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Approaches to Classifying Building Innovations while Implementing Information Modeling and Project Management

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Abstract

The goal of transition to information modeling (BIM) in construction is to increase its efficiency by reducing project collisions, introducing innovations into projects and improving the interaction of participants in the investment and construction cycle on the basis of uniform digital models. Analysis of the Russian and foreign experience of BIM showed similarities in a number of areas such as the creation and use of digital libraries and databases for designing complex buildings. The authors associate prospects for the effective implementation of investment and construction projects in the emerging innovation and digital environment with the integration of BIM and project management methodology and with a territorial innovation management system throughout the object's life cycle. For the first time, on the basis of the international Oslo Guidelines, a classification of energy-saving innovations for a residential house project is given, calculations are made to evaluate their effectiveness at the operational stage, and approaches are formulated to create an innovative investment management system for building projects in the digital economy environment.

Keywords: Innovation; building information modeling; project management; classification of power-saving innovations.

1. Introduction

1.1. The relevance of building information modeling (BIM) for Russia

In the conditions of the transfer to a digital economy, the determinant is the competition between highly innovative manufacturers who subsequently have low costs, high quality of their products, and high output. The relevance of the innovative path of development is currently obvious for Russia, whose technological level of the economy is far behind the world leaders, with only the 15th position by the level of scientific research activity [1].

The state policy in this field is based on the Strategy of Innovative Development of the Russian Federation for the Period until 2020, approved by Order No. 2227-p of the Government of the Russian Federation dated December 8, 2011 [2]. Implementation of this strategy as well as the President's Decree No. 596 dated May 7, 2012 “On the Long-Term State Economic Policy” [3] is meant to change the structure of the country’s economy and increase the share of highly technological products by 30%, while the share of enterprises implementing technological innovations should reach 25% by 2020.

Currently, the share of science intensive Russian products in the global market is substantially lower than that of the developed countries, and the energy intensity of the GDP is by 40% higher than theirs. Energy saving in construction is a priority direction of innovation policy; it ensures reduction of energy consumption during the operation of constructed buildings and structures. For example, the energy efficiency and sustainable use of natural resources were included in the list of critical technologies of Russia by President’s Decree No. 899 dated June 7, 2011 [4]. The cost-effective use of resources associated with the organization of lean production, use of recyclable materials, waste refinement is of equal significance. Implementation of innovations, such as light-weight structures, nanomaterials, composite materials, surrogates of steel and cement is very promising and assumes significant effects when combined with the use of information modeling, being the subject of this study.

1.2. Dimensions of BIM

The information model of a facility in the context of project management cannot have less than five dimensions:

- three dimensions contain information on the spatial parameters of the capital facility, that is, its content;
- the fourth dimension includes the time characteristics of the project;
- the fifth dimension provides the cost estimates of the project as a whole, as well as of its individual components and resources.

Innovative development in construction is primarily associated with the use of new types of resources; therefore, it is expedient to create such classifiers that will evaluate the impact of new solutions on the key project parameters: its quality, timing, and cost [5–8].

It is possible to introduce more dimensions into the information model, depending on the management tasks to be solved in the process of creating and using a capital facility during its life cycle. An example of such a task can be:

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- the construction of a system of interaction between participants in the investment and construction process, including the auditing and supervisory bodies,
- improvement of the energy efficiency,
- improvement of environmental friendliness, introduction of green materials and technologies [9].

1.3. International classification of innovations according to the Oslo Manual

The implementation of the BIM technologies with account of the principles of the innovativeness of the investment and construction project management system required studying the quality content of building innovations and their distribution over the life-cycle phases of the facility, where their implementation is possible, most expedient and efficient, depending on the type, level, focus, and radicality and taking into account the beneficiary's interests.

In accordance with the classification of the Oslo Manual [10], there are *four basic types of innovations*:

- product innovations,
- process innovations,
- organizational innovations,
- marketing innovations.

They can cover different activities (processes associated with the implementation and propagation of innovations) of an organization:

- implementation of a new product or marketing improvement of its design,
- implementation of a new or substantially improved technology,
- fundamental organizational changes in the company's operation.

A feature of innovations in construction is their sophisticated nature, which includes several classification characteristics, as well as the property to be effective throughout the life cycle of the investment and construction project. At the same time, the greatest effect is brought mainly by technological innovations, the development and implementation of which begins at the stage of the facility design development.

2. Application of BIM in Russia

State Codebooks on the building information modeling series

Attaching great importance to the development of the building information modeling, the Ministry of Construction of the Russian Federation commissioned a series of Codebooks on the building information modeling, including:

- rules for the work organization by production and technical departments;
- descriptions of the information model components;
- exchange between information models of facilities and models used in software suites;
- development of project plans implemented using the information modeling technology in different phases of the global life cycle, including rules for the application of information modeling in re-use projects and in association with them;
- requirements for the formation of information models of capital construction facilities for the operation of apartment buildings based on re-use projects [11].

State standards of the Building Information Modeling series

The Ministry approved the following state standards of the Building Information Modeling series:

- GOST R ISO 29481-1-2010 "Guidelines for the Delivery of Information. Methodology and Format";
- GOST R ISO 16354 "Guiding Principles of Knowledge Libraries and Facility Libraries";
- GOST R ISO 12006-2017-02-20 "Model of the Construction Work Data Organization";
- GOST R ISO 12911-2017-03-21 "Key Provisions for the Information Modeling Standard Development";
- GOST R ISO 22263-2017-02-28 "Model of the Construction Work Data Organization. Structure of Project Information Management."
- GOST R "Information Modeling in Construction. Requirements for Operational Documentation of Completed Construction" standard is currently being prepared for approval [12–15].

Thus, the relevant task is the integration of innovative development processes into the construction project management system with account of the digital environment requirements.

3. Analysis of the BIM application efficiency

The analysis of the best practices of the BIM application was performed based on the examples of the construction of sophisticated unique objects abroad and in Russia. BIM's technology helped:

- to improve communication with customers, contractors and other project participants;
- to mitigate the risk of possible conflicts with local residents and municipalities;
- to reduce financial costs and save time;
- to draw and optimize construction schedules that take into account the interests of a large number of project stakeholders to a maximum extent (For example, when working on infrastructure projects and there is a need to block roads) [16].

Many foreign experts believe that software is only 20% of the whole BIM technology, and 80% are the processes of designing, interaction of the participants, search for coordination of mutually acceptable solutions, etc. [17,18].

The Shanghai Tower

According to the designers, the Shanghai Tower was built using design documentation of significantly higher quality, which resulted in saving about $16 million due to eliminating errors at the design stage. However, the improvement of a construction facility quality involves not only eliminating technical problems, but also a more effective placement of structures, mutual arrangement of high-rise cranes, which played a key role in the tower erection. The BIM model was used to design the engineering systems and structures for all floors of the building, enabling the builders to identify and subsequently eliminate 200~300 construction collisions [19].

Dongdaemun Design Plaza in Seoul
Specialists of Samsung C&T chose to use the BIM technology in the construction of the Dongdaemun Design Plaza in Seoul due to the complex geometry (Fig. 1).

Fig. 1. Dongdaemun Design Plaza in Seoul [20]

It was impossible to match the frame details and the junctions of the metal structures. The Tekla Structures software suite was used to develop three-dimensional models of the structure, enabling the builders to accurately combine 45.133 panels of irregular shape, comprising the outer walls of the building. The information model of the facility provided the company with the list of construction materials, precise design and erection drawings. Tekla Structures was used to place orders for building materials, which were delivered for installation according to the work schedule. In addition, crane lifting work was planned using the information model, thus saving time and money. Thanks to Tekla Structures, the Dongdaemun Design Plaza project was completed on time and within the budget [20].

Projects of JSC Design Bureau of High-Rise and Underground Structures in St. Petersburg
In Russia, JSC Design Bureau of High-Rise and Underground Structures (JSC "KB ViPS") in St. Petersburg has gained a vast experience in the design development based on information modelling. The company took part in the construction of the Zenith Arena with a rolling field and inclined retractable roof, the Mariinsky Theater renovation (including the construction of a building for the new stage), and the theater in Perm. The high-rise commercial Lakhta Center of Gazprom, shown in Fig. 2, will be the largest facility built by the company.

Fig. 2. High-rise Gazprom business center in St. Petersburg [21]

Description of the building:

- This building will be the highest one in the city and the second highest one in Europe, next to the Ostankino TV tower in Moscow.
- The height of the building including the spire will reach 462 meters and the total weight of the tower with all the infrastructure, glass, furniture, and people will be 670,000 tons.
- The area of one office floor is from 668 to 2060 square meters.
- The customer and investor of the project is Gazpromneft; the design was developed by the British architectural bureau RMJM (Robert Matthew Johnson Marshal).
- The general contractor is the Turkish company Renaissance Construction.
- The information modeling is carried out by JSC “KB ViPS.”
- In order to achieve a better energy efficiency and architectural expressiveness, the facade of the building is made of 16.505 multi-pane glass units, weighing up to 700 kg, in the form of nonrecurring parallelograms with a concave-convex surface, each of which required precise digital 3D matching with the frame and modeling of the hanging assemblies using the BIM.
- The hanging assembly is a unique innovative solution and allows reducing the stress and the weight of the enclosing structure.
- Another innovation is the unprecedentedly large-volume and fast continuous concreting of the foundation on water-saturated soils in a pile-caisson mold, with special chemical additives, which made it possible to avoid using numerous deformation-shrinkage seams.
- The third innovation is the development of a large-span arched spatial roofing in the stylobate part of the building, using prestressed bolt-ups in the floor to reduce the arch thrust stresses to zero [21].

Thus, information modeling as an element of digital technologies allows stepping up the construction to the next technological level, changing the design process, improving its quality by reducing the number of errors and collisions in the interaction of project participants. It improves the control over supplies and costs which results in a lower construction cost and shorter duration. At the same time, it should be noted that the BIM is both a technological and organizational innovative solution.

Statistical accounting and analysis of building innovations in Russia
Records of technological innovations in the Russian Federation have been kept since 1994 and environmental innovations — since 2008 under the Rosstat form No. 4 “Information on the Innovation Activity of the Organization” (large and medium-sized organizations) [22]. According to these data, the share of industrial organizations, including those producing building materials and structures, that have been implementing technological innovations from 2000 to 2012 in the economy was 10.6–9.9%. The construction sector has the index of changes in the availability of small-scale mechanization means, which can be considered as one of the directions for introducing technological innovations. In comparison with the previous

year, this index exceeded 200% in 2016 and 47% in 2017 in Moscow, while the number of organizations who did not possess construction machinery and mechanisms decreased from 10% to 6% in 2017. As for the service life of the mechanization means, the total reported value in construction fluctuated between 6% and 11%, which indicates a high degree of depreciation.

Thus, we can state a very low and unstable level of innovation in the construction industry and, accordingly, insufficient efficiency of the existing innovative system of investment and construction project management. Information modeling can help eliminate barriers for the diffusion of innovations in construction by making it possible to quickly opt for a new solution and justify the project investment with account of the implemented innovations. The objective is to include in the innovation descriptions the necessary and sufficient technical, economic, environmental, and other parameters for decision-making by the project stakeholders at all stages of the life cycle under the conditions of information modeling for the purpose of sustainable development of the capital facility [23–28].

State programs of innovative development of the economy in Russia

- *Innovative Russia-2020 Program*:

The main objectives of this program are the formation of an infrastructure and territories for innovative development, elimination of obstacles and gaps between science and business. Acceleration of the innovative development of the construction industry is associated with its transition to digital methods in accordance with the BIM technology implementation roadmap [29].

- *The Strategy of Scientific and Technological Development of the Russian Federation, approved by Decree of the President of the Russian Federation No. 642* [30] *dated December 1, 2016:*

According to this strategy, innovative development requires implementing the advanced digital, intelligent production technologies, developing tools for supporting research and creating an effective system of technological transfer of innovations. The key elements of innovative development in the economy are digital technologies and the system of innovation management at the level of enterprises and projects. The innovative and investment-construction activities serve as the development basis for all sectors of the country's economy and are also of project type in their essence. Therefore, the transition to a new technological structure of the economy should be based on three groups of principles: digital, innovative, and project-based. At the same time, the BIM information modeling should be considered as a new effective digital tool for the diffusion of building innovations.

- *The Instruction of the President of the Russian Federation of July 19, 2018:*

This Instruction provides for a transition to the management of capital construction facilities' life cycle by implementing information modeling technologies and applying standard management system models in its individual phases, including the design, construction, operational, and utilization models.

These will be applied as a priority to socially significant projects with the approval of performance indicators for management systems. One of the key indicators and critical technologies is power saving, which is the subject of a more in-depth study in this research.

Analysis of the Moscow system of building innovation management

We have analyzed the functioning of a multilevel territorial and branch system of innovation management in the building industry of Moscow.

Innovative solutions in this system go through a number of stages, such as:

- ✓ selection of innovations developed by scientific organizations and enterprises;
- ✓ their inclusion in the information resource of the Moscow Territorial Construction Catalog (MTCC);
- ✓ the development of organizational and technological publications and cost estimate documentation;
- ✓ implementation of the Targeted Investment Program in the urban order projects;
- ✓ diffusion into commercial projects in subsequent periods at other construction sites and types.

The functioning of the system is based on the management by objectives; 18 urban programs have been developed in Moscow and are in effect in all branches of the city's economy. For example, the Urban Planning Policy provides for the development and implementation of the main city development directions with account of the scientific and technical policy and innovative development of the construction complex, which implements the general state urban policy in the city of Moscow with the aim of creating a favorable urban living environment. Since the main management tool is MTCC, **Fig. 3** shows its structure in 2012–2017.

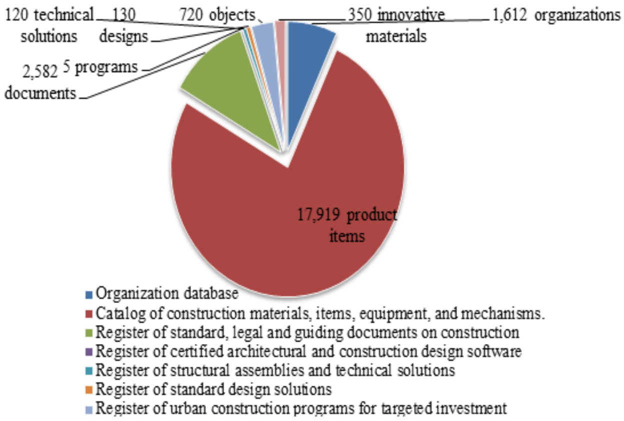

Fig. 3. The Structure of the Moscow Territorial Construction Catalog

An analysis of the provided data shows:

- that on average, up to 50 innovative construction materials are selected per year for their implementation into the urban construction programs.
- 17 technical solutions are selected for implementation in 720 projects for the urban order construction, which is clearly insufficient. In this connection, the Order of the Government of Moscow dated February 09, 2016, No. 46-RP "Measures to Develop Competition in the City of Moscow" established higher standards for the procurement of innovative, high-tech products: 12% in 2017 and not less than 15% of the total volume of purchases of each customer by 2018 [31]. To ensure the compliance with these indicators, a citywide List of Innovative, High-Tech Products and Technologies, including those for construction, is developed in Moscow.

At the same time, in order to accelerate the implementation of innovations, it is important to develop of territorial cost estimate standards for innovative solutions, which are essential for the innovation implementation at the city's construction sites.

- After the development of standards for an innovative product or technology, they are included in the MTCC Register of Innovative Technologies and Technical Solutions.
- Particular attention is paid to product and technological power-saving innovations, including ventilated facades, efficient heaters, individual heat points, heating appliances with automatic heat supply control, etc.
- Other examples of innovative solutions include the remaining formwork for monolithic concrete, the technology of forming prefabricated reinforced concrete products on magnetic carriers, the use of chemical additives to increase the strength of concrete, etc.
- A relevant task at the present stage is the integration of the existing long-term experience in the use of MTCC technologies in the digital environment for managing investment and construction projects.

Phases of the facility's life cycle for the innovation implementation

In the Russian construction industry, the design of capital construction facilities is developed in three stages and innovations can be implemented at each of them. When switching to project management, these processes begin already at the very start of the design development and continue to a full extent during its planning and implementation, preserving continuity, but at the same time increasing the volume and efficiency of innovative solutions.

1) *The first (pre-design) phase* includes:

- development of the town-planning;
- layout and arrangement solution in the form of a concept;
- reference design;
- town-planning solution plan for the land plot;
- justification of investments.

The choice of inefficient solutions or the presence of errors at this stage can cause significant losses for the investor and the developer [19].

2) *The second phase of the project documentation development* includes:
- layout and arrangement;
- constructive, engineering solutions;
- cost estimations;
- basic solutions on the organization of the facility construction.

3) *The third phase* includes:
- development of the working and technological documentation for the construction of the facility by a real contractor with account of its technological capabilities.

Practice knows the rule of "five": 5% of errors in the project lead to fivefold construction losses and even higher operation ones due to higher power consumption, additional repairs, and other losses. In this regard, information modeling creates the conditions for a quick analysis of a large number of design solution options and selection of the best one of them for the given parameters. At the same time, as indicated earlier, errors and collisions are quickly eliminated [24, 32].

During the construction and installation phase, an information model is developed for a real contractor who can implement the innovative solutions simultaneously with the design development process or during the construction, affecting its resource intensity, but the estimate does not automatically change, a transition module is needed to allow for the cost of innovation. The same applies to the technological design development phase: when introducing new technology, construction machines and mechanisms, it is possible to predict a change in the labor intensity of work and the cost of operating machines and mechanisms, as well as the timing of the construction, affecting architectural and design solutions in some cases, which also leads to a change in the project cost.

For example, the studies carried out at the Department of Project and Program Management of the Plekhanov Russian Power Engineering Institute showed the possibility of obtaining an economic effect through the use of the BIM at the stage of the construction process development for the nuclear power plant block, equal to 16% of the estimated cost, by replacing one heavy 1000-ton crane with four smaller cranes, subject to a change in the design of the reactor unit's roofing [33].

Effects from the introduction of the BIM

A study based on Autodesk materials and with account of the foreign experience reviewed made it possible to identify and classify the effects obtained by 90% of companies from the introduction of the BIM as a technological and organizational innovation [17]. Classification of effects of innovations and their distribution over the life cycle of a capital facility is important in the management system, not only for determining their nature and magnitude, but also for the recipients of these effects to make investment decisions [34, 27].

The effect of the innovative BIM technology manifests itself at the construction stage in a reducing number of errors and work time, and the advantage at the operational stage of the facility will be a rapid search for information on the facility and its reliability, in particular, for energy efficiency associated with the engineering systems of the building.

Application of innovative solutions at the early stages of the facility's life cycle ensures the best economic advantages to an investor or a developer, optimizing or reducing investments; the developer improves the design quality and shortens the design development time; builders obtain the opportunity to assess the future cost of construction more accurately and control their costs [35]. At the stage of conceptual design development, the design organization can calculate the energy efficiency and other parameters of the building preliminarily and manage a large number of design changes.

The management problems associated with the process of implementing investment and construction projects can be solved with the suggested classification of effects, depending on the stage of the capital facility's life cycle and based on the impact on the project's controllable parameters, terms, cost, and quality, as shown in **Tab. 1**.

In addition, the division of effects by their types and recipients will be also relevant. At the same time, it is expedient to group the types of effects into four categories: economic, ecological, social, and energy effects.

The effect recipients are the investor, developer, contractors, suppliers of materials and equipment, operating organizations, property owners, and state authorities.

Table 1. Types and magnitude of effects of the introduction of the innovative BIM technology (according to user estimates)

Sq.No.	Indicators of the project	Effect magnitude	Life cycle stage of the facility	Impact on indicators of the project	User (company)
1	Error reduction in the project cost planning during the facility construction phase	up to 5–7% compared to 20% earlier	Construction	Cost	Etalon Group of Companies (LenSpetsSMU), St. Petersburg
2	Significant reduction in the number of the builders' requests for design documentation amendments	The processing had taken considerable time, the request became rare	Design development	Timing, Cost, Quality	Legion-Proyekt, Chelyabinsk
3	Higher efficiency and productivity of the engineering departments	by 60–70%	Design development	Timing	Legion-Proyekt, Chelyabinsk
4	Reduction in the time for issuing the design documentation	by 25–35%	Design development	Timing	NPF Metallimpress, Nizhny Novgorod
5	Successful organization of joint work	Increased coherence of decision-making and higher performance	Design development, construction	Timing, Cost, Quality	NPF Metallimpress, Nizhny Novgorod
6	Elimination of errors during the engineering survey phase	2–5% of the cost of work	Pre-project	Timing	Bamstroymekhanizatsiya, Sochi
7	Improved energy efficiency, environmental friendliness of the facility		Operation	Quality	AECOM Russia, Moscow
8	Reduction of the cost of the investment and construction project in the construction phase, depending on the facility being built	by 10–30%	Construction	Cost	AkademStroyProyekt
9	Reduced cost of changes to project documentation in comparison with the 2D design development	by 40–70%	Design development, construction	Cost	AkademStroyProyekt
10	Reduced initial construction costs and the capital facility operation costs	33%	Construction, operation	The facility's life cycle cost	United Kingdom. Construction 2025 strategy
11	Reduced total time from the project commencement until its completion (for new construction and renovation)	50%	Design development, construction, operation	The facility's life cycle duration	United Kingdom. Construction 2025 strategy
12	Reduced greenhouse gas emissions from the capital construction facilities	50%	Operation	Quality	United Kingdom. Construction 2025 strategy
13	Reduced backlog in exporting construction products, materials, and services	50%	Construction	Quality	United Kingdom. Construction 2025 strategy

Thus, the main effects manifest themselves in the elimination of errors and collisions in the early design phases and consequent improvement of the facility quality at subsequent stages; improved coordination between architects, designers, and engineers within the design organization, as well as with builders and subcontractors; and the control of terms and cost. At the same time, innovative solutions can arise and be implemented at all stages of the facility's life cycle management. This fully applies to innovations that contribute to improving the energy efficiency of capital facilities.

Power-saving innovations

Approaches to the classification of construction innovations were formulated on the example of the innovative solutions in the field of power saving as the most relevant aspect for both Russia and other countries [36, 23, 37]. The Insolar-Invest Group of Companies performed research to develop power-saving innovations, including improvement of the thermal protection of the enclosing structures, automatic regulation of the heating system, ventilation valves for the exhaust air disposal, and took other actions in the residential building to reduce power consumption from 250 kWh/m^2 per year in 2010 to 158 kWh/m^2 per year in 2017. **Fig. 4** shows the power consumption and structure by the load types [38].

The promising innovative solutions for a pilot residential house in Krylatskoye (Moscow) have been developed. They will reduce power consumption to 99 kWh per year per square meter of the total area, i.e. by 37%, thanks to using an innovative hybrid heat supply system, which utilizes the heat of the exhaust air and sewage emissions, as well as the ground heat pumps for hot water supply. In this case, it is possible to completely abandon the centralized heat supply

(0 kWh from external heat system) for the purposes of hot water supply and significantly reduce the operating costs with relatively low capital investments. The values and structure of power consumption are shown in **Fig. 5**.

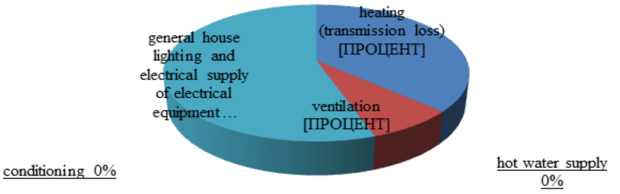

Fig. 4. Energy efficiency of innovations for the specific energy consumption of 158 kWh per year per square meter of the total area of a residential building [38]

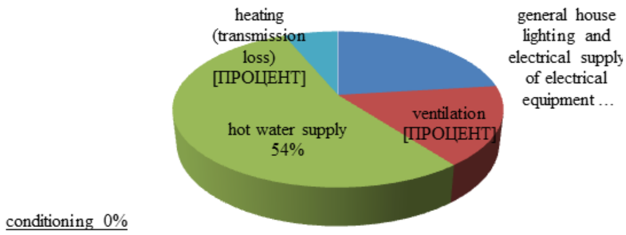

Fig 5. Energy efficiency of innovations for the specific energy consumption of 99 kWh per year per square meter of the total area of a residential building [38]

Table 2. Classification of innovations and their effects in the management of investment and construction projects (on the example of innovations enhancing the energy efficiency of residential buildings)

Innovation type		Life cycle phase of the capital facility					Innovation effect	Recipient of the effect
According to the Oslo Manual	**Under the Digital Econo-my 2035 program**	**Pre-project phase**	**Project phase**	**Working document-tation**	**Construction**	**Operation**		
Product innovations	**3D Printing Additive technologies**	Layout and arrange-ment solutions for ultra-low power consump-tion, the “passive house” technology	Effective sprayed heat insulation of a ventilated facade	Air recuperator for the facade wall	Use of the left-off wall formwork	Certificate of the energy efficiency class of the house	Reduction of project terms	Developer Contractor
Process innovations	**Additive technologies Automation Informatization**	The use of non-traditional and renewable energy sources for the heat supply of the house	The hybrid heating system (HHS) with heat pumps and recupe-rators	The use of automatic HHS control techno-logies with remote access	The apartment-by-apartment automatic heat metering system	Payment for consumed power resources according to the indications of apartment-level automatic accounting systems	Reduction of the project cost	Investor
							Reduction of the cost of utilities	Consumer
Organizational innovations	**Informatization**	Transition to local Smart Grid heat supply networks	Implementation of the BIM for the selection of energy-efficient solutions	BIM modeling and visualization of construction and technological solutions for the work performance	Change-over from steaming prefabricated reinforced concrete to electrical heating of wall panels Modification of construction machinery to use environmentally friendly fuels	Audit of the energy efficiency of residential buildings Exemption from property tax of a class A++ energy-efficient facility	Reduction of the project cost	Investor
							Environmental effect	State
							Reduction of the design time	Designer
							Reduction of the costs and collisions	Contractor
							tax cuts	Consumer

Marketing	**Informatization**	Survey of residents of the apartment buildings for power-saving measures	"Green" certification of the project to attract customers	Refusal to replace high-quality power-saving equipment and materials with their cheap analogs	An incentive plan for achieving municipal economic efficiency of power saving	Discounts for electricity for owners of active buildings with photovoltaic panels	Reduction of the project cost Ecologically clean electricity, saving of municipal investments	Investor State

Multicriteria classification of efficient construction innovations

The creation of an innovative system for managing investment and construction projects should be based on three groups of principles: digital, innovative, and project-based ones. In accordance with these requirements, we propose a multicriteria classification of efficient construction innovations with a view to further digitization of their parameters, taking into account the domestic standards of information modeling. The classification is provided on the example of energy-efficient innovations and presented in **Tab. 2.**

To integrate the proposed innovations into the construction project in the context of information modeling, it is necessary to solve several problems, namely:

1) Unification and digitization of effective innovative design solutions, creation of appropriate libraries for all sections of the project.
2) Development of enterprise-level protocols or standards on interaction between the project participants in the technology of information modeling, proposals for the use of such protocols in the project management system and standard models of the system of management of the project, construction, operational and utilization phases of the capital facility's life cycle with approval of performance indicators.
3) Typification of the visual models and parameters of the innovative solution, creation of a digital model of the innovation development in all phases of the facility's life cycle.
4) Development of the procedure for the formation and codification of costing standards for innovative design solutions, taking into account the design phase.
5) Establishment of a self-regulating organization (SRO) of the participants in the BIM implementation in construction in order to coordinate the interaction of design organizations with the customers and contractors.

4. Conclusion

Information modeling in construction enables the acceleration and enhancement of searching, justifying, and introducing innovations of all types in the life cycle of a capital facility. The creation of the BIM platform is becoming an important factor for improving productivity in the industry, which is currently medium-tech and low-innovative and requires a new approach. Thus, the task of integrating innovation development processes into the system of managing investment and construction projects, taking into account the requirements of the digital environment, becomes urgent.

The lack of an effective regulatory framework for information modeling in Russia is a key problem. Despite the development of the Code of Regulations and State Standards GOST R (ISO) of the Information Modeling in Construction series, the development of organization standards by some design organizations, the BIM technology implementation is largely constrained by the unreadiness to use digital models by facility construction customers and contractors [39,40]. This task must be solved within the framework of the new approach by creating a regulatory document on managing the implementation of BIM in investment-construction cycle organizations and creating a self-regulating organization in this area.

The proposed approach to classification of innovations allows solving a wide range of management problems with account of the phases of the facility's life cycle, types of innovations, descriptions of effects and their recipients. The example of energy-saving innovations shows that under the conditions of the BIM implementation, it is possible to further reduce the cost of energy resources at the operational stage to 37%. The economic efficiency of power-saving building innovations should be calculated with the Insolar-NPV.2014.01.01 software (Certificate of Compliance No. POCC RU.SP15.N00787) developed by the Insolar-Invest group of innovation companies.

The next step should be the creation of a territorial catalog of innovations according to the type of digital development of the Moscow Territorial Construction Catalog.

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