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**Уважаемые читатели!**

Как известно, решение жилищной проблемы является одной из основных задач, стоящих перед любым обществом. Оно требует огромных финансовых и временных затрат, а также способности большого количества людей объединять свои усилия для достижения поставленной цели.

В России проблема жилья была и остается довольно острой. Во многом это обусловлено климатом страны, где возможны только капитальные постройки с мощной теплоизоляцией и в связи с этим высокой себестоимостью жилья. Стремительная урбанизация в начале XX в., переселение огромного числа людей из сельской местности в города привели к дефициту жилья такого масштаба, что на борьбу с ним ушло почти полностью прошлое столетие.

Одной из важнейших характеристик жилищной обеспеченности является наличие ветхого и аварийного жилищного фонда. В советский период государство, являясь основным собственником жилищного фонда, не смогло выработать должной системы его эксплуатации и реновации. Еще более ухудшилось это положение в годы реформ.

Сейчас 3,5 млн человек (около 2,5% населения России) проживают в ветхих и аварийных домах, не приспособленных для постоянного жительства. Количество таких семей составляет 18% от численности семей, стоящих в очереди на улучшение жилищных условий.

По-прежнему значительная часть граждан с низкими доходами не может приобрести жилье в собственность. При этом нам нужно повышать мобильность рабочей силы, студенчества, делать жилье реально доступным для проживания в каждом городе и поселке.

Приобретение жилья, квартиры, комнаты в собственность должно быть важнейшим, но не единственным способом решения данной проблемы, следует стимулировать строительство и фактическое использование арендного жилья, квартир социального найма. Жителям на освобожденных территориях Херсонской, Запорожской областей, Донецкой и Луганской республик мы должны предоставить жилье.

Развитие института наемных домов — это сейчас один из основных вопросов как для жителей Донбасса, так и для всех жителей РФ по обеспечению жилищных прав граждан.

Этим вопросам и проблеме развития жилищного законодательства в части создания наемных домов социального использования, а также механизмам реализации их строительства и эксплуатации будет посвящена Национальная конференция, которая пройдет в ноябре 2023 г. в г. Москве на базе НИУ МГСУ.

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АКЦЕНТЫ НОМЕРА

Луняков М.А., Кирпиченков А.А.

Необходима тщательная проработка действующего порядка взаимодействия участников с целью выявления возможных проблем и совершенствования механизма управления при реализации программы реновации жилищного фонда.

Буданов И.В.

Доказано, что градостроительная деятельность влияет на социальную и экономическую жизнь страны в долгосрочном периоде. Проблемы сохранения баланса между возможностями и потребностями в социальном, финансовом, культурном и экологическом аспектах развития территории города приводят нас к необходимости определения вектора устойчивого развития.

Симионова Н.Е., Симионов Р.Ю.

Стоимостная концепция управления бизнесом является относительно новой для управления в строительной сфере. Применение стандартных подходов и методов оценки бизнеса требует учета специфики строительного бизнеса, особенностей функционирования строительной отрасли, факторов, влияющих на конкурентные позиции строительных компаний, специфики рынка недвижимости.

Беляков С.И.

Вне зависимости от типа применяемой корпоративной модели объединения строительных предприятий неизменными остаются основные цели, мотивирующие субъектов к интеграции и установлению долгосрочного взаимодействия, ключевой из которых является повышение эффективности. Вместе с тем категория эффективности предполагает различные подходы к ее трактовке и методический инструментарий оценки и управления.

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Концепция устойчивых конкурентных преимуществ постулирует их длительность и уникальность, трудность копирования, а главное, способность обеспечить стратегическую направленность конкурентоспособности в условиях трансформации внешней и внутренней среды. Сущностная составляющая устойчивых конкурентных преимуществ видится в возможности ускоренной адаптации предприятия к изменяющимся средовым условиям на основе инновационной способности к созданию новой ценности для стейкхолдеров.

Сезёмин Д.Е.

В рамках многокритериальной системы оценки надежности технически сложного объекта строительства АЭС рекомендовано оценивать всю совокупность факторов организационно-технического процесса, таких как трудовые ресурсы, лицензионно-правовые ресурсы, материально-технические ресурсы, иные ресурсы, которые влияют на безопасность и риски, сопутствующие сложным техническим производственным процессам.

Звонов И.А.

Внедрение и реализация реестрового принципа ведения технических требований в строительстве — одна из задач совершенствования системы технического регулирования. А обеспечение автоматической актуализации реестра и привязки конкретного требования к соответствующим производственным процессам — задача повышенной сложности.

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It is necessary to thoroughly study the current order of interaction of participants in order to identify possible problems and improve the management mechanism during the implementation of the housing renovation program.

Budanov I.V.

It is proved that urban development activities affect the social and economic life of the country in the long term. The problems of maintaining a balance between opportunities and needs in the social, financial, cultural and environmental aspects of the development of the city territory lead us to the need to determine the vector of sustainable development.

**Simionova N.E.,
Simionov R.Yu.**

The cost concept of business management is relatively new for management in the construction sector. The application of standard approaches and methods of business assessment requires taking into account the specifics of the construction business, the functioning of the construction industry, factors affecting the competitive positions of construction companies, the specifics of the real estate market.

Beliakov S.I.

Regardless of the type of corporate model used to unite construction enterprises, the main goals that motivate subjects to integrate and establish long-term cooperation remain unchanged, the key of which is to increase efficiency. At the same time, the category of efficiency implies different approaches to its interpretation and methodological tools for evaluation and management.

Zvonov I.A.

The introduction and implementation of the registry principle of maintaining technical requirements in construction is one of the tasks of improving the system of technical regulation. And ensuring automatic updating of the registry and linking a specific requirement to the relevant production processes is a task of increased complexity.

Lunyakov M.A.
Kirpichenkov A.A.



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Analysis of the efficiency of interaction between participants in the implementation of projects under the renovation programme on the example of the city of Moscow

One of the most important directions of the social and economic policy of each state is to provide citizens with safe and comfortable housing conditions that would meet not only the requirements of current norms and regulations, but also the established requirements of modern society. In order to improve housing conditions and renovate dilapidated and emergency housing, a programme of residential renovation is underway. One of the peculiarities of the housing stock in many cities of the Russian Federation is the large and often predominant number of residential buildings built in the period from 1958 to 1967 — the period of industrial housing construction. According to current regulations, the service life of these houses is up to 70 years, provided that they are maintained in a timely manner. This means that in the next 10–15 years the general condition of the housing stock may significantly deteriorate and there will be a sharp increase in dilapidated and emergency housing. In order to prevent the mass appearance of emergency buildings, for which at this stage of their life cycle capital repairs are inexpedient, a programme of residential renovation is being implemented. The main objective of this programme is to modernize the existing housing stock and renovate the living environment in order to bring it in line with quality standards ensuring comfortable living conditions. Many participants are involved in the residential renovation programme: from government agencies to local contractors. Such a wide range of participants requires the most coordinated mutual work to achieve all the set tasks. But, as practice has shown, the participants do not always act in a coordinated manner, which leads to various consequences expressed in a significant increase in the cost or timing of construction. Thus, it is necessary to thoroughly study the existing procedure of participants' interaction in order to identify possible problems and analyze them in order to improve the mechanism of management and interaction between the programme participants.

Keywords: *residential development renovation programme, integrated territorial development, improvement of the interaction mechanism, Moscow City Renovation Programme*

In many cities of the Russian Federation, including Moscow, the housing stock in large numbers is represented by industrial housing construction — residential buildings built between 1958 and 1967. According to the current normative documents (SP 255.1325800), the service life of these serial houses is from 50 to 70 years (subject to proper maintenance and current repairs) [1–3]. This fact indicates a sharp increase in emergency and dilapidated housing, which may occur within the next 10–15 years. In this regard, the federal and regional authorities have decided to develop and apply a programme of integrated development of the territory. In the Moscow region, this programme is frequent and is called “building renovation programme of residential development”. On the territory of Moscow, the programme of residential development renovation is presented in the form of demolition of outdated, dilapidated and emergency housing stock and construction either in place of demolished houses or on new starting sites of new residential buildings that meet all modern standards and requirements of comfort and energy efficiency [1, 2, 4].

In accordance with the current definitions, the renovation of the housing stock is understood as a process of replacement and restoration of elements of the housing stock (residential buildings and their parts) that have been retired as a result of

functional and physical deterioration by new elements or objects [2, 3, 5].

Renovation of housing stock is a cyclical process of renewal of residential development, which can be represented by the following methods (Table 1):

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

buildings — number and area of flats, construction volume and total area of buildings, as well as purpose of premises [4, 6, 7].

As can be seen, the renovation of the housing stock can be represented by different types. The choice of the type of renovation is based on various factors: the degree of deterioration of the existing building stock, physical feasibility of implementing one or another type, economic feasibility and possibility. For example, in Moscow, new construction prevails within the framework of residential renovation due to the high degree of deterioration of many residential buildings, as well as due to the economic feasibility of implementing a resource-intensive project. In turn, in Europe, such types of residential renovation as reconstruction and modernization have become the most popular [8, 9]. It is also worth noting that the housing stock of eastern Germany has much in common with the housing stock of the Russian Federation, but in eastern Germany the regional authorities have decided to modernize residential buildings in stages, which allows to significantly increase the service life and create comfortable conditions for citizens without demolition of residential buildings [10, 11].

In addition, modernization of residential buildings allows to significantly reduce operating costs for the maintenance of residential buildings through the use of energy efficient solutions in terms of engineering systems, the use of modern insulation materials and so on, which reduces the financial burden on the residents. Nevertheless, many residential buildings built in Moscow and other regions of the Russian Federation do not have the same margin of safety and reliability, and their physical deterioration is significantly higher. In many respects, the changes are the result of lower frequency of current repairs, peculiarities of operation and even weather conditions.

Thus, the most rational method for renovation of the housing stock in Moscow turned out to be new construction [7, 12, 13].

The Moscow housing stock renovation is an extensive programme, which includes more than 5,000 demolished houses, which should result in the construction of more than 9 million sq. meters of housing. In the preparatory phase of the programme, 561 start-up sites have been identified on which modern and comfortable houses will be built. The housing renovation programme is designed for a period of 25 years, from 2017 to 2032, and consists of three phases of wave resettlement [1, 2, 5]. As part of the legal and regulatory framework, government decrees have been developed that define the list of houses to be demolished and dictate the rules for the participants in the process (Table 2).

Given the success of the building renovation programme in Moscow, other cities in the Russian Federation have also announced the start of the renovation programme. For example, cities such as Nizhnevartovsk, Ufa and Novosibirsk have started to develop regulations for the implementation of a region specific programme. In turn, as of the third quarter of 2022, in Irkutsk, Yaroslavl and Yekaterinburg, construction work has already begun on new houses, demolition of the emergency fund, as well as capital and current repairs of habitable residential buildings [11, 14, 15].

Irkutsk should be singled out from the list, as the ratio of emergency building stock to total number of dwelling square meters is the highest in Irkutsk. This arose in view of the large number of wooden houses on its territory, so the implementation of the renovation programme in Irkutsk is particularly detailed. The following table provides a more detailed look at the status of renovation in some of the participating cities (Table 3).

Table 1. Methods of implementation of residential renovation

Renovation methods	Characteristic features	A set of works
New construction	The construction of new residential properties on undeveloped or reused land that has been cleared from existing development	• construction of a new capital construction facility on a vacant land plot or land plot to be vacated through demolition. These works may include the re-laying and installation of new utilities, landscaping of the adjacent area, etc.
Capital repair of housing stock	A set of construction works to restore, replace or reinforce parts of residential buildings or entire structures, parts, and engineering equipment due to their physical deterioration	• restoration of building envelopes, openings, restoration of facade structures; repair and/or replacement of engineering systems and equipment
Restoration of the housing stock	The complex of construction works ensuring restoration of the original architectural, engineering and historical appearance of residential buildings	• restoration of envelope structures, openings, restoration of facade structures; • refurbishment of premises; • repair and/or replacement of engineering systems and equipment
Modernization of the housing stock	The complex of construction works that provides improvement of residential buildings in terms of quality of use and performance without any modification of the building itself. Retrofitting eliminates functional deterioration and is usually limited to redesign of internal spaces, improvement of existing engineering systems	• replacement and improvement of engineering systems, increasing the energy efficiency of buildings; • improvement of envelope and roof structures; • improvement of surrounding area; • redesign of premises and flats; • replacement of glazing
Reconstruction of housing stock	The complex of construction works related to the change of basic technical and economic parameters of residential buildings — the number and area of flats, building volume and total floor area, as well as the purpose of the premises	• modification of the building exterior, improvement of the building envelope; • construction of additions and/or extensions; • enlargement of the flats; • changes in floor plans; • enlargement of window openings; • replacement and modernization of utilities, systems and equipment; • rehabilitation and/or replacement of the load-bearing structures of the building

Table 2. General parameters, indicators and regulatory documents for the renovation of residential buildings in Moscow

The state of Moscow's housing stock	Implementation of the renovation programme	Regulatory framework
- the total housing stock in Moscow amounts to 251.8 million sq. m; - the volume of panel housing of the demolished series is 9.8 million sq. m; - tear-down batch houses were built in the period from 1957 to 1968; - durability of houses of demolished series is no more than 70 years	- The programme is to run until 2032; 1st stage (2020 to 2024) — 930 houses; 2nd stage (2025 to 2028) — 1,630 houses; 3rd stage (2029 to 2032) — 1,800 homes. 561 start-up sites; - Construction potential — 8.8 million sq. m; 75,700 people resettled; 2.7 million sq. m under construction; 2.48 million sq. m under construction	Resolutions have been drawn up: - No. 497-PP “On the Programme for the Renovation of the Housing Stock in the City of Moscow”; - No. 245-PP “On Consideration of Public Opinion on the Housing Renovation Project in the City of Moscow”; - No. 708-PP “On Approval of the Addressed List of Neighbourhoods (Territories)”; - No. 515-PP “On Approval of the Basic Requirements for Improvement of the Residential Development Territory during Implementation of the Housing Renovation Programme in the City of Moscow”; - No. 516-PP “On Approval of the Requirements for Improved Finishing of Equivalent Residential Premises Provided in Replacement of Residential Premises in Multifamily Buildings”

Despite the development of the building renovation programme in various cities and regions of the Russian Federation, it is difficult to assess the quality and effectiveness of the decisions made by regional and municipal authorities at this stage, as the programme is just beginning to take effect. Therefore, it is proposed to assess the effectiveness of decisions in the implementation of the building renovation programme using the example of the city of Moscow, where the programme has been in place since 2017 [13, 15].

The main regulatory document is government decree No. 497 “Moscow Building Renovation Programme”. This decree defines the number of start-up sites: land plots that will be used for new construction [2, 3]. The decree also provides a list of residential buildings to be demolished whose physical and moral

deterioration makes it impossible to continue their safe operation even after a capital repair or it is economically inexpedient.

In accordance with Decree No. 497 the main participants of the Moscow building renovation programme are determined as well as the procedure, methods and stages of their interaction in the process of realization of the goals of the building renovation programme [2–4]. The main participants are:

- Department of Urban Planning Policy;
- Department of Urban Planning Property;
- Committee for Architecture and Urban Planning of Moscow;
- State Housing Inspectorate;
- Moscow Housing Renovation Fund.

Table 3. Progress of the building renovation programme in cities of the Russian Federation

City	Characteristics and condition of the housing stock	Programme implementation phase
Nizhnevartovsk	1,039 multi-apartment houses; - Total housing stock — 6,894 thousand sq. m; 107 houses are to be demolished — 28.1 thousand sq. m	Development of legal and regulatory instruments
Ufa	6,412 multi-apartment houses; - Total floor area — 24,683 thousand sq. m; 201 houses are to be resettled — 61.8 thousand sq. m	- Urban planning and development project is approved; - Drafting of legal and regulatory instruments
Irkutsk	5,589 apartment blocks; - Total floor area — 11,689 thousand sq. m; 597 residential houses are subject to resettlement — 397,09 thousand sq. m	- Elaboration and addition of legal acts; - Elaboration of land development project; - Resettlement of dilapidated wooden houses as part of the “Housing Programme 2019–2024 is underway”
Yaroslavl	4,452 multi-apartment houses; - Total floor area — 14,551 thousand sq. m; 115 dwelling houses are subject to resettlement — 87.3 thousand sq. m	- Development of legal and regulatory framework; - Identification of starter sites for the construction of houses; - Definition of list of houses to be demolished and reconstructed
Novosibirsk	8,107 multi-apartment houses; - Total housing stock — 26,500 thousand sq. m; 405 residential houses are subject to resettlement — 277.6 thousand sq. m	- Start-up sites have been identified; - Areas identified for demolition; - Development of legal and regulatory framework
Yekaterinburg	7,111 multi-apartment houses; - Total housing stock — 32,012 thousand sq. m; 528 residential houses to be resettled = 344.1 thousand sq. m	- Construction of the first new houses has started; - Regulations are being completed; - Site development project developed; - List of houses to be demolished and reconstructed identified

Table 4. Main participants of the building renovation programme in Moscow

Programme participant	Main tasks of each participant
Department of Urban Planning Policy	Within the framework of the State Housing Programme of the City of Moscow, the following tasks are carried out: • Identification of start-up sites for new construction; • Search and evaluation of land plots; • Assessment of transport accessibility and infrastructure
Department of Urban Planning Property	Determination of the list of houses to be demolished, reconstructed or overhauled
State Housing Inspectorate	Commissions to determine the technical condition, obsolescence and physical deterioration of residential buildings
Committee for Architecture and Town Planning of Moscow	• Determination of the architectural and planning solutions for the residential buildings; • Approving the appearance of the building; • Deciding on the landscaping; • Ensuring compatibility with adjacent development
Moscow Building Renovation Fund	• Assistance in demolition works; • Assistance in preparation of engineering surveys, design documents, construction; • Assistance in securing the housing rights of homeowners; • Implementation of investment activities; • Handing over to the city of Moscow the residential premises owned by the fund
General contractors, technical client service, design companies	• Selected after an open tender; • Prepare project documentation in accordance with the elaborated terms of reference; • Carry out construction of the object; • Carrying out engineering surveys; • Acquisition of initial and approval documentation

In order to provide a more detailed study of the functions and interaction of the above-mentioned actors, the information is proposed to be displayed in tabular form (Table 4).

The order and structure of interaction of the voiced participants can be considered in terms of 4 main stages [2, 13, 15]:

- at the first stage, the Department of Urban Planning Policy and the Department of Urban Property determines the list of residential buildings to be included in the programme of residential building renovation, taking into account their technical condition. The Department of Urban Planning Property engages the State Housing Inspectorate to determine the physical and moral deterioration of residential buildings in order to accurately determine and select the method of renovation;
- the Department of Urban Planning Policy together with the Moscow Committee of Architecture search for land plots for the construction of new residential buildings — strata sites. On the basis of the data received, an initial terms of reference are developed and an initial budget for the project is agreed upon;
- at the next stage, the Department of Urban Planning Policy engages the Moscow Renovation Fund to organize and oversee the implementation of residential renovation projects outside of the city. The Renovation Fund, in turn, engages specialized organizations to directly carry out the design and management of the project (as a rule, a technical customer organization is selected for integrated project management). At this stage, an end-planning stage and an album of urban solutions are developed, which should be subsequently agreed and approved by the Moscow Architectural Committee, the Construction Department and the Department of Urban Planning Policy;
- after approval of the concept stage, the technical client organization together with the general design organization

proceed with the development of the design stage, more detailed engineering surveys in order to obtain a positive opinion from Moscow state Expertise [2, 3, 13, 15].

Based on the analysis and study of the regulatory documentation and practical implementation of residential renovation projects, it seems possible to identify the main levels and bring the order of interaction between the participants at the various stages of project implementation to a tabular form (Table 5).

To summaries the above, it can be said: the result of the first stage is the initial terms of reference, technical and economic indicators, and an initial budget for the project.

The next stage involves the Moscow Housing Renovation Fund, which undertakes to supervise and organise the work necessary to implement the renovation programme in accordance with the approved plan. In turn, the Renovation Fund usually organises a tender and concludes a contract with a technical client organization, which undertakes to carry out a set of design works. The result of this stage should be a duly approved architectural and urban design booklet (hereinafter — the AGR booklet). Based on the results of AGR booklet approval, the involved design organization shall develop documentation of “Project” stage for further passage of Moscow state Expertise and obtaining a positive conclusion during consideration of the full set of documentation [10, 12].

The following difficulties may arise during the third stage, which should result in: fully developed documentation of the “Project” stage, positive opinion of the Moscow state Expertise, as well as the clarified budget of the project. Due to the fact that detailed engineering surveys have not been carried out before, they may impose significant constraints on the Project. It is only at this stage that a more in-depth investigation of the area to be constructed begins, specifications are obtained and reports on the engineering survey are produced. Thus, if the results of the engineering survey reveal that it is impossible to design a building with the parameters

Table 5. Procedure of interaction, goals and objectives of the participants of the building renovation programme in Moscow

Level of interaction	Stage of project implementation	Participants in project implementation	Composition of tasks to be solved
I	1	Department of Urban Planning Policy Department of Urban Planning Property	Determination of the stages of citizens' resettlement, identification and approval of the list of houses to be demolished or overhauled
	2	Department of Urban Development Property State Housing Inspectorate	Determination of the technical condition of buildings, determination of the list of apartment buildings in need of maintenance or major repairs; determination of the list of apartment buildings to be demolished
	3	Department of Urban Planning Policy Committee for Architecture and Urban Planning of Moscow	Determination of the list of neighbourhoods and areas designated for the design and construction of starter homes. Development and approval of the primary architectural and planning solutions, external appearance of the designed buildings, definition of the technical assignment for project development
II	4	Department of Urban Planning Policy Committee for Architecture and Urban Planning of Moscow Moscow Housing Renovation Fund	Drafting and submitting the initial technical assignment for the construction of an apartment building within the boundaries of the allocated land plot; approval of the project budget
III	5	Committee for Architecture and Urban Planning of Moscow Moscow Housing Renovation Fund Management company, technical customer service	Approval of architectural and planning solutions; external appearance of the residential building; approval of landscaping solutions
IV	6	Moscow Housing Renovation Fund Management company, technical client service Design companies, general contractor	Implementation of preparation of architectural and urban planning solutions, design and working documentation, passing the Moscow state Expertise, organization of construction production, conducting engineering surveys, construction of capital construction facility

set earlier, one needs to coordinate them repeatedly with the Moscow City Architecture and Construction Department, which slows down or completely stops the design process until a decision is taken. As a consequence, it may be necessary to correct the detailed design documents and re-approve them at the Moscow City Court of Appeal, which also increases the timing and budget of the project [6, 8, 10].

The fourth stage should result in a capital construction project. For this purpose, construction and installation works are carried out by the general contractor. The technical customer performs financial and organizational control of the construction. It should be noted that due to the nature of works, structure of interaction between the sections and stipulated approval process, the working documentation is often issued simultaneously with civil and erection works. Therefore, if errors or inaccuracies are made at the design stage, it may be necessary to revise and modify the applied solutions and re-approve the corrected working documentation [7, 12]. During re-approval it is not possible to carry out construction works, which may have a significant impact on the project schedule. It should be noted that it is often at the construction stage that difficulties may arise in interaction with landowners of adjacent plots, which may also complicate, slow down or completely stop construction and installation works until all necessary approvals are obtained.

In view of the above-mentioned specifics of work performance during the implementation of the renovation programme, the existing procedure of interaction between the participants of the renovation projects may lead to unforeseen situations where project solutions need to be revised, additional approvals obtained etc. which

would either significantly slow down or fully stop the process of construction and assembly works until the situation is resolved.

The assessment shows that a more detailed engineering survey at the stage of land plot selection for residential house construction as well as obtaining approvals from the property owners of neighbouring plots and developing engineering solutions at an early stage of the project can considerably reduce the time needed to design and develop working documentation. Reduce the likely risks of controversy, redesign and design changes, and improve budget predictability. Reduce the duration of construction. Thus, increasing the duration and cost of pre-design work at the first stage of project preparation by 10–15 % can reduce the duration of design and construction work by as much as 25–30 %.

Thus, a change in the methodology of interaction between the participants of the renovation project implementation process may become more efficient and productive, which will have an impact on the financial results of the project. Therefore, the elaboration of new methodologies as well as the adjustment of the scheme and the order of interaction of the process participants is appropriate from an economic point of view.

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Анализ эффективности взаимодействия участников при реализации проектов в рамках программы реновации на примере города Москвы

Одним из важнейших направлений социально-экономической политики каждого государства является обеспечение граждан безопасными и комфортными жилищными условиями, которые бы отвечали требованиям не только актуальных норм и правил, но и сложившимся требованиям современного общества. С целью улучшения жилищных условий и обновления ветхого и аварийного жилья ведется программа реновации жилой застройки. Одной из особенностей представленного во многих городах Российской Федерации жилого фонда является большое и, зачастую, преобладающее количество жилых домов, построенных в период с 1958 по 1967 гг., в период индустриального домостроения. В соответствии с действующими нормативными актами срок эксплуатации данных домов составляет до 70 лет при условии своевременного обслуживания. Это означает, что в ближайшие 10–15 лет общее состояние жилищного фонда может существенно ухудшиться и произойдет резкое увеличение ветхого и аварийного жилья. С целью не допустить массового появления аварийных зданий, для которых на данном этапе их жизненного цикла капитальный ремонт нецелесообразен, реализуется программа реновации жилой застройки. Главной задачей данной программы является модернизация существующего жилищного фонда и обновление среды жизнедеятельности с целью приведения его в соответствие со стандартами качества, обеспечивающими комфортные условия проживания.

В реализации программы реновации жилой застройки задействованы многие участники: от государственных структур до локальных подрядных организаций. Такой широкий круг участников требует максимально слаженной взаимной работы для достижения всех поставленных задач. Но, как показала практика, не всегда участники действуют слаженно, что приводит к различным последствиям, выраженным в существенном увеличении стоимости или сроков строительства. Тем самым необходима тщательная проработка действующего порядка взаимодействия участников с целью выявления возможных проблем и анализа для совершенствования механизма управления и взаимодействия участников реализации программы.

Ключевые слова: программа реновации жилой застройки, комплексное развитие территорий, совершенствование механизма взаимодействия, программа реновации города Москвы

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Л.И. Павлова. Москва. Кремль. Соборная площадь. Рисунок, тушь, перо

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Methodical approaches to justify the sustainable development of a historically established city using the principles of revitalization of territories

The task of urban development is to synthesize resource flows and create adequate anthropological conditions for the implementation of rational programmes and plans for the revitalization of urban spaces. Turning to the essence of the methodological principle of relativism, which consists in the absolutization of relativity and conditionality of any knowledge, and, consequently, restricts the description of the object of research to their immanent properties, the presence or absence of the latter ensures the priority not only of integrity, systemic reality over individual parts, but also of development over preservation. In other words, urban development should be regarded as a managerial functional of expanded reproduction (capitalization) of urban assets in its modern development. In relation to the city, it is also important that the material should not dominate and cannot be considered in isolation. The property of the integrity of urban space creates the basis for the realization of the advantages of systematicity and prioritization of development goals.

The preservation of real estate objects over time allows us to study the dynamically changing parameters of real estate and the logic of urban development, reflecting the meanings of urban life, transformations of production methods, challenges and overcoming, values and preferences. A comparative analysis of the causes of emergence and factors of the development of settlements in Russia and Europe shows the similarity of evolutionary trends. At the same time, the study of natural conditions, specialization and peculiarities of mentality of the population of different countries, urban planning traditions allow us to identify common features and differences in the urban development of cities.

The close relationship between urban development and the socio-economic development of the city has a dual nature of interaction, determined by historical periods, which are essentially discrete projections of each other. It is proved that urban planning activities affect the social and economic life of the country in the long term. The problems of maintaining a balance between opportunities and needs in the social, financial, cultural and environmental aspects of urban development lead us to the need to determine the vector of sustainable development.

It is generally accepted to carry out the processes of real estate conversion in historically developed cities within the framework of the Redevelopment Concept. The change in functionality and operational characteristics is currently subordinated to the logic of the market economy, i.e. the support and multiplication of cash flows at all stages of the life cycle of real estate. The decision on the degree of construction and architectural intervention is subordinated to these motives. Targeted focus on solving social problems significantly changes the conceptual foundations of redevelopment, giving them a social focus on creating a comfortable living environment. In this regard, emergency housing, mothballed or abandoned real estate are subject to not just repurposing, but literally "revitalization", i.e. recreating conditions for comfortable human habitation. In terms of the theory of sustainable development, this means the revitalization of the living space. According to the author, the term "revitalization of urban space" corresponds much more to the targeted focus of National Development projects.

Keywords: *revitalization, sustainable urban development, urban environment regeneration, spatial and territorial development, cognitive approach, anthropological conditions of project implementation*

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INTRODUCTION

The desire of people to improve living conditions has led to the rapid development of urban spaces. The synthesis of these directions makes it possible to highlight the strategic context of urban development (Fig. 1). The practical experience of development of various cities on the regulatory basis of inclusive models due to the underestimation of economic, social and cultural heterogeneity came across inevitably low efficiency of urban development [1].

At present, as a result of numerous studies of the theory of sustainable urban development, five synthesized basic patterns are distinguished:

- 1) Unevenness and heterochrony (management of synchronization processes of development of branches and segments of urban economy);

- 2) Instability and cyclicity (management of cyclical dynamics of development of urban economy systems);
- 3) Sensitivity and manageability (stimulating the perception and processes of overcoming the backlog and parrying the challenges of urban economy);
- 4) Cumulativeness and continuity (planning and analysis of continuity and multiplication of the results of management decisions in the sphere of urban economy);
- 5) Divergence and convergence (expanded reproduction of diversity and convergence of all elements and systems of urban economy).

Taking into account the projections of urban space analysis proposed on the basis of the analysis of the patterns of urban development, as well as synthesizing points of view on the determination of the concept of urban development, as a result of

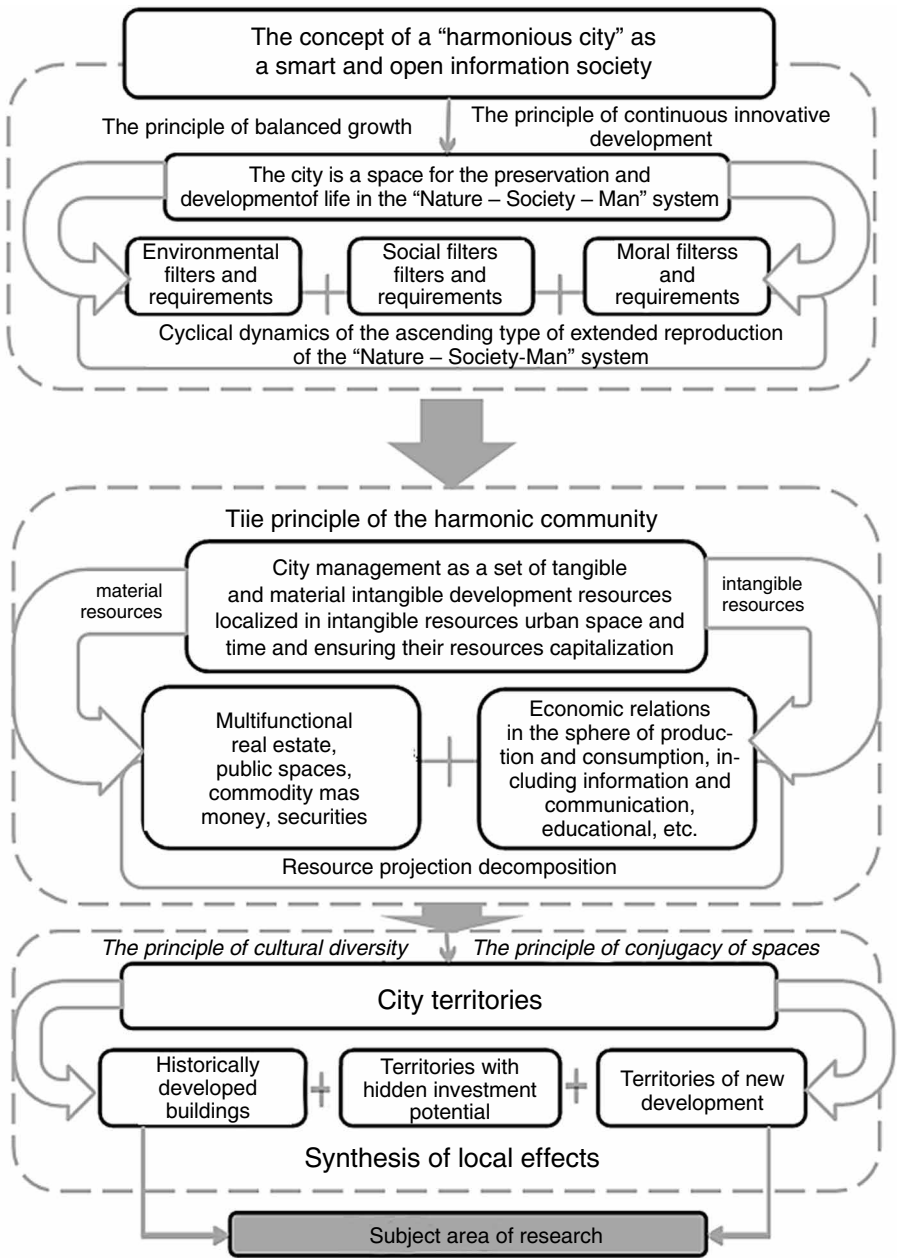


Fig. 1. Fundamentals of the concept of a “harmonious city” in terms of the theory of sustainable development (structured by the author based on the materials of the Shanghai Declaration)

the ontological analysis carried out by the author, we agree that the main focus of the study concerns [2]:

- the use of the concept of an integral urban space of life activity, acting in the form of socio-economic and natural-technological geosystems within the fixed territorial boundaries of historically developed buildings, new areas of complex development, as well as territories with hidden investment potential with objects of cultural and architectural heritage of the historically developed city;
- striving for self-sufficiency of development of each of the districts of the historically formed city. This is manifested in the availability of the necessary material and non-material development resources within the established boundaries, both

for the minimum possible resource provision and for additional investment attraction [3].

The priority of the goals and processes of urban development over the goals and processes of their simple reproduction and preservation requires a targeted focus of chaotically diverse situations, including those related to adjacent areas. At the same time, the quality of the urban environment is created as a result of the interaction of living and non-living matter at three epistemological levels:

- 1) statistical level, recording the facts characterizing the state of the urban environment;
- 2) programme level, which sets the main trajectories for achieving the goals of the development of urban areas of historical development;

3) problematic level, revealing conscious contradictions of development and ensuring the revitalization of the territories of historical development [4, 5].

MAIN PART

Based on the revealed patterns of practical implementation of the holistic approach, we formulate the main immanent properties of urban areas of a historically developed city, bearing in mind that this is, first of all, a community of people living within the specified territorial boundaries and contributing to the revitalization of living spaces. Let us combine the properties into a table and decompose them by study levels (Table).

The preservation of real estate objects over time allows us to explore the dynamically changing parameters of real estate and the logic of urban development, reflecting the meanings of urban life, transformations of production methods, challenges and overcoming, values and preferences. A comparative analysis of the causes and factors of the development of settlements in Russia and Europe shows the similarity of evolutionary trends. At the same time, the study of natural conditions, specialization and peculiarities of mentality of the population of different countries, urban planning traditions allow us to identify common features and differences in the urban development of cities [6–9].

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the market economy, i.e. the support and multiplication of cash flows at all stages of the life cycle of real estate. The decision on the degree of construction and architectural intervention is subordinated to these motives. The targeted focus on solving social problems significantly changes the conceptual foundations of redevelopment, giving them a social focus to create a comfortable living environment. In this regard, emergency housing, mothballed or abandoned real estate are subject to not just repurposing, but literally "revitalization", i.e. recreating the conditions for comfortable human habitation. In terms of the theory of sustainable development, this means the revitalization of the living space. According to the author, the term "revitalization of urban space" corresponds much more to the targeted focus of National Development projects¹ [10].

So, the author's interpretation of the revitalization processes is reduced to the implementation of the following functions:

- 1) urban planning in order to restore the viability of urban spaces of historically developed buildings;
- 2) urban planning and development for the organization of investment and construction processes of renewal (reconstruction, modernization and overhaul) of existing buildings;
- 3) urban planning to ensure the balance of the functional structure of real estate;
- 4) creation of biospheric compatibility of urbanized territories with functional and mobile mobility for various purposes and transport infrastructure facilities;
- 5) urban regulation to create general rules of urban land use and renovation of existing buildings, removing the conflict of private

Interpretation of the properties of territories of the historically formed city by levels of epistemological analysis (compiled by the author)

Features	Statistical level	Programme level	Problem level
The embeddedness of the processes of functioning of the THC* in the spatial vectors of development and national goals	Key performance indicators (KPIs) of the THC	Distribution of KPIs by programmes and projects	Synchronization of KPIs of different levels of urban economy
The integral existence of the material and immaterial, subjective and objective, living and inanimate, objective and subjective	Balance models of the THC city development	Characteristics of strategic initiatives software	Structuring of accumulated imbalances
Constellation of phenomena, processes, elements of the city, spatial synchronization and relative stability of the spatial configuration	The system of indicators of sustainable growth of KPIs of the city	Indicators of programme conjugacy of the THC of the city	Identification of depressive urban development zones
Self-sufficiency and balance (resource, spatial, subjective) of conservation and cyclical development of the ascending type	Dynamics of indicators of sustainable growth of KPIs of the city	Dynamic characteristics of development software	Fixing the dynamics of turbulence zones parameters
Self-optimization and self-regulation as conscious, as well as the reverse as a spontaneous movement of resource flows to the optimum	Results of development, depending on the own capabilities of urban areas	Development indicators included in projects of regional significance	Deviations from the set strategic priorities
Concentration and complex formation of elements of the urban environment	Results of the creation of micro-complexes on the THC of the city	Indicators of the implementation of integrated education programmes	Settling parameters from complexation
Manageability as the ability to achieve goals	Indicators of economic reliability of the management object	System of resource characteristics of the control system	Development resources scarcity indicators

* THC — the territory of the historically developed city.

► and public interests in urban development. Dialog modes of implementation (authorities, business and the population) using platform solutions in order to ensure advanced development and the need for real estate of various types of urban environment.

Often, to characterize the restoration of areas of historically developed cities, the term regeneration is used as a designation of the processes of preserving the historical and urban planning or natural environment. In practice, this term is used in a broader sense, as an integrated approach to the restoration of the historical urban environment on the basis of reconstruction, meaning reconstruction, and sometimes new construction. However, the classical content of the term regeneration means, first of all, the conservation nature of the construction work carried out to restore the historical heritage.

The analysis of historically established criteria for assigning cities to a pronounced type allows them to systematize and substantiate the main features that determine the significant differences in urban living spaces (Fig. 2).

The analysis of the functional content of cities of various types allows us to distinguish five main types of urban spaces: public-business, combining administrative, business, commercial real estate; street-road with the territories of streets, roads, driveways, bridges, overpasses, crossings, parking lots, etc.; social-leisure,

covering medical, educational, cultural and leisure, sports facilities; residential territories, including house territories and other territories of a comfortable environment; citywide territories, including parks and squares of green spaces, public squares, etc.

It is suggested that the features of the real estate sector include the currently accepted profile of characteristics:

- 1) diversity of types and types of real estate segmented not only by location, functional purpose, number of floors, degree of deterioration, etc., but also by the level of capitalization and prospective advantage;
- 2) plurality of object composition with a characteristic internal interconnectedness and interdependence of the incoming objects. For example, the real estate structure of industrial zones and territories sets the configuration of energy, transport, housing and communal infrastructure, and natural or cultural heritage objects objectively limit, and in some cases expand the specific possibilities of new construction;
- 3) functional determinism and relative inertia of real estate objects, requiring either giving the properties of multifunctionality or redevelopment taking into account the dynamics of the structure of needs;
- 4) the possibility of using various economic models of involving real estate in economic turnover. This can be shared-equity

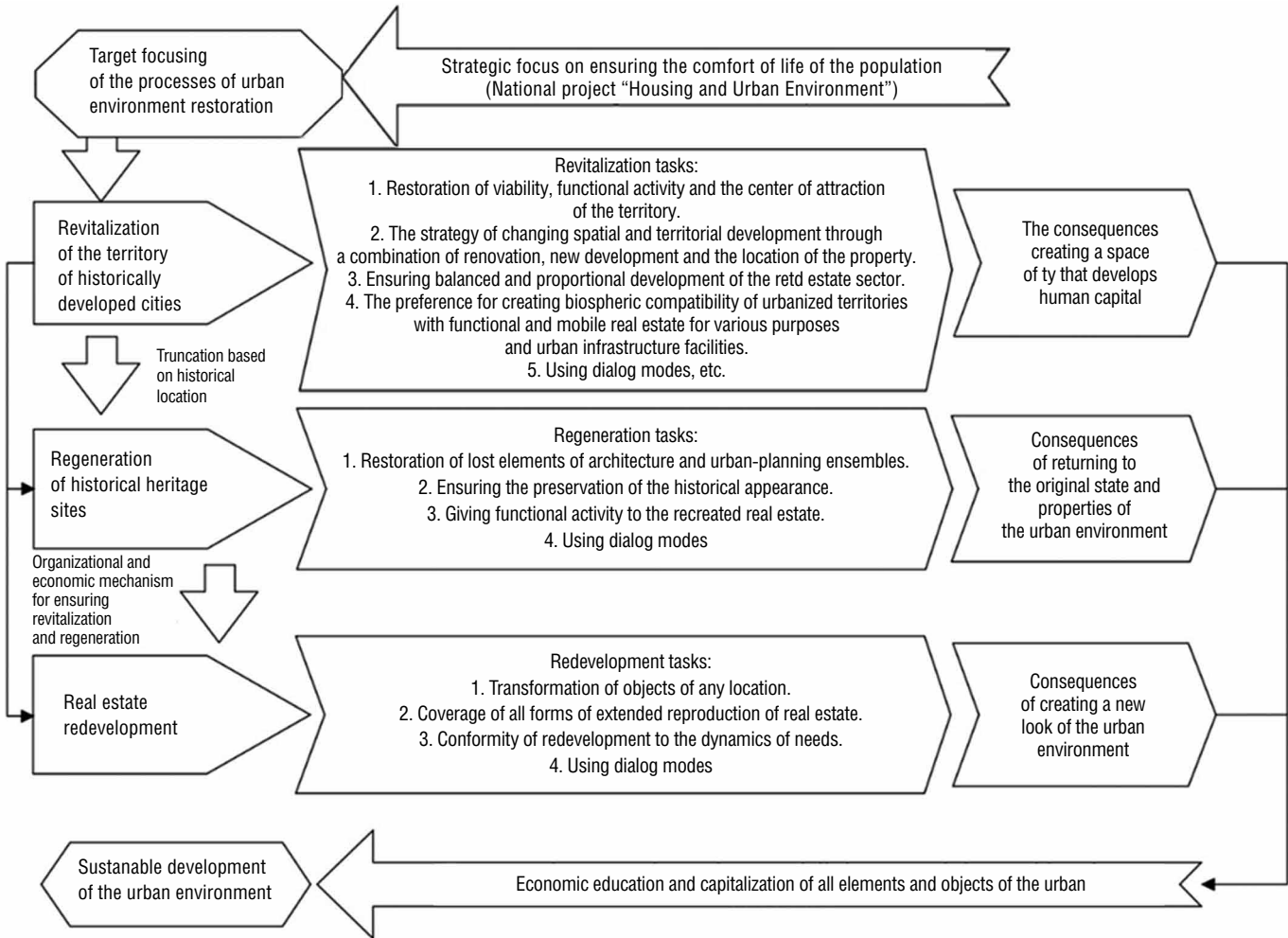


Fig. 2. Hierarchical structure of concepts reflecting the processes of restoration and renovation of real estate in a historically developed city (developed by the author)

construction or project financing of new construction, acquisition of real estate ownership, lease, trust management, co-working, etc.;

5) features of the liquidity of real estate as an investment asset. On the one hand, being a reliable asset, there is always demand, on the other hand, given the capital intensity and duration of pay-back periods, the period of operation of the facility can be long;

6) diversity of business entities involved in the real estate sector. At the same time, not only legal entities, but also individuals participate in the management cycle of real estate, taking into account the organizational and legal forms of ownership of an economic entity. Their dynamically changing needs give impulses to changes in the structure of real estate.

Participants in the processes of cyclical development of real estate carry out their activities in various spheres.

Multifunctionality of real estate was a characteristic feature of the historically developed development of Russian cities. Strategic trajectories of their development, ranging from the creation of defence industry to the formation of scientific and educational clusters, naturally took into account the location, formed production potential, existing specialization, quality of labour resources, business traditions and social characteristics.

The priority of the production sector, the financing of capital investments in real estate serving the consumer sector of the national economy, on a residual basis led to the emergence of the deepest imbalances in the real estate sector, which necessitated the development of a National project "Housing and urban environment".

As the survey of developers, developers, representatives of government and city self-government showed, the most important structural factor characterizing the influence of the urban population on the composition and structure of real estate objects is the income structure of the urban population. Thus, if the vast majority of citizens are in the zone below the subsistence minimum, it is not necessary to count on the prosperity of commercial real estate for non-industrial purposes. According to the respondents, in the so-called "peripheral" areas of the city, the creation of real estate with a large number of jobs is an absolute priority.

Structural factors reflecting the state of the urban population, as shown by the study:

- firstly, they form the requirements for residential real estate, its price characteristics, location, number of floors, apartment construction, etc.;
- secondly, they are decisive in relation to the profile and functional component of real estate of socio-cultural purpose. The new construction of educational institutions, their type and scale directly depends on the dynamics of the proportion of children and young people in the places of settlement of the family part of the urban population;
- thirdly, they set restrictions in the construction of commercial real estate. Residential areas displace factory areas, and their residents, even though they need jobs, oppose the placement of various industries, voting for the development of public spaces, retail and office real estate. Even the location of hotel real estate according to surveys for 40 % of citizens is undesirable;
- fourthly, it is absolutely obvious that the attitude to the targeted use of land in cities often becomes a zone of social tension. This is especially true of the historical centres of cities;
- fifthly, they determine the economically feasible functionality of multi-profile real estate, determining the demand for retail outlets, entertainment venues, catering places, pharmacies, etc.

The existing resource base of urban development requires restructuring taking into account the cognitive approach. The most important role in its framework is played by the quality of labour resources, assessed not only as the ability to work, but also as the initial cost of labour resource that grows as experience accumulates and education improves. In this capacity, it is human capital, on which business and investment activity, the intensity of development processes, the duration of periods of stagnation and crises depend. In this regard, it is the structure of human capital, which is based on the consideration of the previously considered structural factors, that is decisive in the formation of the resource base (RBd):

$$RBd = RBc + RBb + RBa, \quad (1)$$

where RBd — resource base of urban development;

RBc — the resource base available in the city;

RBb — borrowed resources;

RBa — attracted resources.

The task of the city authorities is to:

$RBd \rightarrow \max$, on condition $RBc \rightarrow \max$.

At the same time $RBb \rightarrow \min$, $RBa \rightarrow \max$.

The Coronacrisis also changed the existing trends in the real estate sector. In contrast to the global financial crisis of 2008–2009, the management system of the national economy did not collapse, but functioned in a strictly controlled state regime. The controlled contraction of the economy made it possible to prevent defaults and collapse of prices in the real estate sector. Whatever threats, for example, related to the closure of office and shopping centres during lockdowns did not occur, real estate prices have resisted and remained at about the same level as in the conditions of cyclical crises.

The analysis showed that during the outbreak of the pandemic, in the conditions of changing forms of activity (with the transition to remote employment) and the explosive growth of online commerce, which caused not only new construction and reconstruction of existing warehouses, but also the growth of jobs, including highly qualified ones. Thus, the logistics segment has not only expanded, but also attracted highly qualified personnel.

Thus, the revitalization of historical centres cannot be reduced to the addition, completion, extension or reconstruction of existing real estate. It implies a profound rethinking of urban functionality that requires the reconstruction of industrial buildings and an assessment of the possibility of resettlement, both in newly constructed buildings and in existing areas that are being rebuilt and adapted for housing.

With regard to historically developed cities, we note that the pandemic has only intensified the trends that have formed. In particular, the difficulties of living in city centres with heavy traffic, developed office, retail and sports and entertainment real estate. This requires the revitalization of city centres, which in turn actualizes the scientific justification of the requirements for the implementation of the processes of revitalization of urban centres and the organization of a new wave of their settlement.

Thus, in all cases, it should be taken into that in order to implement structural maneuvers to meet the needs of the population, a system of state support measures is needed that can support demand, switch to an industrial construction basis, lay the infrastructure foundation of a comfortable suburban environment. Otherwise, this type of migration may become an insignificant factor in the implementation of structural maneuvers aimed at revitalizing the centres of historically established cities.

So, based on the study of the response of the urban real estate sphere to changes in structural factors characterizing the influence of the urban population on the dynamics of the development of various types of real estate, we formulate the basic principles of the revitalization of urban spaces of the post-Covid recovery period:

- 1) preference for socially oriented, creative, people-saving, cost-effective and environmentally safe real estate development supported at all levels of public administration;
- 2) understandability and clarity, visibility and popularization of the meanings, goals and accents of the revitalization of urban real estate in the areas of existing development;
- 3) the focus of the declared changes in the structure of urban real estate on ensuring investment attractiveness, allowing to develop and launch a programme of restructuring and new construction in the sphere of urban real estate;
- 4) equalization of comfort levels and prospective advantages (functional content, infrastructure provision, transport accessibility, etc.) of all districts of the city;
- 5) deductiveness of conceptual, strategic, scenario, programme and project approaches to the revitalization of urban space and real estate development;
- 6) consistency of revitalization programmes and projects that ensure the promising nature of creating an investment-attractive image of urban development;
- 7) openness and dialogue mode of urban real estate revitalization processes implemented using information and communication technologies;
- 8) resource competitiveness, investment attractiveness and stimulating nature of the launched revitalization processes.

The specified requirements formulated by the author systematized the features of creating an investment-attractive environment of historically developed cities.

Depending on the historical value of the reconstructed area, its preservation and the degree of destructive interference, the regime of protection of the historical environment, it is assumed to preserve the scale of development, compliance with existing building lines, limitation of number of floors, support of architectural and stylistic features of the environment, etc.

Distinctive for a major and large city is its filling density of 40 people/ha (Fig. 3).

This value of the city density indicator gives the following advantages:

- high efficiency of investments in infrastructure, low costs for

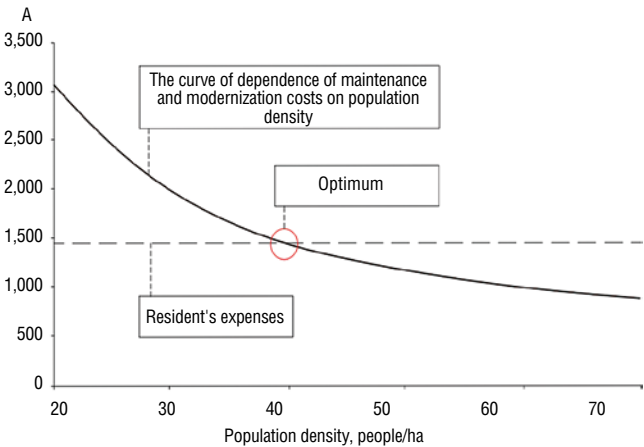


Fig. 3. City density and efficiency of spending/investment in infrastructure. Source: T. Matsumoto

its operation, renovation and new construction, especially for public utilities and transport system facilities;

- high efficiency of budget funds, including those used for the maintenance and development of infrastructure and the growth of the tax base (due to the renovation of the housing row and the regeneration of the centre);
- lower transport and logistics costs, including as a result of optimization of the urban structure;
- increasing accessibility, connectivity, attendance and passability of the urban environment;
- high manageability of the territory in terms of the need to increase administrative resources, motivation and competence of city authorities;
- creation of biospheric compatibility of urbanized territories by reducing the socio-economic damage caused by natural and economic pollution of the environment by historically industrial enterprises by transferring them to the city and reducing the intensity of use of both cargo and personal vehicles.

This creates a sustainable:

- socio-cultural development of the historically developed territory;
- economic recovery and capitalization of all elements and objects of the urban environment [11–14].

The preliminary author's research made it possible to conclude about the possibility and prospects of considering the GRS as a revitalization of the historically established territory (hereinafter, RHET) through the prism of conceptual modelling of spatial and territorial development (PTD_{ip}) with a functionally reliable separate urban planning system consisting of certain stages and subsystems of interaction with a criterion assessment of their planning by integral indicators of total costs, effects and economic reliability.

CONCLUSION

At the first stage of the study, we will perform a conceptual definition and clarification of the innovative term “spatial-territorial development for urban real estate reproduction management” (PTD_{ip}). As the analysis of the theory of development has shown, this terminology is absent in the modern scientific and practical classification. In this regard, the author proposes to introduce the following author's terminological definition of PTD_{ip}.

The spatial and territorial development of real estate revitalization (PTD_{ip}) in the GRS of the cluster territory should be understood as the professional activity of the head real estate developer and specialized developers (investors) in the sphere of urban construction and real estate management with the function of forming a corporate target alliance of business partners (business partners: construction and installation organizations, concessionaires, logistics, transport, operational enterprises and management companies), united by the process of reproduction of a single urban land and property complex for the revitalization of cluster-type real estate (investment projects) and the tasks of effective implementation of cluster objects of various types and purposes as part of an urban megaproject (IP) due to its high organizational and economic stability, maximum economic reliability of the construction of cultural and architectural heritage, historically industrial real estate transport, municipal and logistics infrastructure, etc. with the minimum total cost of their ownership.

A detailed review of scientific research methods allowed the author to establish that the functional reliability approach provides for the consideration of the object of research in the form of a set of functions (targets) that allow such research to be conducted with

a focus and effective obtaining maximum efficiency (commercial, budgetary, social). The functional model of the object under study is primary, and its structural and effective functional-reliability model is secondary (depending on the type of implemented functions).

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Методические подходы по обоснованию устойчивого развития исторически сложившегося города с использованием принципов ревитализации территорий

Задача городского развития заключается в синтезе ресурсных потоков и создании адекватных антропологических условий реализации рациональных программ и планов ревитализации городских пространств. Обращаясь к сущности методологического принципа релятивизма, состоящего в абсолютизации относительности и условности любого знания, а следовательно, ограничивающего описание объекта исследования их имманентными свойствами, наличие последних или их отсутствие обеспечивает приоритет не только целостности, системности реальности перед отдельными частями, но и развития — перед сохранением. Иначе говоря, городское развитие должно рассматриваться как управленческий функционал расширенного воспроизводства (капитализация) городских активов в его современном развитии. Применительно к городу также важно, что материальное не должно доминировать и не может рассматриваться изолированно. Именно свойство целостности городского пространства создает основу реализации преимуществ системности и приоритета целей развития.

Сохранность объектов недвижимости во времени позволяет исследовать динамично изменяющиеся параметры недвижимости и логику развития городов, отражающую смыслы городской жизнедеятельности, трансформации способов производства, вызовы и преодоления, ценности и предпочтения. Сравнительный анализ причин возникновения и факторов развития населенных пунктов в РФ и Европе показывает схожесть эволюционных трендов. В то же время исследование природных условий, специализации и особенностей менталитета населения различных стран, градостроительных традиций позволяет выявить общие черты и различия градостроительной эволюции городов.

Тесная взаимосвязь градостроительной деятельности и социально-экономического развития города имеет двойственный характер взаимодействия, определенного

историческими периодами, по сути являющимися дискретными проекциями друг друга. Доказано, что градостроительная деятельность влияет на социальную и экономическую жизнь страны в долгосрочном периоде. Проблемы сохранения баланса между возможностями и потребностями в социальном, финансовом, культурном и экологическом аспектах развития территории города приводят нас к необходимости определения вектора устойчивого развития.

Процессы перепрофилирования объектов недвижимости в исторически сложившихся городах общепринято осуществлять в рамках Концепции редевелопмента. Изменение функционала и эксплуатационных характеристик в настоящее время подчинено логике рыночной экономики, т.е. поддержке и приумножению денежных потоков на всех этапах жизненного цикла недвижимости. Этим мотивам подчинено решение о степени строительного и архитектурного вмешательства. Целевая фокусировка на решение социальных задач существенно изменяет концептуальные основы редевелопмента, придавая им социальную направленность по созданию комфортной среды жизнедеятельности. В этой связи аварийное жилье, законсервированная или заброшенная недвижимость подлежат не просто перепрофилированию, а в буквальном смысле «оживлению», т.е. воссозданию условий комфортного пребывания человека. В терминах теории устойчивого развития это означает ревитализацию пространства жизнедеятельности. По мнению автора, термин «ревитализация городского пространства» в гораздо большей степени отвечает целевой фокусировке Национальных проектов развития.

Ключевые слова: ревитализация, устойчивое городское развитие, регенерация городской среды, пространственно-территориальный девелопмент, когнитивный подход, антропологические условия реализации проектов

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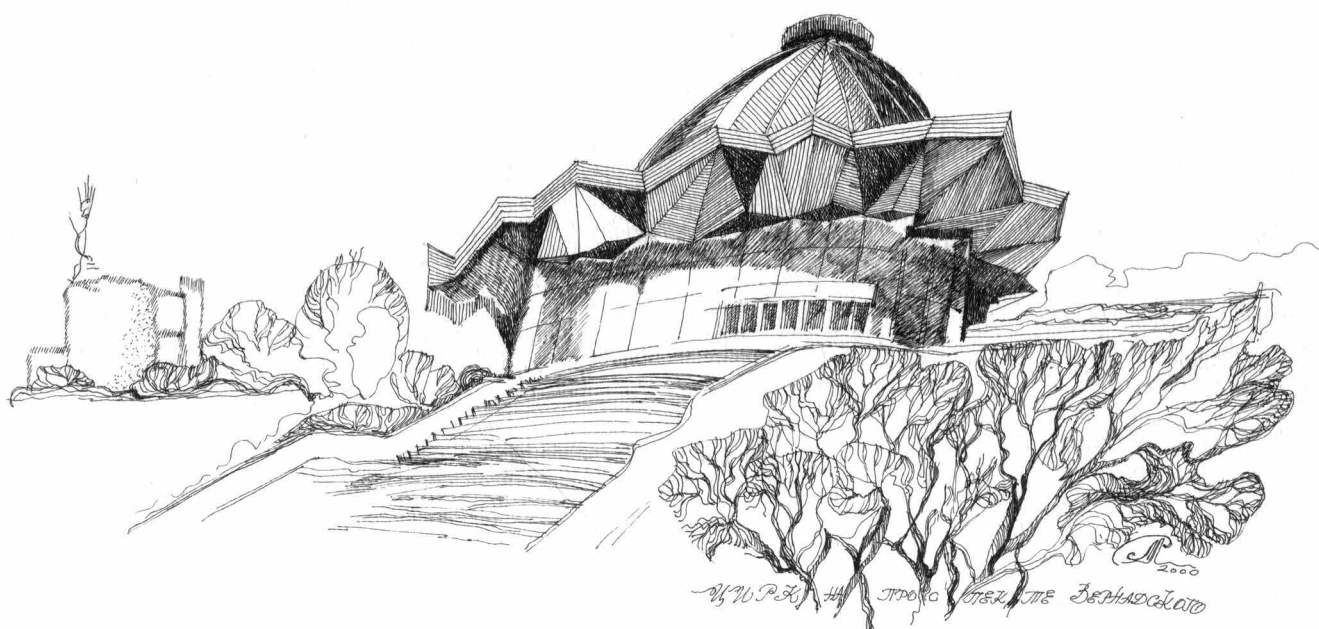
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Л.И. Павлова. Москва. Цирк на Проспекте Вернадского. Рисунок, тушь, перо

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Development of analytical tools for assessing the performance of construction organizations based on the cost management concept

The activities of construction companies are characterized by high resource and capital intensity of products. There are many standards regulating the quality of construction products and technological processes. In addition, construction is characterized by high risks, unstable cash flows, dependence on many external factors inherent in an unstable economy. To ensure sustainable development, it is necessary to have an analytical toolkit focused on the constant search for reserves and capable of systematically and comprehensively reflecting all the problems of the organization. The modern system of complex analysis of economic activity, applied methods and indicators, in general, meet the requirements. This also applies to the methods of rating assessment of companies. According to the authors, it is necessary to improve the system by applying the market capitalization indicator. It requires an annual valuation of the company. The system of business valuation methods reflected in the valuation standards and works of domestic economists requires adaptation to the specifics of construction companies. The article considers the peculiarities of construction activity from in terms of assessing the market value of the company, analyzes approaches and methods of valuation, reveals the peculiarities of application in construction.

Keywords: analytical system of construction organizations, main subsystems, directions of development, cost management concept, specifics of construction business valuation, valuation methods

INTRODUCTION

The constant complication of business environment requires new approaches to sustainable development. Correct setting of goals and their timely adjustment is necessary. The organization cannot influence many external factors, but they must be taken into account. This requires a properly organized analytical system.

The analytical toolkit for assessing the performance of organizations is constantly improving and covers almost all management subsystems. The main directions and subsystems of complex analysis of production and economic activities were formed by the scientific school of A.D. Sheremet, who first developed the theory and methodology of complex economic analysis of enterprise activity. The analytical system contains indicators that practically cover all aspects of the production and economic activity of an enterprise. In particular [1]:

- indicators of income and sales of products;
- indicators of costs and cost of sales;
- indicators of technical and organizational level and other business conditions;
- indicators of efficiency of current and non-current assets;
- indicators of financial position and solvency.

Improvement of the system of indicators continues taking into account the changing business conditions [2–4]. The system of indicators in the author's interpretation does not reflect the specifics of a particular type of business, but it has been developed in modern research and adapted to the activities of construction companies [5, 6]. The system of the above indicators is focused on current management and allows to

identify reserves, plan and implement measures to improve the efficiency of activities.

The system of rating assessment of enterprises' activities has been developed and adapted to the activities of construction organizations. The system reflects not only the interests of the organization itself, but also their environmental and social responsibility, the interests of investors, which affects the competitive position of the organization in the contract construction market. The rating system is used to evaluate the performance of construction organizations not only from the standpoint of internal, but also external factors, and allows timely identification of strategic reserves.

The third direction in the development of the analytical system is the assessment of the company's market capitalization. It does not replace, but only complements the above directions. The market value of an enterprise as an indicator can be used not only for market transactions, but also for measuring the performance of an enterprise. This approach is used in foreign management practice.

The growth of value shows how effective the management system is. The indicator reflects in an integrated way both negative and positive impact of external and internal factors, factors of direct and indirect impact, intensive and extensive factors and the ability of the management system to effectively use the opportunities and adapt to the threats of the business environment. This convinces of the need for further improvement of the toolkit for assessing the market value of an enterprise for management purposes.

The cost management concept opens new opportunities for the development of analytical tools. Company value management is focused on

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▶ the interests of shareholders in order to increase the value of the company and includes the processes of creating, managing and measuring business value¹. The system is different from management focused on profit growth. The system based on the growth of the company's market capitalization. The choice of valuation methods requires reflecting the specifics of the business and, in particular, its industry affiliation.

Increasing the value of a company means managing the factors that affect its value. These factors can be divided into internal factors, which are influenced by the organization itself; and external factors. External factors can affect the value of a business, independently of internal ones, reflect not only threats, but also new business opportunities. External factors should be forecasted and possible risks should be taken into account. There are methods of strategic analysis to identify factors and take them into account to maintain economic sustainability.

The assessment of the market value allows to take into account all factors comprehensively. Market capitalization ratio is able to supplement the system of analytical business indicators for the current management and rating of the company for participation in auctions and investment attraction. The formation of this indicator requires an annual assessment of the market value of the enterprise, selection of a reasonable valuation method that reflects the specifics of construction activities.

ANALYSIS OF MARKET VALUE METHODS

The Federal standard for Business Valuation provides for the application of cost, comparative and income approaches to determining the market value of an enterprise². The object of assessment in accordance with the requirements of the Federal Standard may be the property complex of the organization or part of it. The property complex must be identified.

Business valuation tools are given not only in the valuation standards, but also find constant development in the works of scientists [7–10]. Standard approaches and valuation methods require taking into account the specifics of construction, taking into account the peculiarities of the functioning of the construction industry itself, as well as the real estate market. With regard to the choice of valuation tools, these features appear in instability of the activities of construction companies due to a number of factors, in particular:

- long investment and construction cycle;
- demand for construction products depends on the development of the region;
- the need for a significant amount of investment;
- problems related to the allocation of land for construction;
- unstable cash flows during the investment and construction period;
- regulated requirements to the quality of construction products and construction processes;
- high requirements for the business reputation of a construction company that affect the results of tenders;
- cash flows of construction companies reflect the economic situation in general;
- limited opportunities for market diversification.

Consider the possibilities and peculiarities of application of standard approaches to evaluation of construction companies for management purposes. The cost (property) approach is focused on the calculation of net assets. In this case, assets and liabilities are taken into account not at book value, but at market value. The assessment will reflect the property status of a particular organization and the structure of its obligations.

A company that has construction machinery, equipment and other fixed assets on its balance sheet will receive a high market assessment. Otherwise, the valuation will be undervalued. At the same time, it should be taken into account that construction companies often use leased fixed assets in the production process, focusing on the economic feasibility of leasing. This has the effect of reducing costs and increasing the profitability of the company.

The net asset method can objectively reflect the property status of the company on the basis of market, rather than balance sheet indicators. In this case, the method regulated by the document "Procedure for determining the net asset value"³. The importance of calculating this indicator lies in the fact that it is controlled by the tax authorities. Net assets should not be less than the authorized capital of the company. By conducting a market valuation of assets, a company can avoid problems and timely find reserves aimed at eliminating the discrepancy.

The comparative (market) approach is based on sales information from similar companies. The market multiples thus obtained (value/profit; value/income) are taken into account when calculating the market value of the subject company. Information about the sales of companies can be closed and the income received is distorted. In addition, the market for such enterprises is not active, which makes it difficult to apply the comparative approach.

The income approach is focused on determining the value on the basis of expected future cash flows or other economic indicators. Each of the applied valuation methods has peculiarities, advantages and disadvantages. The analysis of methods allows to justify the choice of evaluation tools within the framework of the cost concept of management, to identify reserves [8].

In our opinion, when evaluating the market value for management purposes, it is advisable to take the income approach as the dominant one. The choice of a specific assessment method must be justified. The most common methods of income approach are: net profit capitalization method; discounted cash flow method; excess profit method. Each of the listed methods has features, advantages and disadvantages, the analysis of which makes it possible to justify the choice of valuation tools within the framework of the cost management concept, to identify reserves. These features are shown below (Table).

The given characteristics predetermine the choice of the evaluation method. To assess the construction business, taking into account all the features of its functioning, a high level of risk, cash flow instability, the discounted cash flow method can be used (1).

$$C = CF + CT,$$

(1)

where C — the market value of the business;
 CF — discounted cash flow of the forecast period;
 CT — terminal value of the post-forecast period.

1

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3

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Peculiarities of applying income approach methods

Income approach methods	Specifics of application
Net profit capitalization method	Method is used to evaluate a stable business. The projected profit for one year is capitalized. The valuation is based on the fact that the level of profit does not change in subsequent periods
Cash flow discount method	The method is used to evaluate businesses with unstable cash flows. The estimate is based on a forecasting cash flow for the period after which the business will reach a stable level. Other approaches to substantiate the forecasting horizon are also possible
Excess profit method	The method is used to evaluate companies with high business reputation, whose profits significantly exceed the industry averages

The method has a number of features. Features must be taken into account in order to obtain a reliable assessment. Firstly, the calculations are based on forecasts, which are difficult in construction due to the large number of risks. With a long-term forecast, the uncertainty of income and costs increases. Secondly, the final result of the assessment depends on the forecast horizon, which requires a reasonable approach to its selection. In particular, there is an approach when the forecasting horizon is taken equal to the period during which a stable level of income [7] will be provided. This is quite justified when it comes to valuation for the purposes of buying and selling a business, which at the valuation stage was characterized by instability of income. For management purposes, the forecasting horizon may be taken equal to the period of contracts concluded by the construction company for the development of residential complexes or other objects.

Thirdly, it is required to substantiate the discount rate to determine the current value of the forecast cash flow and adjust it for risk. In valuation practice, the discount rate is formed on the basis of the current risk-free rate of return on capital. This rate reflects the minimum interest that can be received from investing in risk-free assets with the maximum guarantee of receiving income. Taking the rate as stable for the entire forecast period, a significant error arises in the calculations. Adjustments to the discount rate are made taking into account the risks that have developed at the valuation date. The presence of certain risks is taken into account as a risk premium to the hypothetical buyer. The most typical practice in business valuation are risk premiums of insignificant scale of business; unsatisfactory financial structure of the enterprise; the need to diversify products in response to changing market needs; the need for additional costs to diversify the sales network and customer base; market diversification; inefficient management.

Logically, this set of risks is quite reasonable. Making reasonable cost adjustments is difficult, but necessary within the framework of the application of this method. This requires constant monitoring of the real estate market, the construction market, and assessment of one's own competitive position.

Business instability in construction requires risk identification⁴ [11]. Focusing on the results of research in risk management, we can conclude that, in relation to the activities of construction organizations, when forming the discount rate using the cumulative construction method, it is advisable to take into account the following risks:

1. Business scale risk premium if larger companies operate in the industry market and the scale of their business provides effective management of production costs.
2. Premium for the risk of the financial structure, if the capital structure has a significant share of borrowed funds. For correct

conclusions about the risk of the financial structure, one can focus on the requirements of credit institutions for borrowing enterprises.

3. The risk premium for inefficient management is taken into account if, based on the analysis of profit and profitability indicators, it is determined that these indicators are below the industry average.

The following assumptions can be used to calculate the terminal value, which will determine the choice of calculation method:

- at the end of the forecast period, cash flows will become even; the terminal value is determined by the method of capitalization of the profitability of the post-forecast period;
- at the end of the forecast period, all work under a long-term contract has been completed and the terminal cost is determined by the liquidation balance method.

The specifics of the economic conditions of construction companies allow us to conclude that it is advisable to use the second approach for management purposes.

One of the methods of the income approach is the method of capitalization of the company's net profit. The method is based on the estimation hypothesis that the profit is constant and is projected for a year (2):

$$C = \frac{NP}{CR}, \tag{2}$$

where *C* — market value of the business;
NP — net profit of the forecast year;
CR — coefficient of capitalization of net profit.

This method is suitable for valuing companies with long-term contracts that provide stable income. The problem can arise in the calculation of the capitalization ratio if there is no active market for sales of similar business or shares of companies.

The market value of an enterprise with goodwill can increase significantly. Business reputation (goodwill) as an economic category is characterized by the presence of a permanent clientele, permanent business partners, investors, competitive advantages in product quality, ensuring environmental safety of products and production processes. These items can be valued.

CONCLUSION

The cost concept is relatively new to management in general. This also applies to business activities in the construction industry. The use of standard approaches and methods for business valuation requires taking into account the specifics of construction business, peculiarities of the construction industry functioning. It is necessary to control the factors influencing the competitive positions of construction companies.

4 Tsvetkova E.A. Management of economic risks of a construction organization. URL: <https://cyberleninka.ru/article/n/upravlenie-ekonomicheskimi-riskami-stroitelnyh-organizatsiy/viewer> (rus.).

Studies show that the foundations of the analytical toolkit for the activities of construction organizations have been largely formed. Methods of analysis ensure the identification of problems, the search for reserves, the formation of development directions, and the preservation of the economic stability of organizations. The dynamics of economic activity, the growth of competition in the construction market, ever-increasing requirements for environmental and social responsibility of the construction business require improvement of the analytical system. The market capitalization ratio included in the analytical system characterizes the annual dynamics of changes in the company's market value. This allows to improve the analytical system, focusing it not only on internal management goals, but also on the interests of investors. This is possible only in case of reasonable choice and correct application of the methods of company value assessment existing in the market practice.

In assessing market value, not only the financial stability is important, but also the property condition of the organization. In order to reflect both sides of the activity, it is necessary to use both income and property (cost) approaches. It is quite expected that the market value indicators obtained by different approaches will differ. To generalize the result, it is necessary to determine the weighting coefficients of each approach in the final assessment of the business.

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Развитие аналитического инструментария оценки деятельности строительных организаций на основе стоимостной концепции управления

Деятельность строительных компаний характеризуется высокой ресурсоемкостью и капиталоемкостью строительной продукции, наличием стандартов, регламентирующих не только качество строительной продукции, но и технологических процессов. Кроме того, для строительства характерны высокие риски, нестабильные денежные потоки и зависимость от многих внешних факторов, присущих нестабильной экономике. Для обеспечения устойчивого развития необходим аналитический инструментарий, ориентированный на постоянный поиск резервов и способный системно и комплексно отражать все проблемы организации. Современная система комплексного анализа хозяйственной деятельности, применяемые методики и показатели в целом соответствуют требованиям. Это относится и к методикам рейтинговой оценки компаний. По мнению авторов, необходимо совершенствовать систему за счет применения показателя рыночной капитализации. Система методов оценки бизнеса, нашедшая отражение в стандартах оценки, трудах отечественных экономистов, требует адаптации к специфике строительных компаний. В статье рассмотрены особенности строительной деятельности с позиции оценки рыночной стоимости компании, проанализированы подходы и методы оценки, раскрыты особенности применения.

Ключевые слова: аналитическая система строительных организаций, основные подсистемы, направления развития, стоимостная концепция управления, специфика оценки строительного бизнеса, методы оценки

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Л.И. Павлова. Игналина. Деревянная церковь. Офорт

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Efficiency of construction and modernization of hotel and accommodation facilities in tourist clusters

The article proposes a comprehensive solution to the current problem of the tourism industry, the shortage of accommodation facilities in regional tourist clusters, based on the intensification of construction and modernization of hotel and accommodation facilities (HAF). Based on the existing set of types of accommodation facilities, the authors proposed a classification of collective accommodation facilities currently used in regional tourist clusters. A comprehensive list of types and forms of development of accommodation facilities in two main directions: construction of new and modernization of existing facilities is developed. The article proposes a methodical approach of three-stage formation of complex efficiency of construction and modernization of HAF, as well as a methodology for calculating the expected economic effect based on the income-cost method.

Keywords: *tourism cluster, development of regional tourism clusters, collective accommodation facilities (CAF), construction and modernization of hotel and accommodation facilities (HAF), economic and social efficiency*



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The market of collective accommodation is a basic element of tourism development. As analysis has shown, the Russian Federation has a high potential for the development of the tourism industry, however, the domestic tourism infrastructure is not sufficiently developed to realize this potential¹ [1]. Russia's tourism industry currently lacks quality hotel and accommodation facilities (HAF), as well as there is a serious problem with roads and transport [2]. It is known that tourism clusters are a multi-faceted industry, in which the problem of infrastructure development deficit is closely related to the quantity and quality of services provided and the levels of availability and training of specialists.

It is established that the main priority direction determining the effective long-term sustainable development of tourist clusters is the factor of construction and modernization of HAF².

Based on the Decree of the Government of the Russian Federation of November 18, 2020 No. 1860 On Approval of the Regulation on classification of hotels, as amended on December 26, 2022, the author proposes the following interpretation of the classification of collective accommodation facilities (Fig. 1)³.

Collective accommodation facilities (CAF) are hospitality facilities designed for the temporary accommodation of tourists and travelers, which are provided on a shared-accommodation basis. They

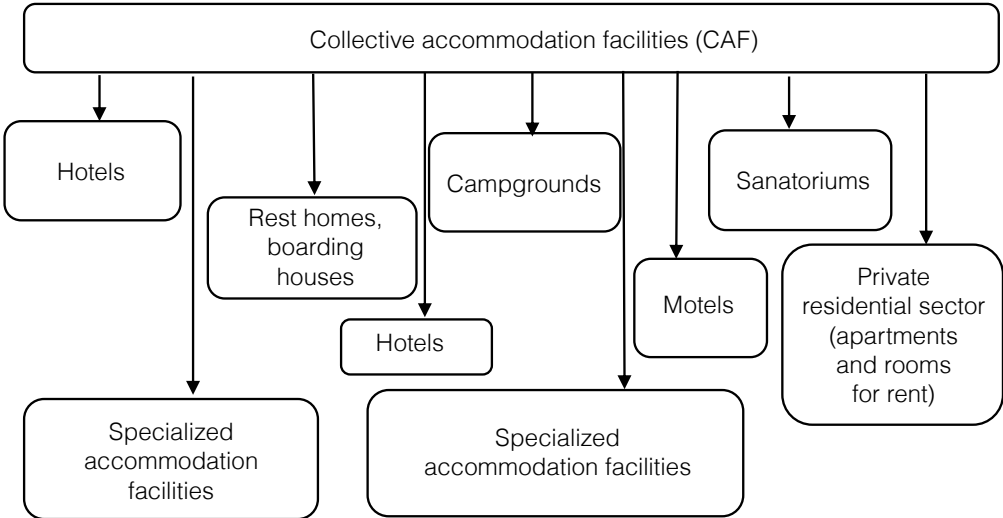


Fig. 1. Classification of accommodation facilities

1 On the Strategy for the development of tourism in the Russian Federation for the period up to 2035 : Order of the Government of the Russian Federation from September 20, 2019 No. 2129-р.

2 On approval of the Concept of the federal target program "Development of domestic and incoming tourism in the Russian Federation (2019–2025 years) : Order of the Government of the Russian Federation of 05.05.2018 No. 872-р (ed. of 07.11.2019).

3 On approval of the Regulations on the classification of hotels : Resolution of the Government of the Russian Federation of 11.18.2020 No. 1860 (ed. of 12.26.2022).

include different types of facilities and can offer different levels of comfort and services, from simple rooms with a minimal set of amenities to premium rooms with a full range of services [3]. Collective accommodation facilities are one of the paramount elements of the infrastructure of the tourism industry and play an important role in attracting tourists to various regions [4].

The development of the hotel and accommodation stock of regional tourist clusters is divided into two groups: new construction of facilities, the second group - the modernization and conversion of facilities (Fig. 2) [5, 6].

New construction of facilities is the creation of new hotels, related structures, utilities and communications in new areas or in place of demolished old buildings, or as part of the existing tourist clusters. New construction includes all stages of the life cycle of the object: design, contracting, construction of the object, commissioning.

Completion of commenced construction is the process of bringing the construction facility to the completion of all work, including interior and exterior decoration and equipment work, as well as technical equipment and preparation for operation. Completion of construction in progress may occur for a variety of reasons, such as changes in design, delays in the execution of work, technical problems, financial difficulties, etc. The purpose of the completion of the started construction is the actual complete delivery of the object to the customer, obtaining operational documentation and permits to use the building or facility [7].

Creating places of temporary seasonal accommodation is the process of creating temporary tourist accommodation facilities for the tourist season. Such facilities may range from tents and campsites, to guarded cottages and turnkey hotels that are erected as part of clusters or on a specific plot of land, often in picturesque locations, and are used to accommodate tourists for the duration of the vacation [8].

The repurposing of existing buildings into accommodation facilities is the process of changing the functional purpose of a building for its use as an accommodation facility. Such conversion can be carried out for a variety of purposes, including increasing

the profitability of the building, meeting new market needs, reducing temporary downtime, and reducing the costs of building new facilities. When repurposing a building, technical, structural, and legal constraints must be considered, as well as the economic impact of the change. As a rule, repurposing requires the reconstruction of the facility.

Reconstruction of facilities is the process of restoring and modernizing existing facilities and buildings. Reconstruction may include changes in the structure, functional purpose, appearance, as well as updating of technical systems (heating, electricity, water, etc.). The purpose of reconstruction can be improvement of living conditions, optimization of production processes, saving energy and resources, increasing the commercial attractiveness of the object, etc.

Capital repair of constructions and engineering networks is a vast complex of measures that includes replacement of outdated or damaged elements, installation of new constructions, reconstruction of objects, strengthening and reconstruction of bearing elements as well as replacement of communications and networks. Usually, major repairs are carried out taking into account the moral and physical deterioration of fixed assets to improve the functional properties of objects of the hotel and housing stock, as well as to increase their operating life.

Improving the comfort and techno-equipment of facilities are modern measures aimed at improving the living and working conditions of people in the accommodation facilities. Improving comfort can be achieved by installing new systems of heating, water supply and water disposal, air conditioning, updating and improving the furniture and interior, creating favorable conditions for recreation. Technological re-equipment includes automation and introduction of new technologies in the organization of tourist facilities, such as online reservation systems, electronic tours, etc. This helps to ensure a higher efficiency of operation, increase revenues and reduce the cost of operation of the facility, which is important in the tourism industry [9].

Routine cosmetic repair is a type of repair that is done to improve the appearance of a room or structure. It may include

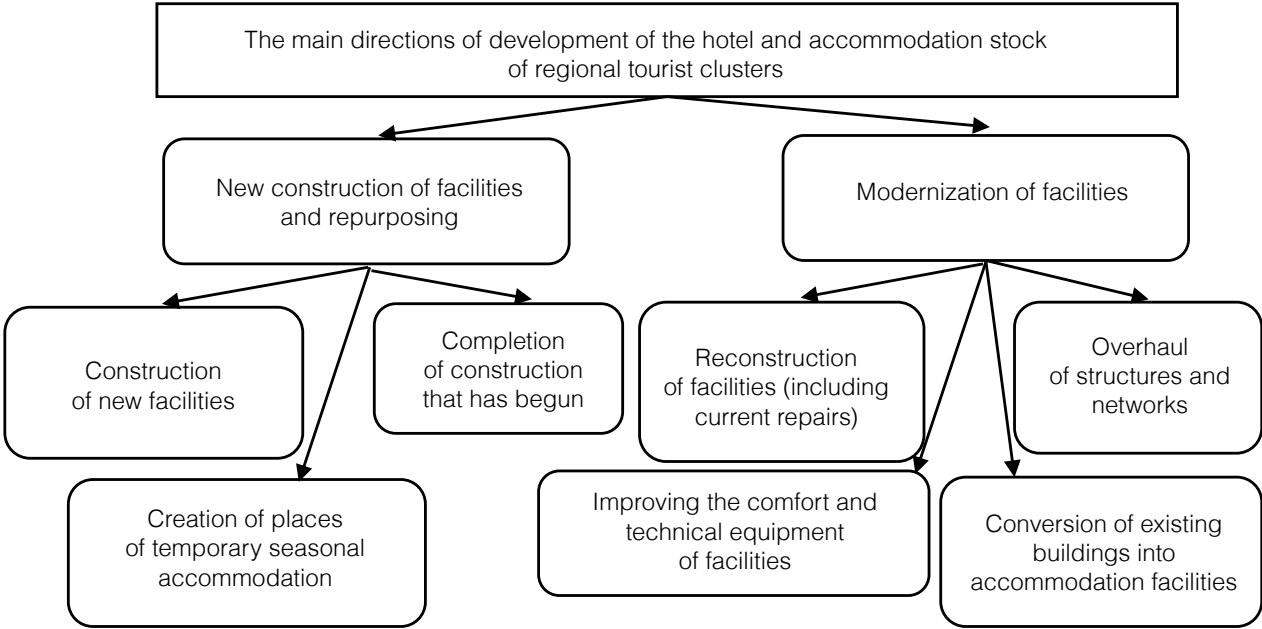


Fig. 2. Types and forms of development of tourist cluster accommodation fund

► painting or wallpapering, replacing flooring, installing new fixtures, etc. The purpose of current cosmetic repairs is to maintain the aesthetic condition of the room.

As the results of the quantitative assessment of the factors of influence and their weighting have shown, the priority area for the effective development of tourist clusters is the construction and modernization of HAF [10].

Improvement of this factor to the greatest extent is determined by the increase in tourist flows and, accordingly, the growth of sales of tourist services.

In addition, the construction of new accommodation facilities allows to equip them with the latest technologies and communications, which increases the quality and level of service, as well as improving the environmental and energy efficiency of HAF. As a result, the main goal of building new accommodation facilities in the process of creating a competitive tourist infrastructure that can attract more tourists and meet their needs for comfortable living conditions is achieved.

During the analysis, the author found that the development of tourist clusters in the aspect of new construction and modernization of accommodation facilities provides a dual effect: economic and

social. Fig. 3 presents the scheme of the process of formation of comprehensive efficiency in enhancing the reproduction of hotel and accommodation facilities (HAF).

The first stage of the scheme outlines the purpose of the process of forming the effects, the second stage sets the target performance indicators of enhanced reproduction of accommodation facilities, the third stage provides evaluation criteria in the form of economic and social indicators.

The economic and social effect of the construction and modernization of HAF as part of tourist clusters is manifested at three levels of the economy:

Micro- meso- and macro-level, i.e.: cluster, region and country. Table shows the three-level structural scheme of the expected types of economic and social effects from the implementation of the cluster development potential, developed by the author.

As can be seen from Table, the formation of economic and social effects begins at the micro level from the activities of tourism cluster enterprises, then the process continues at the city, oblast, regional level and ends at the federal level, taking into account the functioning of not only accommodation facilities, but also all

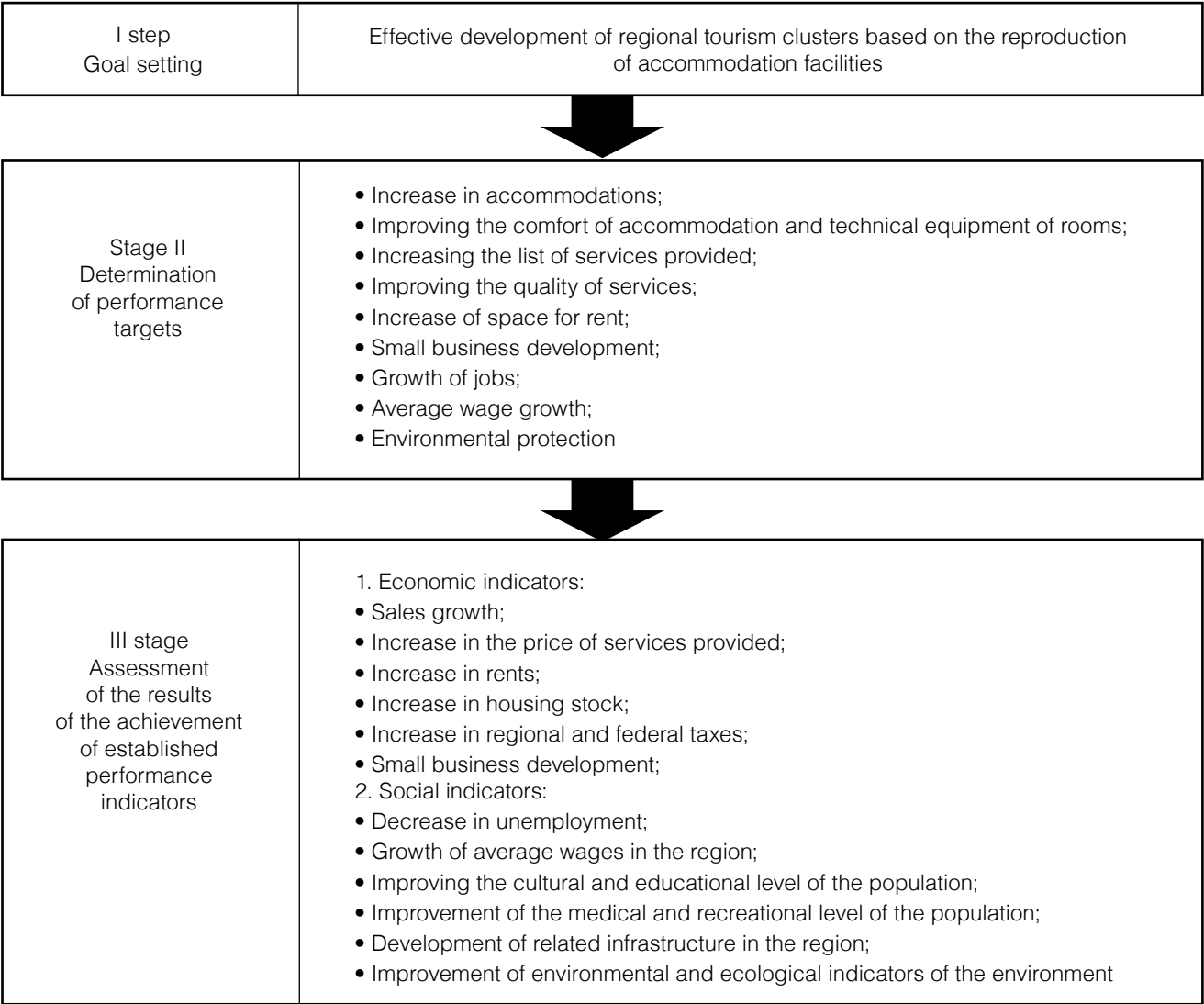


Fig. 3. The process of forming a comprehensive efficiency in improving the factor of construction and modernization of HAF

Types of economic and social effects from the construction and modernization of HAF

Levels	Economic effect	Social effect
I. Micro-level (tourist cluster)	1. Income from the operation of an accommodation facility 2. Rent for non-residential premises 3. Synergistic effect of cluster operation	1. Job growth 2. Increase in wages and salaries 3. Small business development 4. Environmental and ecological effect
II. Meso-level (region, territory, city)	1. Taxes from the operation of the OGVF 2. Taxes from small business operations 3. Rents from the regional share of the OGVF 4. Related cumulative income from the operation of regional infrastructure	1. Reduction of unemployment. 2. Growth of average wages in the region 3. Growing number of tourists 4. Increase in cultural and recreational opportunities for the population 5. Environmental protection
III. Macro-level (country)	1. Tax revenues to the federal budget 2. Increase in hotel rooms 3. Taxes to the federal budget from small and medium-sized businesses 4. Taxes from the use of federal infrastructure	1. Reduction of unemployment 2. Increase in average wages 3. Growth in the tourism industry 4. Increase in the coverage of the population by cultural, educational, therapeutic, sports and other services

small businesses, renting premises, as well as other infrastructure facilities included in the tourism cluster [11].

If the economic effect from the construction and modernization of HAF in the presence of initial data can be estimated quantitatively, the determination of the social effect in most cases is based on the expert assessment and comparison of statistical indicators for the region [12].

The paper proposes a methodology for assessing the economic effect and a methodical approach to determining the social effect.

In developing the methodology for assessing the economic effect the income-cost method was used.

The algorithm of calculations within the method is as follows:

- calculation of income from the construction and modernization of HAF as part of tourist clusters (D_o);
- classification and determination of costs (Z_o);
- accounting for the synergistic effect of cluster functioning (k_{xin});
- distribution of income among the participants in the investment process, depending on the share of participation;
- calculation of the economic effect of the cluster (E_o).

Calculation of income from the construction and commissioning of new hotels in the cluster:

$$D_{tc} = [N \cdot Z_n \cdot \rho_n \cdot k_z + Q_a \cdot Z_a \cdot \rho_n \cdot k_a] \cdot k_{xin}$$

(1)

were D_{tc} — total income from construction.rub.;

N — number of rooms commissioned, pcs.;

Z_n — average price per room.rub. pcs.;

ρ_n — rate of return (average for the cluster);

k_z — room occupancy rate (annual average);

Q_a — area to be rented out, m²;

Z_a — average rental price.rub/m²;

ρ_a — average rental profitability (annual average for the cluster);

k_a — coefficient of leased space (from the total number of Q);

k_{xin} — coefficient that takes into account the synergistic effect of cluster functioning (determined on the basis of expert evaluation).

Calculation of income from modernization of reconstruction and overhaul of existing HAF.

In this case, the income is provided by increasing the number of rooms, the price of rooms and rent for rented space. The increase in prices is explained by an increase in the level of comfort, technical upgrading of rooms, implementation of cosmetic repairs, improvement of the surrounding area, etc.

Income calculation D_m is made according to the formula:

$$D_m = [N_m \cdot Z_m \cdot \rho_m \cdot k_{z,m} + Q_{a,m} \cdot Z_{a,m} \cdot \rho_{a,m} \cdot k_{a,m}] \cdot k_{xin},$$

(2)

were N_m — number of rooms after modernization, pcs.;

Z_m — average price for the room, taking into account the increase.rub/room;

ρ_m — average rate of return;

$k_{z,m}$ — room occupancy rate after modernization;

$Q_{a,m}$ — area to be rented after the modernization, m²;

$Z_{a,m}$ — average rent.rub/m²;

$\rho_{a,m}$ — rate of return on the lease of the premises after the modernization;

$k_{a,m}$ — coefficient of the volume of leased space (in relation to the total);

k_{xin} — coefficient of synergistical effect.

If the overhaul and technical equipment were made in part of the rooms, then in (2) instead of N_m — consider ΔN_m , instead of Z_m — ΔZ_m , instead of $Q_{a,m}$ — $\Delta Q_{a,m}$ and $\Delta Z_{a,m}$ instead of $Z_{a,m}$.

3. After calculating income, it is necessary to make a classification of types of costs and propose formulas for their determination. Consider the following variants of produced costs:

- new hotel construction $Z_{o,n}$;
- modernization of facilities with redevelopment and reconstruction $Z_{o,m}$;
- overhaul of structures and engineering networks Z_{ocr} .

The total cost of new hotel construction is calculated by the formula:

$$Z_{o,n} = [Z_{ird} + Z_{pir} + Z_{smr} + Z_{ob} + Z_{ve} + Z_{blg}],$$

(3)

were Z_{ird} — cost of the initial permitting documentation;

Z_{pir} — cost of design and survey work;

Z_{smr} — cost of construction and assembly work;

Z_{ob} — costs of all types of equipment;

Z_{ve} — commissioning costs;

► Z_{blg} — cost of improving the surrounding area;
 $k_{n.k.z}$ — coefficient taking into account contingency costs, taking into account the construction of facilities in the cluster.

The costs of modernization and reconstruction of HAF are determined by the formula:

$$Z_{o,m} = [Z_{ir dm} + Z_{pirm} + (Z_{raz} + Z_{rsr} + Z_{obm} + Z_{vem}) \cdot k_{prm} + Z_{blm}] \cdot k_{nzm}, \quad (4)$$

where $Z_{ir dm}$ — cost of the initial permissive documentation for the right to work on the modernization of HAF;

Z_{pirm} — cost of design and survey work;

Z_{raz} — costs for the development of structures and engineering systems and waste removal;

Z_{obm} — cost of all types of engineering equipment;

Z_{vem} — cost of putting the facility into operation;

Z_{blm} — cost of improving the surrounding area;

k_{prm} — coefficient taking into account losses from room stock downtime for the period of repair and construction works.

Costs of capital repairs of premises and engineering systems Z_{okr} we calculate by the formula:

$$Z_{okr} = [Z_{pirkr} + Z_{bl.kr} + (Z_{rez.k.r} + Z_{rsrkr} + Z_{obkr}) \cdot k_{pr.kr}] \cdot k_{npkr}, \quad (5)$$

where Z_{pirkr} — cost of developing design and estimate documentation;

$Z_{bl.kr}$ — cost of improving the surrounding area;

$Z_{rez.k.r}$ — costs for the development of structures and utilities and waste removal;

Z_{rsrkr} — costs of repair and construction work;

Z_{obkr} — costs of repair and replacement of engineering and technical equipment;

$k_{pr.kr}$ — coefficient that takes into account the loss of income from the downtime of the room stock;

k_{npkr} — coefficient that takes into account contingencies.

The total cost is also necessary to know in order to plan the necessary amount of investment and determine the sources of their filling.

As a rule, the following main sources are used in the construction and modernization of HAF tourist clusters:

- owners' own funds;
- bank loans;
- budget funds (region, federation);
- co-investors.

During the development and signing of contracts, the distribution of the built areas in accordance with the investment shares of the participants is taken into account.

With the participation of regional and federal budgets, the relevant part of the room stock and rental space is transferred to co-investors.

4. After determining the size of the expected income D_o and the produced costs Z_o we proceed to the calculation of the economic effect:

$$E_{on} = D_{on} - Z_{on} \text{ or } E_{om} = D_{om} - Z_{om}, \quad (6)$$

where E_{on} — effect of new construction;

D_{on} — income from new construction;

Z_{on} — costs of new construction;

E_{om} — effect of modernization;

D_{om} — modernization revenues;

Z_{om} — modernization costs.

For all investors, a very important and sometimes decisive condition for investing in a new construction or modernization project is the expected payback period of the investment T_{ok} .

To this end, given the baseline value of the average profitability of the hotel stock in the region, you can determine the payback period, the invested funds or based on the results of the calculation Z_o or E_o :

$$T_{ok} = \frac{Z_o}{E_o}, \text{ years.} \quad (7)$$

In determining the social effect, the following functional relationships are proposed, at the regional level:

$$E_{soz.r} = f(Q_{ar}; N_{rk}; N_{m.b}; n_{r,m}; Y_{bz}; Y_{zp}; Y_{kp}; I_f; O_{os}), \quad (8)$$

where ΔQ_{ar} — space and room stock transferred to regional management, depending on the share of budget funding;

N_{rk} — taxes from the functioning of the tourist cluster in the regional budget;

$N_{m.b}$ — taxes of small businesses;

$\Delta n_{r,m}$ — growth in the number of jobs in the region;

ΔY_{bz} — reduction of the unemployment rate;

ΔY_{zp} — growth of average wages in the region;

Y_{kp} — increasing the cultural and educational level of the population in the region;

ΔI_f — regional infrastructure development;

O_{os} — environmental protection measures in the environment.

The implementation of investment and construction projects related to the construction and modernization of HAF should be considered appropriate at the regional level if the economic effect of their implementation at the level of the investor is accompanied by the social effect at the regional and local levels.

CONCLUSIONS

The proposals presented in this paper to assess the effectiveness of construction and modernization of hotel and accommodation facilities allow for a comprehensive assessment of investment and construction projects implemented within the framework of tourist clusters. The comprehensive approach includes different types of effects: social, economic for all participants of investment and construction activities at three levels of the economy. The availability of assessment tools allows the analysis to be carried out at the early stages of investment projects, which, in turn, ensures an increase in the quality of investment decisions made at the conceptual stage.

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Эффективность строительства и модернизации объектов гостинично-жилищного фонда в составе туристических кластеров

В статье предлагается комплексное решение актуальной проблемы туристической отрасли, дефицита мест размещения в региональных туристических кластерах на основе активизации строительства и модернизации объектов гостинично-жилищного фонда (ОГЖФ). На основе существующего множества видов объектов размещения авторами предложена классификация коллективных средств размещения, используемых в настоящее время в региональных туристических кластерах. Разработан комплексный перечень видов и форм развития объектов размещения по двум основным направлениям: строительство новых и модернизация существующих объектов. Предлагается методический подход трехэтапного формирования комплексной эффективности строительства и модернизации ОГЖФ, а также методика расчета ожидаемого экономического эффекта на основе доходно-затратного метода.

Ключевые слова: туристический кластер, развитие региональных туристических кластеров, коллективные средства размещения (КСР), строительство и модернизация объектов гостинично-жилищного фонда (ОГЖФ), экономическая и социальная эффективность

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Main approaches to the assessment of the efficiency of corporate integration of enterprises in investment and construction complex



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An important role in the framework of management activities is traditionally performed by the functional unit of efficiency assessment (in a broader sense, effectiveness), which determines approaches to both the justification of management decisions and their evaluation. Modern Russian and global practice of investment and construction activity demonstrates stable trends towards the development of various forms of corporate associations of different entities. Corporate integration can significantly contribute to improving the sustainability and efficiency of the functioning of entities, including through the synergetic effects of integration. The understanding of organizational performance in modern management is significantly expanding and is not limited only to measuring the achievement of results as part of efficiency, but becomes a more systematic and generalizing concept. Based on this, the performance of activities can be defined as a complex multiparametric characteristic reflecting the ability of an organization to achieve balanced strategic and tactical results that meet the interests and requirements of stakeholders, from the standpoint of increasing economic efficiency, improving the quality of management, creating added value, increasing the competitiveness of the organization for its sustainable development. The author's study of modern methodological approaches to determining the performance of economic systems in general and subjects of investment and construction activities in particular allowed us to identify the main approaches to assessing the effectiveness of corporate integration in the investment and construction complex, depending on the prevailing criteria principles and target vectors of efficiency formation as a component of the integral category — performance. The application of this system of approaches in the practice of solving management problems and evaluating the effectiveness of corporate structures can expand the interpretation of efficiency and contribute to the development of management tools.

Keywords: *construction companies, investment and construction complex, corporate associations, corporate structures, corporate models, efficiency, effectiveness*

Investment and construction activity is one of the foundations of the modern Russian economy. The essential importance of this type of economic activity necessitates the constant updating and improvement of scientific and methodological approaches to the effective organization of the functioning of its subjects. An important role in the framework of management activities is traditionally performed by the functional unit of evaluating the effectiveness (or efficiency, in a broader sense) of activities, which determines approaches to both substantiating management decisions and evaluating them.

Organizational and economic features of the functioning of enterprises of the investment and construction complex (ICC) include a number of factors that distinguish them from other enterprises. Here are some of the main features [1–6]:

- long life cycle of projects: the ICC is involved in the implementation of large-scale construction and infrastructure projects, which usually have a long life cycle. It may take several years or even decades from the idea and planning to the completion of the construction and operation of the project. This requires enterprises to seek long-term financing and project management for a long time;
- significant investments: the construction of large facilities requires significant investments. ICC enterprises should have access to large financial resources to finance

projects, whether it is their own funds, borrowed funds or attracted investments. In addition, they also need to be able to effectively manage and use these investments to achieve the goals of the project;

- integrated Project Management: ICC enterprises must have the skills of integrated project management, including planning, coordination, control and risk management. They should be able to manage not only construction, but also other aspects of the project, such as procurement, engineering, deadline management, budgeting, contractual relations and interaction with stakeholders;
- a complex composition of stakeholders: various stakeholders participate in the ICC, including government agencies, municipalities, investors, financial institutions, designers, contractors, suppliers and the public. ICC enterprises should be able to effectively interact and coordinate actions between all interested parties;
- compliance with legislation and regulatory requirements: in the field of construction, there is a complex specific system and standards that companies are required to follow. This includes building codes, land legislation, safety standards and other relevant regulations. ICC enterprises must have a good understanding and experience in

applying these rules to ensure compliance with the law and successful implementation of projects;

- risks and uncertainty: the investment and construction complex includes significant risks and uncertainty. These may be financial risks associated with fluctuations in the cost of construction materials and labour, changes in exchange rates and financial difficulties of investors. In addition, there are technical risks associated with the design and construction of complex engineering systems. ICC enterprises should be able to identify, analyze and manage these risks in order to minimize their impact on projects;
- seasonality and cyclicity: some branches of the investment and construction complex may be subject to seasonal and cyclical fluctuations in demand. For example, the construction of residential buildings may have seasonal peaks during certain periods of the year. ICC enterprises should be flexible and able to adapt to changes in demand, effectively manage resources and maintain stability of operations during less active periods;
- innovations and technologies: the ICC actively uses innovative technologies to increase efficiency and reduce costs in construction. This may include the use of project management information systems, unmanned systems, modular construction and other advanced methods and technologies;
- competition and tender system: in Russia there is high competition between enterprises that are fighting for the right to implement construction projects. Many projects are played out through a tender system, where companies apply for participation and compete on price, quality and deadlines. ICC enterprises should have competitiveness strategies and effective management of bids for tenders;
- procurement and supply: due to the scale and complexity of ICC projects, effective procurement and supply management plays a key role. ICC enterprises should be able to effectively interact with suppliers, conduct competitive bidding for the purchase of construction materials and equipment, control the quality of goods supplied and optimize supply costs;
- social responsibility and sustainable development: in recent years, more and more attention has been paid to social responsibility and sustainable development in the ICC. Enterprises must comply with environmental safety standards, social standards and participate in projects of social and environmental significance. This includes taking care of employees, protecting the environment and participating in social initiatives;
- international activities: many ICC enterprises are engaged in international projects and have business relations outside their country. This requires knowledge of international legislation, standards and regulations, as well as the ability to adapt to cultural differences and work in an international team.

Modern Russian and global practice of investment and construction activity demonstrates stable trends towards the development of various forms of corporate associations of various entities. Corporate integration can significantly contribute to improving the sustainability and efficiency of the functioning of entities, including through the synergetic effects of integration [7–9].

It is possible to distinguish quite a large number of types of corporate structures (corporate models), to varying degrees used in investment and construction activities, as well as alternative approaches to their typology, depending on various criteria [10–13]:

- organizational and legal classification: models can be classified in accordance with the organizational and legal forms of enterprises and their associations. This approach to classification is traditionally basic;
- size and scalability: models can be classified according to the size of the company they are intended for. For example, there may be models for small and medium-sized enterprises or for large corporations;
- functional classification: models can be classified according to the predominant functional orientation of the activities of enterprises and their associations;
- technological classification: models can be classified according to the technical and technological aspects of their implementation. For example, it can be a classification based on the technological paradigms or software used, as well as project management methodologies;
- regional classification: models can be classified according to regional characteristics or requirements. For example, there are models designed specifically for certain countries or regions that take into account local legislative and tax requirements;
- integration level: models can be classified according to the degree of integration or autonomy of individual entities within corporate associations.

Regardless of the type of corporate model of association used, the main goals that motivate the subjects to integrate and establish long-term interaction remain unchanged, the key of which is to increase efficiency. At the same time, the category of efficiency implies different approaches to its interpretation and methodological tools for evaluation and management.

Many scientists have made a significant contribution to the development of the scientific paradigm of performance management and, in particular, the effectiveness of the functioning of socio-economic systems. Among foreign scientists, the works of Peter Drucker, William Deming, Michael Porter, Robert Kaplan and David Norton, Peter Senge should be highlighted.

V.V. Vangilder, V.F. Chepurnykh, Yu.A. Bashkirov, G.I. Osipov, L.M. Glazer and other scientists made a significant contribution to the development of the scientific paradigm of managing the performance of the functioning of socio-economic systems in Russia.

In the context of the construction sector, among the Russian scientists who have contributed to the development of the scientific paradigm of performance and efficiency management, outstanding researchers should be singled out: A.V. Shvedov, A.I. Chuev, A.G. Gushchin, N.A. Palamarchuk, A.A. Brychko.

A significant contribution to the development of this topic was made by representatives of the scientific school of the Moscow State University of Civil Engineering under the leadership of Professor P.G. Grabovyy, having studied models and methods for evaluating performance in the construction sector, they also proposed indicators, indicators and evaluation systems that allow determining the effectiveness and success of construction projects, organizations and management systems [1–6].

The study of modern management approaches to ensuring and evaluating performance in relation to the organization's activities, as well as the reflection of its essence in international and national standards for management systems, allowed us to

conclude that it is necessary to consider this concept primarily from the perspective of modern theory and methodology of enterprise management and project management as an integrating platform of modern management approaches. Understanding of the performance of an organization's activities in modern management is significantly expanding and is not limited only to measuring the achievement of results as part of efficiency, but becomes more systematic and generalizing concept. Based on this, the performance of the activity was defined as a complex multiparametric characteristic reflecting the ability of the organization to achieve balanced strategic and tactical results that meet the interests and requirements of stakeholders, from the standpoint of increasing efficiency, improving the quality of management, creating added value, increasing the competitiveness of the organization for its sustainable development [14].

The author's study of modern methodological approaches to determining the effectiveness of economic systems in general and subjects of investment and construction activity in particular allowed us to identify the main approaches to assessing the effectiveness of corporate integration in the investment and construction complex, depending on the prevailing criteria principles and target vectors of efficiency formation [10, 15]:

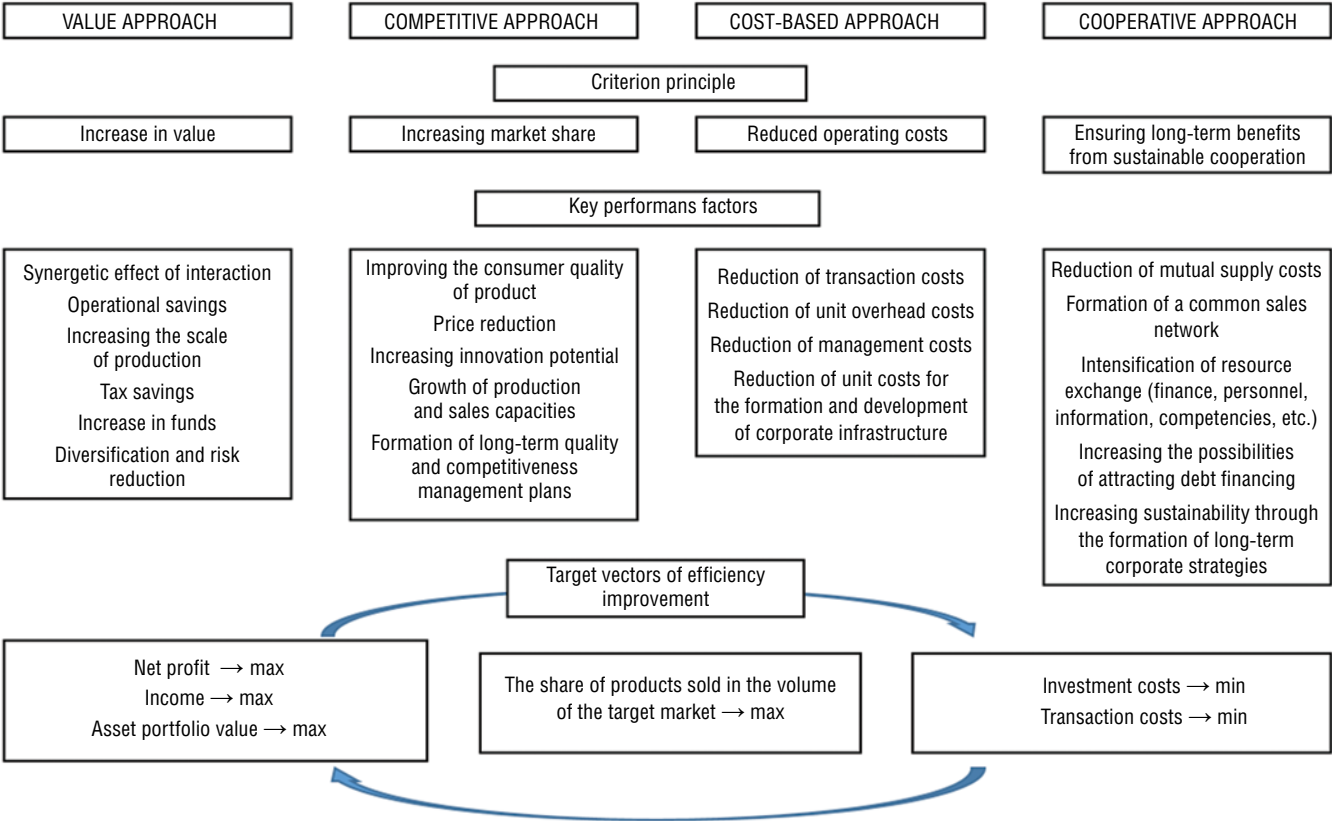
1) **Value approach.** Key efficiency factors:

- synergetic effect of interaction;
- operational savings;
- increasing the scale of production;
- tax savings;
- increase in funds;
- diversification and risk reduction;

- 2) **Competitive approach.** Key factors of efficiency:
- improvement of consumer quality of products;
 - price reduction;
 - increasing innovation potential;
 - growth of production and sales capacities;
 - formation of long-term quality and competitiveness management plans;
- 3) **Cost-based approach.** Key performance factors:
- reduction of transaction costs;
 - reduction of unit overhead costs;
 - reduction of management costs;
 - reduction of unit costs for the formation and development of corporate infrastructure;
- 4) **Cooperative approach.** Key performance factors:
- reduction of mutual supply costs;
 - formation of a common sales network;
 - intensification of resource exchange (finance, personnel, information, competencies, etc.);
 - increasing the possibilities of attracting debt financing;
 - increasing sustainability through the formation of long-term corporate strategies.

The structural decomposition of these approaches is shown in Figure.

It should be noted that these approaches to evaluating effectiveness do not exclude each other, and their separation is dictated by the necessary logic of distinguishing factors and target vectors of efficiency formation.



Content of approaches to assessing the effectiveness of corporate integration of investment and construction complex enterprises

The application of this system of approaches in the practice of solving management problems and evaluating the effectiveness of corporate structures can expand the interpretation of efficiency and contribute to the development of management tools.

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Основные подходы к оценке эффективности корпоративной интеграции предприятий инвестиционно-строительного комплекса

Важную роль в рамках управленческой деятельности традиционно выполняет функциональный блок оценки эффективности (в более широком смысле — результативности), определяющий подходы как к обоснованию управленческих решений, так и к их оценке. Современная российская и общемировая практика инвестиционно-строительной деятельности демонстрирует устойчивые тенденции к развитию разнообразных форм корпоративных объединений различных субъектов. Корпоративная интеграция в существенной мере может способствовать повышению устойчивости и эффективности функционирования субъектов, в том числе за счет синергетических эффектов интеграции. Понимание результативности деятельности организации в современном менеджменте значительно расширяется и не ограничивается только измерением достижения результата как части эффективности, а становится более системным и обобщающим понятием. Исходя из этого результативность деятельности может быть определена как комплексная многопараметрическая характеристика, отражающая способность организации достигать сбалансированных стратегических и тактических результатов, удовлетворяющих интересам и требованиям заинтересованных субъектов, с позиции повышения экономической эффективности, улучшения качества менеджмента, создания добавленной ценности, повышения конкурентоспособности организации в целях ее устойчивого развития. Проведенное автором исследование современных методологических подходов к определению результативности экономических систем в целом и субъектов инвестиционно-строительной деятельности в частности позволило выделить основные подходы к оценке эффективности корпоративной интегра-

ции в инвестиционно-строительном комплексе в зависимости от преобладающих критериальных принципов и целевых векторов формирования эффективности как составляющей интегральной категории — результативности деятельности. Применение данной системы подходов в практике решения задач управления и оценки эффективности корпоративных структур может расширять трактовку эффективности и способствовать развитию управленческого инструментария.

Ключевые слова: строительные предприятия, инвестиционно-строительный комплекс, корпоративные объединения, корпоративные структуры, корпоративные модели, эффективность, результативность

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Л.И. Павлова. Москва. Дьяковские ворота и Георгиевская колокольня в Коломенском. Рисунок, тушь, перо

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Vlasenko V.A.

Formation of sustainable competitive advantages in the development of a construction company strategy based on value innovation

The current situation, characterized in risk management as “external shocks”, leads to the need to adapt the strategy of enterprises to focus on the formation of sustainable innovative competitive advantages that create opportunities for technological breakthrough. The Russian economy still has a low level of innovation activity, high dependence on imported technologies in the most important sectors of the economy, including construction, a number of government programmes promoting innovation have not yielded the expected results. Changing this situation requires new approaches, including the identification of trends in the formation of innovative values. This task is particularly relevant for enterprises in the construction industry, designed to become a driver of economic development in accordance with industry strategic guidelines. The need to increase the competitiveness of Russian construction enterprises in conditions of economic instability and external shocks, which entails the search for possible ways to form and retain competitive advantages. The practical significance of this study lies in the argumentation of sources and methods of formation of sustainable competitive advantages, the key of which is innovation, from the position of value-oriented approach. The application of value innovation, as a source of sustainable competitive advantages has led to the growth of the main indicators of enterprise development. The article presents a methodological toolkit, which consists of the procedure and strategy for the formation of value innovation, as well as the scheme of “six ways” of value innovation, forming sustainable competitive advantages in the development of the strategy of the construction enterprise based on value innovation, implemented on the example of a large infrastructure construction enterprise JSC “RZDstroy”.

Keywords: *strategy, construction company, value innovation, efficiency, competitive advantage*

The relevance of the topic of the article is due to the need to increase the competitiveness of Russian construction enterprises in conditions of economic instability and external shocks, which entails the search for possible ways to form and retain competitive advantages. Moreover, we agree with the opinion of researchers [1–3] about the need to form and develop sustainable competitive advantages in modern conditions, that is, innovations of all types that allow not only to maintain the volume of construction and commissioning of facilities at the existing level in the conditions of shortage of construction materials and equipment, severe sanctions pressure, changes in the principles of globalization of the world economic economy, but also to achieve growth in volume along with a breakthrough in the direction of technological sovereignty of the industry, which should become a driver of technological development¹.

The concept of sustainable competitive advantages postulates their duration and uniqueness, the difficulty of copying, and most importantly, the ability to ensure the strategic orientation of competitiveness in the conditions of transformation of the external and internal environment [4, 5]. The essential component of sustainable competitive advantages is seen in the possibility of accelerated adaptation of the enterprise to changing

environmental conditions based on the innovative ability to create new value for stakeholders. At the same time, the practical significance of this study lies in the argumentation of the sources and methods of forming sustainable competitive advantages, the key of which is innovation, from the standpoint of a value-oriented approach.

The value creation implemented in modern business modelling concepts (A. Osterwalder's business model, “blue ocean” concept, value chain, and so on) proceeds from the creation of a certain need and means to satisfy it in the consumer [6–9]. The long-term period of foresight forecasting, along with existing trends and limitations of the investment and construction sphere development determined by external shocks, leads to the need for value innovation, that is, a qualitative leap in the dynamics of product value for the consumer (both final and intermediate construction products) and the producer. Value innovation comes from the reorientation of the economic thinking of the enterprise from competition-based to the prospects of discovery or creation of new demand. Foresight, presenting, on the one hand, a vision of the goals of innovative development [2], on the other hand, creates the need and the corresponding value innovation within the framework of long-term strategic planning.



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¹ Strategy of innovative development of the construction industry of the Russian Federation for the period up to 2030. URL: https://view.officeapps.live.com/op/view.aspx?src=http://www.minstroyrf.ru/upload/iblock/906/2_finalnaya-versiya-proekta-strategii_irso_28_06_206-s-dopolneniem.docx

Integrating the foresight methodology with the concept of value innovation and the principles of P2M project management², the procedure of value innovation formation in construction is formulated (Fig. 1).

The result of creating value innovation is not just an increase in the volume of innovative products due to the demand for innovative value, but also an increase in the volume of construction products certified according to various criteria ("green" certification, attribution of the project to sustainable development projects, creation of new markets, and so on).

The proposed procedure was tested on the example of JSC "RZDstroy". When developing the Development Strategy of JSC "RZDstroy" until 2018³, the proposed procedure was already used in planning the implementation of innovative projects, however, a problem-oriented approach was used as a starting point for value innovation by searching for "bottlenecks", technical and technological directions of railway construction development (Fig. 2) [10, 11].

Currently, there is a change in the innovation strategy in the direction of reorientation to import substitution technologies and the creation of appropriate Russian technologies, as well as the production of innovative building materials and structures in Russia. This will make it possible to obtain a final product that meets or exceeds foreign analogues in terms of its characteristics, while realizing the effect due to cost savings, as well as reducing the risks of dependence on imports in the unstable geopolitical situation and economic sanctions.

Let's consider the scheme of "six ways" [3, 12] for JSC "RZDstroy" in two time horizons: 2013 (as an empirical confirmation of the reliability of the proposed toolkit) and 2021 (Fig. 3).

The strategic outline of the railway construction industry is as follows (Fig. 4).

Analyzing the strategic outline and strategic profile, we consider it appropriate to implement as an innovation the value of construction and installation works using innovative technologies of the ballastless

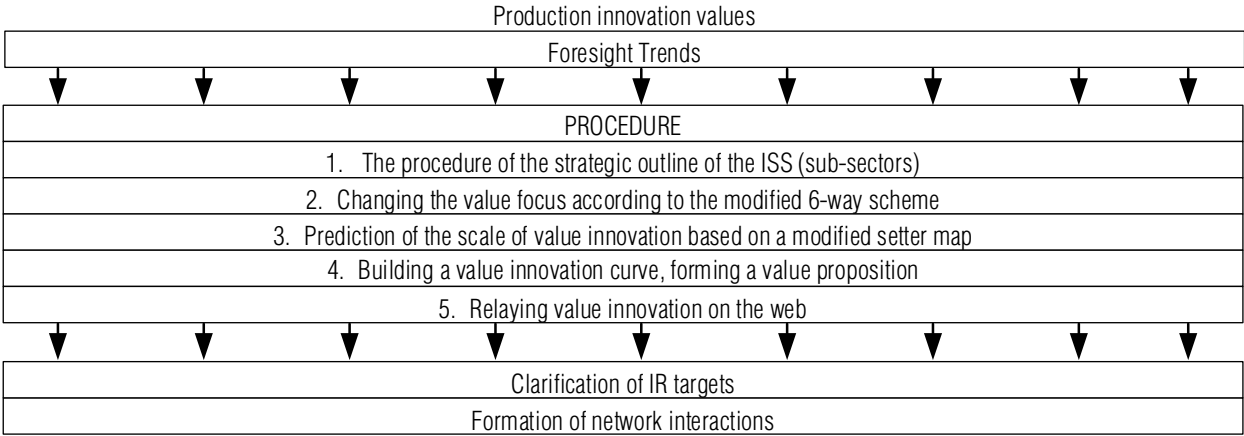


Fig. 1. The procedure of value innovation formation in construction

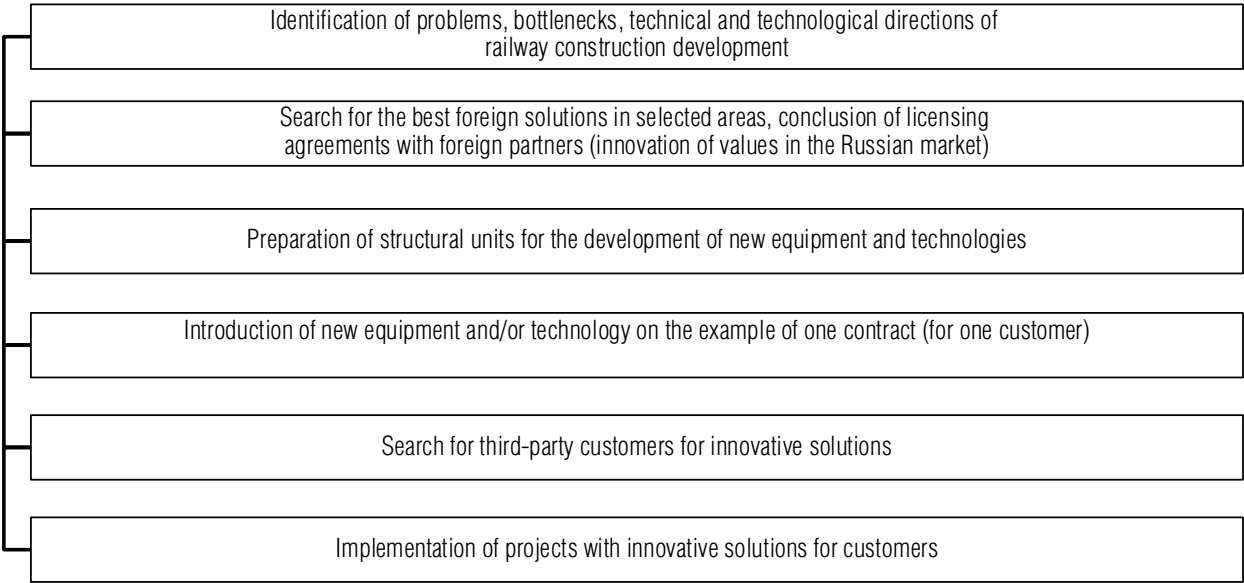


Fig. 2. The procedure of value innovation formation in the Development Strategy of JSC "RZDstroy" until 2018

2 Innovations, startups and inventions. The guidebook for project and program management for enterprise innovation. URL: <https://viafuture.ru/sozdanie-startapa/standart-p2m>
3 Development strategies of JSC "RZDstroy" until 2018. URL: <https://www.rzdstroy.ru/docs/>

Indicator	Traditional industry competition	Value Innovation
Branch	Construction of railway production of building structures	Construction of metro tunnels and railways with BSVP
		Construction of the HSR
		LVT production
		Production of BSVP VSM
Group of buyers	JSC "Russian Railways"	JSC "Russian Railways", other customers
		Private investors of HSM
Product offer volume	Maximum value for JSC "Russian Railways"	Maximum values for JSC "Russian Railways" and private investors
		Maximum values for the State Unitary Enterprise "Moscow Metro"
		Maximum values for railway users
Functional and emotional orientation	Price-quality ratio in the framework of railway construction	Maximum quality of work
		Speed of movement
Time	Adaptation to external trends	Formation of the railway construction trend
–2013		–2020

Fig. 3. Diagram of the “six ways” of innovation values of JSC “RZDstroy”

structure of the upper track, including the use of a seamless ballastless track structure using LVT (Low Vibration Track) technology of Sonneville AG. Accordingly, in 2013, a value innovation for the company was the introduction and application of LVT technology. Further, on the basis of foresight and the application of the four-action matrix,

a value innovation in the area of production of innovative materials and structures was developed — the design of the upper track slab was developed and tested, as well as the organization of production and laying of the slabs was ensured. In 2019, pilot production of track structural elements — VSP rail slabs was launched. The ballastless

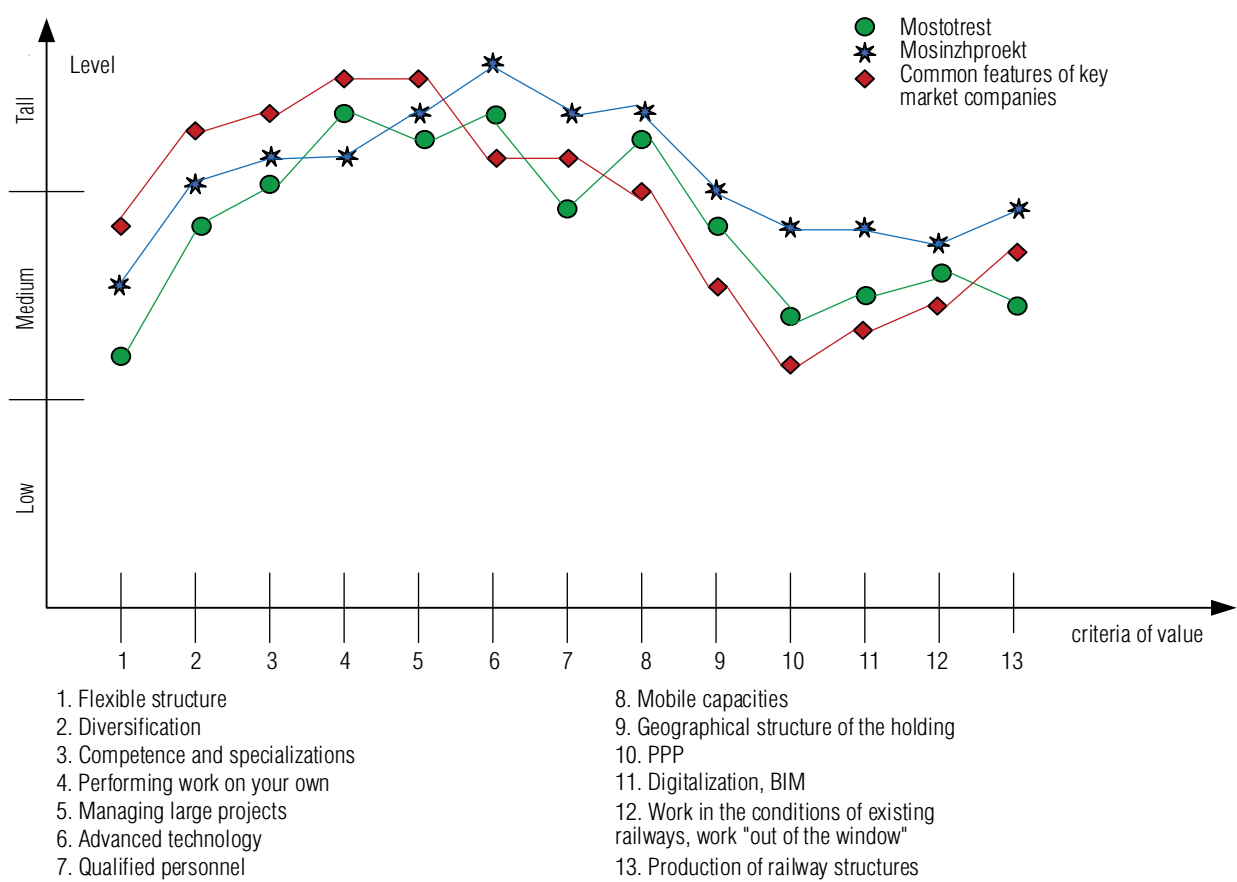


Fig. 4. Strategic outline of the railway construction industry

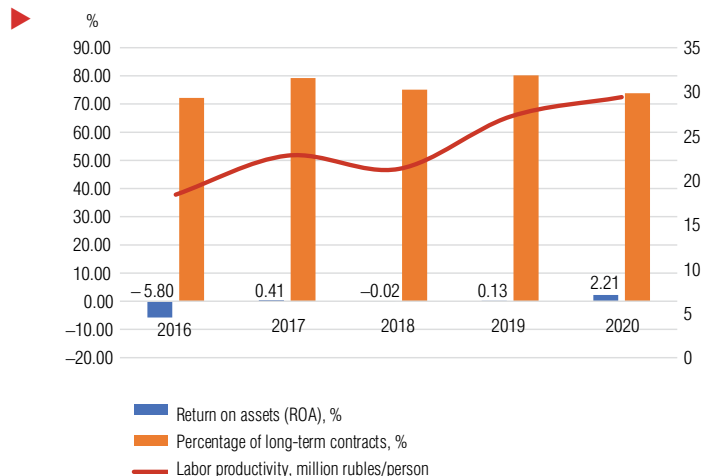


Fig. 5. Analysis of the results of the activities of JSC "RZDstroy" with the use of sustainable competitive advantages based on value innovation

track structure developed by JSC "RZDstroy" is in line with global analogues (China, South Korea, Germany) in terms of its characteristics.

Based on the results of the foresight in 2021, taking into account the forecast of the emergence and development of a new segment — the construction of high-speed railway lines, for the VSP technology, as a result of the application of the four-action matrix, another innovation of the value of JSC "RZDstroy" was developed — the production of innovative VSP.

The use of value innovation as a source of sustainable competitive advantage led to the growth of the main indicators of the company's performance (Fig. 5).

This strategic step of the company showed the effectiveness of the proposed procedure of value innovation in construction as the formation of a sustainable competitive advantage when tested in the practice of JSC "RZDstroy" in the framework of the Development Strategy of JSC "RZDstroy" until 2018 and the Strategy of JSC "RZDstroy" until 2030.

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Формирование устойчивых конкурентных преимуществ при разработке стратегии строительного предприятия на основе инновации ценности

Современная ситуация, характеризующаяся в риск-менеджменте как «внешние шоки», приводит к необходимости адаптации стратегии предприятий в фокусировке формирования устойчивых инновационных конкурентных преимуществ, создающих возможность для технологического рывка. В российской экономике до настоящего времени низок уровень инновационной активности, высока зависимость от импорта технологий в важнейших отраслях экономики, в том числе в строительстве; ряд государственных программ, способствующих стимулированию инноваций, не дал ожидаемых результатов. Изменение этой ситуации требует новых подходов, в том числе выявления тенденций формирования инновационных ценностей. Особенную актуальность данная задача имеет для предприятий строительной отрасли, призванной стать драйвером экономического развития в соответствии с отраслевыми

ми стратегическими ориентирами. Необходимо повышать конкурентоспособность российских строительных предприятий в условиях экономической нестабильности и внешних шоков, что влечет за собой поиск возможных путей формирования и удержания конкурентных преимуществ. Практическая значимость данного исследования заключается в аргументации источников и методов формирования устойчивых конкурентных преимуществ, ключевыми из которых являются инновации с позиции ценностно-ориентированного подхода. Применение инноваций ценности в качестве источника устойчивых конкурентных преимуществ привело к росту основных показателей развития предприятия. В статье дан методический инструментарий, который состоит из процедуры и стратегии формирования инновации ценности, а также схемы «шести путей» инновации ценности, формирующие устойчивые конкурентные преимущества при разработке стратегии строительного предприятия на основе инновации ценности, реализованные на примере крупного предприятия инфраструктурного строительства АО «РЖДстрой».

Ключевые слова: стратегия, строительное предприятие, инновация ценности, эффективность, конкурентное преимущество

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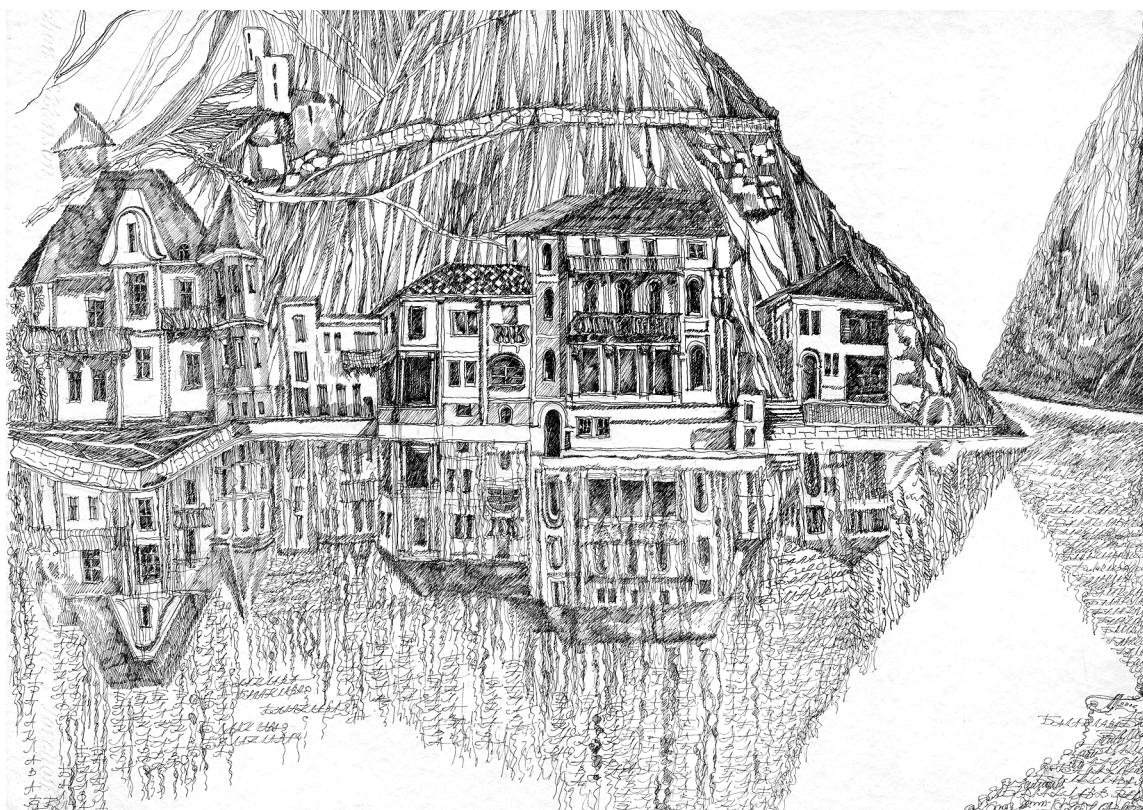
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Л.И. Павлова. Балаклава. Рисунок, тушь, перо

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Sustainability of enterprises in the corporate structure of the construction group: content and determining factors

The development of construction complexes in modern economic conditions is conditioned by the significant impact of negative environmental factors due to geopolitical and macroeconomic crisis phenomena. There is a need to develop approaches to strategic management of construction enterprises and their associations in order to improve sustainability and competitiveness in domestic and foreign markets. The specifics of the development of modern of the investment and construction complex (ICC) enterprises lies in the complexity of the approach to the creation of finished construction products, consisting in the complication of production and economic relations between enterprises, the increase in the number of participants in production processes in construction, the development of mechanisms of corporate associations of individual ICC entities. As an object of strategic management within the framework of the ICC, it is reasonable to consider construction groups as a key form of corporate intra-industry interaction of enterprises of various specializations, which allows to realize to the greatest extent the possibilities of implementing flexible organizational modelling mechanisms both at the level of the construction group and within the functioning of its individual participants. The solution of the tasks of strategic management of the construction group should be implemented when the conditions for maximizing the level of strategic development are met, while ensuring a sufficient level of general stability of the construction group. The key aspect of developing an approach to the formation and development of strategic management approaches is the definition of the factor space that affects the functioning of the managed system as a whole and, as a consequence, the level of its organizational and economic stability. The results of the study allowed the author to form the structure of the general stability of the construction group with an indication of the relationship of individual elements of stability and key factors-indicators of stability at each level of management of the company. The presented structural model of the general stability of the construction group contributes to the development of methodological tools in the implementation of a systematic approach to the strategic management of construction groups and enterprises operating in their composition.

Keywords: *construction enterprises, construction groups, sustainability, factor space, management structures, corporate management*

The development of construction complexes in modern economic conditions is conditioned by the significant influence of negative environmental factors due to geopolitical and macroeconomic crisis phenomena. There is a need to increase the adaptability of construction enterprises and their associations in order to increase stability and competitiveness in domestic and foreign markets [1].

The specifics of the development of modern ICC enterprises lies in the complexity of the approach to the creation of finished construction products, consisting in the complication of production and economic relations between enterprises, the increase in the number of participants in production processes in construction, the development of mechanisms of corporate associations of individual ICC entities [2].

As an object of strategic management within the framework of the ICC, it is advisable to consider construction groups as a key form of corporate intra-industry interaction of enterprises of various specializations, which allows to realize to the greatest extent the possibilities of introducing flexible organizational modelling mechanisms both at the level of the construction group and within the framework of the functioning of its individual participants [3].

A construction group is the most common form of corporate association of ICC entities. A construction group may include contractors, design organizations, engineering and consulting companies, as well as companies specializing in the procurement and supply of construction materials and equipment and other functions [4, 5]. The group may include companies specializing in certain stages of construction, for example, design, construction, procurement, project management, etc. At the same time, the key element of the organizational structure of the construction group, as a rule, is the management link – organizations that perform the roles of customers-developers and management functions in relation to the entire system of the construction group¹ [6].

The formation of construction groups can occur on various grounds:

- specialization by type of work. A group can be formed from companies specializing in certain types of work, for example, design, construction, installation, supply, etc. This allows to ensure a high level of specialization of each participating company;
- geographical localization. A group can be formed from companies located in the same

¹ Artamonova I., Hrustalev B., Grabovy P. The main variants of regional construction complex development on the basis of increasing enterprise flexibility. *IOP Conference Series: Materials Science and Engineering*. 2019. URL: <https://iopscience.iop.org/article/10.1088/1757-899X/471/10/102002> (accessed: 07.16.2023).

region or nearby area. This facilitates interaction between group members and allows to quickly respond to changes in the external environment;

- technological solutions. A group can be formed from enterprises using the same technologies and methods of construction. This allows to reduce the cost of training and training of personnel and increase work efficiency;
- financial decisions. A group can be formed on the basis of financial mechanisms, for example, by creating special funds to finance construction;
- partnership. A group can be formed on the basis of an established partnership between enterprises that have successful experience in joint implementation of investment and construction projects. This allows to achieve deeper interaction and a high level of trust between the group members.

At the same time, the solution of the tasks of strategic management of the construction group should be implemented under the conditions of maximizing the level of strategic development while ensuring a sufficient level of general stability of the construction group [7].

Organizational and economic stability of construction enterprises refers to their ability to function successfully and overcome the negative effects of external and internal factors that may affect their activities and financial situation. This sustainability depends on many factors, including financial condition, management, marketing, strategic planning, personnel policy and other aspects [8].

Important aspects of organizational and economic sustainability of construction enterprises are:

- financial stability: this is the relationship between equity and debt capital, the ability of a construction company to service its obligations and maintain a stable financial position in the long term;
- risk management: construction companies should actively analyze and manage risks related to market conditions, legislation, technical difficulties and other uncertainties in order to minimize potential losses;
- risk diversification: focusing on one type of construction project or market can increase the level of risk. For sustainability, we should strive to diversify orders, customers and markets;
- effective project management: high-quality planning, cost estimation and effective project management help to avoid cost overruns, deadlines and problems with the quality of work;
- qualified personnel: the presence of highly qualified

employees contributes to more efficient operation of the enterprise, improves the quality of construction and reduces the risk of errors.

The key aspect of developing an approach to the formation and development of strategic management approaches is the definition of the factor space that affects the functioning of the managed system as a whole and, as a consequence, the level of its organizational and economic stability [9].

Factor space in general is an area within which a set of factors that determine the state of a system or object is formed.

Due to the assessment of the factor space, it is possible to maximize the efficiency of decision-making, as well as to predict possible scenarios for the functioning of the object under the influence of these factors.

In the process of constructing the factor space, it is advisable to identify the factors of the external environment and the factors of the internal environment that have the most significant impact on the processes under study. It should be clarified that in the conditions prevailing in the construction sector, it is impossible to clearly divide the factors into external and internal, because the internal factors of some elements of the control object will act as external to other elements and vice versa. As a result, a closed chain of the relationship of factors is created.

The influence of environmental factors may have the following effects:

- significant, significantly changing the object of influence;
- insignificant, slightly changing the object of influence;
- weak, practically not affecting the object of influence.

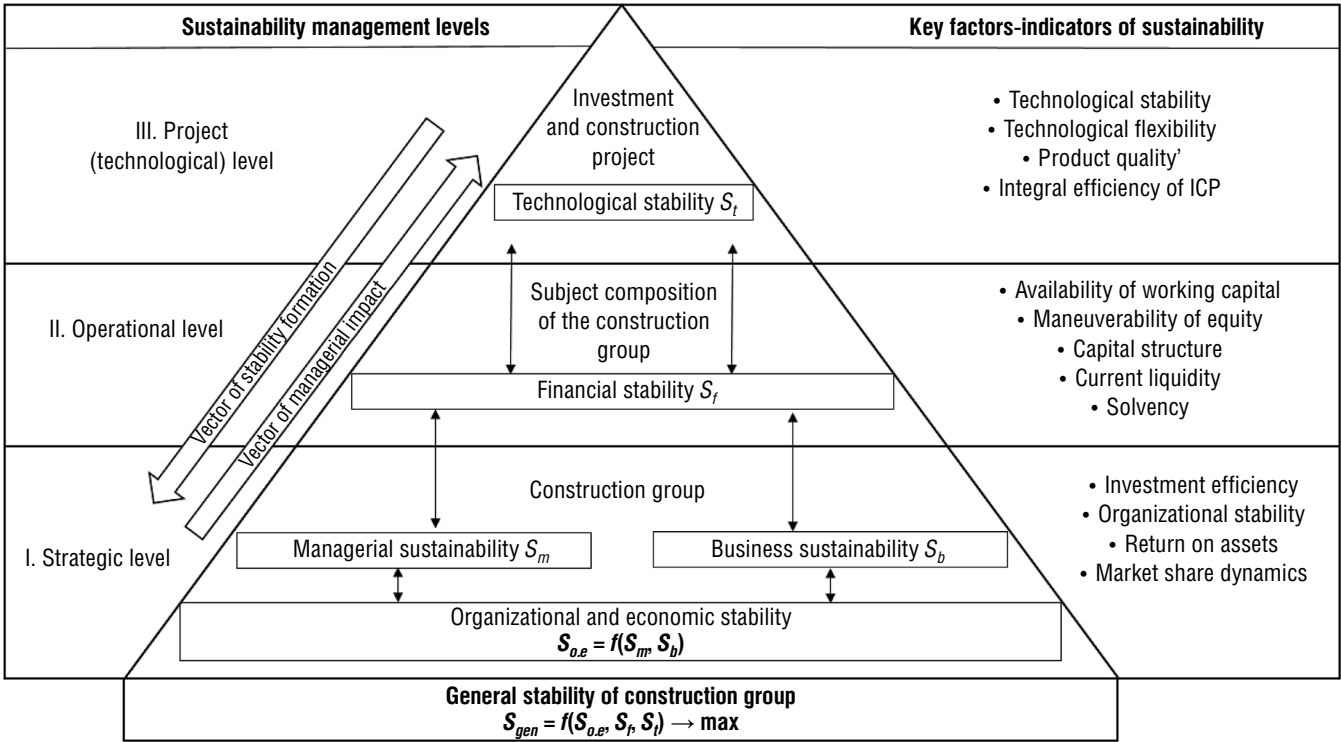
Nevertheless, factors that have a weak impact can form chains of consequences that indirectly have a significant impact on the object under study. In this regard, when studying the factor space, the entire chain of interaction should be taken into account [10].

Table presents the main groups of factors influencing the strategic management and organizational and economic stability of construction enterprises and their corporate associations.

The factor space affecting organizational and economic stability, taking into account the industry aspect, is characterized by the peculiarities of the components of the production process in the implementation of investment and construction projects by ICC enterprises. These production processes affect the efficiency of the enterprises of the construction complex at various stages of the life cycle of the production of a construction object and should be associated with it [11].

Groups of factors affecting strategic management and organizational and economic stability of construction enterprises and their corporate associations

Groups of factors	Characteristic
Microenvironment factors (enterprise and association level)	Structure, size of the construction company's business, its financial indicators, availability of liquid assets and current liabilities, efficiency of organization and management, production potential, logistics, geography of business supplies, innovation potential
Meso-environment factors (regional or industry level)	Trends in the development of the industry in which the company operates, prospects for market expansion, including at the national and regional levels. Interaction with suppliers, contractors and partners. Social capital of the region
Macro-environment factors (federal level)	Investment and innovation potential of the region. Financial and economic policy in the construction sector. Current legislation. The political situation in the country. Fiscal and economic policy of the state



Hierarchical structure of the general stability of the construction group

In addition, for the construction of the factor space, as well as its evaluation, one should proceed from the prerequisites listed below:

- depending on certain limitations and factors of the external environment and the internal environment, certain organizational and economic situations arise, in one of which the enterprise may be located;
- a set of factors influencing the activities of a construction company should be formed for both the external and internal environment;
- when constructing a set of factors, it is necessary to consider various options for such a construction and take into account the interests and needs of participants in the construction industry as a whole [12].

The results of the study allowed the author to form the structure of the general stability of the construction group, which includes 3 main hierarchical levels of sustainability management:

- 1) strategic level;
- 2) operational level;
- 3) project (technological) level.

The hierarchical structure of the general sustainability of the construction group with an indication of the relationship of individual elements of sustainability and key factors-indicators of sustainability at each management level is shown in Figure.

Modern theories of sustainability management of organizations, including construction companies, focus on an integrated approach to ensuring stability and sustainable development [13, 14]. These theories take into account the interrelationships between various aspects of management and strive to create more flexible and adaptive organizations that can effectively respond to changes in the external environment and internal conditions:

- adaptive management theory: the basic principle of this theory is that the organization should be able to adapt quickly to changing market conditions and requirements. This is

achieved by creating flexible structures, training staff for rapid adaptation and constant monitoring of external and internal changes;

- theory of sustainable development: this theory implies that organizations should strive to meet their needs and goals without compromising the ability of future generations to meet their needs. It includes economic, social and environmental sustainability;
- resilience theory: resilience means the ability of an organization not only to cope with crises and stressful situations, but also to revive and strengthen as a result of these challenges. The main elements include the ability to recover quickly after a crisis, learning from experience and the ability to identify and use new opportunities.

The presented structural model of the general stability of the construction group corresponds to the most relevant methodological approaches to the strategic management of economic systems and contributes to the development of methodological tools in the implementation of a systematic approach to the strategic management of construction groups and enterprises operating in their composition.

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Устойчивость предприятий в корпоративной структуре строительной группы: содержание и определяющие факторы

Развитие строительных комплексов в современных экономических условиях обусловлено существенным влиянием негативных факторов внешней среды вследствие геополитических и макроэкономических кризисных явлений. Возникает необходимость в развитии подходов к стратегическому управлению строительными предприятиями и их объединениями с целью повышения устойчивости и конкурентоспособности на внутренних и внешних рынках. Специфика развития современных предприятий инвестиционно-строительного комплекса (ИСК) заключается в комплексности подхода к созданию готовой строительной продукции, заключающегося в усложнении производственно-хозяйственных связей между предприятиями, увеличении числа участников производственных процессов в строительстве, развитии механизмов корпоративных объединений отдельных субъектов ИСК. В качестве объекта стратегического управления в рамках ИСК целесообразно рассматривать строительные группы как ключевую форму корпоративного внутриотраслевого взаимодействия предприятий различной специализации, позволяющую в наибольшей степени реализовать возможности внедрения механизмов гибкого организационного моделирования как на уровне строительной группы, так и в рамках функционирования отдельных ее участников. Решение задач стратегического управления строительной группой должно реализовываться при выполнении условий максимизации уровня стратегического развития при обеспечении достаточного уровня генеральной устойчивости строительной группы. Ключевым аспектом разработки подхода к формированию и развитию подходов стратегического управления является определение факторного пространства, оказывающего влияние на процессы функционирования управляемой системы в целом и, как следствие, на уровень ее организационно-экономической устойчивости. Результаты проведенного исследования позволили автору сформировать структуру генеральной устойчивости строительной группы с указанием взаимосвязи отдельных элементов устойчивости и ключевых факторов-индикаторов устойчивости на каждом уровне управления. Представленная структурная модель генеральной устойчивости строительной группы способствует развитию методического инструментария при реализации системного подхода к стра-

тегическому управлению строительными группами и предприятиями, функционирующими в их составе.

Ключевые слова: строительные предприятия, строительные группы, устойчивость, факторное пространство, структуры управления, корпоративное управление

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Calculation tools for determining the effects of digitalization of housing and utilities sector

This article discusses the digitalization of housing and utilities companies. The relevance and expediency of studying the digitalization of management companies at the present time, taking into account the definition of the effects of digitalization, was analyzed. The author proposed to calculate the economic performance indicators of the digitalization of the management company based on the calculation of transaction costs. Based on the analysis, the author gave the author's interpretation of the concept: transaction costs of the management company in the conditions of digitalization of housing and communal services. The classification of transaction costs of the management company by types was carried out, and their detailing was carried out taking into account the impact of digitalization and the types of cost savings of consumers were identified. The main indicators of savings of the management company as a result of reduction of transaction costs were determined. In addition, the author highlighted the main indicators of consumer cost savings as a result of digitalization of the management company. The author developed a calculation toolkit for determining the indicators for reducing transaction costs of the management company and consumer cost savings, which was applied in practice to calculate the efficiency of digitalization of the management company of Voronezh, LLC "Favorit". The developed calculation toolkit helps to determine not only the amount of cost savings of the management company for each selected type of transaction costs, but also the amount of total savings, taking into account the cost savings of residents. As a result of the calculations made for LLC "Favorit" according to the calculation tools developed by the author to calculate the indicators for reducing transaction costs of the management company and cost savings of residents, and allocating the main costs, it was concluded that digitalization of housing and utilities services is necessary and beneficial.

Keywords: housing and utilities sector, digitalization, "Smart Housing and Utilities", transaction costs, savings of the management company, savings of consumers, "smart" meters



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In the age of information technology, when there is a total digitalization of all spheres of life of the population, we can safely say that it is the widespread penetration of digital technologies into all spheres of the economy that determines the trajectory of the economic development of the entire country and society as a whole. However, here it is worth paying special attention to one of the most basic sectors of the economy, which has a huge impact on the standard of living of the entire population, satisfying the basic needs of people in comfortable housing, water, heat, electricity, gas, namely the housing and utilities sector.

Within the framework of the national programme "Digital Economy of the Russian Federation", the project of digitalization of the urban economy "Smart City" is being implemented, which highlights the standard "Smart Housing and Utilities"^{1, 2}.

"Smart Housing and Utilities" implies great prospects for the development of the housing and utilities sector, and despite the fact that the digitalization of the housing and utilities sector is only at the beginning of its development, we have all heard more than once that it will help make the housing and utilities sector more efficient, profitable, transparent, fair, economical [1–3].

The main economic indicators of the effectiveness of digitalization of the housing and utilities sector, for such participants as consumers and

management companies (MC), can be distinguished as follows:

- time saving;
- cost savings.

The author of this article analyzed possible options for achieving cost and time savings of the MC and consumers of housing and utility services as a result of digitalization and proposed a calculation toolkit that can be used to assess the results of digital transformation and the efficiency of "Smart Housing and Utilities".

The author proposes to calculate economic indicators of digitalization performance for the MC based on the calculation of transaction costs, which are typical for any sphere of the economy, including housing and utilities sector.

In 1937, the English economist R.G. Coase, in his article "The Nature of the firm", for the first time defined the concept of transaction costs as "the costs of using the market mechanism" [4].

Currently, there are many different disputes among scientists regarding the content of the concept of transaction costs, but there is no single approach to their quantification assessment, which contributes to the emergence of uncertainties and inaccuracies in their definition and calculations [5, 6].

Organizations can determine their transaction costs at their discretion, which makes it necessary

1 Passport of the national project "National Program "Digital Economy of the Russian Federation" (approved by the Presidium of the Presidential Council for Strategic Development and National Projects, Protocol No. 7 dated 04.06.2019). URL: <https://sudact.ru/law/pasport-natsionalnogo-proekta-natsionalnaia-programma-tsifrovaia-ekonomika> (accessed: 11.04.2023).

2 "Basic and additional requirements for smart cities (Smart City standard)" (approved by the Ministry of Construction of Russia 04.03.2019). URL: <http://www.minstroyrf.ru/upload/iblock/74f/Standart.pdf> (accessed: 11.04.2023).

► to allocate, classify and evaluate the transaction costs of the MC in order to manage them and accurately calculate.

The author of this article proposed the following interpretation of the concept: transaction costs of the MC in the conditions of digitalization of housing and utilities sector are the costs arising from solving issues related to contractual and analytical work, the functioning of the consumer interaction service and the MC on all issues (including emergencies), information collection, storage, processing and control services.

To determine the calculation tools for evaluating the results of the digitalization of the MC, the author carried out the classification of transaction costs of MC by type and their detailing, taking into account the impact of digitalization of housing and utilities sector and without, as well as the classification of consumer cost savings [7] (Table 1). In accordance with the selected classification, the toolkit for calculating the indicators for reducing transaction costs of the MC and cost savings of consumers were determined (Table 2).

Table 1. The impact of digitalization on the reduction of transaction costs of MC and cost savings of consumers (Source: compiled by the author)

Type of transaction costs of MC and consumer costs	Detailing transaction costs of the MC and consumer costs		Indicators saving of MC and consumer costs
	Before digitalization	After digitalization	
Costs of collecting information on meter readings	The costs of bypassing controllers and manual processing of meter readings, conducting analytical work	Automatic remote transmission, collection and processing of meter readings	• saving on wages ER_{zp}^{si}; • saving labour costs of engineering and technical workers E_t^{si}; • saving paper E_b^{si}; • saving consumables (stationery, shoe covers) E_r^{si}; • savings on transportation costs E_{tr}^{si}
Costs of interaction with consumers of housing and utility services	The costs of organizing reception on the appeals of owners, keeping records on appeals, receiving and registering calls from owners	Automatic remote service for receiving, registering and processing requests. Electronic remote communicative communication with consumers of housing and utility services	• saving labour costs of engineering and technical workers E_t^{vp}; • saving paper E_b^{vp}
The costs of emergencies, troubleshooting and unauthorized connections	The costs of eliminating the consequences of emergencies caused by MC (for example, flooding of neighbors), malfunctions, the costs of unscheduled repairs/replacement of communal property	Instant remote notification of accidents, malfunctions and unauthorized connections. Reducing the number of utility accidents caused by MC	• saving labour costs of engineering and technical workers E_t^a • saving damage from accidents E_o^a
The costs of accrual of receipts, accounting	The costs of conducting analytical work, manual calculation of charges for housing and utilities services. Visiting public service offices for reporting	Electronic document management, automatic generation of reports and receipts. Electronic access to public services, signing documents with a digital signature	• saving labour costs of engineering and technical workers E_t^o • savings on transportation costs E_{tr}^o
Costs of holding general meetings of owners	The costs of organizing general meetings (paper notifications, leaflets, minutes, working hours for a face-to-face meeting of owners and representatives of MC)	Electronic remote notification of the meeting and electronic voting	• saving labour costs of engineering and technical workers E_t^s; • saving paper E_b^s
The costs of consumers for payment of receipts for housing and communal services and utilities	Payment costs: for the consumption of municipal resources according to the standards; "extra lines" in receipts for housing and utilities services; additional unclaimed services	Payment for the consumption of utility resources by "smart" metering devices. Selection of necessary additional services and exclusion of "extra lines" from receipts for housing and utilities services at the electronic general meeting	• reduction of individual consumption of municipal resources R_{kr}; • exclusion of "extra lines" from receipts for housing and utilities services R_k; • reducing the cost of additional services R_D

Table 2. Calculated indicators of savings of MC and consumer costs (Source: compiled by the author)

Indicators	The formula for calculating the savings of MC and consumers	The formula for calculating the total savings
<i>Costs of collecting information about meter readings</i>		
E_{zp}^{si} — saving on wages; E_t^{si} — saving labour costs of engineering and technical workers; E_b^{si} — saving paper; E_r^{si} — saving consumables; E_{tr}^{si} — saving on transportation costs; j — number of groups of dismissed employees; ZP_j — average monthly salary of employees of the j -th group; C_j — number of dismissed employees of the j -th group; L — the number of engineering and technical employees of MC engaged in processing acts of circumvention; ZP_l — average monthly salary of engineering and technical employees of the position l ; ΔT_l — saving of working time of engineering and technical employees of the position l as a result of digitalization; K_{es} — number of personal accounts allocated for crawling; $\bar{K}_b^{ud}$ — the amount of paper spent on circumvention acts for 1 personal account; $\bar{C}_b$ — average cost of paper; $\bar{C}_k^{ud}$ — the average cost of the office allocated for one crawler controller; Ch_k — number of dismissed crawler supervisors; $\bar{K}_{es}^o$ — number of personal accounts allocated for crawling; $\bar{C}_{ba}$ — the average cost of shoe covers; Ch_k — number of dismissed crawler supervisors; $\bar{CT}_k^{ud}$ — the amount allocated for transportation costs per crawler controller	$E_{zp}^{si} = \sum_{j=1}^j C_j ZP_j$ $E_t^{si} = \sum_{l=1}^L (ZP_l - \Delta T_l ZP_l)$ $E_b^{si} = K_{es} \bar{K}_b^{ud} \bar{C}_b$ $E_r^{si} = \bar{C}_k^{ud} Ch_k + \bar{K}_{es}^o \bar{C}_{ba}$ $E_{tr}^{si} = Ch_k \bar{CT}_k^{ud}$	$ER_u^{si} = E_{zp}^{si} + E_t^{si} + E_b^{si} + E_r^{si} + E_{tr}^{si}$
<i>Costs of interaction with consumers of housing and utilities services</i>		
E_t^{vp} — saving labour costs of engineering and technical workers; E_b^{vp} — saving paper; N — the number of MC engineering and technical workers engaged in interaction with consumers of housing and communal services; ZP_n — average monthly salary of engineering and technical employees of the position N ; ΔT_n — saving of working time of engineering and technical employees of position N as a result of digitalization; $\bar{O}$ — average number of registered applications of housing and utilities services consumers in MC; $\bar{K}_{bo}^{ud}$ — the amount of paper spent on registration of registered appeals and responses; $\bar{C}_b$ — average cost of paper	$E_t^{vp} = \sum_{n=1}^N (ZP_n - \Delta T_n ZP_n)$ $E_b^{vp} = \bar{O} \bar{K}_{bo}^{ud} \bar{C}_b$	$ER_u^{vp} = E_t^{vp} + E_b^{vp}$
<i>The costs of emergencies, troubleshooting and unauthorized connections</i>		
E_t^a — saving labour costs of engineering and technical workers; E_a^a — saving damage from utility accidents; B — the number of engineering and technical workers involved in the elimination of municipal accidents; ZP_b — average monthly salary of engineering and technical employees of the position B ; ΔT_b — saving the working time of engineering and technical staff of position B as a result of digitalization; $\bar{R}_{a1}$ — the average cost of eliminating accidents caused by MC before digitalization; $\bar{R}_{a2}$ — the average cost of eliminating accidents caused by MC after digitalization	$E_t^a = \sum_{b=1}^B (ZP_b - \Delta T_b ZP_b)$ $E_a^a = \bar{R}_{a1} - \bar{R}_{a2}$	$ER_u^a = E_t^a + E_a^a$



The costs of accrual of receipts, accounting		
E_t^o — saving labour costs of engineering and technical workers; E_{tr}^o — saving on transportation costs; D — number of MC engineering and technical employees engaged in accrual of receipts and accounting; ZP_D — number of MC engineering and technical employees engaged in accrual of receipts and accounting D ; ΔT_D — saving the working time of engineering and technical staff of position D as a result of digitalization; Ch_B — number of accountants; $\overline{CT}_B^{ud}$ — the amount allocated for transportation costs per accountant	$E_t^o = \sum_{d=1}^D (ZP_D - \Delta T_D ZP_D)$ $E_{tr}^o = Ch_B \overline{CT}_B^{ud}$	$ER_u^o = E_t^o + E_{tr}^o$
Costs of holding general meetings of owners		
E_t^s — saving labour costs of engineering and technical workers; E_b^s — saving paper; V — number of MC engineering and technical employees engaged in accrual of receipts and accounting; ZP_v — average monthly salary of engineering and technical employees of the position V ; ΔT_v — saving the working time of engineering and technical staff of position V as a result of digitalization; K_{es} — number of personal accounts participating in the general meeting of owners; $\overline{K}_{bb}^{ud}$ — the amount of paper spent on ballots for 1 personal account; $\overline{K}_b^s$ — average amount of paper spent on notifications/announcements of the general meeting and minutes; $\overline{C}_b$ — average cost of paper	$E_t^s = \sum_{v=1}^V (ZP_v - \Delta T_v ZP_v)$ $E_b^s = (K_{es} \overline{K}_{bb}^{ud} + \overline{K}_b^s) \overline{C}_b$	$ER_u^s = E_t^s + E_b^s$
Total savings of all transaction costs of MC		
ER_u^{si} — costs of collecting information about meter readings; ER_u^{vp} — costs of interaction with consumers of housing and communal services; ER_u^a — the costs of emergencies, troubleshooting and unauthorized connections; ER_u^o — the costs of accrual of receipts, accounting; ER_u^s — costs of holding general meetings of owners	—	$ER_u = ER_u^{si} + ER_u^{vp} + ER_u^a + ER_u^o + ER_u^s$
Costs of consumers for payment of receipts for housing and communal services and utilities		
R_{kr} — saving individual consumption of communal resources; R_k — saving on “extra lines”; R_D — savings on additional services; $\overline{R}_{ok}^D$ — average consumption for individual consumption of utility resources per consumer of housing and communal services before digitalization; $\overline{R}_{ok}^P$ — average expenditure on individual consumption of utility resources per consumer of housing and communal services after digitalization; K — number of housing and communal services consumers; R_{j1} — expenses for the payment of “extra lines” in receipts for housing and communal services; K_{es} — number of personal accounts in an apartment building; $\overline{R}_{Du}^D$ — average expenditure on additional services per consumer of housing and communal services before digitalization; $\overline{R}_{Du}^P$ — average expenditure on additional expenses per consumer of housing and communal services after digitalization; K_{es} — number of personal accounts in an apartment building	$R_{kr} = (\overline{R}_{kr}^D - \overline{R}_{kr}^P) K$ $R_k = \sum_{j=1}^n R_{j1} K_{es}$ $R_D = (\overline{R}_{Du}^D - \overline{R}_{Du}^P) K_{es}$	$ER_p = R_{kr} + R_k + R_D$
Total cost savings of MC and consumers of housing and utilities services		
ER_u — cost savings of MC; ER_p — saving the costs of housing and utilities services consumers	—	$E(EK) = ER_u + ER_p$

According to the proposed calculation tools (Table 2), in order to determine the effects of digitalization, the author made calculations of indicators for one of the MC, LLC "Favorit" in Voronezh³.

All calculations were made for one house located at: Chelyusintsev str., house No. 140 for one month, taking into account the operation of "smart" utility metering devices. The necessary data for calculations were provided by MC LLC "Favorit", taking into account the indicators before digitalization (December 2022) and after (February 2023). Also, data on tariffs and consumption standards for water and electric energy established in Voronezh^{4, 5, 6} and calculation rules for the consumed utility resource were used to calculate consumer savings in the absence of individual meters⁷:

$$P_i = n_i \cdot N_j \cdot K_{inc} \cdot T^{kp},$$

where n_i — the number of registered consumers living in 1 residential building of an apartment building;

N_j — consumption standard;

K_{inc} — increasing coefficient (1.5);

T^{kp} — tariff⁷.

As a result of the calculations carried out by the author, the following data were obtained:
the total cost savings of MC LLC "Favorit" is

$$ER_U = 121,811.60 \text{ rub};$$

the total cost savings of housing and utility services consumers is

$$ER_p = 91,892.55 \text{ rub}.$$

Clearly, the total cost savings of MC LLC "Favorit" and consumers as a result of digitalization are shown in Fig. 1.

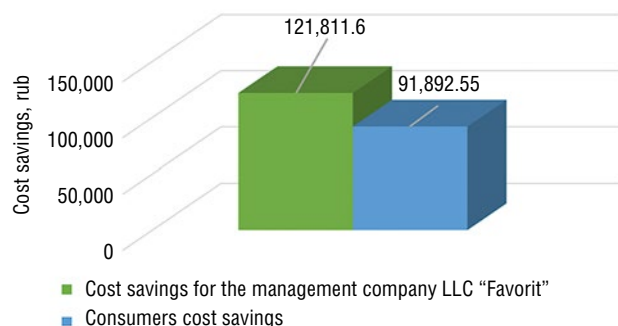


Fig. 1. Total cost savings of the LLC "Favorit" Management Company and consumers as a result of digitalization (Source: developed by the author)

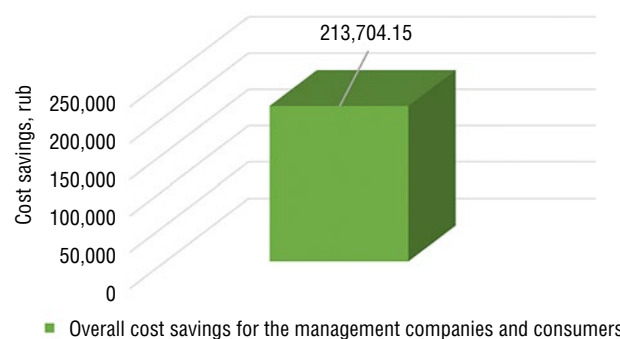


Fig. 2. Total savings as a result of digitalization of the LLC "Favorit" Management Company (Source: developed by the author)

Having determined the amount of cost savings of the LLC "Favorit" Management Company and consumers, we will calculate the total cost savings, which will be:

$$E(EK) = 121,811.60 + 91,892.55 = 213,704.15 \text{ rub}.$$

Fig. 2 shows the total savings as a result of digitalization of the LLC "Favorit" Management Company.

As a result of the calculations made, it can be concluded that the tools developed by the author for calculating indicators for reducing transaction costs of the MC and cost savings of consumers make it possible to determine the amount of money savings of the MC and consumers. Looking at Fig. 1, we can conclude that as a result of digitalization, significant savings were obtained for the MC and consumers and these data for 1 month. Accordingly, the amount of savings for 1 year will increase significantly.

In addition, it is important to pay attention to the costs of the MC and consumers for digitalization. In accordance with the Decree of the Government of the Russian Federation dated June 29, 2020 No. 950, the service provider (in this case PJSC "TNS Energo Voronezh") has established from "Smart" electricity metering devices at its own expense⁸. And consumers have installed "smart" individual metering devices for water supply at their own expense and the cost of such a device is approximately 5-7 thousand rubles (according to consumers), respectively, the amount of savings is much higher than the costs. Which suggests that digitalization of housing and communal services is actually beneficial for the MC and consumers and gives us the opportunity to live more comfortably using "smart" technologies.

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Расчетный инструментарий для определения эффектов цифровизации ЖКХ

В данной статье была проанализирована актуальность и целесообразность изучения цифровизации управляющих компаний в настоящее время с учетом определения эффектов цифровизации. Расчет экономических показателей результативности цифровизации управляющей компании автором было предложено осуществлять, основываясь на расчете транзакционных издержек. На основе проведенного анализа была дана авторская трактовка понятия: транзакционные издержки управляющей компании в условиях цифровизации ЖКХ. Была проведена классификация транзакционных издержек управляющей компании по видам и их детализация с учетом влияния цифровизации, выделены виды экономии затрат потребителей. Были определены основные показатели экономии управляющей компании в результате сокращения транзакционных издержек. Кроме того, автором были выделены основные показатели экономии затрат потребителей в результате цифровизации управляющей компании. Был разработан расчетный инструментарий для определения показателей сокращения транзакционных издержек управляющей компании и экономии затрат потребителей, который был применен на практике для расчетов эффективности цифровизации управляющей компании г. Воронежа ООО «Фаворит». Разработанный расчетный инструментарий помогает определить не только размер экономии затрат управляющей компании по каждому выделенному виду транзакционных издержек, но и размер общей экономии с учетом экономии затрат жителей. В результате произведенных расчетов для ООО «Фаворит» по разработанному автором инструментарию расчета показателей сокращения транзакционных издержек управляющей компании и экономии затрат жителей и выделения основных затрат был сделан вывод о необходимости и выгоде цифровизации ЖКХ.

Ключевые слова: ЖКХ, цифровизация, «Умное ЖКХ», транзакционные издержки, экономия управляющей компании, экономия потребителей, «умные» счетчики

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Cluster as an element of the strategy for the implementation of investment and construction projects in the sphere of individual housing construction

This article describes one of the ways of solving the problem of housing affordability for regions where individual housing construction prevails. According to the National Project “Housing and Urban Environment” by 2030, the annual commissioning of housing in the country should be up to 120 million square metres, of which more than a third should be for individual housing construction. Statistics show that 68 % of Russian families consider an individual house the most preferable type of housing. The transition to the cluster system of territorial development is aimed at improving the efficiency and competitiveness of projects in the field of individual housing construction. The ideology of cluster development projects implies the creation of a common social environment for all residents of the settlement, the main goal of which is: the development of commercial and social infrastructure within the cluster. The main example of this approach is an infrastructure node located within a low-rise development. Within this approach, several small settlements are gathered around one infrastructural core, within which commercial and social infrastructure is located. The concept of cluster development of territories will allow optimizing the costs of infrastructure development not only for one single settlement, but will also contribute to the development of the entire territory. It is assumed that in the future the scheme of cluster development of territories will become the main principle of suburban real estate development. Another indirect advantage of cluster development of territories is the opportunity for the developer to apply additional methods to increase the profitability of their projects. The most popular of them is the sale of ready-made houses with finishing, landscaping, furniture and additional options. As a result of the formation of a cluster, common property is formed, for the management of which a management company is needed, a specialized management company can be attracted to manage the cluster of individual housing construction, which, in addition to the main services, will provide additional services for the maintenance of personal plots. Transition to the cluster scheme for the development of territories will significantly improve the quality of life of people who consider individual housing construction as a place for permanent residence.

Keywords: *individual housing construction, cluster of individual housing construction, countryside real estate, comprehensive development, strategies for the implementation of investment and construction projects in the field of individual housing construction*

Modern economic conditions created through the reforms carried out in the country have led to significant regionalization, which to a large extent predetermined the problems existing at the regional level. In this regard, it should be noted that the region is a social and economic complex, which is aimed at establishing a relationship between business, regional authorities and public organizations. This format of interaction stimulates a more complete use of industrial, natural and labour resources aimed at satisfying all possible needs of the population.

Structural development of the country's economy is impossible without a comprehensive study and resolution of the most acute problems in the social sphere. One of the most important social problems of each region is the problem of housing affordability, the solution of which is impossible without structural changes in the industry and coordinated actions of state authorities, public organizations and businesses [1–3].

One of the possible methods of solving this problem in regions where individual housing construction (IHC) prevails is the transition to a cluster model of territorial development.

According to the National Project “Housing and Urban Environment” by 2030, the annual commissioning of housing in the country should be up to

120 million square metres, of which more than a third should be for individual housing construction.

According to the statistics of the Financial Development Institute in the housing sector of Russia “Dom.rf” and the All-Russian Center for the Study of Public Opinion, which are shown in Fig. 1, the interest in the format of individual housing construction is quite high among Russians. According to data provided by “Dom.rf” in its analytical report, approximately 68 % of 61.8 million Russian families consider an individual house the most preferable type of housing.

Country housing formats have become especially in demand among buyers due to the pandemic and the transition to a remote work scheme. In 10 regions of the Russian Federation, at the end of 2022, half of all new housing turned out to be commissioned in the format of individual housing construction. As for the top three, they have remained unchanged for a long time, these are: Moscow, Krasnodar Territory and Moscow Region.

For quite a long time, the cautious attitude of many banks regarding the potential liquidity of private houses hindered the development of mortgages in this segment of the real estate market. At the moment, the situation has changed for the better. As shown in Table, in 2021, individual housing

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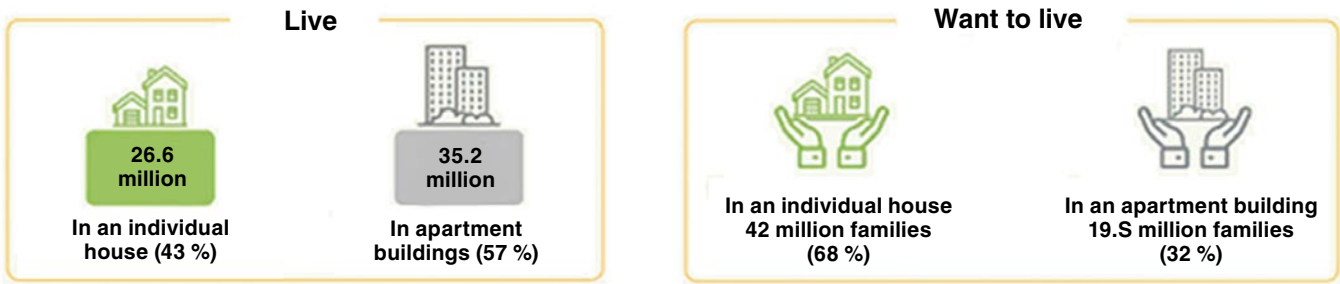


Fig. 1. Share of Russians who want to live in an individual house as of 2022

construction became eligible for most preferential mortgage programmes, such as “Preferential Mortgage”, “Family Mortgage”, “Far East Mortgage” and “IT Mortgage”.

With the help of these programmes, the demand for individual housing construction in 2021 increased by 4 times, and the share of housing loans issued for the construction or purchase of individual housing construction objects increased by 3 times compared to 2020 [4–6].

Despite the increase in demand for preferential programmes, the penetration of mortgages into the sphere of individual housing construction remains low at the moment, in 2022 only every tenth individual house was built using a mortgage, while in multi-apartment buildings 8 out of 10 apartments are purchased with a mortgage. In the current situation, the main constraint to the development of lending for individual housing construction is the lack of a market for standard, liquid private houses, which has a significant impact on the mortgage rate.

The cluster as an element of the strategy in low-rise construction is primarily aimed at improving the efficiency and competitiveness of projects in the field of individual housing construction.

A cluster of individual housing construction (hereinafter referred to as the IHC Cluster) is a certain territory or group of territories that can be distant from each other by a distance not exceeding 30 km.

The territory of the cluster has many common features of urban planning use of territories, these include a total area of at least 100 hectares, location outside the boundaries of urban settlements, and so on. As a rule, cluster development occurs takes place within the framework of the mechanism of integrated development of the territory, within which the territory is built up with individual or blocked residential buildings. During such development, the developer is obliged to provide the population with transport, road, engineering and social infrastructure facilities. The project should also create common areas and places of employment. The main goal of the cluster development of the territory is to create a comfortable

Dates of expansion of preferential mortgage programmes to the segment of individual housing construction

Programme	Mortgage rate	Date of extension to individual housing construction
Preferential mortgage	Up to 7 % in 2022, up to 8 % from 2023	10.18.2021
Family Mortgage	up to 6 %	06.01.2022
Far East Mortgage	up to 2 %	05.01.2021
IT Mortgage	up to 5 %	12.01.2019
Rural mortgage	up to 3%	05.12.2022

and safe living environment for the population. An example of a conceptual plan for the development of territories within the IHC cluster is shown in Fig. 2.

The main principles for the formation of an individual housing cluster follow from its definition and are primarily aimed at meeting the needs of the population living in the territory of the cluster. Among the most significant are:

- good transport accessibility to all social and commercial infrastructure (formation of a network of public transport running through the cluster territory);
- synchronization of schedules for the commissioning of residential buildings with schedules for the construction of infrastructure (when the building area increases, infrastructure facilities increase with it);
- a large number of public spaces located on the territory of the cluster (at least 10 % of the total building area);
- provision of the population with jobs (at least 20 % of the total population should work in the cluster);
- creation of an engineering network, where priority is given to centralized engineering systems;
- arrangement of permanent car storage places within the boundaries of land plots or in the adjacent territory (no further than 800 meters);
- development of recreational and entertainment infrastructure within the cluster (sports grounds, boulevards, parks, cafes).

The ideology of cluster development projects implies the creation of a common social environment for all residents of the settlement. The basis of this concept is a variety of infrastructure facilities within the cluster, aimed at providing a high level of comfort for the owners. In this case, the construction of social infrastructure is carried out in separate blocks, after the completion of the construction of each stage, the population within the cluster will increase,



Fig. 2. Conceptual plan for the development of territories within the cluster of individual housing construction in Dmitrov city

and the emerging need will be covered by commissioning an additional block, so the developer will not have to bear the cost of building a large social facility at one time. Thus, the developer provides a guaranteed volume of potential demand for all social infrastructure facilities [7, 8].

The main criterion for the demand for commercial infrastructure within the cluster is its availability for the surrounding residents. This approach provides the possibility of the functioning of various businesses that cannot function in modern cottage settlements due to the lack of the proper amount of demand.

The main example of this approach is an infrastructure node located inside a low-rise building. As can be seen from Fig. 3, when applying this approach, several small settlements are gathered around one infrastructural core, inside which commercial and social infrastructure is located, as well as landscaping and recreational areas. A unified architectural environment is created inside the infrastructure node and residential development is completely excluded. This location can accommodate both modern schools and kindergartens, as well as shopping centres, gyms and retail areas.

An analysis of transactions with IHC objects shows that only a small part of buyers of suburban real estate objects live in it on a permanent basis, since in the current realities, most high-level settlements do not have sufficiently developed infrastructure. More than half of the population would like to live permanently in the countryside, but not everyone decides to do so due to the lack of critical social and commercial infrastructure. In this regard, potential buyers make a choice in favour of country houses for seasonal residence [9, 10].

At the moment, only 30 % of all settlements in the “business” and “elite” segments can offer buyers at least one type of infrastructure of the proper level, and only 5 % of all projects assume the presence of a full range of educational, social, commercial, leisure and other conditions necessary for permanent residence in the countryside.

The concept of cluster development of territories will optimize the costs of infrastructure development not only for one single settlement, but also contributes to the development of the entire territory. It is assumed that in the future the scheme of cluster development of territories will become the main principle of suburban real estate development. This approach will not only significantly increase the capitalization of land plots and improve the liquidity of investment and construction projects in the field of individual housing construction, but also optimize part of the costs allocated from the municipal, regional and federal budget for the infrastructure development of territories.

The next advantage of cluster development of territories is the opportunity for the developer to apply additional methods to increase the profitability of their projects. The most common of them is the sale of finished houses with finishing, landscaping, furniture and additional options [11, 12].

Such methods are beneficial both for the builder-developer, since they can be used to increase marginality, and to the end buyers.

The main advantages of finished objects include:

1. Savings that occur due to a decrease in the number of transactions and economies of scale, since in order to prepare a house for life, many operations must be done: order design projects for houses, select contractors, purchase furniture, and so on. Since the developer orders this for everyone at once, it costs less.

2. You can move straight into a finished house, rather than waiting for the repair to be completed. The sooner all objects are sold,



Fig. 3. An example of an infrastructure node located inside the designed building

the better for developers and residents, since in this case it is assumed that there will be no stranger in the settlement.

3. When a developer can offer a whole range of services, it widens the target audience, since the buyer can take out a mortgage for the whole cost at once. For potential buyers, paying off the loan and doing the finishing is much more difficult than paying the original mortgage payment. The payment will be higher, but the amount of the payment will be known in advance.

Another competitive advantage that appears with the cluster method of territory development is the ability to attract a full-fledged management company. As a result of cluster formation the common property is formed, it must be managed by someone.

In the current situation, if there is a good management company in the settlement, this is a huge competitive advantage. The market of management companies in individual housing construction in our country is not developed, while the demand for quality services among wealthy buyers is very high.

At the same time, requests from residents show that the services offered by management companies in apartment buildings are not sufficient for individual housing construction. Many residents are ready to pay for additional services such as snow removal, grass cutting, house cleaning, dog walking and other minor work on a regular basis [13–15].

Considering the transition from the current scheme of construction in the field of individual housing construction to the scheme of cluster development of territories, we can conclude that the transition to the new model will increase the availability of social and commercial infrastructure by placing it simultaneously for several settlements within the cluster (now such infrastructure is not actually built). Builders-developers, due to the economies of scale, will be able to sell IHC objects with ready-made finishes and furniture, which will increase their marginality and potential buyers will be able to purchase an object equipped with everything necessary for life. There will be an opportunity to manage the common property

of the cluster, to attract specialized management companies that provide services not only for managing the common property of the cluster, but also additional services aimed at improving the living standards of people within the cluster.

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Кластер как элемент стратегии реализации инвестиционно-строительных проектов в сфере индивидуального жилищного строительства

В статье описан один из путей решения проблемы доступности жилья для регионов, где преобладает индивидуальное жилищное строительство. Согласно Национальному проекту «Жилье и городская среда», к 2030 г. ежегодный ввод жилья в стране должен составлять до 120 млн м², из которых больше трети должно приходиться на индивидуальное жилищное строительство. Статистика показывает, что 68 % российских семей считают индивидуальный дом наиболее предпочтительным видом жилья. Переход на кластерную систему освоения территорий направлен на повышение эффективности и конкурентоспособности проектов в сфере индивидуального жилищного строительства. Идеология проектов кластерного освоения территорий предполагает создание общей социальной среды для всех жителей поселка, основной целью которой является: развитие коммерческой и социальной инфраструктуры внутри кластера. Основным примером такого подхода является инфраструктурный узел, расположенный внутри малоэтажной застройки. В рамках этого подхода несколько небольших поселков собраны вокруг одного ядра, внутри которого расположена коммерческая и социальная инфраструктура. Концепция кластерного освоения территорий позволит оптимизировать расходы на развитие инфраструктуры не только одного отдельно взятого поселения, но и будет способствовать развитию всей территории. Предполагается, что в будущем схема кластерного освоения территорий станет основным принципом деvelopeмента загородной недвижимости. Еще одним косвенным преимуществом кластерного освоения территорий является возможность для застройщика применять дополнительные методы по повыше-

нию рентабельности своих проектов. Наиболее распространенные из них — продажа готовых домов с отделкой, благоустройством, мебелью и дополнительными опциями. Так как в результате образования кластера формируется общее имущество, для управления которым нужна управляющая компания, для управления кластером индивидуального жилищного строительства (ИЖС) можно привлечь специализированную управляющую компанию, которая помимо основных услуг будет оказывать дополнительные услуги по содержанию приусадебных участков. Переход на кластерную схему освоения территорий позволит значительно повысить качество жизни людей, рассматривающих ИЖС как место для постоянного проживания.

Ключевые слова: индивидуальное жилищное строительство, кластер ИЖС, загородная недвижимость, комплексная застройка, стратегии реализации инвестиционно-строительных проектов в сфере ИЖС

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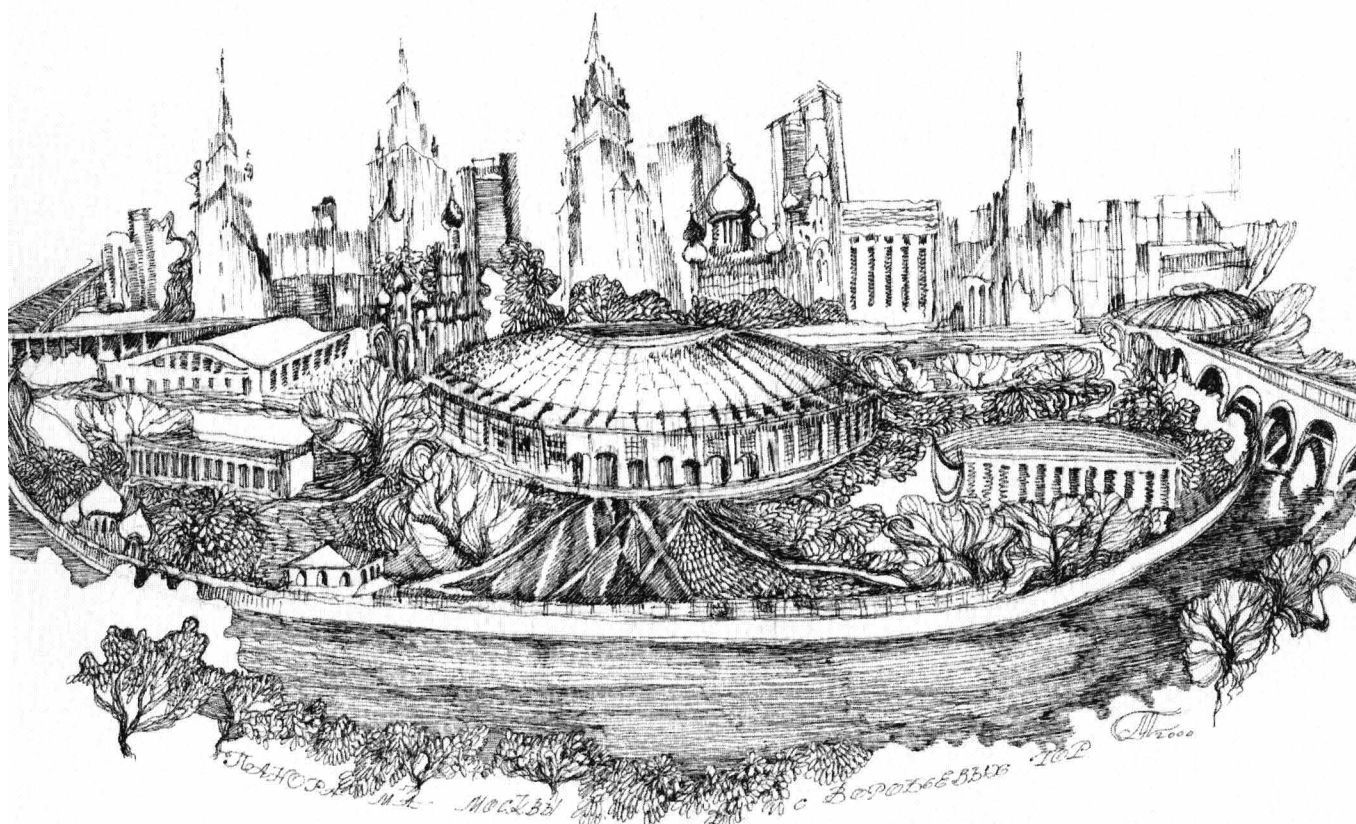
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Л.И. Павлова. Москва. Панорама Москвы с Воробьевых гор. Рисунок, тушь, перо

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Information model of energy and economic efficiency of the capital construction object life cycle

The potential of energy saving can be effectively realized by combining its tools with the methods of information modelling of the life cycle of a capital construction object, which determined the problem statement of this study. In this paper, the dependence of peak and average power of heating systems necessary to maintain comfortable temperature in the building on the climatic characteristics of the construction region is determined. For the dome part, the surface of which is realized in the form of a periodic sequence of elementary cells, the dependences of heat losses through the dome part of the building on the characteristics of the cells are calculated. The parameter describing the energy efficiency of space-planning solutions is determined, and its dependences on the geometric and thermophysical properties of enclosing structures are calculated. The total energy efficiency of the space-planning solution for the heating period is calculated. It is proved that energy optimization of the life cycle is possible only on the basis of heat flows through the surface of enclosing structures, linear and point thermally stressed elements (TSE) arising at the boundary of the dome part, the boundaries of the elementary cells filling the dome and on the structural elements of the triangular hemisphere or stratodesic dome. The formulated algorithms for describing all energy flows through the enclosing structures of the building made it possible to build an information model of the energy and economic efficiency of the life cycle of a capital construction object. The constructed vector information model of the energy and economic efficiency of the life cycle of a capital construction object allows solving the following practical tasks: to determine the dependence of energy costs on climatic parameters; to optimize the composition, terms of implementation and sequence of technical measures aimed at increasing the heat-insulating properties of enclosing structures and thermally stressed elements; to determine the profitability of these measures and their payback period.

Keywords: *information model, life cycle, efficiency, optimization, factors, capital construction object, thermally stressed elements*

INTRODUCTION

Taking into account the thermophysical properties of enclosing structures and climatic characteristics of the building localization allows to describe quantitatively the influence of the space-planning solution on the energy efficiency of the life cycle of a capital construction object. At the same time, it is necessary to take into account both energy flows through the enclosing structures proportional to the area of contact with the environment and the contribution of thermally stressed elements (thermal bridges) to heat losses.

However, in practice, the dome part of the enclosing structures is often structured and implemented in the form of a periodic sequence of elementary cells having the form of regular polygons. In this case, the boundaries of the cells and the points of their intersections represent additional TSE, generating additional heat loss. For buildings, the dome part of which has a radius of curvature much larger than the linear dimensions of the unit cell, individual parts of the dome can be locally considered flat, and the problem is reduced to the problem of regular parquet (mosaics) [1]. There are only three types of such parquet, the elements of which are regular triangles, quadrilaterals (squares) and hexagons.

Linear TSE occur at the interface of the structural elements of the dome part and the base, at the elements of the geodesic or stratodesic frame and at the boundaries of the parquet elements

filling the surface of the dome part. The contribution of this class of thermal bridges is proportional to the extent of the corresponding boundaries. In addition, when the linear elements are coupled, additional point heat-stressed elements arise. For all regular parquet floors without gaps and overlays filling the surface of a domed building, the parameters of thermal bridges are determined by the geometric characteristics of the project, the number of sides and the size of the parquet unit cell. The parameters of the unit cell are determined by technological and economic factors, and the features of the architectural solution of the project.

Taking into account the climatic characteristics of the region where the project is implemented, the algorithm developed in this paper for quantitative description of heat flows through enclosing structures makes it possible to calculate both the peak capacities of the heating system necessary to maintain comfortable temperatures during the coldest periods and the total consumption of thermal energy during the heating period. These data make it possible to optimize space-planning and technical solutions at the design stage and calculate the dynamics of heating costs during operation. In particular, the implementation of technical measures to improve the thermal insulation properties of enclosing structures and thermal bridges can improve the energy efficiency of domed buildings, the compactness coefficient of which is far from optimal.

MATERIALS AND METHODS

Studies have shown that it is impossible to describe the energy characteristics of buildings within the framework of a geometric model and requires additional consideration of the thermophysical properties of the elements of enclosing structures. The contribution of these effects to the energy efficiency of the building is reflected in the directive document SP 50.13330.2012¹ and for some spatial planning solutions is analyzed in [2–6].

The integral heat flow through the enclosing structures is determined by three physical mechanisms with qualitatively different dependence on the geometric parameters of the structure. Firstly, there is the heat flow, the value of which is proportional to the area of the enclosing structures and the average difference in indoor temperature and ambient temperature ΔT . In accordance with the law of thermal conductivity in the static approximation and the one-dimensional temperature distribution along the axis perpendicular to the boundaries of the orthotropic structure, the power of thermal energy losses determined by this part of the heat flow is described by the equation:

$$P = \kappa \cdot S \cdot \Delta T, \quad (1)$$

where κ is the heat transfer coefficient of N -layer building structure, expressed in terms of layer thicknesses d_i ($i = 1, 2, \dots, N$) and the thermal conductivity coefficients of materials λ_i in the form:

$$\kappa = \frac{1}{\sum_{i=1}^N d_i / \lambda_i}. \quad (2)$$

In the areas of sharp geometric and thermal inhomogeneities, the so-called TSE (in English-language literature — thermal bridges) arise, leading to the emergence of additional heat flows through external enclosing structures. TSE arise, first of all, in the areas of coupling of structural elements of the enclosing structure [7]. The presence of TSE leads to a decrease in the integral energy efficiency of the building [8–10]. In addition to reducing energy efficiency in the areas of TSE, the intensity of condensate formation on the inner surface increases, leading to the development of mold, which negatively affects the health of the inhabitants [11, 12].

A highly effective method of reducing the negative impact of TSE formed at the junctions of two outer walls and the interface of the outer and inner walls is based on the addition of local layers of thermal insulation (thermal pads) [13]. Heat flows through the TSE are proportional to the lengths of the interface areas of structural elements. In addition, additional heat losses are realized at the points of intersection of the interface areas, independent of geometric characteristics. The method of calculating heat flows averaged over the area of enclosing structures is formulated in SP 50.13330.2012¹. Similar rules in EN ISO 10211² are mandatory in EU countries.

We present the developed method for calculating the total heat energy losses during the heating period of all types (including components proportional to the areas, linear characteristics of thermal bridges and independent of geometric parameters) through the enclosing structures of perspective buildings having the shape of a spherical segment, and methods of energy optimization of space-planning solutions of such buildings.

The total power of heat losses through the areas of the spherical segment and the circular base in accordance with [14, 15] is determined by the equation:

$$P_s = 2\pi \cdot R \cdot H \cdot \kappa_s \cdot \Delta T_e + \pi \cdot H \cdot (2R - H) \cdot \kappa_b \cdot \Delta T_g = \pi \cdot H \cdot [2 \cdot R \cdot \kappa_s \cdot \Delta T_e + (2R - H) \cdot \kappa_b \cdot \Delta T_g]. \quad (3)$$

where κ_s and κ_b are the heat transfer coefficients of the structures of the spherical segment and the base, respectively;

ΔT_e and ΔT_g represent the average temperature differences of the room and the surrounding air and soil during the description intervals (hour, day, week, decade).

Let us determine the power of heat losses through enclosing structures per unit of useful volume:

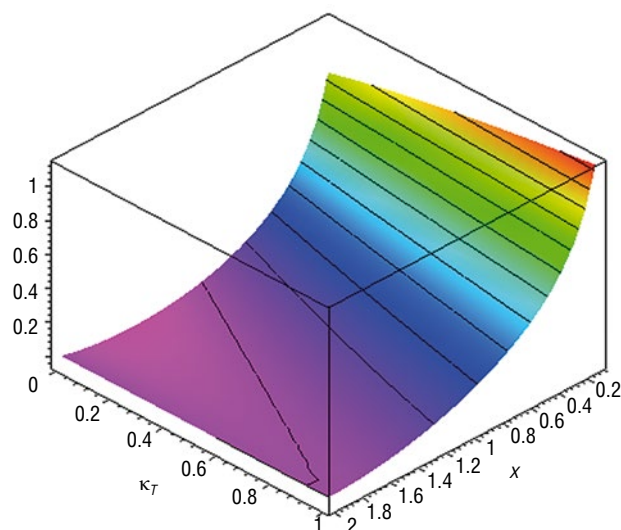
$$P_v = \frac{\pi \cdot H [2 \cdot R \cdot \kappa_s \cdot \Delta T_e + (2R - H) \cdot \kappa_b \cdot \Delta T_g]}{\frac{\pi H^2}{3} (3R - H)} = \frac{3\kappa_s \cdot \Delta T_e \cdot [2 + (2 - x) \cdot \kappa_T]}{xR(3 - x)}. \quad (4)$$

In equation (4), the following notation of a dimensionless thermodynamic parameter is introduced:

$$\kappa_T = \frac{\kappa_b \cdot \Delta T_g}{\kappa_s \cdot \Delta T_e}, \quad (5)$$

from a practical point of view, describing the ratio of flows through the base and the dome part.

Unlike the compactness coefficient, the position and value of the minimum of the heat loss function (5) is determined not only by the geometric characteristics of the space-planning solution, but also by the parameter κ_T . The graph of the dependence of the reduced power P_v on the geometric and thermophysical parameters is shown in Figure. The scale along the application axis is logarithmic. The beginning of the ordinate axis, from a practical point of



The dependence of the reduced power at $R = 1$ (the axis of the application) on the geometric parameter x (the axis of the abscissa) and the thermophysical parameter κ_T (the axis of the ordinate)

1 SP 50.13330.2012. Thermal protection of buildings (Updated version of SNIP 23-02–2009).

2 EN ISO 10211. Thermal Bridges in Building Construction: Heat Flows and Surface Temperatures. Detailed Calculations.

view, corresponds to negligible losses through the base of the building.

By appropriate choice of κ_T , which corresponds to achievement of necessary thermal insulation properties of the elements of enclosing structures, energy optimality can also be achieved for hemispherical dome part at $x = 1$. In this case, expression (5) is simplified and takes the form:

$$P_V(1) = \frac{3\kappa_s \cdot \Delta T_e \cdot (2 + \kappa_T)}{2R}, \tag{6}$$

minimized in the limit of small values of κ_T and large radii of curvature. The nature of the dependence of the specific power on the κ_T and the shape parameter x is reflected in Figure..

Dependencies (3)–(6) do not take into account losses through TSE. Now let us take into account the heat flows through thermal bridges. The interface area of the structural elements of the dome part and the base in the structure under consideration is a circle with a radius of:

$$r = \sqrt{H \cdot (2R - H)} \tag{7}$$

as a result, the power of heat losses through this linear element is determined by the equality

$$P_L = 2\pi \cdot \Delta T_g \cdot \kappa_L \cdot \sqrt{H \cdot (2R - H)}, \tag{8}$$

where κ_L is the linear coefficient of heat transfer TSE at the junction of the spherical segment and the base.

Summing up the heat loss capacities (6) and (8), we obtain the total capacity of the heating systems necessary to maintain a comfortable temperature in the building during the heating period:

$$\begin{aligned} P_{tot} &= \pi \cdot H \left[2 \cdot R \cdot \kappa_s \cdot \Delta T_e + (2R - H) \cdot \kappa_b \cdot \Delta T_g \right] + \\ &\quad + \pi \cdot \Delta T_g \cdot \kappa_L \cdot \sqrt{H \cdot (2R - H)} = \tag{9} \\ &= \pi \cdot H \left\{ 2 \cdot R \cdot \kappa_s \cdot \Delta T_e + \Delta T_g \cdot (2R - H) \cdot \left[\kappa_b + \frac{\kappa_L}{\sqrt{(2R - H) \cdot H}} \right] \right\}. \end{aligned}$$

Formula (3) describes the parameters of the heating system of a building with homogeneous enclosing structures.

Let us consider an example of calculating the parameters of TSE of the dome part of the building with the area $S = 2\pi \cdot R \cdot H$ (3) for a parquet with an elementary cell in the form of a regular triangle with side a and area $S_3 = \sqrt{3}a^2/3$. The number of parquet tiles completely and without gaps covering the dome is equal to $S/S_3 = 3\sqrt{3}\pi \cdot R \cdot H/a^2$. The number of TSE points is equal to one third of the number of tiles, and the total length of linear thermal bridges is determined by half of the total perimeter of all tiles and, therefore, is equal to $9\pi \cdot R \cdot H/\sqrt{3}a$.

The results of calculations of the TSE parameters for all types of parquet are shown in Table 1.

The length of linear thermal bridges and the number of point TSE are normalized by multipliers $\pi \cdot R \cdot H/a$ and $\pi \cdot R \cdot H/a^2$, respectively. Linear thermal bridges and point TSE lead to additional thermal losses, the power of which is described by the equality:

$$P_{add} = \frac{\pi \cdot R \cdot H \cdot \Delta T_e \cdot (a \cdot L_i \cdot \kappa_1 + n_i \cdot \kappa_0)}{a^2}. \tag{10}$$

In equation (10) κ_1 and κ_0 are linear and point heat transfer coefficient, respectively, and the dimensionless normalized parameters L_i and n_i are taken from Table 1. Taking into account equation (3), the total power of the building's heating systems takes the form:

$$\begin{aligned} P_{tot} &= \pi H \cdot \left\{ R \cdot \Delta T_e \cdot \left[2\kappa_s + \frac{(a \cdot L_i \cdot \kappa_1 + n_i \cdot \kappa_0)}{a^2} \right] + \right. \\ &\quad \left. + \Delta T_g \cdot (2R - H) \cdot \left[\kappa_b + \frac{\kappa_L}{\sqrt{(2R - H) \cdot H}} \right] \right\}. \tag{11} \end{aligned}$$

As can be seen from formulas (10) and (11), the contribution of linear and point TSE to energy loss decreases uniformly with the increase in the size of the unit cell and the number of sides. At the same time, the optimal cell size is limited by technological factors, and the number of sides, in addition to energy efficiency requirements, is determined by the features of the architectural solutions of the project.

The highest power is consumed in the coldest periods when the parameters ΔT_e and ΔT_g reach their maximum values. It is this capacity that should serve as a reference point in the design of engineering systems of the project. In addition, formula (11) makes

Table 1. Characteristics of the heat-stressed elements of the dome part of the building for parquet floors consisting of regular polygons with side a

Number of sides of the unit cell	Number of elementary cells	Unit cell area	Length of linear thermal bridges		Number of TSE points	
			General	Normalized	General	Normalized
3	$\frac{3\sqrt{3}\pi \cdot R \cdot H}{a^2}$	$\frac{\sqrt{3}a^2}{3}$	$\frac{9\pi \cdot R \cdot H}{\sqrt{3}a}$	$\frac{9}{\sqrt{3}}$	$\frac{\sqrt{3}\pi \cdot R \cdot H}{a^2}$	$\sqrt{3}$
4	$\frac{2\pi \cdot R \cdot H}{a^2}$	a^2	$\frac{2\pi \cdot R \cdot H}{a}$	2	$\frac{2\pi \cdot R \cdot H}{3a^2}$	$\frac{2}{3}$
6	$\frac{4\pi \cdot R \cdot H}{3\sqrt{3}a^2}$	$\frac{3\sqrt{3}a^2}{2}$	$\frac{4\pi \cdot R \cdot H}{\sqrt{3}a}$	$\frac{4}{\sqrt{3}}$	$\frac{4\pi \cdot R \cdot H}{9\sqrt{3}a^2}$	$\frac{4}{9\sqrt{3}}$

it possible to conduct an economic audit of the project, based, in particular, on the assessment of the cost of measures to increase the thermal insulation of the elements of enclosing structures and reduce the cost of consumed thermal energy.

Energy efficiency of space-planning solutions is characterized by the specific power of heating systems per unit of useful volume of the building, and, in accordance with equations $V = \pi H^2/3 \cdot (3R - H)$ [14] and (11), is equal to:

$$P_v = \frac{3}{H \cdot (3R - H)} \times \left\{ R \cdot \Delta T_e \cdot \left[2\kappa_s + \frac{(a \cdot L_i \cdot \kappa_1 + n_i \cdot \kappa_0)}{a^2} \right] + \right. \\ \left. + \Delta T_g \cdot (2R - H) \cdot \left[\kappa_b + \frac{\kappa_L}{\sqrt{(2R - H) \cdot H}} \right] \right\}. \tag{12}$$

Introducing the following designations for the specific loss capacities through all elements of the dome part of the enclosing structure and the base, occurring per one degree of temperature difference, we define:

$$P_c = \frac{3R}{H \cdot (3R - H)} \cdot \left[2\kappa_s + \frac{(a \cdot L_i \cdot \kappa_1 + n_i \cdot \kappa_0)}{a^2} \right]; \tag{13}$$

$$P_b = \frac{3(2R - H)}{H \cdot (3R - H)} \cdot \left[\kappa_b + \frac{\kappa_L}{\sqrt{(2R - H) \cdot H}} \right]. \tag{14}$$

Let us express the indicator of the current energy efficiency of the space-planning solution in the form of:

$$P_v = P_c \cdot \Delta T_e + P_b \cdot \Delta T_g. \tag{15}$$

The total energy efficiency of the space-planning solution for the heating period can be obtained by summing up the values of current indicators for the intervals of determining average temperatures, in the form of:

$$Q_v = \sum_{t=t_b}^{t_f} \left[P_c \cdot (T_{in} - T_{out}) + P_b \cdot (T_{in} - T_g) \right] = \\ = (P_c + P_b) \cdot \Delta t_{heat} \cdot T_{in} - \sum_{t=t_b}^{t_f} \left[P_c \cdot T_{out} + P_b \cdot T_g \right]. \tag{16}$$

The following notation is used in equation (16):
 T_{in} — room temperature (for rooms of different purposes is determined by sanitary standards);
 T_{out} — average outdoor temperature for the evaluation periods (hour, day, week, depending on the details of the description);
 T_g — average ground temperature for the assessment periods;
 t_b, t_f — the number of the period of the beginning and end of the heating season, respectively;
 Δt_{heat} — duration of the heating season.

The formulated algorithms for describing energy flows through the building's enclosing structures allow us to build an information model of the energy and economic efficiency of the life cycle of a capital construction object. The composition, dimension and formats of the input data are determined by the technical content of the corresponding components and are given in Table 2 and 3.

In Table 2, the data format of the first row is whole, the rest of the data is valid. The data designations in lines 2–8 coincide with

Table 2. Technical parameters of the information model of space-planning solutions

Number	Content	Dimension	Class
1	The number of sides of the unit cell	Dimensionless	Geometric
2	R	m	
3	H		
4	a		
5	κ_S	W/sq. m×K	Thermophysical
6	κ_b		
7	κ_L	W/m×K	
7	κ_1		
8	κ_0	W/K	
9	Specific price of thermal energy	rub/W	Economic

the designations in (1)–(5). The data contained in line 4 describe only heterogeneous dome structures.

In Table 3, parameter C is the unit costs (per unit of thermal power savings) for technical measures aimed at reducing energy consumption in the heating system. The data contained in co. 3 describes the specific cost of technical and technological measures carried out according to the results of an energy audit in the process of capital repairs or reconstruction and aimed at reducing the corresponding heat transfer coefficients of structures and energy costs (co. 2). Co. 5 shows the total duration of heating periods for the period of technical operation of the corresponding elements.

The information model also makes it possible to optimize not only the technical, but also the economic parameters of the project. At the design stage, summing up the cost of the energy carrier for the heating period:

$$G_{tot} = C_e \sum_{t=t_b}^{t_f} P_{tot}(t), \tag{17}$$

where C_e is the unit cost of the energy carrier, we will determine the total cost of heating for the season.

Similarly, the total economic efficiency of the space-planning solution of the object for the heating period is equal to the sum of the values of the current indicators of energy costs:

Table 3. Economic parameters of the information model of space-planning solutions

Number	Reduction of the thermophysical parameter	Unit cost of reduction	Dimension	Period of operation
1	$\Delta \kappa_s$	c_s	W/sq. m×K	τ_s
2	$\Delta \kappa_b$	c_b		τ_b
3	$\Delta \kappa_L$	c_L	W/m×K	τ_L
4	$\Delta \kappa_1$	c_1		τ_1
5	$\Delta \kappa_0$	c_0	W/K	τ_0
9	Unit costs of reducing power consumption	C	rub/W	τ_p

$$Q_v = C_e \sum_{t=t_0}^{t_f} [P_c \cdot \Delta T_e(t) + P_b \cdot \Delta T_g(t)]. \quad (18)$$

Replacing the heat transfer coefficients in (5) with the corresponding specific reduction costs (co. 3 of Table 3) and adding the costs of improving the heating system, we obtain expressions for one-time costs for technical measures to improve the thermo-physical properties of the project in the form:

$$C_{tot} = \pi H \cdot \left\{ R \cdot \Delta T_e \cdot \left[2\kappa_s + \frac{(a \cdot L_i \cdot c_1 + n_i \cdot c_0)}{a^2} \right] + \Delta T_g \cdot (2R - H) \cdot \left[c_b + \frac{c_l}{\sqrt{(2R - H) \cdot H}} \right] \right\} + I. \quad (19)$$

On the other hand, replacing the heat transfer coefficients in formula (5) with their reduction (co. 2 of Table 3) allows us to calculate the amount of reduction in heat consumption:

$$\Delta P = \pi H \cdot \left\{ R \cdot \Delta T_e \cdot \left[2\kappa_s + \frac{(a \cdot L_i \cdot \Delta \kappa_1 + n_i \cdot \Delta \kappa_0)}{a^2} \right] + \Delta T_g \cdot (2R - H) \cdot \left[\Delta \kappa_b + \frac{\Delta \kappa_l}{\sqrt{(2R - H) \cdot H}} \right] \right\}. \quad (20)$$

Summing up the values of the reduction coefficients for the periods of operation of the corresponding elements:

$$K_i = \min[\tau_p, \tau_i] \cdot \Delta \kappa_s. \quad (21)$$

and substituting the result into formula (5), we get the total energy savings during the project implementation:

$$\Delta Q = \pi H \cdot \left\{ R \cdot \Delta T_e \cdot \left[2\kappa_s + \frac{(a \cdot L_i \cdot K_1 + n_i \cdot K_0)}{a^2} \right] + \Delta T_g \cdot (2R - H) \cdot \left[K_b + \frac{K_l}{\sqrt{(2R - H) \cdot H}} \right] \right\}. \quad (22)$$

Formula (22) takes into account that the operating time of individual elements, the modernization of which is carried out during major repairs or reconstruction, may formally exceed the project implementation time.

The total savings from technical energy — saving measures are determined by the expression:

$$\Delta C_{tot} = C_e \cdot \Delta Q. \quad (23)$$

Comparison of costs (19) and savings (23) determines the profitability of technical energy-saving measures and their payback period.

Conclusions and prospects of research. Thus, the information model based on the data contained in Table 2 allows us to calculate and optimize the consumption of stored and non-stored resources necessary for the implementation of the project. The scope of applicability of the model can be significantly expanded with additional consideration of climate information describing the localization region of the project.

In this case, in accordance with formulas (3)–(6) and (10), the following tasks can be solved:

- at the design stage of engineering networks, the parameters of the heating system can be determined, which make it possible to guarantee comfortable temperature in standard climatic conditions and redundancy parameters in extreme conditions;
- the information model makes it possible to calculate the energy effect of using various types of elementary cells of the dome part of the enclosing structure;
- with additional accounting of the specific price of thermal energy, the information model allows you to calculate the dynamics of energy costs in both standard and extreme conditions;
- taking into account the data contained in co. 5 of Table 3, the model allows us to evaluate the energy efficiency of technical measures aimed at increasing the thermal insulation properties of all elements of enclosing structures, and optimize the composition, timing and sequence of these measures.

The information model also makes it possible to optimize the economic parameters of the project.

Supplementing the base of the information model with economic data makes it possible to expand the scope of its practical application. At the operational stage, the extended model allows us to calculate the dependence of energy costs on climatic parameters. At the stage of reconstruction, such information model makes it possible to optimize the composition, timing of implementation and sequence of technical measures aimed at increasing the heat-insulating properties of enclosing structures and thermally stressed elements, to determine the profitability of these measures and their payback period.

Further development of the information model involves the study of alternative methods of structuring the surface of the dome part. For this purpose, it is necessary to develop methods for describing heat-stressed elements for semi-regular and irregular parquet floors and rational methods for filling spherical surfaces with heterogeneous cells. In addition, it is necessary to develop methods for calculating losses through heat-stressed elements of the triangular hemisphere and stratodesic dome.

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Информационная модель энергетической и экономической эффективности жизненного цикла объекта капитального строительства

Потенциал энергосбережения может быть эффективно реализован при сопряжении его инструментария с методами информационного моделирования жизненного цикла объекта капитального строительства, что и определило постановку задачи данного исследования. В данной работе определена зависимость пиковой и средней мощности систем отопления, необходимой для поддержания комфортной температуры в здании, от климатических характеристик региона строительства. Для купольной части, поверхность которой реализована в виде периодической последовательности элементарных ячеек, рассчитаны зависимости тепловых потерь через купольную часть здания от характеристик ячеек. Определен параметр, описывающий энергетическую эффективность объемно-планировочных решений, и рассчитаны его зависимости от геометрических и теплофизических свойств ограждающих конструкций. Рассчитана полная энергоэффективность объемно-планировочного решения за отопительный период. Доказано, что энергетическая оптимизация жизненного цикла возможна только на основе учета тепловых потоков через поверхность ограждающих конструкций, линейные и точечные термонапряженные элементы (ТНЭ), возникающие на границе купольной части, границах элементарных ячеек, заполняющих купол, и на конструктивных элементах треугольной полусферы или стратодезического купола. Сформулированные алгоритмы описания всех энергетических потоков через ограждающие конструкции здания позволили построить информационную модель энергетической и экономической эффективности жизненного цикла объекта капитального строительства. Построенная векторная информационная модель энергетической и экономической эффективности жизненного цикла объекта капитального строительства позволяет решить следующие практические задачи: определить зависимость затраты на энергоносители от климатических параметров; оптимизировать состав, сроки реализации и последовательность технических мероприятий, направленных на увеличение теплоизолирующих свойств ограждающих конструкций и термонапряженных элементов; определить рентабельность этих мероприятий и срок их окупаемости.

Ключевые слова: информационная модель, жизненный цикл, эффективность, оптимизация, факторы, объект капитального строительства, термонапряженные элементы

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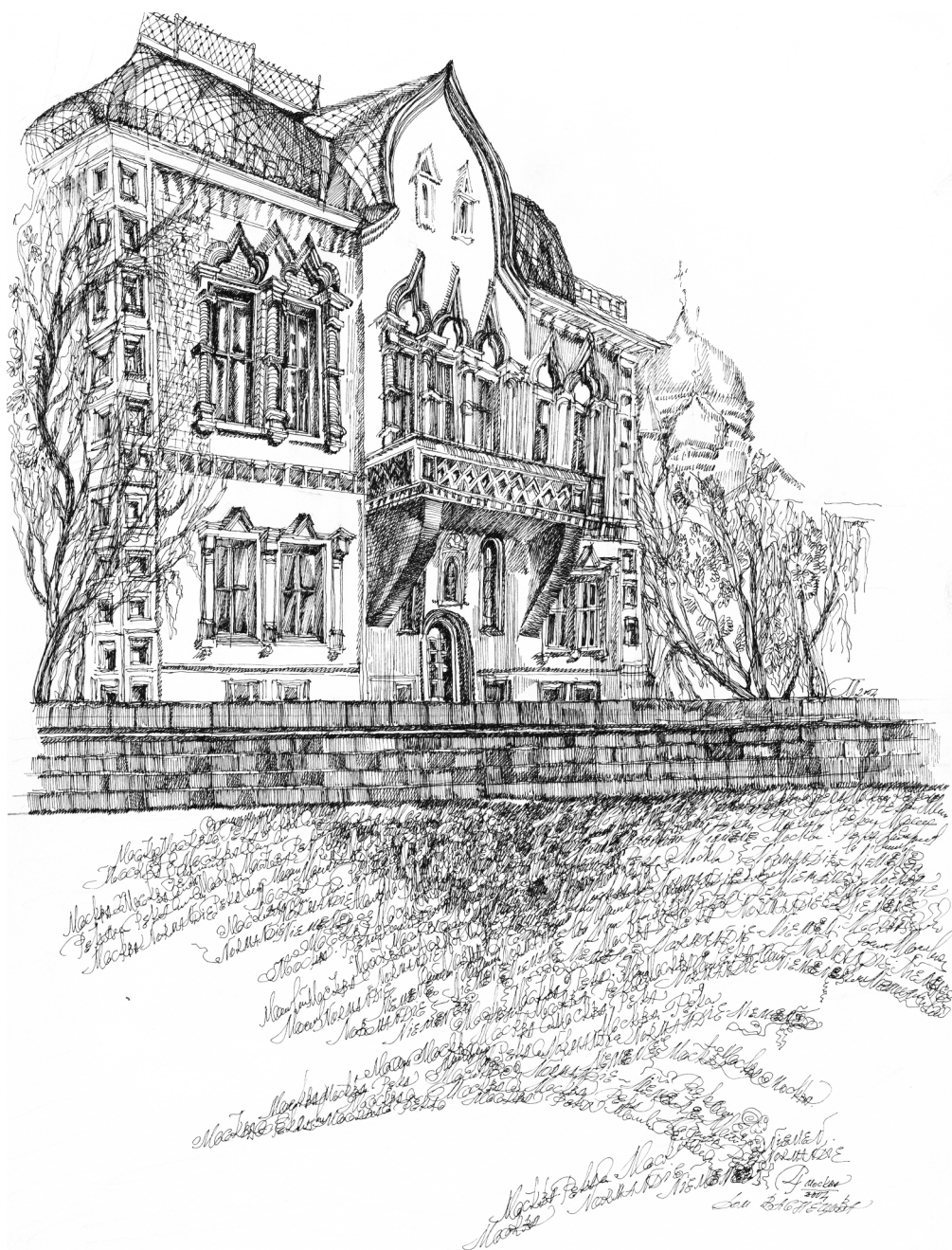
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Sezemin D.E.

NPP as a technically complex facility. Global reliability management using “Between True and False” method

The presented research article gives an overview of modern aspects of the concept of reliability and risk management of technically complex construction objects using the example of a nuclear power plant (NPP). Through the analysis of domestic and foreign approaches to the study of NPP reliability management systems, the paper defines the vector of development of applied science in the field of project reliability assessment. The author outlines the problems of development of an integrated system of organizational and economic reliability management of the main stages of construction of nuclear power facilities. The article presents the main theses and description of the author’s development of the methodology of reliability assessment of the technically complex NPP system on the basis of multi-criteria approach. It is proposed to use stochastic and deterministic methods of reliability assessment for the technically complex NPP system. The relevance of applying the theory of fuzzy sets is substantiated in the context of the analyzed problem when assessing the degree of reliability of the nuclear power plant as a technically complex real estate property. The method of network graphs construction, forming the basis of the applied software of the organizations performing the functions of customer and contractor of NPP construction, is considered as a sub-base of the system of project reliability assessment by its stages and phases. The article formulates the problems of reliability and risk management, draws conclusions and recommendations on the prospects of NPP reliability management systems development, and identifies directions of further research in this field. It is proposed to create a global map-scheme of the international market of nuclear industry facilities based on their reliability data. The paper substantiates the fact that the creation of such a map will make it possible to inform humankind publicly about the state of energy facilities using peaceful nuclear technology.

Keywords: nuclear power plant (NPP), NPP construction, NPP reliability management, construction risk management, construction economics, industrial construction, multi-criteria reliability assessment, fuzzy set theory in reliability assessment, enterprise economics, mathematical modeling



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INTRODUCTION

Within the context of principles, generally recognized by the world community, on the need to enhance international cooperation in the field of nuclear energy and the development of sales markets with a steady growth in demand for nuclear energy, including energy produced using Russian technologies, the issues of safety and reliability of project management in the field of peaceful atom nuclear technology are the most urgent ones that require extensive research. The International Nuclear and Radiological Event Scale, adopted by the IAEA and consisting of seven levels, makes it possible to measure the degree of danger of accidents and incidents that have already occurred. At the same time, it is necessary both retrospectively and prospectively to analyze, evaluate and form safety margins of the existing NPP facilities to prevent similar events in the future, by ensuring the proper degree of reliability of all systems. The presented research and review article is devoted to organizational and economic reliability work in facilities in question. The methodology and principles of reliability management are investigated and the foundations of our own multi-criteria approach to assessing and managing the reliability of a nuclear power facility are proposed. In addition to assessing the reliability of projects, one of the goals of the presented work is to develop the basis for further creation and international use of an interactive map of the world

with zoning of nuclear power facilities (NPP) by their reliability, which will also help to identify the gradation of zones with most favorable conditions for the development of nuclear power. This map will make it possible to observe in real time the current situation in regions whose population and governments are committed to or, on the contrary, opposed to the development of nuclear power technologies, regions with an increasing terrorist threat, as well as regions of prospective development of “peaceful atom” projects.

As a result of the development of the ideas presented in this research, a multi-criteria research method based on a probabilistic approach to reliability assessment using deep expertise was developed based on the obtained and systematized experience in the economic sector under study.

The concept of reliability is at the intersection of such sciences as mathematics and statistics (probability theory, applied mathematics and control processes, physics and chemistry (in terms of studying external physical and chemical influences on the object under study, as well as physical and chemical processes inside the object being studied), as well as economic science (in terms of methods of economic efficiency) (Fig. 1) [1].

According to Nuclear Reactor Information System as of June 2023, the following current statistics of NPP capacity distribution by world regions is given and illustrated at Fig. 2¹.

1 In Operation & Suspended Operation Reactors. URL: <https://pris.iaea.org/PRIS/WorldStatistics/OperationalReactorsByRegion.aspx>

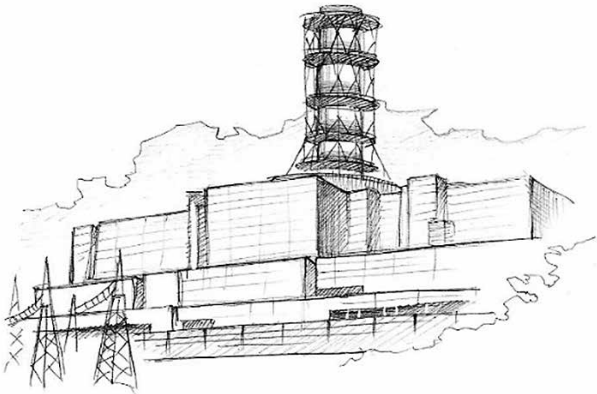


Fig. 1. Sketch to the nuclear plant

This information is of interest for solving the problem of developing and testing a methodology for assessing the organizational and economic reliability of a nuclear power plant project at both the pre-investment and investment stages. In matters of construction of technically complex structures, the basis for the success of the project is location and economic efficiency, determined, among other things, on the basis of the chosen location. The more demanded the project is, the higher its reliability potential due to greater loyalty to the significant costs that:

- must be incurred;
- have guaranteed sources of financing, in addition to subsidy and investment;
- have guaranteed consumption of the project's products, in the case of NPP — this is the supply of electric power and energy to the grid with further distribution to consumer groups [2, 3].

The relevance of the study of project reliability is determined by the fact that in case of lack of reliability or reduction of its threshold in the project, the latter will not be realized. Let us define the concept of organizational and economic reliability. "This is such an economic state of the company, which ensures the effectiveness of its sustainable development, rational use of all types of resources

and satisfaction of all stakeholders within reasonable economic risk" [4].

Initially, let us consider the historical aspect of the scientific development of the concept of reliability. It is accepted to believe that scientific interest was formed in the first half of the twentieth century, when the term "reliability of technical systems" appeared. Later, in the second half of the twentieth and early twenty-first centuries, the concept of economic reliability was formed, following the production reliability [4].

"Modern economic realities of market relations have raised the problem of economic reliability to a new level, ... the indicator of reliability of the organization becomes a key indicator in making managerial decisions; it is given attention by the heads of companies, financial and tax services, government agencies and other organizations that make decisions regarding the position of economic efficiency of the organization's functioning. Absolute reliability of an organization, as well as other systems, is impossible. At the same time, the management of each organization strives for this indicator" [4].

The scientific novelty of the tasks and conclusions presented in the article is due to the fact that many authors of domestic and world science study the theory of economic reliability of the organization; however, the unity in the approach to its definition has not yet been formed.

The author of the presented article sees the future for the development and implementation of the methodology of multi-criteria analysis of system data both at the stage of design and at the stage of construction of a nuclear power plant. Development and implementation of systems of control and management of NPP facility reliability in a unified form is the most important task of the world community, as it becomes obvious that the efficiency of already existing models of control and safety management of high-tech and hazardous facilities has been decreasing. Reducing the influence of the human factor is no longer within the framework of the "four-eyes" method, and "manual" or even "semi-automatic" data collection and input into analytical systems are becoming too politicized and biased, while the world community is making ever-increasing demands to control over the reliability and safety of nuclear facilities. Such integrated systems of management of organizational and economic reliability of the major stages of construction of nuclear power facilities, which can be integrated in a separate system, have

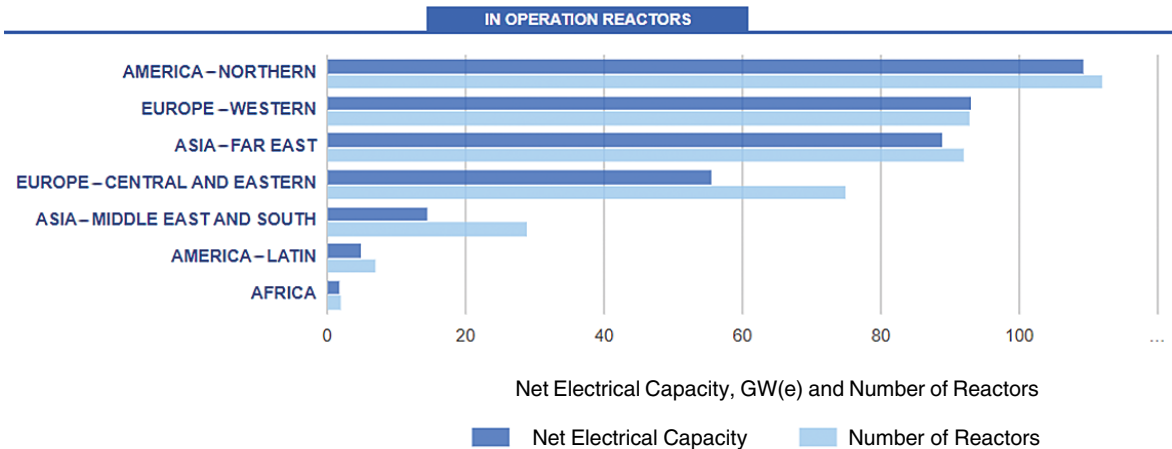


Fig. 2. Regional distribution of nuclear power

not been developed and implemented in the proposed scope. Hence, the article presents the main trends in the development of the nuclear power facilities construction market, as well as the role of ROSATOM in the development of large-scale international projects. In the third decade of the twenty-first century, in addition to the technical reliability of complex structures, the need to develop and improve the methodology for managing the organizational and economic reliability of projects in the nuclear power industry comes to the forefront.

According to the International Atomic Energy Agency, there are currently 438 nuclear reactors in operation worldwide. This figure means that the number of nuclear installations on Earth is more than double than the number of states, and, according to the UN data for 2023, there are 193 of them [5]. Such a scale of coverage of the planet by nuclear technologies makes dedicated specialists consider the reliability of technically complex industrial facilities in the context of organizational and economic problems; first and foremost, how to organize the construction and operation of such facilities reliably and safely [5]. Therefore, the tasks of ensuring the reliability of such systems both at the planning stage (pre-investment stage) and at the stage of implementation and subsequent operation gain crucial importance.

Reliability is "a complex property of systems to perform satisfactorily the required functions within a given time interval, when the probability that the system will perform these functions within a given time interval can be a qualitative characteristic of the property" [6]. **The first method** will be to determine the reliability of the system by means of a number of indicators, the main of which will be the "percentage of implementation" of the economic decision. This indicator will be calculated as follows in the Formula 1 — assessment of reliability of economic decision [6, 7]:

$$H_k = 1 - E = \left(\frac{P_k^0 - P_k}{P_k^0} \right), k = 1, \dots, K, \quad (1)$$

where H_k is assessment of reliability of economic decision by k -indicator of economic solution;

E is mathematical expectation symbol;

P_k^0 is projected (planned) value of the k -indicator;

P_k is its probable actual value;

K is nomenclature of assessed indicators.

The second method is based on the main property of reliability: inverse dependence on risk. Here reliability becomes the main criterion for evaluating the project being implemented. Thus, mechanisms and levers of reduction, mitigation and compensation of risks of the project system are developed and implemented to manage the reliability of a technically complex system such as an NPP. In this case, the concept of inertia of technological and economic processes is involved, and each of the management decisions taken is specified in the model, after which the researcher can estimate how the inertia (namely, reliability reduction) of the system increases with each subsequent stage. The main stages are planning and organization of work, identification of hazards, risk assessment, and development of risk mitigation recommendations [3].

"Risks cannot be separated from each other. Let us complicate the speculative model by the fact that for such an assessment of organizational and economic reliability of production systems we will allocate stages (periods) according to the principle of stage-by-stage analysis. In our case, the first stage will be the assessment of reliability in the process of preparing a feasibility study (FS) of the project". This develops the assumption that "a high level of project reliability at the stage of goal-setting significantly increases

the level of reliability of subsequent decisions related to the realization of this project" [3]. The feasibility study of the project, in addition to all technical and economic parameters, contains a clear formulation of the NPP project goal.

Here, the multi-criteria approach to the reliability assessment of NPP projects proposed by the author of the article comes into force. It is possible to supplement the range of analyzed criteria with such criteria as no-risk and optimality, along with the already known criteria of "adaptability, viability, maneuverability, failure-free operation, and stability" [8]. We complicate the model by adding weight and share characteristics, quantitative and qualitative criteria, where the intermediate task of assessing the weight of each criterion is assigned to a specially formed expert council for assessing the reliability of the construction project. The more technically complex and risky the object is, the greater damage can be caused by an error during construction and operation, and the more criteria will be included in the evaluation program. The reliability of the project becomes multilevel and more sustainable.

The proposal of a new multi-criteria approach is also greatly conditioned by the historical aspect. Appealing to the history of the issue development in the domestic science in the sphere of investigating reliability of technically complex systems such as NPPs, it should be noted that a certain vector of studies has been formed. For instance, according to the opinion of scientists who contribute to the development of the concept of technical reliability of enterprises and who publish scientific papers on this subject in "open press available to a wide range of scientific and technical workers" [8], there is an opinion about some insufficiency of materials due to the established view on "absolute safety" of national technologies and equipment, which "until recently was the foundation for prescribing safety standards". The requirement of "absolute safety, i.e., zero risk, eventually led to costly and even tragic consequences for the country's population and economy" [8]. Accordingly, "specialists operating technical systems and servicing hazardous technologies in the chemical industry, power systems, and pipeline transport turned out to be methodologically unprepared to search for and analyze critical failures leading to accidents" [8]. Thus, referring to the retrospective aspect of the reliability of technically complex systems, and in contrast to the above opinion, we emphasize the need to include in the assessment of the situation the assumption of a possible sabotage that could have taken place in 1986 [8].

For this reason, **the third method** of reliability research and assessment is proposed: reliability analysis on the basis of systematization of system failures by generic attributes together with grouping and identification of regularities when drawing up schedules for NPP organizational and economic management. The consequence and the result of the wide introduction of this method will be the increase of the level of knowledge about reliability and safety of technically complex industrial facilities up to the level of modern requirements in achieving reliability, in compliance with the current and prospective tasks of engineering development and scientific and technical progress.

The method of possible failure investigation should be applied at the pre-investment stage, at the construction stage, and to an even greater extent at the operation stage. This is dictated by the fact that currently the whole world and Russia as the leading state possessing the so-called dangerous technologies, is moving from dry statistics of accidents to the use of engineering methods of preventive analysis and research of "technical systems and high-risk facilities in order to prevent accidents". In fact, the world

In the context of reliability issues of technically complex production facilities the role of the main link — the human resources — cannot be underestimated. The author proposes to adopt the method of human reliability assessment as **the sixth method** of reliability assessment, as the human factor is most important for all technically complex enterprises and production facilities. Reliability assessment with a human factor in mind is relevant both for the investment and design stages of construction, and for the operational and final period. Reliability of human work is measured by the probability of a positive result of this labour, in this case achievement of the task set for a specific period of time is assessed, equal to the stage of the project under certain conditions. Conversely, an error in the work of the project personnel means failure to accomplish the assigned task or a prohibited action or violating the work schedule. It should be taken into account that most of the work at the enterprise is related to human activity, whatever the degree of automation is available.

Human error leads to the failure to fulfill the set goal or, on the contrary, to the performance of a prohibited action, which is the cause of damage to the technical system or violation of the established order of regulated procedures. In the process of operation, most of both automated and non-automated systems require human intervention. Over many years of practice of using both highly skilled and unskilled human labour, it has become obvious that errors are inevitable, and it is impossible to assess reliability without consideration of the results of human participation in the operation of all systems.

Nevertheless, under modern conditions it is not sufficient to assess operator errors from the point of view of the probability of the error itself as an influence of the human factor. There is a relatively new direction in the modern approach of the international scientific community: it involves countering threats from internal violators. This vector, studied and examined at the global level, is under special attention of the IAEA (International Atomic Energy Agency) that developed the relevant Practical Guide in 2008, which will be updated in 2023. The term "operator" or "nuclear operator", as defined by the IAEA, is used "to designate an entity (person or organization) officially authorized to operate a nuclear or radiological facility or officially authorized to use, store or transport nuclear material and/or radioactive material". The main condition for the existence of such a risk is the authority, knowledge, and "access that internal actors at the facility may have, including physical access to certain areas and nuclear material, internal or authorized remote access to a computer or computer network, and access to 'sensitive' information about the facility"³.

A simple example of countermeasures is the "two-person rule" (or four-eyes method, in the language of programmers), meaning a control method used to achieve a high level of reliability and security of sensitive facilities in the field under consideration, whereby access and actions require two or more authorized persons to be present at all times (as an example, start-up of an installation while using two different keys at the same time). The following measures can be useful: unannounced and unscheduled inspections of the implementation of protective measures, development and implementation of instructions, regular application of administrative penalties, confidentiality and secrecy rules, inspections, including

those involving independent groups, changes in the organizational structure by restricting access, changing the amount of available information (transfer to another area).

Drawing conclusions on the basis for the development of a multi-criteria system for assessing the reliability of a technically complex NPP construction facility, it is recommended to assess the entire set of factors of the organizational and technical process, such as labour resources, including their sufficiency, qualification, loyalty to the enterprise, material and non-material motivation; licensing and legal resources, including compliance of available and mobilized resources with the stated objectives in terms of time, scope and quality; as well as material and technical resources, including production and technical resources, and other resources that affect the safety and risks associated with complex technical production processes.

The development of independent multi-criteria approach is dictated not only by domestic, but also by Western developments, including the "Swiss Cheese Model" introduced by James T. Reason in 1990, which, in the context of the researched problems, the author of the article proposes to apply for the analysis of "cumulative consequences of actions" when assessing the technical, organizational and economic reliability of complex production systems, such as NPP. The analytical model should be supplemented by four types of errors that can lead to so-called project failures that, in turn, arise due to one or more of these errors, namely: management errors (as an example, as a result of the crisis, the reduction in training and professional development costs that subsequently led to the accident); insufficient managerial control at all levels; prerequisites for unsafe actions (for example, placing on the NPP dashboard a "destroy everything" button next to the public announcement button); and unsafe actions themselves⁴.

As the conclusion of the development of a multi-criteria system of NPP reliability assessment, various criteria become the prism of design analysis at each of the following stages of NPP construction:

1. Negotiation stage — preparation for an intergovernmental decision.
2. Preliminary feasibility study.
3. Decision-making at the level of state governments, signing of the intergovernmental agreement.
4. Establishment of a joint working group and updating of the feasibility study.
5. Identification of sources of financing.
6. Site assessment and selection, survey work.
7. Design development.
8. Construction of the facility, including supply of materials, complex equipment, organization of works.
9. Pre-commissioning, commissioning and adjustment works.
10. Lifetime of operation.
11. Decommissioning⁵.

It should be noted that stages from 1 to 7 can be referred to the preparatory stage of the construction project, stages 8 and 9 to the main stage of the construction project, and stages 10 and 11 to the operational stage of the construction project. Each stage should have its own scheduling in order to predict the proper level of reliability of each stage. The stages of NPP construction project realization according to the Built-Own-Operate (BOO) model are described in detail in the report and presentation by Denis E. Sezyomin, devoted

3 IAEA, Regulation on preventive and protective measures to counter threats posed by an insider. 2020. URL: https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1858_web.pdf

4 Reason J. The contribution of latent human failures to the breakdown of complex systems. *Philosophical Transactions of the Royal Society*. 1990; 327(121):475-484. DOI: 10.1098/rstb.1990.0090URL: <https://royalsocietypublishing.org/doi/10.1098/rstb.1990.0090>

5 Alshraideh M., Engovatov I., Morozenko A. Issues of NPP life cycle management. *Energy Policy*. 01.24.2023. URL: <https://energypolicy.ru/voprosy-upravleniyazhiznennym-cziklom-aes/energetika/2023/19/24/#:~:text=Жизненный%20цикл%20АЭС%20последовательно%20включает,начале%20и%20завершении%20указанной%20деятельности>

► to the integrated development of undeveloped territories and the experience of “Akkuyu” NPP construction by SC “Rosatom” in Turkey [9]. The results of achieving the design reliability of the NPP construction facility can be illustrated by the creation of a special protective containment resistant to all types of external impacts and their combinations, namely: seismic resistance up to 9 points on the MSK-64 scale, external explosions with a frontal pressure of 30 kilopascals, the fall of an airplane weighing 400 tons at a velocity of 200 m/sec. Fig. 4 shows a general visualization of the containment structure.

In the process of preparing and analyzing the construction schedule, the decommissioning stage is often neglected, which is not quite right, since history knows such examples, in particular, the example of the Berlin NPP, designed, built and excluded from the list of nuclear facilities due to sharp public criticism of the project (1985–1986, coinciding with the Chernobyl accident). The Berlin project underwent radical changes and turned into an amusement park (there is an attraction in the center of the main tower of the NPP, see the Fig. 5). This is not accidental, since from the point of view of reliability in the world practice of creating a nuclear facility, the undermining of confidence in the reliability of NPPs in the global sense led to the rejection of the commissioning and implementation stage of the project, making the project 100 % economically ineffective due to its unreliability⁶. As a result, the investments did not have the planned effect, what is illustrated at well-known panorama at Fig. 5.

When developing the new multi-criteria system, it is important to take into account the domestic experience of studying and using the concept of reliability of NPP project planning, included in Rosatom Order No. 1/1001-P dated 20.09.2013 “On approval of the list of software products for calendar-network planning at the facilities of the Federal Targeted Investment Program”. In order to unify work on schedules, the Order approved the unified use of the Primavera software, with the help of which the relevant schedules are generated. A distinctive feature of the schedules in this software is the division

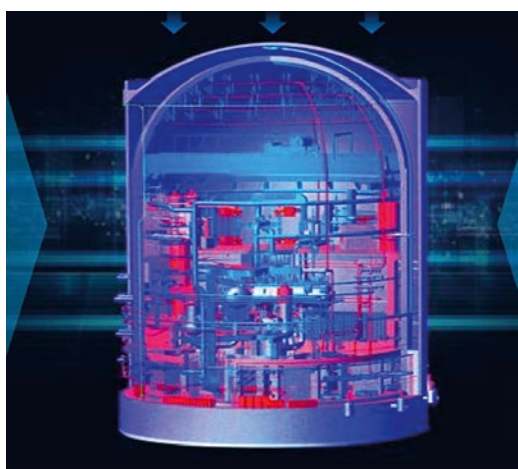


Fig. 4. The containment structure is resistant to all types of external influences and their combinations [9]



Fig. 5. Berliner unrealized NPP⁷

into “top-level schedules that determine the duration of stages and major events of the investment project, the planned date of project completion, a general detailed schedule that provides comprehensive planning of the timing of work (DD, SW, construction and installation, supplies), costs, physical quantities, and detailed schedules of project implementation, which provide management at the level of design, delivery, construction and installation works, commissioning”^{8, 9} [10].

The application of fuzzy set theory becomes a new approach in the practice of developing a set of mathematical multi-criteria models of complex assessment of organizational and economic reliability of the construction of nuclear power facilities. Comprehensive assessment of organizational and economic reliability of the NPP system construction is based on a combination of knowledge and skills of the Customer (society as a whole and public institutions performing functions of the Customer) and the Contractor (in a broad sense, with inclusion of subcontractors, engineers, operational services, etc.); it is also recommended to apply the norms of international law in the field of technical regulation of activities for the creation of technically complex industrial facilities.

Network planning methods based on Gantt charts¹⁰ allow planning compensation measures on the basis of system reliability assessment. They are based on either deterministic network models, where the sequence and duration of works are unambiguously specified or **probabilistic** (or stochastic) **network methods** (models) [11]. In the former methods, an increase in the actual duration of critical works due to certain reasons leads to a corresponding increase in the total duration of the project, while non-critical works have some time reserve.

Because of the dynamic nature of construction and a huge number of factors affecting the success of works, the actual duration and cost of works can only rarely coincide with the parameters set in a deterministic schedule. In the case of technically complex projects aimed at construction of unique buildings using new technologies, it becomes almost impossible to unambiguously identify the duration of works and their interrelation. All this applies not only to the planning of construction works, but also to the planning of other stages of a construction project: development of design and

6 Small Modular Reactors — Was ist von den neuen Reaktorkonzepten zu erwarten? URL: https://www.base.bund.de/DE/themen/kt/ta-deutschland/neue_reaktoren/neue-reaktoren_node.html

7 Wunderland (picture 1). Team Park Project. URL: <https://www.teamparkproject.com/en/projects/wunderland/>

8 Capital construction project management system of the State Corporation Rosatom E70707478. P. 4. URL: atomsro.ru

9 On approval of the list of software products for the implementation of calendar-network planning at the objects of the federal targeted investment program... : Order of the State Corporation Rosatom dated 20.09.2013 No. 1/1001-P.

10 Free Online Gantt Chart Software. No Signup and No Download Required. 100 % Free Forever. URL: <https://www.onlinegantt.com/#/gantt>

estimate documentation, preparation of construction works, etc. The use of stochastic methods leads, on the one hand, to more complicated calculations, but the results obtained are more adequate to real conditions [11].

The application of the project efficiency indicator through net present value (NPV) allows planning quite real probabilistic network models. This method clearly shows that in certain cases when using deterministic models, the project becomes unprofitable and has a negative economic effect. Since the main indicator of the economic reliability of the project is its profitability, this indicator should be planned using a probabilistic approach. A significant novelty of this approach lies in the use of fuzzy set theory, developed back in 1961 by scientist Lotfi A. Zadeh, a Soviet and later American scientist. Currently, the theory is widely used in the management of industrial enterprises and helps to solve challenges with a large number of evaluation criteria. The essence of the method is to determine the best and worst solution, the area between which is called a fuzzy set of solutions. At present, there are digitized mathematical models for analysis of decisions' probable variants; as a result,

a function is created that takes into account the influence of internal and external factors and it is possible to calculate the outcome of organizational and managerial decisions. "The special value of such models lies in the fact that the subject of the management process has numerical values of the controlled parameters at the output of the system, thus he or she not only sees the results of the controlling influence, but also can determine which of them in these conditions are the most flexible and to establish the degree of their influence on the project, which allows to promptly intervene in the management process, choosing the most effective measures of influence" [12–14].

The theory of fuzzy sets and fuzzy logic [12] can be applied as a modern method of assessing the quality of personnel. This theoretical approach is becoming increasingly relevant due to the need to systematize and formalize uncertain information for the creation of mathematical models. In mathematical science, the concept of fuzzy sets is introduced as "the function of belonging of an arbitrary element from a universal set to a fuzzy set", what is well illustrated in modern science and formed in following Table [12–14].

Basic concepts of the theory of fuzzy sets and fuzzy logic [12, 13]

Category	Content
Fuzzy set	A set of pairs where elements have different grades of membership to the fuzzy set
Membership function	Degree of belonging of an arbitrary element of the universal set to fuzzy set $A[0, 1]$
Fuzzy variable	Set $\langle \alpha, X, A(\alpha) \rangle$, where α is the name of the variable; X is the domain of definition of fuzzy variable α (basic, universal set); $A(\alpha) = \{ \mu_{\alpha}(x) / x \in X \}$ is a fuzzy subset of set X describing the constraints on the possible values of the variable
Variable	Set $\langle \beta, T(\beta), X, G, M \rangle$, where β is the name of the variable; $T(\beta)$ is a set of values of variable β (term-set); X is a universal set (definition domain of β); G means general rules, often in the quality or quantity, generating the name of factor; M is the rules specifying the membership functions of fuzzy terms generated by general rules
Fuzzy knowledge base	A set of fuzzy production rules $PR = \{ pr_1, pr_2, \dots, pr_s \}$ of the "if-then" types in deterministic form
Fuzzy logic inference	The general logical scheme of logical inference includes: • fuzzification; • implication; • composition; • defuzzification

CONCLUSION

The article presents an analytical review of methods for assessing the reliability of technically complex projects of NPP construction, systematization of which helps the author to develop an updated methodological multi-criteria approach to assessing the organizational and economic reliability of a production system. The new multi-criteria methodology assesses reliability both at the pre-investment and investment phases of construction of a technically complex industrial facility, such as construction of a nuclear power plant in any state and jurisdiction. The author uses a globalized approach, applying Russian and international experience of addressing reliability problems. The main idea is to develop a unified approach to such an assessment and make the information more open through an interactive map of the global international space with regional zoning of peaceful nuclear technology uses [15, 16].

One of the main directions of research conducted by the author of this work is the development and systematization of methodology recommendations for the selection of a rational option of the plan of work organization on the basis of a simulation model with the use of

modern automated systems of calendar planning. The main research goal of the author for the medium term is the development of a strategy to improve the organizational and economic reliability of the designed construction and technical solutions under risk conditions at the preparatory and main stages of construction of large industrial facilities with the example of high-capacity nuclear power plants.

The author sees further research of the presented topic in the area of development of the state-of-the-art automated system of technical process and reliability management. It is proposed that this automated system should be based on the feasibility study of the project, including data on the design capacity of the plant with indication of the required number of power units, in the composition of which it is necessary to design a certain number of reactors, select the construction area and assess the volume and return on investment, profitability and payback of the construction project. Such a cybernetic model will allow calculation of the economic result of the strategy for each period of the project development [17–19].

The study of issues related to organizational and economic reliability of complex industrial facilities and production systems is one of the leading directions of economic development of the countries all

over the world regardless of climatic, geographical and political features of countries and economies. The multi-criteria approach outlined by the author is applicable to assessing the reliability of technically complex industrial facilities not only in the nuclear industry, but also in other technically challenging sectors of the economy that affect a large number of people, such as the aerospace industry and public healthcare.

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АЭС как технически сложный объект недвижимости — глобальное управление надежностью по методу «betweentrue&>false»

В представленной обзорной научно-исследовательской статье раскрываются современные аспекты понятия управления надежностью и рисками технически сложных объектов строительства на примере атомной электростанции (АЭС). Через анализ отечественного и зарубежного подходов к исследованию систем управления надежностью АЭС в работе определяется вектор развития прикладной науки в области оценки надежности проектов. Автором излагаются проблемы разработки интегрированной системы управления организационно-экономической надежностью основных фаз строительства объектов атомной энергетики. Содержатся основные тезисы и описание авторской разработки методики оценки надежности технически сложной системы АЭС на основе многокритериального подхода. Предлагается использовать стохастический и детерминированный методы оценки надежности технически сложной системы АЭС. Обосновывается актуальность применения теории нечетких множеств в контексте исследуемой проблематики при оценке степени надежности технически сложного объекта недвижимости — атомной станции. Метод построения сетевых графиков, заложенный в основу прикладного программного обеспечения организаций, выполняющих функции заказчика и исполнителя строительства АЭС, рассматривается как подоснова системы оценки надежности проекта по его этапам и стадиям. В статье формулируется проблематика управления надежностью и рисками, в выводах и рекомендациях обозначаются перспективы развития систем управления надежностью АЭС, определяется направление дальнейших исследований в данной области. Предлагается создание глобальной карты-схемы международного рынка объектов атомной промышленности на основе данных об их надежности. Обосновывается факт, что создание такой карты-схемы сде-

лает возможным общедоступно информировать человечество о состоянии объектов энергетической системы, применяющих технологию «мирного атома».

Ключевые слова: атомная электростанция, строительство АЭС, управление надежностью АЭС, управление строительными рисками, экономика строительства, промышленное строительство, многокритериальная оценка надежности, теория нечетких множеств в оценке надежности, экономика предприятия, математическое моделирование

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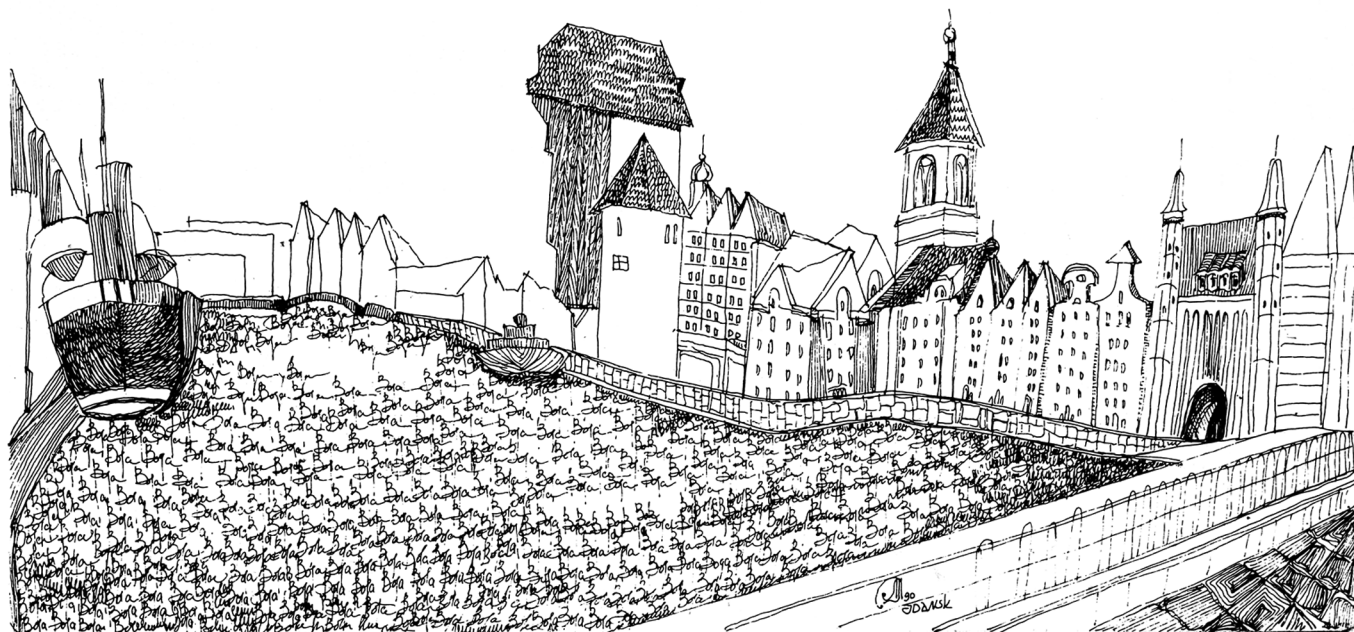
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Л.И. Павлова. Гданьск. Верфи. Офорт

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Digital transformation of standardization and quality control in construction production based on the implementation of the registry principle of managing the requirements of regulatory and technical documentation

Ensuring the quality of construction and installation work is traditionally a priority task of the construction industry, and today it is becoming the basis for the formation of criteria for the effectiveness of transformation processes in the conditions of the formation of the digital economy. The article is devoted to the search for ways to develop methodological tools for digital transformation of standardization and control of construction and installation works for a wide range of construction participants. Large-scale application of information modelling technologies and digital models at all stages of the life cycle of capital construction projects requires radical changes in the organization and development of the industry regulatory and technical framework for quality assurance. In many ways, improving the quality of construction and installation work depends on the loyalty of designers and builders to the registry principle of technical regulation. The author focused on the criteria for improving the quality of technological processes in construction. To achieve this goal, in the article the author proposes to consider the concept of formation and application of registers of regulatory requirements (RRR), designed to change the approach to work with the regulatory document, including in the assessment of conformity of the presented construction and installation works (CIW) carried out in accordance with this standard. The applied RRR assume a different structure of information, where the key element is the requirement. The requirement structure contains numerical parameters generated for specific processes.

The concept assumes integration of the registers of requirements with the building information model, formation of a request and application of data uploaded from the model on the list of works, their volumes, organizational and technological links between the works, etc. The register, with formulas for conformity assessment linked to it, is considered as a tool for automating operational control. When the requirements of work acceptance are met, data are generated to form digital performance documentation and fill in the digital performance model. The concept is being developed as one of the directions of the scientific and educational programme of activities implemented in the Scientific and Educational Center "Digital Construction and Operation" of Moscow State University of Civil Engineering with a partner — JSC "Codex".

Keywords: *standardization of construction technologies, digital tools for construction quality control, construction and installation works, register of regulatory documents, digital register of regulatory and technical requirements, building information model, regulatory and technical requirements*

DEVELOPMENT OF THE REGISTRY PRINCIPLE

The article is a continuation of a series of studies on the role of the registry principle and parametric rationing in the digital transformation of the construction industry.

Introduction and implementation of the registry principle of maintaining technical requirements in construction is one of the tasks of improving the system of technical regulation in construction. In accordance with the Development Strategy of the construction industry and housing and communal services of the Russian Federation for the period up to 2030 with a forecast up to 2035: the registry principle of the development of technical requirements is the principle of development of technical requirements, assuming the possibility of their practical implementation only after the inclusion of such requirements in the relevant register [1]. At the same time, it is assumed that the principle will be ensured by forming an integral system of regulatory documents that establishes uniform mandatory requirements at all stages of the life cycle of a capital construction object (CCO). Currently, regulatory

acts include linking the implementation of the registry principle and the creation of a system for managing safety and quality requirements of the CCO, based on a digital register of requirements in the construction industry. With this in mind, the register of requirements becomes a state information resource designed to provide interested parties with information about the requirements to be applied during the examination, design, construction, reconstruction, operation and demolition of capital construction facilities [2]. It should be noted that the formation and maintenance of the register of requirements in the field of engineering surveys, design, construction and demolition are carried out in Russian in electronic form using the State information system for urban planning activities (SISUPA) system based on Stroykompleks.RF. The requirements included in the register are placed in XML format. For state authorities, local self-government bodies, legal entities and individuals, the requirements included in the register of requirements in the field of engineering surveys, design, construction and demolition become open for review [3]. The most probable scenario is considered to be when the formation of registries will technically take

place in 3 stages: analysis of documents including requirements, detection of requirements in the document and systematization of requirements in the relevant registries.

At the same time, checking the relevance of the requirement is a more resource-intensive process than checking the relevance of the standard [4]. There are several reasons for this:

- document may contain a different number of regulatory and technical requirements;
- same document may contain requirements for different jobs or processes;
- most documents include both mandatory and recommended requirements;
- current document may contain modified requirements;
- document may continue to be valid, but the requirements contained in it may be canceled or supplemented with new requirements;
- multiple documents may contain cross-requirements.

The proposed concept, focused on ensuring the formation of an integral system of regulatory documents that establish uniform mandatory requirements at all stages of the life cycle of the CCO, involves the development by the user of a register of documents containing requirements and further work with requirements, changing to an algorithm for the direct formation by the user of a register of requirements [5]. Moreover, in terms of integration with the digital information model, the registry becomes part of it and receives the parameters of a digital tool.

INTEGRATION OF DIGITAL REGISTERS OF REGULATORY REQUIREMENTS AND BUILDING INFORMATION MODELS

The concept under consideration assumes the initial formation of a register of requirements in the preparation of Technical specifications for the development of design and estimate documentation, including organizational and technological documentation. The formed requirements in relation to the corresponding types of elements, structures, materials and equipment used are integrated into the information model along with other parameters. When forming the structure of the library components of the information model,

the principle of highlighting aspects of the system is applied [6]. According to this principle, the registers of requirements can be included in the model as functional aspects or product aspects. After the transfer of the project information model to the construction site, this makes it possible to obtain from the model, in addition to the names of works, their volumes, materials used, to obtain current requirements for the production of works, requirements for which structures, requirements for elements of engineering systems. The same requirements define quantitative and qualitative criteria when carrying out construction control of the technical customer, as well as when the contractor submits completed works or finished structures for compliance verification. After acceptance of the work, the requirements in the structure of the information model, in turn, become the basis for the formation of operational requirements for structures, elements, and engineering systems. At the stage of building operation, the registers will in turn become the basis of operational service, maintenance, monitoring, current and capital repairs, reconstruction and demolition [7]. Fig. 1 shows a block diagram of the implementation of the concept.

The described concept, which in its structure provides for application of the registry principle of the formation of regulatory requirements, using Russian software and information reference systems, allows us to solve the following tasks:

- implementation of automatic unloading from the information model of lists of construction and installation works, their volumes, with the possibility of visual analysis of organizational and technological links between the works, which allows to provide automation of development of organizational and technological documentation: work production projects (WPP) and technological maps (TM);
- formation of a register of regulatory requirements for the quality of construction and installation works, with formulas attached to it to assess the compliance of the results of construction and installation works with the requirements of national standards, design, working and organizational and technological documentation, which allows to implement automation tools for construction and operational control and generate data for filling the digital executive model.

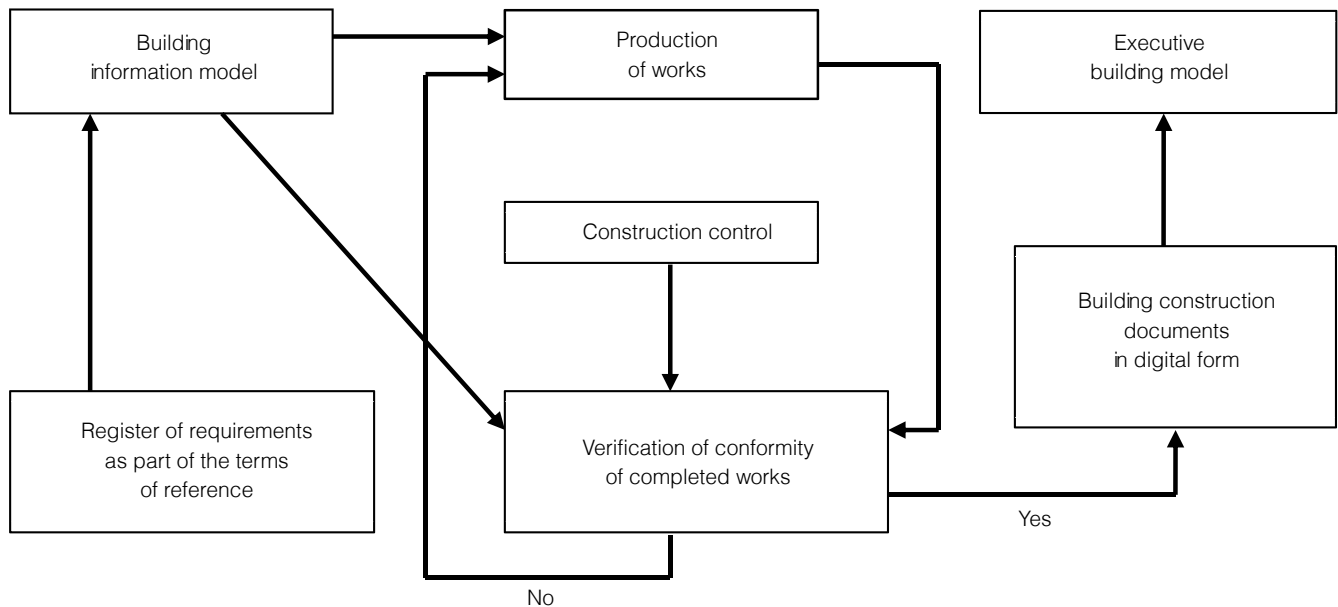


Fig. 1. Block diagram of the concept implementation

- In addition to the basic requirements, the register may include requirements related to the work being carried out and required by applicable regulations. These can be:
- requirements for ensuring technological modes of work, established by organizational and technological documentation;
 - labour protection requirements when performing the relevant production operations;
 - requirements to ensure compliance of quality indicators of operations and their results with standardization documents [8].

IMPACT OF THE REGISTER OF REQUIREMENTS ON THE QUALITY OF CIW

Introduction and implementation of the registry principle of maintaining technical requirements in construction is one of the tasks of improving the system of technical regulation in construction. Ensuring automatic updating of the registry and linking a specific requirement to the relevant production processes is a task of increased complexity. It should be noted that at the moment there are no ready-made registers of mandatory and recommended requirements for construction.

The register of requirements formed by the customer and integrated into the building information model can be applied at one or several stages of the object life cycle, for example, during the examination, preparation of design and estimate documentation, implementation of construction or reconstruction, performance of operational activities or demolition. The methodological basis for the application of data from information models at different stages of the object life cycle, the formation of requirements for them is implemented within the framework of a set of standards of a Unified Information Modelling System [9]. Accordingly, as part of the terms

of reference for the tender documentation or for the contract, the register of requirements can be opened for review or already applied by prospectors, designers, surveyors, contractors, operating organizations. The concept assumes that the registers, together with the requirements, will contain the calculated parameters of the requirements, which in turn determine the calculated parameters of works being carried out. During the period of works, ensuring compliance of the work performed with the project documentation and the requirements of regulatory and technical documentation is carried out by means of current and acceptance control. The result of compliance is a qualitatively completed and commissioned object. At the stage of conformity assessment of the submitted works, controlling precisely the calculated parameters of the work, it will be possible to control the specified level of quality of works, the structures and products used. The concept contributes to the formation of a systematic approach to the work with the registers of requirements through the detection, documentation, tracking of requirements for the created constructions and conducted production processes. It should be noted that in this case, the work with the requirements is carried out without the need for constant work with the entire documents.

From the above, the necessity of solving the problem of requirements management as a task of searching for an individually configured or typical, but in any case balanced set of parameters by which it is possible to determine the actual level of work performed. It can be argued that the requirements management mechanisms will become mechanisms for ensuring the quality of work.

APPROBATION OF THE CONCEPT

As part of the testing of the concept, we will consider the integration of the register of requirements for finishing works and data that make up part of the information model of a residential building.

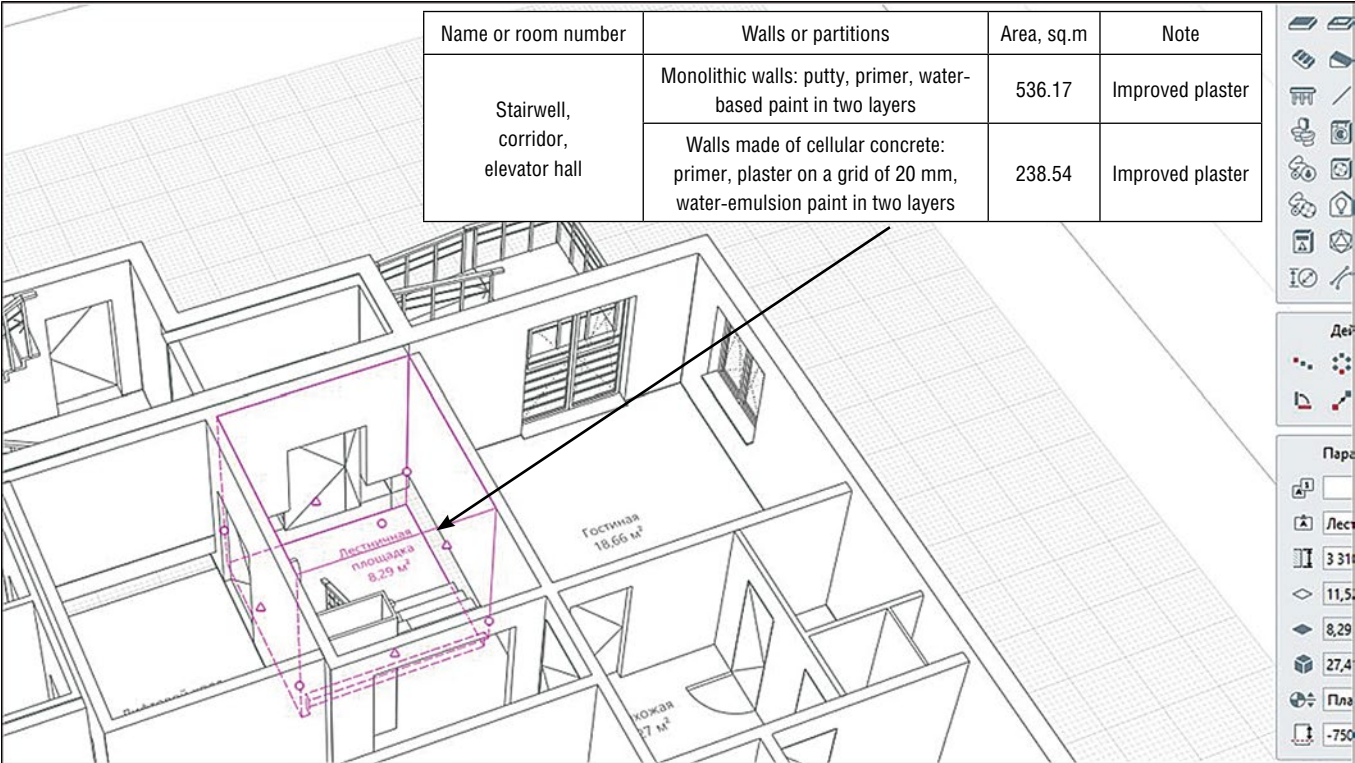


Fig. 2. Data on interior decoration from the building information model

The object of testing will be an 88-apartment residential building in Kaliningrad, Levitan str., 10. The project documentation for the object is included in the GIS of the Unified State Register of Legal Entities and is standard. The model was created in Renga automated building design system (version 5.5). To form a register of requirements for finishing works, we use “Techexpert SMART: design” — a professional reference system containing services for the introduction and use of information modelling technologies (IMT), as well as regulatory documents, reference and consulting information necessary in the work of the designer. Working on the creation of a digital register of regulatory and technical requirements in the “Techexpert” system, it is possible to work with regulatory documents as with “data containers” [10]. When working with the building information model, we will need the materials of the sections “Spatial planning and design solutions” and “Construction organization project”. It is possible to use attracting data from a larger number of model elements. After all, the gradual accumulation in digital format of more and more information about the object in the process of design and construction makes it possible to significantly increase the efficiency of operation of buildings and structures in the future [11].

At the next stage, from the information model of the building, all the data on the decoration of the premises necessary for compiling a statement of the scope of work are unloaded. To simplify, the example considers only one room – the stairwell of the floor. Fig. 2 shows a part of the statement of the scope of work on finishing, with data uploaded from the information model of the building.

The task of forming a register of requirements with the use of modern professional reference systems (for example, “Techexpert” system) for the construction industry is gradually being transformed into a system IT solution that allows you to fully automate the requirements management process and select requirements according to specified parameters. The article presents an algorithm for working with the “Techexpert” system to create a register of requirements for finishing works on the stairwell of a residential building. However, the algorithm is built in such a way that it can be shifted to other, more complex tasks. When working with the standard, mandatory, recommended and reference requirements are

established in separate positions. The formation of the register of requirements in the concept includes the following stages: selection of documents; detection of requirements from different documents; consolidation of requirements in the register. During the production of CIW, respectively, the control of changes in requirements, the analysis of changes, as well as the systematization of information on the compliance of the actual parameters of the work performed with the standards are carried out. The application of the formed register of requirements, in our example, in the conditions of the use of the “Techexpert” system and documents in the “xlsx format, will be presented as follows: automatic binding to the standard with the possibility of automatic updating; manual binding of each parameter to the appropriate place within the standard; verification of the status of the requirement (comparison of standards, comparison of editions); automatic calculation compliance of the performed works with the standards. In previous publications, the issues of solving the main tasks of allocating the registry structure with their connection to the system of automated control of the relevance of regulatory documents in the formation and work with registries have already been disclosed [12]. The main block of work on the register of requirements is undoubtedly the process of comparing the normative values of requirements with the values actually obtained. The registry considered in the example includes requirements for all layers of the walls of the stairwell of the building: improved plaster, primer coating, and painting.

By applying the register of requirements, the building control or supervision officer receives a universal tool in the form of an automated quality control table, the template of which will be updated in real time to ensure compliance with current editions of regulatory and technical documentation. This allows you to analyze information about the quality of requirements and procedures. In addition, many control measures at the federal level will soon receive strict digital binding to norms and requirements [13]. In addition to directly automated data updates, the *xlsx format allows you to automate the analysis of regulatory and real parameters, automate and configure the output of final data in a convenient form. The task of ensuring the relevance of the funds of regulatory documents was taken over by the “Techexpert” system, and the further level of automation of the technological process depends on the skills of a particular employee of the construction control or supervision service [14].

Summing up, here are the main effects of the application of the integration of registers of requirements and information models of the building, directly or indirectly affecting the quality of CIW:

- reducing labour costs, and therefore reducing the risk of errors when working with regulatory standards;
- the ability to automate work with requirements;
- performing calculations in standard programmes with reference to current databases of reference systems;
- the ability to automate individual processes during operational control;
- the possibility of using registers in the formation of digital executive documentation.

CONCLUSIONS

Reproduction of the concept on a sufficient list of CIWs based on the professional and loyal attitude of engineering and technical workers of the construction industry to the use of project documentation in the form of a digital information model will accelerate the digital transformation of construction production and control measures. The creation of such conditions is primarily facilitated by

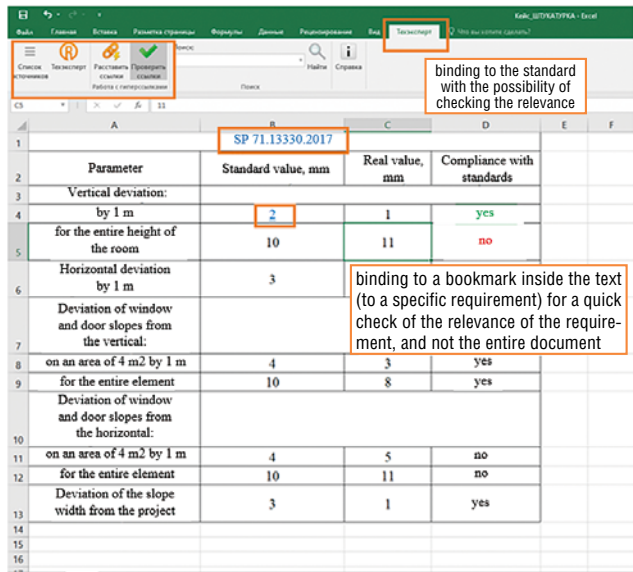


Fig. 3. Fragment of the desktop when comparing requirements values

▶ providing a wide range of engineering and technical workers in construction and operation with simple and reliable tools for solving everyday practical problems of ensuring the quality of construction and installation work. In the future, it can be transferred to more complex tasks, where you need to take into account a whole range of requirements and parameters. Moreover, the development of the proposed algorithm as an integrator technology and its application by enterprises and organizations of the construction industry will help ensure their competitiveness by improving the quality of work at all stages of the life cycle and creating conditions for meeting deadlines for their implementation.

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Цифровая трансформация стандартизации и контроля качества в строительном производстве на основе реализации реестрового принципа управления требованиями нормативно-технической документации

Обеспечение качества выполнения строительно-монтажных работ традиционно является приоритетной задачей строительной отрасли, а сегодня в условиях становления цифровой экономики выступает основной формированием критериев эффективности трансформационных процессов. Статья посвящена поиску путей развития методического инструментария цифровой трансформации стандартизации и контроля выполнения строительно-монтажных работ для широкого круга участников строительства. Масштабное применение технологий информационного моделирования и цифровых моделей на всех этапах жизненного цикла объектов капитального строительства, требует радикальных изменений в организации и развитии отраслевой нормативно-технической базы обеспечения качества. Во многом повышение качества строительно-монтажных работ зависит от лояльности проектировщиков и строителей к реестровому принципу технического регулирования. Автор ориентировался на критерии повышения качества проработки технологических процессов в строительстве. Для достижения цели автор предлагает в статье к рассмотрению концепцию формирования и применения реестров нормативных требований (РНТ), призванных изменить подход к работе с нормативным документом, в том числе при оценке качества предъявляемых строительно-монтажных работ (СМР), проводимых в соответствии с данным нормативом. Применяемые РНТ предполагают иную структуру информации, где ключевым

элементом является именно требование. Структура требования содержит в себе числовые параметры, формируемые для конкретных процессов.

Концепция предполагает интеграцию реестров требований с информационной моделью здания, формирование запроса и применение выгружаемых из модели данных по перечню работ, их объемам, организационно-технологическим связям между работами и др. Реестр, с привязанными к нему формулами для оценки соответствия, рассматривается как инструмент автоматизации операционного контроля. При удовлетворении требований приемки работ формируются данные для создания цифровой исполнительной документации и наполнения цифровой исполнительной модели. Концепция развивается как одно из направлений научно-образовательной программы деятельности, реализуемой в Научно-образовательном центре «Цифровое строительство и эксплуатация» (НОЦ ЦСЭ) НИУ МГСУ в сотрудничестве с партнером АО «Кодекс».

Ключевые слова: стандартизация строительных технологий, цифровые инструменты строительного контроля качества СМР, реестр нормативных документов, цифровой реестр нормативно-технических требований, информационная модель здания, нормативно-технические требования

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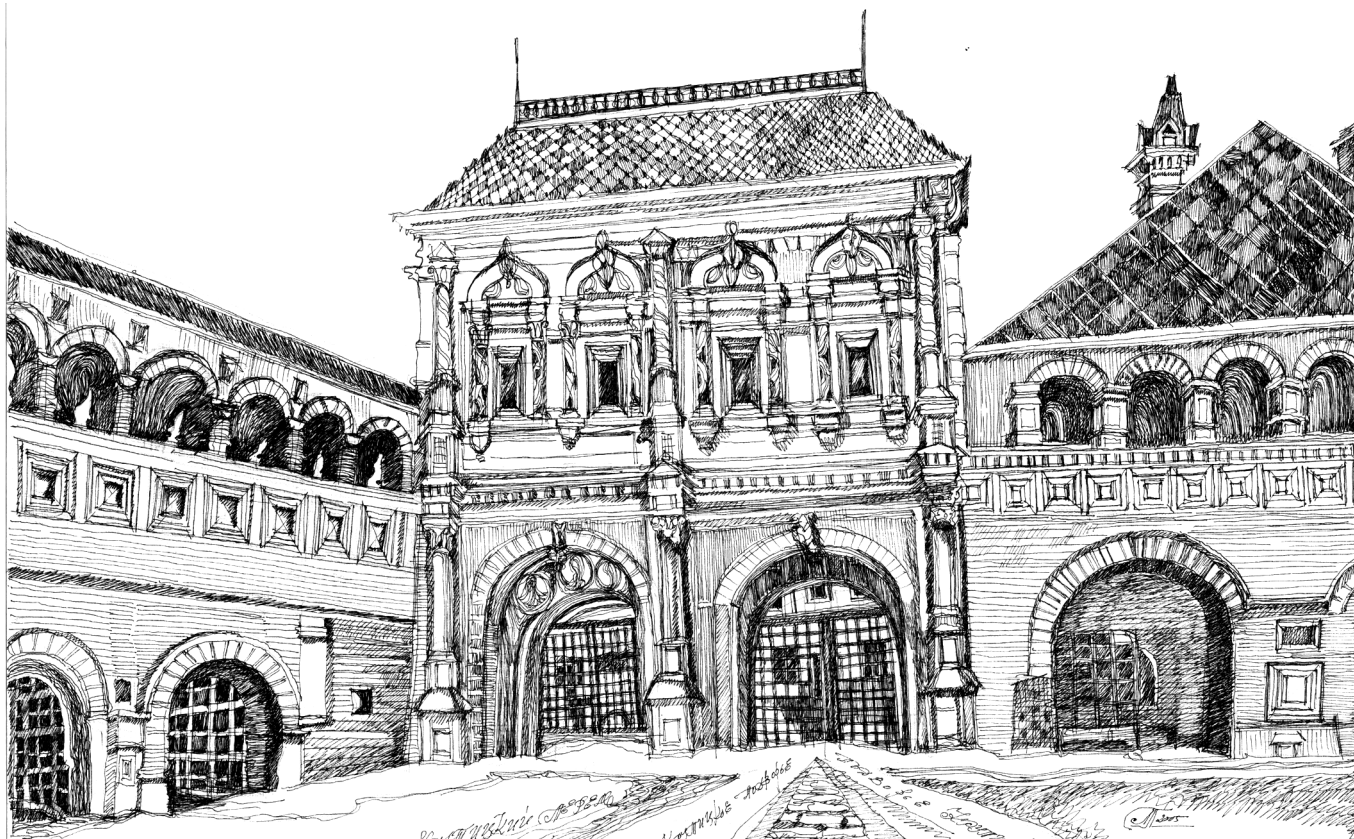
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Л.И. Павлова. Москва. Крутицкий терем. Рисунок, тушь, перо

