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The selection of a methodology for calculating the heat load of hot water supply systems for facilities with significant uneven consumption

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Abstract. When determining the amount of thermal energy required for the functioning of the hot water supply system for any building, the question of choosing a heating method arises. It is especially relevant to accurately predict the capacity of the hot water supply system for facilities with pronounced uneven hot water consumption. In this research, a comparative analysis of methods for determining the maximum design flow rate of hot water was performed, which plays an important role in the selection of equipment for heating water in the flow mode. On the example of the main building of KNUCA, the problem of determining the total design hot water flow rate for buildings characterized by an uneven mode of water consumption is revealed. Monitoring of the actual mode of water consumption of the main building of KNUCA was carried out, as a result of which the real total hot water flow rate during the working day of the university was determined.

Keywords: hot water supply, heat load of the DHW system, simultaneous use of faucets, design hot water flow rate, uneven water consumption.

Introduction. A centralized hot water supply, as one of the components of general centralized heat supply systems, is experiencing a major crisis in Ukraine. The demand for this service from the population is significantly decreasing. Heat supply organizations are constantly looking for ways to stabilize the situation. Among these ways, two directions can be distinguished. The first direction includes the rejection of central heat supply station (CHSS) and, accordingly, four-pipe systems or the replacement of steel pipes of the hot water supply circuit with polyethylene ones where it is still difficult to refuse from CHSS and the comprehensive use of non-traditional and renewable heat sources, including solar systems and systems with heat pumps. The second direction is directly associated with the need to accumulate heat, which increases the cost of equipment. The solution to this problem lies in reducing the cost of equipment by optimizing its capacity and optimizing hot water consumption. In particular, this applies to some public buildings and especially to educational buildings, which forces us to turn to the study of this problem.

Relevance of research. In recent years, the volume of central heat supply services in Ukraine has been constantly decreasing [1]. At the same time, the decrease in the volume of hot water supply services in relation to centralized heating and ventilation is more intense [2]. This leads to the deregulation of existing central heat supply systems and, as a result, to energy overruns. Optimizing the consumption of hot water without changing the conditions of its consumption will help stabilize the above negative processes.

Recent studies and publications. The problem of improving the accuracy of predicting hot water consumption in heat supply facilities with sharp uneven water consumption has not been paid attention to in researches of recent years. Studies have been conducted in the areas of improving the reliability of hot water supply systems in large cities [3] and the use of solar energy to cover the needs of hot water supply [4], including buildings of higher education institutions [5, 6]. A detailed study of the current state of centralized hot water supply systems is presented in the monograph [7]. In this work, much attention is paid to forecasting the consumption of hot water, but by residential buildings, both apartment buildings and cottages It is not possible to use the methods of calculation forecasting given in this paper for buildings with sharp fluctuations in hot water consumption.

In paper [3], the positive experience of deaeration of water for hot water supply was analyzed, which leads to a significant reduction in accidents in four-pipe heat supply systems and an extension of the service life of hot water supply pipes. The paper presents numerical indicators that show a decrease in the volume of centralized hot water consumption in the city of Zaporizhzhia in recent years.

Paper [4] is devoted to the use of high-temperature heat carriers in solar hot water systems. It is shown that the use of a heat carrier with a temperature of up to 300°C can solve the problem of stagnation of solar systems and extend the service life to 10 months in the latitudes of Ukraine, as well as significantly reduce the solar field area and the volume of the heat accumulator. However, in this paper, the object of analysis is residential buildings.

Papers [8, 9, 10] are devoted to improving the efficiency of circuit solutions for solar hot water supply systems and do not highlight the problem of predicting the heat load, which affects the choice of equipment.

Paper [11] is devoted to the narrowly focused topic of using solar energy for hot water supply in individual housing construction. The article describes the choice of economic schemes of solar systems and the possibility of obtaining solar energy in different regions of Ukraine.

Paper [12] is devoted to determining the efficiency of solar hot water systems. In addition to an attempt to optimize the solar field area depending on the solar energy potential by region, the paper shows the positive impact of the introduction of solar hot water systems on reducing anthropogenic pressure on the environment.

Paper [6] analyzes the results of modeling the possible use of a solar system to provide hot water to a complex of university buildings in the city of Mykolaiv. To select the equipment in terms of predicting, the methodology for calculating water consumption in accordance with SNIP «Normy potrebleniya vody potrebitelyami», was adopted, which brings some inaccuracies due to vagueness in the formulation of some points of the regulatory document.

Paper [5] is devoted to modeling the operating modes and, to some extent, the choice of equipment for solar hot water supply systems at a university. In particular, the authors present an algorithm for modeling the operation of a solar system with an accumulator tank and the results of calculations. However, the initial data on the system load for modeling were taken without justification and even explanation.

Main part. When determining the amount of thermal energy required for the functioning of the hot water supply system for any building, the question of choosing a heating method arises. It is especially relevant to accurately predict the capacity of the hot water supply system for facilities with pronounced uneven hot water consumption. The largest consumption irregularities should be expected from educational buildings. For this reason, the KNUCA main building was taken for further analysis. Taking into account that there are no showers or bathrooms in the main building of the university, the only consumers of hot water are washbasins. The highest water consumption occurs during short periods of time (breaks) and very little or no water consumption after classes and on weekends. The approximate chart of water consumption during the university working day is shown in fig. 1.

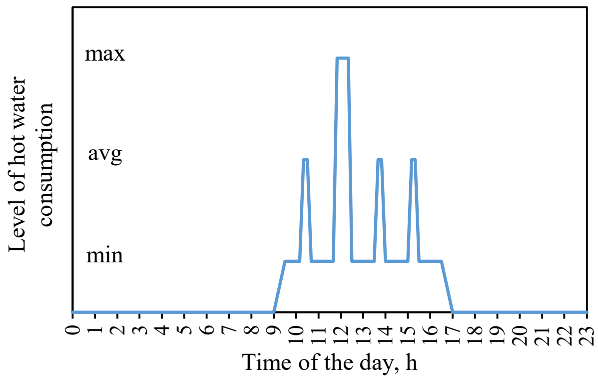

Fig. 1. Approximate chart of water consumption mode of the university:
min – during the classes; avg – during the usual break; max – during the long break.

The graph shows that the building's water consumption pattern is uneven, with short-term peaks with maximum and average consumption and long-term periods with minimum and zero water consumption.

There are two main ways to prepare hot water: in a storage tank with coil and in a flow-through heat exchanger [7].

Water heating in a storage tank with coil requires significantly less capacity from the heat source compared to a flow-through heat exchanger, as it involves the accumulation of hot water to cover the peaks of water consumption. It should be understood that the power of the heat source has a direct impact on its cost and the cost of related equipment. In addition, the selection of a heat source of excessive power will lead to additional heat losses caused by excessive heating during transient periods. For this reason, the method of heating water in a capacitive heat exchanger is advisable to use in cases where the instantaneous heat load of the hot water supply system significantly exceeds the load of the heating system. Also, this method is well suited for buildings where water consumption mode is characterized by short periods of high and medium water consumption and long periods of low or no water consumption. In this mode, the water will be heated during periods of minimal or no water consumption. That is, this method is advisable to use for buildings with a fixed work schedule, without people being constantly present outside of working hours. However, the absence of constant water consumption with insufficient automation will lead to additional heat losses, as the accumulated hot water will gradually cool. This method is not able to provide the set water temperature during long period of water consumption, and therefore is not suitable for buildings characterized by such a mode of hot water consumption.

A hot water supply system that is heated in a flow-through heat exchanger has a much smaller volume, which means it has less inertia and less heat loss. Due to the rapid heating of water, this method is suitable for buildings with both constant and uneven water consumption. However, it requires a significantly higher heat exchanger capacity and therefore a significantly higher heat source capacity due to the need to quickly heat the required amount of water. Therefore, it is usually not advisable to use it in cases where the instantaneous heat load of the heating system is much lower than the load of the hot water supply system. In addition, such equipment requires the installation of an intermediate buffer tank (intermediate heat accumulator), which will accumulate a certain amount of heat necessary to ensure the operation of the flow heat exchanger until the heat source is started during the non-heating period. It should be noted that there is no need for a large buffer volume, since the response time of the heat source (startup time and reaching the rated mode) is usually about 5 minutes [13].

There is a third method - a combined method that combines the advantages of the first and second methods [14]. The combined method involves installing both the accumulator tank and the high-speed heat exchanger at the same time. That is, the water will be heated in a flow-through heat exchanger and accumulated in the tank. In this case, the flow-through heat exchanger can be of a smaller capacity due to the ability to accumulate the necessary amount of water to pass the peak water consumption. At the same time, the system will be able to provide a longer water extraction, because the high-speed heat exchanger will constantly recharge the tank with freshly heated water. Thus, such a system will fulfill the needs of a building with both constant and uneven water consumption. But the cost of such a system will be much higher.

Any water heater must be selected in such a way that it is able to provide the design hot water flow. The method of calculating a water heater will differ depending on the type of water heating method used Since the flow-through method involves heating water at the time of water extraction, it is important to select such equipment with the maximum possible hot water flow rate so that the designed heat exchanger is able to heat this flow rate during peak water consumption.

The design maximum flow rate consists of the flow rates of individual faucets dispensers operating simultaneously [7]:

$$q_{tot}^{H} = q_{i}^{H} \cdot n \tag{1}$$

where q_{tot}^{H} – maximum hot water flow rate by the system, l/s; q_{i}^{H} – hot water flow rate by one faucet, l/s; n – a number of faucets operating simultaneously, pcs.

Thus, the highest hot water flow rate will be at the moment when water starts to flow out of all faucets. The likelihood of such an outcome decreases rapidly with the number of faucets, and the difficulty of accurately determining the total flow rate increases. The more faucets are provided in the hot water supply system, the more important it is to take into account the simultaneous use of them. Indeed, if the estimated flow rate is too high, the capital costs will be higher and the potential of the selected equipment will never be used, while if the flow rate is too low, the water heater will not be able to provide the DHW system with the required amount of hot water.

The minimum power of the heat exchanger required to heat water in the flow mode can be determined by the formula [7]:

$$Q_{DHW} = \frac{q_{tot}^{H} \cdot \mathrm{c} \cdot (t^{H} - t^{C})}{3600} \tag{2}$$

where Q_{DHW} – minimum capacity of the heat exchanger required for heating the water in the flow mode, kW; q_{tot}^{H} – design hot water flow rate, taking into account the simultaneous use of faucets, kg/h; *c* – water specific heat, kJ/(kg·°C); t^{H} – temperature of hot water, °C; t^{C} – temperature of cold water, °C.

The capacity of the heat exchanger is directly dependent on the design hot water flow rate and the temperature difference between hot and cold water. And the heat exchanger capacity, in turn, determines the heat exchange surface area, temperature, and heat carrier flow rate.

The Ukrainian DBN V.2.5-64:2012 Vnutrishnii vodoprovid i kanalizatsiia and the European DIN 1988 standards agree that the temperature of hot water should be at least 55°C, and the temperature of circulating water should be at least 50°C at any point in the system. Moreover, the system should ensure seasonal thermal disinfection at a temperature of at least 70°C. These requirements are put forward to prevent the emergence of the Legionella bacterium. The ability of the bacterium to reproduce is maintained at temperatures from 15°C to 46°C, when the temperature rises to 48°C and above, the bacteria die [7].

When calculating and selecting the heat exchanger, the cold water temperature should be taken for the winter period, that is, equal to 5°C. If the cold water temperature is taken for the summer period, the temperature difference and therefore the determined capacity will be lower, thus the heat exchanger will not be able to heat the design amount of water during the winter period [15].

The power of the heat exchanger depends directly on the maximum design flow rate, so it is very important to choose a value so that during peak water consumption each consumer receives the required amount of hot water at a given temperature. To determine this cost, it is necessary to refer to regulatory documents and usually its value depends on the purpose of the building, the number and type of devices and the number of consumers. It should be noted that for such facilities as higher education institutions, this hot water flow rate is very difficult to determine due to the significant design number of consumers and the large number of faucets.

The current DBN V.2.5-64:2012 Vnutrishnii vodoprovid i kanalizatsiia states that the total calculated water flow per second should be taken from the annexes depending on the design number of consumers and the calculated average water flow per day for one person or depending on the number of faucets and the average flow rate of these devices per hour. The design number of people in educational buildings is quite large and it is certain that a significant part of them will not use water during the day, and in general, taking into account the smallest maximum average daily flow rate (150 l/day per 1 person) proposed in the applications, we can conclude that this method of determining the total second flow rate is intended for residential buildings. Therefore, when determining the total second flow rate for educational buildings, it is necessary to start from the number of faucets. According to the standard, the design average hourly hot water flow rate is initially determined in accordance with the application given in it. Then, taking into account the number of faucets and the average hot water flow rate per hour, the maximum design hot water flow rate is determined. The values of total hot water flow rate indicated in the appendices of the standard already take into account the simultaneous use of faucets, but the standard does not say anything about the methodology used to determine the simultaneous use of faucets.

SNIP 2.04.01-85, which was in force before the adoption of DBN V.2.5-64:2012, provides a methodology for calculating the maximum flow rate, taking into account the simultaneous use of faucets, depending on the design number of people, the number of devices and hot water flow rate per faucet and the average hourly flow rate per person. These costs are presented in the applications of the document, but they are determined for higher education institutions with shower rooms, which introduces an error for educational institutions that do not have them. According to the standard, the maximum calculated flow rate can be determined by the formula:

$$q_{tot}^H = 5 \cdot q_i^H \cdot \alpha \tag{3}$$

where q_{tot}^H – maximum design hot water flow rate, l/s; α – coefficient that is adopted according to the applications of the standard, depending on the total number of faucets N and the possibility of their use P.

The possibility of using devices according to SNIP 2.04.01-85 is calculated by the formula:

$$P = \frac{q_{Hr,u} \cdot U}{q_i^H \cdot N \cdot 3600} \tag{4}$$

where $q_{Hr,u}$ – average hot water flow rate per hour per person, l/h, is accepted according to the application of the standard; U – total number of consumers; q_i^H – hot water flow rate by one faucet, l/s; N – total number of faucets.

In order to calculate the maximum design flow rate for simultaneous use of devices according to DIN1988, the hot water flow rate of a single faucet first needs to be determined. The value is taken according to the applications of the standard. The maximum design flow rate for administrative buildings with a total flow rate $\sum q_i^H \leq 20$ l/s is determined by the formula:

$$q_{tot}^H = 0{,}682 \cdot (\sum q_i^h)^{0{,}45} - 0{,}14 \tag{5}$$

where q_{tot}^H – maximum design hot water flow rate, l/s; q_i^H – hot water flow rate by one faucet, l/s.

At the same time, the hot water flow rate of one faucet specified in this standard is valid at hot water temperatures t^H = 55°C and cold water t^C = 15°C. That is, they are valid only for the summer period. For the winter period, they need to be recalculated. To do this, it is necessary to determine the temperature of the mixed water using the formula:

$$t_{mix} = \frac{t^H \cdot q_i^H + t^C \cdot q_i^C}{q_i^H + q_i^C} \tag{6}$$

where t_{mix} – temperature of mixed water, °C; q_i^H, q_i^C – volumetric flow rate of hot and cold water by one faucet, l/s; t^H – temperature of hot water, °C; t^C – temperature of cold water, °C.

Then, by solving the inverse task, substituting the temperature of cold water in winter and the resulting mixed temperature into formula (6), the flow rate of cold and hot water for the winter period is found at the same total flow rate and mixed temperature.

Another method for determining the maximum design flow rate of hot water with a known number of faucets is given in [7]. Since it is not economically practical to design a system for a level of water consumption that will occur very rarely or not at all, the total design flow rate can be determined by assuming how often it will be exceeded. The total second consumption of hot water is determined based on the number of faucets using the formula:

$$q_{tot}^{H} = a\sqrt{N} + bN \quad (7)$$

where a and b – coefficients of approximating dependencies; N – number of faucets ranging from 40 to 300.

The coefficients a and b given in [7] were calculated for the curves of maximum second hot water consumption with an assumed possibility of exceeding, based on water consumption studies conducted in 2001-2003 in Szczecin, Poland.

As a result of calculating the total design hot water flow rate for the main building of KNUCA from four different sources, it was found that the obtained values range from 1.03 to 2.66 l/s, which means that they are quite wide. To determine the methodology that is closest to reality, we conducted observations of the water consumption regime of the main building of KNUCA.

The maximum possible design hot water flow rate depends on two factors: the average hot water consumption by one device and the maximum number of devices that can operate simultaneously.

The most accurate method for measuring the flow rate of each device is to use ultrasonic flowmeters of the inline type. In our case, there was no such possibility, so to determine the flow rate of hot water by one device, we had to resort to the volumetric measurement method, and to reduce the measurement error, the number of flow measurements by each device was taken equal to ten, with subsequent calculation of the root-mean-square measurement error. It should be noted that when determining the flow rate by one device using the volumetric method, the flow rate of exactly the mixed water was measured, and with the help of calculations for determining the ratio of cold and hot water flow rates, the flow rate of hot water by each device was determined.

The studies described in [7] indicate that people's preferences for a comfortable water temperature vary widely. On average, human hands perceive water with a temperature of 33°C as "neutral", with a temperature of 40°C – as "warm" and with a temperature of 48°C – as "hot". Human heat perception is almost linearly dependent on water temperature. During the measurements, the temperature of the mixed water was set at t_{mix} = 37°C, because this value is in the middle of the range from "neutral" to "warm".

To measure the flow rate, 3 liters and 5 liters measuring vessels, a thermometer, and a stopwatch were used. At first, the temperature of cold and hot water was measured separately using a thermometer and the faucet was set to a position where the thermometer immersed in the water jet showed a temperature of 37°C. The measuring vessel was placed in the washbasin so that the flow of water was directed into the vessel. At the moment the faucet was opened, the stopwatch started counting and ended when the measuring vessel was filled to 3 or 5 liters (due to the installation of some devices, it was impossible to measure everywhere with a 5-liter vessel). In this way, measurements were made on the 7th, 4th, 3rd and 1st floors, 10 times in each WC and with the faucets open at 50 % and 100 %. The measurement results were averaged and the root-mean-square measurement error was estimated for each averaged value according to the method [16]. From the obtained mixed water flow rates, the hot water flow rates for each WC were determined using formula (6), and the results are presented in a histogram (fig. 2).

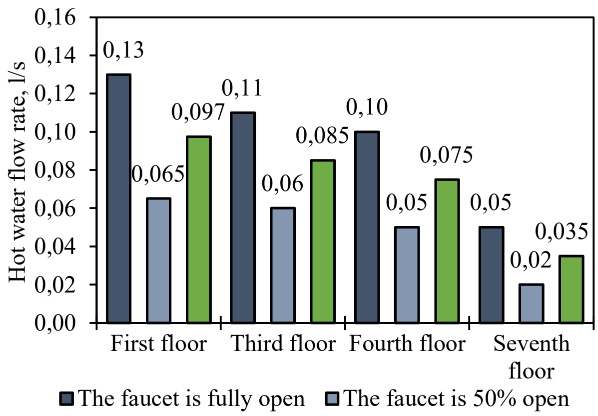

Fig. 2. Average hot water flow rate by one faucet in the main building of the university

The histogram shows that due to the pressure difference, the flow rate on the 1st floor is 60 % higher than on the 7th floor. From the presented range of flow rates, the value that is fair for the entire system was taken - the average between floors. It was also taken into account that there are no classrooms on the 7th floor, and therefore the WCs are used much less frequently there. Therefore, the consumption of this floor was not taken into account in the averaging.

As for the faucet openness, it was assumed that most people open the faucet at least 50 % in order to wash their hands faster, but not 100 % to avoid splashing water droplets. Therefore, the hot water flow rate was also averaged between 50 % and 100 % openness of the faucets. The average volumetric hot water flow rate by one device determined by this method is q_i^H = 0,086 l/s.

The total number of faucets installed in the WCs of the university's main building is 62. The highest consumption will occur when water starts pouring out of all the faucets. Since the building has only washbasins and the fact that people spend no more than a minute washing their hands, the possibility of this outcome is close to zero. It is possible to determine the actual number of faucets that can operate simultaneously by using water consumption monitoring. The greatest accuracy of this monitoring can be achieved by monitoring the water consumption mode of a building during periods of the most active use over a long period of time using ultrasonic flow meters.

In our case, the hot water consumption is measured using tachometric volumetric meters that measure the total volume of water flowing through their cross-section, but they cannot accurately track the peak instantaneous hot water flow rate needed to determine the load of the instantaneously heated DHW system. For this reason, it was necessary to determine the maximum simultaneous use of faucets by observing the use of faucets during the largest periods of water consumption - breaks between classes.

It can be stated with sufficient accuracy that the main consumers of hot water in the main building of KNUCA are students, so the maximum level of water consumption will occur during breaks (fig. 1). All observers monitored the time of opening and closing the faucets and the degree of openness of the faucets and recorded the data in tables. It should be noted that the observers used the exact synchronized time in Kyiv from the source [17] to record the opening and closing times of the faucets. The results of observations of the building's water consumption mode during breaks are shown in fig. 3.

The graphs show that the longest water withdrawal periods were during the second (long) and third breaks. At the same time, the highest level of water consumption occurred only during the long break. At that moment, water was being drawn from four faucets simultaneously, and its total duration was only 20 seconds.

During the observations, it was found that in most cases the faucets were opened between 50 % and 100 %, as expected. In addition, the time spent by consumers washing their hands averaged about 10 seconds, but in WCs with handwashing facilities, the faucets were running slightly longer. Substituting the value of the average hot water flow rate per device and the maximum recorded number of faucets operating simultaneously in formula (1), the maximum hot water consumption per working day of the university was determined, it is 0,344 l/s.

The results of calculating the total second hot water flow rate and the design heat load of the DHW system in the flow heating mode for the main building of KNUCA, determined by different methods, are presented in table 1. The number of simultaneously operating faucets in determining the total hot water flow rate by different methods is shown in the histogram in fig. 4.

Table 1.

A comparison of methods for determining the design hot water flow rate

Methods		Hot water flow rate by one faucet, l/s	Total water flow by the hot water supply system, l/s	Design capacity of the heat exchanger, kW
DBN V.2.5-64:2012		–	1,06	220
SNIP 2.04.01-85		0,090	2,66	553
DIN1988		0,085	1,30	270
Approximating dependence with probability of exceedance [7]	0,1 %	–	1,15	239
	1,0 %		1,03	214
	10 %		0,88	182
Monitoring of the real mode of hot water consumption		0,086	0,344	71

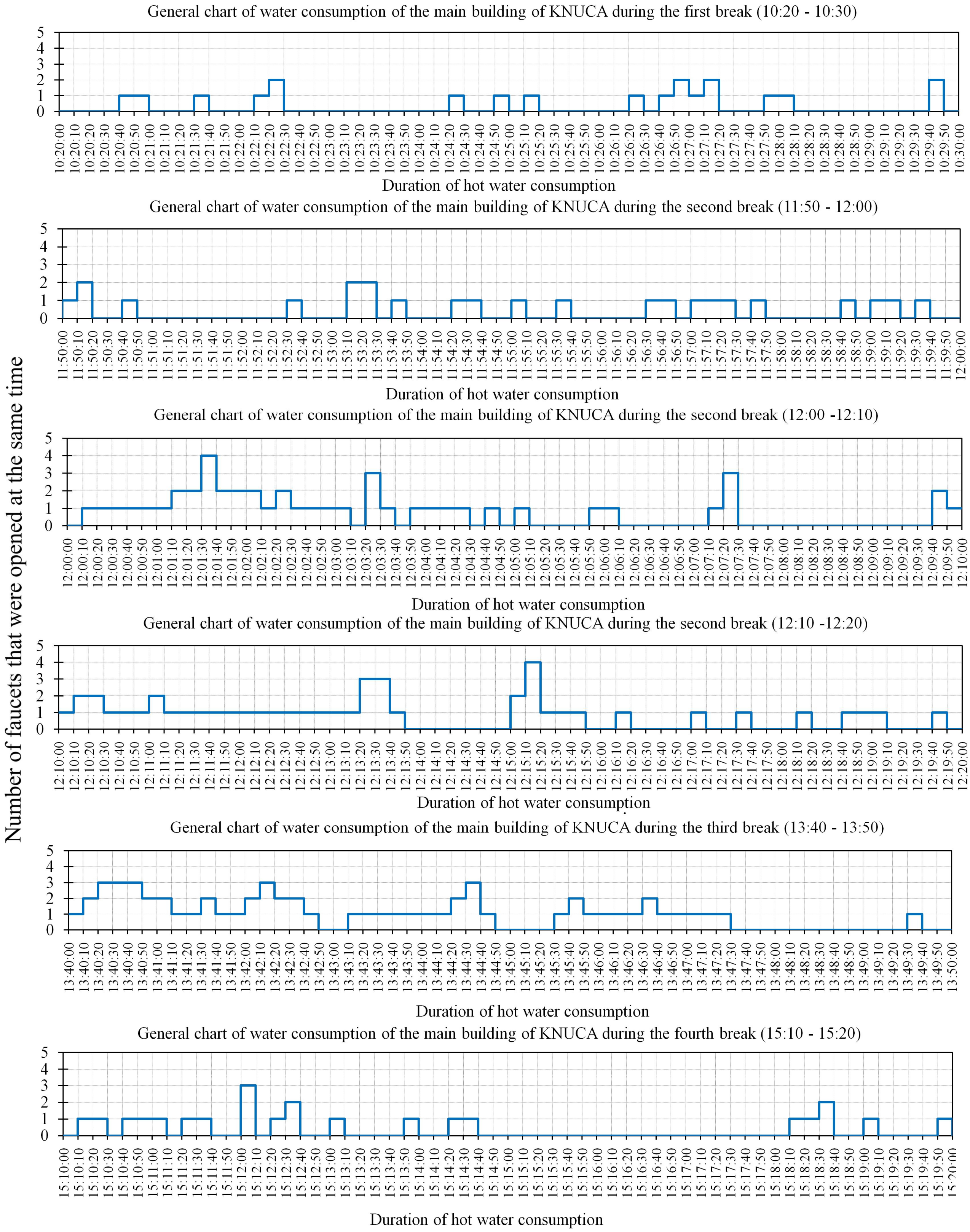

Fig. 3. Water consumption chart of the main building of KNUCA during breaks

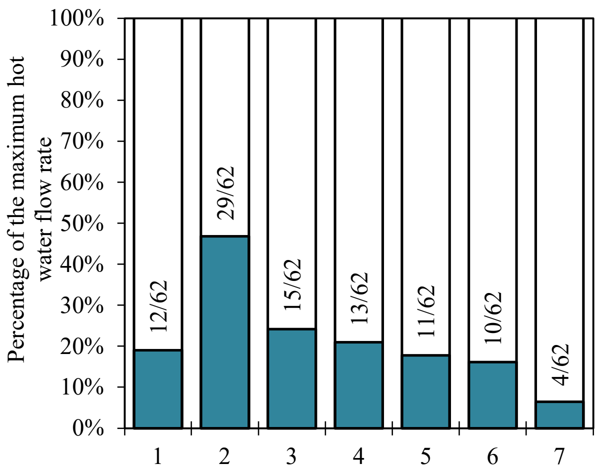

Fig. 4. The number of simultaneously operating faucets when determining the hot water flow by different methods: 1 – DBN V.2.5-64:2012; 2 – SNIP 2.04.01-85; 3 – DIN1988; 4 – an approximating dependence with a possibility of exceeding 0,1% [7]; 5 – with a possibility of exceeding 1% [7]; 6 – with a possibility of exceeding 10% [7]; 7 – monitoring the real mode of hot water consumption;

Conclusions. When determining the total hot water flow rate q_{tot}^{H} for the main building of the university according to the current DBN V.2.5-64:2012, 12 out of 62 washbasins can operate simultaneously without reducing the temperature of hot water. The document does not contain the design hot water flow rate by one faucet q_i^H and does not describe the methodology for calculating the simultaneous use of devices. If we compare this flow rate with those that are determined by the approximating relationship according to [7], then the difference will be only a few percent. Therefore, the possibility of exceeding the consumption determined by DBN V.2.5-64:2012 will also be less than 1 %. However, it should be noted that the studies described in [7] were conducted on residential apartment buildings, so it cannot be argued that the calculated coefficients will be equally suitable for university buildings. Residential buildings are also characterized by peaks in water consumption, even longer ones, but the ratio of the number of consumers to the number of faucets in them is significantly different, which will directly affect the simultaneous use of faucets.

The DIN 1988 standards give the values of the second flow rate by one device for the summer period (at t^C = 15 °C), for the winter period (at t^C = 5 °C) they must be recalculated. The flow rate determined by the DIN1988 methodology is only 5 % higher than the flow rate according to the DBN V.2.5-64:2012. However, it should be noted that due to the absence of coefficients for educational buildings in the standard, the coefficients for administrative buildings were used for the calculation. Unlike the consumption mode of educational buildings, the water consumption mode in administrative buildings is more uniform, so the values obtained by this method cannot be considered more accurate.

In the methodology presented in SNIP 2.04.01-85, the value of the total hot water flow rate directly depends on the number of consumers and the design hot water flow rate per person. The design hot water flow rate per person presented in the document is determined for higher education institutions with shower rooms, and therefore it can be argued that it is overestimated for educational institutions without them. The need to specify the exact number of consumers indicates that this method is oriented towards calculating consumption for residential buildings. After all, when designing a DHW system for residential buildings, the number of apartments is known, and therefore the number of consumers who are likely to use the installed faucets on a regular basis is more accurate. For educational buildings, it is much more difficult to determine the exact number of consumers. Due to the considerable difficulty in calculating the exact number of consumers due to the large total number of consumers and the unpredictability of their visits to the WCs, an approximate number of consumers was used for the calculation: 5000 people. As a result of the overestimated hot water flow rate per person and the likely overestimated number of consumers, the total design hot water flow rate calculated according to SNIP 2.04.01-85 is 27 % higher than the hot water flow rate determined according to DBN V.2.5-64:2012. Therefore, the value obtained by this method cannot be considered more accurate either.

The maximum possible hot water flow rate determined as a result of monitoring under the actual water consumption mode was almost 70 % less than the hot water flow rate of the current DBN B.2.5-64:2012. However, although this hot water flow rate was determined directly at the facility, this does not mean that this result is the most accurate, because at the time of the observations, the education at the university was in mixed form. Although the time chosen for the monitoring was when most students had practical classes at the university, a significant number of them were taking lectures that were conducted online. In addition, the time period for which the observation was conducted is too short to draw definitive conclusions.

At this stage, it is difficult to determine which of the above methods should be used for higher education buildings. Since each of them has its drawbacks. To solve this problem, it is necessary to study the water consumption mode of educational buildings in more detail and over a longer period. To conduct this study, it is necessary to install ultrasonic flow meters on hot and cold water pipelines and monitor the change in flow throughout the academic year. This will make it possible to correct the existing methods and de-termine the most accurate one.

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Вибір методики розрахунку теплового навантаження систем гарячого водопостачання об’єктів зі значною нерівномірністю споживання

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Анотація. Останні роки в Україні постійно зменшується обсяг надання послуги централізованого теплопостачання. При цьому зниження обсягу надання послуги гарячого водопостачання по відношенню до централізованого опалення та вентиляції відбувається більш інтенсивно. Це призводить до розрегулювання існуючих систем централізованого теплопостачання і, як наслідок – до перевитрат енергоносіїв. Один із шляхів вирішення цієї проблеми лежить в площині зменшення вартості обладнання за рахунок більш точного вибору його потужності. Уточнення існуючих методик з визначення потужності обладнання можна досягти шляхом врахування особливостей режиму водорозбору *систем, що може значною мірою відрізнятися в залежності від призначення будівлі. Особливо актуальним є точне прогнозування потужності системи гарячого водопостачання для об'єктів з яскраво вираженою нерівномірністю споживання гарячої води. Це стосується деяких громадських будівель та будівель навчальних закладів, що змушує звернутися до дослідження цієї проблеми. В даній роботі на прикладі будівлі головного корпусу КНУБА обґрунтовано проблему визначення загальної витрати гарячої води для будівель, для яких характерний нерівномірний режим водоспоживання. Проведено аналіз можливих способів нагріву води та запропоновано той, що є найбільш доцільним для будівель вищих навчальних закладів. Представлено порівняння методів з визначення максимальної розрахункової витрати гарячої води, прийнятих в нормативних документах. Описано недоліки кожного з існуючих методів. Проведений моніторинг за дійсним режимом водоспоживання будівлі головного корпусу КНУБА, в результаті якого визначено реальну максимальну витрату гарячої води протягом робочого дня університету. Та проведено порівняння отриманих результатів із розрахунковими витратами, визначеними за допомогою методик прийнятих в кількох нормативних документах.*

Ключові слова: гаряче водопостачання, теплове навантаження системи ГВП, одночасність використання водорозбірних приладів, загальна витрата гарячої води, нерівномірність режиму водоспоживання.

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