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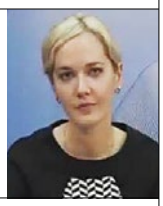
Reconstructing existing urban development in the context of green architecture

The sustainable transformation of urban space is associated with various factors, such as an increase in the density of residential buildings, an increase in the number of floors of business and administrative zones and the intensive development of related infrastructure, as well as a significant change in the functional orientation of individual urban development zones. The central and historical zones have the greatest potential for the modernization of the urban environment. Comprehensive renovation of urban development, as the most significant criterion for the sustainable development of the urban environment, is the most important aspect of its development and is aimed at creating comfortable living conditions and effective use of the capabilities of the construction complex, such as engineering, production, and others.

The relevance of the research addressed in this article is explained by the need to make an organizational model for the reconstruction of existing buildings and to choose the most optimal trajectory of their development and effective use. The article discusses the general principles of development of an organizational and technological model that allows to evaluate and optimize the ways of development using the principle of green reconstruction, as well as the optimized use of urban space.

Particular attention is focused on the need to form and introduce the concept of green reconstruction into the urban environment by integrating elements of landscaping and energy conservation into the spatial structure of buildings. This trend is caused by the pressing need to improve the ecological quality of the urban environment to improve the comfort of life of the urban population, restore the disturbed balance of interaction between man and the natural environment and ensure the sustainable development of the urban environment taking into account the current trends.

Keywords: *green reconstruction, green architecture, urban space, regeneration, reconstruction, organizational model, development of urban environment, urban development, energy conservation*



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INTRODUCTION

Currently, the most significant trend in the development of urban environment is to determine the optimal options for the development of new territories and reconstruction of existing areas. In recent years, reconstruction of urban development remains an important constituent of capital construction and urban planning. This trend is due to the natural "aging" of real estate objects, which is accompanied by the physical and moral wear and tear.

Reconstruction of real estate objects solves a number of important tasks, allowing to improve living conditions, such as quality and comfort; equips buildings with modern engineering equipment, extends the service life and increases energy efficiency. These criteria increase the attractiveness of urban development and make buildings safer and more environmentally friendly. Various organizational and engineering solutions are invested in the reconstructed buildings; hence, individual methods and approaches are required during reconstruction. The relevance of the problem under consideration lies in the fact that in the present-day reality, a new vector is needed for the development of approaches to planning reconstruction works that would meet modern requirements, as well as the fundamental principles of sustainable environment, such as comfort, environmental friendliness, safety, energy efficiency. The model of green reconstruction can become a necessary approach to reconstruction in the current conditions, and it will be based on cutting-edge achievements of the construction industry [1].

As a rule, reconstruction results in the possibility of achieving certain indicators, such as economic effect, reduction of physical wear, change of spatial planning parameters of objects, increase in the usable area, increase in the comfort of living, introduction of innovative technologies and materials, extension of the life cycle of the building.

Having analyzed the above, we can conclude that reconstruction is the most important factor in the production cycle of real estate objects, as well as a special type of investment and construction activity.

The need for reconstruction is caused by the following reasons:

- inconsistency of the existing urban planning structure, increasing functional and environmental pressures on the urban environment;
- insufficiently efficient use of housing stock;
- increase in moral and physical deterioration of the building;
- need to change the functional purpose of the object.

The reconstruction of buildings is conducted in order to improve the quality and comfort of living, increase the useful area of the building, equip the building with modern engineering equipment, increase the period of operation of the real estate object, increase the level of energy efficiency, improve the architectural expressiveness of the object, bring the building to meet modern requirements of regulatory documentation, increase the structural and operational reliability of the object. From a social point of view, the task of reconstruction is to

make more efficient use of urban space, update the planning structure of the city, equalize the living conditions of the population in various urban areas. From a technical point of view, the effectiveness of reconstruction is shown in the use of modern building materials, structures and technologies. The economic efficiency of reconstruction is achieved by carefully developing economic justifications, determining the scale and order of demolition and modernization of existing buildings, taking into account the improvement of the use of urban territory and proportionality in the order and volume of reconstruction of the housing stock and the stock of public buildings. Proceeding from the above, reconstruction is an important type of construction, and also plays a significant role in the reproduction cycle of real estate objects in connection with its technical, economic and socially significant tasks [2].

PROBLEM AREA REVIEW

Modern trends in the development of urban areas determine the conditions in which it is necessary to make optimal decisions on the choice of methods for the reconstruction of urban construction. An actual mechanism is the introduction of green architecture tools to increase the criteria for the effectiveness of urban space reconstruction. The process of green reconstruction involves reducing resource consumption and minimal environmental impact during the production of works and at the stage of operation of similar facilities. Energy efficiency can be achieved in different ways at each stage. When designing the architectural part, it is necessary to use materials and structures with high thermal insulation properties. When planning spaces, it is necessary to apply solutions for the use of natural light, to shield heating from the sun.

The reviewed foreign experience of implementing the standards of green reconstruction demonstrates the trends of increasing environmental friendliness and energy efficiency not only of individual objects, but in general the creation of a green urban environment [3].

For example, in Sweden, the idea of eco-building is supported at the state level, and it is not only about individual green buildings, but in general about creating a sustainable urban environment. So, in Malmo, the municipality initiated the Eco-City Augustenborg project (Fig. 1). In addition to the reconstruction of buildings, improved waste disposal, the use of solar energy, the creation of a botanical garden with an area of 10 thousand square meters on the roofs of houses were introduced here. But the biggest change was the transition to an open storm sewer system with channels and ponds that collect and purify rainwater instead of underground pipes. As a result, the energy efficiency of the district has increased significantly — by about 35 %. And the overall impact on the environment decreased by 20 %. The Olidham area in Umeo has implemented tools to reduce energy consumption and create a safer and more comfortable environment. Solar batteries were installed on the roofs of houses: they generate about 350 thousand kWh of electricity per year. New ventilation and heat recovery systems have been launched in the buildings, and energy-saving LED lamps have been installed. Umeo has a cold climate, but the district heating supply in this area is well developed, and it is 99 % independent of fossil fuels. To further reduce energy consumption, washing machines in buildings were connected to the district heating system [4].

By 2050, the city authorities in Paris intend to reduce the level of carbon dioxide emissions into the atmosphere by 75 %. In this regard, a large-scale project called “2050 Paris Smart City” was developed, which represents several types of towers with different environmental characteristics (Fig. 2).

“Mountain towers” will be characterized as bioclimatic peaks that will combine various renewable energy sources. During the day, photovoltaic and heat shields will be able to generate electricity and hot water. Numerous balconies with green spaces will serve as a filter for residents. In addition, watering and fertilizing of these plants will be conducted at the expense of reused water and biocompost from organic waste. “Antismog towers” implies the construction of a 23-kilometer corridor that will run through the center of Paris along abandoned railway lines. These territories are planned to be transformed into park areas, bike paths and urban gardens, towers erected in the immediate vicinity of them will be designed to filter harmful emissions into the atmosphere, including smog. The structures of these structures will be constructed from modern materials with the function of generating electricity through axial wind turbines and flexible photovoltaic panels. “Photosynthesis towers” involves the transformation of existing buildings into a vertical park, using bioreactors powered by green algae [5].

With a detailed examination of the foreign experience of urban reconstruction, it can be argued that the most significant results of reconstruction were achieved in Germany, Finland, Sweden, France and Poland.

Fig. 1. Eco-City of Augustenborg, Sweden (botanical garden). URL: https://www.arrivalguides.com

Fig. 2. "2050 Paris Smart City", France (project). URL: https://www.novate.ru/

In Germany, one of the well-known methods of reconstruction is used, such as building decompression, in which the building is rearranged with the dismantling of its individual elements and the transformation of the space-planning structure into a new form, for example, a large section or terrace. A similar method of reconstruction was proposed by the architect Sh. Forster, while the projects of reconstructed houses began to be called "urban villas". The main idea of the architect is connected with the transformation of panel buildings into a new form and thereby prolonging their life cycle. Under these conditions, a new image is being given to the areas of panel development by increasing the comfort and architectural expressiveness of housing, the creation of a traditional German garden city in their place [6].

The building conditions in Finland are characterized by a cold climate, and therefore the reconstruction is aimed in most cases at improving the energy efficiency of buildings. The main task of the reconstruction will be based on the introduction of modern engineering solutions and improvement of existing engineering devices, which will contribute to reducing resource costs (water supply, heating and electricity) through the introduction of indoor climate control systems, optimization of lighting modes and heat and humidity conditions.

In Russia, the trends of green reconstruction are being implemented less intensively, which is explained by a number of problematic aspects, such as the harsh climate and high operating costs. In addition to the above, the conducted analysis of the problem area of the study revealed the following groups (Table 1).

MATERIALS AND INSTRUMENTS

Reconstruction is a special kind of construction, and it has a number of features, such as:

- need to perform reconstructive work in cramped conditions;
- possibility of combining the execution of construction and installation works and the functioning of the building;
- need to conduct a technical inspection of the property before starting the design work;
- large amount of work on the dismantling of building structures, as well as the need to replace or strengthen them;
- limited accessibility to some structures that require detailed inspection;
- need to take into account individual space — planning decisions;
- performing specific work;
- increased danger during reconstructive work, especially during work performed without eviction of residents;
- features of technological schemes used in reconstruction;
- high density of buildings.

One of the most important factors that relates to the peculiarities of the reconstruction of buildings is the presence of constraint during the reconstruction work. The constraint is expressed in the limited front of the work, in the difficulties of using construction equipment, machines and mechanisms, as well as in the difficult conditions of storing construction materials. According to the types

Table 1. Analysis of urban development reconstruction problems

Organizational	Technological
Disruption of the timing of reconstruction work, their displacement, as a consequence, an increase in the duration of reconstruction, late provision of documentation, violations of the deadlines of work by subcontractors, changes in the sequence of work, interruptions in resource supply, lack of specialists of the required qualifications	Violations of the technological regulations for the production of works, the appearance of unforeseen works due to incomplete technical inspection of buildings, changes in the numerical and qualified personnel of performers, violation of safety regulations; reduction in the intensity of work in cramped conditions
Managerial	**Financial**
Untimely decision-making, operational planning errors, incompetence of management	Increase in cost during the production of works, as a consequence, a decrease in the effectiveness of the project

of constraint, it can be divided into internal and external. External tightness can be characterized by the ratio of the free area of the construction site to the area of the land plot necessary for the rational organization of construction, the placement of machines and mechanisms, i.e. construction equipment, storage of structures and materials, as well as the location of a household town. The external tightness shows the working conditions on the construction site. Internal constraint refers to the presence of obstacles in the intra-object space. For example, such restrictions as: special equipment that is technically impossible to dismantle or its elimination is economically unprofitable, existing building structures. Internal tightness determines the construction technology, linking reconstructive work in time and space, characterizes the conditions of the organization of workplaces, the limitations of the formation of the front of work, as well as the difficulty of intra-object movement of the building structures used. An important factor in choosing the method of reconstruction is the technical condition of the building, therefore, before the start of reconstruction work, an inspection of the existing building is necessarily conducted [7].

Currently, one of the priority tasks is energy conservation. This is due to the shortage of basic energy resources, the increasing cost of their extraction, as well as global environmental problems. This problem should be solved with the help of reconstruction of buildings. The diverse experience of energy-efficient construction in the world presents the possibility of dividing it into two main directions — energy-passive and energy-active construction. The construction of an energy-intensive building provides an opportunity to exclude the use of a heating system, since such a building is characterized by low heat consumption. Passive construction is designed to provide a comfortable environment in the building, provided that the consumption of thermal energy is reduced, the operation of cooling systems, ventilation and artificial lighting is optimized. These conditions are provided by the use of additional insulation of enclosing structures, the introduction of recovery systems that collect and store warm air from the ventilation system inside the premises, the system for collecting precipitation in the form of rainwater. An energy-active house is characterized by the use of new technologies and modern control systems to reduce the energy load and ensure the independence of the building from external energy sources, ensuring independent energy generation [8].

Resource — and energy-saving technologies have become widespread:

- process automation systems;
- local and autonomous power and heat generation systems;
- cogeneration systems.

The cogeneration system is a complex of complex technical equipment designed for the joint production of electricity and heat. The cogeneration plant includes the following elements: an internal combustion engine, a generator, a heat exchanger system and a control system that allows the installation to be controlled both on-site and from a remote location via a computer or cell phone. Such installations are decentralized energy sources, which means that this system operates in direct proximity to the place of consumption, in this regard, the costs of energy pipelines and energy losses during transportation are significantly reduced (Fig. 3) [9].

Modern technologies can significantly reduce energy consumption, reduce maintenance costs and increase efficiency coefficient. It also provides great savings if, instead of separate central heating points, an individual heating point is placed in the building, equipped

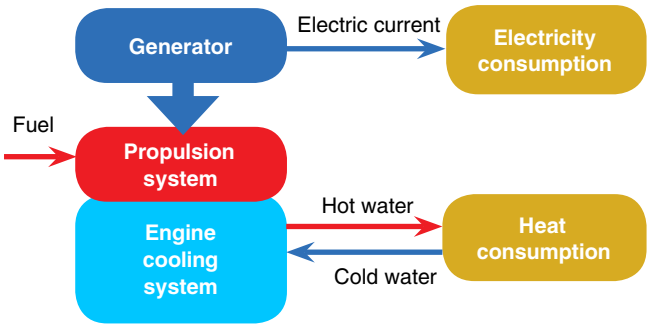

Fig. 3. General scheme of cogeneration

with modern silent pumps, compact and efficient plate heat exchangers. Another area of resource saving and environmental friendliness is the technology of green construction, which can also be used during reconstruction.

Green construction is a full cycle of design, construction and operation of buildings, the main concept of which is the effective introduction of innovative technologies and materials, as well as compliance with environmental safety standards throughout the life cycle of buildings. The main task of such construction is to reduce the level of consumption of energy resources, as well as to increase the comfort of the indoor environment. The construction of such buildings seeks to save money through the introduction of modern management, control and optimization of all systems [10].

Technologies of green construction:

- combined heat and power generation;
- production of green bricks from recycled materials, which are very light in weight and have improved insulation properties;
- use of secondary raw materials in the manufacture of a number of building materials and structures (bricks, flooring, window frames and doors) in order to reduce the consumption of natural resources;
- priority to external glazing of buildings in order to maximize the use of solar energy and, as a result, reduce the cost of heating and lighting of the building;
- implementation of BIPV (Building Integrated Photovoltaics) — modern autonomous installations for converting solar energy into electrical energy using a new generation of solar modules integrated into the building structure (facade or roof) (Fig. 4).

Considering modern technologies that need to be implemented in the reconstruction, it is impossible not to mention the “intelligent” systems of the building. Such systems by automating control systems are designed to ensure control of energy consumption and increase the controllability of engineering systems at home. Such a Building Management System consists of two subsystems: dispatching and automation of engineering systems. The peculiarity of such a building is the integration of individual subsystems into a single managed complex. The automation and dispatching system of the building's engineering equipment provides automatic control, regulation, necessary interlocks, protection from emergency modes, as well as centralized automatic control and remote control of the building's engineering systems. The latest video monitoring, fire and burglar alarm systems — lead to an increase in the safety of the building. Also, novelties are being introduced for such systems, for example, automatic transmission of meter readings, a system for monitoring water leakage, for operational analysis of consumption and emerging problems, which will

Fig. 4. Application of BIPV technology (Building-integrated photovoltaics). URL: https://www. ardexpert.ru/

reduce the amount of resource consumption, or video intercoms to increase security [10, 11].

The recuperation system is also an example of innovative options, such a system takes air from the toilet, cleans it from harmful impurities, heats or cools it, depending on the set mode, and only then feeds it to the apartment. The concept of a smart building creates conditions for saving resources for heating, cooling, water supply and waste collection. Intelligent solutions provide stability, a degree of safety, additional characteristics to preserve the value of assets for the owner. Asmart building is a combination of energy, technology, telecommunications and other building systems that facilitate the automation of advanced construction methods.

The latest aeroponics biotechnology is being introduced, capable of revolutionizing the provision of conditions for vertical and surface gardening. This biotechnology represents artificially created climatic conditions for plant growth and development in the complete absence of soils and substrates, where plant roots are freely placed in an aeroponic model and receive a nutrient solution by spraying in the form of mist or microdrops, which ensures the presence of an air-nutrient medium (Fig. 5).

Aeroponics has many advantages that determine the expediency of its use in the packaging of a green reconstruction, the main ones are the supply of a nutrient solution, and other processes are controlled by a computer and correspond to the phases of plant development; crops grown on aeroponics are characterized by a particularly high rate of growth and maturation; environmental friendliness associated with the use of a closed-loop system a cycle in which there is no complete utilization of the nutrient solution, there is no use of pesticides, soil or substrates. The aeroponics method allows for accurate and rapid control over all technological processes of plant growth and development, while being characterized by a high energy and material intensity of technology.

The practice of using smart-glass is currently widespread in the field of green reconstruction. Its characteristics represent the possibility of introducing it into the glazing system of reconstructed buildings. A special complex of nano-sprays allows you to save on lighting, keep warm and prevent excessive heating from sunlight (Fig. 6) [11].

STUDY RESULTS

The important tasks of the digital age include meeting the needs of the population and making a profit for the investor. Advanced technologies make it possible to extract additional efficiency and profitability in all spheres of urban life, increase the level of sustainable development, open up prospects for new ways of construction and reconstruction and arrangement of living space. The existing system of organizational and technological

Fig. 5. Examples of aeroponics technology application. URL: https://www.greenhouses.ru/

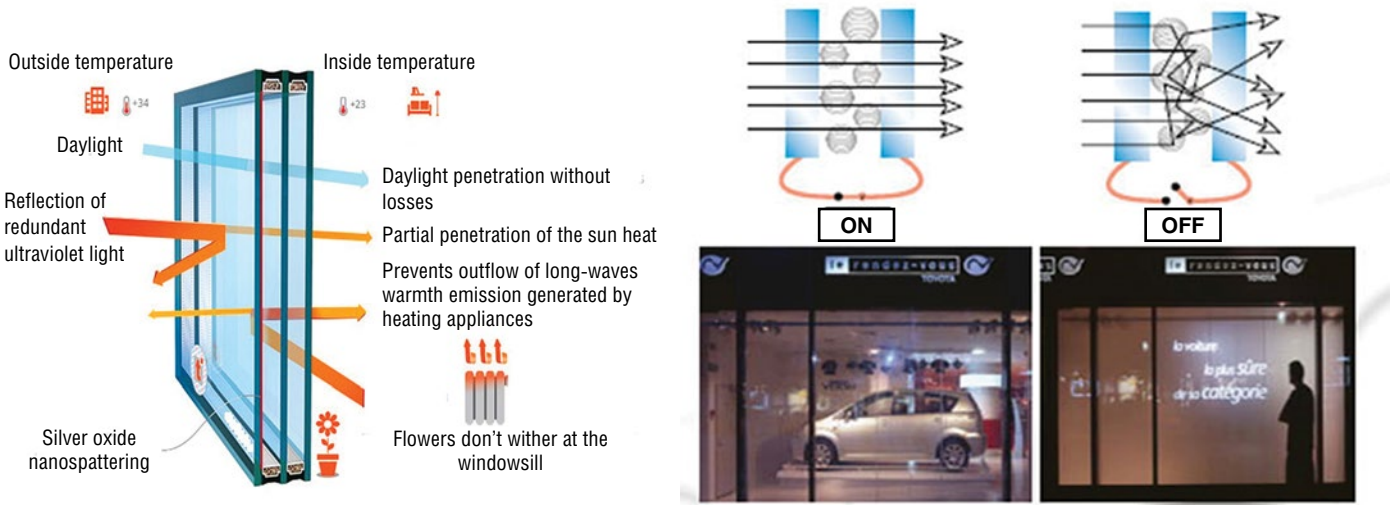

Fig. 6. Smart-glass device schematic. URL: https://www.almaokna.kz

methods of reconstruction in modern realities requires modernization and new approaches to this activity, both at the design stage and at the stage of reconstruction work. Such improvements can be expressed in the form of a schematic model of green reconstruction. Such a model will allow to achieve maximum efficiency of the project taking into account environmental friendliness, energy efficiency, safety and comfort [12].

Green reconstruction is an innovative reconstruction that applies various modern technologies to improve the quality of life, increase its competitiveness, while ensuring that the needs of current and future generations are met in terms of economic, social, environmental and technical aspects. The concept of green reconstruction differs from other concepts in that it does not focus only on information and communication innovations, but it is also focused on achieving a new level of quality in management, organization and control during reconstruction (Fig. 7).

Elements of the model of green reconstruction.

1. Technologies.
2. Ecological safety.
3. Safety.
4. Comfort.
5. Quality.

The concept of green reconstruction is associated with environmental friendliness, innovation, high-tech clusters, information and communication technologies. Since green ecological and technological changes in the development of the urban environment are largely associated with an increase in the efficiency of the use of all types of natural resources, environmental friendliness becomes a key element of the green design. The concept of green reconstruction cannot be implemented without smart management of all components of the organizational model, which in turn cannot be implemented without human participation. All this is created by specialists for the well-being of the population, to ensure the quality and comfort of living, which is also the key elements of the concept [13].

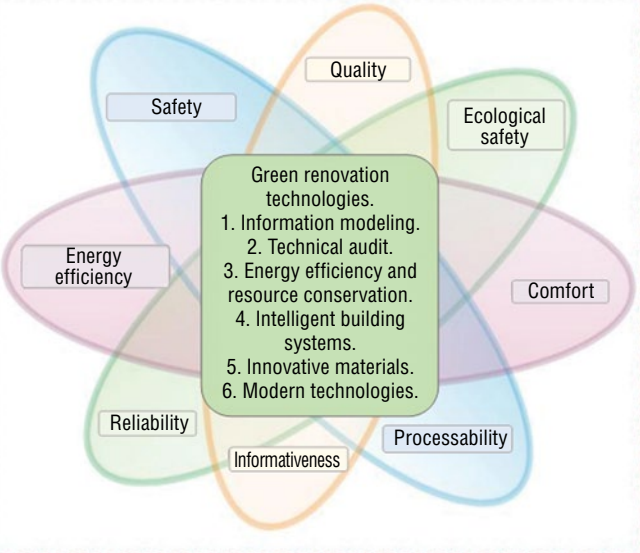

Fig. 7. Organizational model of green reconstruction

Table 2. Opportunities and threats to the implementation of green reconstruction

Opportunities	Threats
Improving the quality of life and comfort of living	High cost of innovative technologies
Improving the quality of reconstruction process management	Project risks are high
Solving pressing economic and social problems through the introduction of innovations	Lack of demand from the unprepared population
Improving resource efficiency	High dependence on the supply of components from abroad
Reducing the time spent on the implementation of projects	
Reduction of financial costs in the field of resource conservation	

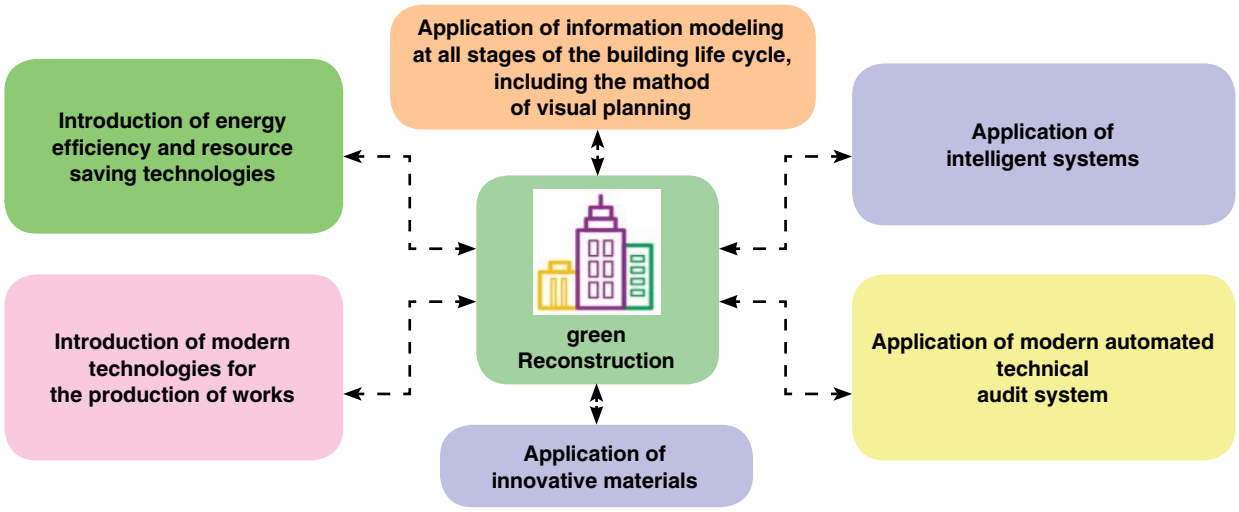

Fig. 8. Components of the green reconstruction model

In the Table 2 the possibilities and threats of the implementation of the green reconstruction model are considered.

The components of the model can be implemented individually or in certain combinations, depending on the goals of the project.

The analyzed methods and approaches to reconstruction have shown a certain "conservatism" in the organization of reconstruction, which is why there is an increasing need to improve these methods with the help of modern technologies of green architecture and information modeling. The modern approach to the organization of reconstruction creates conditions for saving resources, reducing the time of work, improving the efficiency and environmental friendliness of projects (Fig. 8) [14, 15].

CONCLUSION

The reconstruction of real estate is a complex multifaceted problem. The solution of this kind of issue in each specific situation takes into account the following aspects: technical, environmental, economic, social, aesthetic and resource. The improvement and introduction of new progressive technologies into the reconstruction process will stimulate the subsequent increase in efficiency and contribute to the development of green reconstruction, as well as determine the success of its social, urban planning and technical tasks. It is reasonable and environmentally justified to consider the introduction of green technologies into the processes of reconstruction of urban environment objects, in the structure of which spaces for landscaping are structurally designed — terraces, winter and summer gardens, green balconies, facade landscaping, as well as stylobate-platform platforms for landscaping are formed on top of the operated flat coverings of buildings and structures. Such a direction has a sufficiently large environmental potential, which can be effectively implemented in objects of various functional purposes. The trend of green reconstruction has a conceptual focus on improving the ecological quality of the urban environment and the introduction of innovative technological solutions.

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Реконструкция сложившейся застройки в контексте «зеленой» архитектуры города

Развитие городской среды связано не только с увеличением плотности жилых кварталов, повышением этажности деловых районов и интенсивным развитием инфраструктуры, но и изменением функционального назначения отдельных городских зон. Наибольший потенциал развития внутригородских территорий располагается в центральных и исторических зонах. Одним из важнейших аспектов развития городской среды является проведение комплексной регенерации территорий сложившейся застройки города, направленное на создание благоприятных условий проживания и эффективное использование производственного, инженерного, научного и других потенциалов строительного комплекса.

Актуальность исследования, рассмотренного в данной статье, обусловлена необходимостью создания организационной модели по реконструкции сложившейся застройки и выбора наиболее оптимальной траектории их развития и эффективного использования. В статье рассмотрены общие принципы разработки организационно-технологической модели, позволяющей оценить и оптимизировать пути развития при использовании принципа «зеленой» реконструкции, а также оптимизации в использовании городского пространства.

Особое внимание акцентируется на необходимости формирования и внедрения в городскую среду концепции «зеленой» реконструкции путем интегрирования элементов озеленения и энергосбережения в объемно-пространственную структуру зданий. Данная тенденция вызвана острой необходимостью повышения экологического качества городской среды для улучшения комфортности жизни городского населения, восстановления нарушенного баланса взаимодействия человека и природной среды и обеспечения устойчивого развития городской среды с учетом современных тенденций.

Ключевые слова: *«зеленая» реконструкция, «зеленая» архитектура, городское пространство, регенерация, реконструкция, организационная модель, развитие городской среды, застройка города, энергосбережение*

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