Improving the efficiency of capital repairs of apartment buildings through energy-saving measures (on the example of the Republic of Tatarstan)

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Abstract. The article discusses the energy-efficient repair and construction of apartment buildings, as well as the dynamics of changes in the energy efficiency class of apartment buildings in the Republic of Tatarstan. The object of the study is directly the energy efficiency of apartment buildings, as well as its increase in the course of major repairs and construction of apartment buildings. The article also discusses measures to improve the energy efficiency of apartment blocks. The purpose of the study is to analyze the state of management of energy efficient construction and repair of apartment building, mainly using the example of the Republic of Tatarstan.
Keywords. Energy efficiency, major repairs, energy saving, heat loss, energy efficiency class.

1 Introduction

Today, the problem of energy efficiency in housing is especially relevant, and the matter lies not only in the rise in prices for energy resources, which will inevitably be followed by an increase in prices for utilities, but also in changing the environmental situation for the worse, as well as in climatic changes that are directly associated with the greenhouse effect. Energy efficiency of buildings means, as a rule, an indicator of how efficiently a residential building is used during operation of various types of energy, such as electricity and heat, directly for heating, ventilation, and hot water supply. One of the main reasons why it is necessary for major repairs and construction of houses in Russia to be energy efficient is that Russia is a northern country, which is characterized by large temperature fluctuations. During the overhaul, it is necessary not only to carry out work, the purpose of which is to restore the already outdated technical characteristics of the building, but also to ensure an increase in the comfort of living in these buildings, including directly by increasing the energy efficiency of apartment buildings. Carrying out any repairs, together with major ones, requires certain costs, but only energy-efficient major repairs provide an opportunity to recoup the work and services directly performed for its implementation due to energy savings.

Numerous works of foreign and domestic scientists are devoted to the problems of

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sustainable development of cities and houses. The main directions of research in the field of smart home control using energy efficient technologies are determined by the works of scientists Jordan D. Clark, Brennan, D. Less, Max H. Sherman [1], G.P.R. Filho, L.A. Villas [2], who assessed the intelligent infrastructure described the process decision making for the development of urban infrastructure. The processes of introducing smart technologies for urban development are disclosed in the works of Araral E. [3] and Gimpel H., Graf V., Graf-Drasch V. [4]. Energy efficiency for sustainable development like Chen M., Sinha A., Hu K., Shah M.I. [5]. Pelli P. studied innovations in the service sector and green building [6]. House control in solving problems of energy efficient repair was studied by C. Wilson, H. Pettifor, G. Chryssochoidis [7], B. Risholt, T. Berker [8]. The method of optimization of the project of technical innovations for major repairs Na Li, X. Wang, W. Zhang [9] seems to be interesting. The works of scientists H. Feng, D. R. Liyanage, K. Hewage are devoted to the issues of renovation and reconstruction of aging housing stock based on BIM [10]. These works were studied by such authors as H. Rivera-Gómez, A. Gharbi and others [11]. Determination of the energy efficiency class of houses is a research topic by M. Pugach, V. Vyshinsky, A. Bischi [12], P. Kofi Adom [13]. Methods for managing operational services in the context of sustainable development of intelligent technologies were studied by Ilina E.V., Romanova A.I. [14]. Burkeev D.O., Romanova A.I., Murafa A.A., Maksimchuk O.V., Voronin A.V. studied the implementation of innovative technologies in the field of facilities maintenance in Russia [15]. Authors of scientific works Afanasyeva A.N., Fedorova S.F. dealt with issues of housing provision in conditions of sustainable development [16]. The development of the operational cycle of real estate was considered in the works of Ilina E.V., Romanova A.I., Maksimchuk O.V., Voronin A.V. [17]. Despite many studies of the concept of sustainable development, some authors criticize it, this can be found in the works of S. Kwatra, A. Kumar, P. Sharma [18]. Problems and prospects of the field of operational services were touched upon by the following authors: Romanova A.I., Zagidullina G.M., Afanasyeva A.N., Hkairetdinova R.S. [19]. The formation of sustainable development goals can be traced in the work of Rao Y. [20]. Accounting for pipeline losses at work is investigated in the works G. Akhmerova, A. Zalyalova and R. Mukhametshina.

2 Methods

In order to analyze the energy efficiency indicators of repair and new construction of apartment buildings in the Republic of Tatarstan, the dynamics of changes in the energy efficiency class of apartment buildings for 2020 was determined. Based on this analysis, conclusions were drawn and recommended measures were taken to improve the energy efficiency of construction and repair of an apartment building. It is worth noting that there is a list of buildings, in accordance with Federal Law No. 261, article 11, paragraph 5, which do not need to be assigned an energy efficiency class. These, in turn, include: – private houses, individual housing, summer cottages;

– monuments of history and culture;
– temporary buildings;
– objects of cultural heritage;
– buildings with an area of less than 50 m^2.

In this case, the method of forming a fund for capital repairs of apartment buildings is carried out at the expense of a regional operator. The method of forming a capital repair fund at the expense of a regional operator means that the owners' contributions are transferred to the account of a legal entity that was specially created in the region (constituent entity of the Russian Federation) in order to organize an apartment building overhaul. Let us consider the dynamics of changes in the energy efficiency class of apartment buildings in the Republic of Tatarstan as a result of the implementation of the regional program for the overhaul of

apartment buildings.

In total, the report on the Republic of Tatarstan provides information on 17 066 objects (Table). Each of them was assigned a certain energy efficiency class during construction or as a result of major repairs. Thus, for example, a building that is classified as «A+» uses 50-60% less energy than an «average» building in the same region under similar conditions. Tables reflect the change in the energy efficiency class of apartment buildings as a result of major repairs in the Republic of Tatarstan.

Table. Change in the energy efficiency class of apartment blocks as a result of the implementation of the regional capital repair program in the Republic of Tatarstan.

Energy efficiency class	Before overhaul	After overhaul
A++	18	52
A+	99	129
A	192	632
B++	1	1
B+	1	1
B	268	1777
C	902	3442
D	710	2413
E	1076	2116
G	2	39
F	102	192
Not assigned	13695	6272
Total	17 066	

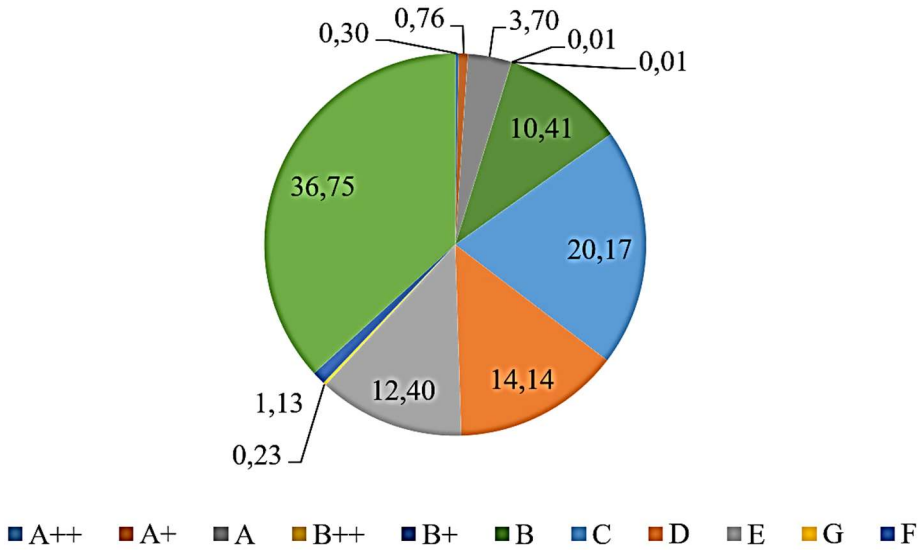
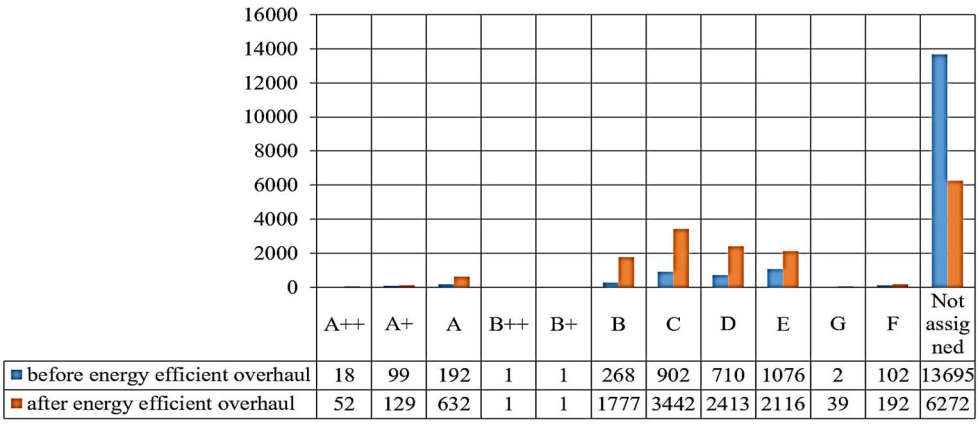


Fig. 1. The share of apartment buildings with an assigned energy efficiency class before overhaul in the Republic of Tatarstan. Source: compiled by the authors.

Based on the data presented in this table, we can conclude that before the overhaul, a larger number of apartment buildings was not assigned an energy efficiency class (13 695 objects), and high energy efficiency classes (A-B) are less, compared to low energy efficiency classes (C-F). After the major overhaul of apartment buildings, which have not been assigned an energy efficiency class, the number of objects with energy efficiency classes «C, D, E» has increased quite significantly. Fig. 1 shows the percentage share of each object

with a certain assigned energy efficiency class after overhaul in the Republic of Tatarstan in the total amount of apartment buildings in which overhaul was carried out in accordance with the regional program for overhaul of an apartment building.

After the implementation of the regional program for the overhaul of apartment buildings in the Republic of Tatarstan, the facilities received the following energy efficiency classes. 52 facilities were assigned the A++ energy efficiency class, which is 34 facilities more than before the repair. 129 buildings received «A+» energy efficiency class, which, in turn, is 30 houses more than before the program. Class «A» was assigned to 632 objects, which are 440 more than before the regional program. The number of objects of classes «B++» and «B+» energy efficiency is both before and after repair – one apartment building. 1 777 houses received class «B», which are 1 509 more than before the implementation of the regional program. Class «C» was assigned to 3442 objects. Class «D» was assigned to 2 413 buildings. 2 116 objects received class «E». 39 and 192 objects received classes «G» and «F», respectively. 6 272 objects were not assigned an energy efficiency class after the regional program, which is 7 423 less than last year. Thus, the majority (36.75%) is occupied by buildings that have not been assigned an energy efficiency class. A significant part is also occupied by apartment buildings with classes «C» (20.17%), «D» (14.14%), «E» (12.40%) and «B» (10.41%), which indicates on a significant number of «medium» (C) and low-energy buildings («D» and «E»). It is worth noting that low-energy-efficient apartment blocks should be subject to mandatory reconstruction or demolition. However, it should be noted that the number of houses with classes «A++», «A+», «A» and especially «B» has also increased, which is a positive trend (fig. 2).



	A++	A+	A	B++	B+	B	C	D	E	G	F	Not assigned
before energy efficient overhaul	18	99	192	1	1	268	902	710	1076	2	102	13695
after energy efficient overhaul	52	129	632	1	1	1777	3442	2413	2116	39	192	6272

Fig. 2. Changing the energy efficiency class of apartment buildings in the Republic of Tatarstan.

Based on the data analysis, it can be concluded that, despite the existing positive trends to improve the energy efficiency of apartment buildings, an increase in the efficiency and effectiveness of energy-efficient capital repairs and reconstruction of apartment buildings is required. It also requires the development and improvement of certain technologies related to improving the energy efficiency of apartment buildings. There is a need to promote the development and implementation of these technologies, as well as to gain experience in this industry, in order to improve the quality of energy efficiency in construction and capital repairs.

3 Results

As a result of the data analysis, we will define and consider the recommended measures aimed at improving the energy efficiency of an apartment building. The main condition for

starting the formation of packages of measures for energy saving and increasing the energy efficiency of apartment buildings, as well as for assessing the economic efficiency of the implementation of such measures, is the presence of energy saving potential in this apartment building. Only if the it has the potential to save energy does it make sense to carry out the above actions. Savings can be obtained even if the potential is small (less than 10%), but only at fairly substantial costs. If the identified potential is higher, then it is necessary to decide which activities in this particular facility will allow to obtain potential savings in reality.

Savings can be obtained even if the potential is small (less than 10%), but only at fairly substantial costs. If the identified potential is higher, then it is necessary to decide which activities in this particular facility will allow to obtain potential savings in reality. The list of measures aimed at energy saving and improving the energy efficiency of an apartment building may include measures to insulate the shell of an apartment building, as well as to modernize the engineering systems of the building, including gas, water, electricity, heat supply and sewerage systems. Let's consider mainly the measures that provide energy savings in heating and hot water supply (DHW) systems, as well as electricity for general household needs. We will also consider two measures in apartments - the replacement of windows and the installation of heat reflectors behind the radiators. From the implementation of such measures, the owners do not receive direct monetary savings if they are not equipped with apartment heat metering devices, but heat energy is saved for the apartment building as a whole. Other measures in apartments that can provide savings in electricity, natural gas and cold water are a separate group of measures that apartment owners can implement on their own.

All the measures under consideration can be regarded resource-saving only if there are installed collective metering devices that do not save resources directly by themselves, but provide an opportunity to record the effects obtained. It is worth noting that not all measures can be applied to a particular apartment building. So, an event can be considered inapplicable in cases where:

– the measure has already been completed, but its useful life, i.e. the period for receiving benefits has not yet expired;

– there is no building element or engineering system corresponding to this measure (for example, pumping equipment, elevator, etc.);

– it is planned to implement a mutually exclusive event.

Measures to save energy and improve energy efficiency of an apartment building:

1) increasing the thermal protection of the outer walls, which provides reduction in transmission heat losses through the outer walls; reduction of freezing of external walls (increase in service life); reduction of heat consumption for heating cold air entering the building through the outer walls;

2) sealing and sealing of interpanel joints (seams) and the elimination of cold bridges, which reduces transmission heat losses through the outer walls;

3) increasing the thermal protection of windows in public places, which provides reduction in transmission heat losses through the windows; reduction of heat consumption for heating cold outside air that penetrates into the apartment building through leaks in window openings;

4) increasing the thermal protection of the roof of the top covering, combined with the roof, which reduces transmission heat losses through the roof; reduction of roof frost penetration (increase in service life);

5) device of a warm attic, which reduces transmission heat losses through the attic floor;

6) increasing the thermal protection of the attic floor, which reduces transmission heat losses through the attic floor;

7) repair (replacement) of pipelines of an in-house heating system in combination with thermal insulation (in unheated rooms), which reduces heat losses in heating pipelines;

8) repair (replacement) of pipelines of the in-house hot water supply system in combination with thermal insulation (in unheated rooms), which reduces heat losses in hot water supply pipelines; reduction of hot water drainage due to cooling (in the absence of hot water draw-off at night or daytime);

9) installation of a circulation pipeline and a pump in the hot water supply system, which reduces the discharge of hot water due to cooling (in the absence of hot water draw-off at night or daytime);

10) installation of a variable frequency drive on the operating pumping equipment of heating systems, hot and cold-water supply, which reduces electricity consumption by pumping equipment;

11) replacement of operating pumping equipment with new, energy-efficient in heating systems, hot and cold-water supply, which reduces electricity consumption by pumping equipment;

12) installation of devices for compensation of reactive power of installed pumping equipment, which ensures decrease in the consumption of electrical energy by pumping equipment;

13) installation of control units and regulation of heat energy consumption in heating and/or hot water supply systems, which provides automatic regulation of the coolant parameters in heating and hot water systems (maintaining the temperature schedule of the heating system and hot water temperature at a given level); elimination of overheating; reduction of heat energy consumption in the hot water supply system (in the case of AITP);

14) modernization of an individual heating point with the installation of a heat exchanger and DHW control equipment (hot water temperature controller), which reduces heat energy consumption in the hot water supply system;

15) installation of a hot water temperature controller at the entrance to the apartment building, which reduces heat energy consumption in the hot water supply system;

16) repair of elevator equipment with a frequency-controlled drive (VFD) and an effective control program, which decreases consumption of electrical energy by elevator equipment;

17) replacement of the elevator equipment in use with a new one with a frequency-controlled drive and an effective control program, which decreases consumption of electrical energy by the elevator equipment;

18) installation of devices for compensation of reactive power of elevator equipment, which decreases consumption of electrical energy by elevator equipment;

19) increasing the thermal protection of the floor over the ground, which reduces transmission heat losses through the floor over the ground;

20) increasing the thermal protection of floors above the basement (technical underground), which reduces transmission heat losses through the floors above the unheated basement;

21) replacement of luminaires with incandescent lamps in public places with energy-efficient counterparts, which reduces consumption of electrical energy for lighting public places;

22) installation of systems for automatic control and regulation of lighting in public places, which reduces the consumption of electrical energy for lighting in public places;

23) sealing of entrance external doors with the installation of door closers, which reduces transmission heat losses through the entrance doors; reduction of heat consumption for heating cold outside air entering the apartment building through leaks in doorways, as well as through open doors;

24) replacement of luminaires with DRL-lamps (arc mercury lamps) in driveway lighting systems with energy-efficient counterparts, which reduces the consumption of electrical energy for general household needs;

25) increasing the thermal protection of windows in apartments, which provides a reduction in transmission heat losses through the windows; reduction of heat consumption for heating cold outside air that penetrates into the apartment building through leaks in window openings;

26) installation of heat-reflecting screens behind heating devices in apartments, which reduces thermal energy consumption.

4 Discussions

According to the results of the study, it can be concluded that, despite the existing positive trends in increasing the energy efficiency of apartment buildings, an increase in the efficiency and effectiveness of energy-efficient capital repairs and reconstruction of apartment buildings are required. It also necessary to develop and improve certain technologies related to improving the energy efficiency of apartment buildings. There is a need to promote the development and implementation of these technologies, as well as to gain experience in this industry, in order to improve the quality of energy efficiency in construction and capital repairs. Before proceeding with the recommended measures that are aimed at improving the energy efficiency of an apartment building, it is necessary:

– to assess the energy saving and energy efficiency potential improvements at home;

– to select the activities that are possible for implementation (in this case, knowing the main effects of the implementation of activities and restrictions on their implementation can help);

– to determine the scope of application of measures;

– to estimate the costs of the selected possible implementation activities;

– to assess the saving of energy resources;

– to determine the payback period for these activities, which will facilitate a decision on the feasibility of the selected activities;

– to carry out the ranking of activities according to the payback period;

– to develop a package of measures based on their ranking according to the payback period.

5 Conclusions

The main problems of domestic energy saving and energy efficiency lie in two dimensions. The first is legislative one. The currently existing federal, regional and municipal programs still leave much to be desired, since, in most cases, they are copied from similar documents of previous periods, which were drawn up even before the adoption of the Federal Law No. 261. There is an urgent need for the development of regulations that are really capable of regulating the issues of energy efficiency and energy conservation. The second one is professional. The serious research is required in the field of adaptation of Western models of energy efficiency and energy conservation in the Russian market; the development of our own technologies for energy efficiency and energy saving, which are focused on the relevant features of domestic residential and industrial facilities available in specific climatic conditions of Russia. The existing problems of improving the energy efficiency of buildings require the formation of certain ways to overcome them. It is necessary to carry out a set of measures aimed at the implementation of the construction of energy-efficient houses in order to solve the main problems. They are: increasing interest in the introduction of building technologies to improve energy efficiency, stimulating investment in the construction and overhaul of energy efficient houses, etc. All this can be the topic of further research to address the issue of improving the energy efficiency of apartment buildings.

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