

# The impact of building-renovation program on the city's environment

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**Abstract.** Implementation of the residential renovation program, which is currently underway in the city of Moscow, as well as in other cities of the Russian Federation, helps to create comfortable and safe living conditions for citizens. In addition, one of the most important tasks of this program is the integrated development of urban areas: development of public spaces, landscaping of districts, organization of parks and recreation areas. These aspects help to create more favorable living conditions and also have a positive impact on the environmental component of the area. As renovation of residential buildings is a combination of renovation or modernization of existing buildings, more attention is being paid to the energy efficiency of buildings, as well as their impact on the environment. For example, modernizing the engineering systems, improving the thermal conductivity of the building envelope and other aspects can reduce greenhouse gas emissions; reduce energy consumption and so on. Thus, the implementation of the housing renovation program, due to its massive scale, has a favorable impact on the environmental condition of the city and its districts.

**Keywords:** energy efficiency of buildings, impact on the environmental condition of the city, renovation of residential buildings, modernization of existing buildings

## 1 Introduction

The creation of safe and comfortable living conditions that meet the requirements of modern society is one of the most important directions of the socio-economic policy of the state, so in order to renew the dilapidated and dilapidated housing, whose volume continues to increase, a program of renovation of residential development is being implemented. Due to the fact of imbalance in the development of urban environment, one of the aspects of which is the presence in the housing stock of first period houses

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built between 1958 and 1967, the next 10-15 years may see a significant increase in the number of dilapidated and emergency buildings. In order to prevent the mass emergence of emergency buildings, for which, at this stage of their life cycle, major repairs are inexpedient, the program of renovation of residential buildings is being implemented. The implementation of the housing renovation program is one of the main aspects of the development of the housing stock in the Russian Federation. The implementation of this program improves the quality of life of citizens, as well as the quality of the living environment, increases the social level, and develops the economy of the regions in the state. The main objective of this program is the modernization of the existing housing stock and the renovation of the living environment to bring it up to quality standards that ensure comfortable living conditions.

## **2 Materials and Methods**

Most of the housing stock in Moscow, Russian Federation was built between 1958 and 1967. The normative service life of these serial houses is, according to the regulatory documents (SP 255.1325800.2016), 50-70 years. Thus, it shows that in the next 10-15 years there will be a sharp increase in the number of dilapidated and dilapidated housing, so it was decided to develop and launch a program of comprehensive development of the areas, which in the Moscow region is called the program of residential building renovation [1].

Renovation of the housing stock is the process of replacing and restoring the elements of the housing stock (residential buildings and parts thereof) that have been removed as a result of functional and physical deterioration with new elements or facilities [1, 13].

Renovation of the housing stock is a cyclical process that generally includes a sequence of housing transformations - renovation methods: new construction, renovation, modernization, renovation, reconstruction, demolition of residential buildings and construction of new facilities.

- New construction refers to the erection of new residential buildings on undeveloped or vacated reused land.
- Capital repair of housing stock - complex of construction works on restoration, replacement or strengthening of separate parts of residential buildings or whole constructions, parts and engineering equipment in connection with their physical depreciation.
- Modernization of the housing stock is a complex of construction works that provides improvement of consumer and operational qualities of residential buildings without restructuring of the objects themselves. Modernization allows to eliminate their functional deterioration and is usually limited to redesign of internal premises and improvement of existing engineering systems.
- Restoration of the housing stock is a complex of construction works that ensures restoration of the lost architectural, artistic, engineering and construction and historical appearance of residential buildings in their original form.
- Reconstruction of housing stock is a complex of construction works related to change of main technical and economic indicators of residential buildings - number and area of flats, construction volume and total area of buildings, as well as purpose of premises. [1]

**Table 1.** Classification of renovation types according to the composition of the work

<b>Renovation methods</b>	<b>Characteristic features</b>	<b>A set of works</b>
New construction	The construction of new residential properties on undeveloped or reused land that has been cleared from existing development.	<ul style="list-style-type: none"> <li>• Construction of a new capital construction facility on a vacant land plot or land plot to be vacated through demolition. These works may include the re-laying and installation of new utilities, landscaping of the adjacent area, etc.</li> </ul>
Capital repair of housing stock	A set of construction works to restore, replace or reinforce parts of residential buildings or entire structures, parts, and engineering equipment due to their physical deterioration.	<ul style="list-style-type: none"> <li>• Restoration of building envelopes, openings, restoration of facade structures; repair and/or replacement of engineering systems and equipment;</li> </ul>
Restoration of the housing stock	The complex of construction works ensuring restoration of the original architectural, engineering and historical appearance of residential buildings.	<ul style="list-style-type: none"> <li>• Restoration of envelope structures, openings, restoration of façade structures;</li> <li>• Refurbishment of premises;</li> <li>• Repair and/or replacement of engineering systems and equipment;;</li> </ul>
Modernization of the housing stock	The complex of construction works that provides improvement of residential buildings in terms of quality of use and performance without any modification of the building itself. Retrofitting eliminates functional deterioration and is usually limited to redesign of internal spaces, improvement of existing engineering systems	<ul style="list-style-type: none"> <li>• Replacement and improvement of engineering systems, increasing the energy efficiency of buildings;</li> <li>• Improvement of envelope and roof structures;</li> <li>• Improvement of surrounding area;</li> <li>• Redesign of premises and flats;</li> <li>• Replacement of glazing.</li> </ul>
Reconstruction of housing stock -	The complex of construction works related to the change of basic technical and economic parameters of residential buildings - the number and area of flats, building volume and total floor area, as well as the purpose of the premises	<ul style="list-style-type: none"> <li>• Modification of the building exterior, improvement of the building envelope;</li> <li>• Construction of additions and/or extensions;</li> <li>• Enlargement of the flats;</li> <li>• Changes in floor plans;</li> <li>• Enlargement of window openings;</li> <li>• Replacement and modernization of utilities, systems and equipment;</li> <li>• Rehabilitation and/or replacement of the load-bearing structures of the building</li> </ul>

Renovation of the housing stock can be represented by various options: new construction (which is predominant in Moscow), major renovation of the housing stock, its restoration, as well as such popular in Europe types of renovation as: reconstruction and

modernization. It is also worth mentioning that the housing stock in eastern Germany has much in common with the housing stock in the Russian Federation. Analyzing the main aspects of the renovation program carried out in the cities in eastern Germany, it can be concluded that most often owners or management companies of such buildings chose renovation or refurbishment of residential buildings. The choice of these types of renovation helped to create a comfortable living environment for citizens, restore the technical condition and increase the lifespan of houses, reduce maintenance costs by using more modern energy efficient systems and technologies, and significantly reduce the cost of renovation relative to new construction. Nevertheless, many residential buildings built in Moscow and other regions of the Russian Federation do not have the same margin of safety and durability as those in eastern Germany. Much of the change is due to the less frequent routine repairs, operational features and even weather conditions. Thus, the most rational method for the renovation of the housing stock in Moscow has proven to be new construction [2, 13, 14].

The Moscow housing stock renovation is an extensive program, which includes more than 5000 demolished houses, as a result of which more than 9 million square meters of housing is to be built. In the preparatory phase of the program, 561 start-up sites have been identified on which modern and comfortable houses will be built. The housing renovation program is designed for a period of 25 years, from 2017 to 2032, and consists of three phases of wave resettlement.

One of the most important aspects of the residential building renovation program is to increase the energy efficiency of residential buildings: reducing energy consumption, reducing harmful emissions into the soil and the atmosphere, increasing the area of landscaping of adjacent territories and the arrangement of "green" zones. It should also be noted that the energy efficiency of new residential buildings is on average 40% higher than that of the obsolete housing stock [2, 15].

Thus, the implementation of the housing renovation program has a direct link with the environmental condition of the district and the city itself.

Such significant results are achieved through the application of the following technologies in new construction or modernization of residential buildings:

1. A modern air conditioning and ventilation system that uses 40-60% less energy (depending on the type of equipment used) to maintain its own performance;
2. Application of materials with better thermal conductivity in facade constructions, which allows keeping heat inside the house longer and, accordingly, reducing energy costs for heating
3. The use of a filtration system in the domestic and storm drainage system, which allows for water purification and prevents the ingress of pollutants into the soil.
4. the use of drainage systems that prevent the penetration of waste water into the soil, purify it and divert it into a single sewage system
5. Use of smart lighting system and energy-saving electrical appliances that reduce energy costs.
6. The creation of a landscaped area on the adjoining territory: the creation of parks, recreational areas, landscaping and planting of trees - allow creating a comfortable environment for living people, as well as positively affecting the environmental situation of the district and the city [2, 6].

It should also be noted that, according to the legislation in force in the Russian Federation, all new residential buildings must meet the energy efficiency requirements of class «B» according to an established classification. [4] The classification of buildings according to their energy efficiency shows the amount of deviation of the energy consumption of a building from the normative (according to approved regulations) values. The energy savings are expressed as a percentage of the energy consumption standard. The

energy performance classification of buildings can be presented in the following tabular form, showing the current classes of buildings in the Russian Federation:

Energy efficiency class of buildings		The amount of the deviation of the calculated (actual) value of the specific energy consumption of the building from the normative amount									
		-100%		-50%		0		+50%		+100%	
Very high	A+	█		█							
	A			█							
High	B++			█							
	B+			█							
	B			█		█					
Normal	C					█					
Bellow normal	D							█			
Poor	E									█	

**Fig. 1** Classification of building’s energy performance

Thus, if a building is given an energy efficiency class of 'A', it means that it uses 50 to 60 % less energy than a similar building in the region under similar conditions. Achieving energy efficiency in residential buildings [5].

Carrying out a renovation program in accordance with the methods mentioned in this study can significantly improve the energy efficiency class of buildings (in case of modernization or reconstruction of obsolete buildings), reduce the amount of energy resources consumed, which in turn reduces the amount of greenhouse gas emissions into the atmosphere and significantly reduces the amount of harmful substances into the soil.

As part of the new construction, urban areas receive new development with state-of-the-art engineering systems to reduce emissions and minimize the environmental impact of residential buildings, and through the solutions used, significantly reduce energy consumption. The surrounding areas of residential buildings are landscaped by planting greenery and lawns, which, as part of the entire housing renovation program, has a significant impact on the environmental situation of the city.

### 3 Results

As a result of this study, the methods of renovation of residential buildings have been classified according to their composition and the impact on the energy efficiency class of the buildings has been characterized.

In accordance with the presented classification of methods of renovation of residential buildings and individual buildings, it is possible to improve the energy efficiency of buildings and structures, as well as create a better area for citizens through improvement and development of adjacent territories, landscaping and arrangement of "green" zones [9].

It should also be noted that the Building Renovation Program which is currently being implemented in Moscow, Russian Federation includes the construction of 561 new houses

which, given such a substantial improvement in energy efficiency, will play a major role in the environmental condition of the entire city in comparison with the houses that are being demolished.

For a better understanding of the construction of new houses in Moscow, the following table is proposed:

**Table 2.** The number of residential buildings to be constructed according to urban construction areas in the main implementation periods of the residential renovation program

	2017-2019	2020-2022	2022-2024	2025-2028	Total
Central District	1	5	11	9	26
North District	12	17	17	18	64
North-East District	12	15	21	25	73
East District	3	21	24	19	67
South-East District	4	17	24	26	71
South District	3	12	17	18	50
South-West District	10	14	22	23	69
West District	13	12	19	19	63
North-West District	1	9	16	14	40
Zelenograd	0	6	9	8	23
Troitsk and Novomoskovsky District	0	5	6	4	15
<b>In Total</b>	<b>59</b>	<b>133</b>	<b>186</b>	<b>183</b>	<b>561</b>

As mentioned earlier, all new buildings under construction as part of the residential renovation program meet at least energy efficiency class "B", which is ensured by the installation of their own individual heating substation regulating the flow and temperature parameters of the heating medium, energy efficient engineering ventilation and air conditioning systems, and reduction of energy consumption through the use of electricity. Modern insulating façade materials (insulators) with a high thermal conductivity coefficient, as well as translucent structures, are also used which allow to keep heat inside the building and consequently reduce heating costs in winter [1, 3].

A multi-level wastewater filtration system also plays an important role in protecting the soil and reducing the building's impact on the environment, by cleaning the wastewater and feeding it directly into the drainage system, which prevents dirty substances from getting into the soil [10].

One of the most important aspects in reducing the environmental impact is the use of an air filtration system from the underground car park. Through the filtration system in the exhaust ventilation, the amount of carbon dioxide emitted into the atmosphere by the cars of the building's occupants is significantly reduced. These measures help not only to create a more comfortable living environment for the residents themselves, but also to reduce the impact on the environment [2, 9].

Therefore, the above-mentioned set of measures to improve the energy efficiency of buildings constructed under the Moscow housing renovation program can create better living conditions for citizens as well as reduce the negative impact on the city's ecology.

## 4 Discussion

The main problem with the topic of housing renovation is the generation of waste and debris during new construction or demolition of old buildings. In the process of new construction, soil may be contaminated with fuels and lubricants, construction waste and polluting emissions from machinery and equipment. The demolition process generates a large amount of varied types of waste, which must be disposed of in an orderly manner to avoid or minimize their impact on the environment as much as possible. In order to reduce or completely prevent the emission of pollutants into the atmosphere or soil, a set of measures is developed to reduce the impact of the construction or demolition work carried out on the environment. State authorities, through which construction companies carrying out construction, also regulate the implementation of protective measures and demolition works are supervised [7, 8].

Among the authors of works on the subject of renovation of residential buildings, there is no consensus on the necessary and the most rational type of renovation which would produce the least impact on the environment. Unfortunately, as the results of the survey show, this issue cannot be based on one position only. Much depends on the existing housing stock in the area being considered for renovation, the condition of the residential buildings: the deterioration of the façade structures, the degree of deterioration of the utilities and systems, and the calculated energy efficiency class according to a combination of factors [11, 12].

Thus, on the example of the city of Moscow it was found that due to the high degree of deterioration of the housing stock and unsuitability for large-scale repair and construction works to improve the energy efficiency class, it would be more rational to choose the type of new construction. Despite the rather large amount of waste and construction waste generated during the demolition of old residential buildings, new construction in the long-term operation will significantly reduce the impact on the environment and the ecology of the city and make the citizens' living more comfortable [4, 9].

In turn, in many European cities, as mentioned earlier, for example in Germany, it will be more rational to choose the modernization and reconstruction of residential buildings. This will include replacing the engineering equipment, replacing the materials for insulating the facade structures, replacing the window units, and using energy-efficient equipment. These measures allow the reduction of energy consumption and the environmental impact of the buildings without demolishing them, thus avoiding construction waste and demolition.

## 5 Conclusion

Based on the results of this study, it seems possible to establish that the implementation of the renovation program has undoubtedly positive and negative aspects and has different types of impact on the environmental situation of urban areas and the city as a whole. However, despite the negative aspects expressed in the production of various types of waste and construction waste from construction and demolition, as well as other types of impacts described in this paper, the positive aspects in the long term play a more significant role and can ensure sustainable development of the city with minimized environmental impacts. Among other things, measures taken by governmental regulatory bodies and ways to reduce the environmental impact during construction or demolition help to minimized damage to soil, atmosphere, flora and fauna. And modern wastewater treatment systems, drainage systems, and energy-efficient engineering equipment used in new or retrofitted buildings can improve a building's energy efficiency class and reduce its environmental impact. As part of the integrated implementation of this program.

In line with the above statements, it can be concluded that a thorough analysis of the housing stock and a survey of existing residential buildings to determine their technical condition and energy efficiency class should be carried out. These detailed studies will allow to formulate a renovation program implementation strategy that will be rational for each particular region, city or urban district.

But irrespective of the chosen type of residential building renovation, it can be concluded that any type can improve the energy efficiency of the housing stock, as well as reduce the impact on the environment, make the urban environment more comfortable for citizens and improve the environmental situation of the entire city.

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