SYSTEM TECHNICAL PRINCIPLES OF ENERGY EFFICIENCY OF BUILDINGS

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Abstract. *This article discusses the development of methodological approaches to ensuring the energy efficiency of buildings, identifies the principles of implementation based on fundamental and modern sciences, such as construction systems engineering.*

Key words: *Energy efficiency, building, system engineering, construction, dynamism, system, design, energy, principles.*

СИСТЕМНО-ТЕХНИЧЕСКИЕ ПРИНЦИПЫ ЭНЕРГОЭФФЕКТИВНОСТИ ЗДАНИЙ

Аннотация. *В данной статье рассматривается разработка методических подходов к обеспечению энергоэффективности зданий, выявляются принципы реализации на основе фундаментальных и современных наук, таких как инженерия строительных систем.*

Ключевые слова: *Энергоэффективность, здание, системотехника, строительство, динамичность, система, проектирование, энергия, принципы.*

INTRODUCTION

An energy-efficient building is a complex energy system, which is not an additive addition of elements, but their systemic, synergistic integration. Systems engineering as a scientific and technical discipline studies man-made complex technical, organizational, and managerial systems, which fully include automated control, planning, design, and construction systems. The formation and development of systems engineering of construction is connected not only and not so much with its computerization, but with the changed engineering thinking. It is necessary for the design, construction and operation of highly complex objects and systems that have shown previously unknown problems, including joint problems.

RESEARCH MATERIALS AND METHODOLOGY

The system engineering approach in construction is based on the postulate of the universality of the principles and laws of organization and development of complex natural biological, socio-economic and technological (including building systems). Common are the requirements for high organization, economy, flexibility, reliability, and adaptability. The practical application of such approaches in many fields of science and technology has confirmed their universality. Biological systems are the most highly organized systems. They have such qualities of stable functioning, which are so far only partially achieved when creating construction objects and their control systems.

At present, the processes of the life cycle of buildings are organized in such a way that the energy efficiency characteristics of buildings are achieved by simply summing up the architectural, structural, engineering solutions of buildings, while their interdependence and interaction in the system is not considered and no attention is paid to the organizational aspects

of the building life cycle. In this regard, the required level of energy efficiency is not achieved and its continuity is not ensured at all stages of the life cycle. That is why it is necessary to consider energy-efficient buildings from the standpoint of the theory of functional systems - dynamically working organizations.

RESEARCH RESULTS

The systemic approach based on the theory of functional systems makes it possible to study the systemic relationship of the building, its inner shell and the external environment. According to academician P.K. Anokhin, "a functional system is a system of actively combined processes that, once united, tend to preserve the created architecture of relationships." The centers that manage the components of a functional system strive to preserve the interactions between them established in a certain way. By its architecture, a functional system entirely corresponds to any cybernetic model with feedback, and therefore the study of the properties of various functional systems of the body, comparing the role of particular and general laws in them, will undoubtedly serve to cognize any systems with automatic regulation. The functional system is a universal principle of organizing processes and mechanisms, ending in obtaining the final adaptive effect.

Interpretation of the life cycle of energy efficient buildings from the standpoint of a systems approach makes the use of systems engineering methods justified and allows:

- consider the building as a single energy system and understand the unifying cause-and-effect relationships that characterize the transformation of the initial situation into the final one;
- establish the relationship of functional subsystems and their processes at the boundaries of the main stages of the life cycle of energy efficient buildings;
- ensure the continuity of the level of energy efficiency of buildings at all stages of the development of the system from design to the liquidation or reconstruction of buildings with the transition to a new level of energy efficiency.

The novelty of applying the systems engineering and functional approaches to the organization of the life cycle of a building lies in the understanding of the building as a system consisting of functional subsystems and going through all stages of the life cycle in its development. The application of the principles of construction systems engineering contributes to the solution of organizational and technical problems that cannot be solved by standard methods.

In order to improve the methodology for organizing the construction production of energy-efficient buildings, the author of the dissertation research formed new principles that take into account a systematic approach to construction and the specifics of energy efficiency, that is, system engineering principles based on the general principles of system engineering and new requirements for energy efficiency.

The Korean architects in the Seoul Energy Dream Center project, a museum and education center, have also achieved 70% energy savings. Such performance was achieved due to the special slope and orientation of the walls, calculated on the basis of the optimal use of wind and sunlight. The necessary 30% of the average amount of energy required to provide such buildings, the center receives from geothermal sources and solar panels (Pic. 1.)

Рис 1. Museum and educational center. Korea

Functional-systemic principle of energy efficiency of buildings. The system-forming factor is a specific result (target function) of the system functioning. This principle is fully consistent with the life cycle of energy-efficient buildings as building systems, where the complexity of the hierarchy, multiple goals, inconsistency and unreliability of criteria for individual subsystems make it very important to achieve the final result in th**e** commissioning and operation of construction objects and many other indicators**.**

The probabilistic-statistical principle of energy efficiency. Modularity and multivariance is one of the main principles for ensuring the flexibility of construction production. In construction, the duration, estimated cost, labor intensity and other indicators are probabilistic due to the impact of random factors on them, therefore they should be characterized by distributions that reflect the probabilities of achieving the designed value of these indicators.

Simulation-modeling principle of energy efficiency of buildings. This principle lies in the study of complex systems using mathematical modeling methods. In construction, with its complex organizational, technological and management systems, modeling becomes the only possible research method.

The application of the principles of system engineering will make it possible to systematically solve the complex problems of organizing the construction of energy-efficient buildings, as well as maintaining the required level of energy efficiency at all stages of their life cycle. Thus, the implementation of system engineering principles should become the methodological basis for the construction production of energy-efficient buildings and contribute to an increase in energy efficiency not only within the limits of normalized indicators, but also within the entire construction industry as a whole.

In London, by order of Siemens, an energy-efficient Crystal complex was built, which houses a center for the study of urban transformation. It was designed by Wilkinson Eyre Architects. The maximum possible surface area of the building is occupied by a glass structure, which allows the maximum amount of sunlight to pass through. The building consumes 50% less energy and emits 65% less carbon dioxide than comparable office buildings. Heating and cooling are entirely provided by renewable energy sources. (Pic 2)

Рис 2. Crystal energy efficient complex. London

The main task of the system approach is to establish a given state of the functioning of the system, which is its target.

Consequently, the main task of a systematic approach in the organization of the life cycle of energy efficient buildings is reduced to such a functioning of the building, which would achieve a high level of energy efficiency at all stages. A systematic approach to the organization of the life cycle of energy efficient buildings also meets the principles of sustainable development of the living environment and system engineering principles of energy efficiency.

The organization of the life cycle of a building as the life cycle of a complex system is a purposeful ordered interaction of interconnected elements (building subsystems) and the external environment to achieve the goal of high energy efficiency. This goal is fundamental, determining the vector of development of the life cycle of buildings and structures. Depicting the life cycle of a building as a system will allow one to conceptually segment it into stages, describe the milestones of the system's progress through the life cycle, and thus make decisions on certain criteria (for example, high energy efficiency) before moving the system to the next stage. Life cycle stages provide a work structure for detailed modeling of system life cycles when using system life cycle processes. One of the most energy efficient buildings in the world is the Canadian office center Manitoba Hydro Place in Winnipeg. Compared to other buildings of this size, this 22-story, 115-meter building uses 70% less electricity. When designing it, the architects took into account the main advantage of the area - constant winds and calculated how to maximize the use of solar energy. To do this, they designed the eastern and western facades to be absolutely transparent, which made it possible to significantly reduce the cost of electric lighting. To save on heating and air conditioning, the architects included automatic windows that prevent the tower from overheating, and geothermal wells that provide a comfortable temperature in the building. Manitoba Hydro Place was designed by Kuwabara Payne McKenna Blumberg Architects and opened in 2009.

Рис. 3. Office center Manitoba Hydro Place. Winnipeg

The target function of the system provides its main characteristics, if the target function is set to energy efficiency, then the building will be energy efficient throughout the entire life cycle, and the concept of "energy efficiency" in relation to buildings combines such important characteristics as energy saving, resource saving without loss of reliability, comfort and contributing to the sustainable development of the human environment.

The life cycle of a building as a system is thus a complex system of processes that usually have parallel, iterative, recursive and time-dependent characteristics: during the life cycle of buildings as systems interact with the external environment, material, human, financial, information and other threads that are subsystems. At different stages of the life cycle of buildings, these flows change in a certain way and leave the system, having performed their functions in relation to it. According to the authors, the proposed scheme can serve as a structural basis for the processes and actions related to the life cycle of any building as a system.

Currently, during the construction and operation of buildings, the continuity of energy efficiency indicators laid down at the project stage is not observed, since there is no center of responsibility and control over their implementation. The energy efficiency of the building must be ensured at all stages of the life cycle. The designed parameters of energy efficiency can undergo a significant change during the construction process and at the stage of operation of the building, as there are a number of subjective and objective factors, such as natural and climatic conditions of construction, changes in the characteristics of the materials used during operation, replacement of engineering equipment at the stage of operation etc.

CONCLUSION

Buildings are static objects, but their life cycles occur in dynamics, the design, construction and operation of buildings are processes. Thus, the energy efficiency of buildings should be ensured at all stages of the life cycle, from the investment concept of construction to their decommissioning, therefore, the life cycle of energy efficient buildings must be considered from the standpoint of not only a systemic, but also a process approach. Thus, the building as an energy system goes through all stages of its life cycle, which are processes. The management of

these processes, according to the process approach, should be based on the allocation of a center of responsibility for compliance with the level energy efficiency of buildings

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