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Risk Management in Implementing Wind Energy Project

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Abstract

Analysis of possible risks in the process of implementing a specific project has been carried out, measures to reduce their negative impact on the project have been developed and proposed. The object of study is a wind energy project, namely a wind farm working as part of the national energy system. The implementation of the project is related to both external and internal risk factors that are characteristic to such projects in the real economy sector under the current conditions. Such risks have been classified and the fractional structure of risk adjustment has been analysed taking into account the properties of the particular wind energy project, which consists of three main components. A description has been given of the innovative technology selected for project implementation, power generation using wind, which is used to limit the negative influence of the above-mentioned risks. The current strategic management tools, such as SWOT analysis and McKinsey matrix, which are useful for the identification of project risks, have been examined. For the wind energy project that is being implemented, the project dot location coordinates were determined in the McKinsey matrix on axes: Advantages against competitors and Market attractiveness. Also, a sector characterising the project development prospects was established to be subsequently used as a tool for risk identification. Following the identification of risks, specific measures of state support and special project management measures were developed and proposed to be implemented with the aim of limiting the negative influence of the possible project risks.

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Keywords: risk management, wind energy project, swot analysis, mckinsey matrix, project risks

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1. Introduction

The risk of the wind energy project (Konechenkov, 2012; Rolik, 2008), as well as the risk of any other project is some unspecified impact or condition that, in the case of occurrence, has an (positive or negative) impact on the project (or on one of the project objectives), thus on its cost, scope or quality. And the wind energy project risk management includes the processes associated with identifying, analysing and responding to project risks in order to increase the probability and degree of impact of positive risks and to reduce the possibility and impact of negative events within the project. In addition, it should be borne in mind that the closer the project is to its completion, the more reduced the possibility of the occurrence of risks is, as well as the possibility of influence on the course of the project and its results. The main purpose of the risk management cycle is preparation for the occurrence of risks, namely risk management planning**.** In order to have the opportunity to plan risk management, it is necessary to identify these risks. After that, it is possible to carry out qualitative and quantitative risk analysis. Once this stage of the cycle is passed, it is possible to plan response measures to risks and then the monitoring and control of risks.

Thus, the project risk management procedure lies in that fact that in the analysis process, involving the detection and assessment of risks, comparing their effectiveness, it is necessary to define a method of impact. Then, after making a decision to carry out an impact on the risk, it is necessary to carry out subsequent control of the impact results. All currently known methods of impact on risk are implemented in three ways: by way of reduction, retention or transfer (Yelistratov *et al.*, 2010). Among these methods, reduction is considered to be the most acceptable method. In turn, the most favourable result of reduction is the complete elimination of risk, i.e. prevention of it (Yelistratov *et al.*, 2013).

If such impact on risk is applied, efforts are made to implement the process as retention without additional funding. If this cannot be avoided, the provision is made for planning the use of funds accumulation, which is called self-insurance, or for the attraction of external financial resources in the form of various loans and grants.

Finally, a type of impact on risk such as transfer makes provisions for comprehensive project insurance. Under this approach, the reimbursement of all possible financial expenses, caused by the damage, is passed on to the insurance company (Rolik and Gornostay, 2015).

In the future the provision will be made for consideration of the impact on risk using the first method–reduction by analysing potential risks arising in the implementation of the specific project, and the development of measures aimed to reduce their negative impact on the project.

2. Object of research

2.1. Description of wind energy project

The wind energy project, which is a wind park, operating within the state energy system, is considered to be the object of research. To begin implementation of this project, it will be necessary to obtain all of the necessary permits and approvals from local governmental institutions and organisations. It is proposed to construct the planned wind park on the basis of the SWT-3.2-113 DD (Siemens, 2013) wind power plants (WPP), manufactured by the SIEMENS Wind Power A/S German concern, the correct functionality of which has been proven for many years of operation in various regions of the world. By the beginning of the project, all of the WPPs shall be ready for delivery and shall be fully fitted with all of the equipment necessary for operation: blades, asynchronous generators, masts, control cabinets and gondolas.

The planned wind park will not occupy a large territory, and the WPPs will only produce clean electrical energy, thereby preventing the harmful greenhouse effect inherent in some other energy producers, which fully meets the requirements of the International Kyoto Protocol (United Nations, 1998). Under this project, during its life cycle each SWT-3.2-113 DD wind-driven power plant will produce 260,000 MWh of electrical energy, preventing the emission of 225,000 tonnes of CO2 into the atmosphere, which corresponds to the amount of CO_2 absorbed by a forest area of 8 sq. km over 20 years (Siemens, 2015).

2.2. Description of the electrical power wind generation technology

The main industrial activities in this project will involve the commercial operation of the constructed wind park. The SWT-3.2-113 DD WPP, manufactured by the SIEMENSAG concern, will be used for the planned wind park. Currently, the concern has installed more than 13,000 of its WPPs around the world with a total installed capacity of21GW. The SWT-3.2-113 DD type WPP is the combination of the direct drive innovative technology and the solid design of the rotor blades. The direct drive technology (no gears used by competitors in other types of WPP) reduces the weight of such WPP by 12 tonnes.

Wind wheel solid blades are used in the WPPs selected for the implementation of the project. These blades are designed strictly according to the strength calculation methodology of the SIEMENS AG concern manufacturer (Siemens, 2013) called the Integral Blade: The modern technology of blade manufacturing. The solid design of blades obtained by using this technology makes provision for: Fatigue life up to 20 or more years, high strength under static load, deflection and deviation.

3. The determination of the project risks for the assessment of the status and prospects for the development of the wind energy project

The assessment of the current status and prospects for the development of the wind energy project is performed by determination (primarily) and documentation of the characteristics of risks that may affect the successful development of the project during its entire life cycle. In addition, the process of identifying project risks shall directly be carried out under the joint consideration of the internal and external environment, i.e. the environment of the wind energy project. This assessment can be performed using various matrices. Moreover, the SWOT-analysis method (Shinno *et al.*, 2006) has become widespread as an operational diagnostic analysis of project environments. The SWOT analysis is a test for each project risk characteristic (Strengths, Weaknesses, Opportunities, Threats), i.e. strong, weak, opportunities, threats. SWOT analysis shows all of the opportunities arising from the strong points of the project and any threats emanating from the weak organisational points.

Table 1. Results of the SWOT-analysis.

I. Potential internal strengths (number of units = 6)	6	Opportunities
1	2	3
1. Full competency in key issues	1	Acquisition of financial resources; Improvement of the environmental situation; Reduction of electrical energy import
2. Adequate financial resources	0	
3. The formed good impression about the company	0	
4. A recognised market leader	0	
5. Well-elaborated functional strategy	1	
6. Economy of the production scale	0	
7. Ability to avoid strong pressure from competitors	1	Receipt of an additional effect when placing orders for the execution of works on the cooperation of local enterprises; Establishment of a local production enterprise
8. Proprietary technology	1	Development of building structure production
9. Lower costs	1	Reduction of the cost of roads and technological platforms; Reduction of the volumes of investments in the production of foundations
10. The best advertising campaigns	0	
11. Experience in the development of new products	0	

End of Table 1

1	2	3
12. Proven management	1	The main criteria for selecting the manufacturer and the type of wind-driven power plants are determined;
		Wind conditions of the terrain planned for construction of the wind park, are analysed;
		Planning of the wind park on the purchased land is performed
13. The best trading opportunities	0	
14. Excellent technological skills	0	
15. Miscellaneous	0	
II. Potential internal weaknesses (number of units = 3)	3	Threats
1. Absence of strategic direction of growth	0	
2. Outdated technology	0	
3. Low profitability	0	
4. Lack of management talent and skills	0	
5. Absence of certain abilities and skills in key areas of activities	0	
6. The company's strategy proved to be poor	0	
7. In-house production problems	0	
8. Stagnation in the area of research and development	1	The leading manufacturer influence is increased;
		Fierce competition reduces the share of market segments
9. Too narrow product range	0	
9. Too narrow product range	0	
10. Poor image in the market	1	The degree of uncertainty in the potential markets is increased
11. Ineffective sales network	0	
12. Poor organisation of marketing activities	1	The degree of reliance on a number of foreign manufacturers is increased;
		The degree of uncertainty in assessing the dynamics of macroeconomic indexes and investment activity is increased
13. Lack of money for financing the necessary changes in strategy	0	
14. Product cost is higher than that of major competitors	0	
15. Miscellaneous	0	

The results, listed in Table 1, were the basis for the evaluation of project development opportunities taking into account the extent of the expected threats during its promotion. For this purpose, the conventional matrix, provided in Table 2, was filled. Each of the four filled quadrants (threats, strengths, opportunities, weaknesses) of this matrix contains information, on the basis of which one can make decisions with respect to the further implementation of the wind energy project.

After the analysis is conducted, it is possible to proceed to the assessment of internal and external points of the wind energy project. The internal points are assessed from the perspective of project competitiveness, and the external points characterise the situation on the market in terms of opportunities and unfavourable trends that may have an impact on the project activities in the future (see Table 3 and 4).

Table 2. The filled quadrant of the SWOT-analysis.

(T) Threats	Strengths (S)
• The increasing influence of manufacturers on potential selling markets; • Fierce competition reduces the share of market segments; • The degree of uncertainty in the potential markets, which increases the risk of entering new markets, is increased; • The location depending on a number of foreign manufacturers is increased; • The degree of uncertainty in assessing the dynamics of macroeconomic indexes and investment activity is increased; • The level of risk when assessing the solvency in various market segments is increased.	• Own research and production potential; • The presence of a territorial self-management development plan with an indication of the location for the construction of the wind park; • Good access roads to the planned construction site of the wind park; • The proximity of the land plots to the 20/110 kV transformer substation and the 110 kV high-voltage line; • The certified report on the analysis of wind conditions of the area planned for establishment of the wind farm; • High average wind speed at the height of the WPP rotor axis; • The basic requirements fulfilled for the installation of WPPs in the park; • Planning of the wind park on the land plots bought into acquisition; • The agreed and approved structural part of the project (foundations, roads and technological platforms) of the wind park; • The agreed and approved electrical part of the project (cable lines, transformer substations and connection points to the high-voltage network) of the wind park; • Knowledge of the potential electricity market; • Operation of wind-driven power plants is remotely controlled by the central control facility of the wind park; • 90% of faults occurring during the operation of the WPP are eliminated remotely from the control facility; • High qualification personnel working for a relatively low salary; • Absence of potential WPP generated electricity production markets within the area.
(O) Opportunities	**Weaknesses (W)**
• Development of electricity production on the basis of environmentally-clean production; • Expansion of the traditional market share and penetration into new segments; • Increasing the number of high-tech workplaces; • Acquisition of financial resources; • Maintaining the level of high-technologies; • Establishment of local industrial enterprises.	• Competition in the market of electricity producers; • Novelty of the problem; • Lack of advertising experience; • Supplies of foreign equipment; • Complexity of the project; • Time lag.

Table 3. Internal diagnostics of the project.

Index	Strengths	Weaknesses	Value for the market
Technology	Meets European standards	Novelty	7
Marketing	Thorough analysis of the market	The activity of competitors	3
Maintenance	Existing service experience		5
Products	Meet global trends	Novelty	6
Finances	There is a possibility of financing		5
Personnel	The possibility of training of qualified personnel	Training of new specialists in the course of the growth of production volumes	6
Market share	There are no strengths	Practically, there is no market share	1
Clients	Demand for electricity production		1

Table 4. Diagnosis of external conditions.

Index	Opportunities	Unfavourable trends	Value for the project
Market growth	Large growth potential	There are no unfavourable conditions	4
Market volume	The ability to accommodate new industrial facilities	The presence of major competitors	4
Aggressiveness of competitors	See-saw policy of competitors	Competition increases	3
Risk of substitution to other products	There are no opportunities	Products will be replaced with competitors' products	1
Currency risk	Diversification by currencies	Change of currency rates	2
Fees and other non-tariff barriers	Protection of local producers	Reduction or elimination of import barriers	2

After the diagnostics of internal and external points of the project as of the reporting period, all of these indexes, given in Table 3 and 4, shall be evaluated by the McKinsey expert assessments (ratings) (Rasiel and Friga, 2004; Rasiel, 1999). These ratings allow for the calculation of the attractiveness of objects of activity and competitiveness of the project in the form of weighted averages for the future positioning of the studied parameters on the McKinsey matrix (see Table 5 and 6).

Table 5. Expert ratings. Competitive advantages.

No. of a criterion	Competitive advantages criteria	Value for the market	In comparison with competitors									Important value
			Weak			Average			Strong			
			1	2	3	4	5	6	7	8	9	
1.	Technology	7				4						28
2.	Marketing	3		2								6
3.	Maintenance	5			3							15
4.	Range of products	6	1									6
5.	Finances	5		2								10
6.	Personnel	6			3							18
7.	Market presence	1		2								2
8	Market share	1	1									1
9.	Clients	2			3							6
Amount of values		36	Amount of valid values									92

In addition, the McKinsey matrix ordinate index (Table 5) – the point position for the Y -axis (competitive advantages) is calculated as follows:

$$K_Y = \frac{\sum_{i=1}^{k} \alpha_i A_i}{\sum_{i=1}^{k} \alpha_i}, \qquad (1)$$

where A_i is the expert assessment of the i-th criterion; α_i – weighting factor, which characterises the relative importance of the i-th criterion for the market; k – number of criteria; i – the current number of a criterion.

The McKinsey matrix abscissa index (Table 6) – the point position for the X -axis (market attractiveness) is calculated as follows:

$$K_X = \frac{\sum_{j=1}^{l} \beta_i B_i}{\sum_{j=1}^{l} \beta_i}, \tag{2}$$

where B_i is the expert assessment of the j-th criterion; β_i – weighting factor, which characterises the relative importance of the j-th criterion for the firm; l – number of criteria; j – the current number of a criterion.

The McKinsey matrix ordinate index calculated by the expression (1):

$$\text{Ordinate index} = \frac{sum \quad of \quad valid \quad values}{sum \quad of \quad impor\tan ce \quad indexes} = \frac{92}{36} = 2.56 \, .$$

Table 6. Expert ratings. Market attractiveness.

No. of a criterion	Attractiveness criteria	Value for the firm	Attractiveness									
			Weak			Average			Strong			
			1	2	3	4	5	6	7	8	9	Important value
1.	Market growth	5					5					25
2.	Market volume	4				4						16
3.	Aggressiveness of competitors	3				4						12
4.	Risk of substitution to other goods	1					5					5
5.	Currency risk	2					5					10
6.	Fees and other tariff barriers	2			3							6
Amount of values		17	Amount of valid values									74

The McKinsey matrix abscissa index calculated by the expression (2):

$$\text{Abscissa} \quad index = \frac{sum \quad of \quad valid \quad values}{sum \quad of \quad impor\tan ce \quad indexes} = \frac{74}{17} = 4.35 \, .$$

Having calculated the coordinates (X and Y) of the project using the McKinsey matrix and having marked them on the matrix, one can determine the sector, characterising the prospects for the development of the project, see Fig. 1.

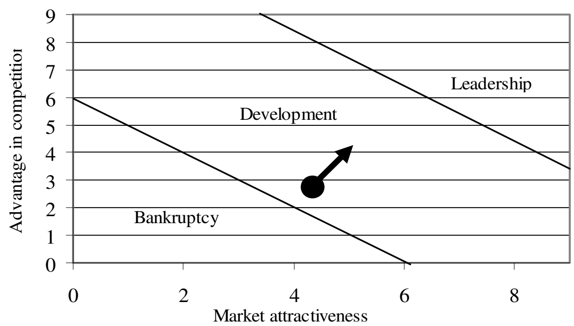

Fig. 1. Position of the project in the studied year.

The marked point and the directed vector of the McKinsey matrix provide evidence of the development of the wind energy project considered.

4. Identification of risks of the wind energy project

Identification of project risks is the first step of the impact on risks – reduction. The implementation of the wind energy project is associated with risks, both of an external and internal nature inherent in such projects in the real sector of the economy in modern conditions (Konechenkov, 2012). Therefore, taking into account the factors influencing the success of the project development, it is proposed to only assess the project under the scenario of its implementation in the process of the identification of risks. In addition to this, the basic account of factors (i.e. the possibility of conditions that lead to a deterioration of the project results) is performed by way of including the risk correction standard during the selection of a value (Yelistratov *et al.*, 2010). The risk correction value for the baseline version of the project is adopted in the amount of 100% of the discount risk-free commercial rate (Yelistratov *et al.*, 2010; Yelistratov *et al.*, 2013). The risks of any wind energy project are classified as follows: Project risks, market risks and management risks.

4.1. Project risk

Given the features of the particular wind energy project, the risk correction shares structure is formed as follows:

- 10% of the risk correction can be attributed to the country risk share (this risk is smoothed by the fact that the project involves the availability of government support);
- 15% – the risk of unreliability of the project participants (in this context, the low level of risk is adopted in the presence of strong partnerships and existing experience of similar work of the project participants, reducing the likelihood of their violation of the transaction terms);
- 75% – the technical, technological and commercial risks, associated with non-receipt of the specified income or exceeding the planned expenses, are major risks of the wind energy project. These risks include (Rolik and Gornostay, 2015):

1. Unpredictable level of inflation, which in the conditions of strict state regulation of electricity tariffs, can reduce the profitability of the project.
2. Unplanned growth of the currency exchange rate leading to an actual rise in the cost of borrowed funds.
3. Potential overestimate of the value of wind energy resources at the site of the wind-driven power plants leading to a lower than planned utilisation factor of the WPP power capacity and to a reduction of project revenues.
4. Reduction of consumer solvency, or under the project, an unforeseen increase in debt receivables for the provided electricity, which can be a consequence of the increase in the cost of financing the project working capital.
5. Rise in prices for spare parts and supplies used in the course of the project increasing its operational costs.
6. Wrong choice of electricity wind generation technologies, of the manufacturer and the WPP type, which lead to a decrease in the project revenues.
7. Growth in property prices can lead to an increase in rent payment for the land plots planned to be used for the deployment of WPPs or cancellation of the rent.
8. In the course of the project, the refusal of the state from the support of the project, manifested in the reduction of the set fixed prices for electricity generated by the wind energy project.

4.2. Market risk

The electricity selling market is practically unlimited. Due to the constant growth of electricity consumption in the short term, it is not required to consider market saturation.

The income from the operation of the WPP park consists of payments for the generated electricity, which shall be paid by the local energy production enterprise. In accordance with the current legislation of the country where the wind energy project is implemented, payments for the electricity produced by the WPPs are made at the rate which is determined by the Regulator according to the State Energy Policy accepted by the Government.

4.3. Management risk

Management risks are generated under legal relations organised between the project participants. The main relations are:

- Type of ownership;
- Enterprise management;
- Formation and use of its own capital;
- Control over the use of funds;
- Owners' liability;
- General meeting of participants;
- Legal succession;
- Termination of the relationship;
- Period of validity and participation of substitutability.

After the wind energy project risks are identified, it is necessary to go on to the development of measures to reduce their negative impact.

5. Measures to reduce the negative impact of risks on the project

Development of measures to reduce the negative impact of risks on the project is the second step of the impact on risks – reduction. In this context, the major reduction factors to be developed are two components: State support measures and project management activities.

5.1. State support measures

The most important state support measures, the provision of which determines the successful implementation of the project, and the reduction of the negative impact of possible risks, are (Rolik, 2008):

5.1.1. Reduction of the negative impact of commercial risks by:

1. Adoption of the government decision on the establishment of a fixed price (feed-in tariffs for 1 kWh) for the electricity transferred from the WPP park substation into the electric utility system.
2. The Government's provision of state guarantees for foreign investors to attract financing for the implementation of investment wind energy projects.
3. Ensuring the protection of producers of energy from renewable energy sources against unfair competition, as well as on the part of legal entities occupying the dominant position in the energy production industry.

5.1.2. Reduction of the negative impact of the project technical and technological risks by:

1. Ensuring a smooth, non-discriminatory and secure connection of the wind park to the nearest point of the state energy networks.
2. Ensuring the receipt of all proposed electricity produced using wind, provided by independent producers in the state energy network, as well as its payment at the established rates over the entire life cycle of the wind energy project.

5.2. Project management activities

In the implementation of the wind energy project with an aim to reduce the negative impact of the possible project risks, the main project management activities are (Rolik, 2008):

5.2.1. Reduction of the negative impact of commercial risks by:

1. Assessment of the viability and financial feasibility of the project (Rolik and Gornostay, 2015), the analysis of the business plan and cash flow correctness.
2. Calculation of the efficiency and profitability of the project, its feasibility, as well as the assessment of the environmental impact and environmental suitability.
3. Buying and acquiring a sufficient amount of land plots with the size and configuration corresponding to the requirements for the installation of WPPs and wind park planning.
4. Selecting the direct drive WPP with a mass of towers of less than 200 tonnes (the new lightweight standard) will help to reduce transportation and installation costs.
5. Provision of the operational control of the WPPs and timely removal of faults (Rolik, 2004), resulting in the process of operation, increases operational readiness and significantly reduces downtime (Rolik and Gornostay, 2010). To do this, in the wind energy project it is necessary to use such wind power plants, which can be remotely controlled from the central control facility of the wind park, which controls the operation of individual units (Rolik and Gornostay, 2016). In this case, about 90% of all faults that occur during the operation of the WPPs will be eliminated remotely from the control facility. The manual removal of faults, which cannot be eliminated remotely, shall be conducted by the specially trained operator technicians of the WPPs.
6. Involvement of a special team performing maintenance of wind parks in sequence on each WDP according to the schedule also reduces downtime, increasing the production of electricity, and hence the project revenues.

5.2.2. Reduction of the negative impact of the project technical and technological risks by:

1. Monitoring the area wind conditions during the period of 1.5 years at the intended site of construction eliminates the possibility of a lower than planned capacity factor of the WPP.
2. Meeting the basic requirements for the installation of the WPPs based on the average annual wind speeds at different heights eliminates unwanted turbulence and inefficient use of the potential of wind energy resources in the wind park.
3. The correct choice of the manufacturer and type of equipment using the main criteria for the selection and analysis of the current world supplier market.
4. Holding of a tender for selecting the manufacturer and type of equipment, during which preference shall be given to innovative technologies having obvious advantages over the competitors' solutions, such as:

- Solid blade technology;
- Increased rotor diameter (113 m) specifically designed for onshore conditions;
- Direct drive innovative technology and the solid design of the rotor blades, based on the experience of working with small direct drive units.

6. Conclusion

In order to identify potential risks, the evaluation of the viability and financial feasibility of the project being analysed shall be done under the joint consideration of the internal and external environment (the SWOT-analysis method), i.e. the environment of the wind energy project.

It is suggested to use the other method for the identification of risks based on the internal and external points of the wind energy project, which have to be evaluated with the help of the McKinsey expert ratings. These ratings help to calculate the attractiveness of the area of activity and the competitiveness of the project in the form of weighted averages for subsequent positioning on the McKinsey matrix.

Positioning of the wind energy project on the McKinsey matrix in the form of a base point and a directional vector allows the prospects for the development of the project to be judged in terms of the occurrence of risks that could hinder this development.

The practical use of these evaluations will allow timely identification of the occurrence and reduction of the negative impact of possible risks, which in turn will help to achieve good results in the implementation of commercial wind energy projects.

Overcoming the commercial risks of the wind energy project is mainly dependent on the project revenues, which are obtained for the electricity yearly generated by the wind parks as per the feed-in tariffs for 1 kWh of electricity. If it is impossible to affect the second performance index in any manner (as it is determined by the state), the first one is entirely dependent on the efficiency of project management, consisting of:

- The correct choice of the manufacturer and type of equipment;
- The correct choice of the proposed construction site with good wind conditions;
- The optimal deployment of plants in the wind park;
- The efficient operation of the equipment during its entire life cycle.

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