MANAGING BUSINESS PROCESSES OF ENERGY EFFICIENT TECHNOLOGIES IN CONSTRUCTION

[a]LARISA GERASIMOVA, [b]NATALYA PARASOTSKAYA, [c]TATIANA MEZENTSEVA

[a]Moscow State University of Civil Engineering (National Research University), Yaroslavskoye Highway, 26, Moscow, Russia, 129337, email:22969@mail.ru
[b]Chamber of Commerce and Industry of the Russian Federation, Ilyinka Street, 1, Moscow, Russia, 109012
[c]Financial University under the Government of the Russian Federation, Leningradskiy Avenue, 49, Moscow, Russia, 125167

Abstract: The methods of cost formation in technologies of improving energy efficiency in construction have been reviewed in the article. The technologies related to energy design have been analyzed. The methods of managing energy consumption by innovative materials, technologies, and space planning solutions have been demonstrated. The most rational solutions of energy consumption control have been suggested.

Keywords: energy design, costs, technologies, materials, management.

1 Introduction

Increasing the energy efficiency is currently regarded as a way of finding measures and instruments, as well as implementing them to create the conditions for satisfying the demand for all the necessary products and services at a minimal cost. This applies to both economic and social costs, which are required to obtain the required energy. The preservation of the natural environment in harmony with stable development at the regional, state, and global levels is required when estimating these costs [1, 2].

At the moment, the efforts are made to build structures with due consideration for the principles of energy consumption savings in construction. Energy sources that can be independently renewed are often considered in projects.

Energy efficiency belongs to the characteristics that are sufficiently important for achieving an economic result. It accounts for the total cost of energy resources spent on production. The amount is taken as a ratio of the useful effect of the energy resources to these costs [3-5].

As such, the construction organizations consider the use of innovative energy design technologies to improve energy efficiency and ensure the desired effect in reducing production costs and obtaining economic benefits.

2 Materials and Methods

Such general scientific methods of research as synthesis, analysis, generalization, and abstraction ones were used in the study.

3 Results

The use of energy saving business processes in construction technologies, also known as energy design, requires an integrated approach, where the financial interests of the property owners and project investors are to be taken into account, alongside with compliance with the legislation [6, 7].

Most of the instruments used in energy design of buildings ensure a lower level of energy consumption. In this case, the cost does not increase significantly.

It must be noted that the cost of building one square meter of energy efficient structure is currently higher than the standard one, approximately by 7 – 9 %. As such, all the additional costs of such construction can pay off in about eight years. It must be noted that there is no need to lay pipes for heating inside the building, or erect boilers and tanks to save fuel.

When business processes of energy design are used in the construction technologies, an energy-oriented building is formed, which reflects the interaction between the main elements and systems of the building, taking into account lighting, heating, and ventilation in different seasons. It is important to note that the functional purpose of the building, its shape and orientation in space also influence the costs formation (Figure 1).

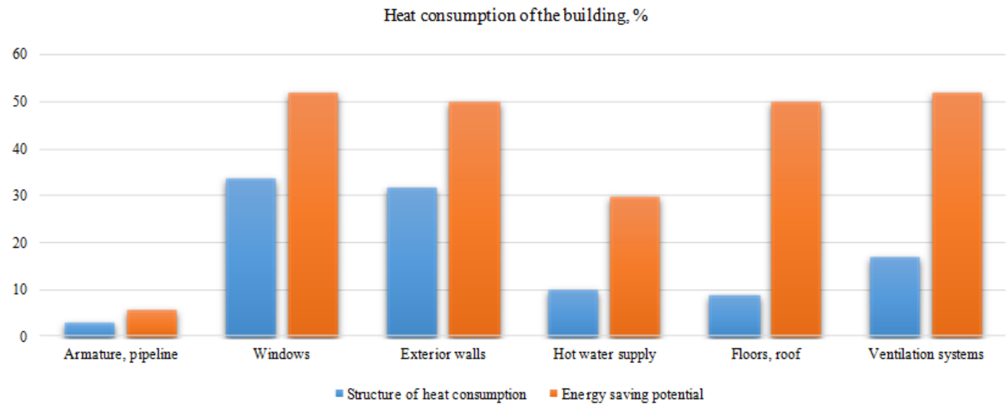

Figure 1: Energy saving potential and structure of heat consumption of a building

For example, savings on heating and air conditioning for public and residential buildings can be from 40 %. This is relevant when using business processes improving the ventilation in the summer and also helping retain heat in the winter [8, 9].

The costs of the organization associated with energy efficiency will directly depend on the selected business process of energy design and space-planning solutions. They are included in the limits and objectives of the project, which indicates the key points of its commercial parameters and technical specifications from the customer.

The priority areas of energy design, which is able to increase the energy efficiency of the building (minimizing heat loss in buildings), should be taken into account while solving these tasks. These include (Figure 2):
use of efficient thermal insulation in the construction and restoration of structures;
reduction of heat loss by using recuperators that allow providing heat recovery of exhaust air into the building;
use of modern window systems, balcony and entrance doors that do not allow the infiltration of heated air;

use of boiler plants with high efficiency, as well as devices for monitoring the thermal regime in each separate flat and individually controlled radiators;
creation of an inseparable contour of thermal insulation; and opting for a thermal insulation system that is able to operate for a long time – for example, the modern plastering systems used for thermal insulation of facades allow reducing heat losses almost twice by using external walls.

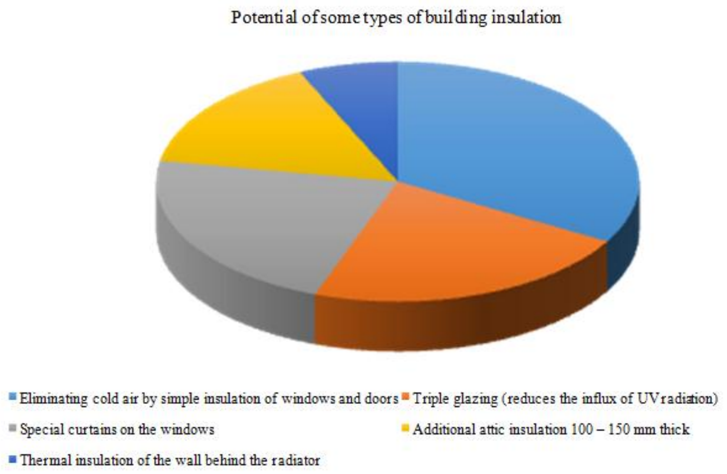

Figure 2: Measures for the insulation of the building envelope and their potential for heat saving

In this case, the criterion of efficiency is the energy consumption during construction, use and subsequent liquidation of the structure. The efficiency criterion includes the consumption of heat and electricity, gas, as well as other sources of heat able to create comfortable living conditions. The level of safety of the applied technologies for environment should be taken into account [10-12].

It must be noted that the energy consumption throughout the entire life cycle is taken into account when applying an energy efficient approach to construction: from the production of building materials to the utilization of a building that has outlived its resource.

This is based on ISO 14044-2006 Environmental management. Life cycle assessment. Requirements and guidelines, and another standard based on it – GOST R ISO 14044-2007 Environmental management. Life cycle assessment. Requirements and guidelines.

Reducing the amount of energy consumed at each construction stage, from the materials production to subsequent operation, leads to reducing the amount of primary fuel used on a global scale and, accordingly, reducing the negative impact on the environment due to emission of greenhouse gases and other harmful substances [13]. Therefore, the cost of the subsequent building operation should be estimated during planning.

When a developer selects a business process of energy design, a management accounting specialist needs to verify its validity. It is not always rational to use cheap materials. One should make sure they are environmentally friendly and reliable. It should also be checked whether the expensive materials are worth the money spent.

This is due to the fact that materials for construction play a very important role. For example, as thin as possible joints should be formed when using aerated concrete blocks. This minimizes heat loss through the solution. When compared with other full-bodied materials, the price of aerated concrete is several times lower, which allows saving up to 80 % on material costs.

The proposals for taking environmental characteristics relating to the energy efficiency of a building into account have become increasingly relevant recently. Manufacturers are increasingly ceasing to use lead stabilizers on window frames. Some switch to safer materials, while material costs also vary. The use of special types of glue is also aimed at reducing heat loss. It is almost reduced to zero when used efficiently. Energy performance testing often includes elevators in buildings. Energy loss of these mechanisms amounts to about 15 %.

As such, the elevator should be evaluated after its installation rather than at the stage of its manufacture. Although this approach affects the cost, the information is more relevant [14, 15].

The above areas differ in degrees of costs. To determine the specific solution, the estimated costs should be compared with the final result of the energy efficiency.

The business processes of energy design under consideration have their advantages and disadvantages. The developer must clearly understand the relation between the construction method and the project cost (Table 1).

Table 1: Energy savings from using energy design instruments

Energy design instrument	Cost savings, taking economic and technical characteristics into account
Heat recuperators	Return of 50 – 90 % heat difference from air exchange
Heat pumps	Reducing energy consumption twice in comparison with solid fuel boilers and up to four times in comparison with electric heating
Solar collectors	Energy savings on heating (depending on the region) – 20 – 80 %
Thermal insulation of envelope	Reducing energy consumption up to 50 %
Windows: low emission coatings (reflect infrared radiation); multi-chambered windows; electrochromatic or gas chromatic glazing	Reducing energy consumption for: heating by 25 – 40 %; cooling by 5 – 30 %
Control of energy consumption in the building	Saving heat and electricity up to 30 %

Besides, it must be taken into account that many technical solutions have strong influence on both the scope of work and the complexity of the building construction process. This also includes the amount of materials spent on construction. For example, the wall thickness can vary several times depending on the selected technologies and materials (Table 2).

Table 2: Thickness of the exterior walls built using different technologies

Technology	Wall thickness, mm
Solid stone materials (bricks + insulation)	480
Combined stone materials	300 – 310
Solid wood materials	250
Frame structures	240

As such, with the same perimeter of the structure, the useful space will differ significantly. If these are stone materials, the wall thickness will be about 480 mm; if frame technologies are used in the building construction, the walls will be 240 – 250 mm thick.

This means that if the outer perimeter of the two above-mentioned buildings is the same, the inner area will be different. This allows to increase the price of a building with a larger residential space.

However, the energy efficiency must be found first, after which the cost of one square meter can be estimated.

It must be noted that various choices of planning solutions can lead to a difference in the materials consumption up to 1.5 times. These results should be correlated with the results of the energy audit, as well as with the total of the financial characteristics.

The cost of heating is the most important factor that significantly affects the cost of maintaining the property.

Electricity or gas are often used in Russia for heating buildings.

At the same time, buildings from various types of wood do not meet the modern standards of thermal insulation. The walls must be 500 – 590 mm thick for wooden structures to meet new standards.

These buildings are comfortable for living, but their heating is too expensive. For example, if a laminated timber house with an area of about 110 square meters is insulated using the energy design technologies, the savings will be 10 % or more per heating period if the gas is used, and about 75 % if the electricity is used. As such, investments will pay off in a year in case of electricity and in six years in case of gas.

Automatic temperature adjustment in individual rooms also helps save heating resources. The automation allows saving on heating several times. However, it is only efficient if the building complies with the energy saving standards.

As such, the total costs related to the creation of the energy efficiency in buildings are determined using the following factors:
wall thickness, their insulation;
space-planning solutions;
use of the energy efficient equipment in the building: boilers, ventilation, and other. Ventilation with recuperation allows heating the air in the house due to the warm air passing through this system; and
landscape solutions. At least, it is required to provide a live fence from the wind by planted trees.

The energy efficiency is estimated with due consideration for the purpose of the structure depending on the energy consumption category assigned (Figure 3). These include industrial and residential buildings. If the building is expected to be supplied with several kinds of resources, then calculations should be made for all of them.

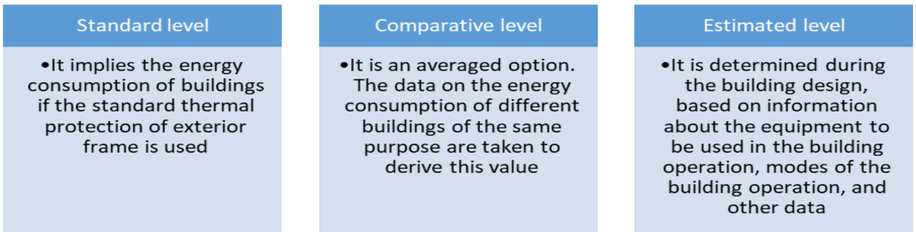

Figure 3: Methods for calculating energy consumption for buildings for various purposes

The documents relating to the building project must contain information about the consumed thermal energy (kW per m2 per year) required for creating the conditions for subsistence of all buildings.

The return on investment should be calculated to understand whether the project implementation is relevant from a financial point of view, taking the applied business processes of energy design into account. Both absolute savings and relative savings are taken into account when calculating the payback period. It is advisable to make a comparison with other options to see a clear difference.

An example of the energy costs for the components of a building made using different technologies is shown in Figure 4.

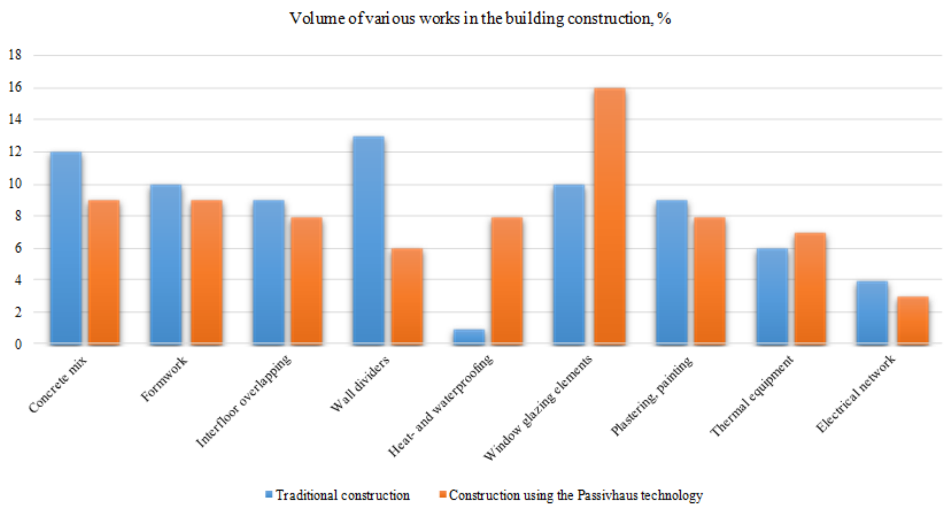

Figure 4 – Energy costs for the building construction using traditional technology and Passivhaus technology.

Some works are the same in both options. For example, excavation – 1 %; armature – 5 %; roof – 4 %; floors and cladding – 7 %; tinning-forging works – 5 %; and sanitary network – 4 %.

The cost of building a house without the cost of improvement, consultancy fees, and the price of the land where the building is located for the construction, is higher by about 7 – 9 % for Passivhaus than for traditional technologies. This amount can pay off within 5 – 7 years of operation.

4 Conclusion

It can be summarized that the ideas about improving energy efficiency are now becoming more common. In case of residential buildings, the flats where modern features of energy saving are taken into account are very popular among buyers.

As such, there is a need for a mechanism for managing energy costs, which could enable an optimal selection of construction technologies that will increase energy efficiency.

In conclusion, it must be noted that the use of the energy design principles allows to create buildings with a low level of energy consumption and comfortable living conditions at the same time.

This can be achieved with a slight increase in the building cost by minimizing the works of the heating and air-conditioning systems (they can be completely discarded in some cases). The total cost of the construction is higher than the standard, but it reduces the cost of connecting some functional systems and using other innovative solutions.

Literature:

1. Kalacheva, O.N.: Leasing relations as an important source of financing the activities of small and medium-sized businesses. *Auditor*, 2017, 11.
2. Carpenters, D.A.: Energy audit: a right or a duty for manufacturers? *Industry: accounting and taxation*, 2014, 4.
3. Bulaev, S.V.: Methodology of accounting in ferrous and nonferrous metallurgy. *Industry: accounting and taxation*, 2017, 10.
4. Iranmanesh, S.H., Shakhsi-Niaei, M., Yazdi, M.A.D.: A Decision Support System for Stakeholder Management During Different Project Phases Considering Stakeholders' Personality Types and Available Resources (The Case of Behsama Web-Based Information System). *Journal of Information Technology Management*, 2018, 9(4), 679-700.
5. Pilkiene, M., Alonderiene, R., Chmieliauskas, A., Simkonis, S., Muller, R.: The Governance of Horizontal Leadership in Projects. *International Journal of Project Management*, 2018, 36(7), 913-924. https://doi.org/10.1016/j.ijproman.2018.06.002.
6. Yarkova, I.V., Glushchenko, A.V.: Development of the method of management accounting of strategic costs at chemical enterprises. *International accounting*, 2017, 9.
7. Human capital reporting. Investing in sustainable growth, 2015. Retrieved June 17, 2019 from http://www.cima global.com.
8. Vasilyev, Yu.A.: Incomplete loading of production capacities. *Industry: accounting and taxation*, 2017, 4.
9. Xiaoxiao, X, Jiayuan, W., Clyde, Z.L., Wenke, H., Nini, X.: Schedule Risk Analysis of Infrastructure Projects: A Hybrid Dynamic Approach. *Automation in Construction*, 2018, 95, 20-34. https://doi.org/10.1016/j.autcon.2018.07.026.
10. Efimova, O.V.: Matrix approach to the formation and disclosure of information about resources in the integrated reporting of the organization. *Auditorskie Vedomosti*, 2017, 3.
11. Meshcheryakova, T.S.: Organization of energy management at an industrial enterprise. *Energy Saving*, 2015, 6, 64-67.
12. Ghodrati, N., Wing Yiu, T., Wilkinson, S., Shahbazpour, M.: Role of Management Strategies in Improving Labor Productivity in General Construction Projects in New Zealand: Managerial Perspective. *Journal of Management in Engineering*, 2018, 34(6). https://doi.org/10.1061/(ASCE)ME.1943-5479.0 000641.
13. Kozyreva, S.N.: Heating service in accounting of criminal code. *Housing and communal services: accounting and taxation*, 2015, 7.
14. Semenikhin, V.V.: *Housing and communal services, real estate activity*. Moscow: Grossmedia, ROSBACH, 2016.
15. Martin, J., Petti, J.: *Value based management: the corporative response to the shareholder revolution*. Boston: Harvard Business School Press, 2012.

Primary Paper Section: J

Secondary Paper Section: JE, JP, JS