

# Engineering management technologies of increasing energy efficiency processes in the investment and construction projects

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**Abstract:** The article deals with the problems of using the energy-efficient materials and engineering technologies during the construction of buildings and structures. As the analysis showed, one of the most important problems in this sphere is the infringement of production technologies working with energy-efficient materials. To improve the given situation, it is offered to set a technological normal at the design stage by means of working out the technological maps studying the set and the succession of operations in details, taking in mind the properties of energy-efficient materials. At Don State Technical University (DSTU) the intelligent systems of management are being developed providing organizational and technological and also informational integration of design and production stages by means of creating the single database of technological maps, volumes of work and resources.

## 1. Introduction

The increase in energy efficiency of buildings and structures is rather an urgent problem for the Russian Federation, 80% of its territory is situated in difficult climatic zones with large temperature difference in winter and summer periods requiring significant energy costs. Energy consumption in our country is 2-2.5 times higher in comparison with Western Europe. Russia has a large underutilized potential of energy saving, which, by ability of solving the problem to provide the country with economic growth, is compared with production growth of all primary energy resources [1].

Energy intensity of Russian economy is rather high than that in the USA in counting by parity of purchasing power in Japan and developed countries of the European Union. Lack of energy can be a main factor of restraining the economic growth of the country. There are enough reserves of oil and gas in Russia, though increase in volume of hydrocarbon extraction and development of transport infrastructure need large investment. In European countries a special attention is paid to the problem of energy saving because of high prices for oil and gas. In Germany as a result of the NEH program a new market appeared – the market of energy-efficient houses. The fact is that, the houses, gone through the sanitation, receives energy passports in which the level of energy consumption is registered and recommendations for further house sanitation are given. Houses with optimal index are given green passports, houses with bad level of energy consumption are given – red. Not only, that banks perceive the happy passport as a background for clients' credit financing, but also this document increases the price for the house many times and makes the house attractive on the sales market and the rental property [2]. At present, in Germany 4 000 houses are considered passive and more and more new houses are



going through the certification in the Institute of the Passive House in Darmstadt. The certificate makes the building prestigious and increases its price.

## 2. Experimental section

Energy Performance of Buildings Directive, adopted by countries from the European Union in December 2009, demands that all the new houses are near the energy neutrality [3].

Transition to the market economy in our country and a significant increase in fuel prices make the questions of energy saving very urgent.

A new impulse to the development was given by the Federal Law №261-FL, 23.11.2009 “About the energy saving and increase in energy efficiency”. The main tasks of this law are [4]:

- Transition to the effective energy-efficient architectural and construction systems and to the engineering equipment in the housing and communal construction;
- Creation of the economic mechanism stimulating the energy saving process.

These trends are reflected in the requirements for new housing: improving comfort and economy in housing operation based on wide use of smart materials and engineering equipment, automation of life processes and etc.

The decision of the mentioned tasks is possible by means of using the engineering technologies at all stages of the life cycle of the investment and construction project (ICP), which is quite an urgent task for Russian innovation system and economy as a whole. Due to their specific activities, the engineering companies of the construction complex, on the one hand, are the main scheme of the technological chain of creating the competitive construction products; on the other hand, they perform functions of direct modernization agents, eliminating the existing infrastructural failures in the innovation cycle.

Engineering technologies in the ICP management focus on providing a full construction project, that implies the management to realize the ICP by stages, not as a set of technologies, badly combined both on the organizational and information levels, but as one single [5]. In the conditions of market relations, while creating the construction products in the housing construction sphere it is necessary to consider the whole range of requirements for consumers besides architectural and artistic expressiveness [6].

The task consists of the fact, that the evaluation and making any decisions of organizational and technological character should be performed considering not only the term and the quality of the construction object, but also the price criterion observing the necessary values of energy efficiency, safety and comfort (Table 1).

**Table 1.** The main criteria and quality values of low-rise housing

| Name of indicator                             | Definition   |
|---|--|
|   | Safety   |
| Service time                                  | Calendar duration of building's operation (its main structures) before full physical wear and tear               |
| Fire resistance                               | Russian Standards SNiP 2.01.02-85* and NPB 106-95  |
| Seismic resistance                            | Russian Standard SNiP II-7-81 *  |
| Environmental safety:                         | Degree of ensuring the standardized accommodation conditions and human health protection against negative impact |
|   | Comfort  |
| Total area of residential building (house)    | Russian Standard SNiP 2.08.01-89*  |
| Thermal protection level of building          | Russian Standards SNiP II-3-79* and STO BDP-4-94   |
| Noise protection level of residential area    | Russian Standard SNiP II-12-77   |
| Natural light level of residential area       | Russian Standard SNiP 23-05-95   |
| Air exchange multiplicity of residential area | Russian Standards SNiP 2.08.01-89* and SNiP 2.04.05-91 *   |

In Russia the introduction of energy-efficient technologies in the sphere of construction face some difficulties:

- Russian builders' and clients' prejudices of using modern materials for erecting multi-storey and low-rise buildings, for example, lightweight cellular concrete instead of brick and heavy concrete;
- lack of implementation the energy passports for construction objects in practice as it is used in the European countries;
- existing opinion among clients – construction costs for energy-efficient houses are higher, than with using the traditional technologies;
- infringement of production technologies with using innovative materials;
- often low quality of energy-efficient materials produced in our country.

Declared value of energy efficiency at the design stage, does not often match with the value, registered during the process of built building exploitation.

From our point of view, one of the main problems of building the energy-efficient houses is the infringement of production technologies working with energy-efficient materials.

For example, when erecting buildings by technology “monolith-frame” the walling is made of energy-efficient materials: aerated concrete or foam concrete, but “the bridges of cold” are not localized, appeared in the intermediate floors, window lintels, what is more, there is no necessary soundproofing between floors which can become additional house warming element. When erecting walling of low-rise building made of concrete using a technology of a fixed formwork, they forget creating the forced ventilation which is reflected on the comfort of living. There is a large number of violations in technologies of using the tiled insulation based on styrofoam in many layered walling.

The reasons of production technologies infringement are the following:

- absence of technological maps for implementation of work with innovative materials;
- executors' intention to reduce costs by means of ignoring some operations;
- low qualification of workers.

To overcome this situation in the sphere of energy-efficient houses in the Russian Federation it is necessary to change the approach to the system of quality management of ICP.

The system of ICP management includes several lines and sub-lines of management [7,8,9]:

- client (developer) – general designer;
- general designer – sub-designers;
- client – general contractor;
- general designer – general contractor;
- general contractor – sub-contractors;
- contractors – suppliers of material resources.

### 3. Results section

Now the main task in the sphere of ICP management is to provide the integration of the project participants at management, organizational, technological and information levels.

Management integration is aimed at creation of the project management system at all stages of life cycle of ICP. It implies improvement of ICP participants' interaction (client-developer → general designer → general contractor → sub-contractor) by creating the system of consolidated responsibility for their final results both on the technical and financial levels.

The necessity of such an approach is explained by the fact that now all the main risks for the terms and the quality of products and also for the financial result are endured by the last participant of ICP project - general contractor construction company.

The system of ICP management, financed from the budget resources, is organized now in such a way, that practically there is no direct interaction of both a designer and a contractor, this interaction is realized indirectly through a client and they contact with each other only if there are disagreements during the general contractor's acceptance of PSD or during the work performance. It mostly happens because there are no financial resources on author's supervision in the client's estimate and practically

a designer doesn't control the quality of the made products, but in fact a general engineer of the project (GEP) must be a member of the team of the management project till the object is put into operation. If financing of the construction is realized from the budget resources, then if there are any mistakes in the working drawings, the designers are not eager to agree with them and the client takes the designer's side because making changes in the project documentation after the state expertise is a long process (45 days minimum). This, in its turn, leads to increase in terms and cost of work, which is not good for the client. That is why, the client offers the contractor to eliminate the mistakes in design from his own resources or in the costs item "unexpended expenses" in the contract.

At Don State Technical University (DSTU) the work on creation of the intelligent management systems of investment and construction projects (IMS "ICP") is being developed, including main participants of management of ICP at all stages of its life cycle (Fig.1).

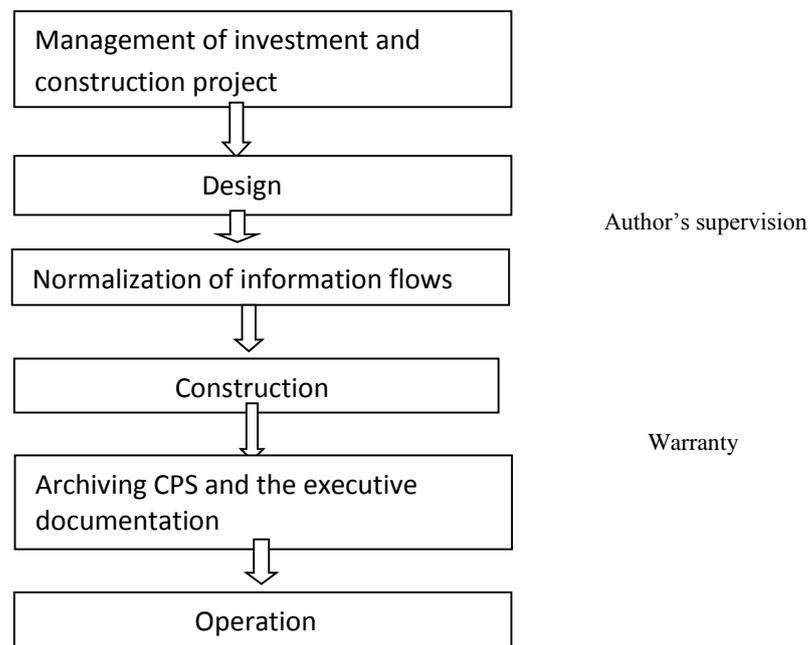
Research done within the framework of creation IMS "ICP" showed, that organizational and technological, information integration of design and construction stages is possible by developing DB volumes of work and resources, and good for both designers and builders. The connecting element of DB volumes of work and resources is DB – resources based on the classifier used at the design stages, construction and operation of buildings and constructions.

DB – resources (material, labour, construction machines and machinery) directly consists of resources classifier and information about resources' suppliers. Initial data for filling in the data of DB taken from WEB and from other information sources about manufacturers and resources' suppliers.

Resource Directory includes 2 levels:

Level 1 – resources class;

Level 2 – name and characteristic of a resource, average price, date of update. On this level there is DB of suppliers.



**Figure 1.** Principal scheme of management of investment and construction projects in Russia.

#### 4. Discussion section

Filling the prices of material resources (MR) in the directory is realized on the basis of a price-list of suppliers chosen from the WEB. Besides the following information is filled in the database of the directory:

Accumulation of information about prices for MR and among suppliers will allow:

- to analyze in dynamics for a given nomenclature group, region, review period;

- to use when calculating estimates, preparation of the offer at the stage of bidding and calculation of the planned cost price of the construction object.

To the resources class in the directory there are additional data characterizing:

- properties and application area of materials and structures;
- technological maps of work performance;
- calculators of work volume calculation and needs for MR per unit volume;
- estimated fragments for CE in accordance with the composition of work set in the technological maps;

Updated date, price, supplier (name, physical address and e-mail) etc.

Database of volumes of work and resources is built on hierarchical principle, considering the partitioning an object as by organizational and technological feature, used during the work performance as well as by spatial feature (space-planning), used at the design stage when developing the working documentation [8,10,11,12].

Principal scheme of database organization of volumes of work and material resources

In the database there are following levels of subordination:

- construction – a complex of technologically interlinked buildings and structures;
- construction object – as part of a construction;
- accounting stage – a set of constructive elements forming a finished part of a building, used in the system of management accounting and budgeting including calculations with a client;
- constructive element (CE) – part of a building or a structure chosen at the design stage for the purpose of its detailed description;
- work – one or some more technologically interacted processes necessary for making CE.

## 5. Conclusions

Working drawings and specifications are connected with CE, having a background information about needs for materials, semi-finished products and wares, used when making CE or when installing technological equipment. Set of works and succession of work performance and CE processes are realized and based on the technological maps.

IMS “ICP” allows to realize organizational, technological and information integration of participants of ICP by means of creation of database of technological maps (DB-TM) of work performance for new energy-efficient materials connected with their constructive elements and kinds of construction.

Creation of DB-TM will allow to make organizational and technological normal already at the design stage and to provide continuity of organizational and technological decisions, designing the project of construction organization, as well as the work performance project, that will allow to provide the system of effective construction control at all the stages of creation of the construction products and the set level of energy efficiency for both separate CE and the whole building.

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