ANALYSIS OF RESULTS OF MEASURES PERFORMED TO INCREASE ENERGY EFFICIENCY IN VASIL KARAGIOZOV HIGH SCHOOL OF YAMBOL, BULGARIA

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Abstract: The report analyzes the results of the implemented measures to improve energy efficiency in Vasil Karagiozov High school of Yambol, Bulgaria. Energy savings are determined by measuring and/or calculating energy consumption with previously adopted baseline levels, implementing a measure or program to improve energy efficiency by providing normalized corrections corresponding to the impact of specific climatic conditions on energy use. A reference heating energy consumption of 38.62 kWh/m² was determined after the renovation of the building. Comparing the reference energy costs for heating before and after the implementation of the energy saving measures show a real decrease of the energy consumption for heating by 53.44%. Compared to the reference energy consumption for heating before and after the energy saving measures show an actual reduction of energy consumption for heating by 47.86%.

Keywords: heat transfer coefficient, energy conservation measures, energy consumption, heated area, heated space.

1. INTRODUCTION

In June 2008, in order to comply with the requirement of Article 19, Paragraph 2, of the Energy Efficiency Act [1] and in connection with the application for external financing of energy efficient reconstruction of the building of Vocil Karagyozev High school of Yambol, for energy efficiency by "Max Max Effect" ELTD, Sliven [2].

Energy calibration modeling has been done to calibrate and normalize the model. The annual reference energy consumption for heating is calculated during the calibration of the model 82,95 kWh/m².

Normalization of the model sets an annual baseline energy consumption for heating of 159.5 kWh/m² to maintain the normative temperature required for the existing building condition.

The reference annual energy consumption for heating - 34.5 kWh/m² is calculated for the specific building, the values of the reference characteristics of the building envelope structures being adopted according to the technical requirements of the norms in force at the time of the energy efficiency audit.

The comparison shows that the normalized heating energy consumption is 4.6 times higher than the building reference [2].

As a result of the survey, the following ESMs (Energy saving measures) were implemented:

- Thermal insulation of external walls;
- Thermal insulation of the roof;
- Replacement of wooden and steel windows with PVC with double glazing;
- Thermal insulation of a floor bordering an unheated basement and a floor bordering on outside air;
- ESM for heating and heating;
- Introduction of a combined DHW (domestic hot water) system.

Figure 1. Facade of Vassil Karagyzov High school

The purpose of the publication is to analyze the results of the implemented energy saving measures prescribed in the Energy Efficiency Survey of the building of Vasil Karagiozov High school building in Yambol, Bulgaria.

2. MATERIAL AND METHODS

The methods for assessing energy savings have been developed on the basis of Art. 22, para. 3, item 4 of the Ordinance under Art. 9, para. 2 of the Energy Efficiency Act [1]. Energy savings are determined by measuring and/or calculating energy consumption with previously adopted baseline levels, implementing a measure or program to improve energy efficiency by providing normalized corrections corresponding to the impact of specific climatic conditions on energy use.

The amount of energy saved is equal to the difference between the energy used before the implementation of the measure or program to improve energy efficiency and energy use measured after this introduction [3].

The model study on energy consumption of buildings aims at:

- Determination of the energy consumption and energy performance indicators of the building;
- Getting the energy needed to maintain the microclimate in the building;
- Comparison with the reference energy consumption of the building;
- Where necessary, specify energy saving measures to obtain an energy efficiency certificate.

General input data to create a building model:

- geographic area – Yambol, climatic zone 6. Climate database parameters are in accordance with the calculation method for determining the annual reference energy consumption;

- type of building - school;
- operating norms for building envelope structures and elements at the time of construction of the building – 1989;
- mode of use - number of students and staff, schedule occupants, schedule heating;
- the characteristics of the enclosing elements.

Model calibration. Calibration of the model aims to determine the reference energy consumption for the year with the highest specific cost. In determining it, the total annual energy consumption, the annual heating cost, the days of the respective climate zone and the days for the year for which the reference energy consumption is determined.

3. RESULTS AND DISCUSSION

Data collected from the energy invoices for heating before the renovation of the building for three consecutive years - 2005, 2006, 2007, 2015 and 2016 after the prescribed energy saving measures have been collected and processed. They are presented in Table 1.

The consumption of heat during the implementation of the project is not the subject of the study.

Table 1. Annual heat consumption by years, reported by invoice data

Object studied	Heat energy, MWh						
	2005	2006	2007	Average annual cost before ESM (2005-2007)	2015	2016	Average annual cost before ESM (2015-2016)
Vasil Karagiozov High school	637,49	825,46	669,37	710,77	303,32	320	311,66

In Figure 2 is the average annual energy consumption for heating before and after the implementation of the energy saving measures. After renovating the building, this cost has decreased 2.3 times.

Figure 2. Average annual energy consumption for heating before and after the implementation of energy saving measures

In order to avoid inaccurate interpretation of the invoice data, Table 2 shows the energy consumption data related to the heating days (DD) for the same heating periods [5].

Table 2. Specific energy consumption [MWh/ DD]

Vasil Karagiozov High school	Year				
	2005	2006	2007	2015	2016
Power consumption, MWh	637,49	825,46	669,37	303,32	311,66
Day degrees, DD	2501	2584	2317	2294,50	2105,7
Specific power consumption, MWh/DD	0,255	0,319	0,289	0,132	0,148

At 2501 day degrees (DD) for 2005, the energy consumption is 637.49 MWh and the specific energy consumption is 0.255 MWh / DD. Similarly, at 2584 days in 2006, the energy consumption was 825.46 MWh and the specific energy consumption was 0.319 MWh/DD and in 2007 at 2317 DD, the energy consumption was 669.37 MWh and the specific energy consumption energy - 0.289 MWh/DD.

After the prescribed energy saving measures are implemented, the specific energy consumption in 2015 is 0.132 MWh/DD, and in 2016 – 0.148 MWh/DD.

When the model was calibrated in the Energy Efficiency Audit, a reference energy consumption for heating of 82.95 kWh/m² was set for the year with the highest specific energy consumption.

After the energy-saving measures prescribed in the Energy Efficiency Survey, the reference energy consumption for heating is 38.62 kWh/m². Comparing the reference energy costs for heating before and after the implementation of the energy saving measures show a real reduction of the energy consumption for heating (by avoiding the impact of climate through the heating dwellings) by 53.44%.

Calculation of CO₂ savings in accordance with Ordinance No. 7 of 2004 (2009, 2010, 2013, 2015) on energy efficiency, heat conservation and energy saving in buildings. The a coefficient is calculated, taking into account the losses for production, production and transmission of natural gas $\epsilon_i=1.1$ [4]. A reference value of the ecological equivalence coefficient $f_i=202$ gCO₂/kWh is taken from the same ordinance (Table 3).

When comparing the energy costs for heating before and after the energy saving measures, there is a potential for reducing the costs actually incurred, with a thermal comfort of 513800 kWh/y with an ecological equivalent of 114.16t CO₂ emitted.

 Table 3. Emission savings of CO₂

Energy consumption for heating, kWh/y		e_i	Primary energy	f_i	Emissions CO ₂
		-	kWh/y	$\frac{g}{CO_2/kWh}$	t
Average annual cost before ESM	825460	1,1	908006	202	183,41
Average annual cost before ESM	311660	1,1	342826	202	69,25

4. CONCLUSION

The Energy Efficiency Audit of Vassil Karagyozov High school, Yambol, implemented by "Max Max Effect" ELTD, Sliven, provided for energy saving measures implemented during the implementation of the project.

A reference heating energy consumption of 38.62 kWh/m² was determined after the renovation of the building. Comparing the reference energy costs for heating before and after

the implementation of the energy saving measures show a real decrease of the energy consumption for heating by 53.44%.

The reduction of the necessary annual heating costs, provided thermal comfort, is 513800 kWh/y with an ecological equivalent saving of 114.16 t CO₂.

5. REFERENCES

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