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[1.] Vladimir MIJAKOVSKI, [2.] Tale GERAMITCIOSKI, [3.] Vangelce MITREVSKI

RESULTS FROM THE ENERGY AUDIT OF THE HIGH SCHOOL DORM "MIRKA GINOVA"- BITOLA

[1-3.] University "St.Kliment Ohridski", Faculty of Technical Sciences, Bitola, MACEDONIA

Abstract: *Measures for increasing of energy efficiency in buildings are closely related to Energy Audit. Faculty of technical sciences – Bitola (FTSB) is one out of five companies that were chosen as educating facilities for training of energy auditors. High School dorm "Mirka Ginova" in Bitola is the only state-owned dorm in the city. Preliminary energy audit for the nearby building of the dorm was performed as a part of the training for energy auditors. The calculations were performed by using of ENSI© EAB software.*
Keywords: *energy audit, dorm, energy class, ENSI software.*

INTRODUCTION

Following recent adoption of EU regulative in the area of energy auditing in the country, [1,2], the first step was to train energy auditors with a purpose of obtaining licenses for energy auditing. One of the institutions licensed for training of Energy Auditors is the Faculty of Technical Sciences in Bitola. In the course of this training, the building of the nearby High School dorm "Mirka Ginova", was used as an example for energy auditing with determination of its energy class using ENSI© EAB software.

The building of the dorm is located in the south-eastern part of the city of Bitola. The object does not have attached building to it, located in averagely urbanized part of the city, next to the city park, bus station and railway station. It was built in 1960 and significant reconstruction and extension took place in 1994. Main entrance of the building is on the south-western side (Fig. 1).

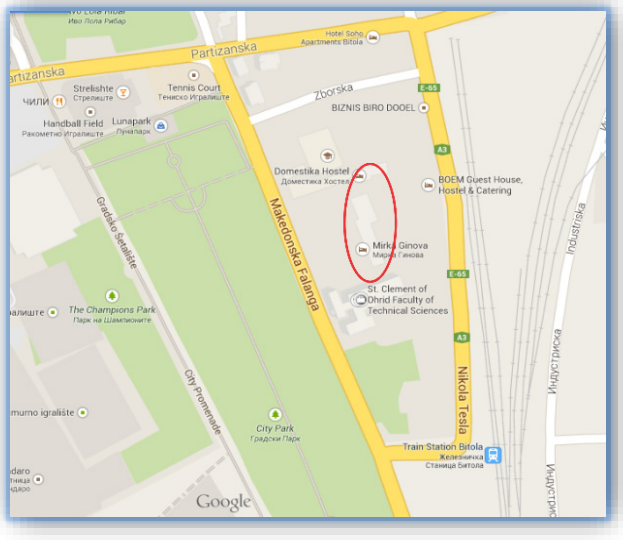

Figure 1. Location of the high school dorm "Mirka Ginova" in Bitola

DESCRIPTION OF THE BUILDING AND OTHER DATA REQUIRED FOR ENERGY AUDIT

Dormitory "Mirka Ginova" in Bitola is educational institution within the Ministry of Education and Science of the Republic of Macedonia, student standard department. The building is mainly divided in 2 parts: north and south part. South part consists mainly of bedrooms, while in the north part, the kitchen, dining room and administration offices are located. South part consists of basement, three floors with wooden roof construction covered with metal sheet roof, while the northern building has basement and two floors also covered with metal sheet roof. The capacity of the dorm is 270 high school students and 26 employees. In the summer months, the dorm is open to accommodate guests of different events in the city. In this period of the year, averages of 100-150 guests are staying at the dorm.

Total net area of the building is 3364 m^2, while total net volume is approx. 9420 m^3.

Last reconstruction of the building consisted of partial replacement of external windows and carpentry and took place in the year 2010.

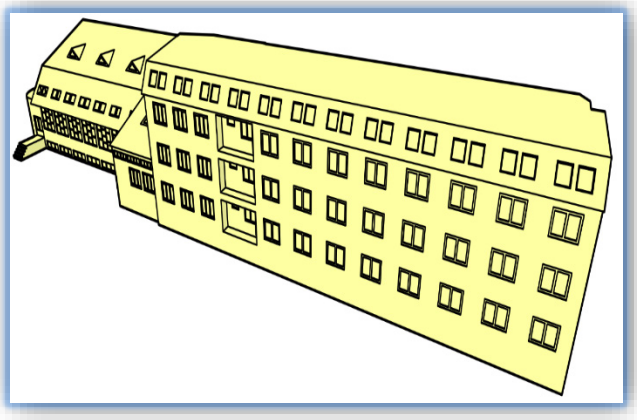

Figure 2. Appearance of the building from the south-west

Part of the other relevant data for the energy audit, required by the legislative, are given in the following table:

Table 1. Part of the data relevant for Energy Audit of dormitory's building

Characteristics of the building construction	Material (concrete, brick, hollow brick)	Total thickness [cm]	Thickness of the thermal insulation layer [cm]	Area of the construction [m^2]	Heat transfer coefficient U [W/m^2K]
External wall NORTH	Concrete	36	5	31,14	0,914
	Brick	43		297,61	1,16
External wall SOUTH	Brick	43		252,40	1,16
	Hollow brick	27		30,22	1,6

Table 2. Heat protection

	Execution of glazing for the windows, for example: triple insulated glass with inert gas and low emission coating	Carpentry – frame for the glazing, for example: wooden, aluminium, plastic etc.	Heat transfer coefficient through the window U [W/m^2K]
North façade [m^2]			
2,76	Double glazing	Wooden	2,9
21,66	Double thermopan glass with inert gas filling	Plastic (PVC)	1,3
15,00	Thermopan glass	Aluminum	3,25
2,54	Single glass	Steel	5,8
South façade [m^2]			
47,5	Double thermopan glass with inert gas filling	Plastic (PVC)	1,3
3,25	Thermopan glass	Aluminum	3,25
6,33	Single glass	Steel	5,8

Prior to entering of data in ENSI© EAB software, a detailed calculation of areas of all surfaces (external building envelope) as well as heat transfer coefficient for all materials was performed. In the following figures, example of calculated areas for building's south façade and cross-section of one type of external wall and roof are shown.

Figure 3. Dormitory's western façade – Total area without windows 517,1 m^2; red colored windows are with double glazing and wooden carpentry; yellow colored are with PVC carpentry and double thermopan glazing with inert gas filling, while blue colored windows are with aluminum carpentry and thermopan glazing.

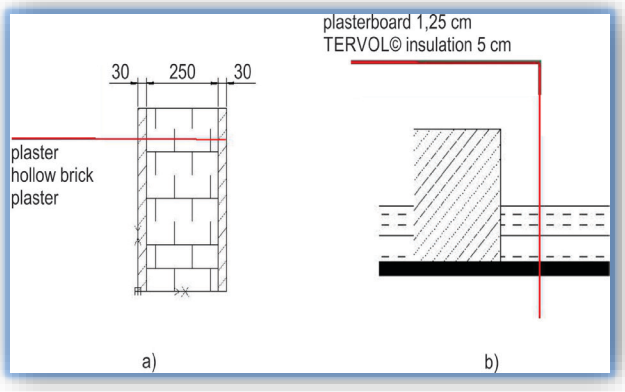

Figure 4. Cross section of construction – a) external wall with hollow brick; b) roof with plasterboard

At the end, we grouped external walls and windows in three groups according to building construction and heat transfer coefficients.

For the heating of building, hot water radiator heating system with forced circulation (with pump) is used. Heating installation is of a two-pipe system with lower horizontal branching. Two pumps are used for circulation of heating media (water). Boiler house consists of three hot water boiler connected in parallel, with a total of approx. 1100 kW installed heat power. Light oil is used as fuel. As part of the energy audit, a measurement of flue gases emission from one of the boilers was also taken.

Electrical equipment in use consists of more than 10 electric heaters (with total installed electric power of 54 kW) that are used prior to/after heating season (before 15.10 or after 15.04), electric appliances in the kitchen (total installed electric power of 116 kW), electric appliances in the laundry (around 53 kW), electric boilers with installed electric power of 102 kW, 15 personal computers copier machines, 11 air conditioning units (split system) etc. There are also around 180 fluorescent lightning tubes with electronic ballast installed for lamination and 52 light bulbs with total electric power of 5,2 kW.

For the purpose of energy audit preparation, detailed invoices – bills for electric energy and water consumption were collected from the accounting department.

INSERTING OF DATA IN ENSI© EAB SOFTWARE AND OBTAINING OF RESULTS

The ENSI© EAB Software, [3, 4], is tailored for quick energy calculations of the energy performance of existing and new buildings. The calculations can either be based on the standard climatic data, standard values and holiday tables that are included in the software, or by creating user defined standard values and holiday tables. In our case, we used the standard climatic values for the city of Bitola with user defined holiday tables, (Figure 5).

After naming the project in the software, the first step is to enter the actual condition of building envelope (areas and U-values). The software allows entering walls and windows in eight directions (N, NE, E, SE, S, SW, W, NW). "Walls" allow input of non-transparent constructions and "Windows" for transparent parts, (Fig. 6).

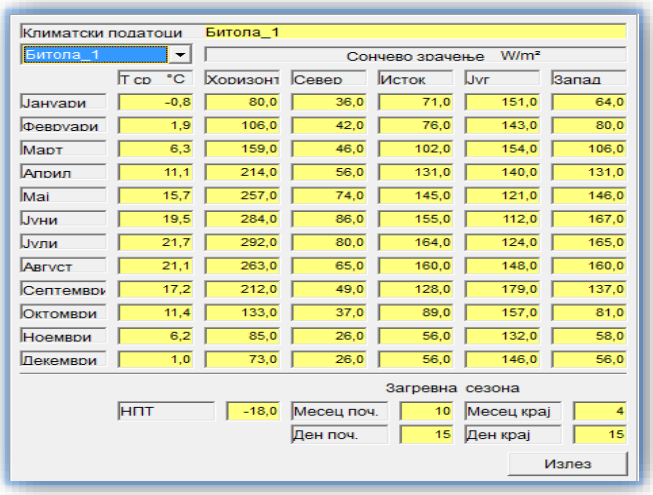

Figure 5. Climatic data for Bitola

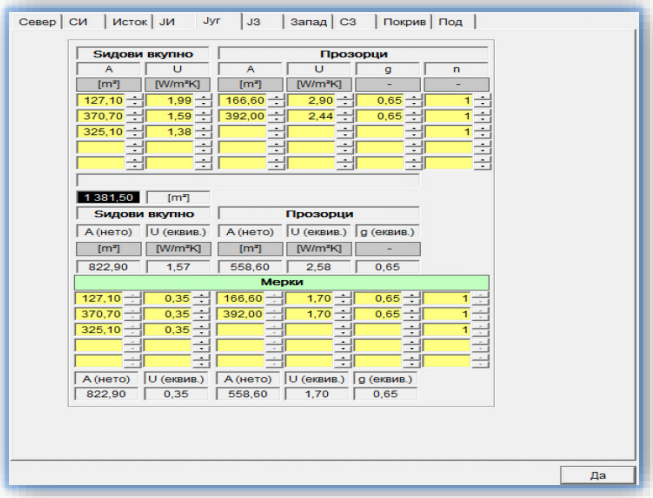

Figure 6. "Actual" and "After measures" condition of walls and windows on building's south façade

After entering of actual U-values, we also enter the U-values for the "Measures" – that is maximum permitted U-values for non-transparent surfaces according to the Rulebook for energy characteristics of buildings, [2]. When the entering of values for building envelope (walls, windows, floor and roof) is finished we proceed to enter the total conditioned (heated) area of the building and heat gains from occupants.

Next step is to enter/modify actual parameters for "Heating". This is done by changing of different efficiency coefficient referring to emission of heating objects, distribution efficiency, automatic control and production efficiency. It is also possible to enter parameters for "Measures" referring to condition after, for example, replacement of hot water boiler running on light oil fuel with corresponding boiler that uses wood pellets as fuel.

The next few steps include entering of values for "Ventilation" (in our case there is no mechanical ventilation of the building), followed by "Domestic Hot Water", "Fans, Pumps and Lighting", "Various exploitable and unexploitable" and "Cooling and Outdoor".

When all the data are filled in, the software gives the results of calculations on five screens. The "Energy Budget" includes the energy use for the standard building and calculated energy use for "Actual", "Baseline" and "After Measures". The "After Measures" values summarize all the savings from the "Measure" columns for each budget item.

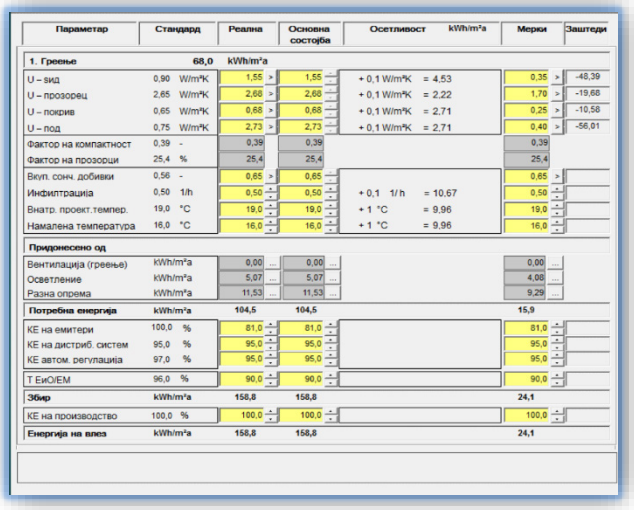

Figure 7. ENSI© EAB "Heating" screen

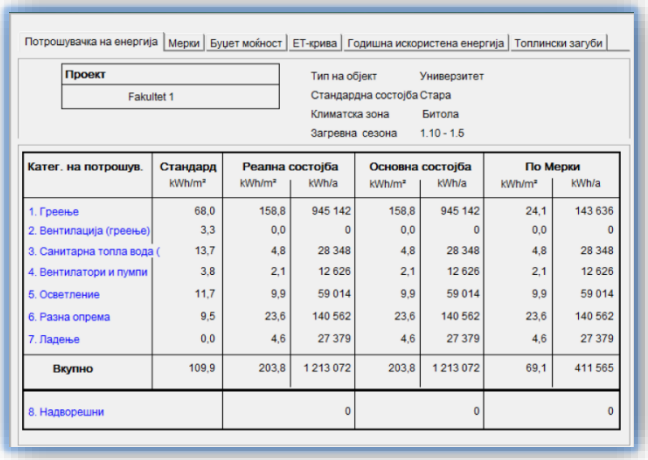

Figure 8. "Energy budget" results screen

By clicking "Power budget", the corresponding budget for maximum simultaneous power demand for each budget item will appear.

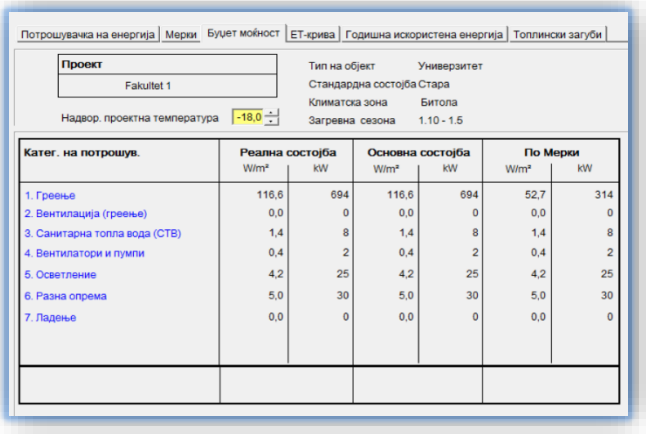

Figure 9. "Power budget" results screen

Both specific and total power demands are presented in the columns "Actual", "Baseline" and "After Measures". The kW's is the specific value multiplied by the conditioned area of the building, defined in the "Building envelope" window.

CONCLUSION

Following recent adoption of EU regulative in the field of Energy Auditing of buildings, the Faculty of Technical Sciences in Bitola is one of country's five licensed training centers for energy auditors, [5]. In the scope of training, practical part, the building of dormitory "Mirka Ginova" was taken as an example and general energy audit was performed on it. Calculations were performed using ENSI© EAB software for quick energy performance calculations.

The results from the calculations categorized the building of the High school dorm "Mirka Ginova" – Bitola as class "E" building. Calculated value of energy consumption is 158,4 kWh/(m²a).

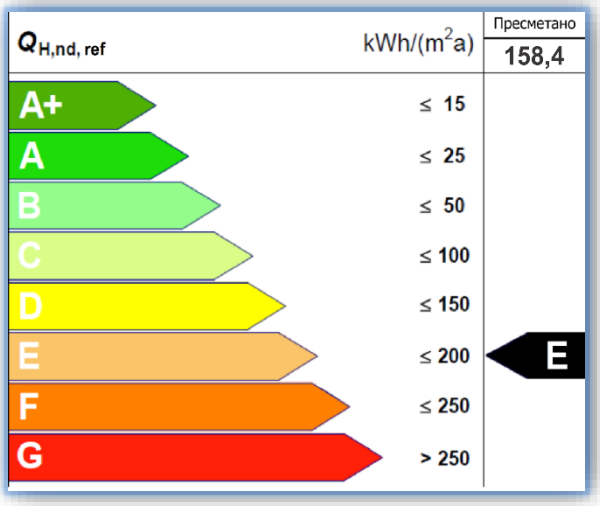

Figure 10. Energy class of the building

According to local legislative, [2], all buildings undergoing 'substantial reconstruction' must reach at least "D" energy class.

In the example of preliminary energy audit of the dormitory "Mirka Ginova" – Bitola building, the proposed measured would include:

- *Thermal insulation of all external walls in order to reach maximum allowed U-value of 0,35 W/m²K;*
- *Partial replacement of windows and carpentry in order to reach maximum allowed U-value of 1,7 W/m²K;*
- *Installation of additional thermal insulation for the roof in order to reach maximum allowed U-value of 0,25 W/m²K;*
- *Replacement of one of the hot water boiler running on light oil fuel with high efficiency hot water boiler running on wood pellets.*
- *Replacement of light bulbs and fluorescent lighting tubes with LED lights;*

Implementation of these measures would 'raise' building's energy class to "C".

Return on Investment (ROI) period for implementation of these measures was also calculated and it ranges from 2 years (lights replacement) up to 5,5 years (replacement of windows and corresponding carpentry).

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