Time and Cost Management in The Construction of Large Energy Facilities

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Abstract
The article deals with the problems of time and cost management in the construction of large energy facilities. The practical value of standards in the field of time and cost management in the construction of large energy facilities is often questioned by specialists in various fields of project activity. Practitioners at lower and intermediate levels often complain about the lack of clear and effective tools for solving specific problems in project management practice. However, the skillful application of standards can not only increase the likelihood of success for a wide range of diverse projects of large energy facilities with obtaining expected business values "at the output" of the project. The purpose of this study was to study the features of management terms and cost in the construction of large energy facilities. The objectives of the study included establishing links between the methods recommended by the project management body of knowledge (PMBoK) guidelines for determining the project budget and the methods used in practice for determining the cost of construction projects for large energy facilities, formalized in the current regulatory documents and state building codes of Russia. For this (according to the PMBoK standard), the basic methodological foundations of the project cost management process, its components and characteristic features were determined. The main stages of the life cycle of construction projects of large energy facilities, in which the cost of design work is assessed, are determined, the goals of such an assessment and the project participants who carry it out are determined. As a result, a complete methodological identity was established between the methods for assessing the project cost of large energy facilities recommended by the PMBoK standard and the methods for determining the cost of construction specified in the current regulatory documents in the construction industry in Russia.

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1. Introduction

Many respected experts in the field of project management share the opinion that project management standards were written by theorists for theorists, which in most cases almost completely deprives this literature of practical value and points of intersection with the realities of project management in the field of large energy facilities [1; 2]. The reasoning behind this approach is usually presented as follows. In practice, project managers of large energy facilities, especially those of lower and middle levels, have no time for theory. They need clear and effective tools to solve specific problems. But specialists usually do not find all this in many modern standards, such as the leading international standard of the Institute - the Guide to the Project Management Body of Knowledge (hereinafter - PMBoK) [4]. But the algorithms of managerial actions are not always defined there. For the main tools, only their names are often given without detailed descriptions, and there are no recommendations for choosing one method or another and linking to specific projects and industries. Specialized editions also do not significantly improve this situation [4; 5] and publications [6; 7], aimed at adapting standards to the practical needs of project managers and large energy facilities. The reason for this is that scientific publications do not always fall into the focus of attention of practitioners of large energy facilities for the same reasons as the standards themselves. However, PMBoK authors from among practitioners in project management have argued that this standard defines the knowledge and practices recommended for use in most projects and in most cases, which, when applied correctly, can increase the likelihood of success for a wide range of different projects, ensuring the output project of expected business values and results "[4, p. 2]. That is why the problem of research of the features of project management in the direction of time and cost management in the construction of large energy facilities is very relevant.

The purpose of the article is to establish links between the methods for determining the cost of work and the timing of projects for the construction of large energy facilities in theory, that is, the methods recommended by the PMBoK standard [3], and the methods used in practice for determining the cost of construction projects of large energy facilities, formalized in the current regulatory documents and state building codes of the Russian Federation.

2. Research methods

The article is based on the generalization, systematization and analysis of scientific literature on the problems of project management in the direction of time and cost management in the construction of large energy facilities [2]. To determine the practical value and universality of the PMBoK standard in the field of construction of large energy facilities, when conducting this study, the authors deliberately do not take into account the Appendix to the PMBoK Guidelines for construction projects [8].

3. Research results

Consider the theoretical and practical aspects of determining the cost of work and the timing of investment, construction and development projects of large energy facilities. According to the PMBoK standard [4, p. 231], project cost management is one of the key branches of project knowledge, including the processes required for planning, evaluation, budgeting, fundraising, financing, cost management and control, ensuring that the project is carried out within the approved budget. Within the framework of cost management, the standard distinguishes four components, two of which are the estimation of the cost of the project work and the determination of the budget. Cost estimation is considered as a process of approximate estimation of the monetary resources required to carry out the work of the project. Determining the budget is

the process of consolidating the estimated costs of individual operations or work packages to create an authorized baseline cost [4, p. 231]. One of the characteristic features of the project cost management process specified in the PMBoK standard is that the estimate of the cost of work is a forecast based on information known at a specific point in time about the estimate of the possible cost of the resources required to carry out the work of the project. That is why the accuracy of the project cost estimate is a variable that increases as the project progresses through the life cycle.

For example, in the project initiation phase, an estimate of the rough order of magnitude (ROM) in the range from -25% to + 75% can be obtained. In the future, as the project works and information on their cost becomes available, the final estimates can narrow the accuracy range from -5% to + 10% [4, p. 241].

Another key feature of the project cost management for large energy facilities specified in the PMBoK standard is the understanding that different stakeholders measure the project cost in different ways and at different points in the project life cycle [4, p. 233]. Therefore, further, based on the analysis of the life cycle of investment and construction projects (ISP) and projects of large energy facilities (CEP), we will establish the main points when the cost of these projects is assessed.

Discussion. In general, for ICP and CEP, researchers define the following phases of their implementation:

- analysis of economic feasibility and acquisition of a land plot;
- design;
- financing;
- building;
- operation and management [9 - 11].

The analysis of the economic feasibility of the ISP and CEP is usually carried out as part of the development of business plans and is carried out by the initiator of the project, which in most cases of the ISP and CEP is the contracting state. The main task facing the state customer of the CEP at this stage is the formation of a promising business idea and the assessment of its feasibility and economic feasibility. For this, information about the future service is collected and analyzed, the main directions and trends in the development of the industry are determined, a business idea is formed and its preliminary technical and economic assessment is carried out. Comparison of the cost of a project of large energy facilities with the expected income from its implementation serves as the basis for justifying its economic efficiency and feasibility. In the field of construction of industrial facilities, such as large energy facilities, the development of business plans is carried out on the basis of the Methodological Recommendations approved by the Ministry of Economy of the Russian Federation [8]. Although the concept of a project budget is absent in this document, according to the methodological recommendations at the stage of developing the production program, the need for initial investments is calculated, the directions for which investments are required and the amount of additional investments are determined. By comparing the need for additional investments calculated for the project and the sources of financing (covering) this need, the amount of the required additional financial resources is determined. The following sources of funding are considered:

- share capital, if an increase in share capital is expected during the period of implementation of the enterprise investment development project;
- attracted capital, if the use of long-term credits and loans, short-term credits and loans (with the exception of state financial support funds) is expected;
- other sources of funding.

The business plan also provides a rationale for investment in the enterprise and the sources of their receipt. Comparison of the amount of invested funds and the results predicted from this investment is carried out using special methods and tools, including: discounting and calculation of compound interest, calculation of indicators of the net aggregate cost of the project and the internal rate of return (internal marginal rate of return), dynamic (discount) payback period of the project.

As part of the development of a business plan, in accordance with the specified Methodological Recommendations [8], the analysis of potential risks of construction of large energy facilities is also carried out. However, within the framework of this analysis, it is recommended to provide information on the assessment of possible risks, sources and prevention measures, and possible insurance. Instructions on the need to take into account risks when determining the volume of project investments, which were laid down in the form of reserves for possible losses for accepted risks or in the form of management reserves for unknown risks, are absent in the Methodological Recommendations [12-13]. We also note that the stage of developing business planning according to the PMBoK standard is a pre-project stage, the results of which, together with other documents of the enterprise business case, are input data for the development of the project charter - the first official project document that formally authorizes the existence of the project and gives the project manager the authority to use the organization's resources in project operations. Consequently, business planning and everything related to it remains "out of the frame" for the PMBoK standard, in which the corresponding processes and methods of business planning are not considered.

The next stage in the life cycle of ICP and CEP is the design stage. This stage opens the investment phase of the project and usually begins after the decision to start the project is made based on the developed business plan. At the same time, the design of ISP and CEP should be understood as the development of a project management plan as the main document for planning project activities in project management, and the development of project documentation for construction. The development of a project management plan is carried out by the project team and its leader, and the project management plan by the PMBoK standard is defined as a document describing how the project will be carried out, how it will be monitored and controlled, and also closed [4, p. 713]. One of the main components of a project or program management plan is the cost management plan - a component that describes how you plan, structure, and control costs. As part of cost management, the project budget is estimated, which includes all funds authorized to carry out the project. On the basis of a certain project budget, a basic cost plan is drawn up - a version of the project budget distributed over time periods has been approved, which provides for reserves for possible losses, but does not include management reserves [4, p. 248].

The transition to the practical plane of ICP and CEP management, including the determination of their cost, forces us to turn to the main document according to which construction objects are created - design documentation. According to the definition of current regulations, project documentation, which is sometimes called design and estimate or design and construction, are approved text and graphic materials that determine urban planning, space-planning, architectural, structural, technical, technological solutions, as well as estimates of construction objects. 13, p. 4]. The need to assess the cost of a construction project for large energy facilities as part of the development of project documentation arises for the first time when determining the estimated cost of design work, which is usually indicated in the form of a rigid contract price in an agreement between the designer and the construction customer. Determination of the cost of design, survey and scientific-design work for the construction of large energy facilities, as well as the examination of design documentation for the construction of facilities implemented in the territory of the

Russian Federation, is carried out by the designer. The cost of design work is determined by applying the average percentage indicators of the cost of design work to the cost of construction work, and for industrial facilities - to the cost of construction work, taking into account the cost of equipment. To determine the cost of developing design documentation for the construction of large energy facilities, you must first determine the cost of construction. In this case, the cost of construction work is determined by the designer, taking into account the category of complexity of the construction object on the basis of the cost indicators of analogous objects or aggregated averaged indicators of the cost of construction per unit of capacity. The choice of an analogue object is carried out on the basis of ongoing construction projects, the design documentation of which is approved in accordance with the established procedure. In order to ensure the maximum correspondence of the indicators of the analogue object to the indicators of the designed object, it is necessary to comply with the conditions of comparability.

The designed object and the analogue object should be erected in a comparable form in terms of the main indicators and initial data:

- in terms of space-planning indicators;
- according to the constructive scheme (system);
- according to the conditions of construction (seismic zones, counterfeit territories, subsidence soils, displacement zones, etc.);
- by natural and climatic loads and impacts.

In the absence of completed projects of analogous facilities for the construction of large energy facilities, the estimated cost of design work can be calculated using the cost indicators of the projected facility with its subsequent refinement based on the cost of construction, confirmed by an expert report, which is stipulated by the contract. In this case, the contract price is set dynamically in the contract between the designer and the customer. The cost of design work may include funds to cover the risks associated with the performance of work, the amount of which depends on a combination of a number of factors (design stage; type of construction; technical and technological complexity of the construction object, type of contract price under the terms of competitive bidding).

Now let's return to the "theory" and compare the method of determining the budget of the construction project of large energy facilities, recommended by the building codes at this stage, with the methods given in PMBoK. To estimate the cost of work, one of the recommended PMBoK methods is the method of estimation by analogs. The analogous valuation method is a method for estimating the duration or cost of an operation or project using historical data from a similar operation or project [4, p. 713]. When estimating cost by analogy, values or parameters taken from previous projects that were similar to the current project are used. Values and parameters of projects can include (but are not limited to): content, cost, budget, duration, and measurement results (eg, size, weight). Comparison of these values or project parameters is the basis for assessing the same parameters or measurements in the current project [4, p. 244]. As you can see, the practically applied method for determining the cost of design work completely coincides methodologically with the method of cost estimation recommended in the "theoretical" standard.

The next step at the same design stage, when the need arises again to determine the cost of construction of large energy facilities, is the development of estimate documentation as one of the components of the design documentation for construction. The cost of construction at this stage is determined by the designer in accordance with GOST R 21.101-2020 - “System of design documentation for construction. Basic requirements for design and working documentation” [20]. This standard is mandatory in determining the cost of construction of facilities under construction at the expense of budget funds, funds of state and

municipal enterprises, institutions and organizations, as well as loans provided under government guarantees. According to this regulatory document, the pricing system in construction is based on regulatory and design indicators and current prices of labor and material and technical resources. The normative indicators are resource element estimate norms. Resource element estimate norms are designed to determine the amount of resources required to perform various types of construction work, installation of equipment, repair and construction, restoration and restoration and commissioning works, to determine the direct costs of construction costs. On the basis of these norms and current prices for labor and material and technical resources, on the basis of instructions for the application of estimated norms, direct costs in the cost of construction are determined [14, p. 464].

These construction costs include [14]:

- general production costs;
- expenses for the construction and dismantling of the title temporary buildings and structures or the adaptation and use of existing and newly constructed buildings, buildings and structures of a sustainable type;
- the cost of construction work in the winter;
- the cost of construction work in the summer;
- other expenses of the customer and contractor construction organizations associated with the implementation of construction;
- the cost of maintaining the customer's service;
- costs of training operational personnel;
- expenses for design and survey work and field supervision;
- estimated profit;
- administrative expenses of construction companies;
- risks of all construction participants;
- costs associated with inflationary processes.

Funds to cover the risks of all construction participants are intended to reimburse:

- an increase in the cost of the amount of work and costs, the nature and methods of implementation of which cannot be accurately determined during the design and are specified when determining the contractor (carrying out the procurement procedure) or during the construction process;
- an increase in the cost of construction caused by a change in state standards for certain materials, products, structures, equipment, etc., due to an increase in fire, sanitary and operational requirements for buildings and structures, with an improvement in the technical and quality characteristics of materials, products, structures ...

The cost of construction of large energy facilities is determined as part of the investor's estimate documentation at the design stage; in the bid price of the bidder at the stage of determining the contractor for construction work before the start of construction; at the stage of construction work when carrying out mutual settlements by clarifying the actual cost indicators in the manner stipulated by the contract and the type of contract price.

The composition of the investor's estimate documentation and the methods for calculating the estimate depend on the design stage of the construction of large energy facilities. The stage design of an object is determined by the class of consequences and the category of complexity. So, local and object estimate calculations are drawn up at the stages of a preliminary design, a feasibility study and a technical and economic calculation, when the scope of work has not yet been determined and are subject to clarification

during the development of project documentation for the "Project" stage. For such calculations, the cost characteristics of analogous objects are used. The corresponding calculation method has already been described above. At the subsequent stages of design, when the scope of work has already been detailed, it is possible to draw up local and object estimates containing calculations of direct and general production costs determined by resource element estimate norms. The resource sheets for local estimates contain data determined for the amount of work provided for by the estimate, for labor intensity and average grade of work, the normative need for material and technical resources in physical units of measurement, as well as the cost of a unit of measurement of labor and material and technical resources adopted in the estimate. If we return to the "theory" of costing, then according to the PMBoK standard, cost estimates include quantitative estimates of the possible costs required to complete the work on the project, as well as the amount of possible losses, taking into account the identified risks, and the management reserve for the production of unplanned works. The cost is estimated for all resources used and includes, but is not limited to, direct labor costs, materials, equipment, services, facilities, information technology and special items of expenditure such as the cost of raising finance (including interest on loans), provision for inflation, exchange rates or reserves for the cost of possible losses. Indirect costs, if included in the project cost estimate, can be taken into account at the transaction level or at higher levels [4, c.246].

One of the methods recommended by the standard for assessing the cost of work, the list and scope of which are already known, is the parametric assessment method. This method is a valuation technique that uses an algorithm to calculate the cost or duration of work based on historical data and project parameters. It allows you to quantify the cost by multiplying the number of units of work to be done by the cost of doing a unit of such work. This method may provide a higher degree of accuracy than others, depending on the experience and data underlying the model. Parametric cost estimation can be applied to the whole project or its parts together with other methods of estimation [4, p. 244]. It is this method that completely coincides methodologically with the method of drawing up local and object estimates using resource elementary estimates in construction. Composite project cost estimates according to the PMBoKta standard in accordance with GOST R 21.101-2020 - “System of design documentation for construction. Basic requirements for design and working documentation ”are also quite identical.

After the completion of the development of the project documentation in full or after the completion of the development of the "project" stage in the 3-stage design, the project enters the execution phase, where the customer is faced with the task of choosing a contractor for the construction work. For this, a competitive bidding procedure is usually used, which is one of the main PMBoK recommended procurement methods for a project. To calculate the bid price of a competitive bidder, the customer provides the contractor with a bill of quantities purchased by the customer, a bill of resources for it with the corresponding estimated prices (or without prices) or approved project documentation [15-17]. According to PMBoK terminology, these documents are a description of work (English Statements of Work, SOW), developed for each purchase on the basis of a baseline plan for the scope of the project and determine only that part of the scope of the project, which should be included in the corresponding contract [4, p. 477]. The contractor's offer price is formed on the basis of the cost of contract work, which includes direct, general production and other costs for the construction of the facility, profit, funds to cover administrative costs of construction organizations, funds to cover risks, funds to cover additional costs associated with inflationary processes, funds to pay taxes, fees, mandatory payments. The bid price of the winner of the competitive bidding is the contractual price for the construction object, which is formed by the general contractor with the involvement of subcontractors, is agreed with the customer. According to the approved General

Conditions for the conclusion and execution of contracts in capital construction [15-17], the contract price can be either a rigid contract price or a dynamic one. Fixed contract price - a contract price determined on the basis of a fixed estimate, which can be adjusted only in individual cases with the consent of the parties in the manner determined by the work contract. This type of contract with a firm contract price, as defined by PMBoK, is a firm fixed price contract (FFP), according to which the price of goods is set at the very beginning and is not subject to changes if the content of the work does not change [4, p. 471]. The approximate (dynamic) contract price defined in the document [18-19] is the contract price determined on the basis of the estimate, subject to adjustment, taking into account the clarification of the scope of work, resource prices and other grounds determined by the terms of the work contract. In PMBoK terminology, such a contract can be classified as a fixed price contract with a Possible Price Adjustment Clause (FPEPA), which is a fixed price contract with a special provision that allows agreed final adjustments to the contract value due to changed conditions, such as a change in the level of inflation or an increase in prices for certain goods. Consequently, the methods for determining the cost of work at this stage, as well as the methods for managing the procurement of the project, used in practice in the management of construction projects for the construction of large energy facilities, completely coincide with the methods recommended by the PMBoK standard.

The last stage, when according to the requirements of GOST R 21.101-2020 - "System of design documentation for construction. The main requirements for design and working documentation " is the next definition, or rather - the adjustment of the cost of construction project work, is to determine the cost of work performed and costs. Settlements for the volume of work performed between the contractor and the customer are carried out for the period specified in the contract (monthly, for a stage, etc.). The cost of the work performed takes into account the cost of construction work, other related costs (for business trips, transportation of employees, additional payments to employees due to the loss of travel time, etc.), as well as profit, funds to cover risks, to cover additional costs associated inflationary processes, taxes, fees, mandatory payments established by legislation and not accounted for by the components of the cost of construction, value added tax [14, p. 465]. When concluding a contract with a firm contractual price, settlements are made on the basis of the volume of work performed and their cost, determined in the contractual price. When using a dynamic contract price, direct costs in determining the cost of work performed are calculated from the standard costs of labor and material and technical resources, based on the physical volume of work performed and the revised prices of resources adopted in the contract price. Reimbursement to the contractor of expenses caused by an increase in the cost of material and technical resources is carried out as part of the cost of these resources at current prices. Funds to cover other items of general production costs and the level of wages of employees, whose wages are taken into account as a whole in general production costs, are specified in the manner prescribed by the contract.

4. Conclusions

As a result of the study, the following results were obtained:

- according to the PMBoK standard, the basic methodological foundations of the cost management process for the construction of large energy facilities, its components and characteristic features are determined;

- based on the results of the analysis of professional publications and regulatory documents in the construction industry, the main stages of the life cycle of ICP and CEP are established, in which the cost of

design work is estimated, the purpose of such an assessment and the participants in the construction of large energy facilities who carry out it are determined;

- by the method of comparative analysis, complete methodological identity has been established between the methods for assessing the cost of a project for the construction of large energy facilities recommended by the PMBoK standard and the methods for determining the cost of construction specified in the current regulatory documents in the field of construction of the Russian Federation.

The results obtained make it possible to consider the goal of the study fully achieved. Proven in this study, the practical value and versatility of the PMBoK standard in managing the cost of construction projects for the construction of large energy facilities is that this standard helps even a beginner in construction to get a clear understanding of the processes and methods of managing the cost of construction work and related project industries such as control of work performance, procurement and contract management. For a more experienced specialist in construction project management, the standard can serve as the basis for the integration and systematization of his professional knowledge in construction, understanding the role and mutual influences of all project management processes in the branches of project knowledge and phases of the life cycle of a construction project. The higher the level of management at which decisions on project activities in construction are made, the more important it becomes to obtain a comprehensive vision of a construction project, which is ensured precisely on the basis of modern standards for project management in the construction of large energy facilities.

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