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INVESTMENT RISK OF WIND POWER

Abstract
The authors analysed investment risk of a wind farm construction in Poland. They specified key risk factors of investment projects and instruments that eliminate or minimize their impact. The article describes also methods that enable to estimate an impact of risk on profitability of the project. This paper is based on a number of newspapers, research articles and reports.
The investment in a wind farm construction due to, among others, a long period of repayment, legal turmoil on green energy, is exposed to a number of factors that may affect profitability of the investment.

Key words
wind energy, risk factors, return on investment, discount methods.

Introduction
Recently, a growing interest in wind power has been observed both on the part governments and the public. In the coming years, there will be, according to the Global Wind Energy Council forecasts, a systematic increase in installed capacity in wind turbines. The wind energy sector in Poland seems to be particularly interesting to foreign investors. The attractiveness of Polish wind energy sector is due to the fact that a large part of the country (about 66%) are areas with favourable wind conditions allowing for energy gain from wind. Poland has become an interesting country to foreign investors due to education, flexibility and performance level increase of Polish employees as well as stabilization of laws in some sectors of the economy. Moreover, even late alarming economy information does not adversely affect perception of Poland as a country where it is worth investing. Depreciated infrastructure, steady growth for electricity demand of households and whole economy causes huge resources to be invested in Poland in the next few years. In the coming years offshore wind farms will be incorporated first.

Literature Review and Hypotheses
Wind energy today. Growth prospects in Poland and Europe.
In Europe a continued growth in the number of wind turbines around the world has been observed from early nineties. In the period of 2001-2012, there was an annual increase in installed capacity of wind power from 3.2 GW to almost 12 GW [1]. According to estimates, owing to currently existing installations it is possible to generate about 231 TWh of electricity, which will cover 7% of total energy demand in Europe. Denmark is the country with (27%) the highest ratio of meeting a demand for electricity by the energy produced with wind power. It is followed by Portugal and Spain, whose ratios are 18% and 17% respectively. Data on wind energy in European Community are presented in Table 1.

Table 1. Wind energy in the selected EU countries in 2012 year

Country	Onshore wind farms [MW]	Offshore wind farms [MW]	Total [MW]	Percentage share
Austria	1 378	0	1 378	1,30
Belgium	996	380	1 375	1,30
Denmark	3 241	921	4 162	3,92
France	7 564	0	7 564	7,13
Greece	1 749	0	1 749	1,65
Spain	22 796	0	22 796	21,48
The Netherlands	2 144	247	2 391	2,25
Ireland	1 713	25	1 738	1,64
Germany	31 027	280	31 307	29,50
Poland	**2 497**	**0**	**2 497**	**2,35**
Portugal	4 523	2	4 525	4,26
Romania	1 905	0	1 905	1,80
Sweden	3 582	164	3 745	3,53
The UK	5 497	2 948	8 445	7,96
Italy	8 144	0	8 144	7,67
…	…	…	…	…
Slovakia	0	0	0	0
Slovenia	0	0	0	0
Summary (EU 27)	**101 048**	**4 993**	**106 122**	**100**

Source: own study based on [1]

A particularly rapid growth of installed capacity occurred in Poland in 2012 and amounted to 880 MW, compared to 436 MW in 2011. This may be due to the fact that investors wanted to complete their projects before the end of 2012 in order to use the old systems of support.

Investment risk of a wind farm construction

There are two concepts of risk in finance theory:

- The negative concept – it is possible that something goes wrong. A risk is defined as a threat, and a result as a damage. The concept is characteristic of insurance theory and practice;
- The neutral concept – it refers to a project, a result of which is not known. The risk may be a threat, but it can also be an opportunity. This is the case when the risk is the possibility of income realization that differs from an expected value.

In the case of investment projects the neutral concept is applied. Risk is inherent to any investment. It should be kept in mind that the higher the risk, the greater potential gain. The following types of risks can be specified during investment in a wind farm construction: interest rate risk, inflation risk, political risk, currency risk, raw materials' price risk, credit risk, technical risk, social risk. Companies financing their activities with foreign capital of variable interest rates are mainly exposed to interest rate risk. The value increase in paid interests negatively affects size of net profit. Furthermore, more expensive capital could cause the company not to take loan, which will result in its inhibition of growth. A significant increase in interest rate during the life of the investment may also result in unviable completion of the project [2].

Inflation refers to a process of a general increase in a price level. The inflation risk is to a very high degree correlated with the above interest rate risk. This is due to the fact that the Polish National Bank performs its task of achieving inflation target through, among others, setting interest rates. High inflation level will increase interest rate values, which will also increase the cost of capital used for investment financing [3]. The provisions on renewable energy investment are subject to frequent changes in Poland. Over the past three years (2011-2013) the energy law has changed 11 times.

Another type of risk is a currency risk, which is a result of fluctuations in individual currencies. Companies most exposed to this risk are those whose activities are related to export or import. Currency fluctuations may also result in implementation of investment projects being unprofitable because of significant increase in capital expenditures. Such situations were noticed in the second half of 2008 and early 2009. During the period, as a result of speculative operations carried out, among others, by Goldman Sachs Group, there has been an increase in value of European currency from 3.2 PLN to about 4.8 PLN, which led to an increase in investment costs by over 50% within only 6 months [4]. Size of income at the market will depend on how the price of 1 MWh will be shaped and above all, on how much size of income will differ from those revenues that were estimated during the preparation of cost-effectiveness analysis. A big drop in the price of electricity may cause a company to lose liquidity and become insolvent.

Credit risk is not due to from a company incurring obligations. It is, however, associated with a company's bankruptcy. The corporate bonds' owners and companies whose contractors were bankrupt and became insolvent are most exposed to credit risk [2]. Technical risk in the case of a wind farm construction is associated in particular with efficiency of infrastructure and possibility of wind turbines failure. The high variability of wind power related to weather conditions and seasons can cause performance of wind farm to be lower than expected level. There might also be periods when a wind farm may not be used. This happens in the case of too high or too low wind speed. These factors may cause a wind farm company owner to achieve lower than expected revenues, which can result in loss of liquidity in a short term.

Social risk is inherent to investments into renewable energy sources. In the case of wind energy wind farm construction legitimacy is questioned due to:

- The negative impact on local ecosystems mainly understood as a threat to birds,
- The negative impact on health. According to opponents of wind farms they cause vibroacoustical disease among residents of nearby villages,
- The risk of icicles falling off or moving parts of the wind turbine,
- The loss of land surrounding wind farms [5].

There have already been a number of studies carried out and reports on the impact of wind farms on both ecosystems and people. The studies and reports clearly show a slight harmfulness of this type of energy. However, many organizations continue to protest against new wind farms constructions. Recently, due to public protests constructions of wind farms located in Lipno, Dębków, Orchów, Łaznów were stopped or abandoned [6]. The cessation of investment projects causes very large economic losses.

The measurement of risk in an enterprise

The measurement and risk management are key steps in a process of business management. Most companies engaged in service activities, commercial or production are exposed to risks associated with changes in interest rates, foreign exchange rates or raw materials' prices. Development of OTC derivatives allowed companies to effectively secure their position, however, it did not allow to completely eliminate an impact of all risk factors. The most commonly used tools to mitigate the risk of prices deflect or interest rates include:

- FRA forward contracts,
- cap and floor contracts,
- swaps on interest rate, currency,
- forward contracts on currency, raw materials' prices.

Moreover, many companies operating at the market are obliged to apply risk measurement. Such an obligation is imposed by supervisory bodies that may operate within a company (Supervisory Board) or in the environment of a company (e.g. Insurance supervision, banking).

Standard deviation and variance

The standard deviation is a tool classified as a category of measurement variability. This theory was developed by Harry Markowitz in 1952 and according to its assumptions, the greater the variability of the variable (e.g. rate of return), the higher the level of risk because there is probability that the rate of return achieved may differ from the expected rate of return for investors. The standard deviation is calculated using the following formula:

In the case of continuous random variable:

$$\sigma = \sqrt{\int_{-\infty}^{\infty} [R - E(R)]^2 f(R) dR}, where$$

f - distribution of risk density function,

E (R) - the expected rate of return value is calculated by using the following formula:

$$E(R) = \int_{-\infty}^{\infty} R f(R) dR$$

- In the case of a random variable with an ankle:

$$\sigma = \sqrt{\sum_{i=1}^{m} [R_i - E(R)]^2 \, p_i}, where$$

m - number of possible variable risk values

p_i - probability of achieving i-th possibility rate of return,

E (R) - expected rate of return value, which is calculated by using the formula:

$$E(R) = \sum_{i=1}^{m} p_i \, R_i$$

The standard deviation determines a degree of dispersion of a studied feature value from arithmetic mean of a given feature. Together with reduction of a standard deviation a degree of dispersion of a feature decreases, which translates into a lower level of risk. The standard deviation is provided in the same units of measurement as a tested feature. It only adopts non-negative values. The standard deviation amounts 0 in the case where all tested features will be characterized by the same value.

Variance is a very similar tool to a standard deviation tool, value of which is equal to the standard deviation raised to the square. Variance also generates information about the degree of dispersion of studied variables in relation to arithmetic mean of these variables. It is worth noting that Harry Markowitz reported variance as the first measure of risk but now, because of better qualities of interpretation, a standard deviation is often used [7]. There are many different varieties of standard deviation and variances, which can include, inter alia, average, quartile deviation.

Value at Risk

Value at Risk (VaR, Value at Risk) is one of the most popular tools of risk measures. It was developed in 1994 by J.P Morgan analysts in response to a question of the bank president about a report. It informed daily about potential loss of an entire portfolio in a single trading day. Currently, it is mainly used in financial institutions to measure market risk. However, it can be successfully used to estimate operational risk or credit.

VaR indicates maximum loss of value (e.g. A portfolio of assets, investments) that may be incurred by an investor in a given period of time at a given confidence level. It should be noted that probability of incurring a greater loss is minimal. From the above definitions, it follows that threatened value depends on two elements:

- confidence level – whose value determines probability of potential loss that will not exceed the level of confidence. J.P Morgan bank uses a confidence level of 95% for calculations. This means that with 95% confidence it can be said that the amount of loss will not exceed a level set by VaR. A higher level of confidence is reflected in an increase of risk value level;
- time horizon – specifies over what period a loss should not exceed VaR.

These parameters may be defined differently in each company or institution.

The concept of value at risk can be represented by the following equation:

$$P(V \leq V_0 - VaR) = 1 - \alpha, where$$

V - Value of investment at the end of the studied period,
V_0 - Value of investment at the beginning of the studied period,
α - confidence level.
The above equation shows only assumptions, and a way to calculate value at risk. The following methods are used to estimate VaR:

- the variance - covariance method
- the historical simulation method,
- the Monte Carlo simulation method.

In practice, the first two methods are usually used. The Monte Carlo method is used only when there is no possibility of using other methods of VaR. This paper shows how a variance – covariance method was used to estimate VaR. The scheme of calculation VaR while using just this method is shown by the following example.
The portfolio of shares value in F company - 4 million PLN;
The one-day share price deviation of F company - 0.5%;
Confidence level - 95%.
In order to calculate value at risk in a one-day time horizon the number of 0.95should be read from statistical tables of normal distribution. This value of 1.645. VaR is calculated as follows:
VaR = value of a portfolio* currency fluctuations * normal distribution value
= 4 000 000 * 0,005 * 1.645 = 32 900
This result means that with 95%probability an investor will not notice a loss of more than 32 900 within twenty four hours. Similar calculations for a period longer than one day can be very quickly made (i.e. 10 days)

$$VaR = 32\,900 * \sqrt{10} = 104\,038,94$$

The interpretation of this calculation is similar to the example described above, except the fact that the level of risk has been set in the horizon of ten days.
Value at Risk is a tool most commonly used by financial institutions. The following modifications to the parameter VaR has been introduced according to needs of non-financial institutions [8]:

- Cash Flow at Risk (CFAR),
- Earnings at Risk (EaR).

The concept of the above-mentioned forms of value at risk is similar as in the case of Value at Risk, and can be represented by the following formulas:

$$P(CF \leq CF_0 - CFaR) = 1 - \alpha, where$$

CF - cash flow in the studied period (a random variable),
CF_0 - cash flow in the studied period,
α - confidence level.

CFAR is defined as a maximum size by which planned cash flow may differ from a real one at a given level of probability. Thus, probability that the difference between cash flows will be greater than CFAR value is 1-α.

$$P(E \leq E_0 - EaR) = 1 - \alpha, where$$

E - net profit in the studied period (a random variable),
E_0 - planned net profit in the studied period,
α - confidence level.
In the case of EaR net profit is a variable. EaR indicator should be interpreted as the maximum difference between planned and achieved net profit for a given probability of 1-α.
It should be noted that there exist some differences between Value at Risk, Earnings at Risk and Cash Flow at Risk, which include:

- Time horizon - VaR refers primarily to short time horizon, which results from the fact that financial institutions use VaR. In the case of EaR or CFAR, however, monthly and even yearly analyses are conducted;
- The reference point - in the case of VaR, the estimates are based on the current value, e.g. investment portfolio. The starting point of applying the CFAR or EaR concepts are planned cash flow or net profit [7].

The concept of VaR assumes that the market behaves normally. It should be kept in mind that unusual circumstances might occur at the market and then measure of the value at risk may be insufficient measure of risk [9].

Analysis of sensitivity
Sensitivity analysis ("what if" analysis) is a simple tool to estimate the sensitivity of NPV criterion for changing value of one of the input variables affecting the value of a project. The disadvantage of the method described

above is that it enables a description of individual variables impact, assuming that other values remain unchanged. There are two approaches in development of a sensitivity analysis:

- Determination of variables' values at which the NPV will be 0,
- Determination of individual variables changes impact on the NPV, e.g. how a reduction in revenue by 10% will affect the NPV [10].

In practice, the results of sensitivity analysis are presented in the chart or placed in the table called "sensitivity matrix".

Risk Analysis

Even though all the above mentioned indicators showed that the construction of a wind farm is economically viable, it does not mean that the project will be profitable. Moreover, use of derivatives to hedge its position also does not guarantee profitability of investments. Investments related to the construction of wind farms are characterized by long duration, which significantly increases a level of risk. The most important risk factors associated with analysed construction of a wind farm include: political risk, wind speed (wind conditions), incomes from RES support system, technical risk, and social protests. These factors may affect profitability of the investment [11].

Political risk is inherent to all kinds of investments. However, in the case of wind energy it is higher than in other sectors of economy. Recently, regulations related to wind power industry have been modified several times. Political risk is one of the factors against which there are no effective methods to minimize its impact. Moreover, investors are not able to estimate an impact of risk categories on the profitability of investment.

Technical risk is associated in particular with possibility of defects. In the case of the analysed project all wind turbines are new and were purchased directly from a manufacturer. Moreover, all maintenance work will also be carried out by Vestas company. Thus, the risk of defects has been minimized, but it cannot be excluded. As in the case of political risk, it is very hard to determine its impact on an implemented project.

Social protests, as well as political risk are important factors that affect activities in the wind energy sector. Social protests often led to the cessation of multi-million dollar investment. The analysed wind farm is built away from residential buildings. In addition, noise analysis has shown that it has no impact on distant residential areas. The risk of social protests is small.

Change of wind conditions and certificates of origin prices can have a significant impact on profitability of the investment. There is no possibility to eliminate this risk, but it is possible to estimate its impact.

Sensitivity Analysis

Below, there is an evaluation of certificates' price of origin and annual working time impact on profitability of the studied wind park project (Figure 1). The drafted analysis does not take into account an impact of electricity prices, because the principles that shape this value are well known, which means that a reasonable estimate of electricity price in the years 2013-2039 is possible. The impact of interest rate and currency fluctuations were also not taken into account, due to the fact that the tools (derivatives) enable elimination these risks.

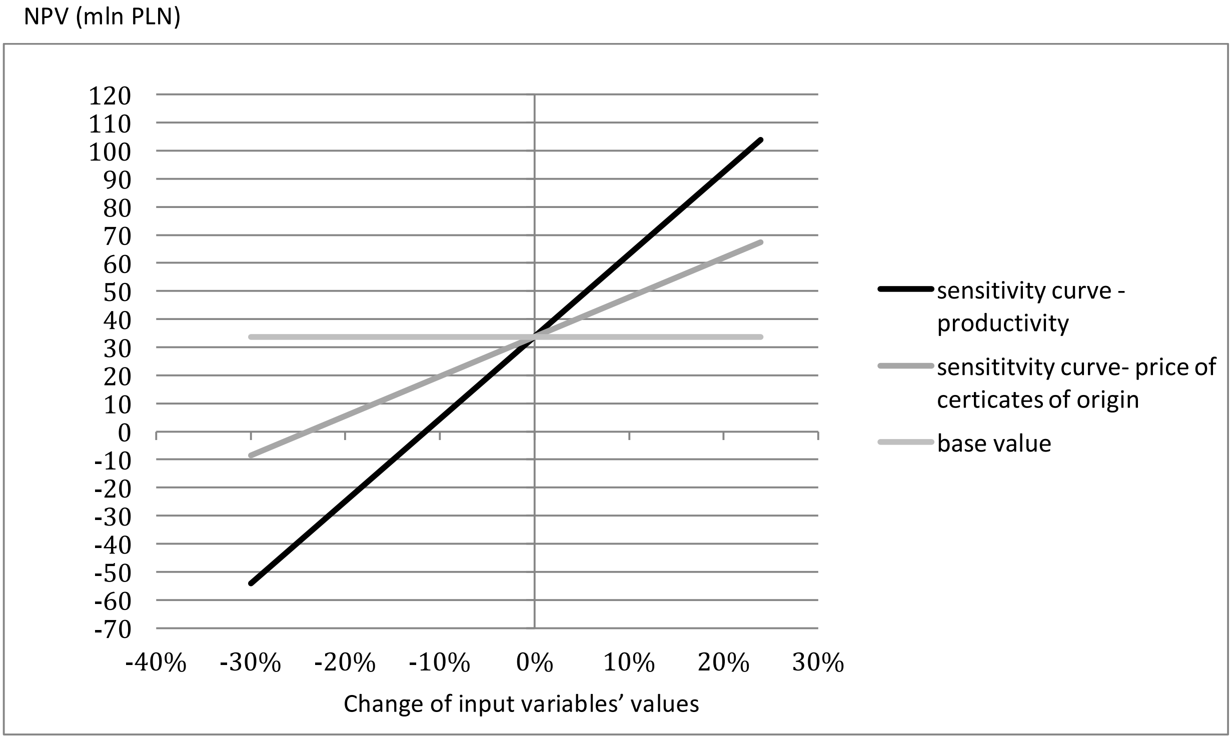

Fig. 1. Sensitivity Analysis
Source: own study

Sensitivity analysis showed that certificates of origin price may be lower in relation to assume by nearly 24% during operation of wind farm. Limit price at which the project will be profitable is 184.08 PLN / MWh. At a price of 184.07 PLN / MWh of certificates of origin NPV value will amount -599.48 PLN. Minimum wind farm productivity should amount no less than 76 594.4 MWh per year for analysed project to be economically viable. Thus, it is possible to decrease production of electricity by 11.5% compared to the assumptions adopted in the analysis. Sensitivity analysis shows that there is a significant margin of safety. Therefore, a significant decrease of one of the above-described parameters is acceptable.

Value at Risk

The concept of Cash Flow at Risk was used for calculation of VaR. The factors related to certificates of origin price and productivity of wind park were subject to evaluation. The annual volatility of certificates of origin prices was estimated at 11.34 PLN / MWh. The certificates of origin price reduction by 11.34 will cause earned income decline by nearly 2.5% per year, which translates into a decrease in the value of cash flow by 76%. Thus, with 95% probability it can be concluded that the value of cash flow in 2015 will not differ by more than 1.3 million PLN for the period of one year [12].

CFAR = change in the Cash Flow value * normal distribution value *projected value of Cash Flow = 76% * 1,645 * 1 045 5 13, 28 = 1307 935.24

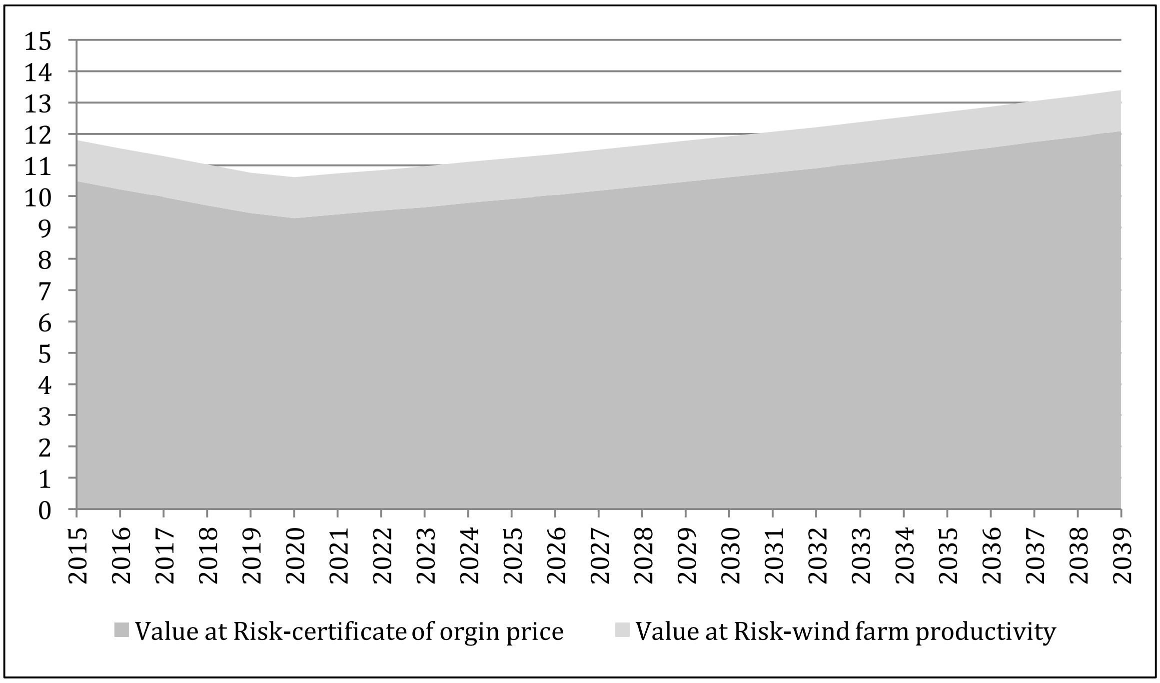

Fig. 2. Value at Risk of the analysed project in the years of 2015-2039 in million PLN
Source: own study

If assumed that price volatility of certificates of origin will remain at 11.34 PLN / MWh level per year, it can be said with 95% certainty that the value of Cash Flow in the coming years will be no less than 1.31 million PLN. Possible decrease in prices of certificates of origin adversely affect profitability of the investment, however, it will not cause its implementation to be unprofitable.

Based on data from the period of 1990-2009, annual variability of wind speed at 0.64 m/s was estimated. The decrease in wind speed by 0.64 m/s will reduce the amount of energy produced to the level of 72 145.62 MWh, which will translate into a decrease in revenue from electricity sales by more than 6.5 million PLN in 2015. It was estimated with 95% probability applying the concept of Cash Flow at Risk that cash flow value in 2015 will not differ from the assumed level of more than 10 490 million PLN [13].

CFAR = change in the Cash Flow value * normal distribution value* projected value of Cash Flow = 610% * 1.645 * 1 045 513.28 = 10 486 735.11

If assumed that variability of wind will remain at a constant level by the year, the value of Cash Flow at Risk in the years will range 10.5-12 PLN million per year.
Total Cash Flow at Risk in the graph below includes both price volatility of green certificates and wind strength.

Profitability analysis
Here are many methods of estimating the profitability of a given venture (Table 2).

Table 2 Methods of evaluating investment profitability

Discount methods	Net Present Value, NPV
	Internal Rate of Return, IRR
	Profitability Index, PI
	Modified Internal Rate of Return, MIRR
	Discounted Payback Period, DPP
Simple methods	Simple payback period
	Accounting rate of return
	Payback period on outlay
	Profitability threshold analysis

Source: own study.

Due to the fact that investment in wind farm construction is characterized by a long payback period, the authors used only the discount method to evaluate its profitability. The net present value of the project analysed is presented in Table 3.

Table 3 Net present value of the project

Year	Cash Flow [zloty]	Discount rate	Discounted Cash Flow [zloty]
2013	-20,367,000.00	9.931%	-20,367,000.00
2014	-20,367,000.00	9.931%	-18,527,100.34
2015	-1,045,513.28	9.931%	4,631,013.07
2016	-45,335.66	9.931%	4,965,526.95
2017	960,213.47	9.931%	5,205,487.84
2018	1,971,268.40	9.931%	5,365,000.52
2019	2,987,966.77	9.931%	5,456,409.85
2020	4,010,449.68	9.931%	5,490,502.47
2021	5,038,861.73	9.931%	5,476,686.54
2022	6,073,351.15	9.931%	5,423,151.79
2023	7,114,069.89	9.931%	5,337,011.94
2024	8,161,173.66	9.931%	5,224,431.41
2025	9,214,822.09	9.931%	5,090,738.03
2026	10,275,178.81	9.931%	4,940,523.06
2027	11,342,411.52	9.931%	4,777,730.16
2028	12,416,692.12	9.931%	4,605,734.24
2029	17,129,623.60	9.931%	4,182,772.60
2030	29,413,566.68	9.931%	5,881,855.15
2031	29,724,748.72	9.931%	5,407,110.15
2032	30,043,710.31	9.931%	4,971,426.02
2033	30,370,645.95	9.931%	4,571,532.74
2034	30,705,754.97	9.931%	4,204,438.23
2035	31,049,241.73	9.931%	3,867,404.38
2036	31,401,315.65	9.931%	3,557,925.26
2037	31,762,191.41	9.931%	3,273,707.4
2038	32,132,089.07	9.931%	3,012,650.28
2039	32,511,234.18	9.931%	2,772,832.30
		NPV	**78,799,501.78**

Source: own study.

The net present value of the project in question amounts to 78,799,501.78 zloty. The NPV≥ condition was met and thus the project should be allowed to go ahead. Using the calculated NPV value, the authors estimated the profitability index. The total discounted positive cash flow equals 117,693,602.12 zloty, while negative cash flow equals 38,894,100.34.87 zloty.

$$PI = \frac{Present\ value\ of\ Future\ Cash\ Flow}{Initial\ Investment} = \frac{117{,}693{,}602.12}{38{,}894{,}100.34} = 3.026$$

The condition PI≥1 is met. This means that the project should go ahead.

The internal return rate of the venture is estimated by the authors at a level of 22.439%. The IRR value exceeds the discount rate, which further supports the decision to proceed with the venture. Using the IRR indicator, the authors defined the margins of safety at 12.508%.

In the monograph to be published at the beginning of 2016, the authors described the following issues: a detailed description of the research, main risk factors, instruments to eliminate or minimize their impact, methods that enable to estimate the impact of the risk on profitability of the project. The article presents the research aim and basic information on profitability of the analysed project.

Summary and conclusions

The final shape of new act on renewable energy sources and stability of provisions related to this act are key factors for development of wind energy sector in Poland in the coming years. Moreover, the size of expenditures incurred for development of energy infrastructure in the country will be of significance. Poland is a country worth investing, especially in the wind energy sector, which is growing at a faster rate than expected. This sector can have a significant impact on the Polish economy in the coming years by, among others, improvement of energy security and creation of new jobs. Investment into construction of a wind farm project is viable, but burdened with high risk. While analysing the profitability, the authors took into consideration also immeasurable aspects. There are, however, factors whose impact cannot be predicted.

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Studies financing from own resources.

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RYZYKO ZWIĄZANE Z INWESTYCJĄ BUDOWY FARMY WIATROWEJ W POLSCE

Streszczenie
Autorzy przeanalizowali ryzyko związane z inwestycją budowy farmy wiatrowej w Polsce. Wyszczególniono podstawowe czynnika ryzyka towarzyszące projektom inwestycyjnym oraz instrumenty pozwalające eliminować bądź minimalizować ich wpływ. Opisano metody umożliwiające oszacowanie wpływu ryzyku na rentowności przedsięwzięcia. Artykuł powstał w oparciu o liczne artykuły prasowe, naukowe oraz raporty. Inwestycja budowy farmy wiatrowej ze względu m.in. na długi okres zwrotu, zawirowania prawne wokół zielonej energii, narażona jest na wiele czynników mogących wpłynąć na opłacalność inwestycji. Autorzy podczas szacowania opłacalności inwestycji wykorzystali instrumenty pochodne (kontrakty terminowe, swapy) pozwalające zminimalizować wpływ wahań stop procentów oraz kursów walut. Ponadto w celu uniknięcia ewentualnych protestów społecznych przeprowadzona została analiza wpływu hałasu, która wykazała, iż poziom hałasu mieści się w dopuszczalnym limicie i nie będzie oddziaływać negatywnie na okolicznych mieszkańców. Na podstawie historycznych pomiarów sił wiatru oszacowali jej zmienność w skali roku, co pozwoliło oszacować minimalną produktywność farmy wiatrowej.

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Słowa kluczowe
energetyka wiatrowa, czynniki ryzyka, opłacalność inwestycji, metody dyskontowe