Problems of Energy Efficiency Management from the Perspective of a Cyclical Approach

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Abstract. This article addresses the issues of energy efficiency management and its characteristics in the light of identified specificities. The key factors shaping the problem landscape for improving energy efficiency are defined, characterizing energy efficiency management as a complex, multifaceted process. The fundamental principles of managing cyclical processes are presented. The characteristics of the life cycle, as a type of cycle encompassing the entire existence period of an entity, are examined. Additionally, the life cycle of a building as an energy system is discussed, along with an analysis of the life cycle of investment projects in the field of energy efficiency and investment-construction projects from the perspective of project management characteristics. One key aspect of managing cyclical processes is identified: the repeatability of actions under changing conditions, which complicates the typification and regulation of processes. A procedure for managing cyclical processes is proposed, taking into account the dynamics of their conditions. The factors that hinder the assessment of the effectiveness of cyclical process management are explored. A list of attributes for cyclical processes is suggested to aid in the development and optimization of management tools. In conclusion, criteria for the quality organization and management of energy efficiency are established.

1 Introduction

Decisions taken in the field of energy efficiency should be based on modern achievements of science and technology, enabling the introduction and development of highly efficient technologies. However, improving energy efficiency is not only a technological, but also an important management task. The problem of development and application of tools and methods of energy efficiency management is one of the important areas that can be considered from the point of view of different approaches.

The issues of energy efficiency improvement have been considered in works [1, 2, 3, 4] and a number of others. Based on the analysis of existing approaches to energy efficiency

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management, it can be concluded that it depends on a significant number of factors that cannot be considered in isolation from others, as this would distort information about the state of the entire power system. The most significant factors determining the level of energy efficiency, from the position of ensuring development and the possibility of management impact on processes and subprocesses, include the following:

1. The degree of progressiveness of the used equipment and technologies, its compliance with the world and domestic level of development;
2. The degree of introduction of scientific substantiation of production and management decisions into the practice of economic management;
3. Qualification of employees and the degree of their orientation to the implementation of progressive energy-saving solutions;
4. Availability and level of development of the energy efficiency planning, accounting and control system;
5. Energy efficiency potential in infrastructure, buildings, and other facilities [5, 6, 7].

Organization and management of energy efficiency is a complex continuous process, which should ensure a high level of consistency and interconnectedness of structurally differentiated components, involving continuous improvement and development, including corrective and preventive actions based on the analysis of the internal and external environment. Based on this, the system of organization and management of energy efficiency can be presented as a set of cyclical processes, each of which consists of key elements characterized by a pool of parameters that determine the achievement of priority indicators in the field of energy saving and energy efficiency policy.

2 Materials and Methods

Cyclicality as a property of functioning and development of systems is characteristic of many phenomena and processes. In energy efficiency management, cyclicality of phenomena and processes can be caused by the need to ensure continuity and continuity of operation, the influence of cyclical processes in the external environment, the internal logic of iteratively implemented procedures and a number of other reasons.

The cycle itself can be characterized as a periodically repeating sequence of states with a period determining the time of its implementation. When the period of repetition of this sequence corresponds to the entire duration of the subject's existence, it represents the so-called life cycle. The part of the cycle that determines the essence, duration and moment of manifestation of what happens during a particular period of time is a phase of the cycle [8].

For example, when considering the life cycle of a building as an energy system, taking into account energy saving and energy efficiency, the phases of the life cycle will form a structure of activities and processes that allow modelling the functioning of the building in time as an integral system. If energy efficiency is set as a target function, it will affect such important characteristics as energy conservation, resource conservation without loss of reliability, comfortability, contributing to the sustainable development of human living environment. The life cycle of a building as a system is thus a complex system of processes, usually having parallel, iterative, recursive and time-dependent characteristics [9].

When considering energy efficiency in the context of implemented investment projects, the life cycle of a project implies covering the time from the beginning of its implementation to the completion of the project and summarizing the results of its implementation. The specific nature of energy saving, the diversity of its forms, which

differ by stages of the building life cycle, determines the peculiarities of investment project management, which are as follows:

- the investment process in the field of energy saving, which is taking place in the internal environment, is subject to a significant influence of external environment factors;
- the strategic goals of the subject of investment and construction activities making decisions in the field of energy efficiency should determine all the investment decisions made;
- the necessity to form alternative options for investment decisions is due to the multifaceted nature of energy saving areas in the building design and during its construction;
- control at the operational stage is designed to strengthen the responsibility of all participants of investment and construction activities for the accuracy of investment decisions and to stimulate further search for progressive ideas in the field of energy saving;
- the investment process in a broad sense is cyclical, as the obtained investment results stimulate further investment activity in the field of energy saving [10].

The content of the life cycle of an investment and construction project can be presented as follows (Fig. 1).

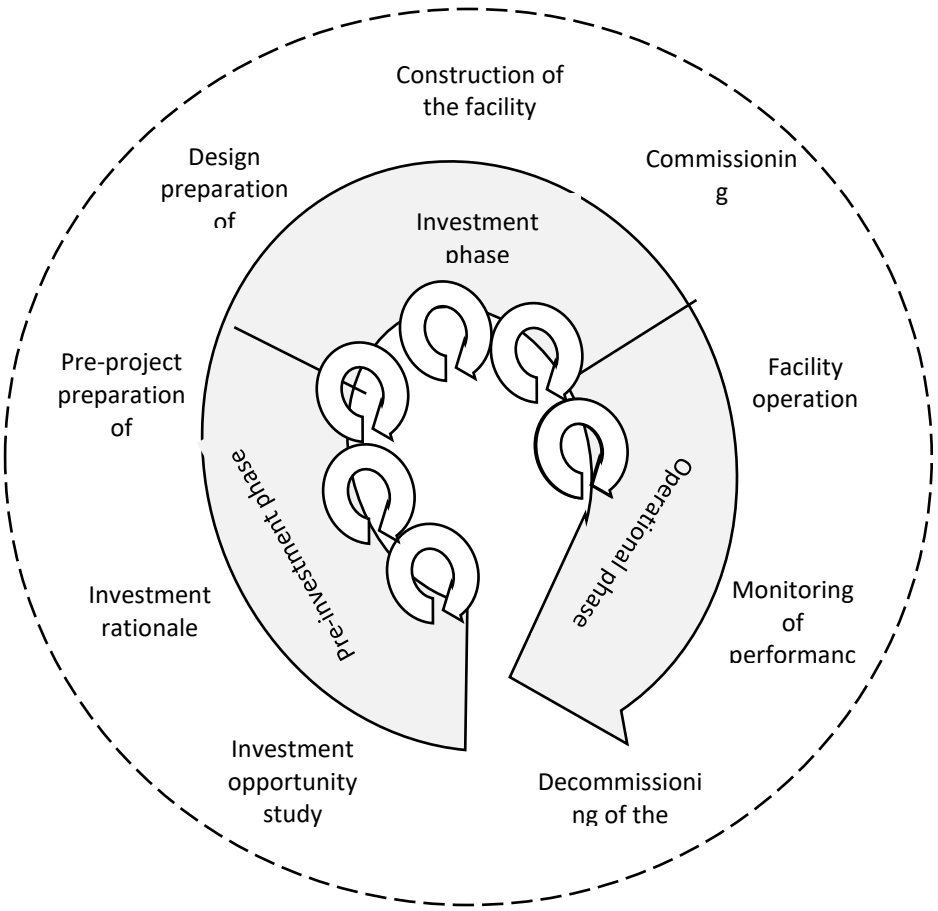

Fig. 1 - Content of the life cycle of an investment and construction project in the context of individual phases

Depending on the phase of the life cycle in which intelligent technologies for managing building engineering systems are introduced, this process can be characterized as innovative design (the period of facility design and documentation approval) or innovative retrofitting (the period of facility operation). At the same time, in the operational phase, the introduction of changes affecting energy efficiency is more complex compared to their initial creation within the framework of the project [11].

The content of the life cycle phases determines the manifestation of lower-level sub-cycles associated with the cyclical nature of the tasks solved in each phase. However, in addition to energy efficiency management within the life cycle, there are many cyclical processes in the course of current activities, which differ in nature, scope of manifestation, frequency, degree of influence on the planned indicators and other characteristics.

3 Discussion of results

The key characteristic of cyclic management, in our opinion, is repeatability under changing conditions. On the one hand, cyclical management implies periodic repetition of typical actions within each phase of the cycle. Therefore, having information about the timing of the next phase of the cycle, goals and objectives, as well as the set of actions planned for implementation in this phase, it becomes possible to optimize management procedures on the basis of previous experience with each iteration. This allows for the elimination of problem areas, greater predictability of phase results, and improved efficiency at each stage of the cycle.

However, since the external and internal environment is characterized by uncertainty and dynamism, any process is subject to changes in the conditions of its occurrence over time. Consequently, the actions repeated in the course of cyclic processes management are subject to changes in the internal and external environment factors, which is aggravated by time gaps between the same-type phases of different cycles. Thus, the changing conditions of the subject functioning environment force to make regular changes in the management process, not allowing to make it sufficiently typical, regulated and extremely effective [12,13]. And the more turbulent the environment is, the harder it is to predict its future state, to identify on its basis the directions of influence of the external environment on the content of the cycle and to determine the required nature of the adjustments to be made.

Proceeding from this, we propose to present the procedure of cyclic processes management taking into account the dynamism of their occurrence conditions as follows (Fig. 2).

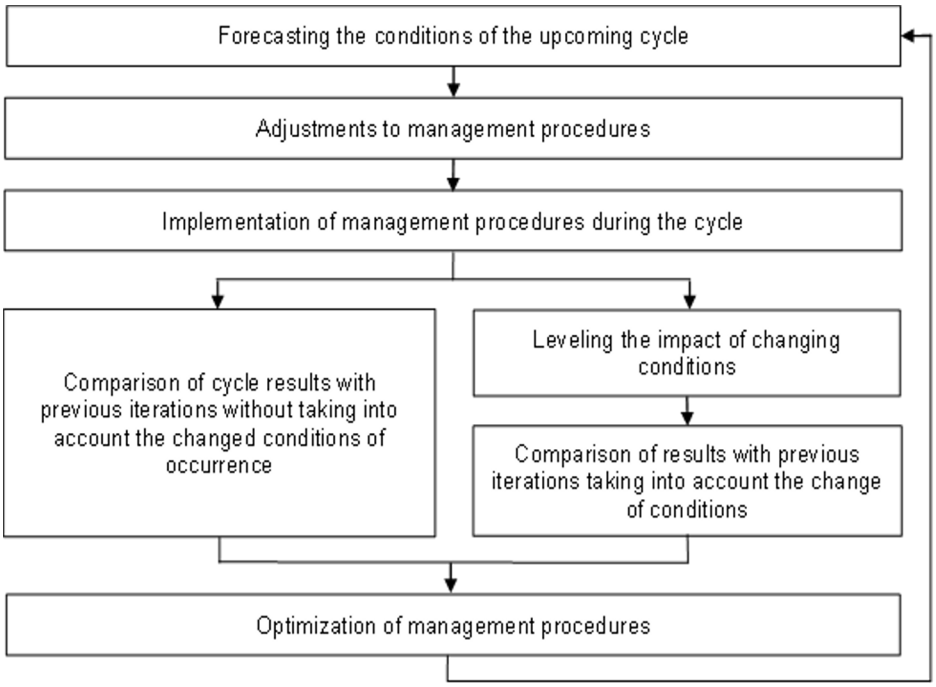

Fig 2. Procedure of cyclic processes management taking into account the dynamism of their occurrence conditions

In addition to the dynamism of the environment, the assessment of the effectiveness of cyclic management is complicated by two factors.
Firstly, the assessment of the quality of management within a particular phase can be carried out only on the basis of comparative analysis with the results of the implementation of similar phases in previous iterations of cycles. This is caused by the fundamentally different characteristics of the phases, which form the basis for their separation into separate elements of the cycle. The longer the cycle, the more time passes between homogeneous phases and, consequently, the greater the change in the environment, which makes it difficult to compare the results of realisation of the cycle phases. This raises the question of the need to eliminate the impact of factors within each phase in order to obtain objective results of such a comparison. Secondly, the predetermined sequence of cycle phases as a specific property of cyclic processes is the reason why the results of the subsequent phase are largely determined by the results achieved in the previous phase. Therefore, the influence of input data inherited from the previous phase significantly complicates the process of assessing the quality of management of each subsequent phase of the cycle.

In our opinion, the following attributes should be identified for cyclic processes to ensure management effectiveness:

- duration of the cycle;
- number of phases (stages);
- duration of phases (stages);

- frequency (number of cycles per period);
- degree of fixity of the beginning and end of the phases;
- inherited characteristics of each phase;
- amplitude of fluctuations of key indicators.

Taking into account these characteristics, management tools for each type of cycles can be developed and optimized.

The quality criteria for the organization and management of energy efficiency can be presented as follows:

- achievement of target and planned indicators (and their exceeding in cases when it does not entail negative organizational, managerial, production, technological and other consequences). In a broad sense, targets serve as an indicator of the achievement of a desired state, while targets take into account specific conditions in a certain period. If we exclude from consideration the quality of planning and target-setting procedures themselves, the degree of reliability and validity of plans and the achievability of goals, then, all other things being equal, the achievement of such indicators is evidence of the absence of significant problems in management;
- Flexibility and adaptability of the system, which makes it possible to take into account the impact of external and internal environment factors. These characteristics are fundamentally important, as they determine the stability and continuity of work, as well as the speed of reaction to changes. Providing the necessary level of adaptability allows, if necessary, to adjust to the turbulent environment in which the object functions, and flexibility reduces the time to implement the necessary changes in the structure or parameters of functioning and reduces the probability of negative consequences of such changes;
- minimum reasonable management costs. The complexity of management is largely determined by the scale and specificity of activities, but regardless of this, management costs should be the minimum necessary, but at the same time sufficient for effective and efficient functioning. Duplication or blurring of functions, their redundancy and other facts may lead to significant overestimation of costs;
- realization of energy efficiency potential as a complex characteristic of current and prospective opportunities and resources, behavioral, economic, technological and regulatory components capable of ensuring efficient use of energy. The fullest realization of the potential is based on effective management, systematic identification of internal efficiency improvement reserves and application of modern methods and technologies.

4 Conclusion

Implementation of projects in the field of energy efficient technologies is currently characterized by a number of problem areas:

- Significant level of risks as a consequence of a set of peculiarities of projects in a given area;
- unacceptability of ‘rigid’ target-setting, incorrect target-setting at the early stages of project implementation and inconsistency of the result with the expected one;
- predominantly individual nature of energy audits;
- the need to cover a significant number of aspects when building a management system for energy saving innovations (including motivation, logistics, marketing, etc.).
- significant diversion of funds from turnover due to the cost of energy projects and long payback period;
- application of standardized management levers to energy efficiency management, similar to other activities;
- high energy consumption and high values of energy saving potential;

- lack of understanding of energy efficiency management as an activity susceptible to external and internal environment factors [14, 15, 16].

Cycle management is characterized by its specificity, certain requirements for the organization, control and planning of cyclic processes. Therefore, understanding the peculiarities of cyclic processes and building a management system that takes into account the peculiarities of cyclic processes is extremely important under the condition of regular dynamic changes in the conditions of activity.

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