

ISSN 2073-8412 (PRINT)

ISSN 3034-1485 (ONLINE)

МЕЖДУНАРОДНЫЙ

НАУЧНО-ТЕХНИЧЕСКИЙ

ЖУРНАЛ

НЕДВИЖИМОСТЬ

ЭКОНОМИКА / УПРАВЛЕНИЕ

12+

4/2025

INTERNATIONAL

SCIENTIFIC & ENGINEERING MAGAZINE

REAL ESTATE

ECONOMICS / MANAGEMENT

4/2025

ISSN 2073-8412 (Print)

ISSN 3034-1485 (Online)

НЕДВИЖИМОСТЬ

ЭКОНОМИКА ■ УПРАВЛЕНИЕ

Учредители:

Федеральное государственное бюджетное образовательное учреждение высшего образования «Национальный исследовательский Московский государственный строительный университет» (НИУ МГСУ);
Издательский дом «АСВ»

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Основан в 2001 году. Выходит 4 раза в год.

Подписан в печать 29.12.2025.

Выход в свет 30.12.2025

СВИДЕТЕЛЬСТВО О РЕГИСТРАЦИИ СРЕДСТВА МАССОВОЙ ИНФОРМАЦИИ: ПИ № 77-11025 от 30 октября 2001 г. выдано Министерством Российской Федерации по делам печати, телерадиовещания и средств массовых коммуникаций. Адрес в сети Интернет: <http://n-eu.iasv.ru/>

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Тел.: +7 (968) 903-00-04; e-mail: journals@mgsu.ru
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**Уважаемые читатели!**

Строительство и недвижимость представляют собой развивающуюся сложную динамическую систему, в рамках которой происходит постоянное совершенствование строительных фирм и управляющих компаний, их интеграция и углубление отраслевой специализации. При этом строительные фирмы отличаются большим разнообразием по своим технико-экономическим характеристикам, числу занятых, объему строительных работ, величине используемого основного капитала, структуре и функциями и т.д.

Организационные механизмы взаимодействия субъектов инвестиционного процесса строительства включают разнообразные типы организаций и договорных отношений, используемых для решения конкретных инвестиционных задач. В практике отечественного строительства прослеживаются три типа организации инвестиционного процесса: *традиционный тип* организации (хозяйственный и подрядный методы), *проектно-строительный тип* организации (проектное управление) и *профессиональное управление* (девелоперский метод).

Система управления инвестиционными проектами, в основе которой девиз «время – деньги», предполагает образ мышления и деловую политику в сфере строительства с его капиталоемкостью и длительностью инвестиционного цикла, т.е. систему управления проектами можно рассматривать как управление инвестиционным циклом и всеми его участниками.

Этим вопросам посвящен номер журнала.

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АКЦЕНТЫ НОМЕРА

Яськова Н.Ю.
В складывающихся реалиях становится чрезвычайно важно сориентировать человека, направить его способности в конструктивное русло, создать комфортную внешнюю и внутреннюю среду для его развития

Сезёмин Д.Е.
В статье рассмотрены вопросы российских и международных решений в области инноваций в проектах комплексного развития территорий

Канхва В.С., Егоров А.А.
Настоящая статья посвящена исследованию жизненного цикла программы реновации жилищного фонда городов, который охватывает подготовку, проектирование, строительство, переселение и последующую эксплуатацию обновленной недвижимости

Бовсуновская М.П., Воронин И.А.
В данной статье проводится комплексный анализ возможностей и ограничений применения технологии информационного моделирования (ТИМ/ВІМ) в контексте управления стоимостью строительства на этапах жизненного цикла инвестиционно-строительного проекта

Тагиров Т.К., Орлов А.К.
Переход к системе мастер-планирования рассматривается как один из ключевых инструментов модернизации градостроительной практики

Адамцевич Л.А.
В статье представлен подход к управлению жизненным циклом объектов строительства в программах КРТ на основе организационно-технологической документации, включающий алгоритм специализированного программного обеспечения для автоматизации процессов планирования, контроля и анализа

1 РАЗДЕЛ — ОФИЦИАЛЬНЫЙ РАЗДЕЛ

6 Яськова Н.Ю.
Горизонты развития сферы недвижимости различных экономических сегментов

2 РАЗДЕЛ — ТЕМА НОМЕРА

12 Сезёмин Д.Е.
Инновации при реализации проектов комплексного развития территорий: российские и мировые тренды

3 РАЗДЕЛ — ЭКОНОМИКА И МЕНЕДЖМЕНТ НЕДВИЖИМОСТИ

17 Канхва В.С., Егоров А.А.
Жизненный цикл программы реновации: идентификация, анализ и систематизация рисков

24 Бовсуновская М.П., Воронин И.А.
Стоимостный инжиниринг в реализации проектов промышленного строительства с применением технологии информационного моделирования

4 РАЗДЕЛ — ГРАДОРЕГУЛИРОВАНИЕ И УПРАВЛЕНИЕ ЖИЛИЩНО-КОММУНАЛЬНЫМ КОМПЛЕКСОМ

29 Тагиров Т.К., Орлов А.К.
Проблемы и перспективы перехода к системе мастер-планирования в градостроительной деятельности

32 Адамцевич Л.А.
Управление жизненным циклом объектов комплексного развития территорий на основе организационно-технологических решений

Семенов А.Л., Курбаков Д.Е., Косенкова Ю.К.

40

Кластеризация и алгоритмизация конфликтов в рамках комплексного развития территорий

5 РАЗДЕЛ — ТЕХНОЛОГИЯ И ОРГАНИЗАЦИЯ СТРОИТЕЛЬСТВА

Новикова А.Ю., Беляков С.И.

45

Современный этап развития механизмов регулирования процедур технологического присоединения объектов капитального строительства

6 РАЗДЕЛ — ОТЕЧЕСТВЕННЫЙ И ЗАРУБЕЖНЫЙ ОПЫТ

Носков И.С., Бороздина С.М.

51

Создание унифицированной методики оценки выбора типа строительства в Арктике на основании совокупного экономического эффекта ключевых параметров строительства в регионе

Телепнева О.А., Кузнецов А.И.

57

Международный проект АЭС как драйвер комплексного развития территорий

7 РАЗДЕЛ — ПРАВОВЫЕ И СОЦИАЛЬНЫЕ АСПЕКТЫ

Зубахин Н.А., Акристиний В.А.

63

Особенности производства судебной строительно-технической экспертизы в отношении объектов самовольной реконструкции

8 РАЗДЕЛ — В МИРЕ ИНТЕРЕСНОГО

Селезнёва А.И.

69

Проектирование городской среды на основе продюсерского подхода к развитию малых городов

АКЦЕНТЫ НОМЕРА

Семенов А.Л., Курбаков Д.Е., Косенкова Ю.К.

С реализацией инвестиционных проектов связано множество проблем, среди которых социальные, организационно-коммуникационные, финансовые и нормативно-законодательные риски

Новикова А.Ю., Беляков С.И.

Инженерное обеспечение объектов капитального строительства представляет собой один из фундаментальных компонентов современной градостроительной деятельности и жизнеобеспечения урбанизированных территорий

Носков И.С., Бороздина С.М.

Повышение значимости роли Арктической зоны Российской Федерации и Северного морского пути, в частности в совершенствовании различных аспектов строительной отрасли страны, достижении целей национальной и экономической безопасности государства, мотивирует научное сообщество тщательнее изучать специфику региона

Телепнева О.А., Кузнецов А.И.

В статье освещаются взаимоотношения Российской Федерации и Арабской Республики Египет в сфере атомной энергетики, их соглашение о сотрудничестве в сооружении и эксплуатации атомной электростанции на территории Египта, рассматриваются сложности, возникшие при реализации проекта, а также описываются и систематизируются результаты и эффекты проекта

Зубахин Н.А., Акристиний В.А.

В статье освещаются вопросы особенностей проведения исследования объектов капитального строительства, обладающих признаками самовольной реконструкции в рамках судебной строительно-технической экспертизы

Селезнёва А.И.

В статье рассматривается проблема деградации малых городов и обосновывается необходимость применения нового управленческого подхода — продюсерского — для их устойчивого развития

REAL ESTATE:
ECONOMICS, MANAGEMENT

Scientific and technical journal

Founded in 2001. Published quarterly
Founders: Moscow State University of Civil Engineering (National Research University) (MGSU), ASV Publishing House
The Journal has been included in the list of the leading review journals and editions of the Highest Certification Committee of Ministry of Education and Science of Russian Federation in which the basic results of PhD and Doctoral Thesis are to be published.
The subject matter coverage complies with the approved list of scientific specialties:
5.2.3. Regional and sectoral economics (economic sciences);
2.1.7 Technology and organization of construction (technical sciences);
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Photographer's work printed on the cover
Yankovskyy A.V.

Address: MGSU,
26 Yaroslavskoye shosse, Moscow, 129337
Tel.: +7 (968) 903-00-04;
e-mail: journals@mgsu.ru
On-line version of journal: <http://n-eu.iasv.ru/>
Signed for printing: 29.12.2025

SECTION 1: OFFICIAL SECTION

- 6
- Yaskova N.Yu.**
Development prospects for the real estate sector in various economic segments

SECTION 2: COVER STORY

- 12
- Sezemin D.E.**
Innovations in the implementation of integrated territorial development projects: Russian and global trends

SECTION 3: PROPERTY ECONOMICS AND MANAGEMENT

- 17
- Kankhva V.S., Egorov A.A.**
Life cycle of a renovation programme: identification, analysis and systematization of risks
- 24
- Bovsunovskaya M.P., Voronin I.A.**
Cost Management in Industrial Construction Projects through Building Information Modelling

SECTION 4: URBAN REGULATION AND MANAGEMENT
OF HOUSING AND PUBLIC UTILITIES

- 29
- Tagirov T.K., Orlov A.K.**
Problems and prospects of transition to the master planning system in urban development practice
- 32
- Adamtsevich L.A.**
Lifecycle management of integrated territorial development projects based on organizational and technological solutions
- 40
- Semenov A.L., Kurbakov D.E., Kosenkova Yu.K.**
Clusterization and algorithmization of conflicts within the framework of integrated territorial development

SECTION 5: TECHNOLOGIES AND ORGANIZATION OF CONSTRUCTION

Novikova A.Yu., Beliakov S.I.	45
Current stage of development of mechanisms for regulating the procedures for technological connection of capital construction projects	

SECTION 6: DOMESTIC AND OVERSEAS EXPERIENCE

Noskov I.S., Borozdina S.M.	51
Development of a Unified Methodology for Assessing the Choice of Construction Type in the Arctic Based on the Aggregate Economic Effect of Key Regional Construction Parameters	

Telepneva O.A., Kuznetsov A.I.	57
International Atomic Energy Project as a driver of integrated development of territories	

SECTION 7: LEGAL AND SOCIAL ASPECTS

Zubahin N.A. Akristiniy V.A.	63
Conducting forensic construction and technical expertise in relation to unauthorized reconstruction projects	

SECTION 8: IN THE REALM OF EXCITING THINGS

Selezneva A.I.	69
Urban environment design based on a producer approach to the development of small towns	

ACCENTS

Yaskova N.Yu.
In the current reality, it is becoming extremely important to guide people, channel their abilities in a constructive direction, and create a comfortable external and internal environment for their development
Sezemin D.E.
The article discusses Russian and international solutions in the field of innovation in integrated development projects
Kankhva V.S., Egorov A.A.
This article is devoted to studying the life cycle of urban housing renovation programs, which encompasses preparation, design, construction, relocation, and subsequent operation of renovated real estate. Special attention is given to identifying, analyzing, and classifying risks associated with each stage of implementation
Bovsunovskaya M.P., Voronin I.A.
This article provides a comprehensive analysis of the potential and limitations of using building information modeling (BIM) technology in the context of construction cost management throughout the lifecycle of an investment and construction project
Tagirov T.K., Orlov A.K.
The article examines the key problems and prospects of introducing a master-planning system into urban development practice
Adamtsevich L.A.
The article presents an approach to managing the lifecycle of integrated development of territories facilities based on organizational and technological documentation
Semenov A.L., Kurbakov D.E., Kosenkova Yu.K.
There are many problems associated with the implementation of investment projects, including social, organizational, communication, financial, and regulatory risks
Novikova A.Yu., Beliakov S.I.
Engineering support for capital construction facilities is one of the fundamental components of modern urban planning and life support for urbanized territories
Noskov I.S., Borozdina S.M.
The growing importance of the Arctic Zone of the Russian Federation and the Northern Sea, particularly in enhancing various aspects of the national construction industry and achieving the objectives of national and economic security, motivates the scientific community to study the specific characteristics of the region more thoroughly
Telepneva O.A., Kuznetsov A.I.
The article highlights the relationship between the Russian Federation and the Arab Republic of Egypt at the field of nuclear energy, their agreement of cooperation in the construction and operation of a nuclear power plant in Egypt, examines the difficulties encountered in the implementation of the project, and also describes and systematizes the results and effects of the project
Zubakhin N.A., Akristinii V.A.
This paper is devoted to the features of construction-technical expertise conducting connected with an unauthorized reconstruction
Selezneva A.I.
The article examines the problem of small town degradation and substantiates the necessity of applying a new managerial approach — the producer model — for their sustainable development

Yaskova N.Yu.



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Development prospects for the real estate sector in various economic segments

Investment and construction projects in real estate sector are currently undergoing significant changes. Not only serving but also influencing the development of production and consumption sectors, real estate must rapidly respond to new and dynamically changing needs. The opportunities offered by new technological structures are driving these changes. Their potential makes it possible to reformat the technological processes of investment and construction activities in order to create conditions for their self-sufficient development and increased efficiency. Meanwhile, in the context of the transition to the post-industrial stage of development, it is impossible to ignore the emergence of the knowledge economy, the experience economy, the network economy, the bioeconomy, the generational economy, and other economic segments. They have new properties and characteristics. Consequently, it is not only a question of the degree of receptivity of the real estate sector to technological innovations. The search for completely new real estate formats that allow the structuring of living space to solve fundamentally new development tasks, as well as support business activity in the demanded segments of creative technologies, is becoming increasingly relevant. The future that is currently being built is impossible without the synthesis of ideas and meanings of development of many economic segments, materializing in real estate with new properties. Identifying and defining ways to solve problems that have never arisen before in the real estate sector is becoming a pressing task in forming a preventive approach to the deepest restructuring of the real estate sector.

Keywords: development goals, economic segments, investment and construction activities, real estate sector, project approach, structured space

INTRODUCTION

The new challenges facing humanity today encompass all spheres of human activity. These include threats to the existence of biological species as a result of the development of genetic engineering, virus modification, and the accelerated spread of genetically modified products without consideration of the long-term consequences, and growing conflict in all strata of society, and the correction of lifestyle models with increasing virtual effects, and new network-type communication mechanisms, and the segmentation of not only creative industries, but also economic approaches. In addition, modern humans are surrounded by a material world with rapidly changing properties (air, earth, and water are changing their composition, which cannot but affect physical and mental health), and the multiplicity of interests and aspirations is continuously and rapidly clustering society. It is divided, fragmented, and interest groups are formed that contradict each other to one degree or another. Their regulation is a non-trivial task of an interdisciplinary nature.

In the current reality, it is becoming extremely important to guide people, channel their abilities in a constructive direction, and create a comfortable external and internal environment for their development. In a poly-saturated information environment, without an awareness of the full range of opportunities and strategic norms, the choice of a model of life is increasingly becoming random, emotional, and short-lived, without taking into account not only the long-term consequences but also the real value for a particular person. Everything that flashes by in the information environment is increasingly offered in the virtual format of the experience economy [1].

Offers are professionally “packaged”, embellished, and in reality are far from always being as attractive and useful. The choice is staged and turned into exciting actions. This is probably only the beginning, and humanity will continue to improve the mechanisms of the experience economy with its inherent information and exhibition capabilities. Nevertheless, this does not negate the importance of direct contact with real goods, benefits, or the environment. As practice shows, it is not only not dying out, but is growing stronger, which predetermines the need to reformat the real estate sector, including the establishment and development of relatively new exhibition formats in the sphere of the experience economy.

One of the most important challenges of the present time is the problem of choosing the target priorities of the activities of all contractors in social development. This task is much broader than the solutions offered by the experience economy. The choice of possible exciting activities is dictated by fashion, imitation, sometimes protest, and, as research shows [2–4], is rarely a conscious preference. Understanding oneself, society, and nature, based on the correct analysis of reliable information and the application of methodological tools, is the subject of the knowledge economy. We emphasize that there is currently a truly unprecedented struggle among economic segments for the time of consumers of knowledge and goods/services. The resolution of this contradiction is seen in the implantation of a number of formats of the experience economy into the processes of the knowledge economy. This refers not only to educational games and teaching methods, but also to educational

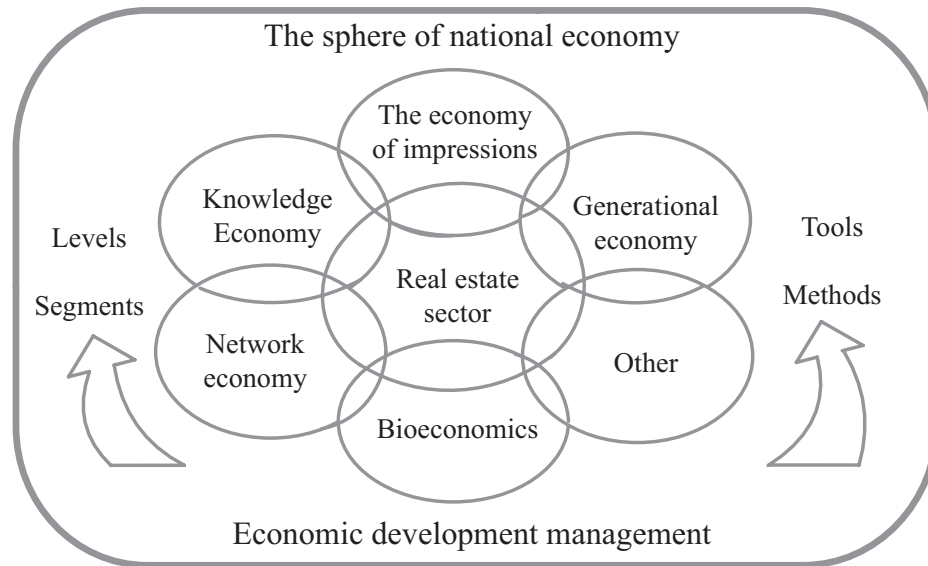


Fig. 1. Economic segments of the real estate sector

spaces in the real estate sector. As shown in Fig. 1, it is the real estate sector that has a unifying character.

Revolutionary changes in social real estate: schools, educational institutions, hospitals, clinics, parks, public areas, etc., clearly demonstrated the intentions of the Russian government in regarding the priorities of capital investment policy. The materialization of opportunities for economic segments to ensure the advanced development of people and society, citizens and the country, poses new challenges for the real estate sector, and perhaps the most important of these is overcoming conservatism in relation to real estate and searching for prospects for its modernization in all economic segments and at all stages of the life cycle.

MATERIALS AND METHODS

With regard to the methodological support for determining the development horizons of various economic segments in a spatial-temporal context, we note the need to answer the following questions:

- determining the place and role of the real estate sector in solving the priority tasks of forming and developing economic segments;
- researching the basic principles of the concept of developing specialized spaces in the real estate sector;
- studying approaches and emerging experience in ensuring the effective functioning of real estate objects in various economic segments;
- development of basic requirements for the spatial structuring of the real estate sector in the context of creating a unified balanced economic space in the country.

The problematic nature of the real estate sector development in various economic segments and the nature of the tasks set predetermine the use of an interdisciplinary approach. Classical economic analysis [5, 6], assessment tools [7], methods of forecasting and risk assessment [8–10], and, in general, the established and applied economic dogma are unable to answer many of the questions that arise. The application of economic theory to explain and evaluate non-economic behavior has proven to be clearly insufficient and unpromising. And this was felt first and foremost in practice.

Spaces structured according to the laws of the market economy clearly contradicted the scale of events and the content of processes. Responses to the challenges of time concerning the formation of the knowledge economy, the experience economy, the network economy, etc., were clearly delayed, reducing the ultimate effectiveness of measures and processes. In developing methodological approaches to the theory of sustainable development [11], it should be borne in mind that its cyclical nature is inherent in all phenomena and processes. The real estate sector is no exception. The cycle of economic development of specialized real estate in various economic segments is shown in Fig. 2.

We emphasize that the ultimate goal of each cycle of economic development is to build a unified, balanced, and sustainably developing economic space for the country. In other words, monitoring the mutual correspondence, proportionality, and adaptability of all subsystems of the real estate sector becomes the most important methodological requirement for organizing the management of real estate development.

In addition to the proposed development logic, it is of paramount importance to clarify the role of the state. The methodology and economic model of non-interference by the state in the development of the real estate sector has also failed, resulting in the formation of a real estate structure that lags behind modern development goals. In this regard, it should be recognized that state intervention in the development of the real estate sector was necessary not only to eliminate the "snowball" of unfinished housing construction that arose at the turn of the century, but also to transform the transport infrastructure, create a comfortable living environment, etc. The correctness of J. Keynes' postulates [12] at the current stage of the life cycle of social development has been confirmed. This fundamental conclusion required clarification and specification of the composition, structure, and scale of the state's use of real estate management methods. In particular, methods of goal setting, grouping, structural-dynamic analysis, content-analysis, predictive and foresight tools, assessment approaches, semantic comparisons, etc. make it possible to identify in a timely manner the main aspects and horizons of development of economic segments of the national economy and, on this basis, to refine the tasks of strategic maneuvering and operational transformation of the real estate sector.

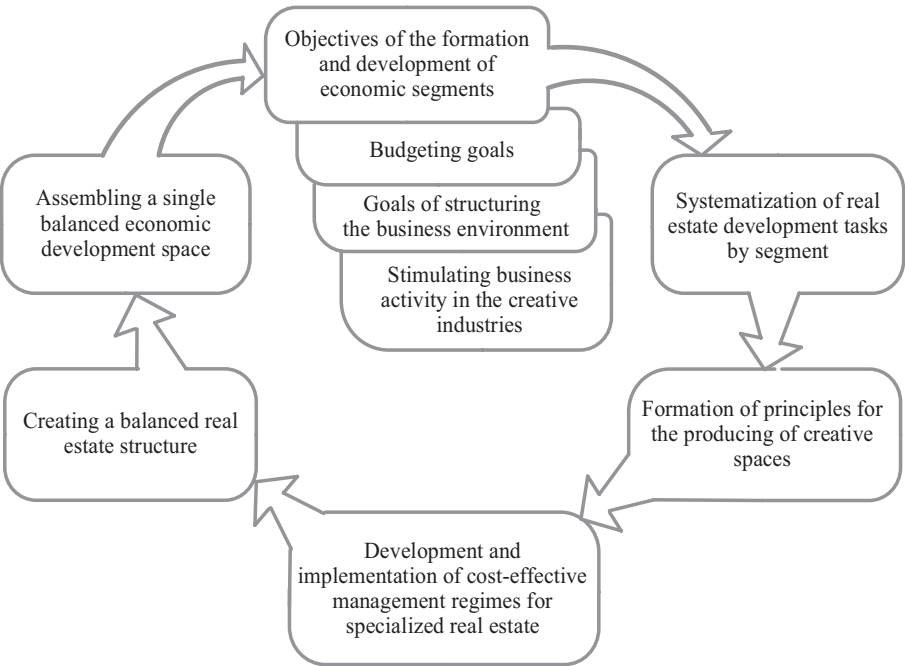


Fig. 2. The cycle of economic development of specialized real estate

RESEARCH RESULTS

A study of various applied aspects of spatial structuring to support the development of economic segments, based on surveys conducted by the Department of Investment, Construction Business, and Real Estate Management at the Russian Presidential Academy of National Economy and Public Administration, showed that only 10 % of respondents answered positively to the question of whether premises are suitable for education, sports, entertainment, medical treatment, health improvement, etc. This is due to the fact that in practice, the model of *rational choice* is most common. Until recently, its target focus was determined by the economic context, often abstracting from the broader task of maximizing the utility of a particular type of real estate [14]. Disputes about measuring utility have been ongoing throughout human history [15]. But in essence, no one denies the initial premise of correlating the expected result (benefit) with the necessary costs. The analysis showed that the answer to the question lies in the definition of the metrics. At the same time, it was found that the vast majority of researchers adhere to the idea of economic efficiency. And as the common saying goes, “they think about one thing, talk about another, and do a third”, the concept of fairness or maximizing utility is transformed into the concept of maximizing economic efficiency. Indeed, as has been proven [16], it creates real incentives to optimize the costs of maintaining, renovating, and capitalizing virtually all types of specialized real estate belonging to various economic segments — the knowledge economy, the network economy, the experience economy, etc. This does not directly contradict the idea of maximizing the value of existing real estate assets. Nevertheless, as early as 1878, Professor F.I. Enrold created a “Course on Bridges”, which should be built in a *practical, durable, inexpensive, and beautiful way!* At the same time, none of the conditions should be fulfilled to the detriment of the others! The task of control was performed at that time by the Ministry of Internal Affairs [17]. In this context, the role of the state is quite obvious.

Responding to the challenges of modern development, we note that the growing role of the state in the formation of specialized economic segments has economic justification. The process of reorienting capital investments not only towards socially oriented economic segments, but also towards more economically efficient economic niches, is accompanied in practice by higher transaction costs. These are far from always affordable for private business. At the same time, as operating modes are mastered and the benefits of entering various formats of economic segments are understood, state regulation takes on institutional forms, and the costs are transferred to non-state participants. At the same time, only institutions of centralized strategic planning of spatial development of real estate are capable of preventing excessive capital investment in a particular economic segment in a preventive manner. Thus, the consumer economy, reinforced by various formats of the experience economy and materialized in real estate such as shopping and entertainment centres (SEC), has clearly overloaded the urban commercial infrastructure. The SEC facing each other in the cities of Kursk, Saratov, Smolensk, and many other examples are a case in point.

The importance of establishing an institutional level of real estate development in various economic segments is confirmed by the fact that they are largely focused on the social sphere. Over the past five years, the pace of construction, major repairs, and reconstruction of social facilities has not fallen below 10 % annual growth¹. The pace of replenishment of real estate in the experience economy has not lagged behind. It covers the spheres of culture and art, sports, leisure and entertainment, modern media and mass communications, research and development, tourism and hospitality, etc. State regulation of their development is carried out within the framework of national projects using development programs. National projects (“Tourism and Hospitality Industry”, “Culture”, “Science and Universities”) are currently accompanied by relevant

¹ Strategy for the Development of the Construction Industry and Housing and Public Utilities of the Russian Federation until 2035. Association of Construction Organizations of Yekaterinburg and the Sverdlovsk Region : Internet portal of the SRO Association. URL: https://assrtm.ru/upload/files/documents/strategy_str_zhkh.pdf

strategies, development concepts, detailed roadmaps, etc. They provide not only deadlines, responsible executors, and specific development indicators, but also the necessary capital investments in construction projects. It should be noted that *concepts for the development of creative industries*, which also affect the manufacturing sector of the national economy, are being developed simultaneously [18]. Thus, in 2016, the Strategy for Scientific and Technological Development of the Russian Federation (No. 642) was approved by a decree of the President of the Russian Federation. The "Strategy for Spatial Development of the Russian Federation until 2025" (dated February 10, 2019, No. 207-r) laid the foundation for the spatial restructuring of the real estate sector. At the same time, at the time of its development, new economic segments were just beginning to form and the necessary structural shifts were not laid down. However, the principle of clustering was already taken into account at that time, and a "Map of Russian Clusters" was created². It included 118 clusters in 37 specialties, covering 4,000 enterprises and 1.5 million employees. It should be noted that it detailed exclusively the experience economy segment (tourism, media, television and film industry, publishing and printing, etc.). It was proposed to support investments in newly created real estate through measures such as subsidies, information support, and the organization of joint events to promote new products, services, and promising projects.

Measures to subsidize the development of priority clusters have been in use since 2012. However, as noted at the St. Petersburg Forum³, analysis over the past period has proven their formal and unsystematic nature. Moreover, as foreign experience in the development of creative industries convincingly shows, there is a clear lack of real estate at the "crossroads of art, culture, business, and technology" that would allow for the formation of a space for development. Thus, this conceptual omission is inherent not only in domestic but also in foreign practice.

When examining the basic conditions for the much-needed structural transformation of the real estate sector, it is impossible to ignore the problem of determining ways to involve the business community in the process of adapting investment and construction norms to the tasks of the new economy. The analysis showed that, to date, the semantic content of new economic segments, such as the experience economy segment, relates exclusively to components of the market product that evoke impressions and emotions at the level of perception of images, shapes, colors, smells, light, sounds, and other aesthetic properties of the market products themselves. The spatial characteristics of their display, environmental and communication design are adapted to the available premises, which do not always create an "atmosphere of acceptance". Thus, in practice, merchandising is reduced to the optimal presentation of goods. The creation of retail space is replaced by the adaptation of existing space.

With regard to segments such as the knowledge economy, generational economy, bio-agro economy, etc., the spatial configuration shows how the practices that have developed in our country are still far from ethical and moral incentives (charity, responsible consumption, environmental neutrality, etc.). It should be noted that these incentives work successfully in developed economies. They are also being successfully implemented in the PRC at present. For example, Xiaomi not only manufactures high-tech products, but also has specialized exhibition spaces and a tourist base in an ecologically clean area 30 km from Beijing on its balance sheet. A distinctive

feature of the Chinese company's approach is the symbiosis of using environmentally friendly building materials and equipment manufactured by the company to promote the idea of environmental responsibility among its employees and partners. It is this approach that has allowed the company to expand its use of *collaboration technologies*. This has made it possible to systematically expand the emotional component of its brand.

Collaboration as a modern method of joint activity to achieve a common result involves combining the resources of participants in relation to sought-after real estate objects. Of particular interest is the bringing together of representatives from different economic segments. This provides a real opportunity to utilize the potential and technologies of various types of activities. It is this type of collaboration that is commonly associated with *creative industries*, which are primarily characterized by a high potential for emotional engagement. Maintaining this requires exhibition and sports complexes, educational and digital clusters. Not to mention augmented and virtual reality! Collaboration between different economic segments on this basis will be able to form new competencies in education, leisure, and entertainment. At the same time, the one-sided use of simulation programs, such as those for production, training on specialized types of equipment, or programs for conducting chemical experiments, medical operations, etc., undoubtedly requires training and practice in the real world. Exhibitions and museums, catwalks and models, stadiums and training grounds are still in demand. The growth in the number of visitors to museums, concerts, and shows is convincing proof of this⁴. The same applies to tourism, which has long outgrown walking routes. A full-fledged tourism product is a complex of services in the hospitality industry, knowledge, and, of course, the experience economy.

The outcome of the battle for the consumer's "wallet" and, most importantly, for the time they are willing to spend on leisure, education, sports, health maintenance, or entertainment is partly predetermined by established values and stereotypes, and partly shaped by methods of attracting and involving various actors in the processes of creating and consuming market products. At the same time, technological innovations in the field of human emotion assessment and information gathering methods have been studied in sufficient detail and are being used in practice. At the same time, the tasks of adapting the real estate sector, aimed, on the one hand, at reformatting specialized development spaces and, on the other hand, at creating real estate objects with new configurations, functionalities, and operational capabilities, have not yet been determined.

CONCLUSION AND DISCUSSION

The evolution of economic theory and practice at the current stage of the life cycle of economic phenomena has revealed many new forms and mechanisms for setting target vectors for the development of the national economy. This has manifested itself in the segmentation of the economy and the emergence at the turn of the 21st century of relatively coherent and independent segments: the knowledge economy, the experience economy, the generational economy, and others. As the analysis has shown, each of these segments has not only its own type of consumers, operational, assessment, and communication tools, but also its own type of real estate. Their common feature is the creation of a developing creative space that corresponds to the goals of a particular segment. Technology package for modern real estate development in new economic segments is shown in Fig. 3.

² Map of clusters of Russia. URL: <https://map.cluster.hse.ru>

³ Recap of SPIEF 2025. St. Petersburg International Economic Forum. URL: <https://forumsfb.com/archive/2025/outcomes-of-spief>

⁴ Moscow Urban Forum. URL: <https://expo77.ru/event/mosurbanforum/>

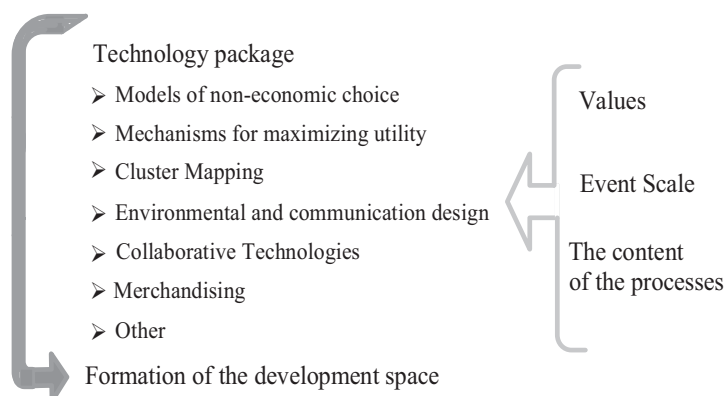


Fig. 3. Technological package of modern real estate development of new economic segments

Given the segmented nature and collaborative character of interactions among economic entities, newly constructed or modernized real estate properties must possess high aesthetic qualities and be not only multifunctional and highly adaptable, but also feature cost-effective operating modes and maintainability.

It should also be noted that the economic efficiency of capital investments in specialized real estate currently has significant growth potential, provided that combined financing and the introduction of collaboration technologies are implemented not only in the format of public-private partnerships, but also in various forms of consumer participation.

Systematizing the tools for the development of specialized real estate, we underline:

- the need to synthesize the sections and indicators of National Projects in terms of capital investments;
- the need to develop an independent strategy, concept, and mechanisms to ensure structural maneuvering and the creation of a unified, balanced economic development space;
- the high potential of modern innovative technologies in the development of real estate in all economic segments, which encourages the creation of a concept for technological support to address the problems of imbalance in the existing real estate structure.

Each of these areas requires decomposition not only by life cycle stages, management levels, and economic entities, but also by the types of technologies used, which requires clarification of a number of tasks of National Projects and sets qualitatively new goals for the formation of a unified space for the country's development.

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Горизонты развития сферы недвижимости различных экономических сегментов

Инвестиционно-строительные проекты в сфере недвижимости переживают в настоящее время существенные изменения. Не только обслуживая, но и оказывая влияние на развитие сферы производства и сферы потребления, недвижимость должна в ускоренном режиме удовлетворять новые, динамично меняющиеся потребности. Источником востребованных изменений становятся возможности нового технологического уклада. Их потенциал позволяет перестроить технологические процессы инвестиционно-строительной деятельности с целью создания условий ее самостоятельного развития и повышения эффективности. Между тем в условиях перехода к этапу постиндустриального развития невозможно игнорировать становление экономики знаний, экономики впечатлений, сетевой экономики, биоэкономики, поколенческой экономики и других экономических сегментов. Им присущи новые свойства и особенности. Следовательно, речь идет не только о степени восприимчивости сферы недвижимости к технологическим инновациям. Актуализируется поиск совершенно новых форматов недвижимости, позволяющих структурировать пространство жизнедеятельности для решения принципиально новых задач развития, а также поддержки деловой активности в востребованных сегментах креативных технологий. Выстраиваемое в настоящее время будущее невозможно без синтеза идей и смыслов развития множества экономических сегментов, материализующихся в недвижимости с новыми свойствами. Выявление и определение путей решения никогда ранее не возникавших проблем в сфере недвижимости становится актуальной задачей формирования превентивного подхода к глубочайшей реструктуризации сферы недвижимости.

Ключевые слова: цели развития, экономические сегменты, инвестиционно-строительная деятельность, сфера недвижимости, проектный подход, структурированное пространство

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For citation: Yaskova N.Yu. Development prospects for the real estate sector in various economic segments. *Real Estate: Economics, Management*. 2025; 4:6-11.

Для цитирования: Яськова Н.Ю. Development prospects for the real estate sector in various economic segments // *Недвижимость: экономика, управление*. 2025. № 4. С. 6–11.

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Innovations in the implementation of integrated territorial development projects: Russian and global trends

The paper discusses Russian and international solutions in the field of innovation in integrated development projects. It provides an analysis of the application of innovative solutions in the field of urban planning and the creation of a comfortable urban environment. Technological solutions of software systems in the field of business intelligence, which allow for the identification of problems and the proposal of solutions that help businesses to implement integrated development projects more effectively, are becoming increasingly relevant in the context of public-private partnership projects. The author's detailed analysis of the structure of integrated development projects helps to apply an innovative approach to each part of the project with maximum economic benefits. The integration of energy-efficient solutions, organizational and technological reliability assessment methods at all stages of the construction project life cycle, weather control systems, and green technologies into territorial development projects creates a positive economic effect from the innovative approach to the design and development of existing new territories. According to the author, innovations in legal regulation have a positive impact on the final implementation time of large-scale infrastructure projects. Smart cities and comfortable environments become centers of attraction for people, which helps to achieve the initial and main goals of implementing integrated territorial development projects.

Keywords: *integrated development, urban planning, urban environment, innovations in construction, smart city, energy saving*

The concept of "integrated territorial development" (hereinafter referred to as ITD) is fixed at the legislative level in the Urban Planning Code of the Russian Federation, which also defines the goals, types and some features of ITD projects. In the modern world, such tasks of the ITD come to the fore as:

- quality of the urban environment;
- efficiency of use of territories (both built-up and only planned for development, both residential and non-residential territories within urban and rural settlements);
- increasing the investment attractiveness of ITD projects;
- comprehensive infrastructure development;
- formation of objects of economic activity of the population within the projects of the ITD;
- other tasks.

The Urban Planning Code defines the ITD as "a set of measures carried out in accordance with the approved documentation on the planning of the territory and aimed at creating favorable living conditions for citizens, updating the living environment and common areas of settlements, urban districts"¹.

According to the author, the integrated development of territories is the most important strategic mechanism for the formation of the urban environment, its transformation, modernization and adaptation to modern requirements imposed by society and the state on cities and settlements. Infrastructure and energy within the ITD projects are becoming drivers, points of growth and attraction for the best

technologies and innovations. As in many, especially in high-tech sectors of the economy, which can fairly include urban planning, an innovative approach to the integrated development of cities and settlements is becoming a leader.

Innovations in the implementation of ITD projects play a crucial role in both the Russian and global economies. There are a number of global and domestic trends, and Russian innovations are leading in a number of industries interacting within the framework of the ITD. Thus, innovations in the ITD include:

- development and application of the latest technological solutions in construction, including new energy-efficient materials and resources, energy-saving solutions such as an "energy-efficient closed-loop house" using earth's heat;
- development and application of the latest methods of urban planning design, including the use of digital twins;
- inclusion of new environmental approaches and solutions in the requirements for the ITD;
- the use of digital technologies, including through the use of emerging opportunities in the field of artificial intelligence and big data analysis;
- innovative optimization solutions in the field of construction object life cycle management;
- innovative technologies in the field of organizational and technological reliability of construction at all stages of the life cycle of the facility;
- innovations in the use of technically complex construction facilities to provide energy-efficient energy resources for ITD projects;

¹ Urban Development Code of the Russian Federation of December 29, 2004. No. 190-FZ (as amended on July 31, 2025). URL: https://www.consultant.ru/document/cons_doc_LAW_51040/ (rus.).



Fig. 1. Assessment of the effectiveness of the innovation process in ITD projects

- innovations in legal issues related to taking into account the interests of all participants and owners of territories and facilities within the boundaries of the ITD-project;
- other innovative solutions, including those under development.

Let's take a closer look at the opportunities offered by modern ITD projects, taking into account the application of an innovative approach. The widespread use of technological and technical innovations in the form of artificial intelligence capabilities in the analysis of regulatory and project documentation makes it possible to significantly reduce the time spent on primary analysis of project databases.

The direction of innovations in energy efficiency opens up a wide range of opportunities to increase the economic profitability of ITD projects, both at the design and construction stages and at the operational stage.

For example, weather control systems for temperatures inside construction sites relative to the external environment are becoming particularly in demand in regions with abnormally cold or hot climates. For regions with a temperate climate, such systems bring effective checks on a relatively smaller scale, but along with other innovative methods of optimizing operating costs, they cannot be ignored in the design.

Digital twin technologies of urban environment objects are becoming indispensable in the implementation of ITD projects. Such technologies allow:

- based on a virtual copy of the city, recreated on the basis of real data, to simulate the state of the urban environment and, based on the accumulated data, make predictive development plans, help to formulate a dynamic approach to the ITD;
- design a management system for the infrastructural elements of the urban environment, including one that allows for real-time regulation of its operation;
- monitor the occurrence of failures and malfunctions online and receive requests for repair and restoration work;
- collect databases for subsequent analytics, while multifactorial models for data analysis actually become plastic material for obtaining certain conclusions about the work of urban systems;
- identify certain patterns in the functioning of all systems included in the ecosystem;

- predict the development and set goals for achieving the key indicators of the systems.

In the presented analytical material, the author systematizes, analyzes and offers solutions in the field of application of innovative approaches in complex processes within ITD projects, taking into account Russian and international experience. It should be noted that an integrated approach to territorial development can be an innovation in itself.

This approach is becoming innovative, used for the first time, for those locations that have not yet been built up or were not supposed to be built, and do not have developed planning documentation that meets modern requirements for comfort and quality of the urban environment. This situation can be typical for both residential and non-residential, including industrial buildings. Here, however, the economic feasibility of an infrastructure construction project comes to the fore in terms of the amount of financial resources spent and the beneficial effect per unit of investment.

The author proposes to systematize the methods of assessing the effectiveness of innovations in ITD projects in the form of a diagram (Fig. 1).

Analyzing current trends in innovative development within a comprehensive approach to territorial development, the author proposes the following systematization of innovations based on their impact factors.

1. Innovations that, at comparable costs, affect the quality of the urban environment, including residential and non-residential buildings. These innovations and their implementation results allow the developer of a ITD project to increase the efficiency of the investment funds invested in the project. This is achieved through:

- resource savings;
- increased user loyalty to the brand;
- increased sales rates and volumes within the project;
- energy security and energy efficiency.

2. Innovations that affect the efficiency of financial and non-financial resources by optimizing a number of processes within the ITD project (flow-based work methods, logistics management within and outside the project framework).

3. Innovations in energy efficiency and green construction for ITD projects that affect the savings of various types of energy resources.

4. Innovations that affect and enable the achievement of sustainable urban development in ITD projects, which aim to create

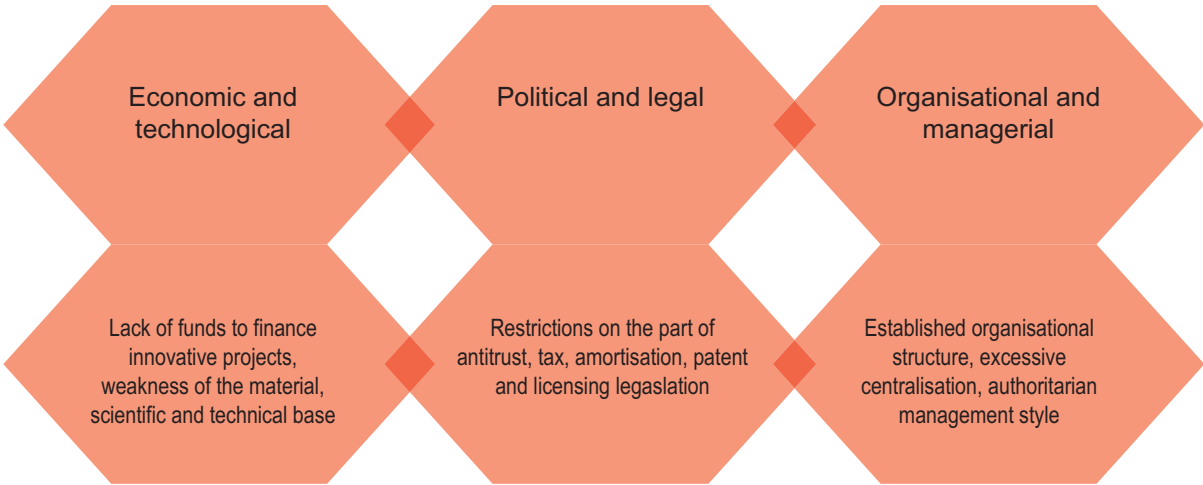


Fig. 2. Factors that influence the structure of the innovation process in ITD projects

construction facilities within ITD that harmoniously interact with the environment and have minimal negative impact on nature and the existing ecosystem throughout their entire life cycle. The sustainability of architecture and the development of innovations in this field are the most important areas of modern urban planning on an international scale, due to global environmental problems and the need to rapidly create a comfortable urban environment in the context of the ever-growing population of our planet.

5. Innovations that affect energy security. Thus, an example of research in this field of innovation is the global implementation of nuclear power projects in already built-up areas and newly built-up locations and scalable on the basis of innovative nuclear power plant projects “already implemented in some countries of the world (Turkey, Bangladesh, Hungary, etc.) (hereinafter referred to as NPP), incorporating ecosystem and infrastructure solutions, including renewable energy sources (hereinafter referred to as RES), smart city technologies, integrated infrastructure development of territories (hereinafter referred to as IIDT), when the bright idea... is that it is the small-capacity nuclear power plants (up to 200 MW) that can become the central axis of the urban planning ecosystem and remove the infrastructure constraints for the development of the economic and social spheres through the use of nuclear carbon-free energy, as well as replace outdated coal, fuel oil, and gas-fired power plants with increased CO₂ emissions into the atmosphere, transferring the projection of the Reimers ecosystem approach [1], where the central role is given to the Sun, to the modern eco-sustainable City, Agglomeration, State, and World” [2].

I would like to dwell a little more on the concept of a low-capacity ground-based nuclear power plant (hereinafter referred to as a LCGBNPP). In the global typology, LCGBNPPs are classified as nuclear reactors with a capacity of up to 300 MW (electrical) per power unit. This type of power generation has numerous advantages over large-capacity nuclear power plants, such as:

- the occupied area (which is crucial in historically established industrial zones);
- the cost of construction and operation;
- greater safety due to multiple safety redundancy;
- shorter construction time and increased service life;
- no need to modify the network infrastructure, etc.

The use of LCGBNPPs in industrial zones of urban agglomerations will significantly improve the energy balance of the metropolis

and make an unconditional contribution to achieving the goals of reducing carbon dioxide emissions into the atmosphere. In recent years, the United Nations has included nuclear energy in the so-called “green square”, along with renewable energy sources (hydropower, solar, and wind generation).

6. Innovations and ideas that affect the sociocultural component of ITD projects (Fig. 2).

A striking example of an innovative approach to solving the socio-cultural challenges facing the integrated development projects in Russian cities and settlements is the 200 Churches Programme, which is being implemented in the city of Moscow. In 2009, the Orthodox Diocese, represented by the Patriarch of Moscow and All Russia, proposed the idea of building two hundred churches within walking distance of the population in Moscow's integrated development areas. Thus, the need for churches within walking distance was analyzed, and in 2011, the first foundation was laid under this programme, which is currently being implemented jointly by the Russian State and the Russian Orthodox Church² [3].

“New churches are not only religious, but also social facilities, as they have clubs and sports sections for children and adults, film clubs, and also implement charitable and volunteer programmes”, said Sergey Levkin, Head of the Moscow Department of Urban Development Policy² [3].

It should be noted that the role of the capital's authorities is to provide territories within the framework of the ITD project for the construction of religious buildings. Territories are provided on the basis of legal acts issued by public authorities, including the quantitative criterion of “one church per 20,000 residents, with a walking distance of about 1 km”³.

As of the beginning of 2025, about 150 churches have been built, and, as Vladimir Resin notes, “in some districts of Moscow, such as the Southern, South-Western, Western, and North-Western districts, we have already reached the «equator» of our Programme. In the Eastern and North-Eastern districts, we are close to completion. However, Moscow is a city that is constantly growing. New residential areas are being developed, especially as part of the renovation and integrated development programmes. And in

² Orthodox church construction program in Moscow. Russian Orthodox Church. URL: <https://200hramov.ru>

³ “The 200 Temples Programme — Facts and Figures”. Pravmir magazine. 09.07.2015, URL: <https://www.pravmir.ru/programma-200-hramov-faktyi-i-tsifryi/?ysclid=mgthbzz16g101864963> (rus.).

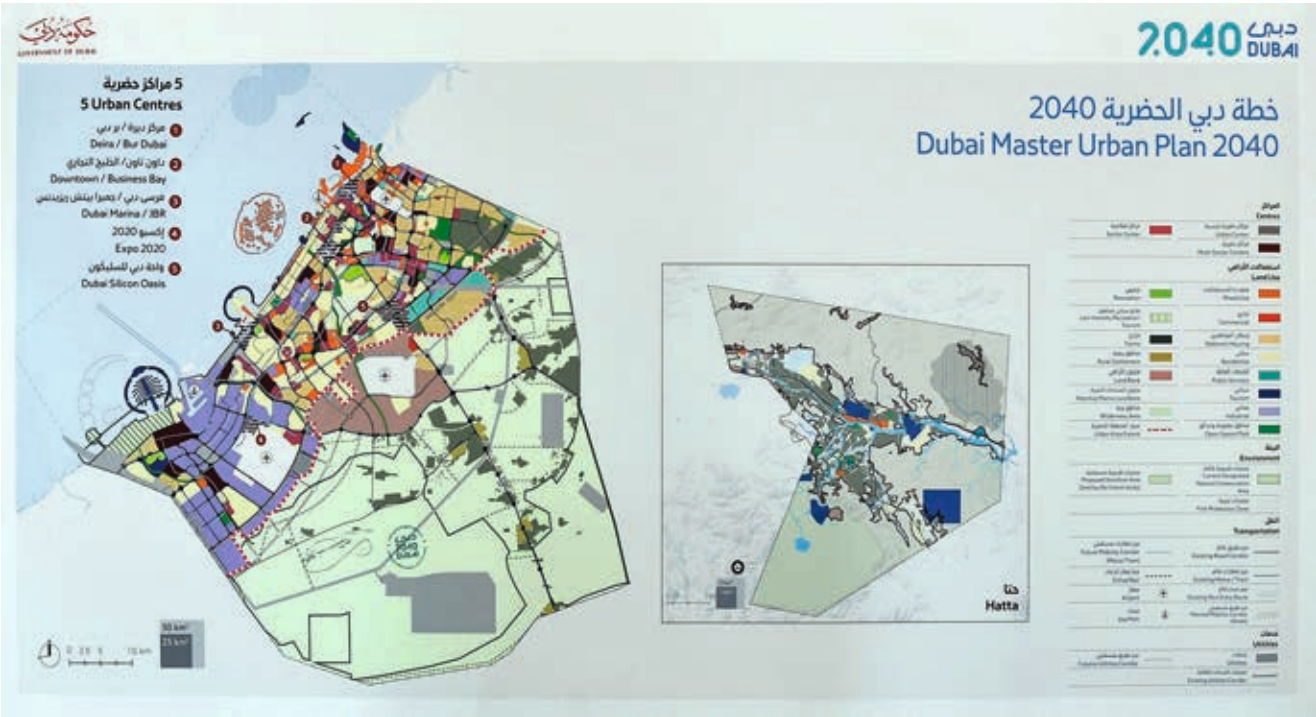


Fig. 3. Urban Planning Master Plan for the Emirate of Dubai until 2040

these new areas, people also want to have churches within walking distance”⁴.

As we can see from the analysis of the innovative approach to the integrated development of territories, innovations affect all areas of urban comfortable environment development. Of course, a separate line should be noted the creation of modern medical and educational clusters on the territory of the ITD projects. Currently, the analysis of the project experience of Russia and other countries using digital technologies and AI methods allows to include technically complex multifunctional construction and operation facilities in the ITD projects [4]. According to experts⁵ in the field of implementing ITD projects, “energy grid infrastructure, including heat and power grids, water supply, sanitation, and water treatment systems, as well as the use of alternative energy sources, becomes a driver for increasing the investment attractiveness of regions and territories when the network development is sufficient” [5].

In the international arena, according to the author of this article, the most striking and successful example of an innovative and comprehensive approach to territorial development is the creation of the United Arab Emirates in 1971. With a 54-year history, this project has a strong economic foundation based on oil revenues, combined with an innovative approach to development and the creation of high-quality infrastructure, as well as the development of territories that are not associated with residential functions, such as industrial and agricultural clusters and special economic zones.

⁴ “First comes the community: Vladimir Resin, curator of the 200 Program, explains why the demand for new churches in Moscow continues unabated”. Foma Magazine. February 17, 2025. URL: <https://foma.ru/snachala-rozhdaetsya-obshchina-kurator-programmy-200-vladimir-resin-rasskazal-pochemu-v-moskve-ne-oslabevaet-zapros-na-novye-hramy.html?ysclid=mgthfahuva637941885>

⁵ Egorova A. Investments in tourism as a driver of sustainable development of territories. RBC news agency. 01.04.2025. URL: <https://companies.rbc.ru/news/u4N7Lsx3bY/investitsii-v-turizm-kak-drajver-ustojchivogo-razvitiya-territorij/>

Thus, the officially published master plan for the development of the Emirate of Dubai contains development intentions until 2040⁶. Essentially, the master plan is an investment map of projects for the specified period of the Emirate's life cycle (Fig. 3)⁷.

Thanks to innovative strategies and technological solutions, once-deserted territories are becoming oases for living and doing business. Innovations in construction technologies, safety, and, in particular, fire evacuations in high-rise buildings, digital climate systems that regulate cold supply and energy efficiency, technologies for rapid-build buildings and construction on the seabed, are being dynamically developed based on the existing global experience of such construction, including the use of blockchain technologies for the secure storage of digitized design and technical documentation⁸.

The principles of sustainable urban development are included in the urban planning agenda of all countries. For example, the development programmes of European countries include the following principles:

- Research and innovation;
- Information and communication technologies;
- Principles of competitiveness for small and medium-sized businesses;
- Plans for achieving low-carbon economy goals;
- Fundamental principles of urban development, etc.⁹

⁶ Urban 2040 Master Plan. Dubai, 2040. UAE Beta. December 30, 2024. URL: <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/transport-and-infrastructure/dubai-2040-urban-master-plan>

⁷ Urban Master Plan. Dubai, 2040 (Dubai 2040 Urban Master Plan). UAE Beta 12/30/2024. URL: <https://u.ae/en/about-the-uae/strategies-initiatives-and-awards/strategies-plans-and-visions/transport-and-infrastructure/dubai-2040-urban-master-plan> (accessed: 11/17/2025).

⁸ Sharma P. The most exciting upcoming mega projects in Dubai & UAE (2025). 2024. URL: <https://www.novatr.com/blog/top-10-upcoming-projects-in-uae>

⁹ Sustainable urban development. European Commission. URL: https://ec.europa.eu/regional_policy/policy/themes/urban-development_en

► Non-profit organizations, including those established with the participation of government agencies, such as URBACT¹⁰, play an important role in promoting innovation in the ITD projects.

Thus, it is impossible to overestimate Vernadsky's scientific concept of the noosphere, where the world of nature and society, where human innovative activity is decisive, and the information generated by all kinds of innovative sensors for accounting and monitoring all processes, is the noosphere, the smart biosphere, or the digital infrastructure innovations of the urban environment, which are developed by the ITD projects [6].

The international and Russian practice of introducing innovations in the field of integrated development of territories is rich in technological solutions, and the possibilities for implementing new ideas and startups with subsequent registration in patent offices are boundless in terms of their existential meaning. The multifaceted nature of the innovations surrounding us is of interest to investors and government agencies, and each innovation described in the article is effective and manifests itself in new projects and solutions in integrated development of territories.

¹⁰ URBACT helps cities develop a comprehensive set of measures for sustainable change URBACT-2025. URL: <https://urbact.eu>

Инновации при реализации проектов комплексного развития территорий: российские и мировые тренды

В статье рассмотрены вопросы российских и международных решений в области инноваций в проектах комплексного развития территорий. Приведен анализ направлений применения инновационных решений в градостроительной сфере, формировании комфортной городской среды. Технологические решения программных комплексов в области business intelligence, позволяющие выявлять проблемы и предлагать способы их решения, помогающие бизнесу реализовывать проекты комплексного развития территорий более эффективно, становятся интересны при реализации проектов по модели государственно-частного партнерства. Проведенный автором подробный анализ структуры проектов комплексного развития территорий помогает применять инновационный подход в каждой из частей проекта с максимальным экономическим эффектом. Встраивание в проекты территориального развития энергоэффективных решений, методик оценки организационно-технологической надежности на всех этапах жизненного цикла объектов строительства, систем погодного регулирования и «зеленых технологий» формирует положительный экономический эффект от инновационного подхода к проектированию и застройке существующих новых территорий. Инновации в правовом регулировании, по мнению автора, положительно влияют на итоговые сроки реализации крупномасштабных инфраструктурно-значимых проектов. Умные города и комфортная среда становятся центрами притяжения людей, что позволяет достичь первоначальных и главных целей реализации проектов комплексного развития территорий.

Ключевые слова: комплексное развитие, градостроительство, городская среда, инновации в строительстве, умный город, энергосбережение

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For citation: Sezemin D.E. Innovations in the implementation of integrated territorial development projects: Russian and global trends. *Real Estate: Economics, Management*. 2025; 4:12-16.

Для цитирования: Сёземин Д.Е. Innovations in the implementation of integrated territorial development projects: Russian and global trends // *Недвижимость: экономика, управление*. 2025. № 4. С. 12–16.

UDC 690.12:658.512

Life cycle of a renovation programme: identification, analysis and systematization of risks

This article is devoted to studying the life cycle of urban housing renovation programmes, which encompasses preparation, design, construction, relocation, and subsequent operation of renovated real estate. Special attention is given to identifying, analyzing, and classifying risks associated with each stage of implementation. For this purpose, a detailed classification of risks has been developed, covering organizational, economic, technical, and socio-environmental aspects. A housing renovation programme represents a complex multi-stage process where every phase comes with specific risk factors. For instance, during the preparatory stage, issues arise concerning urban planning documentation, quality of engineering surveys, and project approval procedures. The construction works are exposed to risks such as insufficient funding, low-quality materials or equipment, adverse weather conditions, and potential legal disputes. The resettlement stage involves communication problems with residents, delays, and litigation processes. The graphic model of the programme's life cycle visualizes its structure and associated risks. The main objective of the study is to develop an effective monitoring and risk management system aimed at enhancing the success rate of implementing the programme and achieving planned indicators for modernizing large cities' residential infrastructure. Additionally, the authors propose optimizing decision-making procedures and coordinating efforts among all participants involved in each stage of the programme's execution. Effective risk management helps minimize negative consequences and improve overall efficiency by ensuring comfortable living conditions for citizens and long-term sustainability of implemented projects. This approach will significantly reduce financial and time costs while mitigating unfavourable impacts and enabling sustainable positive outcomes from the implementation of the renovation programme.

Keywords: *life cycle, renovation programme, risk classification, analysis, project implementation efficiency*

In accordance with the Resolution of the Government of Moscow dated August 1, 2017 No. 497-PP "The Renovation Programme for Housing Stock in Moscow", housing stock renovation in Moscow is a set of measures aimed at updating living environment conditions and creating favorable living conditions for citizens as well as public spaces to prevent an increase in dilapidated housing stock in Moscow, ensuring residential area development and improvement¹.

The solution to problems related to upgrading dilapidated housing in the country requires a special approach to developing and implementing regional renovation programmes. This determines the relevance of the research topic. The author focuses on studying the main stages of the programme's life cycle, such as the preparatory stage, construction stage, resettlement and operation stage.

Any programme envisages a phase of liquidation or closure. However, this study does not consider the closing stage of the programme due to the fact that, according to the experience of the capital city, it is impractical to liquidate or terminate the renovation programme. Therefore, the renovation programme should be made indefinite. After upgrading dilapidated housing, which mainly includes five-story buildings, nine- and twelve-story houses built in the 1960s and 1970s will come next in line for renewal. A proper understanding and implementation of the programme's life cycle stages, along with

risk management, contributes to improving the quality of the programme and ensures its effective realization [1].

The most important characteristic and feature of the process of development and implementation of urban investment programmes is its stage-by-stage or phased nature. The programme and projects included in it go through their entire life cycle. Considered together, they form a programme cycle. Research on scientific approaches to this problem has been conducted by domestic and foreign scholars such as V.I. Voropaev, V.D. Shapiro, A. Daien, F. Boucherel, E. Verzuh, T. Peters, S.E. Portney et al. Their studies mainly focus on project management, which serves as a theoretical basis for projecting established concepts from science and practice onto the field of urban construction-investment programmes [2].

Regardless of the complexity and scope of work required to implement these programmes, they all progress through specific states — phases (stages, steps) — in their lifecycle [3, 4].

The programme life cycle refers to the sequence of stages (phases) that a programme goes through from inception to completion and achievement of results. It describes the path of the programme as an integrated process encompassing sub-stages such as planning, execution, closure, or repetition of implementation cycles if multiple recurring cycles are provided within the programme framework.

There is no single universal method for dividing a renovation programme into life-cycle phases. In this study, the author proposes his own approach to separating the programme's life cycle into distinct stages (Fig.).

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¹ The Housing Stock Renovation Programme in Moscow City : Resolution No. 497-PP of the Government of Moscow dated August 1, 2017. Official website of the Mayor and Government of Moscow : official site. Moscow. URL: <https://www.mos.ru/authority/documents/doc/36739220>

► At each stage of the programme's life cycle, risks may arise that hinder achieving the programme goals. Realization of these risks can affect various indicators of programme effectiveness. Key performance metrics exposed to risk include:

- final cost;
- additional expenses and costs during implementation;
- work efficiency and quality;
- content.

Timelines for implementing individual stages and the overall programme [5–7].

The article outlines certain types of activities and processes carried out by participants at a particular stage of the renovation programme life cycle (Fig.). Additionally, the author identifies potential risks associated with performing these tasks activities [3].

Risk identification involves detecting and analyzing potential risks capable of influencing the outcomes and objectives of a programme. This process includes continuous discovery and examination of diverse factors, circumstances, threats that could lead to negative consequences or uncertainties. Risk identification is crucial for successful and effective programme management. Continuous

risk identification becomes particularly significant during periods of major changes occurring both nationally and within the construction industry [8].

To identify risks, various methods can be employed, including statistical, analytical, expert-based methods, analogy techniques, etc. [9–11].

Identified risks are documented in a risk register. Alongside recording the risk in the registry, it is assigned a probability level and impact severity on the programme [12, 13].

In the paper, some possible risks related to different types of work where various risks may occur during the implementation phase of the renovation programme are presented. Risks associated with programme implementation have been classified by the author according to the stages of realization based on the developed life cycle of the renovation programme (Table 1). Some risks identified include those of the preparatory stage before commencement of construction works, the construction stage itself, the relocation stage, and the operation stage [14, 15].

Table 1. Classification of Risks According to Main Stages of the Renovation Programme Lifecycle. Developed by authors

Stage	Activity	Risk
Preparatory stage	Pre-project preparation, issuance of urban planning documentation	Delay in issuing urban planning documents could affect scheduling of design and construction stages
		Risk of errors in urban planning documentation
		Risk of improperly selected land site for the “starter” housing unit
		Risk of restricted areas (sanitary protection zones, etc.) on the land
		Risk of misalignment with the classification of permitted uses of land
	Contract conclusion	Risk of errors in preparing tender documentation
		Risk of contracting with an unreliable partner
		Risk of working under a poorly-drafted contract (object scope, terms, conditions, payments, guarantees)
	Land and property registration, rights to land parcel	Risk of discrepancies between territorial planning and zoning documents and intended land usage
		Risk of unauthorized activities (illegal construction or land use) leading to penalties and lawsuits
		Risk of late establishment of easements if depending on adjacent properties
		Risk of legislative changes necessitating additional costs and delays
		Risk of unregistered land and property relationships
	Surveys, design, expertise	Risk of issues arising from poor quality engineering surveys
		Risk of extended approvals for architectural and urban planning decisions
		Risk of negative expert opinions due to design flaws
		Risk of lacking full package of initial permission documentation
	Relocation and Demolition (for second and subsequent waves of relocation)	Risk of prolonged resident relocation linked to court cases, extending demotion and new constructions
		Risk of complications in disconnecting homes from utilities
		Risk of delayed demolition processes due to lack of authorization
	Site preparation	Risk of increased construction delays due to preservation or realignment of existing utility networks
		Risk of presence of limiting elements like sport fields, garages, influencing programme timeline
		Risk of conducting preparatory works in constrained environments
Construction stage	Permit application for construction	Risk of errors in applying for construction permits
		Risk of not meeting operational schedules
	Demolition of residential buildings	Risk of negative impacts on surrounding buildings
		Logistics risks near neighboring structures
		Safety risks for individuals and staff involved in demolition
	Construction	Risk of supplying low-quality construction materials
		Risk of using sub-standard construction equipment
		Risk of having no skilled workforce available

End of the Table 1

Stage	Activity	Risk
	Completion of construction	Risk of long delays in accepting projects at commissioning
		Risk of failing to finish construction within specified road map schedule
		Risk of errors in registering newly-built assets with cadasters
		Risk of errors in applying for construction permits
Relocation and exploitation stage	Hand-over of housing units for settlement	Risk of postponement of relocation due to detected defects
		Risk of prolonged correction of defects found during apartment inspections
		Risk of changed need for relocation without reserved flats
	Exploitation	Risk of delaying transfer of asset for occupation
		Risk of selecting an untrustworthy management company
		Risk of imposing high rates by the management company on public services

Most risks associated with the implementation of a renovation programme can also be categorized according to the following categories of risks [16, 17]:

1. Construction Risks: these relate to any type of construction activity. They represent a set of risks that might emerge at any time during construction and assembly operations, potentially destroying or significantly distorting building structures or components, extending deadlines, and affecting the overall timetable of the renovation programme.

2. Design Risks: these refer to potential issues or adverse effects arising during the design process that could negatively influence project goals, schedules, budgets, or quality. Such risks may be either evident or latent and result from internal factors like design errors or resource shortfalls, as well as external ones such as legislative changes or market fluctuations.

3. Management Risks: these involve wrong managerial decisions leading to financial losses, reputational damage, or other unfavorable outcomes for the renovation programme.

4. Legal Risks: these pertain to potential legal challenges, loss of revenue, capital erosion, additional expenses, or liabilities stemming from violations or non-compliance with regulatory norms throughout the programme's lifecycle (laws, regulations, directives, corporate documents, etc.).

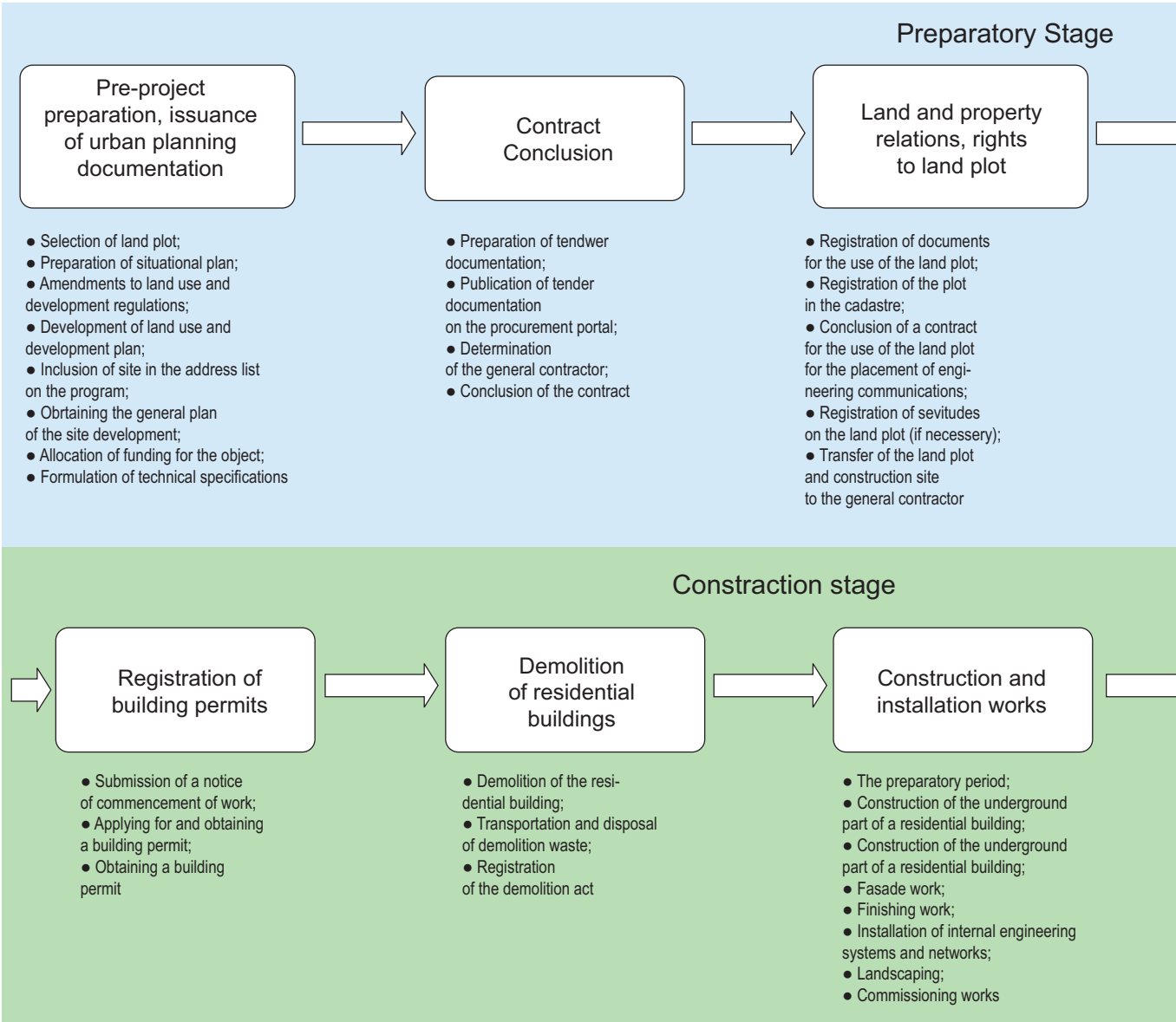
5. Financial Risks: renovation programmes inherently carry high levels of expenditure and operational risks. Often, unforeseen financial expenditures necessitate extra funding for project execution. Financial risks denote the likelihood of monetary losses incurred while conducting business activities.

6. Reputational Risks: these entail potential harm to the image or credibility of the renovation programme due to public dissatisfaction, lawsuits, or other detrimental events.

7. Environmental Risks: these concern harmful environmental impacts resulting from anthropogenic or natural processes during renovations. They may affect human health, biodiversity, ecosystems, and, when poorly managed, cause severe ecological damage in areas undergoing extensive transformation. Typically, these arise because of breaches in environmental protection standards or safety regulations.

Table 2. Classification of renovation programme risks across major categories. Developed by the authors

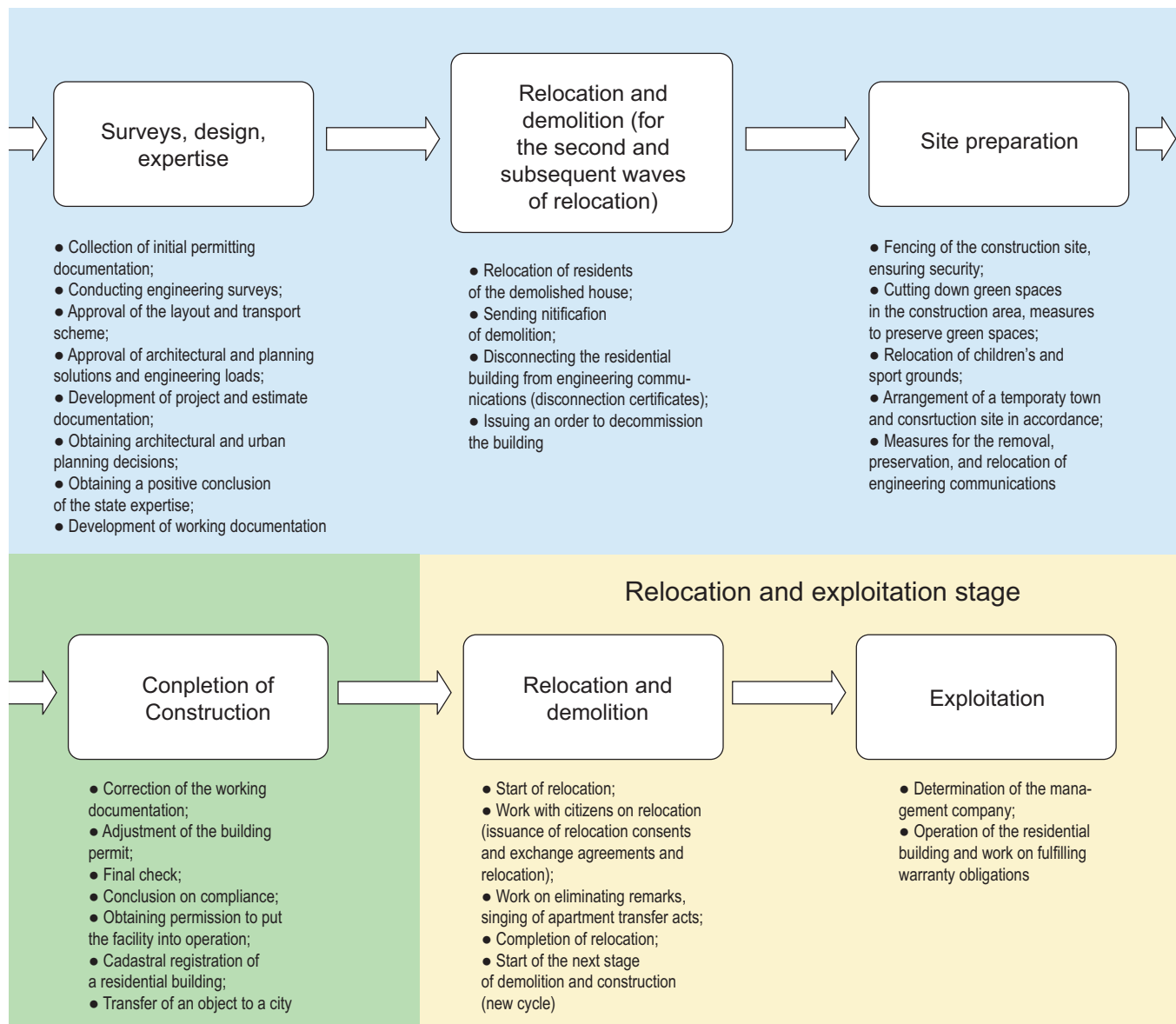
Number	Category of risk with renovation programme	Risk Characteristic for Category
1	Construction risks	Risk of staffing construction phases with qualified personnel
2	Design risks	Risks of making amendments to technical specifications, technical requirements, floor plans, etc.
3	Management risks	Risks of inefficient allocation of labor and material resources
4	Legal risks	Risk of violating contractual obligations
5	Financial risks	Risk of significant increase in the initial cost of the programme
6	Reputational risks	Risk of reputation loss due to changes in initial conditions and guarantees of the programme during its implementation
7	Environmental risks	Risks of deterioration in urban environment quality and comfort, climate and landscape changes resulting from destruction of green zones and plantations
8	Political risks	Risks of sanctions being introduced on special machinery and materials supplies
9	Marketing risks	Risk of choosing erroneous marketing strategy and sales portfolio
10	Operational risks	Risk of inadequate maintenance of built facilities by the management company
11	Social risks	Risk of increasing load on social infrastructure due to higher density of construction
12	Economic risks	Risks associated with tax increases
13	Commercial risks	Risks of losing revenue or incurring extra expenses as a result of commercial transactions
14	Information security risks	Risks associated with information leakage
15	Operational risks	Risks of employee mistakes caused by negligence or insufficient qualifications



Lifecycle of renovation programme (key stages). Developed by the authors

8. Political Risks: these reflect the possibility of losses or reduced profitability caused by political decisions or events.
9. Marketing Risks: marketing risks encompass deviations in financial and production indicators of the renovation programme, often triggered by demand contraction, price declines, intensifying competition, deteriorating market conditions, ineffective marketing strategies, or other risk factors.
10. Operational Risks: these include the possibilities of losses or damages during the use of buildings, equipment, engineering systems, or transport networks constructed under the renovation programme. Issues may range from physical damage to assets, infrastructure, or properties, inadequate maintenance causing environmental harm, non-adherence to instructions, accidents, emergencies, increased operational costs, or failures in utility systems.
11. Social Risks: these describe the likelihood of negative societal impacts or disruptions caused by shifts in social dynamics or deviations from accepted norms.

12. Economic Risks: economic risks signify the chance of financial losses resulting from random outcomes of economic decision-making or actions. They arise from adverse economic changes within the enterprise, the renovation programme specifically, or the broader national economy. Broadly speaking, economic risks encapsulate all minor risks and primarily manifest as changes in market conditions or liquidity mismatches.
13. Commercial Risks: commercial risks arise during the sale of goods and services, resulting from the potential loss of resources, missed income opportunities, or additional costs incurred through commercial transactions.
14. Information Security Risks: characteristic of renovation programmes, these risks relate to data storage and processing vulnerabilities involving architectural plans, blueprints, financial information about programme costs, personal details of employees, contractors, and clients. These risks emerge from digitization trends, as electronic formats dominate data storage, contract signing, modeling, and project management practices.



15. Operational Risks: these are linked to mistakes made during operational procedures, exceeding official authority limits, misconduct, or abuse of power. They reflect the likelihood of losses, revenue reduction, or capital depletion due to inefficient internal processes, employee errors, technological malfunctions, or external influences (Table 2).

Thus, systematic classification of risks across implementation stages and risk categories, along with understanding the life cycle of the renovation programme and accompanying risks, enables us to select appropriate risk management methods aimed at reducing costs, improving programme efficiency, and achieving predefined objectives.

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Жизненный цикл программы реновации: идентификация, анализ и систематизация рисков

Статья посвящена исследованию жизненного цикла программы реновации жилищного фонда городов, который охватывает подготовку, проектирование, строительство, переселение и последующую эксплуатацию обновленной недвижимости. Особое внимание уделено выявлению, анализу и систематизации рисков, присущих каждому этапу реализации программы. Для этого разработана подробная классификация рисков, охватывающая организационные, экономические, технические и социально-экологические аспекты. Программа реновации представляет собой сложный многоступенчатый процесс, каждая фаза которого сопровождается определенными факторами риска. Например, подготовительная стадия характеризуется проблемами градостроительной документации, качеством инженерно-геологических изысканий и согласованием проектной документации. Строительно-монтажные работы подвержены риску недостаточного финансирования, низкому качеству материалов и техники, неблагоприятным погодным условиям и возможным судебным спорам. Этап переселения населения вызывает проблемы коммуникации с жителями, задержки сроков и судебные разбирательства. Разработанная графическая модель жизненного цикла программы визуализирует структуру этапов и ассоциированные с ними риски. Основная цель исследования заключается в формировании эффективной системы мониторинга и управления рисками, направленной на повышение успешности реализации программы и достижение запланированных показателей модернизации жилищной инфраструктуры крупных городов. Кроме того, авторы предлагают оптимизировать процедуры принятия управленческих решений и координировать усилия всех участников программы на каждой стадии ее реализации. Эффективное управление рисками помогает минимизировать негативные последствия и повысить общую эффективность процесса реновации, обеспечивая комфортные условия проживания горожан и долгосрочную устойчивость реализуемых проектов. Такой подход позволит значительно снизить финансовые и временные затраты, уменьшить влияние неблагоприятных факторов и достичь устойчивого положительного эффекта от реализации программы реновации.

Ключевые слова: жизненный цикл, программа реновации, классификация рисков, анализ, эффективность реализации проекта

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For citation: Kankhva V.S., Egorov A.A. Life cycle of a renovation programme: identification, analysis and systematization of risks. *Real Estate: Economics, Management*. 2025; 4:17-23.

Для цитирования: Канхва В.С., Егоров А.А. Life cycle of a renovation programme: identification, analysis and systematization of risks // Недвижимость: экономика, управление. 2025. № 4. С. 17–23.



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Cost Management in Industrial Construction Projects through Building Information Modelling

This paper provides a comprehensive analysis of the potential and limitations of using building information modelling (BIM) technology in the context of construction cost management throughout the lifecycle of an investment and construction project. The study covers stages from initial conception and pre-project analysis to facility operation and decommissioning. Emphasis is placed on the challenges of early pre-project stages, such as feasibility studies and conceptual design, which are particularly important when implementing complex industrial projects. The authors highlight a key problem in this area: the lack of specialized, aggregated cost indicators (standards) for industrial construction projects adapted to the specifics of BIM, as well as a shortage of specialized software. This combination significantly reduces the accuracy and validity of initial cost estimates.

The paper systematizes the key challenges and benefits that BIM implementation can address in cost engineering at each subsequent stage of a project. The analysis revealed a systemic gap in the current regulatory and methodological framework, which currently does not fully regulate the processes of calculating construction cost estimates at the design stage using digital information models (DIM).

Based on the conducted research, a substantiated conclusion is reached regarding the critical need for active development of methodological and regulatory support specifically for the feasibility study and conceptual design stages of industrial facilities. Addressing this challenge is fundamental to achieving end-to-end digitalization of the investment and construction process, increasing the investment attractiveness of projects, and minimizing financial and time risks at all stages of the life cycle.

Keywords: construction cost, cost engineering, Information modelling, BIM, facility lifecycle, industrial facilities, regulatory framework, feasibility study, conceptual design, digital information model

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INTRODUCTION

Russia's state policy on economic digitalization, ambitious infrastructure development plans, and commitment to technological independence increase the importance of adopting information modelling (IM) technology in the construction industry. This process is important for both government agencies and those involved in investment and construction activities. Although the regulatory framework and issues related to domestic software provision have been largely resolved, the practical aspects of using digital information models (DIM) require further study [1, 2].

A key challenge when working with the DIM remains data quality control, including its compliance with regulations, completeness, and consistency. For most users, interacting with the model involves running numerous automated checks: for compliance with regulations, the absence of collisions in geometry, and the sufficiency of attribute information [3].

One promising area for the development of information modelling technology is the use of digital models for calculating and monitoring industrial construction costs. DIM data, in the form of cost indicators and their derivatives, can serve as the basis for implementing cost engineering, which, according to the current GOST¹, includes planning; value, economic, and financial analysis; assessment and audit; control and optimization; and performance,

change, and cost risk management at all stages of the project lifecycle. At the same time, the availability of up-to-date regulatory and methodological materials governing these processes remains critical for cost engineering specialists, particularly with regard to the most underdeveloped aspect — construction cost assessment.

Of all the currently available regulatory documents concerning the application of the information modelling technology, the vast majority address issues of developing the DIM and the interaction of process participants at various stages of the life cycle. However, issues related to determining the cost of construction using the DIM are almost absent from any of these regulatory documents. One such document, approved by Order No. 854/pr of the Ministry of Construction of the Russian Federation dated December 24, 2020, establishes a methodology for determining the cost of work on preparing design documentation containing materials in the form of a digital information model². A similar document applies to the development of projects for the construction of facilities financed by the Moscow budget³. Both documents focus not on the estimated cost of construction, but on the cost

¹ GOST R 58535–2019. National Standard of the Russian Federation. Cost Engineering. Terms and Definitions. Electronic Fund of Legal and Regulatory Technical Documents. URL: <https://docs.cntd.ru/document/1200167735?section=text> (rus.).

² Methodology for determining the cost of work on the preparation of design documentation containing materials in the form of an information model, approved by Order of the Ministry of Construction of Russia dated December 24, 2020 No. 854/pr (as amended). Federal State Information System for Pricing in Construction. URL: <https://fgiscs.minstroyrf.ru/frsn/standard/methodical/ee87485b-4468-4d12-9826-c7905636dbac> (rus.).

³ Methodological recommendations for calculating design costs using information modeling technology, carried out with the involvement of funds from the Moscow city budget MRR-12.1-18, as amended as of August 6, 2021. Electronic fund of legal and regulatory documents. URL: <https://docs.cntd.ru/document/565439796> (rus.).

of design work, i.e., they partially address cost determination at the architectural and construction design stage. The methodology for determining estimated construction costs, approved by Order No. 421/pr of the Ministry of Construction of the Russian Federation dated August 4, 2020, regulates the determination of the developer's costs for maintaining a digital information model during the construction phase⁴. This method, however, focuses on the construction phase and does not address the issue of determining the construction cost, but only the additional costs associated with bringing the digital information model into compliance with the as-built documentation.

At the same time, all existing regulatory and methodological documentation in the field of cost estimation is oriented toward working with so-called flat or 2D construction drawings and their corresponding specifications. For example, the rules for calculating work volumes imply manual calculation of all values, without the use of geometric solvers. Another feature of the existing technology is the dependence of the structure of the cost estimate documentation on the structure of the design solutions, i.e., on how the design solutions are displayed on the sheets of design or working documentation. All design volumes are calculated and included in the specifications in accordance with how the drawings are compiled. The volumes of material resources and, accordingly, the volumes of work are typically calculated separately for each drawing and rounded to significant digits, most often to 2–4 decimal places, depending on the unit of measurement. Such volumes are included in the estimate documents in the same sequence, with the accumulation of the total volume and the formation of the cost as a sum of intermediate rounded values.

Information modelling implies a fundamentally different approach to design solutions. Essentially, all work shifts from drawing-based to element-based. However, with the element-based method of calculating material and labor volumes, final estimates can vary significantly. Consequently, cost estimates can vary by several percent, depending on the design stage and the pricing methodology used.

Despite the apparent fragmentation of approaches to determining construction costs based on the DIM in methodological and regulatory documents at the state level, construction organizations are developing and applying these approaches, as they see high potential for solving a wide range of problems in the field of cost engineering [1, 2]. Let us consider the key stages of industrial construction project implementation, the role of the information modelling technologies in each of them, and their implications for cost determination.

PRE-INVESTMENT STAGE AND CONCEPTUAL DESIGN

At the initial stage, a feasibility study (FS) and a concept for the future facility are developed [4]. The information modelling technologies are used for 3D visualization and preliminary analysis, since creating even simple sketch models helps the client and investors evaluate architectural solutions. At this stage, a cost estimate is also generated using aggregated standards, such as construction cost standards, or data from similar projects. Most of the necessary data can be obtained from a digital information model based on parametric modelling, allowing for cost forecasting

⁴ Methodology for determining the estimated cost of construction, reconstruction, major repairs, demolition of capital construction projects, work on the preservation of cultural heritage sites (historical and cultural monuments) of the peoples of the Russian Federation on the territory of the Russian Federation, approved by order of the Ministry of Construction of Russia dated 04.08.2020 No. 421/pr (as amended). Federal State Information System of Pricing in Construction. URL: <https://fgiscs.minstroyrf.ru/frsn/standard/methodical/10c50a07-101d-493d-bf3e-6bea9208c76d> (rus.).

before detailed design development. However, there are almost no developed solutions for the current stage. At this stage, the task of selecting optimal solutions is typically resolved by comparing options based on energy efficiency, materials, and other parameters, including cost. Using the information modelling technologies at this stage helps avoid costly changes at subsequent stages.

DESIGN

This is the stage of detailed design documentation development, one of the most important for the application of the information modelling technologies. Here, the technology ensures coordination between specialists – architects, designers, and engineers work in a single environment, which reduces the number of collisions [3]. The digital information model allows for almost complete automation of calculations: checking structural loads, engineering system parameters, and their compliance with regulations. At this stage, precise specifications for all material resources and volumetric indicators are also generated [5]. Using modern information modelling systems, it is possible to automatically generate bills of materials and equipment, which requires strict adherence to the requirements for detail and information content of the DIM⁵ [6]. To estimate costs at the design stage, a cost estimation and regulatory framework is applied, using elemental cost estimates or rates depending on the adopted pricing method, such as GSN-2022 or TSN-2001 (Fig.).

Cost data obtained on the basis of the DIM data are downloaded from it in the form of traditional cost estimates and are the basis for calculating the initial (maximum) prices of contracts (agreements) (hereinafter referred to as the IMPC(A)).

CONSTRUCTION

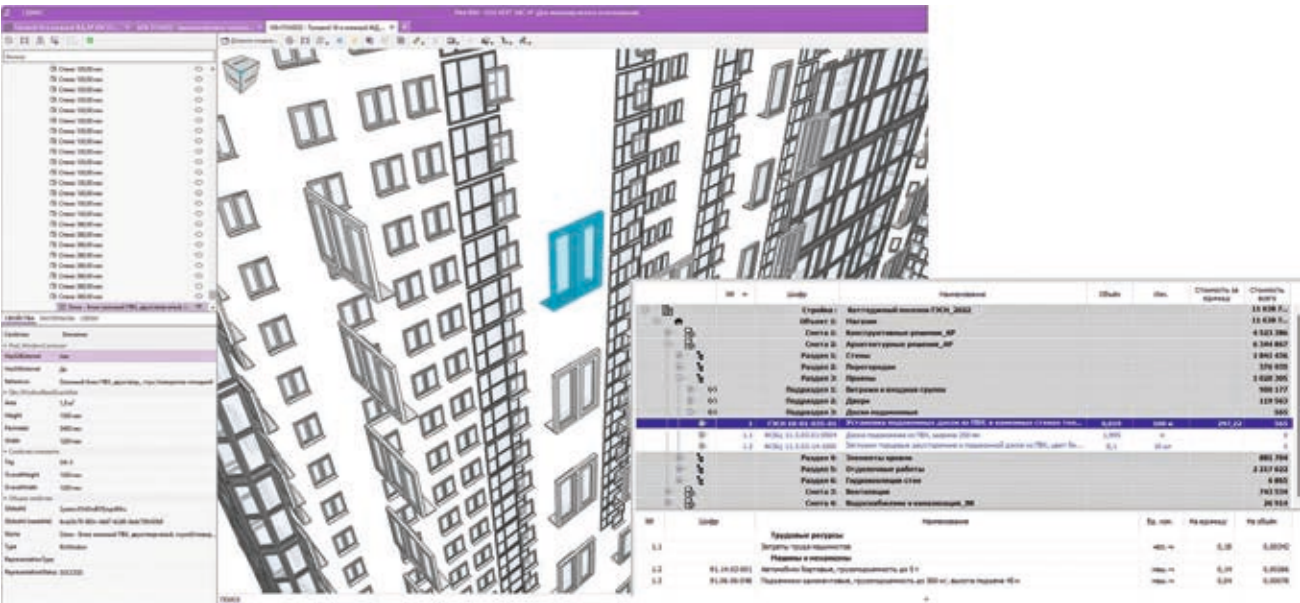
During construction, the information modelling technology (IMT) is most often used for logistics and planning. For this purpose, 4D modelling (time + 3D) is used, which helps optimize the construction and installation schedule and material procurement schedule. In addition to logistics and planning, quality control tasks are also addressed by verifying execution against the design model using laser scanning. IMT is sometimes used during the construction phase to manage construction resources through integration with the construction company's Enterprise Resource Planning (ERP) systems for accounting for labor costs, materials, and equipment. The use of IMT on the construction site reduces the number of reworks by 20–30 % [7, 8].

OPERATION OF THE FACILITY

Once commissioned, the information model becomes the basis for facility management. Using the information model, it's possible to perform maintenance while organizing the storage of data on utilities, repair schedules, and warranties. To optimize operating costs, energy monitoring can be performed by analyzing sensor readings. To address building lifecycle management issues, information modelling technology is now often transformed into the concept of a Digital Twin.

To determine the cost of operating a building, including the cost of routine and major repairs, various approaches are used, based on both standard costing approaches and the recording of actual expenditures incurred during implementation.

⁵ Benklyan S.E. *Levels of detail of elements of the information model*. Portal isicad. 2014. URL: http://isicad.ru/ru/articles.php?article_num=17329 (rus.).



Example of determining the cost of a BIM element (based on the integration of Pilot-BIM and ABC-Estimates software systems). The technology is identical for industrial construction

Determining the cost of an industrial construction project at different stages of the life cycle of an investment and construction project

Life cycle stage	Application of IMT	Problems to be solved	Determination of cost
Pre-investment stage and conceptual design	Analogue object or conceptual model	Concept analysis, visualization. Selection of project options	Formation of the estimated (marginal) cost for similar objects or aggregated indicators based on the DIM (if available)
Design	Design model	Development of design documentation, calculations of building structures	Calculation of the estimated cost of construction with reference to the elements of the DIM
Construction	As-built model	Construction management, logistics, preparation of as-built documentation	Formation of the IMPC(A). Audit, iterative cost changes based on the DIM. Formation of the book value of the asset based on actual data
Operation	Digital twin	Current maintenance of the facility, repairs	Calculation of the cost of maintenance and repairs based on regulatory data and DIM data
Demolition and disposal	Digital twin or simplified design model	Calculation of demolition volumes, planning of materials disposal	Calculation of the estimated cost of demolition and disposal works based on the DIM data

DEMOLITION AND DISPOSAL

At the final stage of a building's lifecycle, the IMT helps plan safe demantling by analyzing building structures to select the optimal dismantling method, as well as taking into account environmental disposal requirements (information about materials enables their effective recycling). In terms of cost determination, demolition and disposal work is, in most cases, similar to the approaches used during construction cost determination.

The tasks solved using the IMT at different stages of an investment and construction project's lifecycle can be summarized in the following table (Table).

IMT transforms all stages of investment and construction projects, ensuring:

- end-to-end digitalization of data — from concept to disposal;
- risk reduction — through early error detection;
- resource savings — time, money, and materials.

However, for maximum efficiency in the application of IMT, it is necessary to develop a regulatory framework⁶ [1, 7] and train qualified personnel who are proficient in interdisciplinary ap-

proaches [2, 9], both in the area of IMT application and in the area of cost engineering.

CONCLUSIONS

The ability to apply an end-to-end approach to determining the cost indicators of an industrial construction project based on the DIM at various stages allows for a new approach to construction cost estimation. This approach uses DIM data for phased cost justification, linking it to model elements and increasing the accuracy of the estimate depending on the model's content and development. It also allows for iterative auditing and cost adjustments based on the impact of internal and external environmental factors and the ongoing implementation objectives of the investment and construction project. The resulting information models with assigned costing properties can serve as the basis for generating aggregated indicators of industrial construction costs, making the investment justification stage more transparent and the cost justified at this stage. Due to insufficient regulatory and methodological support for using DIM to generate cost estimates at various stages of the project lifecycle, it is necessary to develop detailed methods for determining construction costs using IMT, as well as the corresponding software tools.

⁶ Urban Development Code of the Russian Federation of December 29, 2004, No. 190-FZ. URL: http://www.consultant.ru/document/cons_doc_LAW_51040 (rus.).

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Стоимостный инжиниринг в реализации проектов промышленного строительства с применением технологии информационного моделирования

В данной статье проводится комплексный анализ возможностей и ограничений применения технологии информационного моделирования (ТИМ/BIM) в контексте управления стоимостью строительства на этапах жизненного цикла инвестиционно-строительного проекта. Исследование охватывает этапы — от первоначального замысла и предпроектного анализа до эксплуатации и вывода объекта из использования. Акцент делается на проблематике ранних, предпроектных стадий, таких как технико-экономическое обоснование (ТЭО) и концептуальное проектирование, особенно значимых при реализации сложных промышленных объектов. Авторы отмечают ключевую проблему этой сферы: отсутствие специализированных укрупненных стоимостных показателей (нормативов) для объектов промышленного строительства, адаптированных под специфику ТИМ, а также дефицит специализированного программного обеспечения, что в совокупности приводит к значительному снижению точности и обоснованности первоначальных стоимостных оценок.

В работе систематизированы ключевые задачи и преимущества, которые позволяет решить внедрение ТИМ в области стоимостного инжиниринга на каждой последующей стадии проекта. В результате анализа выявлен системный пробел в современной нормативно-методической базе, которая на сегодняшний день не в полной мере регламентирует процессы формирования сметной стоимости строительства на этапе проектирования с применением данных цифровых информационных моделей (ЦИМ).

На основании проведенного исследования делается обоснованный вывод о критической необходимости активного развития методического и нормативного обеспечения именно для этапов ТЭО и концептуального проектирования промышленных объектов. Решение этой задачи является фундаментальным условием для достижения сквозной цифровизации инвестиционно-строительного процесса, повышения инвестиционной привлекательности проектов и минимизации финансовых и временных рисков на всех этапах жизненного цикла.

Ключевые слова: стоимость строительства, стоимостный инжиниринг, информационное моделирование, BIM, жизнен-

ный цикл объекта, промышленные объекты, нормативная база, ТЭО, концептуальное проектирование, цифровая информационная модель

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For citation: Bovsunovskaya M.P., Voronin I.A. Cost Management in Industrial Construction Projects through Building Information Modelling. *Real Estate: Economics, Management*. 2025; 4:24-28.

Для цитирования: Бовсуновская М.П., Воронин И.А. Cost Management in Industrial Construction Projects through Building Information Modelling // Недвижимость: экономика, управление. 2025. № 4. С. 24–28.



UDC 711.4:332.1

Problems and prospects of transition to the master planning system in urban development practice

The paper examines the key problems and prospects of introducing a master-planning system into urban development practice. It analyzes institutional, legal, and economic barriers that hinder the transition from situational project design to a comprehensive strategic approach at the territorial level. Particular attention is paid to coordination between different levels of government, the integration of long-term target programs, and the consideration of multidimensional constraints — natural-climatic, infrastructural, and social. Based on a comparative analysis of foreign and Russian urban practices, practical recommendations are formulated to improve the regulatory framework, strengthen the institutional role of local self-government, and create financial instruments that stimulate integrated territorial development. The conclusion presents forecasts for the sustainable implementation of master-planning under systemic reforms and proposes a pilot roadmap for its introduction in Russian conditions. The author provides detailed explanations and examples of master-planning implementation in various regional contexts, emphasizing the need to adapt international practices to local specificities and legal frameworks.

Keywords: *master planning, urban planning, integrated territorial development, institutional mechanisms, urban policy*

The transition to a master-planning system is increasingly viewed as a key instrument for modernizing contemporary urban development practices. In contrast to fragmented project-based initiatives, a master plan provides strategic coordination of territorial development, integrating demand forecasting, the synchronization of infrastructure investments, and assessments of economic feasibility. However, in the Russian context, the implementation of such a system faces numerous constraints, ranging from deficiencies in the regulatory framework to limited institutional capacity at the municipal level and the lack of robust financial mechanisms [1, 2].

In international practice, master planning is employed as a strategic instrument for the development of major cities and urban agglomerations. A review of academic and policy sources shows that successful cases — such as those observed in several European cities and parts of Asia — are built upon a combination of well-defined legal frameworks, transparent procedures for public participation, and long-term financing arrangements [3–5]. In Russian academic literature, issues of territorial planning and the integration of functional components are examined by domestic researchers who emphasize the need to adapt international approaches to the specific institutional conditions of the Russian context [6, 7].

This study represents an analytical investigation based on a comparative review of existing practices, an examination of regulatory documents, and a synthesis of findings from thematic publications. The research applies methods of system analysis, expert evaluation, and case-study approaches. The use of qualitative analytical techniques makes it possible to identify the key factors influencing the effectiveness of master planning and to formulate practical recommendations for the Russian regulatory and administrative context [1, 3, 6].

The absence of a unified competency framework across federal, regional, and municipal levels results in a fragmented distribution of responsibilities. Strategic planning objectives often diverge from the short-term operational interests of local authorities, which slows the coordination and approval of long-term development projects [2, 8]. Such misalignment leads to duplication of functions and reduces the overall effectiveness of administrative decision-making [6, 9]. In addition, inconsistencies in regulatory approaches and spatial-planning instruments complicate the implementation of inter-regional initiatives and comprehensive territorial-development programs [10, 11]. Overcoming this gap requires institutional integration across levels of government and the establishment of unified methodological standards for master planning [4, 12]. Such harmonization would strengthen vertical accountability and improve the quality of interaction among stakeholders involved in urban-development policy [3, 13].

The existing legislative framework, which is primarily focused on municipal regulations and land-use relations, does not always provide sufficient instruments for the implementation of comprehensive master plans. This includes the absence of robust mechanisms for mandatory infrastructure financing and long-term public–private partnership arrangements [6, 9]. The need to address this gap is driven by the requirement for a comprehensive assessment of planning decisions, incorporating economic, social, and environmental dimensions. In addition, potential alternative development scenarios should be taken into account and evaluated through a comparative analysis based on a set of performance indicators.

The need for extensive use of GIS technologies, transport-flow modelling, and scenario-based forecasting is constrained by a shortage of qualified

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► specialists and limited access to advanced analytical tools [12]. This requirement arises from the necessity to conduct a comprehensive assessment of the impacts of planning decisions, encompassing economic, social, and environmental dimensions. Furthermore, it is essential to consider potential alternative development scenarios and perform their comparative evaluation using a defined set of performance indicators.

Master planning constitutes a critical instrument for the strategic optimization of land use, facilitating the coordinated deployment of infrastructural investments while enhancing the predictability of territorial development, thereby mitigating transaction costs and augmenting investment appeal [3, 5, 10]. This methodology underpins the articulation of a comprehensive vision for urban spatial organization, ensuring a calibrated balance between residential, public, and industrial zones [4, 6]. Moreover, master planning provides a framework for the systematic allocation of transport flows and the efficient management of engineering networks, which exerts a direct influence on urban environmental quality and the overall standard of living [7, 9, 11]. A further salient advantage pertains to the increased transparency of planning outcomes: the existence of a consolidated master document reduces administrative barriers and promotes participatory engagement of stakeholders in strategic decision-making processes [5, 8]. From a long-term perspective, such an approach reinforces the sustainability of territorial development, fosters the expansion of the municipal tax base, and contributes to the enhancement of investment ratings for local authorities [3, 6, 10].

Key risks associated with master planning include the potential politicization of planning decisions, insufficient adaptability in the context of rapidly evolving economic conditions, and the risk of overestimating initial assumptions, which may result in inefficient resource allocation [8, 11]. Addressing these risks necessitates a comprehensive assessment of the implications of planning decisions, encompassing economic, social, and environmental dimensions. Additionally, it is essential to consider alternative territorial development scenarios and conduct comparative evaluations against a defined set of performance indicators.

Several implementation models can be identified: a centralized model based on regional programs; a project-oriented model implemented through pilot projects; and a hybrid model, which incorporates private capital through public-private partnership mechanisms and designated territorial development zones. In the context of Russian urban development, the hybrid model appears most feasible, as it allows for the integration of governmental regulation with market-based incentives [4, 9, 13].

Several implementation models can be distinguished: a centralized approach, based on regional programs; a project-oriented approach, implemented through pilot projects; and a hybrid model, which involves private capital participation via public-private partnership mechanisms and designated territorial development zones. In the context of Russian urban development, the hybrid model appears most feasible, as it enables the integration of governmental regulation with market-based incentives [4, 9, 13].

The implementation of a legal framework to ensure compliance with approved master plan provisions is essential, including the assignment of accountability for parties failing to meet deadlines or adhere to implementation parameters [7, 10]. Such a framework would enhance procedural transparency, mitigate the risk of administrative errors, and strengthen trust among stakeholders engaged in investment and construction activities [3, 8, 11].

Strengthening the role of municipalities through the enhancement of their competencies and the provision of financial instruments is essential, alongside the establishment of cross-sectoral

coordination councils for major territorial projects, comprising representatives from government, business, and civil society [2, 7]. This requirement stems from the necessity of a comprehensive assessment of the implications of planning decisions, encompassing economic, social, and environmental dimensions. Furthermore, alternative territorial development scenarios should be considered, with comparative evaluations conducted against a defined set of performance indicators. The formation of such councils ensures a balanced consideration of the interests of various stakeholders and enhances the transparency of urban planning decision-making processes [5, 9]. The involvement of public institutions and professional associations in the approval of project decisions fosters trust in governmental authorities and reduces the risk of conflicts during project implementation [10, 11]. Municipalities must possess the methodological and analytical resources required to assess the consequences of planning decisions [4, 6]. Effective interaction between municipal and regional structures will establish a resilient feedback system and improve the quality of strategic planning [8, 14]. In the long term, this will provide a foundation for integrating master planning principles into spatial governance mechanisms, enabling more coordinated territorial development [12, 15].

The implementation of long-term infrastructure bonds, a "land bank" mechanism, and public-private partnerships with guaranteed long-term returns for investors is recommended. Additionally, targeted territorial development funds involving regional budgets and private capital may be established [10, 11]. This approach is necessitated by the requirement for a comprehensive assessment of the implications of planning decisions, encompassing economic, social, and environmental dimensions. Furthermore, alternative territorial development scenarios should be considered, with comparative evaluations conducted using a defined set of performance indicators.

It is essential to develop continuing education programs for urban planners, expand access to analytical platforms, and promote interdisciplinary education integrating urban studies, economics, and information technology [12, 14]. This requirement arises from the necessity of a comprehensive assessment of the implications of planning decisions, encompassing economic, social, and environmental dimensions. Furthermore, alternative territorial development scenarios should be considered, with comparative evaluations conducted against a defined set of performance indicators.

An illustrative roadmap for pilot implementation can be structured as follows: Phase 1 – Preparatory (0–6 months): formation of the project team, preliminary territorial audit, data collection, and identification of key constraints. Phase 2 – Design (6–18 months): development of territorial development scenarios, stakeholder consultations, and refinement of financial mechanisms. Phase 3 – Implementation (18–60 months): phased deployment of infrastructural measures and monitoring of execution. Phase 4 – Institutionalization: amendments to regulatory frameworks and scaling of successful solutions [3, 5].

The transition to a master planning system offers significant opportunities for sustainable and coordinated urban territorial development. However, the realization of this transition necessitates a comprehensive approach aimed at overcoming institutional, legal, and financial barriers. Key success factors include the establishment of a transparent regulatory framework, the development of financial mechanisms, and the enhancement of municipal competencies. When these conditions are met, master planning can serve as an effective instrument for transforming spatial policy and promoting sustainable urban development.

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Проблемы и перспективы перехода к системе мастер-планирования в градостроительной деятельности

В статье рассматриваются ключевые проблемы и перспективы внедрения системы мастер-планирования в градостроительной деятельности. Проанализированы институциональные, правовые и экономические барьеры, препятствующие переходу от ситуативного проектирования к комплексному стратегическому подходу на уровне территорий. Особое внимание уделено вопросам координации между различными уровнями власти, интеграции долгосрочных целевых программ и учету многомерных ограничений — природно-климатических, инфраструктурных и социальных. На основе сравнительного обзора практик зарубежных и российских городов формулируются практические рекомендации по совершенствованию нормативно-правовой базы, усилению институциональной роли местного самоуправления и созданию финансовых инструментов, стимулирующих комплексное развитие территорий. В заключении представлены прогнозы устойчивого внедрения мастер-планирования при условии системных реформ и предложена дорожная карта пилотного внедрения в российских условиях. Автор дает подробные пояснения и примеры реализации мастер-планирования в разных региональных контекстах, подчеркивая необходимость адаптации международных практик к местным особенностям и правовым реалиям.

Ключевые слова: мастер-планирование, градостроительство, комплексное развитие территорий, институциональные механизмы, городская политика

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For citation: Tagirov T.K., Orlov A.K. Problems and prospects of transition to the master planning system in urban development practice. *Real Estate: Economics, Management*. 2025; 4:29–31.

Для цитирования: **Тагиров Т.К., Орлов А.К.** Problems and prospects of transition to the master planning system in urban development practice // Недвижимость: экономика, управление. 2025. № 4. С. 29–31.

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Lifecycle management of integrated territorial development projects based on organizational and technological solutions

The paper presents an approach to managing the lifecycle of integrated development of territories (IDT) facilities based on organizational and technological documentation. This approach includes the development of an algorithm for specialized software to automate planning, monitoring, and analysis processes. The proposed methodology enables the creation of a unified information space for all project participants and ensures end-to-end management from the design stage through to facility decommissioning. It is noted that during the operational phase, Organizational-Technological Solutions (OTS) are not required; their adoption becomes necessary only during repair and maintenance activities on facilities. Crucially, retrospective information about operational conditions plays a vital role in justifying such decisions, and this data can only be collected during the operational phase. The implementation of the proposed solution will enhance the manageability of IDT projects and establish a foundation for sustainable territorial development. Future research prospects are associated with integrating the proposed model with BIM-based software systems while considering facility autonomy levels, developing intelligent algorithms for predicting the technical condition of facilities, and creating economic-mathematical models for assessing the comprehensive efficiency of IDT projects throughout their complete lifecycle. **Keywords:** *life cycle of an object, sustainable development of territories, integrated development of territories, organizational and technological solutions, Project Organization Concept, Project Production Report, Decommissioning and demolition plan*

INTRODUCTION

Integrated development of territories (IDT) is a form of state-regulated spatial development management aimed at the structural transformation of urbanized areas. The goal of OTS programmes is to systematically transform areas characterized by inefficient use, degradation, deindustrialization or a complete lack of development, and to create a multifunctional, socially balanced, environmentally sustainable and economically viable urban environment. A distinctive feature of the IDT programme, compared to traditional approaches to urban development, is its integrative nature. IDT projects are implemented as a single programme-targeted complex in which all components are synergistically linked, from residential development, social infrastructure facilities (education, healthcare, culture), engineering and transport infrastructure to recreational areas and environmental requirements, etc. [1–4]. In international terminology, terms such as “urban redevelopment”, “comprehensive urban renewal”, “mixed-use development”, and “territorial regeneration” are used for the IDT concept. However, these terms focus on different aspects of the process: “redevelopment” — physical transformation and modernization, “mixed-use” — functional diversity, “renewal” — modernization of existing buildings, and “regeneration” — comprehensive socio-economic and physical revitalization of territories [5–17]. Thus, IDT is a strategic approach to urban planning aimed at creating a balanced and sustainable urban environment, where effective management of the life cycle of construction projects is a critical element for successful implementation.

The life cycle of a capital construction project encompasses a sequence of interrelated stages from the initial concept to the decommissioning of the facility. Each of these stages requires careful planning, coordination and control, which is particularly relevant for IDT projects, which are characterized by their complexity, scale and multifunctionality. Managing facilities at different stages of their life cycle within a single territory presents a particular challenge. The coordinated operation of facilities under construction, in operation and undergoing reconstruction requires the development of an integrated management system based on uniform principles and approaches. The lack of a unified methodology for managing the life cycle of facilities in IDT programmes can lead to imbalances in regional development, delays in implementation, and a decline in the investment attractiveness of the project. At the same time, the main tool for ensuring the manageability of construction processes at all stages of the life cycle is organizational and technological documentation (OTD), which allows for the optimization of resource planning, improvement of the quality of construction work and operational characteristics of facilities, as well as ensuring compliance with regulatory requirements and standards to minimize potential risks and unforeseen costs. Thus, the relevance of the study is determined by the need to develop comprehensive solutions for managing complex urban development projects that ensure the efficient use of resources, compliance with implementation deadlines, and high quality of the urban environment.

MATERIALS AND METHODS

CP 48.13330.2019¹ regulates the design, construction, reconstruction, major repairs, and demolition of construction projects in terms of construction organization. The document applies to work on projects involving civil and industrial facilities, and is also aimed at the redevelopment of industrial areas in existing built-up areas.

This document defines a “capital construction facility” as a building, structure, or facility whose construction has not been completed, with the exception of non-capital structures, facilities, and inseparable improvements to the land plot (paving, covering, etc.).

A facility is a collective term that combines capital construction facilities, facilities undergoing reconstruction, facilities undergoing major repairs, facilities subject to demolition, etc.

The document also specifies that organizational and technological solutions, calculations, measures and requirements for the performance of relevant types of construction and installation works are contained in the organizational and technological documentation.

Thus, the goal of OTD is to ensure that the facility is commissioned with the required quality, within the established deadlines and in compliance with safety requirements.

This goal is achieved through the following documentation: POC (project organizational concept), PPR (project production report), PORSiD (demolition or dismantling organization plan). Fig. 1 shows the life cycle of a construction project in relation to the process of transforming organisational and technological documentation and, as a result, OTS.

It should be noted that OTS are not required during the operation phase; their adoption becomes necessary when carrying out

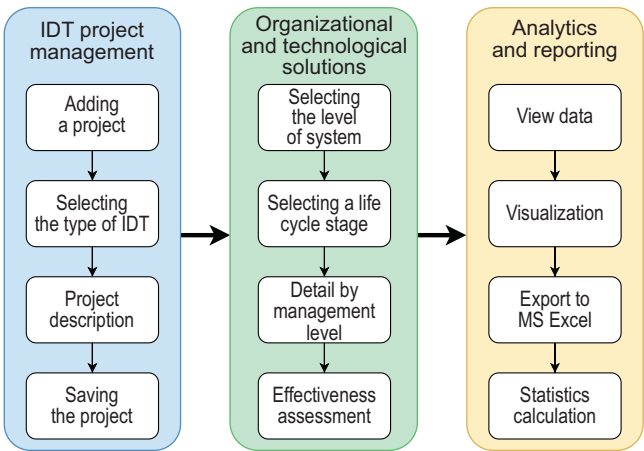
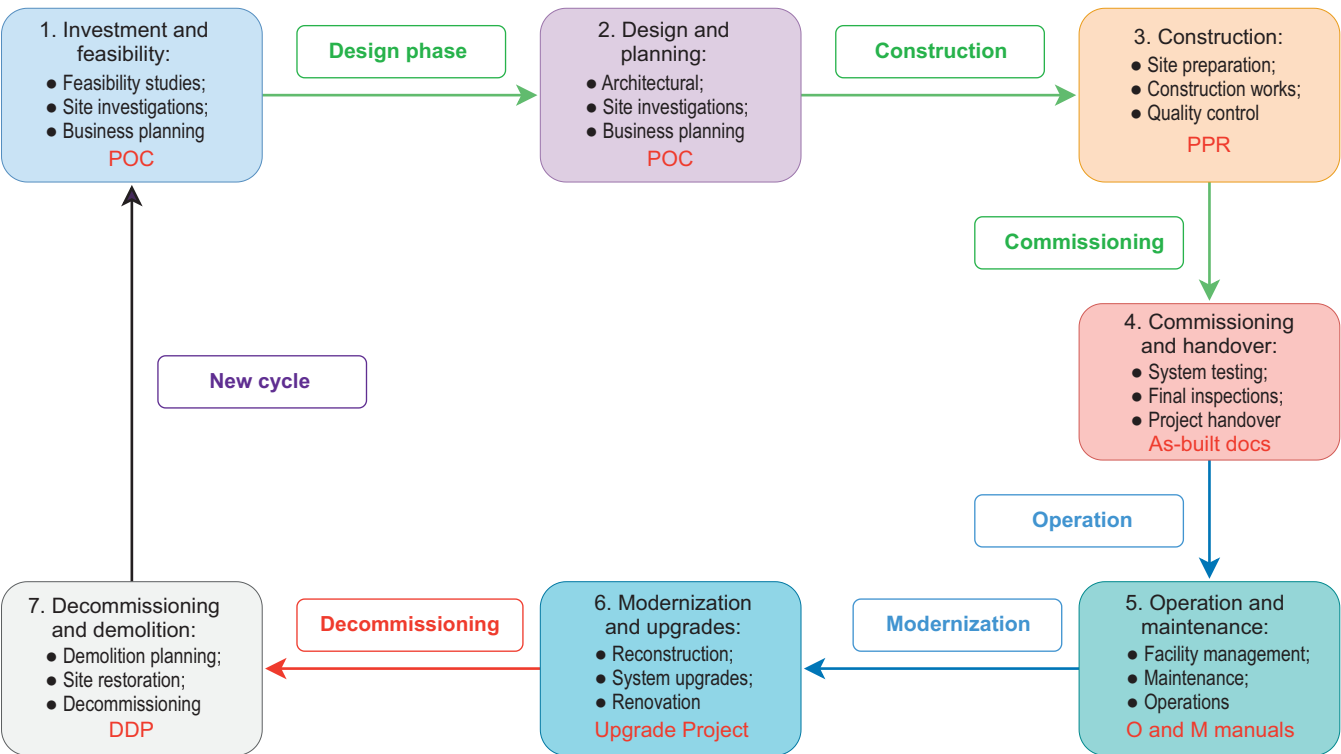


Fig. 2. Conceptual framework of an end-to-end organizational and technological solutions design system across all stages of the integrated territorial development facility lifecycle

repair work. At the same time, retrospective information about operating conditions, which can only be collected during this stage, plays a critical role in justifying such decisions. This relationship demonstrates the fundamental importance of implementing comprehensive management of the entire life cycle of facilities within the framework of integrated territorial development programmes.

Thus, the conceptual diagram of the end-to-end OTS design system at all stages of the IDT facility life cycle can be represented in accordance with Fig. 2.

The author discusses object management levels in IDT projects in more detail in [18].



Project documentation management (PDM): POC-Project Organization Concept; PPR-Project Production Report; DDP-Decommissioning and demolition plan

Fig. 1. Life cycle of a construction project in relation to the organisational and technological documentation transformation process diagram

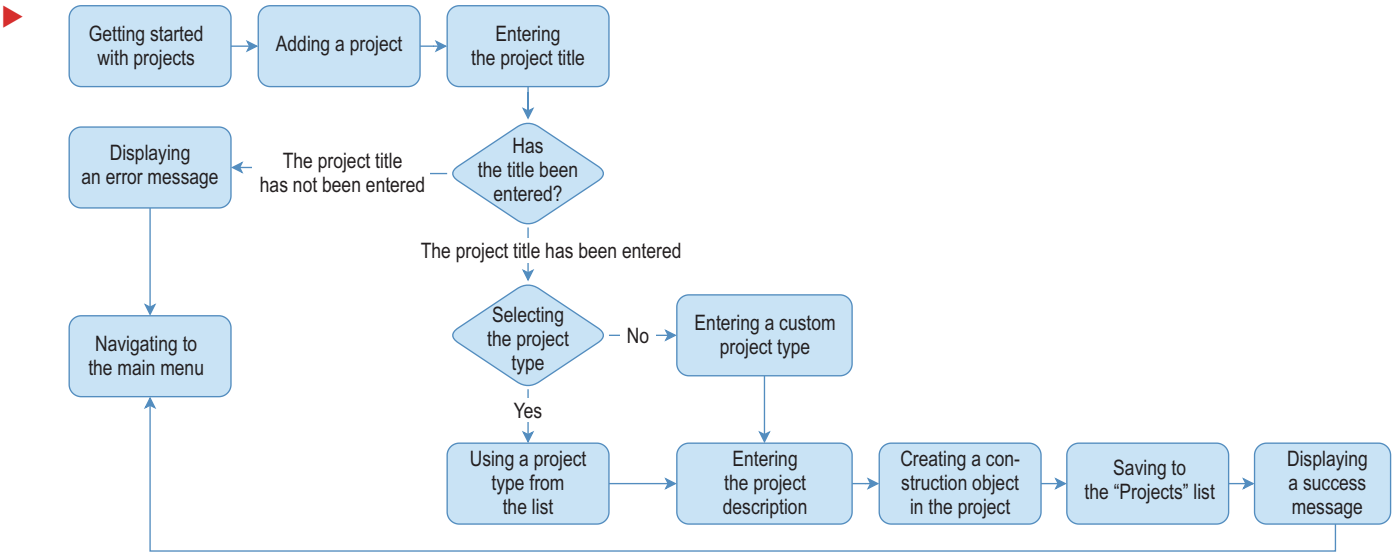


Fig. 3. Block diagram of the “IDT Project Management” module

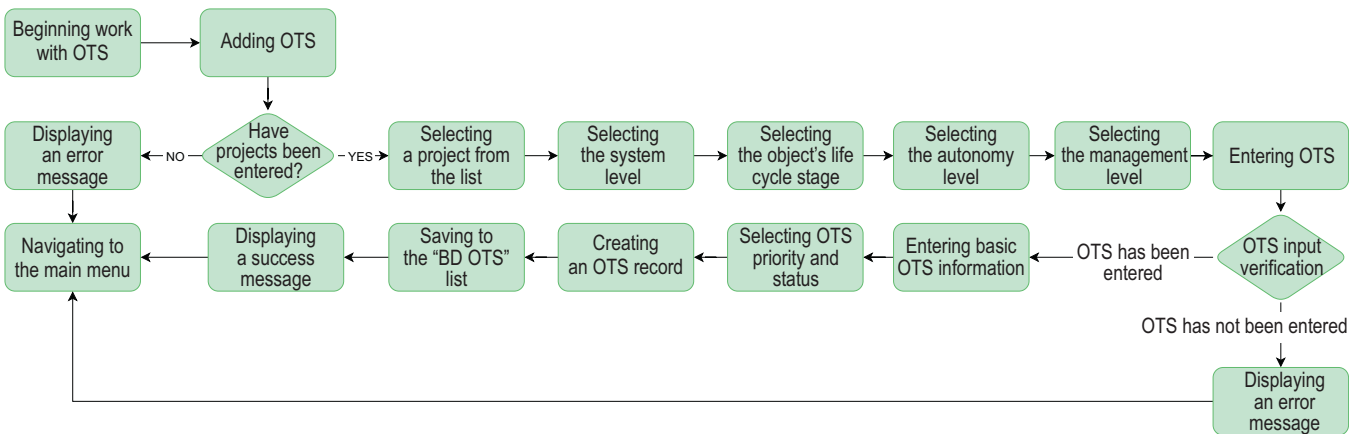


Fig. 4. Block diagram of the “Organisational and Technological Solutions” module

RESULTS

As a result of the research, detailed block diagrams of the operation of the OTS end-to-end design system blocks at all stages of the IDT facilities life cycle have been developed, which are presented in Fig. 3–5.

Fig. 6 shows the programme interface as one of the possible options for implementing software based on the proposed block diagrams.

The software interface is implemented as a modular system consisting of five interconnected functional blocks, each of which solves specific tasks within the framework of the unified methodology for managing the life cycle of objects in IDT programmes proposed in this work.

The IDT programme management module (marked with a red rectangle in Fig. 6) is designed to enter and systematize information about new projects. A key feature of the module is the implementation of cascading logic for selecting hierarchical levels, where the sequential selection of the system level automatically determines the options available at the subsystem level, and the selection of the subsystem level determines the options available at the component level, which ensures data integrity and eliminates the possibility of selecting incorrect combinations (which ultimately

reduces possible errors in working with the system). In addition, this module allows you to record financial characteristics and a detailed description of the project, as well as key life cycle milestones, thus forming a comprehensive view of each project. The main key features of the project can be added to the project description in order to subsequently correlate the project features with the effectiveness of the OTS adopted.

The module containing information about organisational and technological solutions (OTS) is shown in Fig. 7 (highlighted with a red rectangle).

In this module, you need to fill in the key aspects of the project (specifying the management level (strategic, tactical, operational, local), the object level (system, subsystem, component, element) and the object life cycle stage), as well as a description of the accepted OTS, including their effectiveness, indicated as a percentage.

The analytical module with data visualization capabilities is shown in Fig. 8 and contains several types of analysis:

- comparative analysis by management levels and system levels, showing average efficiency indicators and project distribution;
- analysis of time trends, a feature of which is the construction of graphs showing the dependence of efficiency on the actual commissioning dates of objects;

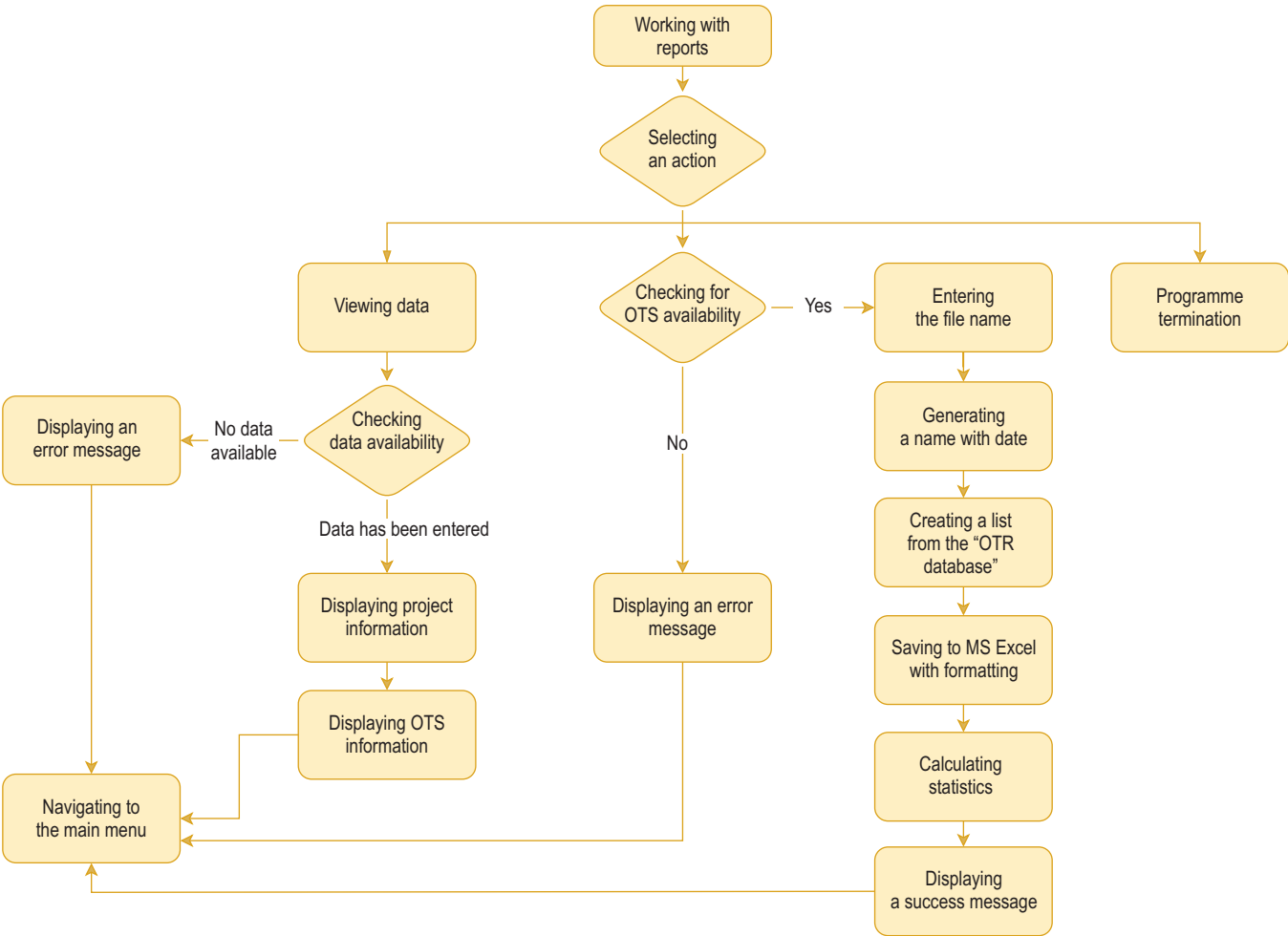


Fig. 5. Block diagram of the Analytics and Reporting module

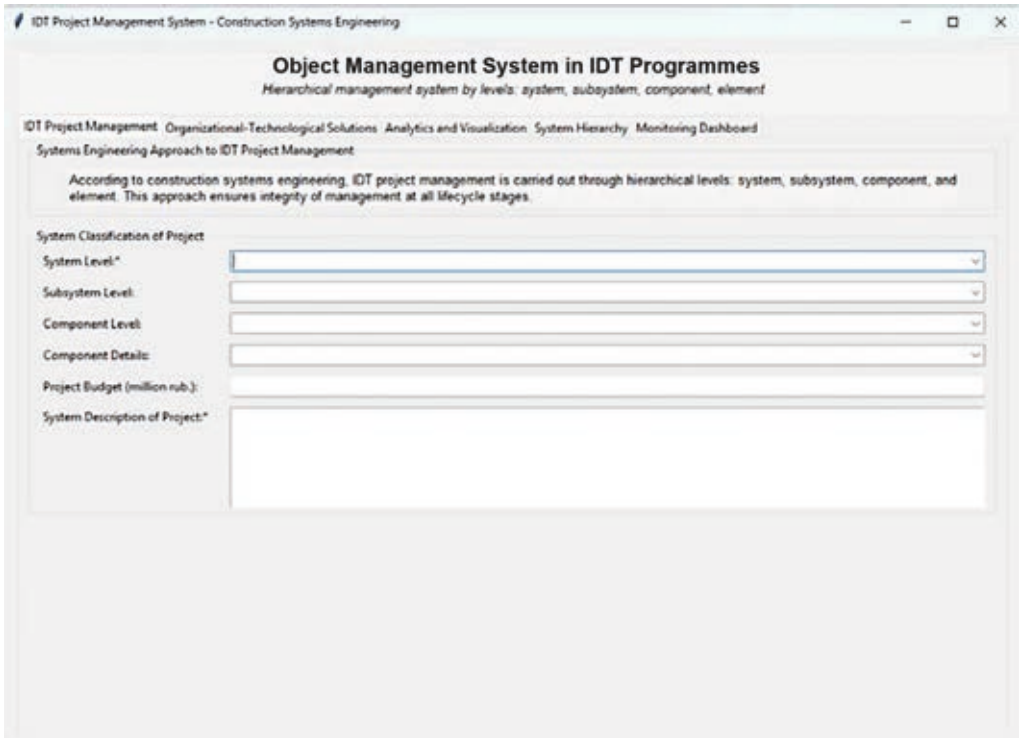


Fig. 6. Interface of the object management programme in IDT programmes

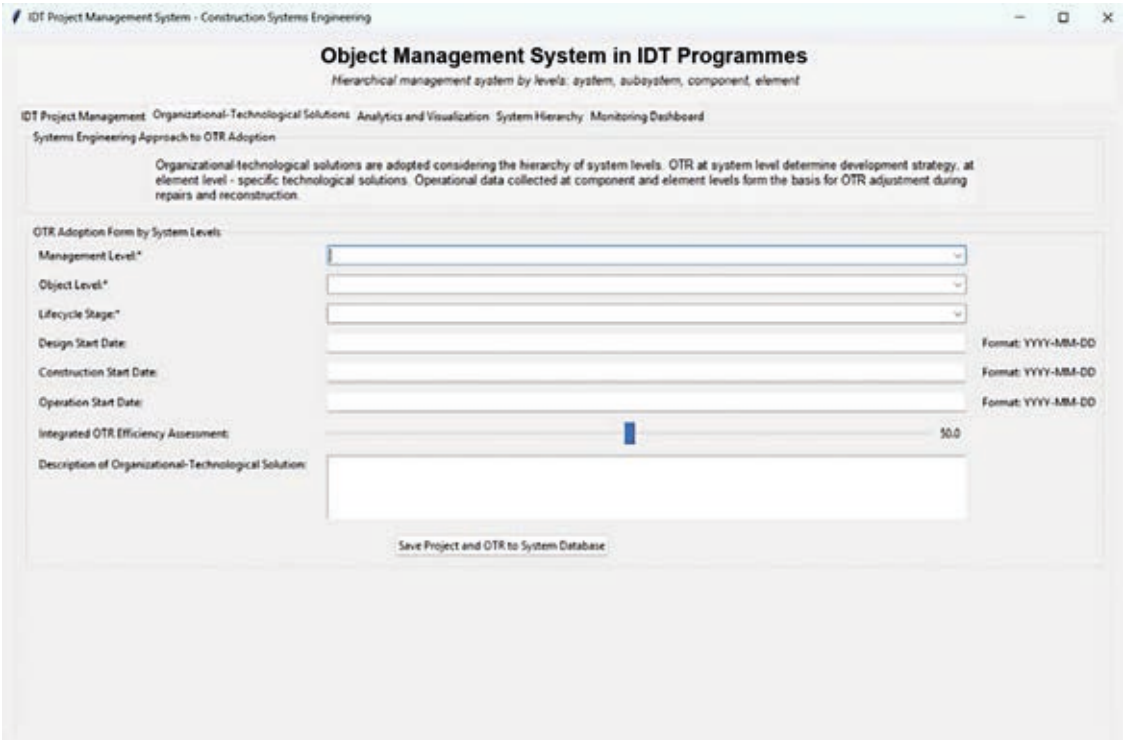


Fig. 7. Module “Organisational and Technological Solutions”



Fig. 8. Analytics and Visualization Module

- calculation of weighted average efficiency indicators, taking into account the financial characteristics of projects;
- comparative analysis of efficiency distributions using box-and-whisker plots.

It is also possible to export data in MS Excel format with a structured presentation of information, including source data and summary statistics.

The reference module contains a system hierarchy of objects in IDT projects and serves as a visual reference guide based on the hierarchical classification of objects built into the system (Fig. 9). The information on the tab is presented in a tree structure, sequentially displaying all levels — from system to element — providing users with the ability to navigate the classification system and promoting a uniform understanding of structural elements.

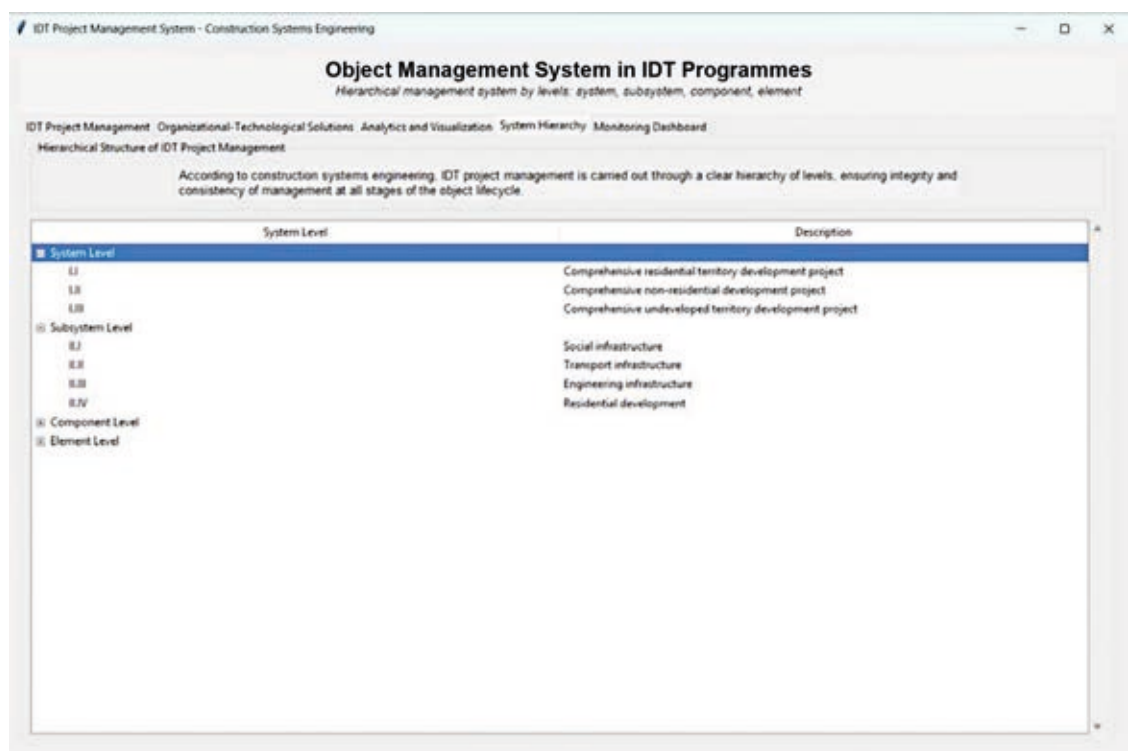


Fig. 9. Reference module “System hierarchy”

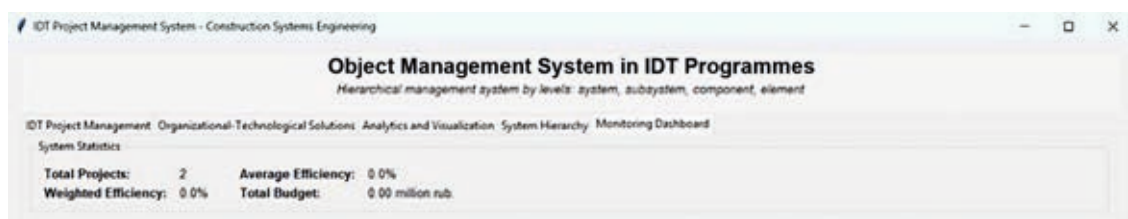


Fig. 10. Monitoring Panel Module

The integrated monitoring panel (the last module of the system) (Fig. 10) is implemented as an overview dashboard that provides summary information about key system indicators. This dialogue box displays aggregated statistical data, including the total number of projects, average efficiency values, and aggregate financial indicators (e.g., project budget).

The presented architecture of the software complex provides end-to-end management of information about IDT projects — from entering initial project data to complex analytical analysis, which complies with the principles of a systematic approach and meets the requirements of comprehensive and integrated management.

CONCLUSIONS

As a result of the research, a system for end-to-end design of organisational and technological solutions for comprehensive development projects at all stages of their life cycle has been developed and presented in the form of detailed block diagrams.

One of the software options is presented, in which the basic logic of the methodological principles of the proposed approach is implemented, but the block responsible for the level of autonomy of the facility is not integrated.

The practical significance of the research lies in the fact that the developed methodological principles and block diagrams can be directly implemented in the practice of IDT project management.

Their application will improve the soundness of decisions, reduce unforeseen costs by lowering the probability of risks, and create a basis for the digitalization of territorial development management.

The proposed solutions form the methodological foundation for the creation of modern systems for managing the life cycle of IDT facilities and ensure the transition from reactive management (elimination of consequences) to proactive management (prevention of problems based on data analysis).

Prospects for further research are related to the integration of the proposed model with software complexes based on BIM modelling, the development of intelligent algorithms for predicting the technical condition of objects, and the creation of economic and mathematical models for assessing the integral effectiveness of IDT projects, taking into account the entire life cycle.

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Управление жизненным циклом объектов комплексного развития территорий на основе организационно-технологических решений

В статье представлен подход к управлению жизненным циклом объектов строительства в программах комплексного развития территорий (КРТ) на основе организационно-технологической документации, включающий алгоритм специализированного программного обеспечения для автоматизации процессов планирования, контроля и анализа. Предлагаемый подход позволяет создать единое информационное пространство для всех участников проекта и обеспечить сквозное управление от стадии проектирования до вывода объектов строительства из эксплуатации. Отмечено, что на этапе эксплуатации организационно-технологические решения (ОТР) не требуются, их принятие становится необходимым при проведении ремонтных мероприятий по объектам. При этом критически важную роль в обосновании таких решений играет ретроспективная информация об условиях эксплуатации объекта, сбор которой возможен лишь непосредственно на этапе эксплуатации.

Внедрение предложенного решения позволит повысить управляемость проектов КРТ и создать основу для устойчивого развития территорий.

Перспективы дальнейших исследований связаны с интеграцией предложенной модели с учетом уровня автономности объекта с программными комплексами на основе BIM-моделирования, разработкой интеллектуальных алгоритмов для прогнозирования технического состояния объектов и созданием экономико-математических моделей для оценки интегральной эффективности проектов КРТ с учетом полного жизненного цикла.

лирования, разработкой интеллектуальных алгоритмов для прогнозирования технического состояния объектов и созданием экономико-математических моделей для оценки интегральной эффективности проектов КРТ с учетом полного жизненного цикла.

Ключевые слова: жизненный цикл объекта, устойчивое развитие территорий, комплексное развитие территорий, ПОС, ППР, ПОРСид

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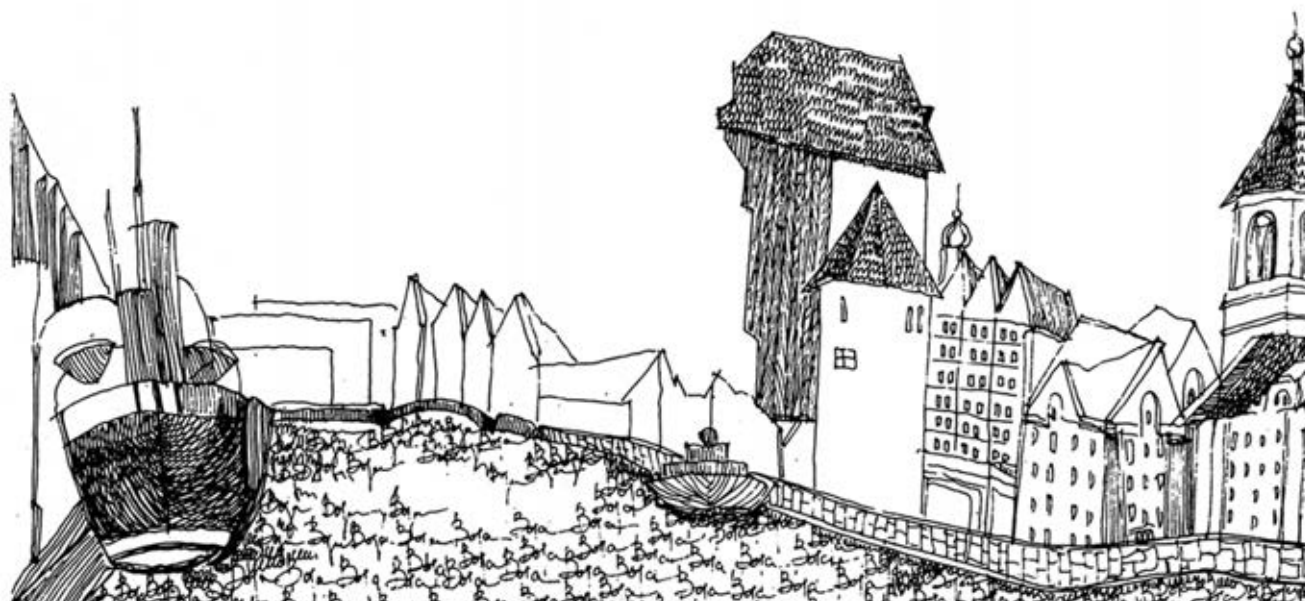
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For citation: Adamtsevich L.A. Lifecycle management of integrated territorial development projects based on organizational and technological solutions. *Real Estate: Economics, Management*. 2025; 4:32-39.

Для цитирования: Адамцевич Л.А. Lifecycle management of integrated territorial development projects based on organizational and technological solutions // *Недвижимость: экономика, управление*. 2025. № 4. С. 32–39.



Гданьск. Верфи. Офорт

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Clusterization and algorithmization of conflicts within the framework of integrated territorial development



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It has been established that the integrated development of territories is the basic direction of the construction industry. The main goal of this state programme is to improve the quality of life of citizens, renew and develop the urban environment based on the principles of sustainability, increase the efficiency of using territories and solve problems with emergency housing. There are many problems associated with the implementation of investment projects, including social, organizational, communication, financial, and regulatory risks. The imperfection of the mechanism of integrated territorial development leads to a multitude of conflicts that require classification, analysis, and management measures to resolve them. To do this, a system should be developed that allows the use of machine algorithms, that is, an automated conflict classifier. To this end, algorithms for typing and clustering conflict situations have been developed based on hierarchical analysis and spatial clustering based on hierarchical density, taking into account noise. Hierarchical analysis creates a tree-like structure of clusters, which can help, if necessary, create a common structure of information about projects and contradictions that have arisen. Density clustering allows you to determine “conflicts-departures” and is necessary for analyzing the internal structure of groups of typical conflicts. In addition, using a system of weights, a method is proposed for determining the integral assessment of significance, that is, the degree of influence of contradictions on the implementation of the project.

Keywords: complex development of territories, investment and construction project, risks, conflict, clusterization, hierarchical analysis, spatial clusterization

The integrated development of territories (hereinafter referred to as the IDT) has long been part of state policy, but it was legally enshrined in the Urban Planning Code of the Russian Federation (hereinafter referred to as the UPC RF) by Federal Law as Chapter 10 of the UPC RF¹. This process makes it possible to involve various degraded territories in economic activities with the most modern infrastructure [1].

The main goal of the IDT is to improve the quality of life of citizens, renew and develop the urban environment based on the principles of sustainability, increase the efficiency of using territories and solve problems with emergency housing. Within the framework of the IDT, new urban areas are being formed on the basis of integrated urban planning plans, which provide not only for the construction of new residential buildings, but also for providing citizens with access to newly built social facilities, i.e. schools, clinics, etc. the goals of integrated development of the territory. These processes involve not only budgetary, but also private financing sources, as well as experienced developers who implement development projects together with municipal and federal authorities. It should be noted that a single IDT mechanism operates throughout the Russian Federation, providing for the demolition of dilapidated housing and the construction of modern apartment buildings in these territories, and the resettlement of citizens in more comfortable conditions [2]. Representatives of the construction industry and the Government of the Russian Federation consider IDT projects as the most promising mechanism for urban renewal. For example, Irek Fayzullin, Minister of Construction and Housing and Communal Services of the Russian Federation,

noted that the regions plan to apply IDT in more than 1,200 territories. In turn, Marat Khusnullin stated that the implementation of the national project “Infrastructure for Life” is aimed at the integrated development of at least 2 thousand settlements, and 120 billion rubles will be allocated for the implementation of the IDT projects [3]. The success of the implementation of the IDT projects is shown in Fig. 1. The diagram shows a steady increase in all indicators, an increase in the number of approved documents, and the expansion of territories involved in integrated development projects. The number of regions where the IDT is being implemented has also increased.

Thus, IDT is the flagship of the development of the construction industry, however, it is necessary to note the numerous contradictions in the mechanism of its implementation, which lead to various organizational conflicts [4]. This problem is related to the inevitable risks of the IDT programme, which are shown in Table.

Scientists investigating this problem list the bottlenecks of the legislative framework and the IDT method. For example, A.G. Vyazov in his work [5] indicates that “the decision to apply the IDT regime to a certain territory can be made regardless of whether such an area is intended for IDT in accordance with the rules of land use and development”. The author also points out the lack of clarity about what percentage of the territory planned for IDT should be occupied by dilapidated and dilapidated housing in order for an informed decision on the project to be made. Other authors also point out the various disadvantages and risks that exist in the framework of the implementation of IDT projects [6–8].

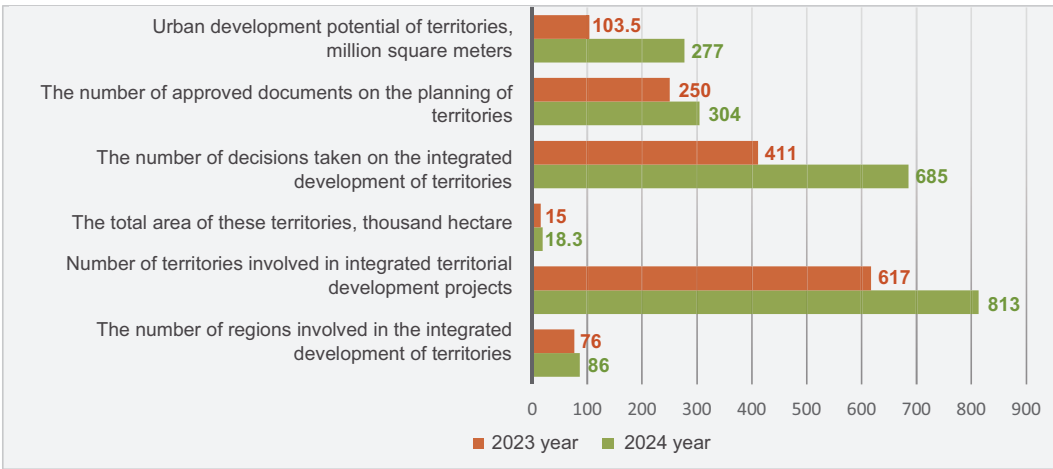


Fig. 1. Indicators of IDT projects in Russia for 2023–2024

Disadvantages and risks of the IDT programme

Social	Organizational and communication	Financial	Regulatory and legislative
- unwillingness of citizens to change their area and place of residence; - potential violation of the rights of citizens (1/3 of the owners) who voted against at the meeting on the issue of the inclusion of an apartment building in the IDT project; - lack of access of citizens to the territory where the IDT project is being implemented; - the risk of socio-economic displacement of the poor from a developed area; - the risk of unequal housing replacement, insufficient compensation	- delays in project implementation, postponement of construction dates; - poor interconnection of project stakeholders	- understatement the estimated cost of an apartment in a demolished building; - lack of project financing; - rising real estate prices, especially in economically developed regions; - instability of the real estate market due to the implementation of the IDT project and the uncertainty of the final cost per square meter of housing; - the risk of uneven development of IDT (in some regions, IDT is realized faster than in others)	- the decision on the IDT project can be made regardless of whether such an area is designated by the rules of land use and development; - there is no mixed-use development in the list of IDT territories (one of the most common forms); - the absence of a law on public-private partnership in the implementation of decisions on IDT; - obligations of investors to build social facilities; - weak investor protection; - it is not possible to determine all the essential terms of the IDT agreements at the time of conclusion; - the need to commit to projects that have not yet been formed, there is no approved documentation on the planning of territories and the final price at the stage of concluding contracts

A significant list of conflicts requires their systematization, analysis using machine mechanisms, automation of conflict typing and the search for possible standard solutions [9–11]. The object of such research is the management processes of investment and construction projects implemented within the framework of the IDT, and the subject is contradictions, problems and conflicts in these processes.

As part of the formation of a conflict classifier with an automated selection of corrective actions in order to resolve contradictions, it is necessary.

- Entering into the classifier information about implemented IDT projects and conflicts that arose during the implementation, decisions taken to eliminate contradictions.
- Two-stage clustering of conflicts.
- Entering information about a newly arisen conflict in the field of IDT into the classifier.
- Classification (typification) of the conflict according to various groups of features with an integral assessment of the significance, that is, the influence of each classifying feature (according to the system of assigning weights).
- Selection of a solution based on the data already available in the database, and further adoption of the selected measures.

The general scheme of the process is shown in Fig. 2, and the detailed algorithm is shown in Fig. 3.

The third stage is performed on the basis of hierarchical analysis and spatial clustering algorithms. Hierarchical analysis will create a tree-like structure of clusters, which can help, if necessary, create a common structure of information about IDT projects and contradictions that have arisen, that is, separate groups of typical conflicts. HDBSCAN (Hierarchical Density-Based Spatial Clustering of Applications with Noise) is a density-based clustering algorithm that finds clusters of different densities and noise in datasets. This approach allows you to identify “conflicts-crashes” that are too different from the others. This algorithm is necessary for analyzing the internal structure of clusters (conflict groups) [12–15].

Let's identify all possible signs of conflicts that arise during the implementation of integrated territorial development projects, including Y , and all feature groups are a subset of X , which belongs to the set $Y(X \subset Y)$. x_{ij} is the i -th feature of the j -th group of n -possible groups, v_{ij} is the weight of each feature that belongs to the range of values from 0 to 1. Then the integral assessment of the significance of the conflict is determined by the formula:

$$ZK_{int} = \sum_{i=1, j=1}^n x_{ij} \cdot v_{ij}; \quad v_{ij} \in [0, 1].$$

(1) ▶

Entering a data array that contains information about construction projects that have already been implemented, organizational conflicts that have arisen during their implementation, causes and remedial measures, as well as the results of the measures taken

Conflict clustering based on hierarchical analysis with the formation of an external end-to-end dendrogram structure

Conflict data is structured and ranked according to any combination of features in a single tree (for example, a specific Russian region — the most frequently occurring conflicts in IDT projects for this region – causes of conflict – measures taken – result)

Spatial clustering of conflicts with detection of “crashes” based on hierarchical density, taking into account noise (analysis of the internal structure of clusters based on the HDBSCAN algorithm)

- 1. The density of the distribution of points within each cluster is determined (the typification of the conflict within the group is determined).
- 2. The hierarchy of clusters is being clarified in terms of their density levels.
- 3. The most stable clusters at each level of the hierarchy (groups of typical conflicts) are determined.
- 4. Data points, that is, conflicts that cannot be attributed to a stable cluster (group), are considered “crashes”, that is, noise

Entering an array of data about a new conflict and analyzing the data

Comparison of the input information with the data-base	Conclusion about	Decision-making options
	1. The conflict belongs to existing clusters (groups).	1. A standard decision is made on a standard conflict.
	2. Similarities with the existing “departure” (the beginning of the formation of a new cluster).	2. Information on other “departures” is taken into account. If there is a similarity between the new data array and the parameters of at least one of the existing ones, a new cluster arises, that is, a new group of typical conflicts. The conflict resolution is formed taking into account decisions on a similar “departure”.
	3. The complete atypical nature of the conflict (placed by the system as a new “departure”)	3. The conflict is classified

Selection of a solution and adoption of selected measures to resolve the conflict

Fig. 2. Clustering and conflict typing scheme

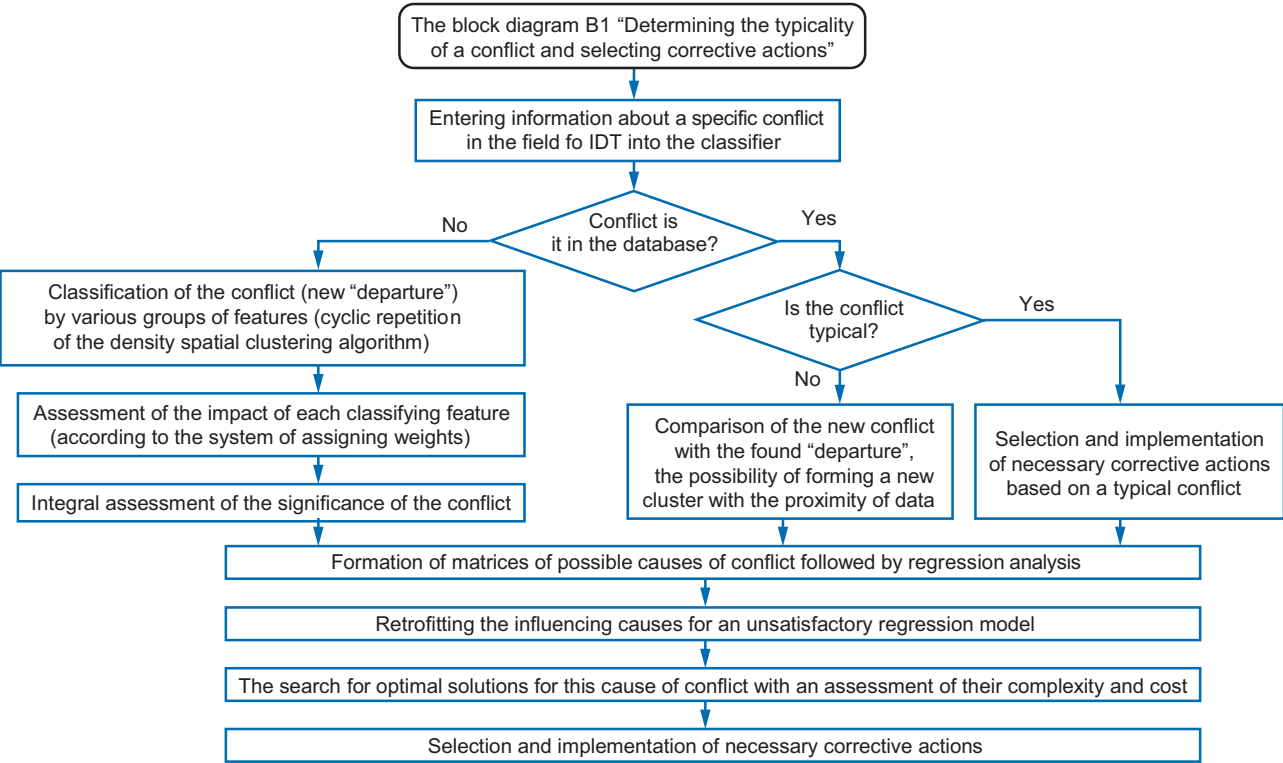


Fig. 3. The algorithm for determining the typicality of the conflict, the integral assessment of its significance and the selection of solutions

The selection of the solution is also carried out using machine methods and auxiliary algorithms.

It has been established that the integrated development of territories is the basic direction of the construction industry, however, in the process of implementing investment projects, many conflicts and contradictions arise that require classification, analysis and decision-making. Algorithms for classifying conflicts and a method for determining the integral assessment of significance, that is, the degree of influence of contradictions on the implementation of the project, are presented.

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Кластеризация и алгоритмизация конфликтов в рамках комплексного развития территорий

Установлено, что комплексное развитие территорий является базовым направлением строительной отрасли. Основной целью данной государственной программы является повышение качества жизни граждан, обновление и развитие городской среды на принципах устойчивости, повышение эффективности использования территорий и решение проблем с аварийным жильем. С реализацией инвестиционных проектов связано множество проблем, среди которых социальные, организационно-коммуникационные, финансовые и нормативно-законодательные риски. Несовершенство механизма комплексного развития территорий приводит к множеству конфликтов, требующих классификации, анализа и принятия управленческих мер с целью их решения. Для этого следует разработать систему, позволяющую применять машинные алгоритмы, т.е. автоматизированный классификатор конфликтов. С этой целью на базе иерархического анализа и пространственной кластеризации на основе иерархической плотности с учетом шума разработаны алгоритмы типизации и кластеризации конфликтных ситуаций. Иерархический анализ создает древовидную структуру кластеров, что может помочь при необходимости создать общую структуру информации о проектах и возникших противоречиях. Плотностная кластеризация позволяет определить «конфликты-вылеты» и необходима для анализа вну-

тренней структуры групп типовых конфликтов. Кроме того, с помощью системы весов предложен способ определения интегральной оценки значимости, т.е. степени влияния возникших противоречий на осуществление проекта.

Ключевые слова: комплексное развитие территорий, инвестиционно-строительный проект, риски, конфликт, кластеризация, иерархический анализ, пространственная кластеризация

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For citation: Semenov A.L., Kurbakov D.E., Kosenkova Yu.K. Clusterization and algorithmization of conflicts within the framework of integrated territorial development. *Real Estate: Economics, Management*. 2025; 4:40–44.

Для цитирования: **Семенов А.Л., Курбаков Д.Е., Косенкова Ю.К.** Clusterization and algorithmization of conflicts within the framework of integrated territorial development // Недвижимость: экономика, управление. 2025. № 4. С. 40–44.

UDC 658.5

Current stage of development of mechanisms for regulating the procedures for technological connection of capital construction projects

The paper presents a comprehensive analysis of the mechanisms of state regulation of interaction between developers and resource supply organizations (RSO) in the context of technological connection of capital construction facilities to engineering networks. The study covers a wide range of aspects: from analyzing the current regulatory framework and its application practice to identifying typical violations that occur at various stages of implementation of connection procedures, as well as evaluating the effectiveness of state and municipal control institutions in this area.

Particular attention is paid to the legislative transformations that took place in the period 2023–2025, including the strengthening of antimonopoly regulation, the initiative to introduce digital platforms to simplify administrative procedures and increase transparency in the interaction of market participants. The authors consider the concept of “technological processes” of interconnection not only as an engineering and technical, but also as a socio-economic and legal category, including both physical connection to water supply, sanitation, heat, gas, electricity and communications networks, as well as integration into the digital infrastructure of “smart” cities.

Based on a systematic legal analysis, key systemic problems have been identified that hinder the effective implementation of developers’ rights and ensure the reliable functioning of engineering infrastructure. These include: legal uncertainty in the interpretation of certain norms, an imbalance in the distribution of risks between participants in interaction, inconsistency in tariff policy and investment programmes of RSO, as well as insufficient coordination between federal and regional authorities.

The purpose of the study is to develop scientifically sound recommendations for improving legal regulation in the field of technological connectivity, aimed at increasing the investment attractiveness of the construction sector, ensuring legal certainty and stimulating the introduction of innovative, including digital, solutions into the engineering infrastructure of the modern urban environment.

Keywords: government regulation, technological connection, engineering networks, life support for real estate, heat consumption, resource supply organizations

INTRODUCTION

Engineering support for capital construction facilities is one of the fundamental components of modern urban planning and life support for urbanized territories. It ensures the functional suitability of buildings and structures, as well as compliance with the requirements of sanitary and epidemiological well-being, energy efficiency and sustainable development of the urban environment [1–3]. Despite the apparent technical and legal regulation of this process, in practice, the procedure for technological connection to engineering networks, including electricity, water supply, sanitation, gas and heat supply systems, often becomes a critical moment in the implementation of investment construction projects.

These difficulties are caused by a complex of interrelated legal, administrative and economic factors. Among them are the ambiguity of the regulatory framework, which allows for different interpretations of certain provisions by participants in legal relations; excessive bureaucratization of administrative procedures, the lack of unified standards of interaction between developers and resource supply organizations (RSO) (Figure), as well as systemic risks associated with the monopoly position of the latter in local engineering infrastructure markets. In a number of cases, there is abuse of a dominant position on the part of RSO, expressed in the imposition of unjustified

conditions, artificially inflating tariffs for accession, or deliberately delaying deadlines for fulfilling obligations. According to a study by the Higher School of Economics describing approaches to regulating tariffs for connecting capital construction facilities to infrastructure, in 76.5 % of cities the developer will face some form of opaque tariff regulation in the field of connection to heat supply systems, 45.1 % in the field of water supply and 49 % in the field of sanitation [4].

In practice, the procedure for technological connection of construction projects for developers is accompanied by a multi-stage coordination of technical conditions, each of which initiates a chain of individual requirements from RSO, some of which go beyond federal standards and require additional engineering surveys, redesign or purchase of specialized equipment [5–7]. The lack of unified forms of documents and the variability of local regulations lead to repeated approval cycles, which increases the duration of the preparatory stage. The procedure for removing engineering networks from a building site, namely, a change in the compensation policy from property to monetary, stretches work deadlines for builders for years instead of 3–6 months [8]. At the same time, RSO often forms connection tariffs without a public cost audit, which leads to a significant increase in the developer’s capital expenditures, destabilization of the project’s financial model and disruption of approved implementation schedules. According to

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► an article from the Vedomosti online publication, in some cases, connection costs can reach up to 10 % of the construction budget [9]. Delays in issuing an act of admission or commissioning of engineering networks delay the deadline for obtaining Permission to put the facility into operation, provoking penalties and increasing the cost of maintaining the construction site and interest on loan agreements. The combination of these factors transforms technological connection from a routine procedure into a critical moment, through which a part of the working capital of construction companies is lost annually and the deadlines for implementation are disrupted.

In response to these challenges, the Government has stepped up regulatory activities in this area. The Ministry of Construction and Housing and Communal Services of the Russian Federation, the Federal Antimonopoly Service (FAS of Russia), as well as relevant federal and regional executive authorities play a key role in this process. Their efforts are aimed at creating a balanced regulatory environment that ensures the harmonization of the interests of all participants: developers as subjects of investment activity; resource supply organizations, as operators of critical infrastructure; and end users, including future tenants and owners of real estate.

In recent years, a set of measures has been implemented to optimize legal and administrative regulation in the field of technological connectivity: digital services are being introduced (including within the framework of the national Housing and Urban Environment project), deadlines for approving and issuing technical specifications are being regulated, tariff approaches are being reviewed and antimonopoly control mechanisms are being strengthened. Nevertheless, the effectiveness of these measures remains a matter of debate, as significant barriers remain on the ground that hinder the achievement of the stated goals. In this regard, the relevance of this study is due to the need for a comprehensive assessment of the existing legal and institutional mechanisms for regulating the interaction between builders and RSO.

The purpose of the article is to conduct a systematic analysis of the regulatory framework, identify key problem areas in the practice of implementing technological connection procedures. The results of the study can serve as a basis for the development of scientifically sound recommendations for improving legal regulation and improving the efficiency of engineering support for construction projects in the Russian Federation.

MATERIALS AND METHODS

In the course of this study, a comprehensive methodological approach was applied, combining regulatory, statistical and comparative analysis. The information base is based on the current regulatory legal acts of the federal level, as well as orders of the Ministry of Construction and methodological recommendations of FAS of Russia [10].

According to official data published by the FAS of Russia on August 21, 2025, since the beginning of this year, the agency has brought to administrative responsibility a number of RSO for violations related to the procedure of technological connection to the networks of the communal infrastructure.

During the monitoring, FAS of Russia identified 43 cases of violations in the field of water supply and sanitation. In 14 of them, given the nature and severity of the violations, the anti-monopoly authority issued warnings as preventive measures aimed at preventing repeat offenses without immediately imposing financial sanctions. This approach indicates the application of a differentiated regulatory strategy that combines both punitive and preventive tools.

For a contextual comparison, it should be noted that for the whole of 2024, in similar areas of activity, including water supply, sanitation and heating, the total amount of fines imposed by FAS of Russia on RSO amounted to 9.2 million rubles, and the total number of violations identified reached 79 cases. Thus, by the middle of 2025, a significant intensification of law enforcement activity is being recorded: the volume of sanctions imposed in the eight months of this year is about 78 % of the annual figure of the previous period, which may indicate both an increase in the number of appeals from interested parties and increased proactive control by the antimonopoly authority departments [11].

In its official commentary, FAS of Russia emphasizes the inadmissibility of violations of the rules for connecting to public infrastructure networks, which directly affect both the interests of investors in the construction industry and the rights of citizens to access basic life support services. The Agency declares its readiness to promptly respond to any cases of abuse of a dominant position by monopoly operators, especially in conditions where such actions hinder the implementation of investment projects or create unreasonable administrative barriers. It is emphasized that the protection of competition and ensuring transparency of technological accession procedures remain priority tasks of antimonopoly policy in the context of the implementation of national goals in the field of housing construction and sustainable urban development.

These data indicate the continuing tension in law enforcement practice in the field of engineering and confirm the need for further improvement of both the regulatory framework and the mechanisms for its implementation at the regional level.

On May 21, 2025, the President of the Russian Federation approved a list of instructions following the meeting of the Presidium of the State Council on the topic "The development of infrastructure for life", which took place on April 15, 2025. The key points related to infrastructure organizations are listed below:

- the possibility of reducing the established regulatory deadlines for the technological connection of capital construction facilities to electricity, gas, heat, water supply and sanitation networks, as well as the introduction of a phased advance system, in which subsequent financing is carried out only after the resource supply (network) organization confirms the actual completion of work in the amount corresponding to the previously paid advance is valid until October 1, 2025;
- to conduct an experiment in the Moscow Region to create an electronic service for consultations with the balance holders of federal network facilities until October 1, 2025;
- to prevent the introduction of requirements for developers in the regulatory legal acts of the subjects of the Russian Federation and municipal legal acts that are not provided for by federal legislation and are not included in the unified register of documents, information, materials and approvals, established by the legislation of the Russian Federation on urban development activities, until November 1, 2025;
- methodological assistance to municipalities in bringing legal acts into line with federal legislation — until October 1, 2025;
- introduce a moratorium on changes to the requirements for the construction of social infrastructure facilities for up to five years in order to prevent an increase in their cost — until June 15, 2025.

The President's instructions have become an important impetus for systemic changes in the regulatory framework governing the interaction of developers with resource supply organizations. In particular, as early as August 2025, the Government of the Russian

Resolution of the Government of the Russian Federation No. 1246 of August 20, 2025 On Amendments to Resolution of the Government of the Russian Federation No. 861 of December 27, 2004

Aspects of regulation Categories of rules	Categories of applications	Major applicants	Configuration of the application	Deadline for submission of document	Payment by invoice	Document management	Small applications
Before 2025	Only legal entities proprietors (150–670 kW)	>150 kW — special conditions	10 days from the act/notifi-cation	10 days for everyone	Uniform deadlines	Paper documents	Simplified procedure
Since 2025	Any persons, including individuals (150–670 kW)	>670 kW — special conditions	60 days from the invoice	10 days — general; 20 days — 150–670 kW	5–15 days depending on the category	Only electronic ones with EDS	Mandatory participation of energy supervision
Regulatory Framework	Section II, paragraph 12	Section II, paragraph 15	Section IX, paragraph 103	Section IX, paragraph 105	Section IX, paragraph 106	Section IX, paragraph 110	Appendix No. 17, paragraphs 6, 8

Changes in the rules of technological connection

Federation implemented one of the key guidelines — optimizing the timing and procedures for technological connection to the grid through amendments to the current resolution.

The data presented in Figure illustrates the key changes made to Decree of the Government of the Russian Federation No. 861 of December 27, 2004 “Approval of the Rules for Technological Connection of Power Receiving Devices ...” as a result of the issuance of Decree of the Government of the Russian Federation No. 1246 of August 20, 2025, which entered into force on September 2, 2025 [12]. The data is grouped according to six main parameters of the applicant’s interaction with the RSO: the category of applicants, criteria for classifying as “large” applications, deadlines for confirming the application, deadlines for submitting documents, payment procedure and workflow. The comparison is made for two time periods “until 2025” and “from 2025”, which allows us to identify the direction of the reform and its practical consequences.

The changes introduced in 2025 to the Rules of Technological Connection represent a systemic reform aimed at expanding access

to engineering infrastructure, unifying and simplifying procedures for most applicants, digitizing and formalizing interaction through electronic document management and the use of electronic digital signature, differentiating terms and conditions depending on the scale and complexity of the project, improving the responsibility of RSO for the quality and timeliness of the provision of services [13].

These measures comply with modern international standards for regulating engineering infrastructure and are aimed at creating a favorable investment climate in the construction industry. They also contribute to the implementation of national goals in the field of housing, sustainable urban development and digital transformation of public administration [14]. The mandatory participation of energy supervision in the procedure for small applicants has been introduced, which means increased control over compliance with technical requirements, increased connection security, and a guarantee that even small facilities will be connected in accordance with the Rules of Electrical Installation (REI) and SNiP.

Table 1. Identified problems and measures to eliminate them

Problem	Proposed solution/implemented measure	Status	Comment
Ambiguity of the regulatory framework, allowing for discrepancies	Resolution No. 861 has been reformed, unified rules for technological connection have been introduced since September 2, 2025	Partially solved	Monitoring of the application of the new rules on the ground and explanatory work are required
Excessive bureaucratization of procedures	Proposal for the introduction of digital services, including within the framework of the national project “Housing and Urban Environment”	In process	Effectiveness depends on the readiness of the regional RSO and the level of digital literacy of applicants
Lack of uniform standards for interaction between developers and RSO	Development and implementation of unified electronic forms and terms of interaction, stipulated in Resolution No. 1246	Partially solved	Adaptation at the regional level and training of participants in the process are required
Abuse of authority by RSO (overstating tariffs, delaying deadlines)	Strengthening antimonopoly control: in 2025, an increase in the number of violations and fines was recorded	Partially solved	Preventive measures and tariff transparency need to be strengthened
Local barriers not provided for by federal legislation	Instruction of the President of the Russian Federation (May 2025) to prevent the introduction of requirements not included in the unified register	In process	Methodological assistance to municipalities and compliance control of legal acts are required
Insufficient transparency and deadlines for approvals	An experiment in the Moscow region to create an electronic approval service with the balance holders of federal networks	In process	Scaling of successful experience to other regions is required

Table 2. Problems of technological connection and proposals for their solution

Problem	Possible solution
Heterogeneous practice of implementing federal standards of technological connection at the level of subjects of the Russian Federation and municipalities	The introduction of a multi-level system of vertical legal control and feedback, the consolidation of personal administrative responsibility of the heads of regional authorities and RSO for the admission of local acts contrary to federal law
Shortage of feedback mechanisms and quantitative assessment of the quality of services provided by resource-supplying organizations	Formation and constant updating of the publicly available rating mechanism of RSO, integrated into a single digital platform for technological connection, with mandatory consideration of quantitative (connection time, frequency of violations, fee amount) and qualitative (satisfaction of applicants, transparency of procedures) indicators; parallel implementation of a system for filing, reviewing and publishing substantiated complaints with open review statistics, for ensuring public and antimonopoly control
Insufficient level of legal competence of applicants (developers, design organizations) regarding the regulatory and legal regulation of procedures for technological connection to utility networks	Creation of a system of legal education for applicants, including the development and integration into digital platforms of technological connection, interactive training modules reflecting current regulatory changes; conducting webinars and face-to-face consultation sessions; creating a constantly updated online directory of typical errors and judicial practice on technological connection

However, the success of the implementation of these changes will depend on the readiness of regional RSO to introduce digital services, the level of legal literacy of applicants and the effectiveness of control by executive authorities and antimonopoly authorities.

RESULTS

Thus, the paper analyzes the presented data, which allows us to draw the following conclusions, shown in Table 1.

In 2025, significant steps have been taken to simplify and digitalize the processes of technological connection, a number of problems remain unresolved or require systematic monitoring and refinement. The issues listed in Table 2 remain particularly relevant.

To sustainably improve the investment climate in the construction industry, not only regulatory reform is needed, but also institutional support, including training, monitoring, feedback, and digital transparency at all levels of interaction.

In the future, it is necessary to accelerate the introduction of digital tools (register of technical specifications, electronic interaction), unification of regional procedures, and strengthening the personal responsibility of RSO officials. Only with the synergy of state control and an active business position can the accession process be transformed into a standard technical procedure.

CONCLUSIONS

In conclusion, we note that the conducted research has made it possible to comprehensively assess how the state is developing mechanisms for regulating the procedures for technological connection of capital construction facilities, implementing a set of targeted measures aimed at reducing the administrative, legal and financial barriers faced by developers. Comparing the regulatory texts, we see that the reform of recent years, aimed at tightening antimonopoly supervision, launching a “one-stop shop” on digital platforms and reducing the time for approvals, sets out more transparent and faster procedures that help reduce negative consequences for builders, namely, reduce the risks of schedule disruption and prevent unforeseen costs. However, the final effect depends on how quickly regional authorities and network companies rebuild internal processes, train staff, and start working in a new electronic environment.

The conclusions obtained indicate that in order to transform engineering connection from a risk factor into a stable service, it is necessary to bring simplification of regulations to its logical conclusion, introduce understandable and non-discriminatory tariffs, create a mechanism for quick compensation of developer’s losses in

case of delay, as well as strengthen the responsibility of network organizations for unjustified refusals and overcharging. The implementation of these measures will increase investor confidence, accelerate housing starts, and provide an additional incentive for the introduction of smart technologies into urban infrastructure.

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Современный этап развития механизмов регулирования процедур технологического присоединения объектов капитального строительства

Представлен комплексный анализ механизмов государственного регулирования взаимодействия между застройщиками и ресурсоснабжающими организациями (PCO) в контексте технологического присоединения объектов капитального строительства к инженерным сетям. Исследование охватывает широкий спектр аспектов: от анализа действующей нормативно-правовой базы и практики ее применения до выявления типичных правонарушений, возникающих на различных этапах реализации процедур подключения, а также оценки эффективности институтов государственного и муниципального контроля в данной сфере.

Особое внимание уделено трансформациям законодательства, произошедшим в период 2023–2025 гг., включая усиление антимонопольного регулирования, инициативу внедрения цифровых платформ для упрощения административных процедур и повышения прозрачности взаимодействия участников рынка. Авторами рассматривается понятие «технологических процессов» присоединения не только как инженерно-технической, но и как социально-экономической и правовой категории, включающей как физическое подключение к сетям водоснабжения, водоотведения, теплоснабжения, газоснабжения, электроснабжения и связи, так и интеграцию в цифровую инфраструктуру «умных» городов.

На основе системного правового анализа выявлены ключевые системные проблемы, препятствующие эффективной реализации прав застройщиков и обеспечению надежного функционирования инженерной инфраструктуры. К ним относятся: правовая неопределенность в толковании отдельных норм, дисбаланс в распределении рисков между участниками взаимодействия, несогласованность тарифной политики и инвестиционных программ PCO, а также недостаточная координация между федеральными и региональными органами власти.

Целью исследования является разработка научно обоснованных рекомендаций по совершенствованию правового регулирования в сфере технологического присоединения, направленных на повышение инвестиционной привлекательности строительного сектора, обеспечение правовой определенности и стимулирование внедрения инновационных, в том числе цифровых, решений в инженерную инфраструктуру современной городской среды.

Ключевые слова: государственное регулирование, технологическое присоединение, инженерные сети, жизнеобеспечение недвижимости, теплотребление, ресурсоснабжающие организации

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For citation: Novikova A.Yu., Belyakov S.I. Current stage of development of mechanisms for regulating the procedures for technological connection of capital construction projects. *Real Estate: Economics, Management*. 2025; 4:45–50.

Для цитирования: Новикова А.Ю., Беляков С.И. Current stage of development of mechanisms for regulating the procedures for technological connection of capital construction projects // Недвижимость: экономика, управление. 2025. № 4. С. 45–50.



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UDK 332.1+338.001.36

Development of a Unified Methodology for Assessing the Choice of Construction Type in the Arctic Based on the Aggregate Economic Effect of Key Regional Construction Parameters

Relevance of research. The growing importance of the Arctic Zone of the Russian Federation (hereinafter referred to as the AZRF) and the Northern Sea Route (hereinafter referred to as the NSR), particularly in enhancing various aspects of the national construction industry and achieving the objectives of national and economic security, motivates the scientific community to study the specific characteristics of the region more thoroughly. The extensive system of benefits and incentives offered for conducting financial and economic activities in the Arctic opens up significant prospects for optimizing costs and investment expenditures incurred by key economic actors in the region. However, the harsh climatic conditions, the generally low level of infrastructural development, and the vast total area of the AZRF represent substantial barriers to achieving the goals of sustainable economic development in Russia's Arctic. The application of advanced technologies and modern principles of economic management can significantly improve the region's economic performance.

Purpose of the study. To describe the methodological foundations and propose an algorithm for developing a methodology to assess the economic feasibility of applying a specific construction approach in the Arctic.

Methods. The unified methodology for evaluating the effectiveness of applying modular elements of maximum readiness (MEMR) represents a sequence of interrelated blocks (stages), with the overall result expressed in the form of a consolidated financial model of the project.

Results and novelty. A unified methodology for assessing the choice of construction type in the Arctic is proposed. Based on this methodology, it is possible to develop a consolidated financial model of a construction project in the region, which effectively becomes the first comprehensive tool for justifying modular construction in the Arctic — integrating regulatory requirements, economic feasibility, and managerial aspects into a single framework.

Keywords: *Economy, Arctic, project financial model, Arctic Zone of the Russian Federation, modular construction, economic effect, MEMR (Modular Elements of Maximum Readiness)*

When studying and conducting research in such a strategically important and complex region as the Arctic, special attention must be given to the economic sciences, as they are critically important both in the context of the Arctic Zone itself and in terms of economic activity within it. Several key factors affect the macroeconomic interests of the Arctic states, as well as other actors engaged in economic activity in the region.

The Arctic possesses an enormous mineral and resource potential, which makes it strategically significant for both the global and national economies. The region contains vast reserves of hydrocarbon resources located on the continental shelf and in coastal areas, and it is also rich in metals, minerals, and other valuable resources, including biological ones such as fish and seafood. Economic science plays a crucial role in assessing their profitability, forecasting demand and impact on global markets, also determining optimal models for extraction and transportation. The development of these resources requires large-scale construction of infrastructure, industrial, and extraction facilities.

Global warming and the melting of Arctic ice are creating the potential to transform the Northern Sea Route (NSR) into a year-round transport corridor, which also requires substantial investment. Economists analyze the NSR's potential as an international transit corridor¹, estimate the necessary

investments in icebreakers, ports, and navigation systems, and assess the route's competitiveness compared to traditional logistics pathways to Asia via the Cape of Good Hope and the Suez Canal.

The specific characteristics of the Arctic entail significant economic costs for any type of construction due to the harsh climatic conditions, limited logistics [1], infrastructural deficit, and short construction season, all of which increase both project costs and implementation timeframes. Economic analysis plays a key role in identifying the most efficient technologies and projects in terms of cost and benefit, taking into account the high expenses of construction, logistics [1], and operation under conditions of permafrost and low temperatures [2]. Moreover, economic science examines how financial, political, environmental, and technological risks affect the profitability of Arctic projects, contributing to the development of mechanisms for their mitigation — for example, through public-private partnerships or special tax regimes.

Thus, the economy serves as both a key driver and a limiting factor for the Arctic. It determines the feasibility, scale, and pace of regional development, while simultaneously underscoring the need to overcome significant financial and technological challenges [3, 4] associated with the unique conditions of Arctic construction. In this sense, the economy functions as a bridge between scientific discoveries and their practical, sustainable application in the interests of states and local communities within the region.

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¹ Urgent information for mariners, Glavsevmorput. Rosatom. 2005. URL: https://nsr.rosatom.ru/srochnaya-informatsiya/?ELEMENT_ID=208232 (rus.).

As mentioned above, construction in the Arctic Zone of the Russian Federation (AZRF) is characterized by specific conditions. According to regulatory documents, including CP 131.13330.2020², the effective construction season in the Arctic and adjacent regions lasts only 2–4 months per year. In practice, productive work is carried out for no more than 100–130 days annually, while the remaining time is marked by forced downtime. These factors result in the high cost and elevated risks associated with capital construction in the AZRF³.

According to estimates, up to 70 % of the construction budget in the Arctic is spent on personnel logistics, accommodation, security, and rotation³. In addition, there is a high likelihood of project delays and the need to “conserve” construction sites until the following season, which leads to frozen investments and additional costs. Thus, there is an objective need for a methodology that enables the optimization of construction timelines and costs under conditions of a short building season and limited accessibility.

One of the promising solutions addressing the challenges outlined above is the use of Modular Elements of Maximum Readiness (MEMR) — pre-fabricated block modules manufactured at industrial facilities and assembled on-site within the shortest possible timeframe [5]. Modular construction is currently considered one of the most economically efficient technologies in the industry. The use of MEMR reduces construction time by 60–80 %, which not only shortens the overall duration of work but also mitigates the risks of project freezing and unforeseen budget overruns by ensuring a more predictable schedule of construction and installation activities [5].

However, the transition to modular construction in the Arctic Zone of the Russian Federation (AZRF) is constrained by the absence of a unified methodology for efficiency assessment and planning. Existing regulatory documents also fail to reflect the current level of development of modular technologies in construction across the Far North⁴ [4]. For instance, the state Strategy for the Development of the Arctic Zone of the Russian Federation until 2035⁵ and the sectoral Strategy for the Development of the Construction Industry until 2030⁶ both envisage an increase in construction volumes within the AZRF while simultaneously reducing costs and enhancing the environmental sustainability of projects. These objectives highlight the need for innovative methods of organizing construction processes. In the context of climate change [6] and growing institutional pressure toward decarbonization, the shift to modular construction is viewed by scholars as a strategically sound approach to the development of the North in the 21st century. Consequently, the development of a unified methodology for assessing

the effectiveness of MEMR implementation in the AZRF has become an urgent and essential task.

The Guidelines to SNiP 3.01.01–85⁷ specify that the comparison of organizational and technological solutions should be based on the minimum value of the reduced (brought) costs [7], which include current expenses (construction and installation costs) and standard deductions from capital investments, while also necessarily accounting for the economic effect resulting from the reduction of the project's construction duration. Formally, this is expressed through the indicator of reduced costs for each alternative:

$$Z_i = C_i + E_s K_i, \quad (1)$$

where C_i — the total cost of construction and installation works for the i -th alternative;

E_s — the standard coefficient of investment efficiency in construction;

K_i — additional capital investments (fixed assets, machinery, and equipment) required to implement the given alternative.

At present, the coefficient E_s is regulated at the level of 0.15 (15 %) for calculations in the construction industry⁷. The preferred option is the one with the minimum value of Z_i , which accounts for the effect of shortened construction duration; in cases where the results are equal, the alternative providing greater social benefit is considered more advantageous. This regulatory principle establishes the theoretical foundation for the proposed methodology — to reduce the total brought costs compared to the traditional approach by decreasing construction time and related temporal expenditures.

According to data from Rostekhnadzor⁸, the injury rate at northern construction sites operating under the shift method is nearly twice as high as the national average across the Russian Federation, whereas the transition to factory readiness significantly improves safety levels. All these factors were taken into account in the development of the proposed methodology in the form of corresponding coefficients, adjustment factors, and constraints.

Based on empirical data, the methodology also incorporates the regulatory and technical conditions of construction in the Arctic. It integrates the requirements of current codes and standards, including CP 131.13330.2020² (which regulates the specifics of foundations on permafrost soils, temperature regimes for construction works, etc.), GOST R 71617–2024⁹ (which defines the requirements for modular buildings and structures), among others.

Thus, the methodology synthesizes scientific knowledge and practical experience. It is important to note that the foundation of the methodology is complemented by modern digital planning tools. The use of Building Information Modeling (BIM) technologies and data analytics opens up new opportunities for implementing the unified methodology. Information models of modular elements (IMMEMR) enable the accumulation of all properties and characteristics of the modules in digital form [8]. So, the theoretical foundations of the methodology lie at the intersection of construction

² On approval of SPP 131.13330.2020 “SNiP 23-01–99” Construction Climatology”: Order No. 895/PR of December 24, 2020. Ministry of Construction of the Russian Federation. URL: <https://www.minstroyrf.gov.ru/docs/118243/> (rus.).

³ Features of Housing Construction in the Arctic Zone of the Russian Federation: Federation Council Committee on Federal Structure, Regional Policy, Local Self-Government, and Northern Affairs (Minutes No. 249 of April 12, 2021). URL: http://region.council.gov.ru/activity/activities/round_tables/126006 (rus.).

⁴ SNiP 1.04.03–85*. Standards for Construction Duration and Resources in the Construction of Enterprises, Buildings, and Structures. Part I (General Provisions. Section A). Electronic Collection of Legal and Regulatory Documents. URL: <https://docs.cntd.ru/document/1200000622> (rus.).

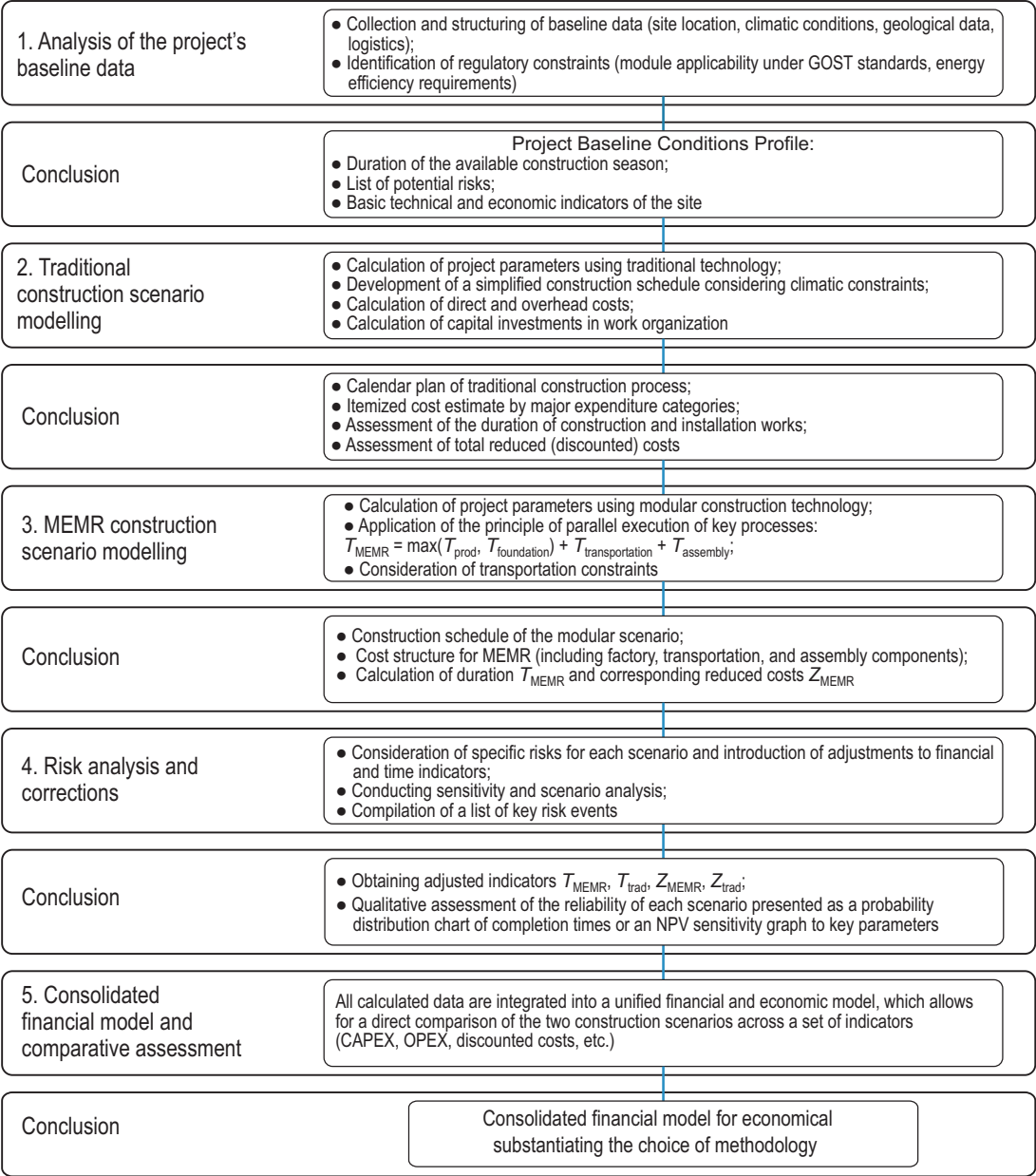
⁵ Strategy for the Development of the Arctic Zone of the Russian Federation and Ensuring National Security for the Period up to 2035. Ministry of the Russian Federation for the Development of the Far East and the Arctic. URL: https://strategy.arctic2035.ru/c/documents/strategiya-razvitiya-arkticheskoy-zony-rossiyskoy-federatsii-i-obespecheniya-natsionalnoy-bezopasnos/?sphrase_id=6355 (rus.).

⁶ Draft strategy for the development of the construction industry and housing and public utilities of the Russian Federation until 2030 with a forecast for the period until 2035. Ministry of Construction of the Russian Federation. September 30, 2021. URL: <https://www.minstroyrf.ru/docs/18723/> (rus.).

⁷ Guide to Developing Construction Organization Projects and Work Production Projects for Housing and Civil Construction (to SNiP 3.01.01–85). Approved by Order No. 211 of the Central Research Institute of Industrial Construction of the USSR Gosstroy dated October 8, 1986. URL: <https://focdoc.ru/fd/pdf/pue/snipu/p3.01.01.pdf> (rus.).

⁸ Analysis of accidents at power plants supervised by Rostekhnadzor. Federal Service for Environmental, Technological, and Nuclear Supervision (Rostekhnadzor). URL: http://szap.gosnadzor.ru/activity/energonadzor/nesc_sluch/ (rus.).

⁹ GOST R 71617–2024. Modular Buildings and Structures. Terms and Definitions. Classification. Federal Agency for Technical Regulation and Metrology. Moscow, Russian Institute of Standardization, 2024. URL: https://gpao.ru/lib/u/file/Law_docs/gost_r_71617-2024.pdf (rus.).



Algorithm for selecting the optimal organizational and technical construction solution in the Arctic

economics, project management, and construction climatology, while its empirical foundations are based on real project performance indicators^{7, 10, 11} and current regulatory standards that confirm the effectiveness of modular technologies in the Arctic.

The unified methodology for evaluating the effectiveness of applying Modular Elements of Maximum Readiness (MEMR) represents a sequence of interrelated blocks (stages), with the overall outcome expressed as a consolidated financial model of the project. The architecture of the methodology can be presented as an algorithm for selecting the optimal organizational and technical construction solution in the Arctic Zone of the Russian Federation (AZRF), which includes the following key steps (Fig.).

¹⁰ Yamal LNG megaproject, Central Dispatch Office of the Fuel and Energy Complex website. 2023. URL: https://www.cdu.ru/tek_russia/articles/3/1107/ (rus.).

¹¹ Modernization of primary healthcare. Ministry of Health of the Republic of Sakha (Yakutia). URL: <https://minzdrav.old.sakha.gov.ru/modpervzvena> (rus.).

All the listed indicators are compiled into a summary table comparing the two scenarios. The table may include rows such as Construction Duration (months), Total Budget (million RUB), Reduced Costs (million RUB), NPV (million RUB), IRR (%), CO₂ Emissions (tons), etc., with two columns — Traditional vs. Modular. Based on the results of this comparative assessment, the economic and managerial effects of implementing MEMR are identified. As a rule of thumb, the modular option demonstrates a shorter construction duration and lower reduced costs, which indicates its overall efficiency.

The consolidated financial model represents these results in a form convenient for decision-making and also serves as an optimization tool. The application of the unified methodology for assessing MEMR provides a number of positive effects by reducing construction costs and increasing the predictability of both budgets and schedules. The modular approach makes it possible to lock in

▶ a significant portion of project costs already at the stage of the factory contract, which greatly facilitates project management.

The third significant effect is the improvement of quality and occupational safety. Modules are manufactured under controlled factory conditions, which enhances the structural quality characteristics. For investors, this translates into reduced costs for defect correction, increased building reliability, and an extended service life. Workplace safety is also improved, as hazardous operations are performed either partially in factory environments or to a much lesser extent on-site.

The fourth effect is rooted in environmental and social performance, which under current conditions translates into reputational and regulatory advantages. Within the framework of the methodology, these environmental effects can be accounted for in the form of reduced additional costs for environmental protection measures¹². Moreover, projects demonstrating improved environmental performance may qualify for sustainable construction certifications. The presence of such certifications and environmental benefits enhances the overall investment attractiveness of the projects.

Social effects are also significant. Within the methodology, the social effect can be considered indirectly. From a managerial perspective, the unified methodology contributes to the standardization and replication of successful solutions. Furthermore, it facilitates communication with the authorities and expert review bodies: the presence of a scientifically grounded efficiency assessment [9, 10] makes it possible to substantiate and convincingly demonstrate the advantages of the project.

For the sake of completeness, it is necessary to conduct a comparative analysis [7]. Traditionally, in Russian practice, the assessment of the economic efficiency of capital investments in construction has been based on the Guidelines for Determining the Economic Efficiency of Capital Investments (Gosstroy of the USSR, 1980s¹³) and subsequent methodological recommendations of the Ministry of Economic Development of the Russian Federation. However, these documents do not directly account for the specific Arctic factors. In contrast, our unified methodology directly integrates climatic and logistical constraints at the stages of data collection and calculation. The methodology anticipates these cost increases in advance, based on CP 131.13330² (seasonal limitations) and MDS 12-81.2007 [11] (work organization regime), while simultaneously offering an alternative solution in the form of a parallel workflow approach.

There are also specialized methodologies for comparing technical solutions in construction, for instance, the Guidelines for Evaluating the Efficiency of New Technologies and Inventions in Construction. Our methodology essentially extends this approach by applying it to the comprehensive technology of modular construction. The classical formula for calculating the annual economic effect (2) is as follows:

$$E_{year} = (C_{base} - C_{new}) + \Delta_{exp}, \tag{2}$$

where C_{base} and C_{new} — the cost under the baseline and the new technology;

Δ_{exp} — the change in operating costs under AZRF conditions is complemented by a time factor.

¹² Russia has approved the GOST R "green" standard for multi-apartment housing. Ministry of Construction of Russia website. 2022. URL: <https://minstroyrf.gov.ru/press/v-rossii-utverzhdyen-zelenyy-standart-gost-r-dlya-mnogokvartirnogo-zhilya/> (rus.).

¹³ State Planning Committee of the Council of Ministers of the USSR No. 40, State Committee of the Council of Ministers of the USSR for Construction No. 100, Presidium of the USSR Academy of Sciences No. 33. On Approval of the Standard Methodology for Determining the Economic Efficiency of Capital Investments : Resolution of September 8, 1969. URL: <https://normativ.kontur.ru/document?moduleId=1&documentId=145572&ysclid=mgwdicjbl629672276> (rus.).

The proposed methodology demonstrates that the advantages of modular technology are manifested through the reduction of total discounted costs due to shortened timelines and mitigated risks. Traditional methodologies typically do not emphasize the economic value of time reduction, whereas in Arctic conditions, time becomes one of the key economic categories. Our approach enables the quantitative assessment of the cost of construction time (through indicators such as reduced costs, NPV, and opportunity costs), thereby filling an existing gap in conventional evaluation methods.

When compared to international practices, it should be noted that methodologies for assessing modular construction at the global level are still in the process of formation. The proposed unified methodology effectively becomes the first comprehensive tool for substantiating modular construction in the Arctic, integrating regulatory requirements, economic feasibility, and managerial aspects into a single framework. The advantages of this methodology in Arctic conditions can be summarized as follows: it ensures an interdisciplinary approach, linking technical solutions with financial indicators and management risks — an aspect of particular importance in the Arctic context. The methodology has been specifically developed for the conditions of the Far North. Our tool accounts for extreme temperatures, permafrost, and the polar night, all of which are reflected in the calculations of time and cost.

Moreover, in the Arctic Zone of the Russian Federation (AZRF), logistics is often the determining factor for project success. In this context, logistics is treated as an integrated component: the methodology enables the planning of module deliveries within specific navigation windows, the assessment of freight costs, and the optimization of transportation routes. Our methodology provides a transparent and well-substantiated financial outcome, supported by references to regulatory standards and empirical research data. This greatly facilitates project review and approval processes. By incorporating environmental and social criteria, the proposed methodology ensures that projects align with the principles of sustainable development. In the AZRF, this is of critical importance, as the fragile ecosystem and the presence of indigenous communities require a careful and responsible approach.

Consequently, a project evaluated under our methodology is more likely to receive support within the framework of AZRF development programs and special investment regimes, and to avoid public opposition related to environmental concerns.

In conclusion, it should be emphasized that the unified methodology for assessing efficiency and the consolidated financial model for the application of MEMR in the AZRF do not contradict but rather develop and refine existing approaches. They provide a scientifically grounded decision-making toolkit that contributes to reducing construction costs and improving overall efficiency.

The primary advantage of this methodology in Arctic conditions lies in its ability to translate the region's unique challenges into quantifiable indicators that can be systematically analyzed and optimized. The initial study of the techniques and methods applied in this article highlights its economic significance in the context of Arctic research and economic activity in the region. By adhering to the algorithm described herein, economic actors operating within the AZRF can intensify their economic activity in the region and improve their overall financial performance.

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Создание унифицированной методики оценки выбора типа строительства в Арктике на основании совокупного экономического эффекта ключевых параметров строительства в регионе

Актуальность исследования. Повышение значимости роли Арктической зоны Российской Федерации (АЗРФ) и Северного морского пути (СМП), в частности, в совершенствовании различных аспектов строительной отрасли страны, достижение цели национальной и экономической безопасности государства мотивируют научное сообщество тщательнее изучать специфику региона. Широкая система льгот и преференций, предлагаемая в рамках ведения финансово-хозяйственной деятельности в Арктике, открывает широкие перспективы по оптимизации затрат и инвестиционных вложений, осуществляемых основными акторами хозяйственной деятельности в данном регионе, однако, суровые климатические условия, низкий уровень инфраструктурного развития региона в целом, а также большая совокупная площадь АЗРФ являются существенными барьерами в достижении целей устойчивого экономического развития отечественной Арктики. Применение передовых технологий и принципов ведения хозяйственной деятельности может существенно улучшить экономические показатели в регионе.

Цель исследования. Описать методологические основания и предложить алгоритм создания методики для оценки экономической целесообразности применения определенного подхода строительстве в Арктике.

Методы. Унифицированная методика оценки эффективности применения модульных элементов максимальной готовности (МЭМГ) представляет собой последовательность взаимосвязанных блоков (этапов), а совокупный результат выражается в виде консолидированной финансовой модели проекта.

Результаты и новизна. Предложена унифицированная методика оценки выбора типа строительства в Арктике, на основании которой можно строить консолидированную финансовую модель строительного проекта в регионе, которая фактически становится первым комплексным инструментом для обоснования модульного строительства в Арктике, собирающим воедино нормативные требования, экономическую целесообразность и управленческие аспекты.

Ключевые слова: экономика, Арктика, финансовая модель проекта, Арктическая зона Российской Федерации, модульное строительство, экономический эффект, МЭМГ

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For citation: Noskov I.S., Borozdina S.M. Development of a Unified Methodology for Assessing the Choice of Construction Type in the Arctic Based on the Aggregate Economic Effect of Key Regional Construction Parameters. *Real Estate: Economics, Management*. 2025; 4:51-56.

Для цитирования: Носков И.С., Бороздина С.М. Development of a Unified Methodology for Assessing the Choice of Construction Type in the Arctic Based on the Aggregate Economic Effect of Key Regional Construction Parameters // Недвижимость: экономика, управление. 2025. № 4. С. 51–56.



Москва. Колокольня и Смоленский собор Новодевичьего монастыря. Рисунок, тушь, перо

UDC 711:621.039

International Atomic Energy Project as a driver of integrated development of territories

The IAEA predicts that in the middle of the 21st century, the total capacity of nuclear energy could grow by more than two and a half times and reach almost a thousand GW. Moreover, in the large part of the growth in demand for peaceful atom will be ensured by the countries of the Global South and East, which are strengthening their technological and industrial potential. Another significant factor of the growing interest in nuclear energy is the relevance for green standards and technologies which minimize the impact to the environment and climate, at the same time the nuclear power plants are an important source of clean, low-carbon energy. It favourably differs of other energy sources by the price ratio, environmental component, and the ability to provide stable energy capacity. The State Atomic Energy Corporation Rosatom (Rosatom) plays a key role in the production of atomic energy in Russia. Today, Rosatom continues to build 39 power units in 11 countries around the world: Hungary, Latin America, Bolivia, Bangladesh and others. The authors of the article presented an analysis of international projects, highlighting the most significant effects obtained from the creation of nuclear power plants. The authors of the article presented an analysis of international projects, and highlighted the most significant effects obtained from the creation of nuclear power plants. Special attention was paid to the implementation of the megaproject of the international intergovernmental atomic energy complex "El-Dabaa" in Egypt. The article highlights the relationship between the Russian Federation and the Arab Republic of Egypt at the field of nuclear energy, their agreement of cooperation in the construction and operation of a nuclear power plant in Egypt, examines the difficulties encountered in the implementation of the project, and also describes and systematizes the results and effects of the project (technical, political, social, economic, and development effects of the territory).

Keywords: *International project, international cooperation, nuclear energy, nuclear power plant, NPP, State Atomic Energy Corporation Rosatom, integrated development of the territory, El Dabaa NPP (Egypt), International Atomic Energy Agency (IAEA), socio-economic effects, territorial development effects, technological effects*

Electricity consumption is growing rapidly worldwide: according to estimates by the International Energy Agency (IEA), global electricity consumption increased by 4.3 % in 2024, and growth of 4 % per annum is forecast for 2025–2027¹. The reasons for the rapid growth in energy consumption include the development of industrial production, an increase in the number and capacity of data centres, the development of electric transport, the use of air conditioning systems in buildings and premises (especially in countries with hot climates), and the overall electrification of the economy worldwide (Fig. 1) [1]. It should be noted that nuclear power plants are best at ensuring a uniform, uninterrupted power supply.

Another significant factor is the focus on environmental safety, the transition to the mandatory use of green standards and technologies, and the minimization of negative impacts on the environment, nature and climate. Today, nuclear power plants are the main source of clean, low-carbon energy; along with solar, wind and hydro power, nuclear energy is included in the "green square" and has been included by the European Parliament in the list of environmentally sustainable types of energy generation [2]. It is also important to note the socio-economic effects of the introduction and use of peaceful nuclear energy: high energy intensity (production of large amounts of energy with low fuel consumption and reduced dependence on fossil fuels), the ability to produce significant amounts of electricity in a relatively small area, as well as regional economic

growth and the development of science and technology. Thus, nuclear power plants are ahead of other energy sources in terms of cost, environmental impact, and the ability to ensure stable power generation. In this regard, an increasing number of countries are considering peaceful nuclear energy as a key resource for the long-term comprehensive development of their countries, public opinion is gradually forming in favour of nuclear energy as an environmentally friendly and safe technology, and reliable solutions are being developed on the basis of which advanced nuclear power units are being created, thus giving rise to a fundamentally new technological paradigm².

Currently, Russia, with its expertise across the entire chain of technological processes and its creation of safe, externally resilient nuclear power plants, is one of the world leaders in the development and use of nuclear energy. Rosatom State Corporation is the national leader in electricity production (about 20 % of total output) and ranks first in the world in terms of the size of its order portfolio for the construction of nuclear power plants: 41 power units in 11 countries are at various stages of implementation³. Table presents an analysis of international nuclear power plant construction projects implemented by Rosatom. Rosatom also has projects that have been temporarily suspended due to geopolitical force majeure, such as the Hanhikivi-1 nuclear power plant [3].

¹ Record Terawatts: How Electricity Consumption Grew in 2024, Strana-Rosatom. URL: <https://strana-rosatom.ru/2025/04/07/rekordnye-teravatty-kak-rosli-obemy/> (date of access: 26.09.2025).

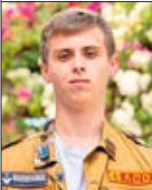
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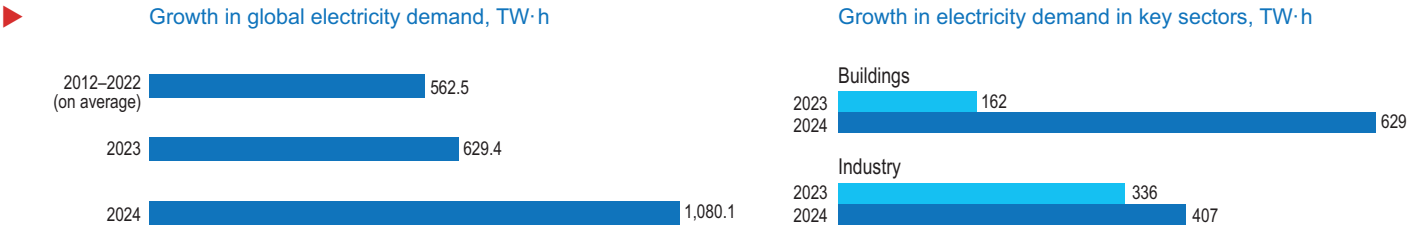


Fig. 1. Growth in global electricity demand according to IEA data

International nuclear power plant construction projects implemented by Rosatom State Corporation

Name and location	Photo/visualisation	Project implementation timeline	Brief description of the project	Achieved results	Status
Akkuyu Nuclear Power Plant (Turkey) Location near Mersin (Mersin Province) ⁴		2010–2028	Reactor type: VVER-1200. Total capacity: 4,800 MW. Number of power units: 4 (under construction). Total area — 1,075.4 ha. Estimated service life — 60 years (+20 years — possibility of extension). Total project cost ≈20 billion dollars	• generation ≈35 billion kWh per year; • coverage of up to 10 % of the Turkish Republic's electricity needs; • training/retraining of specialists from among Turkish citizens at the expense of the Russian side; • implementation of the project in difficult mountainous terrain, subsequent development of adjacent territories; • strengthening of international cooperation between Russia and Turkey	During construction
Belarusian Nuclear Power Plant (Belarus) Located 18 km from Ostrovets (Grodno Region) ⁵		2011–2023	Reactor type: VVER-1200. Total capacity: 2,400 MW. Number of power units: 2. Total area — 450 ha. Estimated service life — 50 years (+10 years — possibility of extension). Total project cost ≈11 billion dollars	• providing ≈40 % of the Republic of Belarus' electricity needs; • the largest Russian-Belarusian cooperation project; • a move towards carbon neutrality and energy independence; • creation of infrastructure and commissioning of new microdistricts with comfortable housing; • tax effect: ≥\$650 million in VAT paid to the country's budget; • satisfaction of the doubled (up to 18.5 million kWh) demand for electricity by electric transport	Implemented
Kudankulam Nuclear Power Plant (India) Location: near Kudankulam (Tamil Nadu state) ⁶		1998–2026	Reactor type: VVER-1000. Total capacity: 4,000 MW. Number of power units: 4 (2 in operation, 2 under construction). Total area — 1,060 ha (+20 years — possibility of extension). Total project cost ≈11.4 billion dollars	• reduced dependence on coal production (about 70 % of generation); • reduction of the country's energy deficit; • introduction of advanced approaches to ensuring the safety of nuclear power plants, creation of passive safety systems; • employment prospects for the population, development of local businesses, construction of new roads and increased trade; • attracting investment to the region	During construction
Paks-2 Nuclear Power Plant (Hungary). Location: near Paks (Tolna region) [4]		2019–2030	Reactor type: VVER-1200. Total capacity: 2,400 MW. Number of power units: 2. Estimated service life — 60 years (+20 years — possibility of extension). Total project cost ≈€12.5 billion	• savings of ≈4.2 million tonnes of CO₂ emissions annually (9 % of current levels), as well as a 13 percentage point increase (to 76 %) in the share of electricity generated by low-carbon sources; • provision of electricity to ≈4 million people (42 % of the country's population); • creation of 2,200 jobs at the nuclear power plant and in service organisations;	During construction

⁴ Akkuyu NPP. Rosatom Foreign Generation. URL: <https://rosatom-energy.ru/projects/akkuyu/> (date of access: 27.09.2025).
⁵ BelNPP. Republican Unitary Enterprise Belarusian Nuclear Power Plant. URL: <https://www.belaes.by/ru/> (date of access: 27.09.2025).
⁶ Kudankulam NPP (India). ASE-Rosatom. URL: <https://ase-ec.ru/about/projects/aes-kudankulam/> (date accessed: 26.09.2025).

Continuation of the Table

Name and location	Photo/visualisation	Project implementation timeline	Brief description of the project	Achieved results	Status
				• involvement of local companies in the nuclear power plant construction project (more than 140); • achieving carbon neutrality by 2050	
Ruppur Nuclear Power Plant (Bangladesh). Location: near the village of Rooppur (Pabna District) [5]		2017–2026	Reactor type: VVER-1200. Total capacity: 2,400 MW. Generation volume — 17.4 TWh per year. Number of power units: 2. Estimated service life — 60 years (+20 years — possibility of extension). Total project cost ≈13 billion dollars	• covers more than 10 % of Bangladesh's total energy consumption; • provides electricity to ≈36 million people (21 % of the country's population); • GDP growth: ≈\$2.5 billion (0.6 % of the country's GDP); • growth in industrial production and development of social infrastructure, previously hampered by electricity shortages; • training of the local population (≥ 10,000 people will receive training with the support of Rosatom), as well as providing jobs for the local population: 81 % of workers during the construction phase will be local Bangladeshi residents	During construction
Xudapu Nuclear Power Plant (China). Location: near Huludao (Liaoning Province, North-East China)		2019–2027	Reactor type: VVER-1200. Total capacity: 2,400 MW. Number of power units: 2 — power units No. 3 and 4. Estimated service life — 40 years (+20 years — possibility of extension). Total project cost ≈1.5 billion dollars	• providing energy to the rapidly developing industrial region of Northeast China, reducing dependence on coal mining; • development of local supplier enterprises; creation of modern training centres, cooperation with universities, improvement of technical education in the region; • reformatting Huludao County from an “old industrial centre” into a territory of advanced and environmentally friendly technologies, attractive for new investments and personnel	During construction
Bushehr-2 and Bushehr-3 nuclear power plants (Iran). Southeastern suburb of the city of Bushehr, on the Persian Gulf coast in Bush-ehr province ⁷		2016–2027	Reactor type: VVER-1000. Total capacity: 2,100 MW. Number of power units: 2 — power units No. 3 and 4. Total area — 500 ha. Estimated service life — 60 years (+20 years — possibility of extension). Total project cost ≈10 billion dollars	• Russian influence in the region, high-tech exports, jobs, high profits; • electricity generation and development of advanced technologies supplied by Russia under sanctions, training of local personnel; • profitability: with gas priced at \$200 per thousand cubic metres, additional income will amount to \$700–800 million per year, each reactor should pay for itself in 10 years	During construction
Uzbek ASMM. Jizzakh Region, Uzbekistan, in the Farish District ⁷		2025–2033	Reactor type: RITM-200N. Total capacity: 330 MW. Number of power units: 6 (2025: 2 third-generation VVER units). Estimated service life — 60 years. Total project cost ≈1 billion dollars	• use of the ASMM format — a compact and technologically advanced solution that is effective for a country with growing energy consumption but no excess resources; • combining a hybrid approach (ASMM and subsequent construction of a high-capacity two-unit power plant) will allow the advantages of both formats to be combined: the compactness of modular installations and the stability of large-scale generation; • the possibility of exporting surplus energy to neighbouring countries in Central Asia; • new jobs, skills and technological expertise	During construction

⁷ BeINPP. Republican Unitary Enterprise Belarusian Nuclear Power Plant. URL: <https://www.belaes.by/ru/> (date of access: 27.09.2025).



End of the Table

Name and location	Photo/visualisation	Project implementation timeline	Brief description of the project	Achieved results	Status
El Dabaa NPP (Egypt). Location Matruh region on the Mediterranean coast [4]		2020–2029	Reactor type: VVER-1200. Total capacity: 4,800 MW. Number of power units: 4. Total area — 5,700 ha. Estimated service life — 60 years (+20 years — possibility of extension). Total project cost ≈30 billion dollars	• coverage of up to 50 % of Egypt's electricity needs; • creation of more than 50,000 jobs; the share of low-carbon sources will increase to 25 %, CO ₂ emissions will decrease by 6 %. The effects of the construction of the El Dabaa nuclear power plant will be discussed in more detail below	During construction

EL DABAA NUCLEAR POWER PLANT PROJECT (EGYPT)

On 15 November 2015, the Agreement between the Government of the Russian Federation and the Government of the Arab Republic of Egypt on cooperation in the construction and operation of a nuclear power plant on the territory of the Arab Republic of Egypt was signed, which was a natural continuation of the long-standing relationship between the two countries in the field of nuclear construction: in 1956, an agreement was signed between the USSR and Egypt on the development of Egypt's first research nuclear reactor, ETRR-1, in the city of Ashanse. In 1958, it was commissioned and became the second oldest research reactor in the Middle East [6]. In 1981, a site was allocated for the construction of a new nuclear power plant in Egypt, but the project was suspended due to the Chernobyl accident. In 2008, relations in the energy sector were resumed with the signing of an intergovernmental agreement on cooperation in the peaceful use of nuclear energy between Egypt and Russia, but due to the events of the Arab Spring and a period of political instability, it was not until 20 July 2022 that the ceremony to pour the first concrete into the foundation of the plant's first power unit took place⁸.

In accordance with its contractual obligations, the Russian side will build a nuclear power plant in the Arab Republic of Egypt consisting of four power units based on a Russian-designed water-water energy reactor (VVER) with an installed capacity of up to

1.2 GW per power unit, as well as seawater desalination plants at each power unit with a capacity of up to 170,000 cubic metres per day. The agreement also provides for Russia to supply nuclear fuel throughout the entire operating life of the plant, to assist Egyptian partners in training plant personnel during the operation and maintenance phase for the first ten years of the nuclear power plant's operation, to construct special storage facilities and to provide containers for storing spent nuclear fuel [7].

The El Dabaa NPP construction site (S = 5,700 ha) is located in the province of Mersa Matruh, adjacent to the southern border of El Dabaa (the administrative centre of the district), 120 km south-east of Mersa Matruh (the administrative centre of the governorate). The construction site is located between the southern coast of the Mediterranean Sea and the Alexandria-Mersa Matruh motorway, 135 km west of Alexandria. The nearest residential buildings are located more than 3 km from the NPP. Decisions on the improvement of the construction site and surrounding areas during the construction period are made by the General Design Department and are formalized in the project documentation (Fig. 2)^{9, 10, 11, 12}.

⁸ "Egypt and Russia to sign contract for Dabaa nuclear power station very soon," says MP, aramonline. URL: <https://english.aramonline.org/NewsContent/1/64/263003/Egypt/Politics-/Egypt-and-Russia-to-sign-contract-for-Dabaa-nuclea.aspx> (date accessed: 26.09.2025).

⁹ EL DABAA-1 Under Construction. PRIS power reactor systems. URL: <https://pris.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=2127> (date of access: 25.09.2025).

¹⁰ EL DABAA-2 Under Construction. PRIS power reactor systems. URL: <https://pris.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=2127> (date of access: 25/09/2025).

¹¹ EL DABAA-3 Under Construction. PRIS power reactor systems. URL: <https://pris.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=2127> (date of access: 09/25/2025).

¹² EL DABAA-4 Under Construction. PRIS power reactor systems. URL: <https://pris.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=2127> (date accessed: 25.09.2025).



Fig. 2. Location of the El Dabaa NPP (Egypt)

One of the main difficulties encountered during the implementation of the project was the negative attitude of the local Bedouin population: the 65 sq. km of land allocated for the NPP historically belonged to Bedouin tribes, who were offered resettlement, but the compensation was minimal. During the period of political instability in 2011–2013, the Bedouins attacked the El Dabaa facility and seized the territory, causing damage amounting to approximately \$ 80 million, which led to the suspension of the project. In 2017, following negotiations, the government reached an agreement with local tribes, providing them with fairer compensation. Climatic conditions also had an impact: El Dabaa has an arid climate with hot summers (March – October), when air temperatures can reach + 46.5 °C, limiting the use of labour. In February – March, dust and sand storms occur, with maximum wind speeds reaching 26.3 m/s. In addition, the shortage of highly skilled local personnel in this field also had a negative impact [8].

However, despite all the problems arising during the implementation of this project, its role cannot be overestimated: among the effects that will be obtained from the implementation of the El Dabaa NPP project (Egypt), the following can be noted [4].

Technical effects:

- generation of 35 billion kWh per year, which will cover up to 50 % of the country's electricity consumption, ≈22 million people (20 % of the country's population) will be provided with electricity;
- an increase in the share of electricity generated by low-carbon sources by 12 percentage points (up to 24 %);
- "From ore to waste" contract format: Rosatom's obligation to supply fuel and dispose of waste throughout the entire life cycle of the NPP;
- Rosatom will provide full engineering support for 10 years, ensuring the safety and reliability of the nuclear power plant.

Political effects:

- enhancement of Egypt's technological progress and political weight in the international arena;
- a long-term technological alliance between Russia and Egypt, strengthening Russia's position in the countries of the Global South;
- Egypt is the first country in North Africa to build a modern nuclear power plant with VVER-1200 III+ generation reactors.

Social effects:

- training involving Rosatom for more than 3,700 local residents, which will increase literacy levels by 93 % by 2030;
- the creation of approximately 5,000 jobs, which will help reduce the number of residents living below the poverty line by 22 % by 2030;
- more than 50 % of workers during the construction phase will be local Egyptian residents (more than 14,000 people).

Economic effects:

- GDP growth: approximately \$4 billion (0.9 % of the country's GDP) will be added to Egypt's GDP during the construction of the El Dabaa NPP;
- support for local suppliers: ≈ 85 local companies are participating in this project.

Environmental effects:

- CO₂ emissions savings ≈ 11 million tonnes equivalent per year (5 % of current levels);
- environmental monitoring of all types of engineering surveys;
- equipping water intake structures with fish protection devices;
- ensuring the treatment of wastewater and storm water;
- prevention of pollutants entering water bodies thanks to a closed dual-circuit cooling system;

- use of modern technologies for effective treatment of radioactive environments.

Effects of territorial development:

- creation and development of social infrastructure: educational (school, kindergarten, children's centre, library), medical (first aid stations, pharmacy), sports (sports area with swimming pool, table tennis, football field, gyms, playground, workout area), commercial (cafes/fast food outlets, grocery stores, beauty salon);
- creation and development of transport infrastructure: access road to the nuclear power plant (Alexandria-Marsa Matruh motorway and El Dabaa nuclear power plant), as well as a seaport in the El Dabaa area;
- landscaping and greening of the desert area.

CONCLUSION

The experience of considering the nuclear power plant project as a driver of comprehensive regional development has demonstrated an effective global trend towards increasing the social acceptability of nuclear energy, leading to a transition to "clean" energy. The development of new infrastructure and technologies allows people from third world countries to take a new step in the development of technology and science, which leads to the development of the country as a whole and an improvement in the quality of life of its citizens [9]. Modern Russia plays an important role by offering favourable commercial conditions, including maintaining active dialogue with all participants and implementing a universal communication strategy.

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Международный проект АЭС как драйвер комплексного развития территорий

МАГАТЭ прогнозирует, что к середине XXI в. совокупная мощность атомной энергетики может вырасти более чем в два с половиной раза и достигнуть почти тысячи гига-ватт. Причем рост спроса на мирный атом в значительной степени обеспечат именно страны Глобального Юга и Востока, которые укрепляют свой технологический, индустриальный потенциал. Другой значимый фактор роста интереса к атомной энергетике — это востребованность «зеленых» стандартов и технологий, которые сводят к минимуму воздействие на окружающую среду и климат, при этом значимым источником чистой, низкоуглеродной энергии являются атомные станции. Они выгодно отличаются от других источников энергии по соотношению цены, экологической составляющей, возможности обеспечить стабильную энергомощность. В России ключевую роль в производстве атомной энергии занимает Госкорпорация «Росатом». Сегодня «Росатом» продолжает строительство 39 энергоблоков в 11 странах мира: Венгрии, Латинской Америке, Боливии, Бангладеш и других. Авторы статьи представили анализ международных проектов, выделив наиболее значимые эффекты, полученные от создания АЭС. Особое внимание было уделено реализации мегапроекта международного межправительственного атомно-энергетического комплекса «Эль-Дабаа» в Египте. В статье освещаются взаимоотношения Российской Федерации и Арабской Республики Египет в сфере атомной энергетики, их соглашение о сотрудничестве в сооружении и эксплуатации атомной электростанции на территории Египта, рассматриваются сложности, возникшие при реализации проекта, а также описываются и систематизируются результаты и эффекты проекта (технические, политические, социальные, экономические, а также эффекты развития территории).

Ключевые слова: Международный проект, международное сотрудничество, атомная энергетика, АЭС, корпорация Росатом, комплексное развитие территории, АЭС «Эль-Дабаа» (Египет), МАГАТЭ, социально-экономические эффекты, эффекты развития территорий, технологические эффекты

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For citation: Telepneva O.A., Kuznetsov A.I. International Atomic Energy Project as a driver of integrated development of territories. *Real Estate: Economics, Management*. 2025; 4:57-62.

Для цитирования: Телепнева О.А., Кузнецов А.И. International Atomic Energy Project as a driver of integrated development of territories // *Недвижимость: экономика, управление*. 2025. № 4. С. 57–62.

UDC 347:69

Conducting forensic construction and technical expertise in relation to unauthorized reconstruction projects

This paper is devoted to the features of construction-technical expertise conducting connected with an unauthorized reconstruction. There isn't a definition of the term "unauthorized reconstruction" in Russian legislation nowadays. Therefore, requirements attitude different forms of buildings modification interpret by many in various ways. For real, it often happens that results of major repair, replanning or reengineering turns out to be the reconstruction indeed. On the other hand, the project of reconstruction which was officially announced and approved can be transformed into new unauthorized construction. Both these cases are dangerous because neglect the rules in construction can lead to violating the third rights, humans' life and health. The complexity of the subject in term of identifying the type of works in construction with the features of technical regulation in this area becomes a reason of using the special knowledge of expert to give court a hand. Researching the juridical practice, real cases show us that there isn't a united algorithm or methodical approach of how investigate the unauthorized reconstruction. It all leads to instinctive actions from expert, big numbers of mistakes in his opinion. The transformation task, which mostly must be solved by expert in case of unauthorized construction also seems quite difficult.

Keywords: *unauthorized reconstruction, replanning, reengineering, forensic construction-technical expertise, full-scale investigation, expert opinion*

The life cycle of buildings is characterized by its high duration. From the creation of one to the moment of its demolition can be passed more than 100 years. Over time construction systems tend to accumulate tears. Tear can be physical that leads to decreasing project quality, endurance of elements and merging of defects. It also can be moral wear, which connected with the reducing of ability of real estate to meet the needs of owners. Due to this phenomenon of buildings development, different processes can be carried out to modernize construction facilities, make their comfort level as well as safety parameters suitable to current requirements of legislation, people and business [1]. The major repair, reconstruction, replanning or reengineering are little part of variety of building improvement stated in Russian law. Nevertheless, in case of technical and legal regulation features of these processes there is a place for unauthorized actions in construction, reflected in juridical practice. There is not an official definition of the term unauthorized for itself. It only noted in articles 330 of the Criminal Code of the Russian Federation and 19.1 of the Administrative Code of the Russian Federation as a part of term arbitrariness, which means exercise of an existing or only assumed right contrary to the relevant legal acts. However, there is an article 222 of the Civil Code of the Russian Federation devoted exactly to an unauthorized construction. The law mentioned three signs of unauthorized construction they area violation of the land plot using order, an absence of necessary permission documents and a violation of the current urban planning and construction regulation [2].

The lack of legal regulation of other unauthorized actions with buildings, including reconstruction, becomes a reason of misinterpretation of legislation by courts and leads to situational nature of their decisions about modified real estate objects.

The analysis of juridical practices how us that issues about unauthorized reconstruction are contained in reviews devoted to arbitrariness construction as well as in materials about illegal replanning and reengineering in apartment buildings. It all can be explained by the complexity of reconstruction as a technological process. In one case, it may include transformation of exterior of building with the help of extension or superstructure what is similar to new construction. In another case, reconstruction can be local and connected with the changing or reinforcing supporting structures what is alike major repair. Thus, the specific of unauthorized reconstruction of real estate objects in the author's opinion require its allocation to a separate category of cases. It is important in case of developing methodical approaches to forensic construction-technical expertise of reconstructed with violations buildings.

To sensitize the juridical practice two groups of unauthorized reconstruction motivators can be distinguished [3]:

- an initiator of reconstruction, mostly an owner, act as he assumed it should be correct but in term of misinterpretation on law or his insufficient level of legal qualifications, he does it wrong. Real cases show that signs of unauthorized reconstruction can appear if construction and installation work about repair premise beyond established and become to affect the capital walls and callings, change the size and the area of building, or new entrances group are being built;
- in opposite, owner or user of building while reconstruction can act deliberately circumventing the law. Often a person wants to facilitate the process of transforming his construction object into desired state. Therefore, an owner names construction works as major repair not

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► to get premises or pass an expertise of project documentation but in fact reconstruction occurs. It is possible and attractive option because of the opportunity of legalizing results of unauthorized construction after its holding [2].

Both cases arbitrariness in construction industry, which is a part of technical regulation, threatens a public danger and may pose risks to life and health of an unspecified group of people. Such circumstances substantiate a necessity from judges to attract a knowledgeable person in sphere of design, erect, maintenance and demolition of buildings to investigate issues about unauthorized reconstruction. Thanks to the expertise factual data about compliance of construction works with norms and rules, the degree of deviation from them, the safety of reconstructed structures and the possibility of their further usage can be defined [4].

Having identified the main reasons for committing violations with real estate objects, it becomes possible to write down the order of conducting forensic construction-technical expertise connected with unauthorized reconstruction. To be more consecutive let's divide some milestones based on expert tasks solved by a knowledgeable person.

The first step and expert's task are classification one. It let expert solve the issue of assignment of the object to a certain class, species, genus. To do it a knowledgeable person should learn information from the case material and check if data is enough. Firstly, expert can identify the functional purpose of the building, it could be residential, commercial or industrial. This information can help him to select technical standards and regulations which contain specific requirements for object under investigation [5]. Secondly, it is important to identify the category and the type of permitted usage of the land plot to select urban planning regulations spreading on it. It should be noted that the availability of data which helps to track changes in an object over time is quite important for expert's activity. These are documents such as technical passport for the building, floor plans, acts of previous inspections or examinations, acts of acceptance of repair works, some technical conclusion and initial project (if any). There is also a necessity for availability of project and permissions devoted to construction and installation works being the subject of a dispute. The absence of any document from the list above allows the expert to apply a petition toward the court about providing him with missing materials in accordance with procedural legislation [6]. Thirdly, works performed on the site can be classified. Expert-engineer while studying secondary documentation with his special knowledge defining what types of work are supposed to be doing or what of them are presented as completed [7]. For separating construction work carried out on buildings that may be confused with reconstruction a brief description of all of them will be given:

1. The reconstruction itself according to article 1 point 14 of Urban Planning Code of the Russian Federation is aimed to change the main parameters of current buildings including enlarging of volume and area, increasing number of floors, or replacement or restoration of load-bearing structures [8]. There is a necessity to design project documentation to perform the reconstruction in legal order. Positive result from an expertise of construction project must be received, permission of construction and commissioning also need to be got. Reconstruction as a rule can be carried out with the relocation of dwellers in case of residential buildings or cessation of main production processes in industrial objects. Typical features of reconstruction are extensions of current object, replanning or changing its functional purpose and exterior. As about factories

and manufactories reconstruction accompanied by technical re-equipment [9].

2. The major repair also is a type of work that is regulated by Urban Planning Code. Major repair is devoted to reinforcement of non-load-bearing elements of building or fractional replacement of load-bearing structures with similar properties or restoration engineering and technical supplying systems. As it is stated in article 48 of Urban Planning Code, designing project documentation for major repair is optional, but necessary in case of using budget funds, similar with getting different permissions. An expertise of construction project was carried out only in part of the reliability of the estimated section. Major repair can be comprehensive when most of construction elements of building are being replaced or restored. It also can have a local scale when only one or some elements or parts of building are being maintained. Both cases are not supposed residents or users of object to be relocated. It is not allowed to change main technical and economical parameters of building, its functional purpose in result of major repair it is only let decrease the level of tear and wear.

3. New construction is pointed to the erection of buildings and structures with the creation of new real estate objects in legal sphere. This process demands not only architectural and construction projects to be created and permission and approvals to be received but also purchasing of land plot and registration of rights on it also must be done [10].

4. Restoration is a type of architectural and art works that are aimed at recreation or preservation of objects with historical and cultural value, some pieces of décor and interior items. This activity demands a comprehensive rehearsal in term of fulfilling the historical and culture expertise. Restoration is based on the principles of minimizing changes in exterior, using the original materials and gentle technologies of repair works [1].

5. Replanning is a concept from residential legal relations. This procedure is aimed at changing of technical and economic parameters, inner layout of particular apartment or several adjacent apartments including merging of new one from them [11]. Results of replanning must be reflected in Register of Real estate. The project of replanning must be created and approved by local government before the start of works. Act of commissioning ought to be fulfilled, cadastral measurements reflected of all changes in premise must be done after repair work and then owners have to apply to Register of Real estate to correct graphical data about his apartment [12].

6. Re-engineering is also suitable for premises only. It is a type of work that is carried out on engineering networks and equipment including their replacement or renewing. Such works demand project and approving stage and making an entry in the technical data sheet. In spite of it there is no necessity to reflect changes in Register.

The next step for the expert is conducting nature studies of objects under investigation. In cases of unauthorized reconstruction this phase is so important because studying of buildings only by its description in documents and materials is not allow to state the factual data about it. So, such principles as completeness, reliability and objectivity of expert's research can't be done. A knowledgeable person solves existential, volumetric and situational tasks with help of visual or instrumental examination. Existential research let expert answer a question of the presence of argued object, its part or result of unauthorized reconstruction in general [13]. Carrying out measurements in frame of volumetric task it becomes possible to establish real volume of fulfilled construction and installation works on object and compare it with stated in documents. There are a lot

Main features of unauthorized reconstruction

Feature	Norm of the law	Characteristics
Illegal usage of the land plot	LC, CCar. 5.2	Contradiction of the building parameters or functional purpose to the category or type of permitted use of the land plot
Violation of urban planning rules	Ch. 4 UPC, LC, ar. 222 CC	Changing technical and economical parameters of building with the exceeding that is set in baseline and permission documents. Contradiction of exterior to urban planning regalement
Violation of construction rules	Ar. 222 CC, ar. 5 FL No. 384, FL No. 123	Non-fulfillment of mechanical, fire, ecological safety requirements
Absence of permission documents	Ar. 48, 51, 52, 55 UPC	Absence of permission to construction (reconstruction) and commissioning, positive opinion from expertise, technical condition to increasing the power demanding
Contradiction of types of construction works to the legal description of reconstruction	Ar. 1 UPC	Changes not stated as reconstruction but lead to transmogrify initial parameters of buildings or serious work with load bearing elements
For apartments only. Decreasing the area of common shared ownership without legal decisions of all owners	Ar. 36 HC	The absence of the protocol of owner's meeting decision about alienation of part of common property. Illegal reconstruction of attics and basements

Abbreviations: Ch. — chapter; ar. — article; LC — the Land Code of the Russian Federation; UPC — the Urban Planning Code of the Russian Federation; HC — Housing Code of the Russian Federation; CC — the Civil Code of the Russian Federation; FL — Federal Law.

of cases where, for instance, project suppose only replacement of rafter system of the roof but in fact the mansard floor is erected. Such changes are going out from the legal frame of major repair and can be named as illegal reconstruction. Group of situational tasks is aimed to capture the placement of building in space or its location in attitude neighborhood objects. These types of research can help to examine cases with signs of enlarging of construction side spot and changing border lines of land plot [7].

Further expert's steps should be pointed to solving diagnostical tasks. They mean establishing of current technical condition of construction object. A knowledgeable person solves more detailed issues called attributive subtasks. Step by step parameters of individual structures and nodes or microclimate characteristics like lightning level, temperature and so on are researched. Then expert accumulates all the information about fragmental parts of building and is willing to make a decision about object's condition in general. Detected defects and incongruities allow expert to say if the object is safe for users and further exploitation or not, what is particularly important when reconstruction was held with violations of technical regulations and rules [14].

Next stage can be carried out already in cabinet conditions. It is a normative study. Based on data represented in another article [15], questions about the following to technical rules, fire safety standards, compliance with the urban planning regalements and different premises both construction works and reconstructed building itself may be expert asked by judge. All what have been understood within normative analysis helps an expert to know whether there are signs on unauthorized activity, how serious are the violations or could they be fixed. So, it is necessary to highlight the main features of unauthorized reconstruction of real estate objects, they are synthesized in Table below.

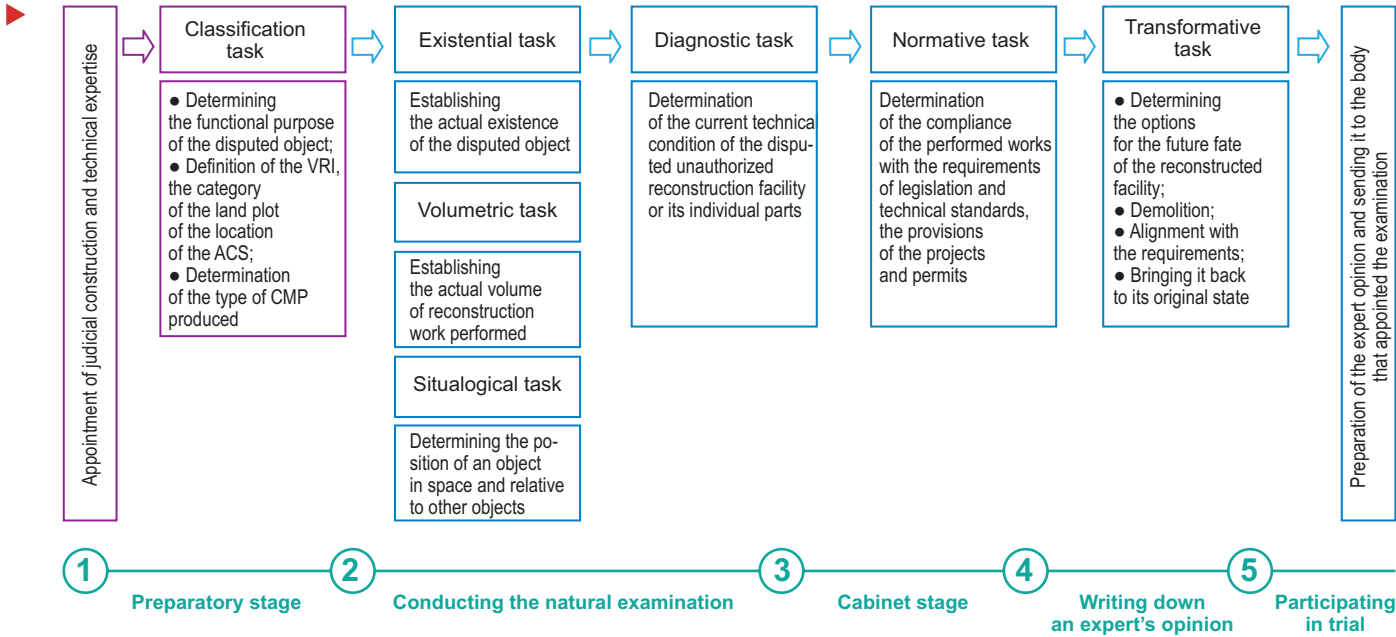
Finally, the key expert's task is transformative one. It consists of analysis and creation options of further fate of building. This question is characterized as ambivalent due to an imperfection of legislation. On the one hand, compared to expertise connected with division households the number of transformation options for unauthorized objects is limited by article 222 of UPC. They could be the demolition of object, bringing the object in accordance with construction rules and regalements or turning back to the original state (applicable for reconstruction only). On the other hand, there

are no legal norms regarding legitimization of illegal reconstruction in comparison to cases with unauthorized construction or algorithm of actions when one part of building suit the legislation while other not. An additional clarity brings the Resolution of the Plenum of the Supreme Council with number 44. This document says that the key principal for unauthorized reconstruction is proportionality of the punishment. So, the demolition of ones is considered to be an extreme measure. Have mentioned this fact an expert should create variants for reconstructed objects based on safety parameters of building or ability of bringing its condition to state available to use.

That is why the absence of permitted documents is less significant than contradictory the reconstructed building to requirements of technical rules and regalements and least than the existence of real threat to lives and souls without ability of its elimination to write down an opinion of necessity of demolition the object. The Resolution of Plenum No. 44 also prohibit to demolition such categories of real estate objects as individual residential houses and cultural heritage sites [7].

Talking about expert's opinion in cases of unauthorized reconstruction, an unambiguous or probabilistic answer may be given. For instance, the unambiguous one "To ensure that the building after unauthorized reconstruction meets all requirement it is necessary to install a dormer window ow ventilation holes in the vertical wall of the new roof to ventilate an attic space, waterproofing the basement of new foundation and complete installation work connected with stair and entrance to object". The probabilistic wording example "There is a successful case of reinforcement load-bearing constructions from similar building in construction practice. That is why object could be brought in line with requirements theoretically". The second variant would be less preferable to court needs and unclarity and incompleteness of a construction-technical expertise may become a reason of demanding an additional investigation [16, 17].

The other features of expert's opinion also should be noted. To describe the variant of bringing the condition of object to the previous state it is obviously that deinstallation of all erected or replaced elements is impossible because can lead to degradation of endurance and safety of other structures. Despite it the functional purpose of premise, exterior of building, some entrances or engineer systems' location can be turned back to original state but also



Algorithm for conducting research on unauthorized reconstruction of real estate object

with the condition of decreasing their tear percentage [18]. Well, the more rational way for expert would be the description of certain element what demolition or restatement is technologically and economically possible and approved [19]. In case of reconstructed building's parts what demolition is necessary but difficult to occur like disassembly of masonry of upper floors or extensions expert should write down the volume of demolition and works connected with conservation and restoration of modified parts. There is a general scheme of expert's research algorithm of unauthorized reconstruction in the Figure below.

To summarize, construction-technical expertise of unauthorized reconstruction has unique features what separate it from investigation of illegal construction or replanning premises. However, there aren't any difference between them in current legislation and juridical practice what leads to unreasonable and unsystematic decisions. Remaining the fact that phenomenon of illegal construction and reconstruction affect the state's interests, investigations connected with such cases were allowed only to government experts in 2023. Increasing cases of unauthorized reconstruction multiply the burden on experts what in the situation of absence of comprehensive methodical recommendations make their work less operative and more intuitive. That is why cases of unauthorized reconstruction should be synthesized in manuscripts for knowledgeable people. List of difficult issues about illegal reconstruction also must be described. For instance, what expert should do if the reconstruction has been already done when others requirement for it were relevant but for today, they have changed.

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Особенности производства судебной строительно-технической экспертизы в отношении объектов самовольной реконструкции

Освещаются вопросы особенностей проведения исследования объектов капитального строительства, обладающих признаками самовольной реконструкции в рамках судебной строительно-технической экспертизы. В настоящий момент из-за отсутствия в законодательстве указанного понятия многими неоднозначно трактуются требования к строительно-монтажным работам (СМР), связанным с различными вариантами изменения объектов недвижимости. Нередко реконструкцией оборачиваются результаты, полученные в рамках капитального ремонта зданий, реставрации, перепланировки или переустройства помещения. С другой стороны, проект, изначально заявленный и согласованный как реконструкция, может преобразоваться в создание новых объектов капитального строительства. В любом случае неправомерное использование земельных участков, действия в отсутствие на то технической или разрешительной документации, а также нарушение предъявляемых к СМР требованиям — все это признаки самовольности. Самоуправство в области строительства и реконструкции чревато множеством негативных последствий, начиная от нарушения прав третьих лиц, заканчивая возникновением угрозы жизни и здоровью людей. Сложность вопроса отнесения СМР к тому или иному процессу, а также комплексность регулирования в строительстве являющаяся причиной назначения строительно-технической экспертизы для исследования самовольных построек. Судебная практика показывает отсутствие единых методических рекомендаций к экспертизе самовольной реконструкции и ситуативность действий сведущих лиц, неверную ориентацию на алгоритмы исследования самовольных построек, большое количество ошибок и неточностей в заключениях. Также особенно затруднительной представляется преобразовательная задача, которая должна разрешаться экспертами для помощи суду в принятии решения о дальнейшей судьбе самовольно реконструированного объекта.

Ключевые слова: самовольная реконструкция, перепланировка, переустройство, судебная строительно-техническая экспертиза, натурное обследование, заключение эксперта

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For citation: Zubakhin N.A., Akristinii V.A. Conducting forensic construction and technical expertise in relation to unauthorized reconstruction projects. *Real Estate: Economics, Management*. 2025; 4:63-68.

Для цитирования: Зубахин Н.А., Акристиний В.А. Conducting forensic construction and technical expertise in relation to unauthorized reconstruction projects // Недвижимость: экономика, управление. 2025. № 4. С. 63–68.



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UDC 693

Urban environment design based on a producer approach to the development of small towns

The paper examines the problem of small towns degradation and substantiates the necessity of applying a new managerial approach — the producer model — for their sustainable development. The relevance of the topic is driven by the persistence of negative trends, such as population outflow, economic stagnation, and the loss of cultural identity in small towns, despite the implementation of state programmes. The aim of the research is to analyze the conceptual foundations of designing a comfortable urban environment for small towns based on the principles of producing. The study reveals the essence of the producer approach, which implies a transition from administrative management to the creation and implementation of an integrated territorial “product”. Key principles of the approach are identified: forming the city's unique selling proposition, implementing participatory design with resident involvement, and applying project management and crowdfunding tools. The stages of implementing the producer model and the expected results are outlined, including the creation of economic growth points, increased investment attractiveness, and the formation of a comfortable, distinctive urban environment. The novelty of the approach lies in adapting producing tools, characteristic of creative industries, to the practice of urban development for small towns. The practical significance is that the proposed mechanisms can be used by municipal government bodies and investment-construction companies to develop and implement effective territorial development strategies.

Keywords: *small town, urban environment design, producer approach, sustainable development, territory development management*

The development of small towns remains one of the most pressing issues in the spatial development of the Russian Federation. Despite the existence of state programmes and national projects such as “Housing and Urban Environment”, many small towns continue to face complex challenges: outflow of the working-age population, degradation of economic potential, deterioration of the housing stock and public spaces, and loss of cultural and historical identity [1, 2]. Traditional administrative management methods, often reactive and subsidized, are unable to fundamentally change the situation. Under these conditions, new, proactive approaches to development management are required that would harness the inherent potential of the territory and transform it into an attractive and competitive “product”. One such approach, which has significant potential, is the producer approach, which has proven itself successful in the creative industries and complex project management.

The aim of this study is to use the principles of the producer approach in the design of a comfortable urban environment for small towns. To achieve this goal, the following objectives were set: to reveal the essence and content of the producer approach as applied to territorial development. To identify key principles and tools for producing and to propose a model for its implementation in urban planning practice.

The study is based on a systemic and project-based approach, which allows us to consider a small town as a holistic, complex system, the development of which requires integrated management, as noted by domestic and international scholars in the fields of urban studies, territorial marketing, and project management [3–5].

Let us consider the essence and principles of applying the producer approach to the development of small towns. The producer approach, in the context of small towns development, is a management system in which the manager (producer) acts not as a bureaucratic administrator, but as the creator, organizer, and implementer of a comprehensive “project” for the transformation of the territory. Its key objective is to identify the city's unique potential (human, cultural, historical, natural) and create conditions for its capitalization through the design of a comfortable and functional urban environment [6].

Based on the need to combine many diverse functions, the key principles of the producer approach can be formulated as follows.

1. Developing a city's Unique Selling Proposition (USP). Every small town possesses unique assets: historical heritage, natural landscape, location on a tourist route, and the presence of unique artisans or industries. The producer's task is to find this “golden key” and turn it into the foundation of the brand and economy [7]. For example, successful cases include Vyksa (Nizhny Novgorod Region) — urban development through culture — and Divnogorsk (Krasnoyarsk Krai) — with an emphasis on nature-based tourism and active recreation.

2. The principle of participatory design and crowdsourcing. The producer does not impose a vision from above, but rather acts as a moderator, identifying the needs and potential of the residents themselves. Through workshops, public discussions, and online platforms, ideas are collected and local activists and volunteers are united [8]. This creates a sense of ownership and responsibility for the city's transformation, which is a key factor in project sustainability.

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3. The principle of project management and attracting funding. City development includes specific, achievable projects (e.g., "Creation of a Historical and Crafts Cluster", "Development of the Embankment as a Public Space", "Launch of an Urban Culture Festival"). To finance these projects, alongside budgetary funds, extra-budgetary sources are actively involved: fundraising, private investment, and grants [9, 10]. The producer is responsible for creating an attractive investment package and finding partners.

Vyksa, a city in the Nizhny Novgorod region, provides an outstanding example of how culture can become a catalyst for economic growth. Here, thanks to a forward-looking strategy, the city-forming enterprise (United Metallurgical Company) took on the role of producer, investing not simply in infrastructure upgrades but in the creation of new meanings and values.

Key factors in the success of this model:

- Art-Ovrag Festival: This festival became the foundation of transformation, turning an industrial city into a magnet for contemporary art lovers;
- Co-design: Residents actively participate in the transformation, becoming co-creators of change rather than mere observers;
- Cooperation between business, government, and society: UMK, acting as producer, pooled the resources and expertise of all stakeholders.

As a result, Vyksa has transformed from an ordinary single-industry town with a negative image into a cultural center renowned throughout the country. This has led to increased tourism and, most importantly, increased pride among residents in their city. This experience clearly demonstrates that investments in culture and community development bring tangible benefits, improving the quality of life and the investment attractiveness of the city.

The expected results of this approach are: the creation of economic growth opportunities based on the uniqueness of the territory; increased investment attractiveness; the creation of a comfortable, consistent urban environment that motivates people to stay in the city or return; and the development of local community and civic engagement.

One of the risks is resistance from the traditional bureaucratic system, which requires political will at the regional and municipal levels to empower producers with the necessary authority.

The producer does not impose a vision from above, but rather acts as a moderator, identifying the needs and potential of residents themselves. Through workshops, public discussions, and online platforms, ideas are collected, and a pool of local leaders and volunteers is formed [8]. This creates a sense of ownership and responsibility for the transformation of the city, which is a key factor in the sustainability of projects.

The implementation of the producer model can be divided into several stages:

1. Diagnostic stage: a comprehensive audit of the territory, including urban planning, economic, social, and cultural analysis. Identification of key stakeholders and their interests.

2. Strategic stage: developing a unique selling proposition and city development concept. Formulating a roadmap with a package of specific projects for urban development.

3. Project stage: implementation of pilot projects with maximum visual and social impact (tactical urbanism, launching event-based activities). Active community engagement.

4. Integration and scaling stage: implementation of successful practices in the municipal governance system, attracting major investors for large-scale projects. The expected results of this approach are: creation of economic growth opportunities based on the uniqueness of the territory; increased investment attractiveness; creation of a comfortable, consistent urban environment that motivates people to stay in the city or return to it; development of the local community and civic engagement.

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Проектирование городской среды на основе продюсерского подхода к развитию малых городов

В статье рассматривается проблема деградации малых городов и обосновывается необходимость применения нового управленческого подхода — продюсерского — для их устой-

чивого развития. Актуальность темы обусловлена сохранением негативных тенденций оттока населения, стагнации экономики и утраты культурной идентичности малых городов, несмотря на реализацию государственных программ. Цель исследования — анализ концептуальных основ проектирования комфортной городской среды малых городов на принципах продюсирования. В результате исследования вы-

явлена сущность продюсерского подхода, предполагающего переход от административного управления к созданию и реализации комплексного «продукта» территории. Выделены ключевые принципы подхода: формирование уникального торгового предложения города, реализация соучаствующего проектирования с вовлечением жителей, применение инструментов проектного управления и краудфандинга. Изложены этапы внедрения продюсерской модели и ожидаемые результаты, включая создание точек экономического роста, повышение инвестиционной привлекательности и формирование комфортной, идентичной городской среды. Новизна подхода заключается в адаптации инструментов продюсирования, характерных для креативных индустрий, к практике градостроительного развития малых городов. Практическая значимость состоит в том, что предложенные механизмы могут быть использованы органами муниципального управления и инвестиционно-строительными компаниями для разработки и реализации эффективных стратегий развития территорий.

Ключевые слова: малый город, проектирование городской среды, продюсерский подход, устойчивое развитие, управление развитием территорий

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For citation: Selezneva A.I. Urban environment design based on a producer approach to the development of small towns. *Real Estate: Economics, Management*. 2025; 4:69-71.

Для цитирования: Селезнёва А.И. Urban environment design based on a producer approach to the development of small towns // Недвижимость: экономика, управление. 2025. № 4. С. 69–71.



Москва. Школьная улица. Рисунок, тушь, перо



Москва. Ул. Моховая