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USE OF ENERGY-EFFICIENT SYSTEMS FOR ENSURING THE MICROCLIMATE OF THE PREMISES

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Summary. *The article considers the use of the WLHP system, which is an alternative to already existing heating systems. It allows you to streamline engineering networks and implement energy-saving measures in the heat consumption sector. The advantages of the system are noted and the use of a heat pump in the system is recommended for the disposal of excess heat in the premises in order to reduce heat consumption. Measures related to energy-efficient technologies in Poland, Germany, and Sweden, including the use of heat pumps, were considered. The information regarding of the measurements COP of energy-saving equipment implemented in Ukraine, in accordance with current standards, with the aim of improving the quality characteristics of the equipment present in the WLHP system, was introduced. The advantages of such a solution in comparison with traditional systems for ensuring the microclimate of premises are noted.*

Key words: *heat pump units, ventilation, WLHP system, energy saving, energy efficiency, thermal power, microclimate, COP, circuit.*

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Statement of the problem in a general form and its connection with important scientific or practical tasks. Taking into account the exhaustion of natural fuel resources and the slow recovery of reserves, the significant increase in prices for imported energy carriers, the constant growth of the need for heat, the basis of the energy policy in the field of heat supply should be energy conservation in the field of consumption and a fundamental increase in energy efficiency in the field of generation, transportation and distribution of heat. The implementation of energy-saving measures in the consumption sector involves the transition to modern norms and standards in public construction, first of all, in the field of construction and reconstruction of the housing stock, in all branches of industry.

The main direction of the development of heat distribution and consumption systems should be the reduction of natural fuel consumption levels due to the increase in the efficiency of its use, the development of heat supply systems based on electric energy, non-traditional and renewable energy sources, secondary energy resources, natural heat resources, etc. [1–5].

Analysis of recent research and publications. Analysis of recent research and publications. In most premises of public buildings, during operation, significant excess heat is released into the environment by various sources, which, as a rule, is irretrievably lost by removing it into the atmosphere through exhaust ventilation systems. When installing heat pump water heaters systems, these heat surpluses can be used – due to this, operating costs can be reduced by 20–40% compared to other heating and air conditioning systems [6–7].

Sources of internal thermal energy of the building can be: electric lamps; office workers, visitors, etc.; computers and office equipment; technological equipment and facilities; solar radiation; the air of mechanically driven exhaust ventilation systems in which the energy source is air and which directly depend on the outside air temperature compared to heat pumps that draw energy from the ground, air or water. There are also other

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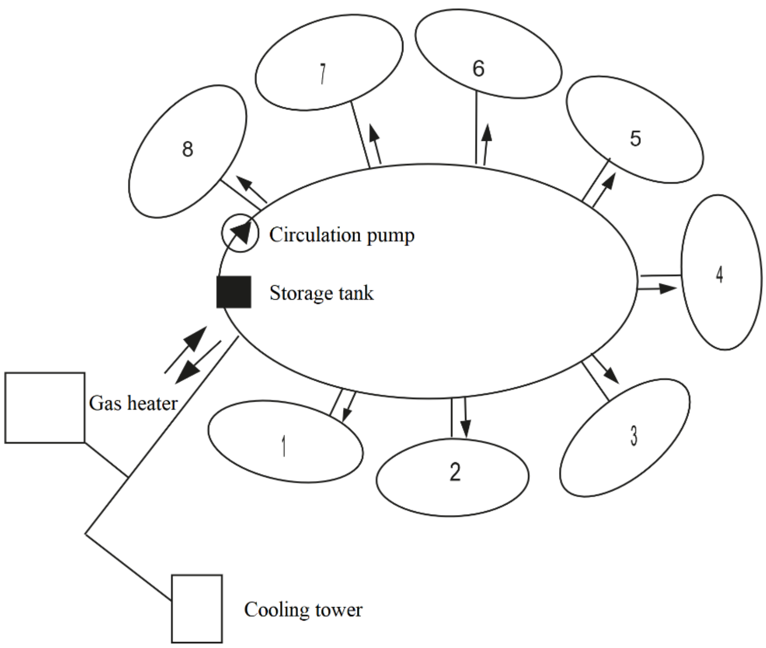
sources of excess heat in the building, but the above are the most significant. With a WLHP system, all this heat can be extracted from the rooms that require cooling and transferred to the rooms that require heating. Due to this, a significant reduction in operating costs can be achieved. There are also known examples of the use of internal energy from the building's technological systems (for example, household water drainage) with constant heat emission. The WLHP system allows, in turn, to include almost any consumer in the general water circuit, while streamlining the engineering systems [9].

The purpose of the work is: To justify the possibility of using air to water heat pumps for the utilization of excess heat in public premises in order to reduce the thermal power, and accordingly, the consumption of organic fuel, which is the main source of heat for the building.

Setting objectives. In global practice, the WLNP system acts as a fundamentally new alternative to the already existing schemes for the organization of heating, air conditioning and ventilation of objects of various purposes. This system is completely «decentralized» and is capable of:

- simultaneously work on cooling and heating;
- maintain individually set microclimate parameters independently in each zone;
- ensure efficient exchange of thermal energy between premises.

The main advantages of the system: energy efficiency, high reliability and flexibility, simplicity in design, installation and maintenance, environmental safety.



1 – refrigerating chambers;
2 – greenhouse, winter garden;
3 – functional, residential premises;
4 – office premises;
5 – water supply and drainage, household needs;
6 – auxiliary premises, utilities;
7 – room for cooking;
8 – sauna, swimming pool.

There are also other sources of excess heat in the building, but the above are the most important [11–12]. When using the WLHP system, the entire heating system is interconnected in a ring.

Figure 1. An example of a ring heat pump system

Heat pumps in the WLHP system function as heating climatic elements that form a system for the utilization of thermal energy (Heating Recovery System), which, for example, in traditional systems is irreversibly removed into the atmosphere (Fig. 1). The WLHP system consists of individual units of the air to water heat pumps type, interconnected by a closed water circuit. Water in this circuit performs the function of a heat carrier, and also redistributes energy between different rooms of the building, being at the same time a source of so-called low-potential heat. Excess heat in the premises of the building can be considered as nothing more than low-potential sources of heat.

Considering the microclimate engineering systems of a public building, three main variants of the building's functioning can be distinguished depending on the period of the year:

1. In the warm period of the year, the premises of the building need cooling – excess heat is removed by heat pumps and transferred, for example, with the help of water in a closed circuit, to the external cooling system (chiller, cooling tower, etc.).
2. In the cold period of the year, the heat loss of the room should be compensated (the building must be heated) – the heat taken from the energy source should be transferred to water in a closed circuit and distributed individually in individual rooms depending on the need with the help of heat pumps. In the case of excess heat losses from possible heat inputs, their compensation occurs with the help of traditional heat-generating units or renewable sources.
3. In certain periods of the year, part of the premises of the building should be heated, and part of it needs to be cooled. At this time, heat pumps absorb excess heat and it enters the premises that require heating. Depending on the amount of excess heat that can be utilized, at a certain temperature of the outside air, the equilibrium state of the thermal system is established. This means that there is no need for reheating or cooling of the liquid circulating in the circuit.

The level of thermal equilibrium is reached at a water temperature in a closed circuit within the range of about +(16...36) ^{0}C. At lower temperature values (in the cold period of the year), thermal energy is supplied from an additional source of heat to the water circuit in order to keep it in the above range. In the warm period of the year, excess heat is removed from the water circuit with the help of coolers – the temperature should not exceed +36 ^{0}C. Such a temperature range for water in a closed circuit guarantees the full functionality of the installed equipment, which means that each heat pump is able to provide heated or cooled air to each of the rooms served by this system.

The performed calculations showed sufficient efficiency of the proposed solutions – the heat capacity of the heat generating unit can be reduced by half of the need. This approach to design became possible due to the addition of all heat pump compressors to the consolidated balance of thermal power. It is worth noting that thanks to this, there is a reduction in both capital and operating costs, as well as emissions of pollutants – products of fuel combustion – into the atmosphere. The source of cold in such a system can be, for example, wet cooling towers of a closed type. As a rule, such equipment is placed on the roof of buildings. In order to avoid the transfer of vibration from the aggregates to the supporting structures of the building, anti-vibration protection should be provided. Cooling towers were selected on the basis of the sum of the calculated capacities of the heat pumps and the consumed electric power of the heat pumps. Since this equipment is installed outside the house, it is necessary to use water-glycol solutions in a closed hydraulic circuit to protect against freezing in the cold period of the year. NIBE F2040 type monobloc heat pump of horizontal design, interconnected by a water circuit of steel pipes on welded joints, can be offered as such equipment. The hydraulic system of heating heat pumps is made as a two-pipe system with main risers and circuits on each floor of the building. The connection of individual heat pumps on each floor is made according to a system with accompanying water movement and additional flow regulators for each heat pump. Why? Heat pumps work in water circuit systems and require careful regulation of water flow. This is the main condition for the correct operation of the equipment.

The above-described analysis of the operation of heat pumps operating in the water circuit system shows how important it is to ensure the necessary flow of water through the heat exchanger. In order to achieve the required consumption, it is mandatory to use effective regulatory elements.

The principle of operation of the system can be represented by the following ratio [12]:

C= L+E (1)

C – heat released in the condenser;

L – work (electrical energy) of the compressor;

E – heat absorbed by the evaporator.

In the cooling mode, the unit works according to the direct cooling cycle, in which the refrigerant evaporates in the heat exchanger of the evaporator, absorbing heat from the cooled air and enters the condenser, being fed with water from the loop, giving the heat of condensation to water.

E= C-L (2)

Work in heating mode. The cycle is reversed and the refrigerant evaporates in the condenser, which is now used as an evaporator absorbing heat from the water circulating in the loop. The heat absorbed from the water in the loop is added to the work done by the compressor and we get the heat given to the heated air.

In this case, we get:

C= L+E (3)

C – thermal energy given to the room;

L – electrical energy of the compressor;

E – thermal energy absorbed from the cooling water loop.

The Renewable Energy Sources Act in Germany pushes all new residential and commercial buildings to an efficient heating scheme [13]. From January 1, 2016, the construction of new buildings is allowed only if they use energy produced from renewable sources for space heating and hot water supply. This includes the use of solar energy, biomass burning, efficient heat pumps, etc. Boilers burning liquid fuels are completely prohibited as a means of heating and DHW of new buildings.

However, this law is not so strict for old buildings, because they do not have the possibility of pre-planning. Instead, the renewable repairs will be funded by the government's Market Incentive Program (MAP) to install more efficient technologies – biomass, solar thermal, solar power, heat pumps and pellet boilers.

Heat pumps in Sweden are absolutely commonplace [14]. Over the past 14 years, sales of heat pumps in Sweden have more than doubled – now there are 1.7 million heat pumps installed in the country, which work for the benefit of 10 million residents.

At Sustainable Heating and Cooling at the Nordic Clean Energy Week in Malmö, Sweden, Per Jonasson (Swedish Refrigeration and Heat Pump Association) and Signhild Gelline (Swedish Green Energy Center) gave a presentation to the public about the development of the Swedish heat pump market.

Sweden now has the highest percentage of heat pumps per capita in the world, resulting in a dramatic decrease in fossil energy consumption for heating and hot water over the past 30 years.

One notable building that uses heat pumps is the Wasa Ship Museum in Stockholm, which uses seawater for cooling. This is a real «flagship» from the point of view of heat pumps (despite the fact that the Wasa ship itself suffered a disaster in real life). The only thing that is sinking now is the consumption of fossil energy and the cost of renewable energy!

The results of the study of the heat pump market in 2021, carried out by the Polish Organization for the Development of Heat Pump Technology (PORT PC), provide a basis for optimistic forecasts of the further development of the heat pump market in Poland in the next few years [15]. In recent years, the use of air/water for central heating systems has increased by 55%, and the market for all types of heat pumps related to central heating has increased by 30%.

The entire market of heat pumps in Poland increased by approximately + 22%. According to PORT PC estimates, around 27,000 heat pumps were sold in 2021. Observing the sale of heat pumps in 2016-2021, one can see the harmonious and continuous growth of the market. The share of heat pumps in new single-family houses also increased significantly. According to PORTPC, in 2021 it was 12.5% (every eighth new building). In 2016, PORT PC estimated that the share of heat pumps in new buildings was less than 3%. With the optimistic market growth forecast made by PORTPC, in 2025 the share of heat pumps in newly built one-story houses may reach 20–25%. It is noteworthy that the market of these devices in Poland is the only market in Europe where the growth of heat pump sales has been recorded for seven consecutive years

For several years in a row, there has been a strong interest in air to water heat pumps, which are used for heating (and often cooling) buildings. The number of devices sold in 2021 is estimated at approximately 8,100 units. Compared to 2020, the market has increased by approximately 55%. Everything seems to indicate that this trend will continue in the coming years. PORTPC estimates that, under an optimistic scenario, the number of heat pumps sold in 2025 could reach 20,000–3,0000 units. According to Pavel Lachman, the chairman of the Board of PORT PC, five main reasons for the growth of this market segment can be identified. «The first is increasing trust in innovative technologies such as heat pumps. The second reason is the increase in environmental awareness of Poles, related to the study of the impact of air pollution caused by boilers for solid fuel. The third reason is the noticeable increase in competition in this market segment (air heat pumps). Many manufacturers choose these technologies as solutions of the future and conduct active market activities in this field. Fourth, there is also an increasing tendency to build smaller houses, without basements and space for solid fuel and boilers, but increasingly comfortable. And fifth: the market for devices with medium and low prices is growing the fastest. In many cases, the use of a heat pump can be compared, in terms of investment, with the costs of installing a gas boiler or a biomass boiler (in particular, taking into account all the elements of the investment: gas connection, flue pipe, boiler room or space for fuel)”.

The strict policy of the EU, regarding the improvement of energy-efficient technologies, forces manufacturers to be more responsible when designing heat pumps and bringing COP measurements in accordance with existing standards [16].

Example: every European manufacturer of any heating equipment must indicate the energy efficiency class of its product.

Class A – 50–80% more energy efficient;
Class B – 25–50% more energy efficient;
Class C – 10–25% more energy efficient;
Class D – 0–10% more energy efficient;
Class E – 0–10% less energy efficient;
Class F – 10–25% less energy efficient;
Class G – more than 25% less energy efficient.

Therefore, if you compare the COP of different heat pumps, pay attention to which «standards» were conducted.

For example, a manufacturer can make a COP measurement by measuring how much heat the compressor produces – for example 4.5 kW of thermal energy – and how much the compressor consumes – for example 1 kW of electricity. The resulting COP is 4.5. At the same time, it should not be forgotten that the operation of a geothermal pump requires the almost non-stop operation of at least two circulation pumps: a circulation pump for the soil circuit, a circulation pump for the heating circuit. If we take into account the electricity consumption of these circulation pumps, we will get the total electricity consumption of the system, for example – 1.1 kW of electricity. This means that the COP will no longer be 4.5 but 4.09. Is there a difference? [17-18].

Therefore, it is recommended to look for a COP value that complies with one of the standards, such as EN14511 [19].

This European standard takes into account the power consumption of circulation pumps. It also regulates at what temperature parameters at the input and output of the heat pump, it is necessary to carry out purge.

Let's say you read the specifications for a good European heat pump.

The manufacturer is a well-known brand, all measurements are made in accordance with EN14511 standards.

What should you pay attention to? Let's consider all the same circulation pumps [20-21]. We have already understood that any manufacturer measuring their equipment according to EN14511 must take into account the power of circulation pumps. But pay attention to the design of the heat pump. What if it does not have built-in pumps, and the manufacturer offers to purchase them separately. In such cases, the manufacturer, in order to increase the COP, is interested in reducing the amount of electricity used by the circulation pumps. Therefore, it takes into account the characteristics of the most energy-efficient circulation pumps. But in practice, when you install such a heat pump, they will most likely supply ordinary circulation pumps, because the use of the most energy-efficient circulation pumps can increase the estimate by a decent amount.

In this regard, heat pumps with built-in circulation pumps have a more plausible COP, because you actually get those circulation pumps that were actually taken into account in the COP measurements [22]. The situation is similar with built-in boilers. If the boiler is built-in, there is a minimum distance from the heat source to the boiler, correspondingly less heat loss on the main pipelines. As a rule, systems with built-in boilers have a higher energy efficiency class than systems with separate boilers.

At the moment, there is a certain number of industrial facilities in Ukraine that have implemented schemes for the use of heat pumps with the extraction of heat from waste water.

For example, in one of the sanatoriums, a NIBE heat pump is installed, which takes heat from the sewage coming from the therapeutic baths. Since the temperature of such effluents is high, the COP is also quite high. In private houses where even 10 people live, it is impossible to get such a large volume of warm water from which the heat pump could extract heat for heating. Therefore, in real conditions, the temperature of the carrier from which we take heat (soil, water, etc.) cannot be high, and therefore the COP cannot be more than 5 [23].

Conclusions. Conducted studies have shown the advantages of the WLHP system in that excess heat can be used for the benefit of the building and people; installation of a low-temperature heating and air-conditioning system in the building provides an energy class and increases investment attractiveness; thanks to the system, full independent temperature control is provided in each room; water/air heat pumps operate with a high energy efficiency COP, resulting in lower energy consumption and lower operating costs. Studies related to increasing the use of energy-efficient indoor microclimate systems that would meet the standards of SOR and EN14511 are not exhaustive and require further research.

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ВИКОРИСТАННЯ ЕНЕРГОЕФЕКТИВНИХ СИСТЕМ ЗАБЕЗПЕЧЕННЯ МІКРОКЛІМАТУ ПРИМІЩЕНЬ

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Резюме. *Розглянуто застосування системи WLHP, що є альтернативою вже існуючим системам опалення, кондиціонування та вентиляції приміщень різного призначення. Вона дозволяє впорядкувати інженерні мережі та реалізувати енергозберігаючі заходи у секторі теплоспоживання. При застосуванні системи WLHP вся теплота від джерел надлишкової теплоти приміщення може бути відібрана в приміщеннях, які вимагають охолодження, і передана в приміщення, які потребують опалення. За рахунок цього можна зменшити експлуатаційні витрати. Система дозволяє, в свою чергу, включати в загальний водяний контур практично будь-якого споживача, одночасно впорядковуючи інженерні системи. Вона може одночасно працювати на охолодження Й нагрівання; підтримувати індивідуально задані параметри мікроклімату незалежно в кожній зоні; забезпечувати ефективний обмін тепловою енергією між приміщеннями. Система складається з індивідуальних агрегатів, з'єднаних між собою замкненим водяним контуром. Вода, що циркулює в цьому контурі, виконує функцію теплоносія, а також перерозподіляє енергію між різними приміщеннями будівлі, будучи водночас джерелом так званої низькопотенційної теплоти. А теплонадлишки у приміщеннях будівлі можна розглядати не чим іншим як низько потенційними джерелами теплоти. Обґрунтовано можливість застосування теплонасосних установок для утилізації надлишкової теплоти у приміщеннях з метою зменшення теплової потужності, а відповідно, і споживання органічного палива, яке є основним джерелом теплоти в приміщенні. Відзначено переваги системи та рекомендовано використання в системі теплового насоса для утилізації надлишкової теплоти у приміщеннях з метою зменшення теплоспоживання. Розглянуто заходи, пов'язані з енергоефективними технологіями в Польщі, Німеччині, Швеції, що включають використання теплових насосів. Ознайомлено з інформацією щодо проведення вимірювань СОР енергоощадного обладнання, що реалізується в Україні відповідно до діючих стандартів з метою покращення якісних характеристик обладнання, яке присутнє в системі WLHP. Відмічено переваги такого рішення у порівнянні з традиційними системами забезпечення мікроклімату приміщень.*

Ключові слова: *теплонасосні установки, вентиляція, система WLHP, енергозбереження, енергоефективність, теплова потужність, мікроклімат, СОР, контур.*

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