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IMPROVING ENERGY EFFICIENCY IN PUBLIC BUILDING IN THE MUNICIPALITY OF ČAČAK

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Abstract: There are a lot of important factors that influence building energy consumption. The building energy saving effect is an integrated acting result, it has a relationship between thermal characteristics of the building envelope, ventilation ways, efficiency of heating system, and the increasing range of energy saving rate will be different as the energy saving measures are different. In this paper, the public building in the municipality of Čačak was analyzed in order to examine the impact of different retrofitting measures on heating energy consumption. In terms of retrofitting to study, various energy efficiency measurements have been considered such as improving levels of insulations of different building envelope elements. Results show that the annual heating energy consumption could be reduced up to 61 %.
Keywords: energy efficiency, public building, saving energy

INTRODUCTION

Improving energy efficiency in buildings is one of the most cost-effective ways across all sectors to reduce energy consumption and hence greenhouse gas emissions. More than a third of the primary energy used in developed countries is used to heat, cool, and light buildings or is utilized within buildings. Energy efficiency is at the cornerstone of the European energy policy and one of the main targets of the Europe 2020 Strategy for smart, sustainable and inclusive growth adopted by the European Council in June 2010. This includes the objective for a 20% reduction in primary energy consumption by 2020. As energy related emissions account for almost 80% of total EU greenhouse gas emissions, the efficient use of energy can make an important contribution to achieving a low-carbon economy and combating climate change, [1-3].

Public policies in the most countries to promote building energy efficiency have addressed many of the same issues. These include: Building codes, Energy efficiency certificates, Promoting energy efficiency in public buildings, Training and certification of experts and White-certificate programs. Building codes have been effective in improving energy efficiency in new buildings and in some buildings undergoing major refurbishments, because they are mandatory and generally quite specific about requirements. Energy certification of buildings is a key policy instrument for reducing the energy consumption and improving the energy performance of new and existing buildings, [4,5]. One way to improve energy efficiency is to modernise public buildings because hospitals and schools are among the most important public facilities in Serbia. In this paper the possibilities of improving energy efficiency of public facility which is owned by the city of Cacak is analyzed. The current energy condition of the object have been proposed, than measures to increase energy efficiency and the energy state of the object after the application of the proposed measures are shown.

MATERIAL AND METHODS

Case study

The subject of analysis is a public facility Medical Health Care Center Čačak. Location is in the urban area of Čačak and it is free to all four sides. The floors of the building are Su + P + 1 with a total area of 3579,09 m^2, as shown in Figure 1.

To build a site the standard structure for this type of object is used. Horizontal bearing elements are "Avramenko" concrete ceiling, whose overall height from the floor and ceiling is 45 cm. All vertical bearing elements are reinforced-concrete columns. Roof construction is wooden with supporting beams and pillars, which relies on reinforced-concrete construction, which is set for thermal insulation of durisol panels. Over these elements beds, wall panelling, plating of boards, tar paper and tin covers are set up. On the outside of the roof structure was set up copper sheet thickness of 1 mm, while inner roof planes are made of tin plated copper.

Figure 1. The external appearance of the building and the view of situation of the Medical Health Care Center Čačak

Facade walls are constructed of brick or hips of the slag thickness from 25 to 38 cm depending on the position, while the partition walls constructed of hollow brick thickness of 7 cm. The walls are derived, without thermal insulation. All parapet walls are made of the hollow and clay brick, thickness 25 cm. Flooring in the areas are covered with linoleum, ceramic tiles or concrete. Thermal envelope of the building has an area of 6442,37 m^2. The building is attached to a remote system of heating with individual gas boiler room that is located in the courtyard in the Health center.

Present state energy audit

The analyzed object belongs to the category of objects for health care and social protection, as defined by the State Regulations on energy efficiency in buildings. This building is an existing building and it applies energy rehabilitation, which is also defined in the Regulations. The program KnaufTerm2 PRO S, version 27.2 was used for energy efficiency analysis of the Health Center building in the current state.

Based on the conducted investigation, it is possible to analyze and evaluate the energy efficiency of the building of the Health Centre in Cacak in the current state. The results show that the annual transmission heat losses through certain parts of the building envelope in the current situation are:

1. External walls: 112417,16 kWh;
2. Pitched roof: 97916,75 kWh;
3. Window and curtain wall: 140545,99 kWh;
4. Partition walls towards the unheated area: 11102,92 kWh;
5. Ceiling below unheated space: 161805,10 kWh;
6. Floor above unheated space: 8987,82 kWh;
7. Ground walls (basement): 46842,85 kWh;
8. Ground floors: 111551,21 kWh.

The Figure 2 shows the heat loss percentage through certain components of the facility in the total heat losses.

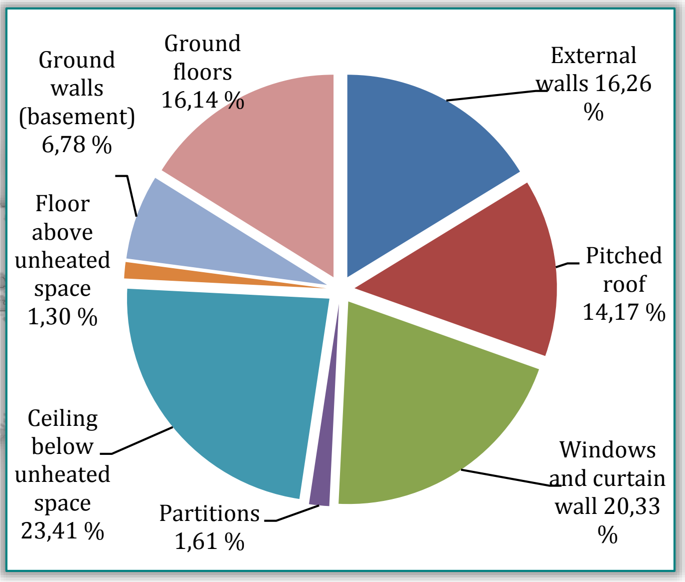

Figure 2. Percentage shares losses through the envelope building elements in the total heat losses in the present state of building

The analysis of heat losses shows that the greatest heat loss is through the basic ceiling below unheated space located below the ceiling, as this surface is the largest of all the areas that make up the thermal envelope of the object and which accounts for 18,5 %, and was conducted without heat insulation. Then the greatest heat losses are through windows and curtain wall, although their surfaces 11,78 % of the total thermal envelope. Losses through the exterior walls and under the floor of the facility amount to about 16 % of total heat loss. By analyzing the characteristics of the circuits forming the thermal envelope of the building, it was noted that the heat transfer coefficients of all the areas that make up the thermal envelope of the object is greater than the allowable values that are defined in the State Regulations on the energy efficiency of buildings. It was also observed that the thermal envelope assemblies such as external slanted walls and a piece of the roof above the heated area leads to the formation of condensation.

Total energy demand for transmission losses of the building is 733,77 MWh and for ventilation losses 229,86 MWh, in its present state. Annual energy building gains in the current state are:

1. Solar gains: 91,37 MWh;
2. Gains from energy consumption: 23,84 MWh;
3. Gains heat from electrical appliances: 45,36 MWh.

Annual energy consumption for heating the building in its present state, using the central gas heating system is 803 MWh, while specific annual heat consumption for heating is 276,48 kWh/m^2. Since the adoption of energy-class benefits of the specific thermal energy for heating systems operating with a recess, on the basis of which this building belongs to the energy class F. Regulations on the energy efficiency of buildings stipulates that the maximum allowed annual consumption of energy for heating buildings allocated to health care and social protection 120 kWh/m^2. Based on the results of the analysis can be concluded that the annual energy consumption for heating of the Health Centre in Čačak 2.3 times higher than allowed for the analyzed object.

Review of measures to improve energy efficiency

Based on the analysis of energy efficiency of the building, it was noted that it is necessary to improve the thermal characteristics of all the components that make up the building envelope and proposes the implementation of the following measures, [6]:

1. On the external walls add a thermal insulation Knauf Insulation FKD-S Thermal 7 cm thickness and on the side walls add thermal insulation Knauf Insulation NaturBoard FIT-G PLUS 8 cm thickness, both on the outside of the building wall;
2. In order to prevent condensation in the roof structure is necessary to reconstruct the roof and replace the covers. On the roof, under the roof construction, install vapor permeable film layer Knauf Insulation LDS 0.02, then a layer of Termal mineral wool Knauf Insulation Unifit 035 thickness of 18 cm and a vapor barrier Homeseal Knauf Insulation LDS 5 Silk. Aluminum replaced with the cover tiles;
3. It is necessary to substitute the existing five-chamber PVC windows and curtain wall with double-layer glass thickness of 4 mm filled with air thickness of 12 mm with six chamber PVC windows with low-emission double-layer glass (4 + 12 + 4) with krypton;
4. On the walls towards the unheated space should be placed insulation rock mineral wool Knauf Insulation NaturBoard FIT-G PLUS thickness of 5 cm;
5. From the floor joists above unheated spaces to remove a layer of cod and the underside of the installed thermal insulation rock mineral wool Knauf Insulation CLT C1 8 cm thick and a layer of vapor permeable film;
6. On the basic ceiling below an unheated attic space on the bottom side install thermal insulation of mineral wool Knauf Insulation Unifit 035 8 cm thickness and a layer of vapor permeable film;
7. On the brick walls in the ground, basement, which are oriented to the south, add insulation rock mineral wool Knauf Insulation FKD-S Thermal 4 cm thickness and on the other basement walls made of concrete in the ground, it is necessary to add on the inner side the same insulation thickness of 5 cm and a layer of vapor permeable film;
8. On the floors of the facility in working spaces in the basement proposes to install a slab of rock mineral wool Knauf Insulation NaturBoard POD EXTRA thickness of 9 cm and utility rooms and 8 cm thickness cement screed.

Table 1. Review of the heat transfer coefficients through the thermal envelope of the building of the Health Centre in Čačak

Building envelope structure	Umax (W/m^2 K)	Present state U (W/m^2 K)	Present state Satisfied	Proposed state U (W/m^2 K)	Proposed state Satisfied
External walls	0,40	1,595	No	0,379	Yes
External slanted walls, north-south oriented	0,40	3,378	No	0,400	Yes
Pitched roof above heated area	0,20	1,464	No	0,152	Yes
Window and curtain wall	1,50	2,800	No	1,300	Yes
Partition walls towards the unheated area	0,55	2,294	No	0,546	Yes
Ceiling below unheated space	0,40	2,564	No	0,374	Yes
Floor above unheated space	0,40	0,544	No	0,361	Yes
Ground wall, south oriented	0,50	1,013	No	0,461	Yes
Ground wall, other	0,50	1,592	No	0,485	Yes
Ground flor - utility rooms	0,40	2,375	No	0,395	Yes
Ground flor – working spaces	0,40	3,155	No	0,376	Yes

* According to the Regulations on energy efficiency in buildings

Proposed measures to improve energy efficiency of the object can be achieved by using elements (material) Knauf systems that are tailored to each individual site which can improve and meet the requirements defined in the Regulations for the Energy Efficiency Facility for existing buildings for this purpose.

Implementation of the proposed measures to increase the energy efficiency of the building is fully justified. Table 1 provides an overview of the coefficient of heat transfer through the thermal envelope of the building in its present condition and after the implementation of measures to improve the energy rating of the building. After the application of the proposed measures will not come to the formation of condensation in all the assemblies of the building.

RESULTS AND DISCUSSION

After the implementation of measures to improve energy efficiency of the building annual transmission heat losses through certain parts of the building envelope should have the following values:

1. External walls: 20386,27 kWh
2. Pitched roof: 10166,22 kWh
3. Window and curtain wall: 65253,50 kWh
4. Partition walls towards the unheated area: 2642,63 kWh
5. Ceiling below unheated space: 23601,84 kWh
6. Floor above unheated space: 5964,35 kWh
7. Ground walls (basement): 15890,35 kWh
8. Ground floors: 15143,94 kWh.

Figures 3 and 4 show a comparative analysis of transmission heat losses data and their percentage share in the total heat loss of the building, for the present and the proposed case. The analysis results showed that after the implementation of measures for improvement of building energy efficiency the transmission losses through all the elements decrease, but their share in total losses changed.

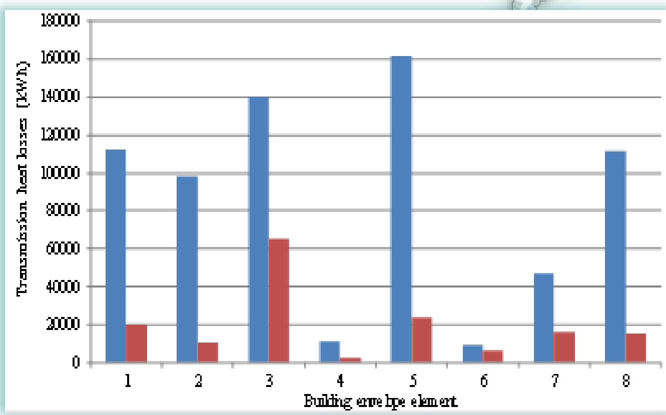

Figure 3. Transmission heat losses for present v.s propose state: 1 – External walls, 2 – Pitched roof, 3 – Window and curtain wall, 4 – Partition walls towards the unheated area, 5 – Ceiling below unheated space, 6 - Floor above unheated space, 7 – Ground walls, 8 – Ground floors;

After the application of the proposed measures for improving energy efficiency the greatest reduction in transmission losses could be expected in pitched roof in which the losses can be reduced by up to 90 %, while the floors on the ground and floors below an unheated area can be achieved reduction of heat loss up to 85%.

Reduction of heat transmission losses through the exterior walls could be up to 82 % and by replacement of a window can be achieved energy savings up to 53%. Total energy use for compensation of transmission losses of the building in the present case amounts to 202 MWh.

The application of the proposed measures can be achieved annual energy savings up to 73 % for the entire object. Solar heat gain in the present case was reduced by 46 % and amounted to 49,10 MWh, while the gains from energy consumption and electrical appliances remained unchanged. Annual energy consumption for building heating in the present state is 313 MWh, which is 61 % less than it consumes in its present condition.

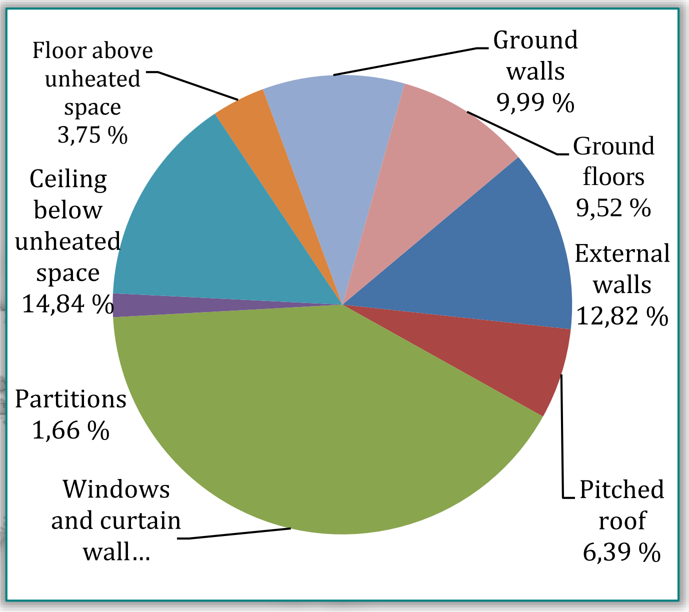

Figure 4. Percentage shares losses through the envelope building elements in the total heat losses for the propose state of building after implementation of measures for energy efficiency improvements

For the proposed state of the building specific annual heat consumption will be 107,83 kWh/m², which is below the 120 kWh/m², which represents the maximal value of heat energy specific consumption of existing buildings allocated to health care, according to the Regulations for energy efficiency in buildings Republic Serbia. After implementation of measures for improvement of energy efficiency, analyzed object belongs to C energy class, which is two ranges up according to present state.

CONCLUSION

This paper considered the impact of retrofit schedule influence on energy use. The research suggests that improving all building envelope elements insulation level helped significant heating energy reduction. Results show that after applying the proposed measures CO_2 emission can be reduced from 192 CO_2/year t to 75 t CO_2/year. Plenty of studies have considered the effect of improving fabrics' thermal property on heating energy consumption and some provided strong evidences why we need to improve public building energy efficiency. However, even in objects that have achieved specific standards, the energy consumption may be dramatically different depending on the occupants' energy use behavior, and any extensions or alterations they make to the objects. More research is needed into the effects of occupant's behavior on energy use which will allow for more targeted interventions to be applied.

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Note

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