-dimensioning program WP_{SOURCE} (developed as part of the R & D project "future:heatpump" at the Institute for Building Services and Energy Design (IGS) of the Technical University of Braunschweig) is a multifunctional tool that can be used in many areas for project-specific pre-selection and dimensioning of heat sources and heat exchanger systems for heat pumps.

On the basis of the results and experiences from the research project future: heatpump and the development of WP_{SOURCE}, new key aspects arise with regard to the integration and application of heat pumps as well as various additional components that can be coupled with heat pumps. As part of the research project "future:heatpump_II", topics beyond the content of the research project future:heatpump will be dealt with. The processing and analysis of the selected aspects enable an extension of WP_{SOURCE} and contribute to the increased use of heat pumps.

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2. Pre-dimensioning program WP_{SOURCE}

In order to facilitate the evaluation of suitable heat pump systems together with their low-temperature heat sources (ground, water, air) and heat exchangers, as well as to promote the dissemination of heat pump technology in general, a clear compilation of different technological approaches is helpful. WP_{SOURCE} is designed for the use by a broad range of users and considers different levels of detail and aspects in the planning of buildings and planning of heat pump systems. For this reason, flexibility and versatility is a key feature of WP_{SOURCE} with the adjustments and settings.

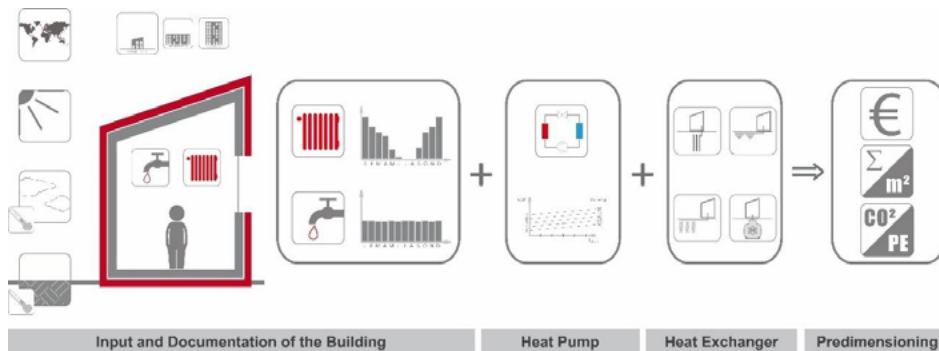


Fig. 1. Scheme for the structure and information flow in WP_{SOURCE}

The operation of WP_{SOURCE} (Fig. 1) starts with the documentation and specification of the initial situation and the boundary conditions of the respective project. After entering general project data, the user enters known parameters such as the plot area, the type of building (single-family or multi-family house or office building) and its thermal standard as well as energy demand values, if applicable. In addition, the user specifies the heating and/or cooling system to be designed. From these inputs and other project-specific selection options for the building, the program determines the heating and cooling energy demand (kWh) as well as the heating and cooling capacity (kW).

In principle, a user with detailed knowledge of the basic data and of the heat pump system to be created can benefit from the program, as well as a user with only rough project information can. Depending on the level of information, the user can define the building, e.g. by means of data from an EnEV balance sheet (Energy Saving Regulation (Energieeinsparverordnung - EnEV) presents one of the most fundamental tools of the German federal government's energy and climate policy, it defines requirements and implementation tools for residential, non-residential buildings and refurbishments) [1], according to his own data on heating energy consumption or based on the building's type and year of construction.

Depending on the heating capacity requirement of the defined building, WP_{SOURCE} uses heat pumps with corresponding performance for further calculation. The characteristics of the heat pumps implemented in the program were generated from data from a large number of devices currently on the market. The devices analytically generated for the program represent heat pumps of average quality for the respective output and are used for internal program calculations, e.g. of seasonal performance factor.

The required extraction energy from the low-temperature heat source is calculated using the average monthly coefficient of performance of the heat pump and the monthly heating requirement. This extraction energy forms an essential basis for the selection and (estimated) dimensioning of the low-temperature heat source.

On the basis of the inputs and the functions stored in the program, WP_{SOURCE} derives the sizes required for pre-selection and approximate dimensioning of suitable low-temperature heat sources and associated heat exchangers for an individual application. Ecological (CO₂ emissions, primary energy) and economic factors (investment and operating costs) for the various low-temperature heat source/heat exchanger combinations are also documented.

Figure 2 shows an example of the user interface of WP_{SOURCE}. During the development, attention was paid to clarity and user-friendly operation.

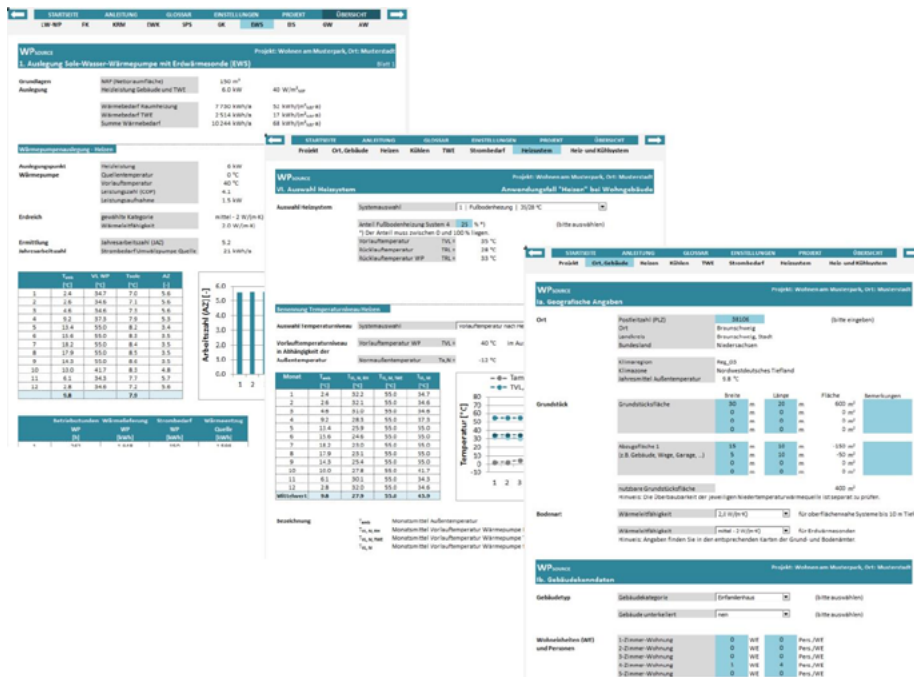


Fig. 2: User interface for WP_{SOURCE} (only in German available)

3. Extension of the pre-dimensioning program - additional applications and combinations of or with heat pumps

Today, heat pumps are no longer used exclusively to heat buildings as part of an energy supply concept for buildings. Within the framework of the development of climate-neutral building concepts, heat pumps are seen as a "fundamental element" and are combined with other components to form holistic supply concepts.

With the help of the WP_{SOURCE} program and the extensions currently being implemented, e.g. bivalent systems or the integration of photovoltaics and solar thermal energy, the concept development and planning phase of buildings and systems is to be supported with a focus on sensible integration of regenerative energy sources and various energy producers. Therefore, it can support the dissemination of climate-neutral buildings in praxis.

Within the framework of the research project future:heatpump_II, solutions for additional topics will be developed and analyzed, which will be made available to the planner and user of the systems for practical use in an updated version of WP_{SOURCE}. Different system combinations will be evaluated and meaningful results on their performance will be documented. In the course of the analyses and studies, the concepts under consideration are to be tested for their suitability for practice (meaningfulness and practicability). The results should scientifically prove which concepts are applicable for future buildings and which could possibly be too extensive.

In the following, the first results and work status of the key aspects of future:heatpump_II are summarized. During the project, the presented results for the different key aspects will be implemented in the pre-dimensioning program, so that at the end of the project a new extended version of the program with further energy concept approaches will be available.

3.1. Heat pump typologies and applicable low-temperature heat sources

As far as heat pump technologies are concerned, the current market situation in Germany can be characterised by different types of heat pump. The most common heat pump types can be classified as follows:

- Type of heat source (air, water, brine)
- Type of system to be heated, i.e. the heat sink (water or air)
- Type of driving energy (electric, gas)
- Type of compressor (thermal, electrical)
- Type of capacity control (On-Off, Inverter)

In addition to classic electric compression heat pumps, gas-operated heat pumps are increasingly being offered, although without high market shares yet, as well as different types of sorption heat pumps (thermally compressing absorption and adsorption heat pumps). (Fig. 3)

Gas-operated heat pumps are primarily an alternative to gas condensing boilers in existing buildings. Gas heat pumps and gas-powered sorption systems are based on gas condensing boiler technology, which is well established in Germany, and combine highly efficient gas condensing boiler technology with the use of environmental heat. Sorption heat pumps are currently only of minor importance on the market. Sorption technology is primarily used in refrigeration and is therefore more likely to be found on the market for cooling machines. In sorption technology, high temperatures are used as drive energy, mostly from waste heat from industrial processes ($> 50^{\circ}\text{C}$ or $> 75^{\circ}\text{C}$). Low-temperature heat sources are therefore not suitable and can only be integrated as a heat source in conjunction with the gas-powered heat pump (driving energy: gas combustion).

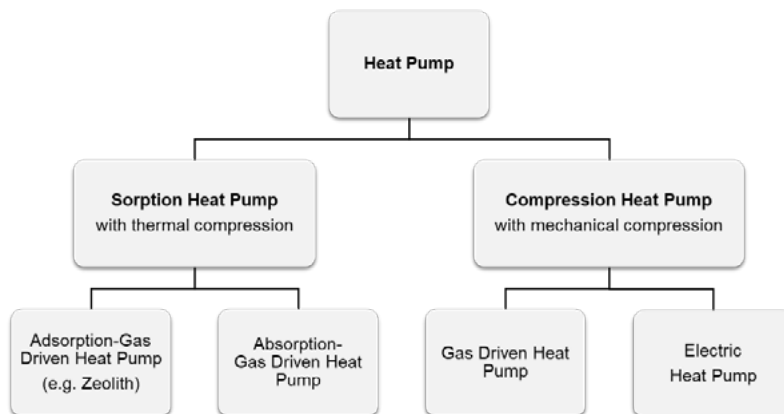


Fig. 3. Classification of heat pump types according to their drive technology

A comparison of the heat pump technologies mentioned shows that the mode of operation and the configuration of the individual designs differ only slightly from each other. All technologies can be used for space heating and domestic hot water production as well as for cooling in reversible operation. The fundamental difference between electric heat pumps and gas motor heat pumps is the type of compressor drive. The thermodynamic cycle is identical for both types. While in an electric compression heat pump an electric motor drives the compressor to compress the working fluid, in a gas heat pump this is done by a gas motor. In contrast to the electric drive, the heat generated by the operation of the gas engine is also used for heating, i.e. as useful heat. In addition to mechanical compressors, there is also so-called thermal compression. Sorption heat pumps use this process. A distinction is made here between absorption and adsorption heat pumps. Thermal compression in sorption heat pumps is based on the physical binding of a gas to a solid (adsorption) or the physical binding of a liquid or gas in a liquid (absorption). Both processes take place with the release of heat. With regard to the usability of different low-temperature heat sources with the heat pump technologies described, it can be seen that, in principle, all heat sources - outdoor air, brine and water - can also be used for gas-operated heat pumps, analogous to the electric heat pump (Fig. 4).

When dimensioning and planning a heat exchanger system, an advantage of gas-operated heat pumps (mechanical as well as thermal) becomes apparent. With this technology, the combustion heat can also be used and thus the source system is less stressed, i.e. less energy is withdrawn from it. For this reason, the heat exchanger system for using environmental heat with gas-operated heat pumps can be made smaller in size than for conventional electric heat pumps.

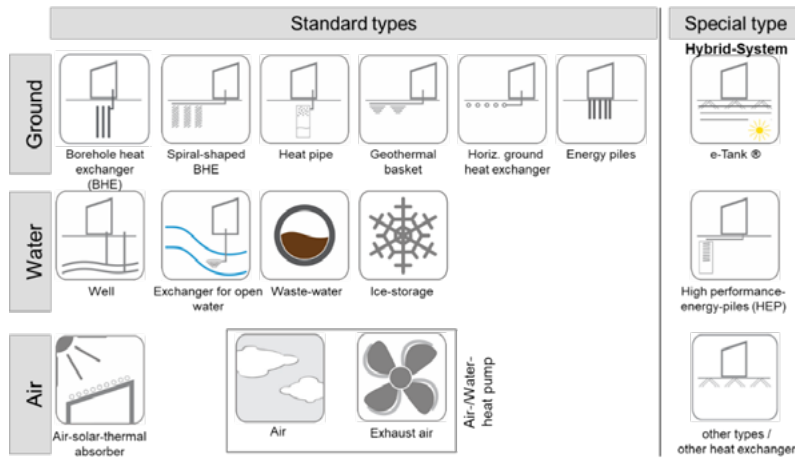


Fig. 4. Low temperature heat sources for heat pumps considered within the framework of future:heatpump and future:heatpump_II

Table 1 summarises the heat pump technologies considered here and presents their advantages and disadvantages. Assessments of the ecological and economic effects of the individual technologies depend, among other things, on current and future electricity and gas prices as well as CO₂ equivalents.

Table 1. Differences and fields of application of different heat pump technologies (main topics / information of the manufacturers)

	Electric heat pump	Gas driven heat pump	Adsorption gas driven heat pump	Absorption gas driven heat pump
Operating mode / medium	mechanical compressor / electrical	mechanical compressor / gas	thermal compressor / gas; (zeolite)	thermal compressor / gas
Temp. level of the source	Depending on source type (air, water, soil) -5 °C to 25°C			
Flow temperature	35 - 55 °C / 65 - 70 °C (heating / domestic hot water)			60 - 70 °C
Thermal capacity range (depending on heat pump, cascades possible)	4 - 300 kW	50 - 200 kW	up to 10 kW (products no longer available on the market)	20 - 45 kW (150 - 5000 kW, for district heating and technical industry)
Application	Residential buildings (single and multi-family houses) to non-residential buildings (office buildings, hospitals, ...) and district heating networks as well as production facilities	Multi-family houses (new construction), commercial and industrial, not residential buildings, existing buildings	single-family house construction	Apartment buildings, industry, commerce, hotels and service companies, existing buildings and for buildings with high water requirements
Advantages	all low-temperature heat sources can be used	for a simple and effective energetic renovation of gas heating systems, since the existing heat distribution and transfer system can largely be reused (existing gas infrastructure mostly usable). Use of combustion heat, therefore up to 40% smaller low-temperature heat source possible. Heat is available at different temperature levels.	hardly any mechanically moving parts, therefore particularly low-noise and low-maintenance	
Disadvantages	Investment costs and space requirements for source system	Gas connection and exhaust system required; mostly only air-water heat pumps on the market		

3.2. Bivalent heating operation mode of heat pump systems

With regard to heat pump systems, bivalent systems or a bivalent mode of operation are heating systems which, for example, combine an electric heat pump with another heat generator (e.g. gas or solid fuel boiler or district heating) and a control system.

The bivalent operation of two heat generators can be a good option for retrofitting existing heating systems. Also, for new office buildings and other non-residential buildings, as well as for new multi-family buildings, a heating system that permits the bivalent operation of a heat pump system is often expedient from both an ecological and an economic point of view. In this context, the heat pump is ideally used to cover a base load. The second heat generator serves to cover the peak load. Due to the low performance requirements, a classical bivalent operation in new single-family houses is rather rare.

The bivalent operation of a heat pump system can be reasonable for various reasons:

- The heat pump cannot provide the temperature required for room heating and/or domestic hot water all year round or can do so only very inefficiently.
- The minimum permissible heat source temperature for the heat pump is not reached during operation.
- The space requirement for the low-temperature heat source is not sufficient for monovalent operation.
- The heat pump cannot provide the heating output required for heating or domestic hot water all year round.
- As part of the energetic modernisation of a building, the existing heating system is supplemented by a heat pump. Renovation of the building shell reduces the heating load so that the existing boiler can be taken out of operation at a later date.
- By using different energy sources, bivalent systems offer a higher security of supply.

Different operating modes result from different applications (Fig. 5). Basically, the operating mode of a heat pump and an additional heat generator can be implemented as follows

- monovalent
The heat is provided exclusively via the heat pump. A second heat generator is not operated and is not required.
- bivalent parallel
Above the defined bivalence point (e.g. a defined outdoor temperature (frequently used), CO₂ emissions or the energy prices, etc.), heat is provided exclusively by the heat pump. Below the bivalence point, the second heat generator is operated parallel to the heat pump.
- bivalent partially parallel
Above the bivalence point, heat is provided exclusively by the heat pump. Below the bivalence point, the second heat generator is operated parallel to the heat pump. If the outside temperature is below an additionally defined switch-off point, the heat pump is switched off and the entire heating heat is provided by the additional heat generator.
- bivalent alternative
In this operating mode, heat is provided above the bivalence point exclusively by the heat pump. Below the bivalence point, the heat pump is switched off and the entire heating heat is provided by the second heat generator.

Within the framework of the research project and the implementation in the pre-dimensioning program, bivalent parallel operation is considered in addition to monovalent operation. Other modes of operation are named for information purposes, but are not analysed in detail for dimensioning purposes.

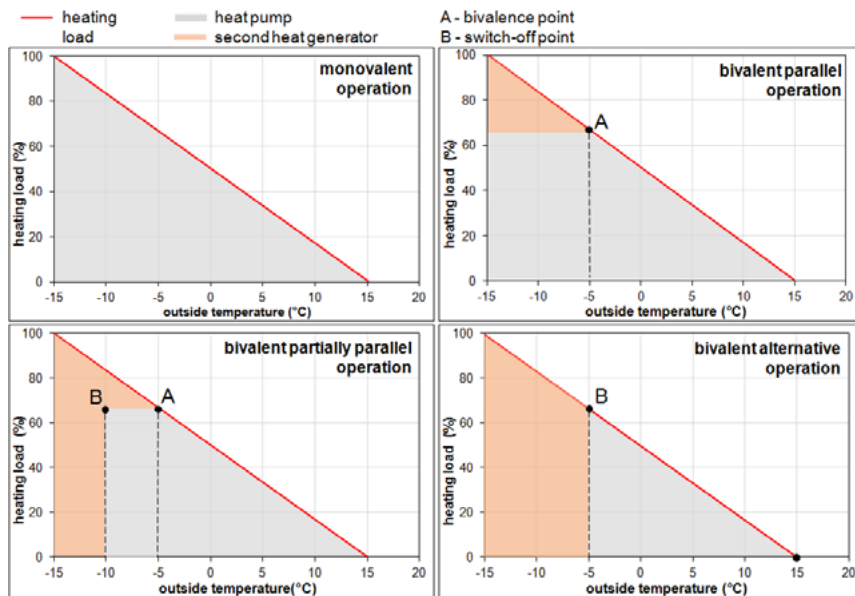


Fig. 5. Operating modes of a heat pump and an additional (second) heat generator

With regard to the integration of a bivalent operation and the associated control as well as the dimensioning of the system components, the expansion of WP_{SOURCE} is initially based on the specifications of DIN V 4701-10 [2] as well as the information sheet no. 57 of the Federal Association of the German Heating Industry (BDH) [3]. The outdoor temperature is used as the numerical value for the bivalence point.

For the dimensioning and the determination of the bivalence point the user has two alternatives at his disposal:

1. Direct determination of the bivalence point, i.e. the switching point of the heat pump to the second heat generator. In addition, the program and the location information are used to determine the share of the total heat requirement and the individual performance data for the generators, as well as the energy quantities that further influence the dimensioning of the low-temperature heat sources and the associated heat exchangers.
2. Determination of the share of the heat pump in the total capacity requirement. On this basis and the location and performance data of the heat pump, the program determines the bivalence point and the amounts of energy that further influence the dimensioning of the low-temperature heat sources and the associated heat exchangers.

Another application for bivalent operation is the integration of solar energy. Building services planners and/or architects are often interested in integrating the thermal use of solar energy not only to support domestic hot water, but also for space heating in the heat supply of single-family and multi-family houses. In addition to a gas condensing boiler or connection to district heating and other heat sources, solar thermal energy can also be used to heat domestic hot water or to support room heating in order to build up a bivalent heat supply. In the context of the extension of WP_{SOURCE} , solar support for domestic hot water and space heating is considered separately. In the project work and in WP_{SOURCE} , the thermal use of solar energy does not fall within the scope of a "classical" bivalent operation.

3.3. Integration of solar thermal energy for the regeneration of geothermal heat sources

The use of solar thermal collectors or absorbers in connection with ground-source heat pump systems has already been investigated in various research projects. For example, the relevance and effects of solar thermal regeneration of the soil were demonstrated in the projects "Terra-Solar-Quelle" and "GeoSolar-WP" [4-6] carried out at the Institute for Solar Energy Research in Hameln (ISFH). The concepts considered are

based on the fact that, starting from a heat pump, a solar system is integrated into the primary circuit (low-temperature heat circuit) of the heat pump. Since the temperature level of the primary circuit is lowered by the heat pump, a larger share of the available solar energy can be used in comparison to the classical installation. The reasons and objectives for the integration and use of thermal solar energy in connection with heat pump systems are based on

- a reduction in the required areas and/or depths of the ground system,
- a reduction in material and/or construction costs,
- the positive influence of regeneration on the operation of the heat pump,
- the achievement of balanced energy and temperature balances and partial compensation of the seasonal shifts between heat supply from the environment and heat demand, as well as
- the cost-benefit ratio of the measure(s).

The use of ground-coupled low-temperature heat sources to provide heat for heat pumps leads to demand-oriented heat extraction from the ground, which cannot always be compensated by natural heat fluxes or active heat input. This leads to long-term cooling effects of the subsurface, especially in geothermal borehole heat exchangers, which causes a negative influence on system efficiency or a larger heat exchanger. With the aid of solar thermal collectors or solar absorbers, regenerative, thermal energy can be injected into the ground in a targeted manner and heat extraction by a heat pump can be compensated. In this way, the soil can be regenerated and a long-term temperature decrease can be avoided. Additionally, the increase in the source temperature for the heat pump results in higher system coefficients of performance.

When dimensioning geothermal heat collectors, the targeted injection of thermal energy into the ground can contribute to reducing the required collector area. By avoiding critical frost and exhaustion conditions as a result of regeneration, a smaller distance between the collector pipes can be achieved. Since the high demand for unsealed surfaces represents a major obstacle to the use of surface collectors, the reduction of the required surface area through regeneration is of particular interest for the application of this technology.

When injecting thermal energy into the brine circuit of a heat exchanger system, the permissible inlet temperatures must be observed. For example, the inlet temperature to a surface collector must generally not exceed 25 °C. For this reason, unglazed collectors, usually solar absorbers, are generally used to regenerate the soil.

Table 2 summarizes key data and applications relevant for the regeneration of ground-coupled low-temperature heat sources.

Table 2. Differences and influences of solar regeneration of geothermal collectors and borehole heat exchangers

	Geothermal heat collectors [4]	Borehole heat exchangers [5-6]
The objective of regeneration	Reduction of the collector surface area with constant efficiency	Reduction of borehole length and improvement of system efficiency
Integration of solar thermal technology	Primary side series connection of the solar collectors or absorbers with Geothermal heat collectors	Primary-side series connection of solar collectors or absorbers with borehole heat exchangers
Investigated collector types	Swimming pool absorber, uncovered PVT- and facade collectors	unglazed collector (solar absorber)
Control	Inlet temperature of Geothermal heat collectors max. 25 °C	
Influence of regeneration	Avoidance of critical frost conditions and limitation of exhaustion conditions of the Geothermal heat collectors	Avoiding long-term cooling effects and increasing the annual coefficient of performance (COP)
Effect	Reduction of the collector surface up to 50%. Applicability independent of the type of soil. Good compensation measure for undersized Geothermal heat collectors.	Increase of the COP and increase of the minimum temperatures in the soil. Reduction of the borehole length by up to 30 %. In clearly undersized systems, the influence is significant. Otherwise, efficiency gains are in no economic relation to effort.

3.4. Applicability of heat pumps in local heating networks

Against the background of the energy transition, energy-efficient heat provision for space heating and domestic hot water is essential. Local heating networks with heat pumps will be an important infrastructure element for the heat supply of settlements and quarters in the future. Heat pumps can provide the required heat in comparison to fossil heat generators with low primary energy shares and, if correctly dimensioned, have high efficiency. They offer the possibility of spatial and temporal coordination of heat source, heat generation and heat demand via network design, network temperatures and heat storage. In this way, economically and technically optimised heat supply systems can be created.

The integration of heat pumps in local heating networks can enable the development of previously unused and natural low-temperature heat sources for heat supply. This can reduce primary energy and CO₂ emissions during heat generation.

Based on the basics developed in the project and the example networks considered, different scenarios for a future-oriented local heat supply of quarters with heat pumps can be developed. The concepts differ in the network temperatures, operating modes and usable low-temperature heat sources as well as in the areas of application.

Conventional local heating network with central heat pump

The implementation of conventional local heating networks is primarily of interest for areas with buildings that currently need to be supplied, where heat generation within the building and fuel-based heat generation are available, which require high inflow temperatures. This means that existing quarters with conventional heating systems, which generally also have high heat demand densities, can be considered. Residential and mixed areas with multi-family houses and commercial properties are particularly interesting for conventional local heating supply concepts. Due to the lower density of heat demand, supply areas with single-family housing only (especially new buildings) are less suitable. For consumers, the conversion to conventional local heating involves manageable investments, essentially in new heating technology (replacement of the old heating system with a local heating transfer station).

In conjunction with an environmental heat source, a central heat pump (covering the base load of the heat network) in conjunction with another heat generator provides flow temperatures between 60 °C and 85 °C. This temperature level of the local heating network is usually sufficient for space heating and domestic hot water heating. The return flow temperature is between 50 °C and 35 °C, depending on how much heat is removed. It can be deduced from the networks investigated that route lengths of about one and a half kilometres can be realised.

The potential heat sources for the heat pumps are geothermal borehole heat exchangers, groundwater and solar-thermal long-term heat storages. If the supply area offers the necessary infrastructure, waste water can also be used as a heat source.

Conventional local heating network with central heat pump				
Supply area	Building	Network	Heat generation	Heat source
<ul style="list-style-type: none"> Existing quarters Residential and mixed area 	<ul style="list-style-type: none"> House transfer station Conventional heating system (high flow temperatures) Hot water / storage loading system 	<ul style="list-style-type: none"> Flow temperature 60°C to 85°C 	<ul style="list-style-type: none"> Central water/water heat pump or brine/water heat pump (base load) CHP or biomass combustion 	<ul style="list-style-type: none"> Geothermal borehole heat exchangers Groundwater Sewage Solar thermal with long-term heat storage tank

Fig. 6. Overview of a conventional local heating network with central heat pump

Low-temperature network with decentralised heat pumps (Cold local heating network)

A low-temperature network with decentralised heat pumps is particularly suitable for supplying new residential areas. The advantage of cold local heating is not necessarily the heat price, but the fact that the network can be integrated into supply areas characterised by low heat densities, uncertain demand structures

and possible extensions due to further settlements. With brine as the heat transfer medium, the networks usually provide temperatures in the range of 5 °C and around 20 °C. Due to the low heat losses, cold local heating networks can be operated efficiently even with low heat demands. No additional heat generator is required for normal network operation. If eco-electric power is used for the heat pumps, the heat supply can be operated CO₂-neutral. Cold local heating networks are particularly interesting because the heat consumption of buildings decreases due to building insulation and as a result the heat demand density is reduced, too. In order to ensure economic operation of the distribution network, it may be advisable in new housing estates to require a connection to the cold local heat.

The analysis of sample quarters suggests that pipeline lengths of at least one and one and a half kilometres can be achieved. The transport of the heat transfer medium in the distribution network is realised by the individual feed pumps of the decentralised heat pumps in the connected buildings. If there is no heat demand, the heat transfer medium in the distribution network is at a standstill. In order to prevent the temperature level from being lowered by heat exchangers between the heat source and the distribution network, the heat transfer medium from the low-temperature heat source flows directly through the distribution network. Depending on the local conditions, a number of environmental heat sources may be available that are sufficient to cover the required load and do not require an additional heat generator. Common heat sources in this context are geothermal borehole heat exchangers and agrothermal collectors as well as long-term heat storage units such as ice storage units or geothermal storage units.

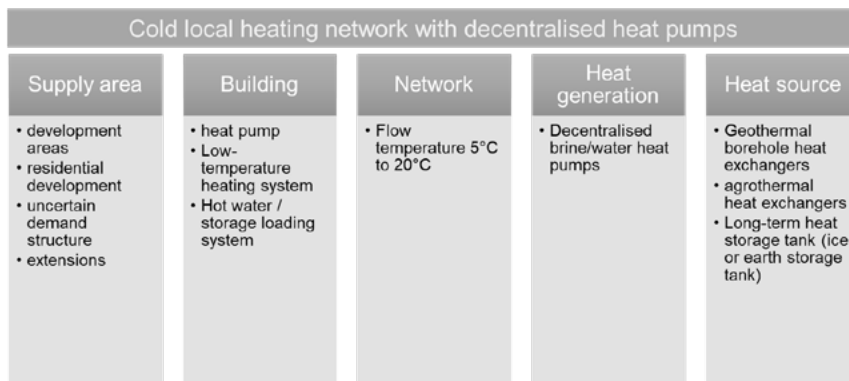


Fig. 7. Overview of a cold local heating network with decentralised heat pumps

Mixed networks

The conversion of an existing (conventional) local heating network to a mixed network with centralised and decentralised heat pumps can improve the efficiency and sustainability of the heat supply. During the winter months, the network is operated as a conventional local heating network with central heat generation and supply flow temperatures in the range of approx. 70 °C to 80 °C. A combined cogeneration unit together with a central heat pump serves as a heat generator. In the summer months, the network temperature is reduced to around 20 °C to 40 °C, and the space heating and domestic hotwater heating is provided by decentralised heat pumps in the connected buildings. The heating system with the cogeneration unit can be switched off during this time. Mixed networks offer the advantage of providing heat at demand-oriented temperature levels. Since the existing local heating routes are used, no work is usually required on the pipelines to convert to a mixed network. For the network operator, investment costs are usually relatively low.

In principle, all environmental heat sources used as heat sources for the heat pump can also be used for heat pump operation in a conventional local heating network. Due to the constant source temperatures of around 10 °C during the winter months, the use of geothermal borehole heat exchangers or groundwater is particularly suitable.

Mixed network with centralised and decentralised heat pumps				
Supply area	Building	Network	Heat generation	Heat source
<ul style="list-style-type: none"> Existing quarters Residential and mixed area existing network 	<ul style="list-style-type: none"> Heat pump House transfer station Conventional heating system (high flow temperatures) Hot water / storage charging system 	<ul style="list-style-type: none"> Flow temperature summer: 20°C to 40°C Flow temperature winter: 70°C to 80°C 	<ul style="list-style-type: none"> Summer: decentralised water/water heat pumps Winter: central heat pump and CHP unit 	<ul style="list-style-type: none"> Geothermal borehole heat exchangers Groundwater Solar thermal with long-term heat storage tank

Fig. 8. Overview of a mixed network with centralised and decentralised heat pumps

4. Conclusion

Energy concepts with innovative systems and components such as solar thermal energy, photovoltaics, heat pumps and geothermal energy are increasingly being implemented in building technology. Design aids, such as dynamic simulation, are becoming increasingly important for these systems. The design and dimensioning aids currently available on the market for heat pumps and their low-temperature heat sources and heat exchangers are generally individual solutions that are often provided by manufacturers or suppliers of corresponding products. These design and dimensioning aids usually do not offer planners and architects the possibility of verifying the output results or providing an overview of the alternatives. In particular, the comparison of systems and individual components in different applications and their applicability is a unique characteristic of WP_{SOURCE}.

On the basis of the experiences and results from the research project future:heatpump, the follow-up project "future:heatpump_II" will mainly deal with topics and focal points which on the one hand support the application and expansion of heat pump systems and on the other hand serve the extended use of the WP_{SOURCE} program. The focus will be on other heat exchanger systems, the bivalent operation of heat pump systems, the regeneration of geothermal heat exchangers and the integration of photovoltaics and solutions for districts/quarters. The expansion will enable the programme to present more advanced concepts and approaches with heat pumps.

The current state of work in the area of the new thematic priorities shows that

- different heat pump technologies are available on the market, but the application is primarily focused on electric heat pumps. Gas-operated heat pumps are currently not very important on the market, but can be a sensible solution, e.g. for existing buildings with an existing gas connection.
- the use of bivalent heat pump systems can be a way of resolving the modernisation backlog in existing buildings. They make it easier for the plant operator to decide on future energy sources for heating the building. Bivalent systems can often be installed cost-effectively by extending existing heating systems. Bivalent heat pump systems are also of economic interest in new buildings, especially with high heating loads and different temperature requirements.
- a regeneration or coupling of ground heat exchangers (surface collectors and geothermal borehole heat exchangers) with thermal solar energy leads to a reduction of the collector surface or geothermal borehole heat exchanger length. In addition, the temperatures in the soil rises and the annual performance factors can be increased. Coupling with thermal solar energy has a significant positive influence on undersized systems. In other cases, the efficiency gain is not economically proportional to the effort required to use thermal solar energy to regenerate geothermal heat exchangers.
- a local heating network offers the possibility of a sustainable and economical heat supply with a high flexibility and expandability. In the sense of a future-oriented energy supply, the implementation possibilities of different heat pumps and environmental heat sources in local heating networks should be investigated and, where possible, applied to quarter solutions.

Acknowledgements

The research projects are funded by the German Federal Ministry for Economic Affairs and Energy.

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