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MODERN ORGANIZATIONAL AND TECHNOLOGICAL MODELS OF ENERGY EFFICIENCY IN CONSTRUCTION

СУЧАСНІ ОРГАНІЗАЦІЙНО-ТЕХНОЛОГІЧНІ МОДЕЛІ ЕНЕРГОЕФЕКТИВНОСТІ В БУДІВНИЦТВІ

Pastukhova S. / Пастухова С.
ORCID 0000-0002-9324-3065
Senior Lecturer of the Department of Industrial and Civil Engineering
Старший викладач кафедри промислового та цивільного будівництва
Mishuk K. / Мішук К.
ORCID ID: 0000-0001-5480-6032
Associate Professor of the Department of Industrial and Civil Engineering
Доцент кафедри промислового та цивільного будівництва
Krasylnykov M. / Красильников М.
https://orcid.org/0009-0009-5263-8376
postgraduate of the Department of Industrial and Civil Engineering
аспірант кафедри промислового та цивільного будівництва
Samovar Y. / Самовар Я.
https://orcid.org/0009-0007-8704-5461
Student of the Department of Industrial and Civil Engineering
Студент кафедри промислового та цивільного будівництва
Zaporizhzhia National University, Zaporizhzhia
Запорізький національний університет, Запоріжжя

Abstract. *Modern scientific research in the field of energy conservation increasingly contributes to the development of cities. The use of advanced technologies in the reconstruction of public buildings is a relevant topic in today's realities that unites all aspects of urban life: healthcare facilities, energy facilities, transport, resource management, educational facilities, residential buildings, etc. The following three main ways of implementing energy-efficient technologies can be distinguished: the beneficial use of energy losses, modernization of equipment to reduce energy consumption, and intensive energy conservation. To evaluate organizational and technological energy-efficient solutions, it is advisable to use the method of discounted cash flows estimations. According to this method, all resources spent on construction are reduced to a single point in time using discount rates. This will allow to predict energy-efficient results, as well as the costs of their implementation.*

In practice, to assess the energy efficiency of the organizational and technological model, it is proposed to use an indicator equal to the ratio of the actual (predicted) effect to the resources spent to obtain the beneficial effect.

Keywords: *construction, reconstruction, organizational models, energy-efficient technologies, innovations*

Problem statement.

In projects for the construction of public buildings, in order to reduce the costs of energy, economic and other resources, it is recommended to implement energy-efficient constructive and space-planning solutions. However, the implementation of innovative energy-efficient technologies, unlike standard solutions, require higher costs of all types of resources: material and technical, labor, energy, etc.

Analysis of the latest research and publications, highlighting of previously unsolved parts of the general problem.

The issues of energy-efficient monolithic construction are investigated in the works of many scientists. Their scientific and practical results allowed to generalize and improve the basic principles of the organizational and technological model of energy-efficient construction. Monolithic reinforced concrete is one of the main tools of modern architecture, but at the same time, the energy-efficient aspects of the architectural expressiveness of monolithic concrete buildings are still insufficiently utilized in the domestic construction industry.

The purpose of the study is to select organizational and technological models for providing public buildings with energy-efficient resources using multi-criteria analysis.

The methodology is based on the analysis of domestic and foreign scientific literature devoted to organizational and technological solutions for buildings energy efficiency. The following methods were used as research tools: expert evaluations, system analysis, mathematical statistics, mathematical experiment planning and system engineering.

Presentation of the main material.

Selection of organizational and technological model

Calculation of total discounted costs of the organizational and technological construction model considering the discounting of interim revenues:

1. Calculation of total discounted costs:

$$TDC = SC\left(1+\frac{DR}{100}\right)+\sum_{i=1}^{P} Oi\left(1+\frac{DR}{100}\right)^{i},$$

where:

SC – sum of additional capital costs

DR – discount rate

P – calculation period (years)

Oi – annual operational costs on energy resources for the i-th year of operation

2. Calculation of the actual discounted payback period:

$$DPP = -\ln\left(1-\frac{DR*Pu}{100}\right) / \ln\left(1+\frac{DR}{100}\right),$$ where:

Calculation of total discounted costs of the organizational and technological construction model with the capitalization of interim revenues:

3. Calculation of total discounted costs:

$$TDC = SC + \sum_{i=1}^{P} Oi\left(1+\frac{DR}{100}\right)^{i},$$ where

SC – sum of additional capital costs

DR – discount rate

P – calculation period (years)

Oi – annual operational costs on energy resources for the i-th year of operation

4. Calculation of the actual discounted payback period:

$$DPP = \ln\left(1+\frac{DR*Pu}{100}\right) / \ln\left(1+\frac{DR}{100}\right),$$ where

Economic evaluation of the selected model

Analyzing the sources of previous researchers, the energy efficiency of the construction object is defined as the ratio of the beneficial effect of using energy resources to the costs incurred to achieve this beneficial effect. But in practice, it is advisable to use this indicator as a ratio of the beneficial effect to the resources used to achieve this beneficial effect. In this case, it is advisable to use energy savings as the beneficial effect.

The modern model of organizational and technological parameters of energy-efficient construction can be divided into the following aspects: assessment based on comparing expenditures of electrical and thermal energy, both capital and annual; forecasted assessment of energy efficiency; actual assessment of the energy efficiency of the organizational and technological model.

The described energy efficiency assessment procedure uses the energy efficiency indicator of the organizational and technological model of energy-efficient construction. Therefore, the forecasted energy efficiency indicator can be represented as follows according to Formula 5:

$$FE = \left(\sum_{i=1}^{p} \frac{O_i + ECO_i + SOC_i}{(1+FD_i/100)^i}\right) / \left(TC + \sum_{i=1}^{p} \frac{EC_i}{(1+FD_i/100)^i}\right), \quad (5)$$

where:

E is the forecasted energy efficiency at the i-th stage;

ECO – forecasted ecological results at the i-th stage;

SOC – forecasted social results at the i-th stage;

FDi – forecasted discount rate;

TC – total capital expenditure;

EC – expected costs at the i-th stage of model implementation.

All the parameters indicated in the formulas are forecasted, which means that it is impossible to determine these parameters precisely. This is due to many influencing factors, risks, external economic factors, tariff rates, etc. However, by evaluating energy efficiency based on expert assessments, the values of these parameters will fall within a certain interval, then the formula can be represented as follows:

$$[B_1, B_2] = [TC_1, TC_2] + \sum_{i=1}^{p} [EB_{i,1}, EB_{i2}] \div \left(1 + \frac{DR_1, DR_2}{100}\right)^i, \quad (6);$$

where: $[B_1, B_2]$, $[EB_{i,1}, EB_{i2}]$, $[DR_1, DR_2]$, $[TC_1, TC_2]$ are interval estimates of the respective parameters of the construction project.

The actual assessment of the energy efficiency of organizational and technological solutions should be carried out during the operational stage of the construction project according to Formula 7:

$$\overline{\Pi E} = \frac{(\overline{EC} + \overline{ECO} + \overline{SOC})}{\overline{\Pi B}} \quad (7)$$

where: $\overline{EC}$, $\overline{ECO}$, $\overline{SOC}$ – confirmed costs for energy conservation, ecology, and social results, respectively.

Conclusions and prospects of further investigations in this field.

When constructing residential buildings, the predominant organizational, technological and energy conservational solutions are constructive and space-planning solutions, energy conservation engineering communications, which are based on renewable energy technologies and feature autonomous energy supply system. Analyzing the above, in order to determine the effectiveness of organizational and technological energy-efficient solutions, which are used during the construction of various-purpose facilities, it is necessary to take into account their peculiarity, which revolves around the use of constructive and space-planning components as an indicator of energy efficiency.

Therefore, to ensure the energy efficiency of public buildings, it is advisable to utilize energy-saving engineering systems based on renewable energy technologies with autonomous energy supply systems. At the same time, in the case of connecting individual buildings to central power supply systems, it is crucial to choose optimal combinations of autonomous and central power supply systems based on their energy efficiency indicators.

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Анотація. *Сучасні наукові дослідження у сфері енергозбереження дедалі більше сприяють розвитку міст. Використання передових технологій у реконструкції громадських будівель є актуальною темою в сучасних реаліях, яка об'єднує всі аспекти міського життя: медичні заклади, енергетичні об'єкти, транспорт, управління ресурсами, навчальні заклади, житлові будівлі тощо. Можна виокремити три основні способи впровадження енергоефективних технологій: ефективне використання енергетичних втрат, модернізація обладнання для зниження енергоспоживання та інтенсивне енергозбереження. Для оцінки організаційних і технологічних енергоефективних рішень доцільно використовувати метод оцінки дисконтованих грошових потоків. Згідно з цим методом, усі ресурси, витрачені на будівництво, зводяться до однієї часової точки за допомогою дисконтних ставок. Це дозволить передбачити енергоефективні результати, а також витрати на їх впровадження. На практиці для оцінки енергоефективності організаційно-технологічної моделі пропонується використовувати показник, що дорівнює відношенню фактичного (прогнозованого) ефекту до витрачених ресурсів для отримання корисного ефекту.*

Ключові слова: *будівництво, реконструкція, організаційні моделі, енергоефективні технології, іннов*ації.