Evaluation of reproduction processes and efficient operation of apartment blocks stock interrelation

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Abstract. The article is dedicated to the interrelations analyzes of the reproduction processes in apartment blocks housing stock and efficiency indicators of housing operation in the region. Scientific novelty of the research is presented by the proposed system of criteria for assessing the reproduction and operation efficiency of housing, interaction modification diagram of housing stock markets and housing services.

Introduction
The apartment blocks management system comprises two interrelated areas: reproduction management and housing management.

New construction and capital repairs are the main forms of housing reproduction. The possibility and feasibility of new construction depends on the situation in the housing market, the availability of necessary resources, the efficiency of investment and construction activities in the housing sector, and the capital repairs depend on the initiative and the availability of homeowners’ investment resources, state and local governments, as well as management companies. That is, in the market economy housing construction is a subject to the market laws as opposed to the capital repairs. However, the capital repairs feasibility of residential buildings should be assessed in relation to the new housing construction.

The implementation of housing stock reproduction in the Russian Federation as a whole is facilitated by the comprehensive implementation of projects and programs at various levels. At the same time, an important role in this process is played by the implementation of the federal program “Provision of affordable and comfortable housing and communal services to citizens of the Russian Federation”, as well as regional programs for capital repairs of apartment blocks.

The purpose of the housing stock reproduction is to reduce the level of its wear and tear in order to improve the quality of housing services and the efficiency of its operation. The solution of this problem in the process of capital repairs is especially relevant in modern conditions.

The reproduction of housing stock in the cities of the Russian Federation is a complex process aimed at increasing the level of housing provision and comfort of living there. An important factor in the effectiveness of this process is a clear interaction of its participants, which requires an integrated approach that takes into account all factors of influence. Nevertheless, against the backdrop of state programs and projects being implemented, there is no systematization in determining priorities and ensuring a socially and economically justified correlation between the ongoing reproduction processes. Therefore, in order to create an effective management system for reproduction of apartment blocks...
resources in each municipality, it is necessary to systematize goals, objectives, criteria and measures, and to balance them with the available resource potential and time parameters.

Domestic science and practice pay enough attention to the development of organizational and economic mechanisms of housing reproduction: management of investments in housing construction and its effective organization in the regions of the Russian Federation; development and use of repair fund in the housing sphere in the cities; attraction of credit resources for investment in the construction and capital repairs of apartment blocks stock, etc. Therefore, now it is necessary to make systematic use of existing developments. However, as practice shows in each region of the Russian Federation it is expedient to use their own adapted approach to ensure complex reproduction of housing stock taking into account local characteristics.

The scientific literature presents the development of organizational and economic mechanism elements of management, development and effective investment support to housing construction and capital repair of apartment blocks stock. The problems of housing stock reproduction were discussed in the works [1, 2, 4, 8, 9, 10].

However, as practical experience shows that in the Russian Federation it is necessary to improve approaches to the feasibility of housing stock reproduction providing a systematic solution to the problem of increasing the quality of housing services and the comfort of the population living. Therefore, in modern conditions, a conceptual approach is needed to implement a balanced economically justified reproduction of key objects of the urban environment, taking into account local special aspects, which will ensure the social and economic efficiency of the functioning of municipal facilities.

**Formulating the objectives and setting tasks for work**

The aim of the research is to identify the relationship of reproduction processes and the operation efficiency of apartment blocks stock for the further approaches development to substantiation of the feasibility and planning for the reproduction of apartment blocks stock.

In this regard, the following scientific problems arise:

- building a system of interrelated criteria of operation efficiency and housing reproduction;
- conceptual model development of housing stock reproduction management focused on key criteria of its reproduction and operation efficiency.

To create an effective investment system of construction, repair and housing stock modernization; it is necessary to create a scientific system of goals and tasks based on identified problems, and to suggest possible algorithms to achieve them. At the same time, the key objectives for the reproduction process of apartment blocks is to increase operational efficiency including energy efficiency.

In this regard, it is necessary to clarify the concept of "energy efficiency" and "operational efficiency" of the housing stock, indicators of social and economic efficiency of implemented measures and projects in housing. It is also necessary to systematize criteria and methods of evaluating the effectiveness of implemented programs [6].

**Presentation of the main research material with full justification of the scientific results obtained; formulating the recommendations**

In Bryansk region, as in other regions of Russia, there is a regional program for capital repairs of apartment blocks that was approved by the regional government. The regional program includes 6,008 apartment blocks in 139 municipalities with a total area of 15.28 million square meters.

Understanding the accumulated wear and tear in previous years and the poor technical condition of the housing stock, the region had to abandon comprehensive repairs. Therefore, many priority works were planned — mainly repairs of roofs and utility networks, which is a serious implementation drawback of the regional capital repair program [11].

The main social and economic efficiency criterion of the implemented program is to ensure the sustainable functioning of the capital repairs system of the common property in apartment blocks within the territory of Bryansk region. The program implementation will help to reduce the general
deterioration level in the housing stock; improve the housing and communal services quality and reliability. At the same time, the following indicators should assess the capital repairs program effectiveness: reduction of energy consumption; saving of thermal energy; prolongation period of the cost-effective buildings operation; operating costs reduction after capital repairs.

To assess the relationship between reproduction and energy efficiency indicators of apartment blocks stock, we compared the housing reproduction rates and changes of some energy efficiency housing indicators.

As the analysis showed, while we can observe the housing construction growth in the region, there is a relatively constant heat consumption value per unit of housing area. It is connected with rather high level of housing wear and utility objects and slow pace of capital repairs. Electricity consumption in the region is also increasing per inhabitant (refer with table 1).

The reproduction efficiency of housing stock and communal infrastructure must directly affect the energy efficiency of housing and public utilities and the economy as a whole. Energy efficiency is considered by us as a target function to ensure the economic efficiency of the complex reproduction process in the housing sector.

In order to find cause-effect relationships and create an economic mechanism for effective reproduction in housing, it is necessary to identify a clearer relationship between types and pace of housing reproduction and its energy efficiency.

As can be seen from the analysis, despite the pace growth of housing reproduction in the region and the unit costs for capital repairs, the specific value of heat energy consumption practically does not change. This leads to the conclusion that the apartment blocks reproduction in the region is insufficient.

The ratio between the amount of apartment blocks stock, the level of its wear and reproduction is the most important characteristic of the stock condition. At the same time, the results of the analysis when planning the residential environment development should be considered together with the municipal infrastructure reproduction, road network, green spaces, and elements of outdoor area improvement.

**Table 1.** Analysis of housing stock reproduction rate and indicators of housing energy efficiency in Bryansk region

| Indicators                                                                 | 2014     | 2015     | 2016     | 2017     |
|----------------------------------------------------------------------------|----------|----------|----------|----------|
| Total area of housing stock in the region, [thous. sq.m.]                 | 33888    | 34,432   | 35,024   | 35,574   |
| Total area of new housing construction, [thous. sq.m.]                    | 550.7    | 644.3    | 665.1    | 558.3    |
| Average cost of housing construction, [thous. rub / sq.m.]                | 29.7     | 31.7     | 28.7     | 29.2     |
| Area of residential buildings with major repairs, [sq. m]                 | -        | 12,343.0 | 64,461.5 | 22,557.1 |
| Average cost of capital repairs per 1 sq.m of housing, [rub / sq.m.]      | -        | 14,190   | 17,328   | 36,942   |
| Housing share with major repairs in the total area of the housing stock, [%] | -        | 0.04     | 0.18     | 0.06     |
| New construction share of residential buildings in relation to the total area of the housing stock, [%] | 1.63     | 1.87     | 1.93     | 1.57     |
| Specific value of electricity consumption in apartment blocks of urban districts, [kW·h per 1 resident] | 536.5    | 554.1    | 597.9    | 584.3    |
| Specific consumption value of heat energy in urban districts, [Gcal per 1 sq. meter of total area] | 0.11     | 0.11     | 0.11     | 0.11     |
Specific value of natural gas consumption in urban districts, [cubic meters per 1 resident]

|          | 256.6 | 288.1 | 274.5 | 277.3 |
|----------|-------|-------|-------|-------|

The efficiency indicators of reproduction processes in the housing sector include criteria for improving the population living comfort. For this purpose, a set of criteria indicators is proposed, which can be divided into groups: housing provision and condition of housing; of reliability and quality level of housing and communal services; operational efficiency; green plantings provision, outdoor areas and their maintenance quality.

The energy efficiency of the housing stock can be measured on the basis of a set of relative indicators that characterize not only the energy consumption per unit of the housing stock – square meter or cubic meter, but also the heating costs share in the utilities payments structure by consumers.

It is also possible to use additional indicators (criteria) of energy efficiency in the housing stock, which should be taken into account in the justification of reproduction processes efficiency:
- volumes of heat losses during transportation (difference in the amount of heat supplied and heat received by consumers);
- volumes of electricity losses during transportation (difference in the amount of electricity supplied and electricity received by consumers);
- actual heat consumption ratio per area unit of a certain house type, and standard consumption.

These heat and electricity losses may be much higher than the energy saved as a result of capital repairs or new construction.

Thus, the energy efficiency of the housing stock should be managed both in the process of housing reproduction and during its operation. Improving energy efficiency in our view implies not only a focus on reducing the relative energy consumption indicators, but also on improving the investments efficiency in energy saving measures in the construction of new housing, as well as in the capital repairs of existing housing.

Improvements in housing energy efficiency should be considered as one of the indicators and factors of operational efficiency improvement, which definition is unclear in the scientific literature.

In addition to energy efficiency indicators, the criteria for operational efficiency may also include:
1. Current expenses of the management company and housing owners on maintenance of common property per unit of housing area (or volume) and their share in the structure of housing and communal payments.
2. Necessary investment to carry out planned maintenance and capital repairs per unit of housing area (or volume).
3. Average annual cost of emergency response related to communal housing services per unit of housing area (or volume).

Thus, the effective management targets of the apartment block stock reproduction is an achievement of the comfortable living indicators set and operational efficiency where energy efficiency plays a special role.

In the Russian Federation, the housing sector ranks second after the manufacturing industry in terms of energy consumption. At the same time, most apartment blocks are characterized by resource consumption that is on average 1.5-2 times higher than in countries with similar climate. One of the main reasons for this situation is that the apartment blocks built before 1995 were designed according to the old building standards and, therefore, heat loss through the enclosing structures are up to 40%.

The operational properties of new residential buildings as a type of construction products in modern conditions are increasingly associated with energy efficiency. Now, following the implementation of regulatory requirements on energy efficiency in the Russian Federation for the facilities under construction and in operation, this problem is especially urgent.

In order to create an effective system for managing the apartment blocks reproduction, it is necessary to systematize goals, objectives, criteria and measures. It is necessary to develop this system on the basis of the following principles:
1. Ensure consistency with other elements reproduction in the urban environment.
2. Economic justification of the choice expediency among housing stock reproduction forms.
3. Information communication improvement system between the participants of this process.

4. Mathematical modeling in economics for the reproduction process with focus on key targets of operational efficiency (in particular energy efficiency).

Reproduction processes in modern conditions cannot be carried out qualitatively without taking into account regional features of investment resources building, financial opportunities use of regional and local budgets, estimation of the investments ratio for capital repairs and new construction.

The proposed conceptual approach to the management of the housing reproduction resources should cover and balance the work of the following blocks: construction and modernization management of public infrastructure facilities, taking into account coordination with road construction and improvement projects; implementation management of new construction projects in housing; current and capital repairs management of the housing stock.

In addition to focusing on the ratio between wear and reproduction of these objects, a system of criteria considered above is necessary.

Thus, the aim of the proposed approach is to systematize the housing stock reproduction management focused on achieving the system of operational efficiency targets, including the aim to improve the housing efficiency.

The reproduction of apartment block stock needs to be managed by modeling the ongoing processes using the proposed interaction modification model of the housing markets and housing services (refer with figure 1).

![Diagram](image)

**Figure 1.** Transformed diagram of the interaction between housing stock markets and housing services to analyze the reproduction and operation efficiency in the housing stock

The original model was proposed by American economists and was repeatedly interpreted by Russian scientists [6, 8].

The use of the proposed diagram in mathematical modeling for the reproduction processes economics will allow to systematically analyze the information on the efficiency of new construction and capital repair of various types of housing stock. This is necessary to ensure that investments in reproduction (especially budgetary investments) are economically viable and have the maximum social economic impact.
The effect of the proposed management model should be supported by the development and application of an effective motivational mechanism for all actors involved in the reproduction process, energy supply and energy consumption.

**Summary**

The state policy of the housing sector in the Russian Federation and the emerging problems testify to the need for continuous improvement of the management mechanism, complex reproduction as well as operation of the housing stock, which provides a systematic solution to the problem of the population’s living comfort improvement and the of housing operation efficiency.

Currently, there is no approved system of interlinked performance indicators of housing reproduction and maintenance management at the government level, which should provide integrated management of the reproduction processes for apartment blocks stock.

In order to create an effective system of housing stock reproduction management it is necessary to establish a system of objectives and criteria in each municipality. Then all possible algorithms for their achievement should be proposed, the most optimal one should be chosen after pre-estimating and forming the balance of available resources.

Therefore, a systematic conceptual approach to the implementation of expanded reproduction and use of objects of residential environment, taking into account regional and local characteristics, is necessary.

The proposed elements of the management mechanism will allow to create the organizational and economic basis for reproduction of housing stock in the regions of the Russian Federation, but this development requires further improvement of criteria and methods system for assessing social economic efficiency of reproduction process and feasibility studies.

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