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RISK LEVEL ANALYSIS IN THE SELECTED (INITIAL) STAGE OF THE PROJECT LIFE CYCLE

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Abstract

This paper focuses on the analysis of selected risks as part of investments in the power engineering at the initial (tender) stage of the life cycle in the context of the method of project management by the Contractor. The study was carried out on the basis of an analysis of over 500 tenders in the power engineering, from the last 5 years, taking into account future forecast data. The analysis carried out in this article was aimed at achieving specific and unique goals and results aimed at creating a useful product, which is the Contractor's offer in the power engineering, taking into account the most significant risks. The result of this article is to support the project team in implementing risk management in the project at the tender stage. For this purpose, the risks with their basic parameters were defined, which allowed for the development of a risk matrix taking into account the data obtained in the tender procedures of leading electric power distributors. Based on the proposed risk quantification criteria, a list of remedial actions was prepared for all risk types listed in this article. In addition, the aspects of possible elimination/reduction of the impact of the most significant risks that occur at the analyzed stage of the investment life cycle were developed.

Keywords

Project management, risk management, life cycle, power engineering, electrical grid.

Introduction

Defining possible risks in the project is an indispensable element of the investment process [1]. Based on [2] in the field of risk management in the construction industry, the most frequent types of risk can be listed, as follows: investor's interference, lack of adequate contractor experience, investment financing conditions, low level of work efficiency, lack of decision-making, mistakes in investment planning, subcontractors.

According to [3], the risk should be assessed based on an analysis of the possibilities of controlling the stage of work that has been completed. Considering the aforementioned, there are three most important risk groups in construction – weather conditions, work and equipment performance, as well as quality parameters of selected 54 materials. To quantify the risk, its source must be clarified. According to [4], the source of risk is the interdependence of tasks and uncertainty that occurs during the project implementation. In order to minimize this uncertainty, the Contractor must consider the possibility of coordinating activities between the entities that implement the project and their future relationships that go beyond a single project in a timely manner. Because of that, the changing mode of communication is the main reason for short-term optimization that inhibits long-term results, the development of innovation and people, who are working on this project [4–6]. At the same time, the period when the risk was identified is an important factor. The results of the research, which were presented in [7], showed that the standard risk is identified at the early stages of the project (during the development of feasibility study and project planning), while the impact of these risks is not noticeable until the start of construction and assembly works.

Solving the problems of analysis, assessment and risk management requires a comprehensive examination of all factors whose impact may affect the ability of project participants to achieve their goals [8]. Achieving the goal of the project requires understanding the level of influence of all possible stakeholders on the project. It is necessary to analyze the goals and relationships between all parties to the project, i.e. in the case of this paper, these would be the relations between the Investor and the Contractor at the tender stage [9–11]. The Investor sets himself the goal of implementing such investments to meet the needs of his clients. The methodology for assessing the risk aspect on the road to meeting these needs will be discussed in this article. Consideration of experimentally proven, at the initial stage of investment life cycle, the following factors:

- proposals for the organizational structure of the management process of the analyzed life cycle stage,
- identification of possible risks,
- risk assessment methods,
- type of remedial action,
- how to manage selected risks,

will ensure the successful implementation of the first stage of the life cycle. The result in a given case is to improve the reliability and security of supply, as well as satisfy an increasing energy demand for the region. Such investments are associated with preparations for the development of a given region.

This article will attempt to explain what risks may occur at the initial stage of a line's life cycle. This initial life cycle is not sufficiently studied, but is a very important stage because it guides the further implementation of the entire project. Later stages of this cycle have different types of risk assessment models in the project using several indicators, thereby reducing expenditure, assuming better fitness and a longer life cycle, which may have more positive consequences in terms of safety and reliability [12–14]. Therefore, in order to obtain reliable results in this article, the proposed methodology uses data obtained in the power industry.

Tender data and the Contractor's organizational structure of the power engineering

Following the needs of the market, the scope of investments in the power industry includes, among others, the design and construction of overhead power lines of all voltages.

An important aspect in terms of risk assessment is the implementation of a multi-branch project, especially in case where it is a project that is based on new technology [15–18]. The overhead line is an example of a multi-branch project that is implemented based on new construction technologies (new tower series due to standard updates, new types of phase conductors due to technical standards update) and requires project management at the level of large infrastructure projects in the power engineering [19, 20].

In this article, the author will focus on the analysis of selected types of risk related to the most time-consuming and cost investment category, implemented in the power engineering, which is the construction of the highest voltage overhead line. High requirements, innovative solutions, unexpected difficulties and unusual conditions for the implementation of works are terms that most accurately describe the construction of such a line. The tender stage from the Contractor's side of the given investment will be subject to analysis.

The basic stages of the above investment can be presented as follows:

- announcement of the start of the tender procedure,
- settlement of the tender procedure,
- signing a contract.

First of all, the elements that may affect the course of the tender procedure shall be considered. Here, attention should be paid to the organizational structure of the unit that deals with the preparation of the offer. It can be a department of bidding, tenders, etc. The structure of the course of activities in such a unit is shown in Fig. 1. This figure illustrates the process from the analysis of the tender announce-

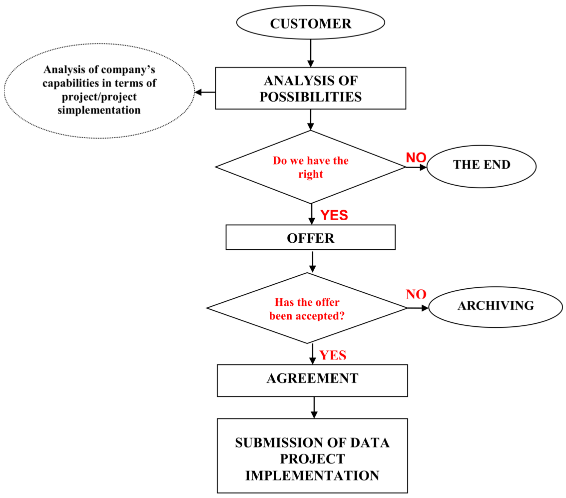

Fig. 1. Sample organization chart of the bid submission process.

ment till the submission of the offer (which is basis for singing the contract with the Employer) to the department that deals with implementation of projects.

The implementation of the project in the power engineering at the tender stage requires establishment of certain restrictions relevant for such a task. It includes the expansion of the high-voltage power grid, which includes, among others, design, finance, future contracts with subcontractors and project management [21–23]. Regarding to the details related to the tender stage, it should be noted that a significant risk in the case of turnkey investments fits into the concept of implementing this investment. In case of an energy facility, such as an overhead line, development of the concept of the planned overhead line route is done by the planning department. Whereas, responsibility and all risks in the scope of the tender are considered by another unit; for instance, it might be the department of offers, tenders, etc. The quality indicator in the above diagram may be the quotient of the number of bids excluded from tenders to the number of bids submitted per year or the number of winning bids to the number of bids submitted per year. At the same time, taking into account the current expectations of the Investor, the Contractor usually indicates that, being guided by the utmost diligence and experience, he will make efforts to perform his duties within the deadline currently expected by the Investor, provided that there are no risks at the preparation and implementation stages that will have a negative impact on the implementation of specific works.

As part of this article, tender data was analyzed (over 500 tender notices from the largest power grid distributors and the Contractor's offers). As a result of such analysis, the most common types of risk that occur in the power engineering at the initial stage of the investment's life cycle, i.e. the tender stage, are defined below (Table 1).

The Table 2 contains information on averaged tender data for 5 years, including forward-looking forecast data. As a result of the analysis, it was discovered that, on average, the Contractor in the power industry submits about 108 offers per year. Approximately, 21 of these offers lead to the signing of the contract. Furthermore, the information on the frequency of individual risks at the tender stage based on the average quantitative characteristics of tender data over a 5-year period will be presented below.

The above analysis includes information on taking remedial actions to eliminate/reduce risk under the tender/investment, which is presented in the Table 3.

Table 1
Risk types at the initial (bidding) stage of the investment life cycle.

N	Type of risk	Description of risk
1	Risk A	Failure to meet the requirements set out in the tender documentation and the risk associated with the implementation of the contract.
2	Risk B	Modification of the provisions of the Specification of the Essential Terms of the contract by the Investor during the tender procedure.
3	Risk C	Announcement of a large number of tenders at the same time.
4	Risk D	Short deadline for submitting bids (deadline set by the Investor).
5	Risk E	Incompatibility of the subcontractor/supplier's offer with the Terms of Reference or an error in the offer.
6	Risk F	There is not enough experienced/trained people in the team that can efficiently run several tenders at the same time.
7	Risk G	Extending the duration of the tender procedure.
8	Risk H	No offer submitted on time.
9	Risk I	Non-compliance of the developed attachments to the offer with the requirements of the specification of essential terms of the contract.
10	Risk J	Underestimation of the Contractor's price or incorrect estimation of the contract value by the Investor, which may result in an abnormally low price in the tender procedure.
11	Risk K	Preparation of attachments to the offer (concepts, schedules, access to resources) by third parties.

Table 2
Quantitative characteristics of individual risks in tender notices (averaged data over 5 years).

N	Type of risk	Tender announcements with risk analyzed			Offers with risk analyzed		
		Total number	Not accepted/resignation to/ from implementation by the Contractor		The scope of the Contractor		The scope of the Investor
			No remedial action	With remedial action	Number of offers submitted	Number of offers won/contracts signed	Number of rejected offers
1	Risk A	24	19	2	3	1	0
2	Risk B	95	9	3	83	20	1
3	Risk C	15	8	5	2	1	0
4	Risk D	32	7	4	21	2	2
5	Risk E	91	0	0	91	14	0
6	Risk F	15	3	4	8	0	3
7	Risk G	47	2	3	42	17	6
8	Risk H	3	1	1	1	0	1
9	Risk I	7	0	1	6	3	0
10	Risk J	92	0	2	90	6	3
11	Risk K	28	2	3	23	9	1

Table 3
Summary of remedial actions for individual types of risk.

Type of risk	Type of remedial action
A	Sending to the Investor a proposal to modify the tender specification, information meetings with the Investor, access to the missing range by external entities, intensification of the company's operations
B	Reliable verification of tender materials, sending to the Investor a proposal to modify the tender specification, information meetings with the Investor, employing qualified human resources that respond quickly to changing requirements.
C	Selection of the most appropriate tender notices in relation to the company's goals and strategy, information meetings with the Investor, intensification of the company's operations.
D	Modular (based on experience) preparation of the offer, sending to the Investor a proposal to extend the deadline for submitting offers, information meetings with the Investor, supplementing the missing elements of the offer at the Investor's request stage, employing qualified human resources that respond quickly to changing requirements.
E	Reliable verification of subcontractor and supplier offers, modular (based on experience) offer development, contact with subcontractors and suppliers, employment of qualified human resources that respond quickly to changing requirements.
F	Intensification of the company's operations, contact with subcontractors and suppliers, modular (based on experience) offer development, employment of qualified human resources that respond quickly to changing requirements.
G	Establishing cooperation with several entities in the field of legal assistance and providing guarantees, employing qualified human resources.
H	Establishing cooperation with several courier companies, regular monitoring of courier services, employment of a driver or other person responsible for delivery of the offer in critical situations.
I	Establishing cooperation with several external entities (project department), employing qualified human resources. contact with subcontractors, suppliers (who submitted bids under the tender procedure) and the Investor, employment of a lawyer or establishment of a legal department, intensification of the company's activity.
J	Reliable verification of offers from subcontractors and suppliers, regular monitoring of the power engineering market, contact with subcontractors, suppliers and the Client, employment of qualified human resources.
K	Establishing cooperation with several design offices, regular monitoring of design and concept services in the power engineering, employing a designer or establishing an office/design department responsible for the preparation of technical attachments to the offer.

Analyzing the tender data presented in the Table 2, one can make a conclusion regarding the share of individual types of risk in the tender process in the power industry (Figs 2 and 3).

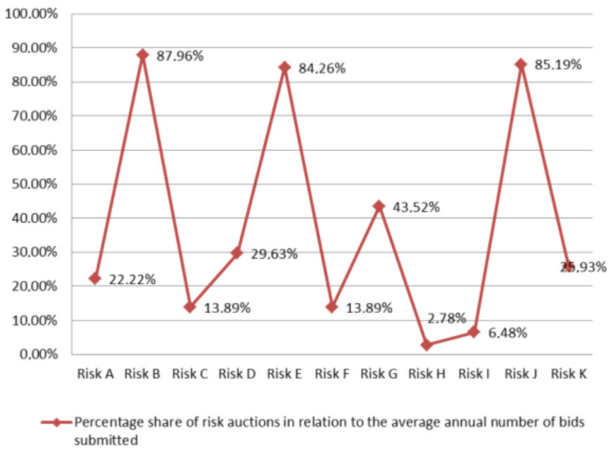

Fig. 2. Percentage of risk contracts won on the sum of contracts won in relation to the types of risk considered.

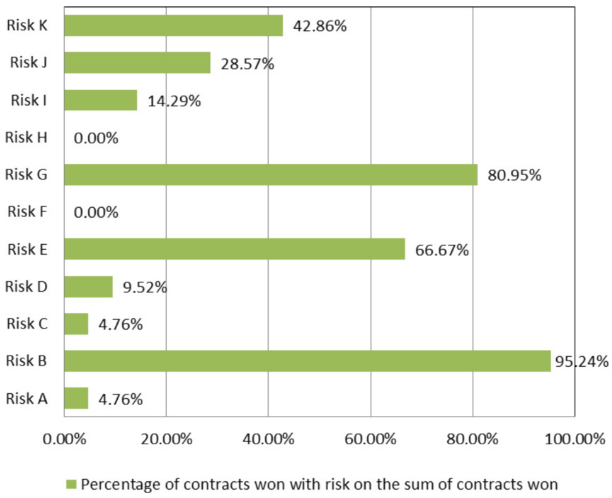

Fig. 3. Percentage of risk contracts won on the sum all bids submitted to the Investor.

As can be seen from the Fig. 2, risks B, E and J have a high share in the analyzed tender offers. Risks A, D, G and K have an average share; whereas, risks C, F, H and I have the smallest share in the analyzed tender announcements. However, in a given case, only a single aspect regarding the impact of risk is described.

For example, Percentage of risk contracts won on the sum of contracts won in relation to the types of risk considered may also be a reliable indicator (Fig. 3).

From the Fig. 3, we can see that risk B most often appeared in tender notices. At the same time, it has minimal impact on achieving the customs duty, i.e. signing the contract by the Contractor (previous drawing). A similar situation occurs with respect to risk G. However, H and F risks have zero level of signed contracts. Though, it does not mean that mainly these risks are those, which prevent you from winning the tender. In this case, the above issue requires a more comprehensive analysis, which will be conducted in the following chapters of this paper.

Risk assessment at the tender stage of the investment process

The following is an analysis of the risks that may occur at the bidding stage if the Contractor prepares an offer in the power engineering, taking into account tender data (presented in the previous chapter) for the last 5 years (over 500 offers) and based on forward-looking forecast data (Table 2). In order to carry out the analysis, Table 5 presents the criteria for assessing the level of risk, which were included in Table 4. It should be noted that the risk expectation that might occur at the tender stage should include the aspect of the crisis, which may extend into a larger area related even to conducting future proceedings [24].

Below is a proposal to define risk quantification criteria.

Rare – occurs in the subject's activities/3 times for 1-2 years.

Unlikely – it happened in the entity's activity/3 times for 1 year – 10 times for 1 year.

Possible – the event took place in the entity's activity/10–20 times for 1 year.

Likely – a large event has occurred many times in the entity's operations/20–40 times for 1 year.

Almost certain – a very large event occurs almost regularly in the entity's operations/>40 times for 1 year.

Catastrophic – an event of damage for the entire entity, resulting from large-scale impacts. There is a permanent deterioration of relationships within the team and between cooperating entities. The event requires corrective action to replace the people responsible for the event in an equivalent manner.

Severe – the event related to an area of activity that goes beyond the control of an entity preparing the offer. The event requires preventive actions to prevent or reduce damage with the involvement of individuals from outside the preparation unit.

Serious – the event is associated with a significant negative impact on the activities of the entity that deals with the preparation of the offer. The impact of the incident is limited; however, it requires preventive action to avoid or reduce damage.

Table 4
List of risks at the bidding stage.

N	Risk related to the process	Event Likelyhood (P)	The Consequence of the event (S)	Risk [his level] (R)	Person responsible for monitoring
1	Risk A	Likely (4)	Insignificant (1)	4 (Low risk)	Person responsible for preparing the offer
2	Risk B	Almost Certain (5)	Insignificant (1)	5 (Low risk)	Person responsible for preparing the offer
3	Risk C	Possible (3)	Insignificant (1)	3 (Low risk)	Head of Department
4	Risk D	Likely (4)	Insignificant (1)	4 (Low risk)	Person responsible for preparing the offer/ Head of department
5	Risk E	Likely (4)	Insignificant (1)	4 (Low risk)	Person responsible for preparing the offer
6	Risk F	Possible (3)	Moderate (2)	6 (Low risk)	Head of Department
7	Risk G	Almost Certain (5)	Moderate (2)	10 (Medium risk)	Person responsible for preparing the offer/ Head of department
8	Risk H	Rare (1)	Catastrophic (5)	5 (Low risk)	Board
9	Risk I	Unlikely (2)	Moderate (2)	4 (Low risk)	Person responsible for preparing the offer/ Head of department
10	Risk J	Almost Certain (5)	Serious (3)	15 (High risk)	Board/Head of department
11	Risk K	Likely (4)	Insignificant (1)	4 (Low risk)	Person responsible for preparing the offer/ Head of department

Table 5
Risk quantification criteria.

Consequence		Likelyhood				
		Almost Certain	Likely	Possible	Unlikely	Rare
		5	4	3	2	1
Catastrophic	5	25 Extreme risk)	20 (High risk)	15 (High risk)	10 (Medium risk)	5 (Low risk)
Severe	4	20 (High risk)	16 (High risk)	12 (Medium risk)	8 (Medium risk)	4 (Low risk)
Serious	3	15 (High risk)	12 (Medium risk)	9 (Medium risk)	6 (Low risk)	3 (Low risk)
Moderate	2	10 (Medium risk)	8 (Medium risk)	6 (Low risk)	4 (Low risk)	2 (Low risk)
Insignificant	1	5 (Low risk)	4 (Low risk)	3 (Low risk)	2 (Low risk)	1 (Very Low risk)

Moderate – the event is associated with a negative impact on the operations of the entity that deals with the preparation of the offer. The impact of the incident is limited; however, it requires preventive action to avoid or reduce damage.

Insignificant – an event without a direct impact on the entity's operations. The return to balance occurs as part of the implementation of the next offer.

Based on the above information, a graphic illustration of the risk level is presented in the Fig. 4. Selected risks (marked in Fig. 4) with the highest level (medium and higher) will be discussed in more detail.

The results obtained on the basis of the method proposed in this paper are innovative. This is due to the fact that the tender stage of an investment in the power engineering was not previously analyzed separately from the remaining stages of the investment life cycle or separately from the other stages preceding the commissioning of the facility. This approach results from the used organizational structure of entities implementing such investments. Due to the fact that the tender stage is separate from the implementation stage, it also required a separate analysis of the risks associated with this approach.

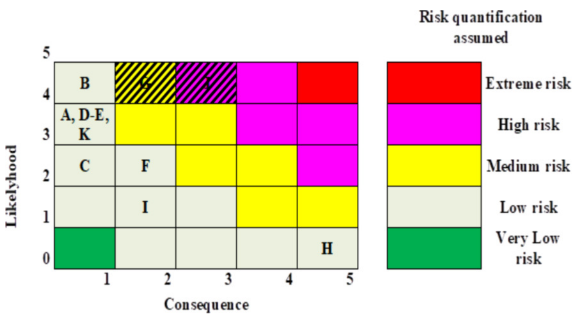

Fig. 4. Graphical risk quantification with presentation of assumed levels.

The advantage of this approach is a broad and detailed analysis of all possible and significant risks that may occur and have effects not only at the tender stage, but also at subsequent stages of the investment life cycle. For example, some of the risks may even lead to a repetition of the tender stage, which, depending on the reserves established, may have greater or lesser negative effects for the subsequent stages of the life cycle of the critical energy infrastructure facility. A detailed assessment of such a relationship can only be made for a specific case, i.e. a defined investment and assumptions of the parties involved in its implementation. The above-mentioned effects will also depend on the degree of application of preventive and eliminating actions. The range of options related to the possible application of such measures is analyzed in this article.

However, each method of risk analysis is largely dependent on legal regulations, as well as international ones, prevailing in a given country. Regulatory volatility may result in some or all remedial actions not being applicable. At the same time, a change in the law may result in the elimination or reduction of the impact of risks which, according to the current analysis, are quite significant. Therefore, after each updating of the laws, the risk level analyzes should be revised to maintain a high level of their precision. This proposed method uses an approach that takes into account several series of changes to legal regulations, which made it possible to increase the resistance of this analysis to possible subsequent changes that will be introduced in the near future. This was taken into account by averaging 5 years data in the power industry.

A brief description of the highest level of selected risk

As can be seen from Table 4 and Fig. 4, at the stage of the tender procedure, there are two risks of the highest level (risk G and J). Hence, these risks will be considered in more detail due to the largest possible negative effects that they cause:

A) underestimation of the Contractor's offer price or incorrect estimation of the contract value by the Employer, which may result in the appearance of abnormally low price in the tender procedure (Risk J from Table 4),

B) extending the time for conducting the tender procedure (Risk G from table 4).

The author will discuss in detail the situations below.

Ad. A) Due to the fact that there has been an abnormally low price recently, we will focus on this risk. This situation occurs due to the fact that the Employer often announces tender procedures with some delay. Thus, these procedures‘ budget is estimated on outdated indicators and prices of labor, equipment and materials that do not take into account the surge in prices of recent years.

The discrepancy between the offer price and the budget may be affected by the following factors (in the case of the Order being carried out by large companies):

- possessing own base of regular suppliers and subcontractors;
- own machinery and equipment park;
- no need to use external sources of financing.

An abnormally low price is always an unrealistic price, inadequate to the scope and costs of the works constituting the subject of the contract, assuming the performance of the contract below its actual costs and, in this sense, is not a market price. Thus, it does not generally appear on the market where prices are set through:

1) the general economic situation prevailing in a given industry,
2) its business environment,
3) technological and organizational progress,
4) as well as functioning of fair competition of entities rationally operating in the market.

Such a definition has been developed in case-law and there are no controversies in this respect, so the judgment of the National Appeal Chamber (NAC).

Due to the fact that the concept of "abnormally low"" price is not precise, the analysis of offers should always be based on other criteria. For example, these include: deviation of the total price of the offer from the prices in force in a given market. In such a way, it is not possible to execute the order assuming profit; offering a price whose implementation does not allow the contractor to remain profitable on this task; unbelievable price due to detachment from market realities. In addition, there may be a situation when the Investor does not take into account/does not update budgets in the event of a change in legal circumstances, in which a given investment may be implemented.

The entry into force of the provisions of the Act of July 2015 on the preparation and implementation of strategic investments in the field of transmission networks significantly removes the risk of administrative and legal barriers in preparation for the construction of the line. At the time of awarding the contract, offers that could not assume the existence of the so-called special law must lead to the conclusion that the prices of these offers should be higher by at least a risk assessment of administrative barriers.

The detailed explanations presented above indicate without doubt that the price offered by the Contractor does not pose a risk of non-performance of the contract, and thus, a positive outcome of the procedure and signing of the contract.

Ad. B) There are situations when public procurement procedure, which is conducted in an open tender, from the time of announcement to the conclusion of the contract may last over a year. In any given case, none of the following may apply:

- the evaluation period for the offers in question,

- control period of the President of the Public Procurement Office,
- date of announcement of the commencement of the procedure,
- extension of the deadline for submitting bids,

in no way depend on the Contractor. The evaluation of tenders aimed at resolving the proceedings is carried out directly by the Client, and the relevant prior control is carried out by the President of the Public Procurement Office, which is out of the Contractor‘s control. The situation related to filing an appeal to the National Appeal Chamber may also affect the period of final settlement. As a result, the Contractor must prove that the Client is responsible for late signing of the contract in accordance with its factual and financial schedule. This schedule is an important element for the Contractor if it indicates the exact date of completion of the entire investment, milestone or a particular stage. At the same time, referring to the deadlines for the implementation of the investment task, it should be noted that the factual schedule is an attachment to the draft contract forming part of the Specification of the Essential Terms of the Contract. The Investor usually includes deadlines for the implementation of some stages, the beginning and end of which depends on the date of signing the contract. It is the Investor who indicates the deadline for the performance of the contract for the number of months from the date of signing.

In case if the Investor has not indicated the date of commencement of the task in the contract award procedure, including deadline of signing the contract for performance of the task. It justifies the validity of the solution consisting in the adoption of terms of contract performance calculated in months, starting from the date of signing contracts, and the "rigid" date may change as the tender process is extended.

Conclusion

Investments in the power engineering include the provision of comprehensive formal, legal, design, construction and assembly services. At the same time, achieving success in the implementation of these services depends on the correctness of the ongoing tender process. The project faces many unforeseen threats. Hence, the success of the project should be based on clear risk management, from planning to the end of the analyzed life cycle stage. Given the above, the purpose of the paper was to analyze the impact of potential barriers in the preparation of offers (constituting part of the strategic management process in companies) as part of large strategic infrastructure projects in the power engineering.

At the same time, it should be noted that minor modifications of the obtained results are possible due to a different level of rated voltage or type of investment. Moreover, as we can see on the example of the current market situation related to the COVID-19 epidemic, the considered risks that occur at the tender stage may change due to the aspect related to the financial crisis. As competition increases in this context, prices fluctuate rapidly and long-term or medium-term forecasts cannot be made.

The timeliness and credibility of the results obtained increases due to the current limitations caused by COVID-19. The restrictions introduced by various countries lead to the extension of the tender stages and the delay in signing the contract. At the same time, due to the inability to plan the availability of resources, materials and the manner of carrying out works, there are significant deviations in investment budgets in relation to the offers submitted by Contractors. Even a reduction in the amount of investments, which lowers the costs of hiring subcontractors, does not translate into lower value of the offers. This is due to the high level of consideration of the possible risk related to the uncertainty of the development of the situation in the coming months and high levels of inflation processes.

Conducting the above analysis allowed formulation of answers to a number of questions:

Ad. 1) The organizational chart of the unit proposed in this article deals with the tendering process on the side of the Contractor. It was developed based on data from more than 500 tender notices of leading power grid distributors and the Contractor's offers (including forecast data) risk quantification criteria resulted in identification of 11 types of the most common types of risk.

Ad. 2) A list of remedial actions for individual risk types was developed that will allow reducing/eliminating the impact of risk on the tendering process on the side of the Contractor in the power industry. The most recurring remedial actions could be: employment of qualified human resources and meetings with subcontractors, suppliers and the Employer. Therefore, it can be concluded that the human factor is an important element in the risk management.

Ad. 3) As a result of the analysis of individual risk indicators, it was determined that the share of risk J (the highest risk level) in participant tenders is equal to 28.57%, which is significantly a lower value than those of other types of risk. At the same time, analyzing the share of this risk in all tenders, the 85.19% level is one of the highest. We have a practically opposite situation in the case of risk G (medium risk level), where the share of this risk in participant tenders is at the level of 80.95%, and the share of this risk in relation to all tenders is only 43.52%. Hence, it confirms that the analysis of individual types of risk at the tender stage in the power industry requires a multilateral approach.

Ad. 4) Based on the analysis of the level of individual types of risk, the most significant risks were identified: underestimation of the Contractor's bid price or incorrect estimation of the contract value by the Employer (risk J). as well as extension of the time of the tender procedure (risk G). As part of this article, the most significant risks (with high and medium risk) have been discussed in detail, with guidelines that will allow eliminating/reducing the impact of a given type of risk in legal terms (as suggestions to project teams in the power industry) and clarifying issues that may have an impact on the further implementation of the stages of the investment's life cycle (design, implementation, operation and dismantling stages).

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