Ministry of Education and Science of Ukraine
Black Sea Universities Network

ODESA NATIONAL UNIVERSITY OF TECHNOLOGY

International Competition of
Student Scientific Works

BLACK SEA SCIENCE 2022

PROCEEDINGS

ODESA, ONUT 2022

Ministry of Education and Science of Ukraine

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Odesa National University of Technology

International Competition of Student Scientific Works

BLACK SEA SCIENCE 2022

Proceedings

НТБ ОНТУ

Odesa, ONUT 2022

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Proceedings of International Competition of Student Scientific Works «Black Sea Science 2022» contain the works of winners of the competition.

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Odesa National University of Technology, 2022.

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INTRODUCTION

International Competition of Student Scientific Works “Black Sea Science” has been held annually since 2018 at the initiative of Odesa National University of Technology (formerly Odesa National Academy of Food Technologies) with the support of the Ministry of Education and Science of Ukraine. It has been supported by Black Sea Universities Network (the Association of 110 higher education institutions from 12 countries of the Black Sea Region) since 2019, and by Iseki-FOOD Association (European Integrating Food Science and Engineering Knowledge into the Food Chain Association) since 2020.

The goal of the competition is to expand international relations and attract students to research activities. It is held in the following fields:

- Food science and technologies
- Economics and administration
- Information technologies, automation and robotics
- Power engineering and energy efficiency
- Ecology and environmental protection

The jury includes both Ukrainian and foreign scientists. In the 4 years that the competition has been held, the jury included scientists from universities of 24 countries: Angola, Azerbaijan, Benin, Bulgaria, China, Czech Republic, France, Georgia, Germany, Greece, Israel, Italy, Kazakhstan, Latvia, Lithuania, Moldova, Pakistan, Poland, Romania, Serbia, Slovakia, Switzerland, Turkey, USA.

At the same time, every year the geography has expanded and the number of foreign jury members has increased: from 46 jury members representing 25 universities from 12 countries in 2018, to 73 jury members of the 46 universities from 19 countries in 2022.

More than a thousand student research papers have been submitted to the competition from both Ukrainian and foreign institutions from 25 countries: China, Poland, Mexico, USA, France, Greece, Germany, Canada, Costa Rica, Brazil, India, Pakistan, Israel, Macedonia, Lithuania, Latvia, Slovakia, Romania, Kyrgyzstan, Kazakhstan, Bulgaria, Moldova, Georgia, Turkey, Serbia.

The interest of foreign students in the competition grew every year. In 2018, the students representing 15 institutions from 7 countries have submitted 33 works. In 2021 the number of submitted works increased to 73, authored by the students of 40 institutions from 18 countries.

The competition is held in two stages. In the first stage, student research papers are reviewed by members of the jury who are experts in the relevant fields. In the second stage of the competition, the winners of the first stage have the opportunity to present their work to a wide audience in person or online.

All participants of the competition and their scientific supervisors are awarded appropriate certificates, and the scientific works of the winners are included in the electronic proceedings of the competition. Every year the competition receives a large number of positive responses from Ukrainian and foreign colleagues with the desire to participate in the coming years.

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4. POWER ENGINEERING AND ENERGY EFFICIENCY

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INFLUENCE OF HEATING AND VENTILATION MODES ON THE ENERGY CONSUMPTION OF UNIVERSITY EDUCATIONAL BUILDINGS UNDER QUARANTINE CONDITIONS IN UKRAINE

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Abstract. *In the work, a dynamic energy model of the building was created on the example of the educational building № 17 Igor Sikorsky Kyiv Polytechnic Institute. Simulation dynamic modeling of the energy consumption of the educational building for heating needs was carried out for normal operating conditions and quarantine conditions (only a certain part of the premises is operated where the standard temperature value is maintained during the stay of people) when implementing the three proposed modes of operation of the heating and ventilation system. Based on the results of the study, recommendations were formulated for the introduction of energy-saving heating modes in the normal and quarantine regimes. The features of the energy consumption of the building during quarantine restrictions, subject to the partial use of the building, are analyzed, the main disadvantages of such a regime are identified.*

Keywords: *quarantine, educational institutions, average radiation temperature, energy consumption, energy saving, air exchange*

I. INTRODUCTION

Since the end of 2019, humanity has faced an unprecedented phenomenon for the modern world - the global pandemic COVID-19, which has dramatically changed the lives of each of us. First of all, the changes for people concerned the usual modes of work for them - most organizations introduced remote modes of work for their employees, or - semi-remote, when employees partially visited their jobs. The same changes have taken place in the field of education. Educational institutions, particularly in Ukraine, have switched to remote or mixed mode. At the same time, the issue of expediency in maintaining the normative operational characteristics of educational buildings for their entire heating volume with partial use has become especially relevant. Therefore, simulation dynamic modeling of the consumption of heat energy by the building of the educational building for the heating season for various modes of operation of the heating and ventilation system during the quarantine period with partial use of the building is the most convenient tool in order to obtain a set of energy characteristics that will help draw conclusions about the feasibility of implementation. a specific mode of operation of the heating and ventilation system and choose the most energy-saving mode, as well as analyze the features of heat energy consumption during quarantine. Carrying out a number of simulations allows us to estimate the amount of heat transfer between the premises for different modes of their operation and to justify the location of the premises that will be used during the period of quarantine restrictions.

II. LITERATURE ANALYSIS

Energy saving and increasing the level of energy efficiency are priority areas of political activity in Ukraine (as well as in the world as a whole), since they are mandatory conditions for the European integration of the national energy system. Buildings deserve special attention in the field of energy saving, because they account for more than a third of the world's energy consumption [1]. At the same time, when evaluating and developing an energy saving action plan, it is necessary to take into account a number of parameters that characterize the building, and, first of all, these are its operational and behavioral factors that determine the set of conditions under which the building is operated (work schedule, indoor air temperature, quantity and the period of stay of people, the mode of operation of lighting, equipment, etc.). Educational institutions are interesting from the point of view of operation, since during normal operation they are characterized by a large number of people staying during working hours [2, 3], which in turn largely affects the integral characteristics of heat gains into the premises and energy consumption depending on the level of awareness potential consumers (whether the light is turned off, the faucet is closed towards the end, windows are opened / closed, etc.) [4, 5]. However, the COVID-19 pandemic has had a significant impact on the energy demand of public institutions, in particular higher education institutions. Since the beginning of 2020, the virus began to spread rapidly around the world. In March 2020, the World Health Organization declared the COVID-19 outbreak a global pandemic. At the same time, it was indicated that social distancing, sufficient ventilation of enclosed spaces and personal hygiene are the main measures that can prevent the spread of COVID-19 [6].

Therefore, to avoid crowds, most countries have introduced partial or complete closure of educational institutions, commercial and industrial companies [7]. This has led to radical changes in energy consumption [8]. In Ukraine, in the field of education, some institutions continued their work in a blended learning mode, while some completely switched to remote mode (depending on the epidemiological situation in the district where the institution is located) to prevent the spread of coronavirus disease (at the same time, if necessary, some educators visited their workplaces). In such conditions, to avoid excessive use of energy and ensure the normal functioning of buildings, a very important issue arises - to have schedules for the rational use of energy for heating needs, considering the operation of the premises

Therefore, it is obvious that it is relevant to conduct an in-depth analysis of the introduction of intermittent and energy-saving modes of operation of the heating system for isolated rooms of a building of educational institutions for quarantine conditions in order to regulate energy consumption in accordance with the Law of Ukraine "On the Energy Efficiency of Buildings" [9], as well as an analysis of the influence of modes ventilation of premises on their energy consumption.

III. OBJECT, SUBJECT, AND METHODS OF RESEARCH

The object of the study is the educational building №17 of NTUU “I. Sikorsky KPI" The subject of the study is the consumption of heat energy by the building for the heating season under various modes of operation of the heating and ventilation system under quarantine and normal conditions. Research task:

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1. Create a dynamic model of the building on the example of the educational building №17 Igor Sikorsky Kyiv Polytechnic Institute Igor Sikorsky in the DesignBuilder program, considering the internal zoning of premises.

2. Simulate the energy consumption of the building for normal operation under three proposed scenarios: №1 – at a constant temperature and steady air exchange (t = const, n = const); №2 – with intermittent heating mode (lowering the temperature during non-working hours and weekends) and steady air exchange (t = var, n = const); №3 - with intermittent heating and intermittent air exchange (t = var, n = var).

3. Conduct a simulation of the energy consumption of the building under quarantine, considering the schedules for using the premises and the permissible levels of temperature drop in them when implementing the three proposed scenarios (№1, №2, №3 - similarly).

4. Analysis of the results of modeling and assessments of the possible level of energy consumption of the building during the period of quarantine restrictions.

To create a building model in the DesignBuilder software environment, the educational building №17 of the Igor Sikorsky Kyiv Polytechnic Institute was used. It was built in 1969. The building is located in Kiev. Geometrically, the building is a regular extended rectangular shape. The main part of the facades is oriented to the north and south sides of the world. The building has 5 floors, as well as a heated basement and an unheated technical floor**.**

The heating volume of the building is 42371,34 m^3, the area is 12184,75 m^2. All windows of the building were replaced with metal-plastic single-chamber double-glazed windows with air-filled chambers, with the exception of the technical floor, where glass blocks are installed. At the same time, the share of the area of translucent structures is 36,73%, 12,02%, 35,44% and 12,02% in the northern, eastern, southern and western orientations, respectively. The bearing layer of the outer walls of the building is made of expanded clay concrete. For external walls U-Factor with Film – 1,021 W/m^2·K. Covering of the building – flat roof, rolled: U-Factor with Film – 0,803 W/m^2·K; one part of the coverage is the coverage of the 5th floor, another part is the coverage of the technical floor. Foundation – concrete blocks (floor U-Factor with Film – 0,748 W/m^2·K. Glass U-Factor for windows – 2,382 W/m^2·K. The building is supplied with heat through the networks of a centralized heating system, the model of which allows the introduction of intermittent heating modes. In addition, it is provided that the heating devices installed in the premises are M140 cast-iron radiators with thermostatic heads, which allow adjustment by building zones.

The ventilation system is natural - it is provided at the level of 0,7 ac / h by opening the windows; another 0,3 ac/h is provided by the infiltration component (due to the looseness of the enclosing structures). Thus, the total air exchange is 1 ac/h, which corresponds to the standard for educational buildings. The number of people in the building during normal operation is 2763. The hourly climate data used for the simulation is an IWEC hourly file for a typical year for Kiev conditions [14]. The 3D model of the building of educational building №17, created in the DesignBuilder software environment, is shown in Fig.1 [15-17].

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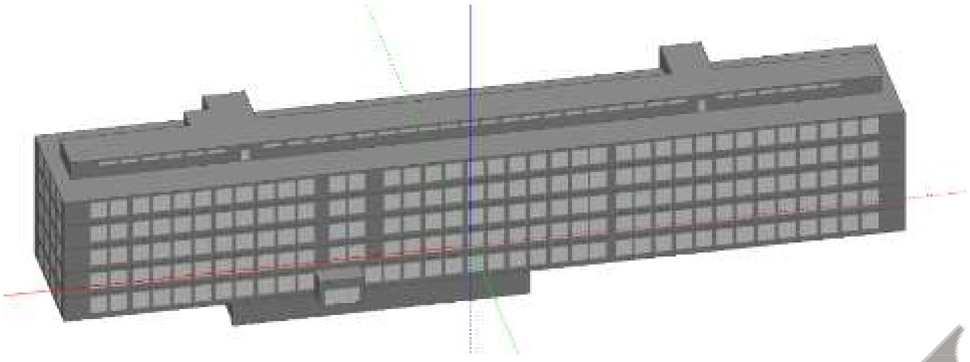
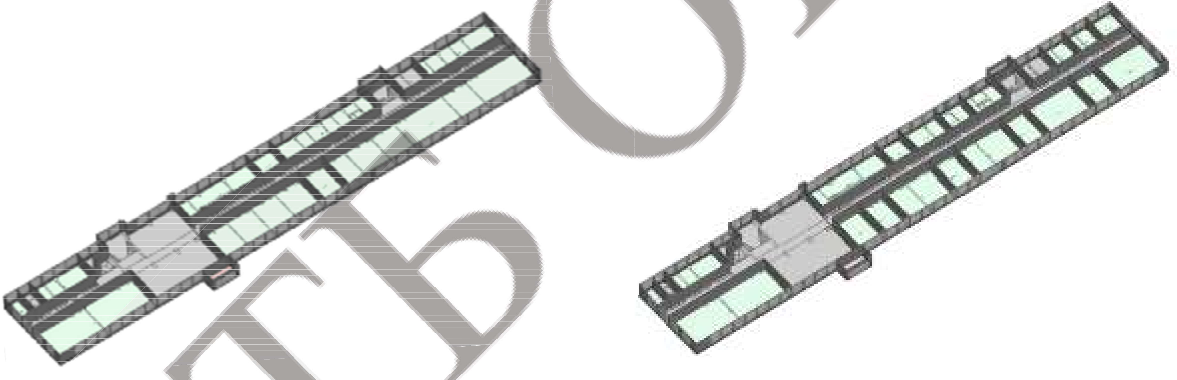


Fig. 1. 3D-model of educational buildings №17 NTUU "Igor Sikorsky KPI" [15-17]

For the normal mode of operation of the building, the premises of the same functional purpose were combined into thermal zones (auditoriums, corridors, toilets, basement, attic, vestibules). In normal operation, heat and mass flows between classrooms are quite active, and the parameters (temperature, air exchange, number of people per unit area) are the same, so to separate each audience in a separate area is not advisable (fig.2a). For the quarantine regime, as the difference between heat and mass flows, as well as the parameters set between the zones is significant, additional thermal zones were identified that geometrically coincide with the classroom boundaries and set the necessary parameters for each zone according to the scenario that is simulated (fig. 2b).



a b

Fig. 2. Zoning, 1st floor:
a – normal mode, b – quarantine mode

The calculation of the basic level of energy consumption was carried out in accordance with the comfort parameters according to the standards [9 – 13] and typical climatic conditions for Kiev [14]. For the normal mode of operation of the building and premises used during quarantine, scenario №1 provides for maintaining the temperature and air exchange at stable values throughout the entire time; when implementing scenario №2 – lowering the temperature during non-working hours and weekends to 17°C; under scenario №3 - temperature decrease during non-working hours and weekends to 17°C and a decrease in the standard air exchange during non-working hours and weekends to the level of 0,3 ac/h (during non-working hours, the windows are not open and only the infiltration component remains). Detailed parameters of the proposed modes are given in table 1.

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Table 1. Parameters of the proposed modes

Scenario	Normal mode of operation	Quarantine mode	
		Used premises (separate auditoriums on the 1st and 2nd floors, as well as toilets on the 1st and 2nd floors)	**All other unused premises**
№1 ***t = const*** ***n = const***	t = 20°C [24/7] n = 1 ac/h [24/7]		t = 14°C 24/7 n = 0,3 ac/h 24/7 (*only infiltration*)
№2 ***t = var*** ***n = const***	$t_{heating}$ = 20°C [from 7:00 until 18:00] $t_{heating\ set\ back}$=17°C [from 18:00 until 07:00 + Weekends]		
№3 ***t = var*** ***n = var***	$t_{heating}$ = 20°C [from 7:00 until 18:00] $t_{heating\ set\ back}$=17°C [from 18:00 until 07:00 + Weekends] n = 1 ac/h [from 7:00 until 18:00] n = 0,3 ac/h [from 18:00 until 07:00 + Weekends] (*only infiltration*)		

IV. RESULTS

Consumption of heat energy, according to the results obtained in the simulation are given in table 2. The first number in the designation shows the mode of operation: 1X - normal mode, 2X - quarantine; the second number corresponds to the scenario number (for example, X3 is scenario №3). Similar designations will be maintained here and below.

Table 2. Heat consumption by created models (part 1)

1	**Scenario**	**11**	**21**	**Δ%**
2	Heating area of the building, m^2	12184,75		**-**
3	Area of premises used during quarantine, m^2	12184,75	992,12	**-91,86**
4	The need for heating, used premises, kWh/season	-	219482,97	**-**
5	Energy consumption for the heating season, kWh/season	1596335,75	617532,91	**-61,32**
6	Specific energy consumption, kWh/m^2	131,01	50,68	**-61,32**
7	Specific energy consumption of used premises, kWh/m^2		221,23	**68,86**
8	Specific energy consumption of the used representative premises, north orientation kWh/m^2	131,907	241,700	**83,23**
9	Specific energy consumption of the used representative premises, south orientation kWh/m^2	115,116	215,134	**86,88**

Table 2 (part 2)

1	**12**	**22**	**Δ%**	**13**	**23**	**Δ%**
2	12184,75	12184,75	**-**	12184,75	12184,75	**-**
3	12184,75	992,12	**-91,86**	12184,75	992,12	**-91,86**
4	-	169745,73	**-**	-	120678,27	**-**
5	1363925,06	592825,96	**-56,54**	829736,11	546852,79	**-34,09**
6	111,94	48,65	**-56,54**	68,10	44,88	**-34,09**
7		171,09	**52,85**		121,64	**78,62**
8	110,793	185,150	**67,11**	66,878	134,261	**100,76**
9	94,375	161,989	**71,64**	53,039	112,237	**111,61**

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Graphically, the results are shown in fig 3.

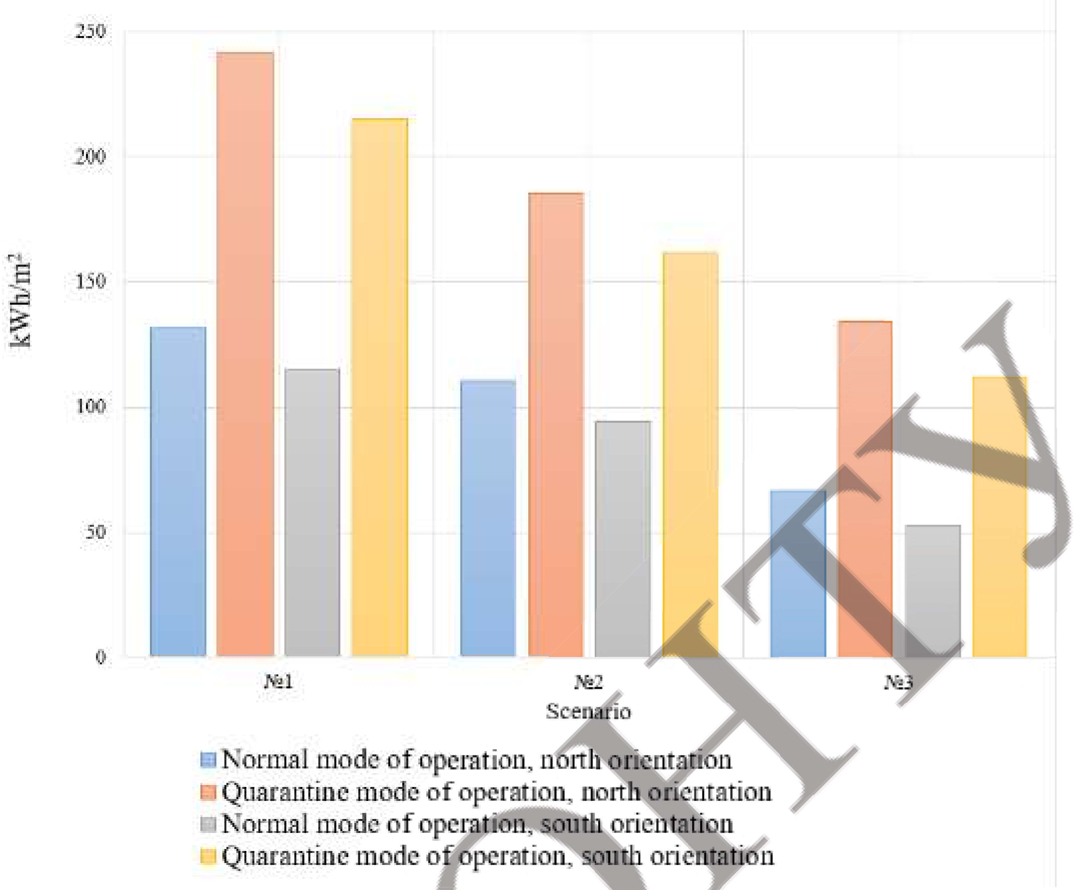

Fig. 3. Specific consumption of heat energy of the research premises during the heating season

Thus, according to the results of scenario №1 we have: partial use of the building during quarantine allows to reduce the consumption of heat energy during the heating season by 61,32%. At the same time, the specific consumption to the total heating area is reduced by the equivalent value. However, if we compare the specific consumption of heat energy in heated rooms to the appropriate level, this value increases by 68,86% compared to the usual mode. If we consider a single room, which is zonally separated in both models for analysis, its specific consumption increased by 83,23% and 86,88% for the northern and southern orientation compared to the usual regime, respectively. Similar observations can be made for scenarios №2 and №3. If we compare the scenario №1 and №2, we see that the use of intermittent heating mode reduces energy consumption both in normal operation (by 14,55%) and in quarantine (by 4%, due to the flow to adjacent premises savings are reduced). The reduction in heat energy consumption during quarantine is not so significant, as only a small part of the premises are operated and, accordingly, will have a decrease in temperature during non-working hours. Scenario №3 is the most energy efficient, as evidenced by the results obtained. Energy savings compared to scenario №2 for the normal regime is 39,17% and for the quarantine – 7,75%. Thus, the total energy savings between scenarios №1 and №3 for normal/steady state are 48,02% and for quarantine – 11,45%.

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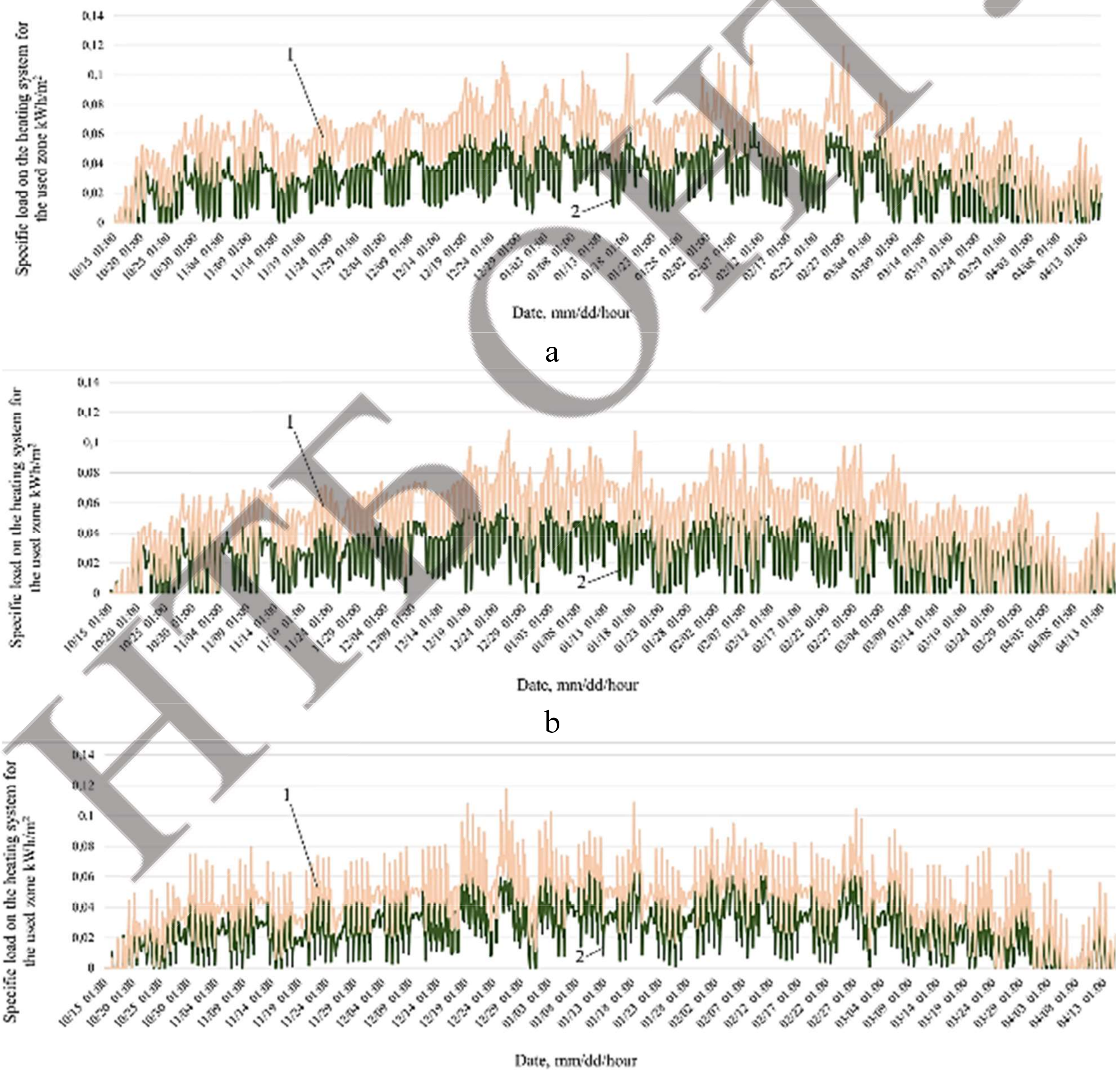
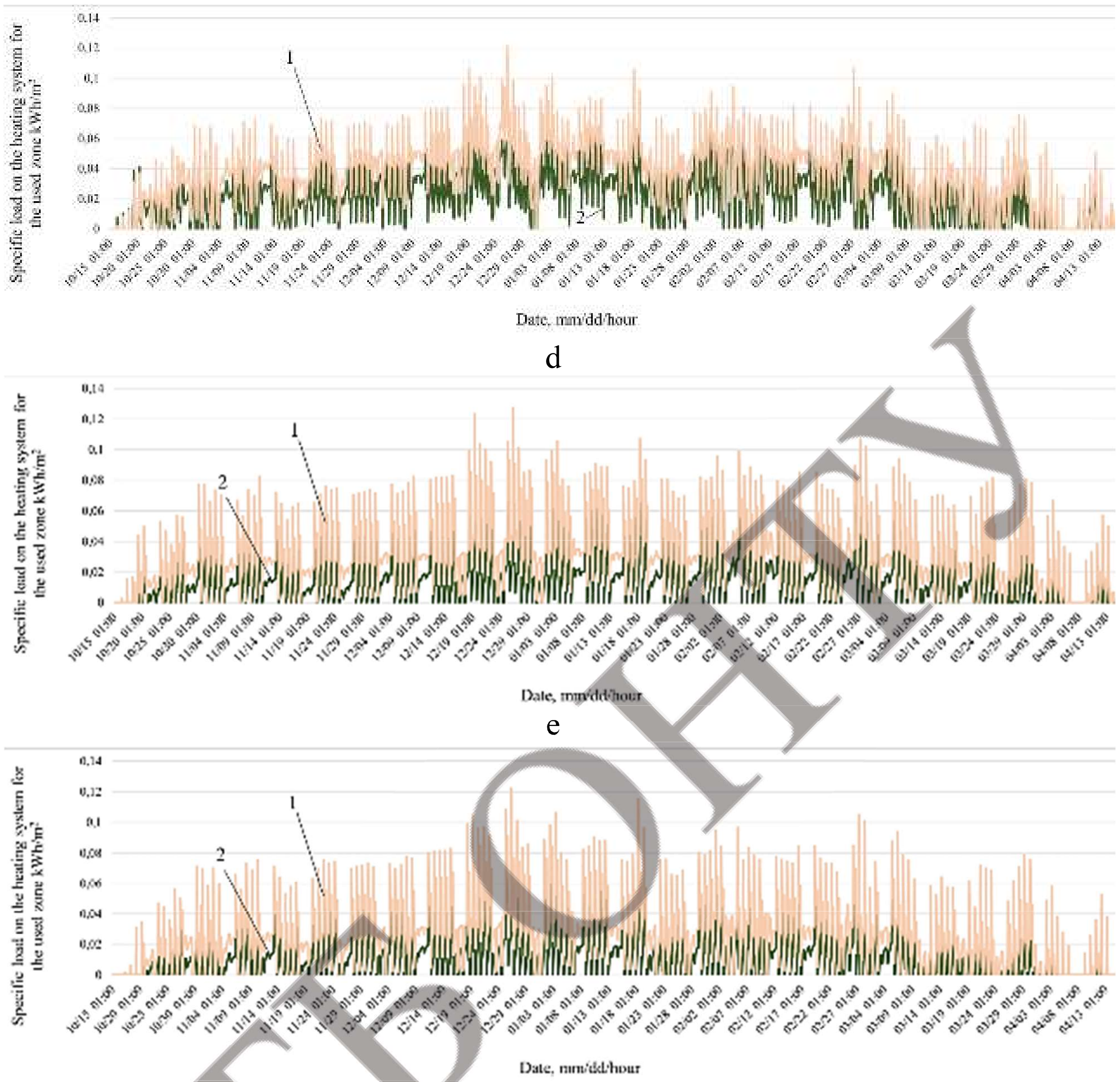
However, as noted, the specific energy consumption per unit of heating area (up to the appropriate temperature level) has increased. Figure 4 shows the graphical hourly specific consumption of heat energy for the heating of a separate room, which is operated for quarantine and normal conditions. To compare the consumption of heat energy at different orientations, the azimuth of the building model was rotated in the program by 180 ° and one room was considered for two cases. The room under consideration has an area of 37,43 m^2 and two windows (5,4 m^2), the glazing factor is 0,524. The increase in specific consumption indicates that in rooms where the proper temperature is maintained during working hours, the heat flow through the inner walls intensifies to neighboring rooms, where the level of heating is reduced. The southern orientation is characterized by more frequent shutdowns / reductions in the load on the heating system compared to the northern orientation, which is due to the intensity of solar revenues.



a

b

c



d

e

f

a – 1_N, b – 1_S, c – 2_N, d – 2_S, e – 3_N, f – 3_S
Fig. 4. Hourly heat consumption by a representative premises:
1_X – scenario №1; 2_X – scenario №2; 3_X – scenario №3;
X_N – north; X_S – south
1 – quarantine mode, 2 – normal mode

Figure 5 shows the hourly load on the heating system of the building as a whole for normal operating conditions and quarantine restrictions. It follows from Fig.4 and 5 that when the proposed operating modes are implemented under quarantine restrictions, the load on the heating system is generally reduced, and scenario №3 is the most energy efficient for both operating modes.

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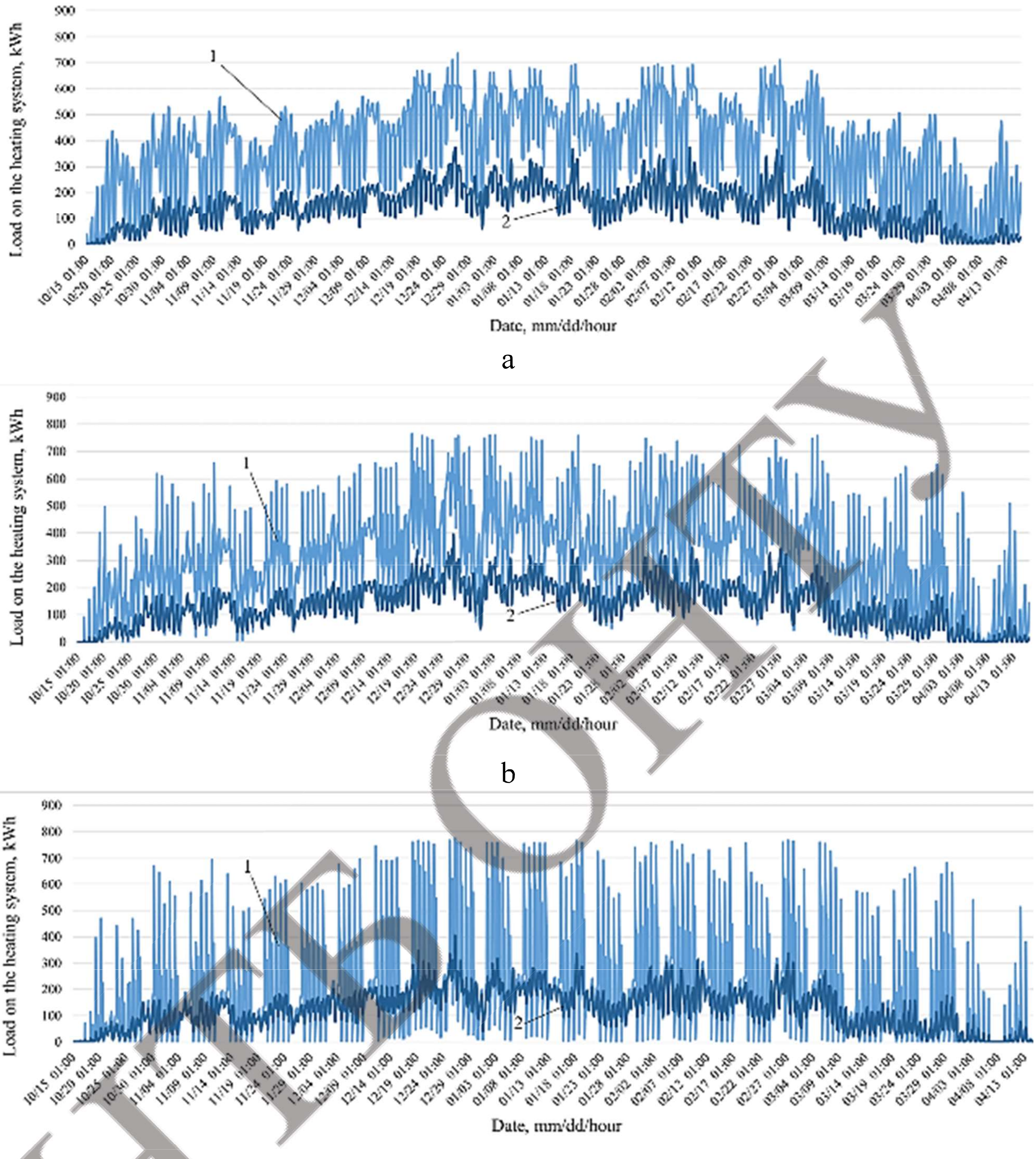

a

b

c

Fig. 5. Hourly heat consumption by the building:
a – scenario №1, b – scenario №2, c – scenario №3
1 – normal mode, 2 – quarantine mode

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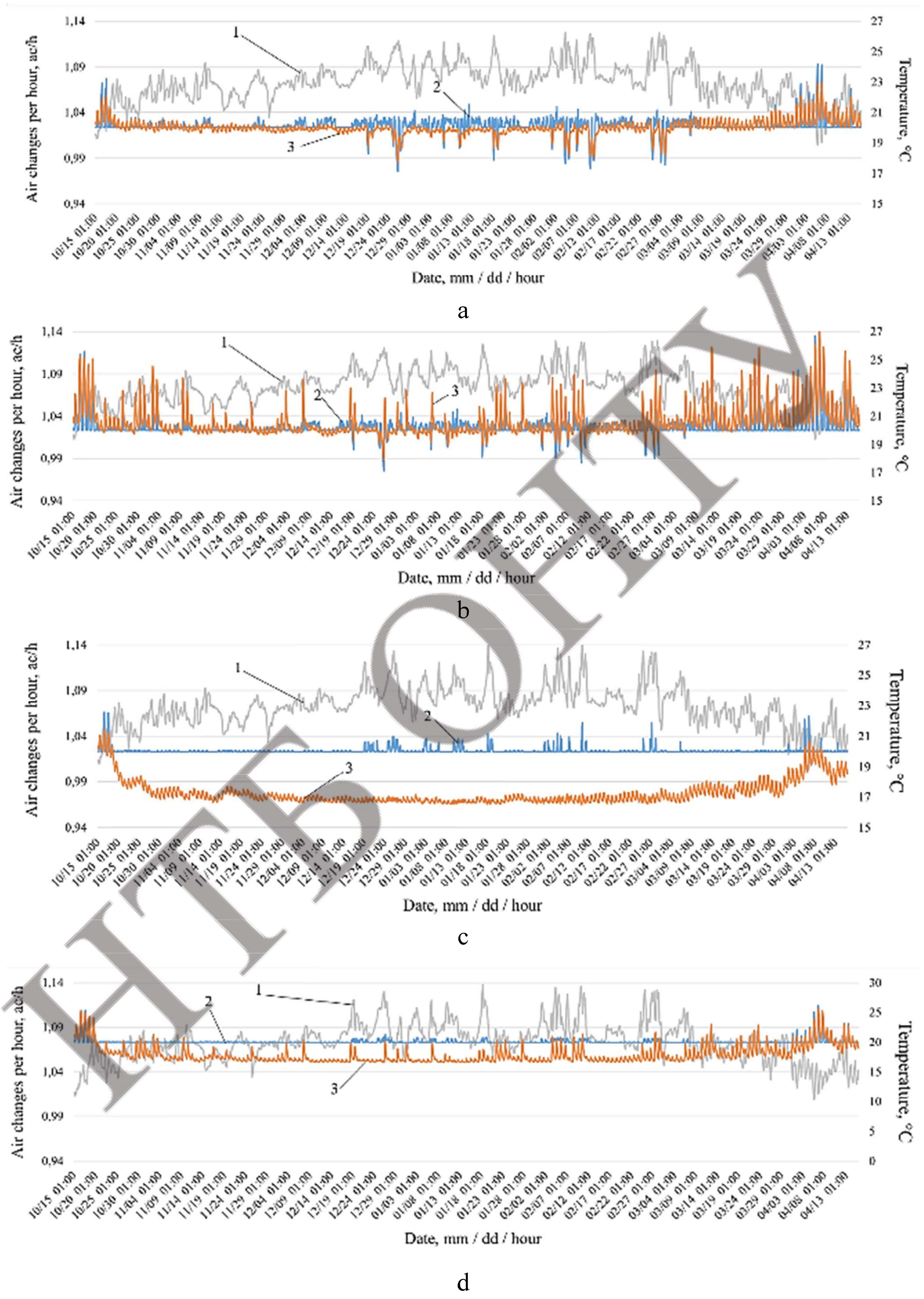
Figure 6 shows hourly graphs of air temperature changes in the considered representative rooms of Monday and Friday orientations, average radiation temperature and air exchange in them for normal operation and quarantine. In fig. 7 shows the hourly change in outdoor temperature and the level of solar heat gains that the room receives through window structures, per unit of heated area of this room



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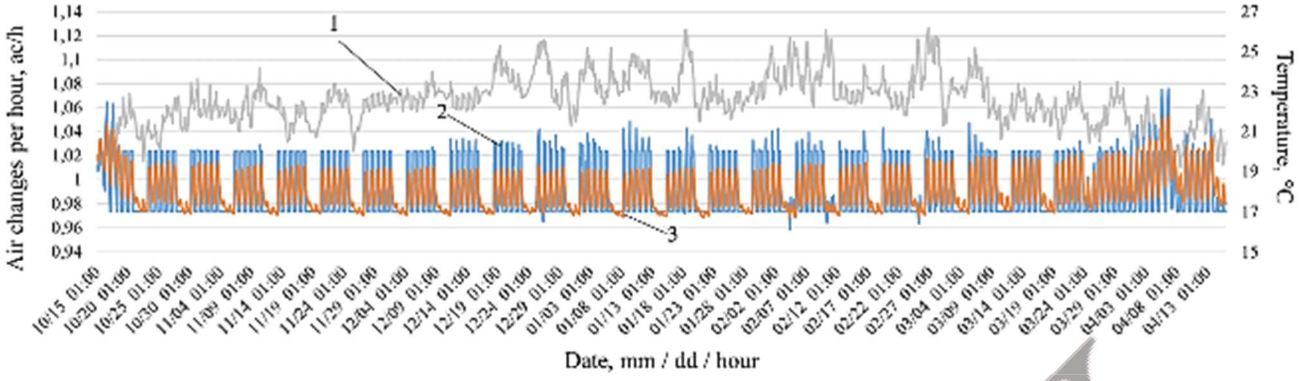

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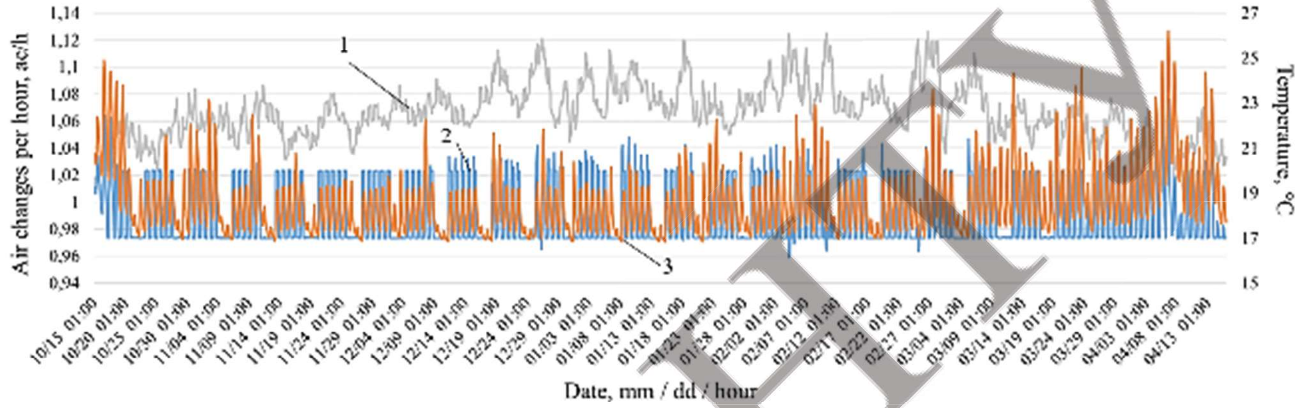

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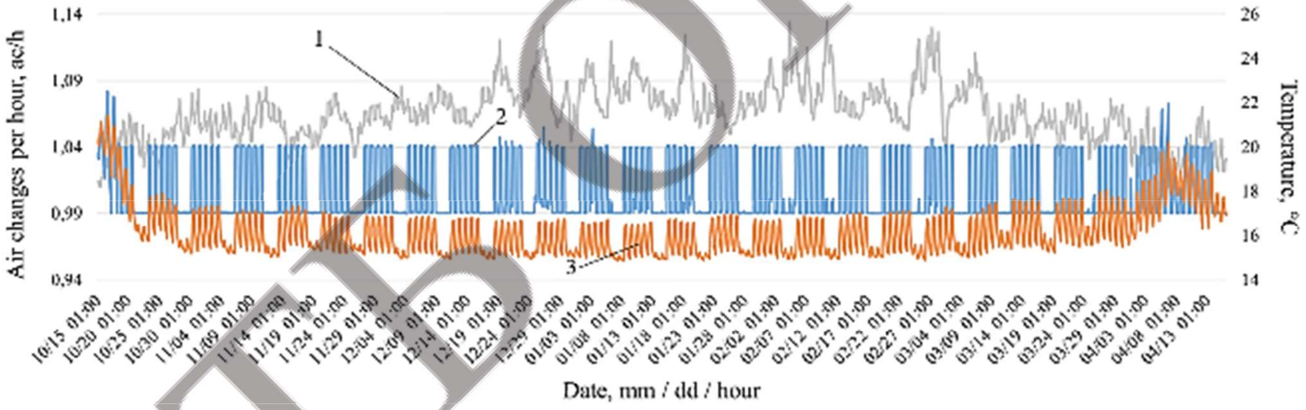

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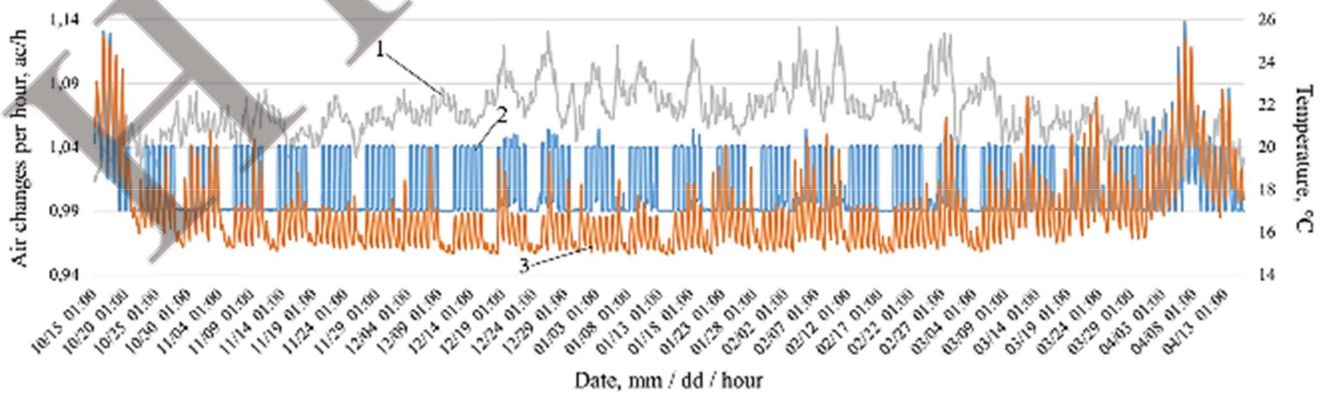

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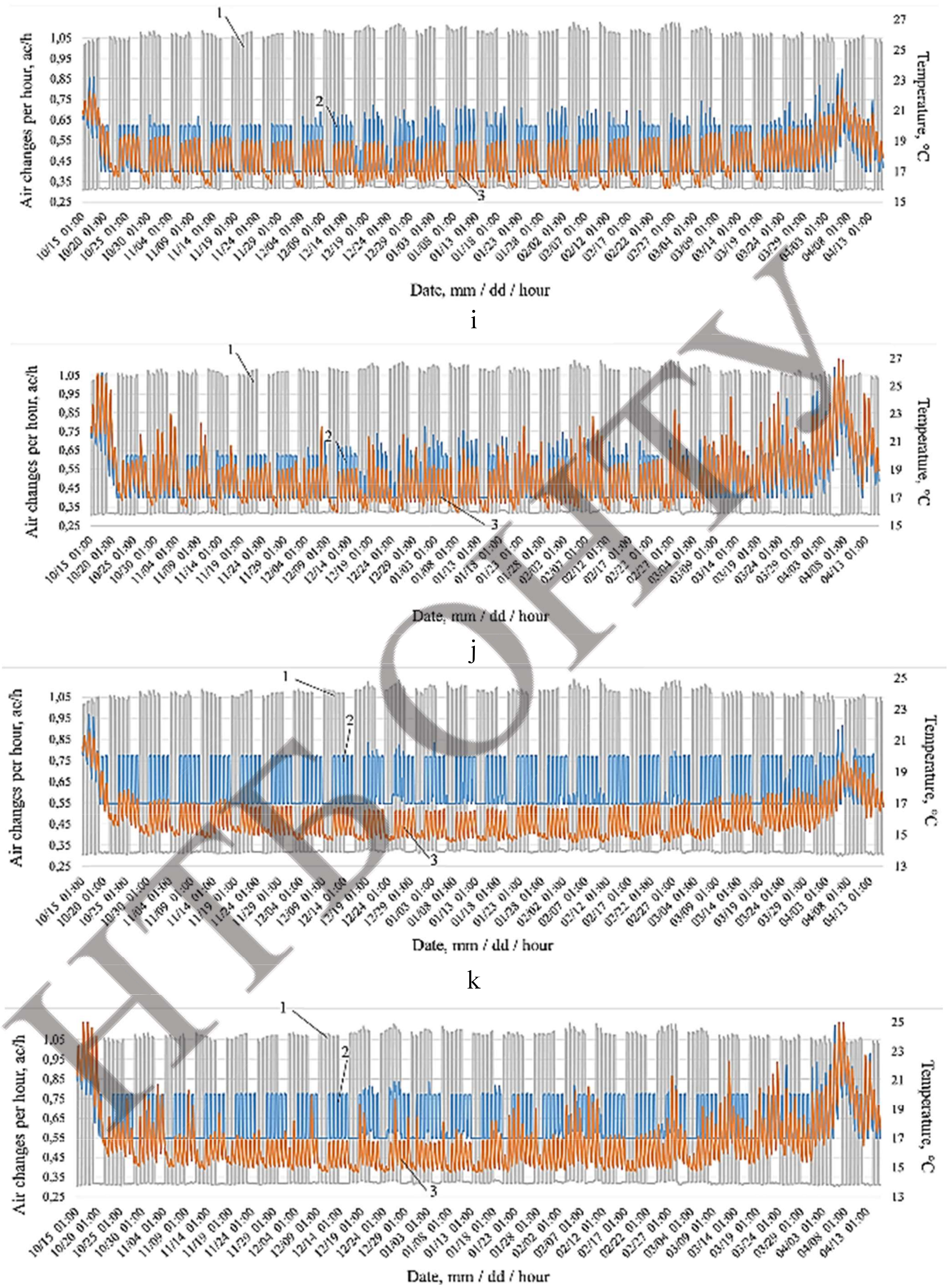

i

j

k

l

a – 11_N, b – 11_S, c – 21_N, d – 21_S, e – 12_N, f – 12_S, g – 22_N, h – 22_S, i – 13_N, j – 13_S, k – 23_N, l – 23_S

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Fig. 6. Chang in air temperature, average radiation temperature, air exchange level during the heating period for a representative premises:
1X – normal mode, 2X – quarantine mode, X1 – scenario №1, X2– scenario №2, X3– scenario №3, XX_N – north, XX_S – south, 1 – air exchange; 2 – deviation of indoor air temperature, 3 – deviation of the average radiation temperature,

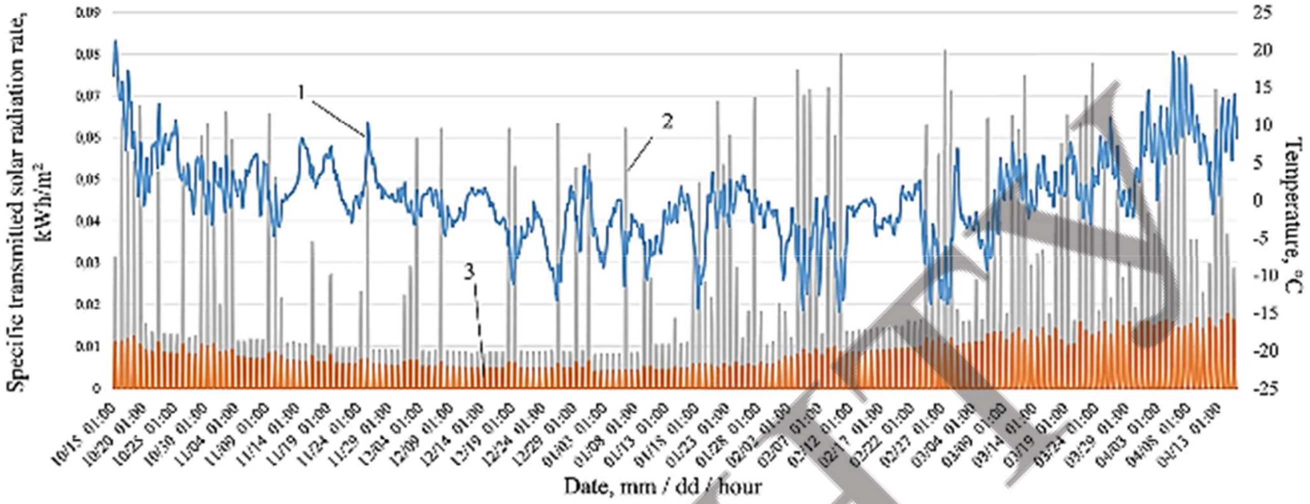

Fig. 7. Hourly values of outdoor temperature and solar radiation rate per heated area according to the IWEC weather file [14]:
1 – outside air temperature, 2 – solar radiation rate on the south side,
3 – solar radiation rate on the north side

Consider the average difference between the room temperature and the average radiation temperature for the calculation period (table 3).

Table 3. Indoor air temperature and average radiation temperature for the obtained models

11_S		**11_N**		**21_S**		**21_N**	
t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}
20,11	20,02	20,25	20,60	20,06	17,28	20,15	17,94
Δ = 0,09		Δ = -0,35		Δ = 2,78		Δ = 2,21	
12_S		**12_N**		**22_S**		**22_N**	
t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}
18,09	18,07	18,26	18,67	18,08	16,17	18,22	16,88
Δ = 0,02		Δ = -0,41		Δ = 1,91		Δ = 1,34	
13_S		**13_N**		**23_S**		**23_N**	
t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}	t_{air_in}	t_{mean_rad}
18,30	17,86	18,64	18,61	18,13	16,02	18,34	16,76
Δ = 0,45		Δ = 0,03		Δ = 2,10		Δ = 1,59	

Visual representation of the results is shown in fig.8, 9.

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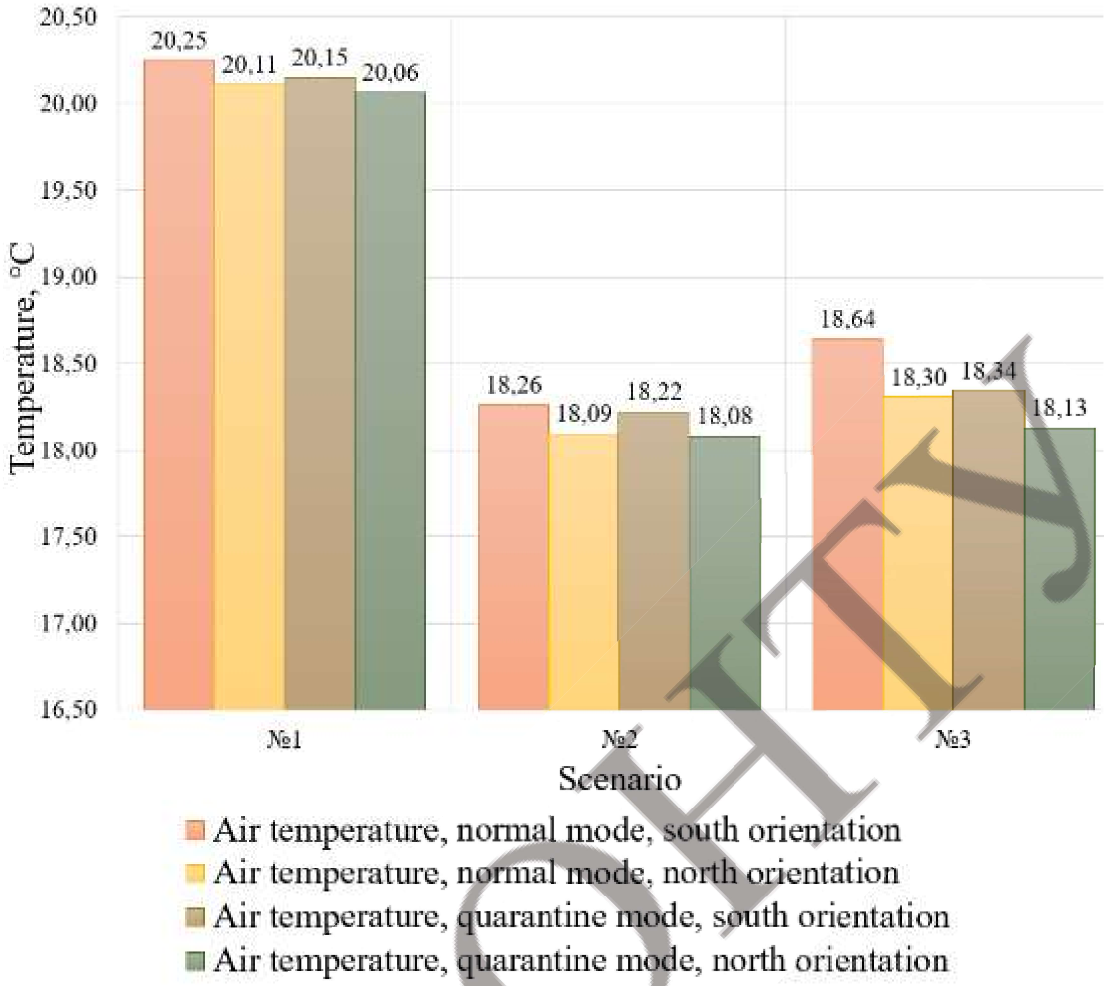

Fig. 8. The average temperature in the room during the heating season

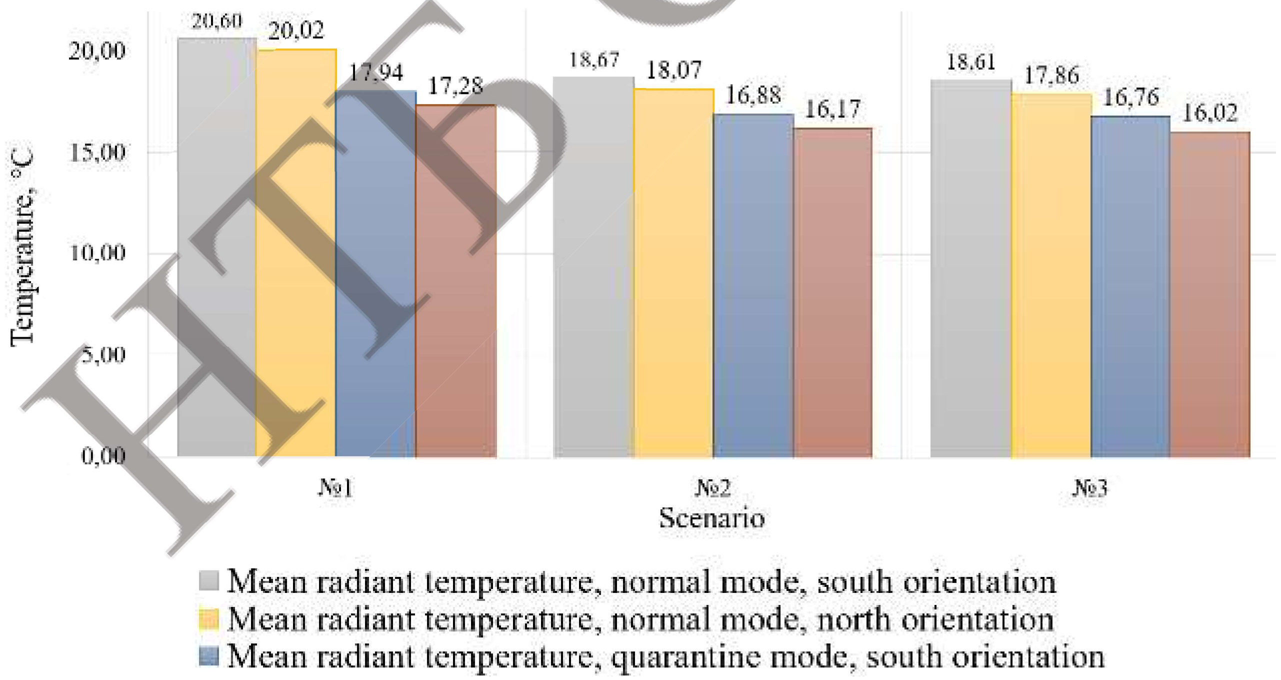

Fig. 9. The average value of the average radiation temperature for the heating season

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From the given graphs and diagrams, it follows that the parameters of comfort in the premises used under quarantine restrictions are deteriorating (the average radiation temperature decreases). This phenomenon is due to the fact that these rooms are in contact with cold areas, where a constant temperature is maintained at all times (t_{air_in} = 14°C). Internal heat flows lead to a transferring heat to cold zones and decrease in the average radiation temperature (t_{mean_rad}). For scenario №1, the lowest average radiation temperature is typical for the northern orientation room used in quarantine. The highest – for the southern orientation in normal operation (in this case, the average radiation temperature even exceeds the air temperature by 0,35°C). A characteristic feature of south-facing rooms, in addition to the general increase in average radiation temperature, is the increase in the amplitude of fluctuations in both average radiation temperature and indoor air temperature during the day and night, due to additional heat from the sun on the south side. Similar analogies are observed for scenarios №2 and №3. Scenario №2 is characterized by a decrease in the average value of the average radiation temperature and air temperature during the heating season. At the same time the difference between the room temperature and the average radiation is reduced too. Scenario №3 compared to №2 is characterized by an increase in indoor air temperature, as the air exchange in the premises during non-working hours decreases. However, this slightly reduces the average radiation temperature. As a result, in the implementation of scenario №3, the moisture in the air condenses to a greater extent than in №2 and diffuses into the enclosing structures, removing heat from them and as a result reducing the average radiation temperature. However, the reduction is very small compared to the savings of heat energy in scenario №3, so it is most appropriate to use for both modes of operation scenario №3.

V. CONCLUSIONS

1. According to the results of modeling of the three proposed modes of operation of the heating system and natural ventilation, it is established that the most energy-saving mode corresponds to scenario №3. The total energy savings between scenarios №1 and №3 for the normal mode is 48,02% for quarantine – 11,45%.

2. It is established that in case of partial use of the building during quarantine in the presence of zone regulation the total energy consumption of the building decreases by 61,32%, 56,54%, 34,09% in the implementation of scenarios №1, №2 and №3 respectively.

3. The specific consumption of heat energy per unit of heating area to the appropriate level during the partial use of the building in quarantine increases compared to the normal mode of operation by 68,86%, 52,85% and 78,62% for the scenario №1, №2 and №3 respectively. In this case, if we consider a separate research room with north and south orientation, the difference in specific consumption in the southern orientation will be greater (+86,88%) compared to the northern orientation (+83,23%), due to uneven heat from the sun.

4. The introduction of intermittent heating allows to reduce energy consumption in normal mode of operation by 14,55%, in quarantine – by 4% (internal heat flows lead to heat transfer to cold areas and reduced energy savings). The introduction of intermittent ventilation allows to increase energy savings by 39,17% for normal operation and 7,75% for quarantine. Thus, the total energy savings from the

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introduction of intermittent heating and ventilation for the normal mode is 48,02% and for quarantine – 11,45%.

5. The increase in the specific consumption of heat energy by the premises used in quarantine is due to their proximity to cold zones, which also leads to a decrease in the average radiation temperature, and hence the comfort parameters, especially for premises with a northern orientation, as evidenced by the obtained hourly data on temperature changes air in the premises, the average radiation temperature and their average values for the heating season. Therefore, when choosing separate working areas during quarantine, preference should be given to south-facing rooms.

6. As a conclusion from the analysis of various parameters, we have: the most energy-saving mode is scenario №3. The disadvantage of this mode is a decrease in the intensity of mass transfer processes as a result of a decrease in the level of air exchange. This leads to moisture retention on the enclosing structures, which leads to a decrease in the average radiation temperature compared to scenario №2. However, this decrease is very small and imperceptible for the human body. Therefore, this mode can be recommended for implementation in quarantine mode and normal mode.

To ensure compliance with comfort under quarantine restrictions during partial operation of the premises, it is appropriate to study the effect on energy consumption of increasing the air temperature in the operated premises to a level that will correspond to the PMV comfort parameter in the range of -0.5…0.5.

VI. REFERENCES

1. International Energy Agency. EBC Annex 53: total energy use in buildings: analysis and evaluation methods. (2013). https://www.iea-ebc.org/Data/publications/EBC_Annex_53_Main_Report.pdf

2. Saraiva, T.S.; De Almeida, M.; Bragança, L.; Barbosa, M.T. (2018) Environmental Comfort Indicators for School Buildings in Sustainability Assessment Tools. *Sustainability*, *10*, 1849. https://doi.org/10.3390/su10061849

3. Katić, D.; Krstić, H.; Marenjak, S. (2021) Energy Performance of School Buildings by Construction Periods in Federation of Bosnia and Herzegovina. *Buildings*, *11*, 42. https://doi.org/10.3390/buildings11020042

4. H. Zhiyuan, H. Tianzhen, Siaw K. C. (2021) A framework for estimating the energy-saving potential of occupant behaviour improvement. *Applied Energy*. Vol. 287. DOI: 10.1016/j.apenergy.2021.116591

5. Laaroussi Y., Mankibi M., Draoui A., Bahrar M. (2019). Occupant behaviour: a major issue for building energy performance. *IOP Conf. Ser.: Mater. Sci. Eng.* 609 072050

6. Sun, C., & Zhai, Z. (2020). The efficacy of social distance and ventilation effectiveness in preventing COVID-19 transmission. *Sustainable cities and society*, *62*, 102390. https://doi.org/10.1016/j.scs.2020.102390

7. D. Ivanko, N. Nord, Y. Ding. (2021). Heat use profiles in Norwegian educational institutions in conditions of COVID-lockdown. REHVA Journal of Building Engineering, 43, Nov, https://doi.org/10.1016/j.jobe.2021.102576

8. A. Bahmanyar, A. Estebsari, D. Ernst (2020). The impact of different COVID-19 containment measures on electricity consumption in Europe. *Energy Research & Social Science,* 68. https://doi.org/10.1016/j.erss.2020.101683

9. Pro enerhetychnu efektyvnist budivel: Zakon Ukrainy vid 22.06.2017 r. № 2118-VIII : stanom na 1 hrud. (2020). URL: https://zakon.rada.gov.ua/laws/show/2118-19#Text

10. DSTU-N B V.1.1–27:2010. Budivelna klimatolohiia; chynnyi vid 2011-11-01. Vyd. ofits. Minrehionbud Ukrainy. K.: Ukrarkhbudinform, (2011). 123 s.

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12. DBN V.2.6–31:2016. Teplova izoliatsiia budivel; chynnyi vid 2016–10–08, na zaminu DBN V.2.6–31:2006. Vyd. ofits. Minbud Ukrainy. K.: Ukrarkhbudinform, (2016). 33 s.
12. DBN V.2.5-67:2013. Opalennia, ventyliatsiia ta kondytsiiuvannia; chynnyi vid 2014–01–01. Vyd. ofits. Minbud Ukrainy. K.: Ukrarkhbudinform, (2013). 149 s.
13. DSTU B A.2.2-12:2015. Enerhetychna efektyvnist budivel. Metod rozrakhunku enerhospozhyvannia pry opalenni, okholodzhenni, ventyliatsii, osvitlenni ta hariachomu vodopostachanni; chynnyi vid 2016-01-01. Vyd. ofits. Minrehionbud Ukrainy. K.: Ukrarkhbudinform, (2015). 145 s.
14. *EnergyPlus*. URL: https://energyplus.net/weather-location/europe_wmo_region_6/UKR.
15. Дешко В. І., Білоус І. Ю., Суходуб І. О., Бойко Т. Ю. Енергоспоживання навчальних корпусів університету в умовах карантинних обмежень України. *Вісник Київського національного університету технологій та дизайну Серія: Технічні науки.* №2. 2021. С. 9-19. (Фахове видання України категорія Б)
16. В.І. Дешко, І.Ю. Білоус, Т.Ю. Бойко. Енергоспоживання навчальних корпусів університету в умовах карантинних обмежень України. *X Міжнародна науково-практична конференція «Енергоефективний університет»*. 28 жовтня 2021, Київ.
17. Білоус І.Ю., Бойко Т.Ю. Енергетичне моделювання навчального корпусу №17 КПІ ім. Ігоря Сікорського. *XVI Міжнародна науково-практична конференція аспірантів, магістрів, студентів «Сучасні проблеми наукового забезпечення енергетики».* Київ 20-23 квітня 2021 р. С. 302-303.

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