Energy modeling of the DSTU new campus business center building

*Olga Vorontsova**, *Yulia Shvets*, and *Svetlana Sheina*

Don State Technical University, 1 Gagarin sq., Rostov-on-Don, 344000, Russia

Abstract. The article describes the possibilities of buildings' energy modeling, the purpose of which is to assess the energy-saving solutions implementation effectiveness. Also, energy modeling makes it possible to analyze the application correctness of certain architectural, engineering and other design solutions. The article describes energy-saving technologies used in the design of a business center on the DSTU campus territory. Measures and technologies to improve the energy efficiency of the building have been considered, and the energy passport of the considered building has been calculated. Energy modeling of the business center building has been completed. The article contains the results of the performed energy modeling.

1 Introduction

Certification according to international systems (BREEAM, LEED) includes building energy modeling, which allows not only to pass certification, but also to attract investment in the project.

Modeling will allow obtaining accurate information about the reliability degree of the decisions made in the project, as well as taking into account all the factors when assessing energy-saving measures and assessing the payback period of the selected technical and design solutions.

Based on this, conducting energy modeling of buildings helps to optimize the consumption of energy resources during the operation phase and, as a result, reduce unnecessary operating costs.

2 Materials and methods

The building of the considered business center is located on the Don State Technical University (hereinafter - DSTU) new campus territory.

The purpose of creating a new campus for DSTU is to form a technological environment for the functioning of the university, contributing to the effective development of technologies in promising areas of production, as well as training highly qualified personnel for the labor market of the city in southern Russia. [1]

* Corresponding author: vorontsovaolyaa@mail.ru

The planned zoning of the campus includes an educational, scientific and innovation zone, a business zone, a social and cultural, sports and recreation and recreational zone. [2]

The total cost of creating a new campus is estimated at 8.0 billion rubles. The sources of financing for the project are the investor's funds in the amount of 30%, which is 2,400 million rubles, 70% - the creditor's funds in the amount of 5,600 million rubles.

To obtain credit funds within the framework of the project, it is planned to create an SPV (special purpose vehicle) - a special purpose vehicle created for the implementation of the project and its goals. The planned loan term is 10 years. Thus, it is obvious the need for the availability of funds that will give an opportunity to pay off the loan debt on time or earlier.

To obtain such funds, within the framework of the DSTU campus project, a project for the business center construction intended both for practical work of students and staff, and for renting free space is proposed, which will make it possible to receive income to pay off credit debt. [3]

Fig.1. Scheme of the DSTU campus on Gagarin sq.

The world experience of the existence of major universities presupposes their active cooperation with business representatives. Vivid examples of such cooperation are the University of Aalborg (Denmark), the University of Canterbury (New Zealand), the University of Massachusetts (USA), the University of California at Berkeley (USA), etc.

Typically, several large companies are based on their campuses, which opens up the possibility of close interaction between the research areas, educational programs and enterprises. Constant interaction between business experts and academics, students and the academic environment of universities enhances their competitiveness. [4]

Sustainable development of urban areas is directly related to the careful attitude to available resources and environmental potential. Therefore, the main direction of territorial sustainable development is the concept of "green construction", which determines the transition to a new technological order to reduce the negative anthropogenic impact degree on nature, increase competitiveness with industrialized countries by reducing the share of carbon raw materials in the cost of the final product.

Currently, there is a new upsurge in the development of an ecological approach to urban planning, which is based on the populated areas sustainable development concept.

Implementation of green building projects is closely related to the possibility of economic regulation of such parameters as return on investment and profitability of projects.

To improve the energy efficiency of the DSTU business center building, as a part of the project development, it was decided to install the following energy-saving equipment.

1. Solar panels. Using solar panels during operation will reduce energy costs by up to 30-40%. [5]

Figure 2 shows the location of solar panels on the roof of a business center building (the model was created in PO Revit).

Fig. 2. Location of solar panels on the business center building roof

2. Energy efficient elevators. Energy efficient elevators reduce building operation and maintenance costs, significantly saving energy throughout the lifespan of the elevator.

The costs of assembling and installing such elevators are 7-8% higher than for conventional two-speed elevators, however, energy savings pay off the investment already in the early stages of elevator operation.

3. Energy efficient double-glazed windows. The profile used for the manufacture of energy-saving glass has a large number of air chambers, just the air in them is a heat-insulating material that prevents the passage of cold into the building.

4. Installation of luminaires with motion sensors. The use of motion sensors saves energy by turning on lighting devices only while people are in the room, which makes it possible not to waste electricity. When using light and noise sensors, the operating time of the luminaire is reduced from 24 hours a day to 5-7 hours a day. [6]

The main advantage of using energy efficient technologies in the business center construction is a reduction in costs of up to 40% for the subsequent facility operation, due to a decrease in utility bills for energy resources.

To assess the proposed energy-saving solutions' effectiveness, as well as to ensure the most favorable microclimate parameters, thermal protection of the building, protection against high humidity of the enclosing structures and the efficiency of heat energy consumption for heating and ventilation, the energy passport of the DSTU business building center was calculated.

The obtained value of the heat energy consumption deviation for heating and ventilation of the building from the standardized is equal to minus 77% corresponds to the highest energy efficiency class "A ++", it follows that the considered project of the business center building meets the regulatory requirements for thermal protection.

Energy modeling of a building makes it possible to study both the energy and financial aspects of energy resources use. The study was carried out according to the structure operation annual cycle simulation results. The results are information about the energy efficiency of the structure.

The results of calculating the energy passport of a business center are presented in Figures 3 and 4.

Indicator	Designation and units of measurement	Normalized value
Calculated specific characteristic of heat energy consumption for building heating during the heating period	$q^p, \text{ W}/(\text{m}^3 \cdot ^\circ\text{C})$	0,058
Normalized specific characteristic of heat energy consumption for heating and ventilation of the building during the heating period	$q^p_{\text{от}}, \text{ W}/(\text{m}^3 \cdot ^\circ\text{C})$	0,25
Energy saving class	A++ - very high	-0,77
Does the building design meet the regulatory requirements for thermal protection		Respond

Fig. 3. Complex indicators of heat energy consumption

Indicator	Designation	Unit of measurement	Indicator value
Specific consumption of heat energy for heating buildings during the heating period	q	$\text{kW} \cdot \text{yr}/(\text{m}^2 \text{ yr})$	13,23
Consumption of heat energy for heating buildings during the heating period	Q^{yr}_{heat}	kW h/yr	66004
Total heat loss of the building during the heating period	Q^{yr}_{total}	kW h/yr	190046

Fig. 4. Building energy loads

The following parameters also affect energy efficiency level: [7]

1. Location and geographical orientation of the building;
2. Dimensions of the building, premises zoning;
3. Constructive solutions;
4. Efficiency of engineering systems;
5. Indirect factors.

Energy modeling includes the following steps:

1. Simulation of the annual life cycle of a building in a standard configuration (basic model);
2. Simulation of the annual life cycle of a building, taking into account the use of energy-efficient technologies (analytical model). [8]

The resulting model is a powerful control tool from the design phase to the operation of the building, and also makes it possible to evaluate:

1. Energy consumption of the building;
2. Thermal characteristics;
3. Water consumption by internal and external building systems, as well as water costs;
4. Insolation of windows and surfaces during the annual cycle;
5. The coefficient of natural light, as well as the levels of illumination in the building;

Based on the energy modeling results, the customer receives information about all possible technical solutions, which contributes to the formation of predicted costs for the operational phase of the building. [9]

Energy modeling methods make it possible to develop a set of measures aimed at increasing energy efficiency, as well as to obtain an energy passport of a building containing parameters of the resource use efficiency. [10]

Energy modeling of a business center building is carried out in order to check the change in the energy efficiency class of the building, as well as the level of energy consumption for heating and ventilation, by establishing dependencies on various options for combining solutions in terms of orienting the building to the cardinal points, as well as using various design options, the solutions of enclosing structures.

Combination options for design solutions are shown in Figure 5.

Version	Building dimensions (length, width), m	Structural solution of the wall	Orientation of translucent structures to the cardinal directions
Basic version	38,9x23,3	– reinforced concrete (monolith) – 200mm;	North – 30%,
		– thermal insulation (extruded polystyrene foam) – 250mm;	South – 25%,
		– aerated concrete blocks – 300mm	West – 25%,
			East – 20%
Version 1	38,9x23,3	– ceramic brick – 120 mm;	North-20%,
		– aerated concrete blocks – 300 mm;	South -30%,
		– expanded polystyrene – 50 mm	West-25%,
			East-25%
Version 2	38,9x23,3	– silicate brick – 65 mm;	North-25%,
		– mineral wool – 120 mm;	South-20%,
		– silicate brick – 380 mm	West-25%,
			East-30%
Version 3	38,9x23,3	– mineral wool slabs made of stone fiber –200mm;	North-25%,
		– silicate brick on cement-sand mortar – 65mm;	South-25%,
		– silicate brick on cement-sand mortar – 300mm	West-20%,
			East-30%

Fig. 5. Combination options for design solutions

The energy modeling results of a business center are shown in Figure 6.

Indicator	Designation	Basic version	Version 1	Version 2	Version 3
Energy saving class		A++ (-77)	A++ (-81)	A++ (-70)	A++ (-82)
Specific heat consumption for heating and ventilation of the building during the heating period	q_v , kW* h/(m³ yr)	13,23	10,96	16,94	10,46
	q_v , kW* h/(m² yr)	4,41	3,65	5,65	3,49
Consumption of heat energy for heating and ventilation of the building during the heating period	Q_{heat}^{yr} , kW h/yr	66 003,96	54 623,97	84 439,55	52 120,37
Total heat loss of the building during the heating period	Q_{total}^{yr} , kW h/yr	190 045,89	187 251,37	182 192,86	176 116,98

Fig. 6. The results of modeling the energy efficiency level of the building

A comparative diagram of heat energy consumption indicators for ventilation, heating and total heat loss for all options is shown in Figure 7.

Fig. 7. Comparison of indicators Q_{sep} and Q_{total}

The calculated payback schedule for the energy efficient technologies’ introduction showed that the latter will be paid off in 4 years. (Figure 8)

Fig. 8 Payback schedule for the energy efficient technologies’ implementation

3 Results and discussion

Based on the data obtained, it is possible to conclude that the basic option is the most optimal in terms of the energy consumption volume for heating and ventilation of the building and ensures that the building achieves a "very high" energy efficiency class "A ++".

Thus, the result of the energy efficient technologies use is the achievement of an economically beneficial and reasonable consumption of energy resources based on the latest achievements of science and technology. Reduction of heat losses and reasonable consumption of heat energy makes it possible to achieve maximum energy efficiency for the building.

4 Conclusion

Energy modeling introduction is especially important today when assessing the use of modern energy-saving technologies in "green" construction.

Energy modeling is a promising tool for comprehensive building analysis to improve comfort, economy and energy efficiency. The most important is the use of energy modeling in assessing the modern energy-saving technologies effectiveness, as well as in certification according to international systems.

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