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HEAT PUMP HEATING SYSTEMS AND LOW POTENTIAL HEAT SOURCES

Розглянуто проблему відновлюваних джерел енергії у вигляді теплових насосів та їх застосування в системах опалення. Енергетичний менеджмент сьогодні, коли ціни на енергоносії постійно зростають, є надзвичайно важливим питанням. Одна з основних причин полягає в тому, що використання первинних джерел енергії (вугілля, нафта) призводить до неминучого виснаження їхніх світових запасів. Використання відновлюваних джерел енергії тепер стало загальносвітовою тенденцією. Це один із способів отримати доступне джерело первинної енергії, яке мінімально впливає на навколишнє середовище порівняно зі звичайними кінцевими джерелами енергії (наприклад, нафта, вугілля).

Використання теплових насосів як основного джерела нагрівання та охолодження в будинках порівняно з установками з використанням викопного палива стає більш економічним. Це пов'язано з підвищенням цін на викопні види палива, важчим їх придбанням та обмеженою кількістю. Теплові насоси також сприяють досягненню цілей Європейського Союзу до 2020 року: економії енергії, скороченню викидів CO_2 і збільшенню частки відновлюваних джерел енергії на 20 %. Важливість і значення теплових насосів зростає зі збільшенням частки поновлюваних джерел енергії у виробництві електроенергії.

Ключові слова: поновлювані джерела, тепловий насос.

This paper focuses on the application of renewable energy resources in the form of heat pumps and their use in heating systems. As the energy prices are constantly rising, the energy management is currently a very important issue. One of the main reasons is that obtaining the primary energy sources like coal and oil is much more difficult than in the past. The use of renewable energy sources has become a worldwide trend and is one of the ways to get cheaper and more accessible primary energy that has a minimum impact on the environment compared to conventional sources of energy (e.g. oil, coal).

The implementation of heat pumps as the primary source of heating and cooling in buildings, compared to installations using fossil fuels has become increasingly economical. This is due to increasing prices of fossil fuels, which is directly influenced by their accessibility and limited quantity. In addition, heat pumps contribute to the energy objectives of the European Union set for 2020. It specifically deals with achieving energy savings, reducing CO_2 emissions and increasing the share of renewable energy by 20 %. The significance and relevance of the application of heat pumps is increasing with the rise in use of renewable energy for electricity generation.

Key words: renewable resources, heat pump.

Introduction. Heat pumps are mostly comprised of two units - external and internal. The indoor unit is at first glance indistinguishable from any normal gas boiler or water heater. It functions to transfer heat to the heating system. The external unit extracts heat from the selected low-temperature source (earth, air, water). The size and form of the outer part depends on the type of low-temperature source and the desired output [1].

In designing part of heat pump systems, it is important to correctly determine the overall heat demand to prevent it's overrating and ineffective operate. A great influence on operation of the heat pump has a choice of energy source and terminal elements of the system. The most frequently used terminal elements are for example: floor, wall and ceiling heating. Other suitable alternatives are fan coils and classic panel convectors. Heat pump systems are usually low temperature with a maximum temperature of 55 ° C. System temperature directly affects the efficiency of the heat pumps. 0

Purpose of work. Basic categories of heat pumps:

– Compressor driven heat pump,
– Sorption heat pumps (absorption, adsorption),
– Hybrid heat pumps (a combination of compression and sorption pumps).

Classification according to ensuring the energy needs of the building:

– Monovalent systems,
– Bivalent systems,
– Mono energy systems.

Low potential heat sources are associated with the type of the heat pump used. Table 1 introduces the basic distribution of heat pumps under the category of low potential heat source and a sampling systems in accordance with STN EN 15450: Heating systems in buildings - Design of heat pump heating systems.

Table 1

System of heat pumps in accordance with STN EN 15450 [5].

Source – system (energy source)		Sampling system (energy transmission)	
Energy source a)	medium b)	medium	extraction point c)
Exhaust air Ambient air	air	air	indoor air
		water	indoor air water
Surface water Ground water	water	water	indoor air water
		air	indoor air
soil	salt (water)	air	indoor air
		water	indoor air water
	refrigerant	water	indoor air water
		refrigerant	indoor air

a) The energy source is where the energy is obtained.
b) A medium is used to transfer heat in a distribution system.
c) Extraction point is where the heat energy is released; it can be a heated space or water in the case of hot water for households.

This type of heat pump is amongst the most prominent systems. It is regarded as the most stable when subjected to varying external climate conditions. Heat pumps of this type are usually operated with a bivalence ranging between -5 to -8 °C. Temperatures below the bivalence point triggers an additional heat source such as an electric boiler [1].

The elements within the earth's crust undergo constant nuclear decay. Energy seeping from the Earth's core infiltrates the surface in the form of heat. Temperature is directly proportional to the depth below the surface in which a temperature rise of approximately 1°C is achieved for every 30 m below the surface. At a depth of 100 m the ground temperature is about 10 °C. The average heat flux incident on the earth is 60 °C 10 m W/m2. When assessing a potential site an important parameter to consider is the thermal conductivity of the earth [6].

Horizontal ground heat exchanger

It is less difficult to implement and finance, then a bored vertical ground heat exchanger. The drawback is that it requires a large area around the building. The collector is made of polyethylene pipe, which is placed in a trench at a freeze resistant depth ranging from 1.2 to 1.5 m. The length of individual lines is approx. 100–300 m. For heating and hot water solar energy accumulated in the upper layer of the earth is used. According to the type of soil and its properties the theoretical performance of the surface collector is between 8–40 W/m^2, see. Table 2. If a larger output and lack of space for ground collector is required then it is preferable to bore shafts. [1].

Table 2

Example requirements for soil quality in Central Europe according to STN EN 15450 [5]

Quality of soil	Specific heat flow obtained	
	Work time1 800 h/year	Work time 2 400 h/year
incohesive dry soil	10 W/m²	8 W/m²
wet cohesive soil	20 - 30 W/m²	16–24 W/m²
water saturated sand or gravel	40 W/m²	32 W/m²

Additional heating power for hot water can be considered in the table for extended periods of activity.

Vertical heat exchanger

Earthworks associated with the implementation of wells are expensive compared to printed collectors. Bored wells range between 70 to 140 m depending on local geological conditions. The distance between holes should be approx. 1/10 of the length of the borehole. Depending on soil type and properties the theoretical performance of the borehole ranges from 20 to 85 W / m, see Table 3 [1].

Table 3

Specific amount of heat extracted for different types of soils in Central Europe according to STN EN 15450 [5]

Types of soil	Specific amount of heat extracted	
	Work time 1 800 h	Work time 2 400 h
Input values:		
unfavorable subsoil (dry sediment λ < 1,5 W/(m K)	25 W/m	20 W/m
normal underground and saturated sediment 1,5 < λ < 3,0 W/(m K)	60 W/m	50 W/m
compact rock with high thermal conductivity λ > 3,0 W/(m K)	84 W/m	70 W/m
Special soil types:		
dry gravel or sand	< 25 W/m	< 20 W/m
gravel or sand saturated with water	65 - 80 W/m	55 - 65 W/m
gravel or sand with high flows of ground water	80 - 100 W/m	80 - 100 W/m
moist clay	35 - 50 W/m	30 - 40 W/m
solid limestone	55 - 70 W/m	45 - 60 W/m
sandstone	65 - 80 W/m	55 - 65 W/m
silica magmatit (e.g. granite)	65 - 85 W/m	55 - 70 W/m
magmatit without quartz (e.g. basalt)	40 - 65 W/m	35 - 55 W/m
diorite	70 - 85 W/m	60 - 70 W/m
NOTE -Values valid for heat pumps with a heat output up to 30 kW		

To accurately determine the performance of the well it is necessary to conduct a Thermal Response Test TRT.

Water as a source of heat. This type of heat pump can absorb heat energy from surface or groundwater. The performance of the heat pump depends on the geological position and yield of the spring (source). Groundwater has a relatively stable temperature of about 10°C, the warmest amongst natural sources [1].

A pumping well is used to extract the heat from ground water which after cooling is discharged to a second infiltration well. The advantage of this source is a high and almost constant temperature of groundwater, which is approx. 8–10 °C at a depth of 10 m. Prerequisite includes sufficient volume of the source, no mechanical impurities and low mineral content [6].

For surface water, the collector is placed at the bottom of the water flow in order to absorb heat efficiently. Due to the low water temperature in winter you can only cool it by a few degrees. This requires the need for large heat exchangers, which are costly [6].

Air as a source of heat. This type of heat pump has the advantage of easy installation and great versatility. Its installation does not require complex earthworks. The output of the heat pump varies with ambient air temperature. A higher external temperature, results in improved performance and vice versa. Heat pumps air / (water, air) are usually operated in a bivalence of approx. -3 C to -5 °C. Temperatures below the bivalence triggers an additional heat source eg. electric boiler. At prevailing low ambient air temperature, heat must be supplemented by additional resources that are able to cover the heat demand of the whole building [1].

Heat pumps of this type are made up of external and internal units commonly called split systems or from a compact design in which the full heat pump is placed in front of the object respectively in the house. The external unit draws in ambient air and is usually located on the south side of the building. The indoor unit generates heating and hot water [1].

The energy content of the air depends on its moisture content. In contrast to other substances (water, minerals) the amount of energy in the air is not directly proportional to temperature, but decreases rapidly. It follows that at the lowest ambient temperatures the heat pump utilizing outside air has the lowest performance [1].

For buildings which are mechanically ventilated indoor exhaust air can be recycled as a heat source. Indoor air generally has a relatively high temperature 18-24 °C. The heat pump can operate effectively even when subjected to conditions where it is not possible to use a recuperation system. The primary disadvantage is a limited amount of ventilation air, requiring an additional heat source such low potential soil collectors [6].

Basic classification of the systems

- Monovalent systems with heat pump

Heat pump covering the whole of energy needs of the building for heating and hot water, when you use monovalent system. The most commonly used systems, which use the energy content of ground or water. The ground and water provides a stable heat source, since they are the most resistant to temperature changes, and ensure enough thermal energy at low temperatures. Monovalent connecting heat pump to the heating circuit is shown in fig. 1.

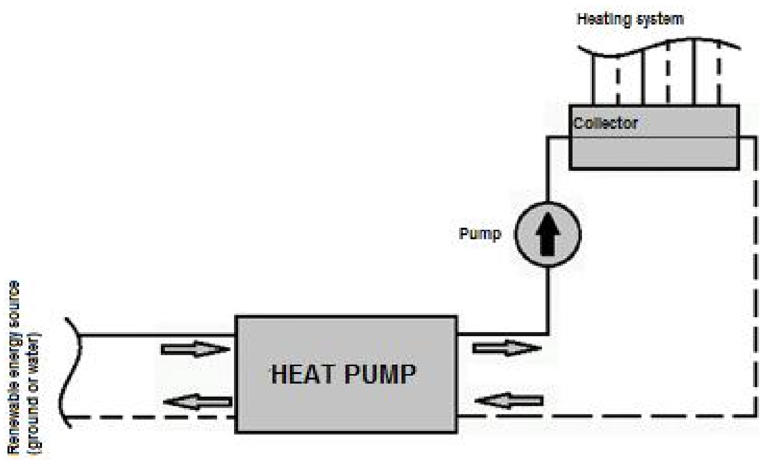

Fig. 1. Monovalent system with heat pump

Monovalent connecting heat pump with heating circuit and storage tank is shown in fig. 2. Storage tank helps to overcome the increased consumption of thermal energy 0.

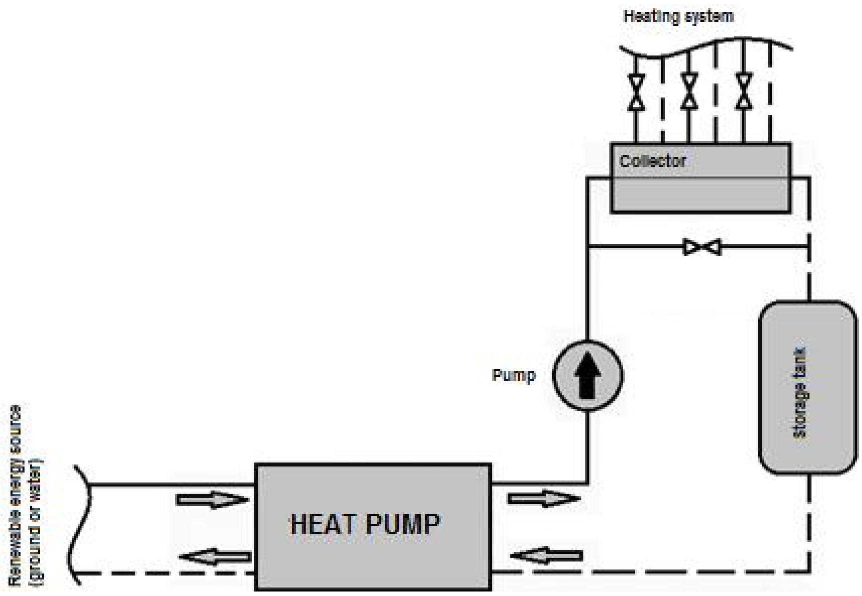

Fig. 2. Monovalent system with heat pump and storage tank

Monovalent connecting heat pump with hot water tank is shown in fig. 3. Heat pump provides hot water through a heat exchanger in the tank. The increased consumption of hot water helps to overcome electrical heating element mounted directly in the tank 0.

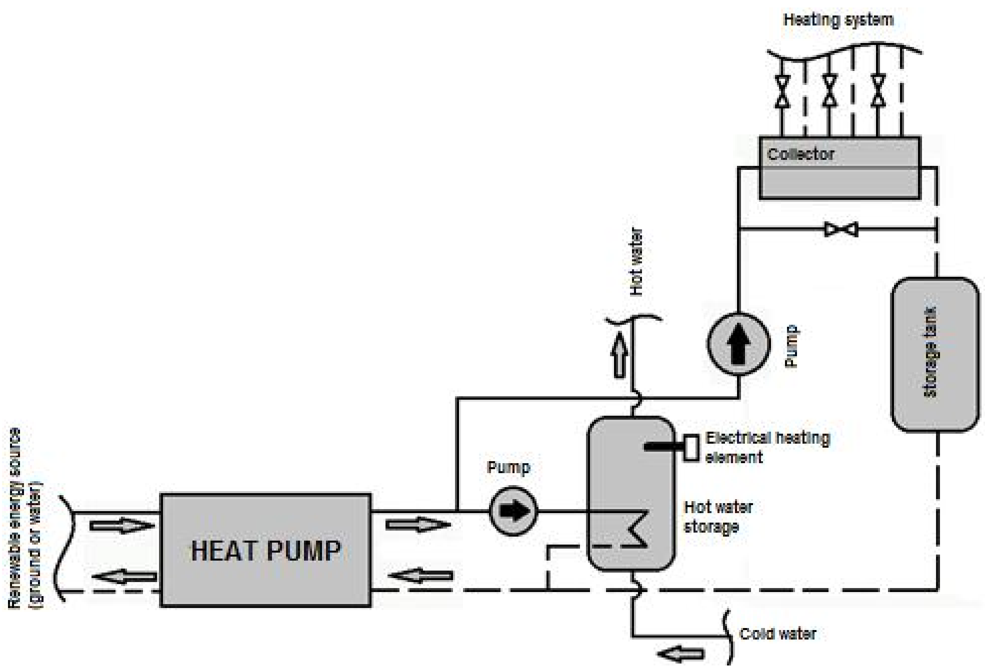

Fig. 3. Monovalent system with heat pump and hot water tank

- Bivalent systems with heat pump

Bivalent systems are similar to the monovalent but heat pump covers only part of energy needs of the building for heating and hot water. Heat pump is designed based on the bivalence point. Example of bivalence point for heat pump air/water is shown in fig. 4.

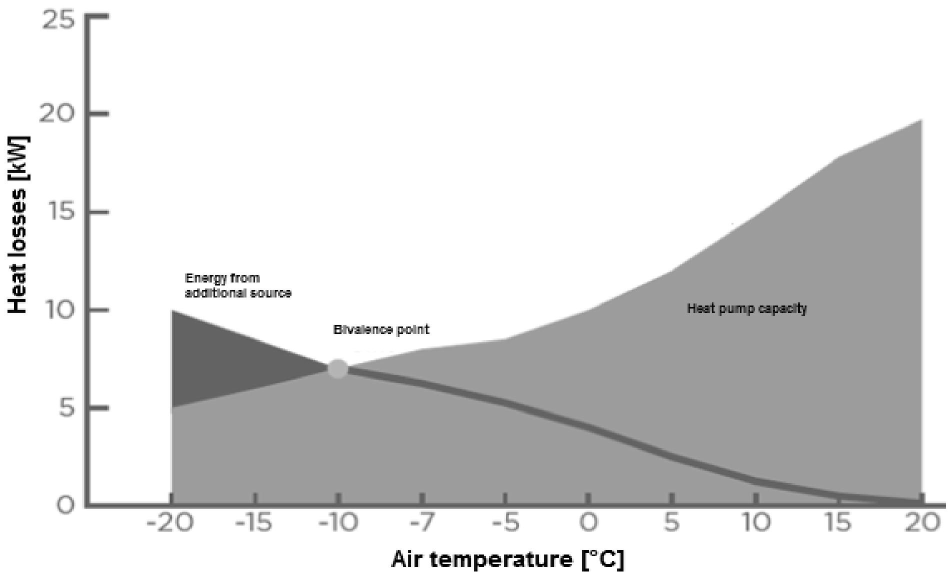

Fig. 4. Example of bivalence point for heat pump air/water

Bivalence point determines the temperature at which heat pump can't cover the energy needs of the building. Bivalent systems are the most commonly used especially with heat pump, which use as a source of energy content of atmospheric air. The air is at least stable source low potential energy in terms of temperature changes, so the system needs to be added so-called bivalent energy source. Bivalent energy source covers the remaining part of energy needs. It can also be designed as a backup energy source that can cover the entire energy needs of the building. This source can also be designed as a backup energy source. In this case bivalent energy source can cover the entire energy needs of the building. Example of bivalent system with bivalent source in the form of a boiler is shown in fig. 5.

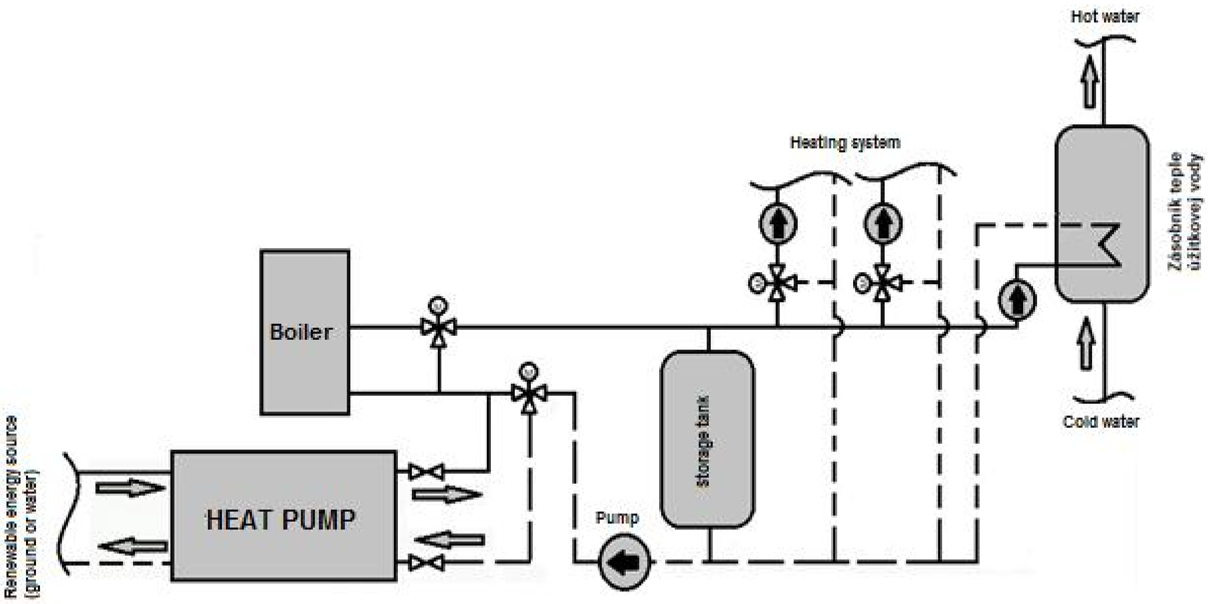

Fig. 5. Example of bivalent system with heat pump

- Mono energy systems with heat pump

Mono energy systems usually use additional electrical heating element mounted directly in the tank. These systems are the most commonly used especially with heat pump, which use as a source of energy content of atmospheric air. Additional electric heating element is very important for defrosting heat pump evaporator. Electric heating element is an auxiliary source of energy for reversible - inverted mode of the heat pump, when is frozen the evaporator. Heat pump used for defrosting heat pump evaporator the heat energy from the storage tank. Example of mono energy system with heat pump is shown in fig. 6 0 0.

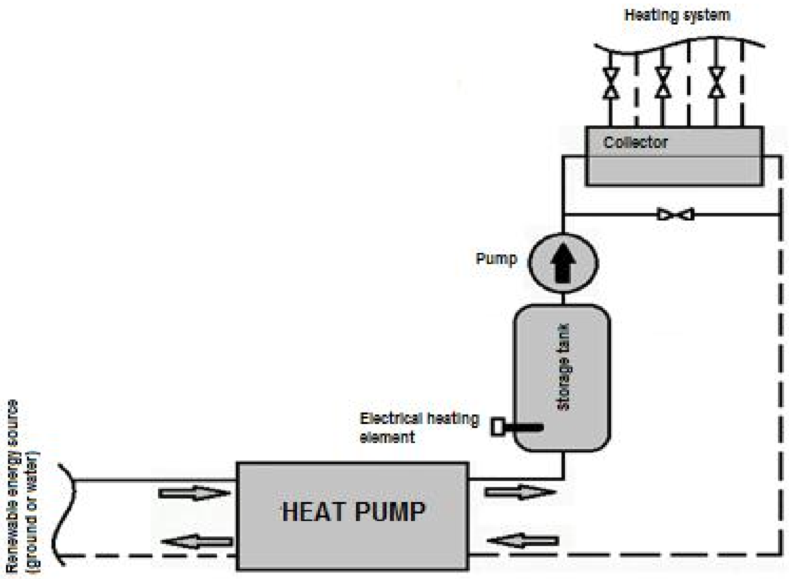

Fig. 6. Example of mono energy system with heat pump

Conclusions. The use of renewable energy sources has become a worldwide trend and is one of the ways to get cheaper and more accessible primary energy that has a minimum impact on the environment compared to conventional sources of energy (e.g. oil, coal). The heat pump is one of the effective ways to use renewable energy sources for the preparation of heating and cooling in buildings. The selection of a suitable type of heat pump and low potential source of energy should be based on the climatic conditions in which the building is located. Despite the higher initial costs, a well-designed proposal can be a both economical and environmentally friendly method for preparing heat compared to conventional devices using fossil fuels.

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