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Błażej Pilarczyk, M.A.

**Oddziaływanie finansowych mechanizmów wsparcia
na inwestycje w energię wiatrową w Polsce**

**The Impact of Financial Support Mechanisms
on Wind
Energy Investments in Poland**

Summary of Ph.D. dissertation

Supervisor: Assoc. Prof. UEP Dr. Marta Kluzek, Ph.D.

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Institute of Finances
Department: Investments and Market Assets

1. Justification of subject selection

The arguments in favour of selecting the topic of this doctoral dissertation - "The Impact of Financial Support Mechanisms on Wind Energy Investments in Poland" - are primarily the statistics resulting from the publication of the Central Statistical Office - GUS (2022) - "Energy from Renewable Sources in 2020", and Eurostat (2021) - "Statistical Data on Renewable Energy". The published data indicate dynamics of growth regarding renewable energy sources (RES) generated by land-based wind farms (LBWF). Sustainable and environmentally-friendly wind technology has the greatest influence on the production of electric energy from renewable sources and covers, to the greatest extent, the share of RE in the energy mix in Poland. Between 2005-2020, LBWF recorded the highest dynamics of growth concerning installed generation capacity from 0.1 to 6.3 Gigawatts (GW) and electric energy generation from 0.1 to 15.8 Gigawatt hours (GWh) compared to other RES technologies operating on the market Polish. LBWFs are currently a technology with an estimated development potential of 22-24 GW in the 2030-2035 perspective (PSEW, 2021) and 35 GW of land-based wind farms by 2050 (McKinsey & Company, 2020). Investments in wind energy can significantly contribute to the achievement of the share of energy from renewable sources in the final gross energy consumption in 2030 of at least 32% in the energy sector, as set out in the "National Energy and Climate Plan for 2021-2030" (Ministry of State Assets, 2019).

Poland has adequate wind conditions (Bochenek et al., 2021; Mazur, 2022), therefore, it should promote LBWF technologies that use a free energy source, i.e. wind. Worldwide trends clearly show (International Energy Agency, 2022; WindEurope, 2021) that the wind energy sector in renewable energy is the most developed in countries with appropriate wind potential. Continuous technological progress means that both capital expenditures (CAPEX) of wind projects and the costs of electricity generation by wind farms are decreasing compared to conventional energy, as confirmed by reports from international and national research institutions (PSEW, 2021). In the case of energy technologies currently accessible and promoted in Poland as 'climate-friendly', wind energy is the least expensive option available. LBWFs are characterised by the shortest construction period in the European Union (EU), twice as fast as biomass cogeneration systems, four times shorter than hydropower plants and six times quicker than nuclear power plants.

Additional financial factors of LBWFs positively influencing the economic environment of the country are budget revenues of communes from property tax and income for land owners from the lease of land for wind farms. The development of the wind sector contributes to the minimisation of carbon dioxide emission as well as pollutants and toxic waste harmful to the environment, which allows to reduce related costs. The existing potential in Polish wind investments has a positive effect on the development of the economy, meeting the assumptions of the EU climate policy, maintaining the country's energy independence and limiting energy imports from abroad. In order to effectively utilise wind potential in Poland, investments should be implemented with the use of appropriate and well-designed growth stimulating mechanisms. The effectiveness of support mechanisms, measured by the increase in generation capacity and the volume of generated energy, thanks to the appropriate policy and state support, will satisfy the domestic demand for electricity while also strengthening the export of 'green' energy.

2. Research objectives

The main objective of the work is to assess effectiveness regarding the impact of financial support mechanisms on the economic profitability of investments in wind power plants. In order to achieve the main goal of the work, secondary goals have been defined:

- 1) Reviewing existing support systems regarding the possibility of optimal impact on investments in wind farms and the development of this sector;
- 2) Assessing economic conditions, stability and predictability of the legal environment and economic efficiency of investments related to the generation of electric energy from wind farms;
- 3) Identifying the motives of entities conducting economic activity to engage their own financial resources in electricity generation projects with the use of wind farms;
- 4) Assessing the impact of financial support instruments on the effectiveness of investment projects in wind farms, obtained by business entities in the form of rate return from invested capital.

In this paper, a hypothesis was formulated that in the financial and economic conditions outside the support system, investment projects in wind farms are not profitable.

3. Research methods and dissertation structure

The work comprises five chapters. In the first chapter, theoretical foundations are presented regarding economic aspects of environmental protection and the criteria for qualifying financial support instruments formulated by economists dealing with issues in this research area. Also described are the effects of introducing economic support mechanisms, which are mainly market-induced adaptation reactions on part of investors, consumers and the state. In the second chapter, legal regulations are assessed with regard to the support mechanisms in force in Poland and the introduction of common rules under the provisions of EU directives, as well as the implementation of these principles into national legislation. The guidelines that EU countries should meet in a specific time frame were also approximated.

In chapter three, specific solutions are demonstrated in detail with reference to financial support instruments affecting enterprises generating electricity via wind farms. The legal act regulating the analysed issues is the Act from February 20, 2015 on renewable energy sources, which, as a result of legislative work, has adopted the described support systems. The development of energy wind farms in Poland was implemented with the use of basic systems for shaping the amount of generated energy:

- 1) in the green certificate formula;
- 2) auctions for the sale of electricity from renewable sources.

The profitability of the investment was also influenced by:

- 3) subsidies to construction costs from EU funds, incl. the Cohesion Fund under the "Infrastructure and Environment" project, the European Regional Development Fund, as well as national funds, incl. NFOŚiGW – National Fund for Environmental Protection and Water Management;
- 4) corporate energy purchase agreements.

The legal definition of a renewable electricity purchase contract, the closest to the CPPA – Corporate Power Purchase Agreement - concept, is contained in the Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources. Pursuant to Art. 2 point (17) of the Directive, a renewable electricity purchase contract should be understood as an agreement under which a natural or legal person agrees to purchase renewable energy directly from an electric energy producer (Directive from 11 December 2018). In the Polish legal system, CPPA has not been defined. Having a CPPA, in addition to hedging against an abrupt risk of price reduction and a gradual reduction in demand, becomes a guarantee of the creditworthiness concerning financing invest-

ments, ensuring a predictable stream of revenues. In order to improve the efficiency and stability of investments, CPPAs require the implementation of appropriate legal regulations, allowing for the proper shaping of conditions and management of the risks associated with their conclusion.

The harmonisation of the excise tax on electric energy in EU countries, regulated by the European Union Directive and tax regulations in Poland, has been presented. According to the current legal status, they assume the form of different rates and exemptions in the excise tax on energy. In this chapter, among others, issues concerning the determinants of development and barriers to investments in wind energy are discussed.

In the fourth chapter, the process is presented of comprehensive analysis concerning the profitability of investments in electric energy generation systems from wind energy, with a discussion on all significant financial aspects that should be included in such an analysis. In the empirical part, the criteria and methods for making investment decisions in the production of electricity from wind generation are exhibited, with the use of classic project profitability ratios, including net present value (NPV), internal rate of return (IRR) (Gnatowska and Wąs, 2017) and the average LCOE – Levelised Cost of Electricity - typical for the electric energy sector (Dzieża, 2017), (Skrodzka, 2017), (Stehly, Beiter, Heimiller and Scott, 2018). In order to carry out calculations using the methods given above, assumptions were made regarding the financial and economic conditions, in particular, CAPEX forecasts, subsidies and public aid funds (state aid), the level of electricity sales prices, the amount of taxes and tax preferences, the cost of capital, the structure of current operational costs, with the occurrence of which the examined investment will be profitable.

In the fifth chapter, specific risk analysis was carried out using extended methods of assessing investment project effectiveness, which include sensitivity analysis, scenario analysis or Monte Carlo simulation. As a result of sensitivity analysis, the degree of fluctuations in the dependent variable as a result of changes in individual variables adopted for the analysis was estimated. Sensitivity analysis made it possible to determine the strength and direction concerning the impact of individual variables on the final effectiveness of the project. The purpose of the sensitivity analysis was to determine the permissible deviations in the values of individual variables affecting the profitability of an investment project. Sensitivity analysis of the forecasted deviations in the value of factors determining the NPV presented in the paper was based on the following assumptions:

- dependence of the change in NPV related to the change in capital expenditures;
- dependence of the change in NPV value with regard to the change in the volume of energy generation;
- dependence of the change in the NPV with regard to the change in the electricity prices.

The Monte Carlo method was used to assess the financial risk of the investment. The essence of the Monte Carlo method is the ability to generate any finite number of results concerning the financial evaluation of an investment. The implementation of the project is analysed in accordance with the investment environment conditions adopted in the plans and comparing them with the current state in order to obtain the assumed rate of return. Therefore, there is a need to exercise on-going control related to the dynamics and direction of changes taking place in the investment environment, and, as a result, to make an appropriate choice of the investment course scenario (Wiśniewski, 2013; Sartori et al., 2014; Zemke, 2017; Ligus and Słoński, 2018).

4. Results of research and conclusions

Investment risk related to the construction of wind farms concerns achieving a lower-than-expected profitability level of the project, examining problems related to financing the investment, assessing failure to realise the assumed operating parameters and delays in the implementation of the investment. Investments in wind farms are strongly associated with regulatory risk, consisting in legislative changes affecting the implementation and operation of individual projects. Materialisation of risk may lead to suspension of implementing investment plans or an increase in operating costs.

The EU legislation presented in Chapter 2, through the adaptation of the national legal order to European standards, had major impact on the shape of Polish legal regulations in the area of renewable energy support in the analysed period. The stability and predictability of the legal system is an important risk factor in the implementation of long-term investments. The quality of the adopted law, preceded by public consultations, impact assessment, with respect for the principles and regulations of reliable legislation, eliminates arbitrary decisions by the executive. The case of real estate tax on wind farms, presented in Chapter 3, allows to show the problem of imperfect legislation and discrepancies in doctrine and jurisprudence. Tax issues in this area have negative impact on the profitability of investment projects in the wind energy sector. The introduced regulations raise interpretation-related

doubts, because administrative courts recognise the wind farm - as a whole - as a building and, consequently, recognise that the tax should be calculated based on its entire value.

As a result of the profitability assessment of land-based wind farm investments conducted in this study, it should be stated that the above provided legal solutions for financial support in the wind industry operating in Poland have significant impact on its development. The dynamic growth in wind energy in Poland, which took place in 2006-2016, was the result of the support system in the form of property rights resulting from certificates of origin (green certificates) operating from October 1, 2005 to July 16, 2016. Increases in installed wind capacity during this period increased from 172 MW to 5,747 MW, i.e. by 1,778%. As a consequence, additional wind power generation volumes also appeared, increasing by 9,189% from 256 GWh to 12,586 GWh per year. However, when the system of certificates of origin was destabilised, the financial condition of wind farms shook sharply, as a result of which many of them were forced to declare insolvency.

In 2016, as a consequence of change in the regulations abolishing the rights to use the certificate system by new investors, the regulations (Act from February 20, 2015) gave the right to issue green certificates only to existing wind installations. The condition for using further support up to 15 years from the date on which the installation introduced energy to the grid for the first time was the commencement of wind energy generation before July 1, 2016. At the end of 2022, wind farms with a power of approx. 5,400 MW will be maintained. After such a dynamic period of development, in 2016, there was a slowdown in wind investments, mainly due to the termination of the green certificate system and regulations limiting the area that meets the requirements of the "Distance" Act (Act from May 20, 2016). Between 2016-2020, the capacity of wind farms slightly increased from 5,747 to 6,298 MW, i.e. by 551 MW (9.6%).

Along with the enactment of the Act on Renewable Energy Sources, a new type of support was designed and introduced, i.e. the auction system, which ensures the competitiveness of entities participating in auctions and translates into favourable energy prices, consequently, affecting energy costs for end-users. The auction is won by the entrepreneurs who offer the lowest selling price of energy. As a result of support system evaluation, it should be stated that in dynamically-changing financial and economic conditions, the auction system demonstrates higher efficiency. The advantage of this system is stability of the parameter in the form of the energy price, annually indexed with the inflation index, which largely affects

the profitability of investments in wind energy. The auction system protects capital commitment against market risk and affects the stability of investments in the long-term term. For the purposes of assessing the profitability of the investment presented in the paper, a price variation of PLN 233/MWh was adopted, resulting from the URE – Energy Regulatory Office’s auction contracted in December 2019, subject to additional annual inflation indexation. The results of the investment profitability calculations presented in Chapter 4 allow to indicate profitability at the level of $NPV < 0$, -49,438 PLN, while the $IRR = 4.35\%$.

On the basis of the calculations of sensitivity coefficient values, it results that a change of one percentage point in the selling price of electricity expressed in PLN/MWh causes a change of 6.58 percentage points in the NPV ratio. A one percentage point change in the electricity generation volume (MWh) causes a 6.59 percentage point change in NPV. A change by one percentage point in capital expenditure expressed in thousands of PLN, changes by 6.50 NPV percentage points. The analysis allows to show that these are the three most sensitive financial parameters, with the strongest impact on the profitability of investments. In the case of a variable in the form of electric energy selling prices, there is a positive sensitivity coefficient, meaning a positive correlation between the indicator and the variable, i.e. an increase in the variable induces an increase in NPV, and a decrease in the variable causes a decrease in NPV. From the perspective of the implemented support systems, stability and the level of electricity prices are of particular significance. Support in the form of an auction system reduces the risk of large fluctuations in electric energy prices and ensures stability of revenues. During the upward and downward trends in electric energy prices, the potential gains and losses are offset by the price guaranteed during the auction in a 15-year time frame.

Based on the financial assumptions specified in the paper, the Monte Carlo simulation was performed, as a result of which the profitability of the investment was estimated for $NPV = -2,325$ PLN with a probability of 48.43%, and $IRR = 7.83\%$ having a probability of 100%. The justification for including the market price of electric energy in the analysis is the fact that in the concluded wind-photovoltaic auction for projects with a capacity of over 1 MW in December 2019, the producers decided to diversify their revenues and offered only part of the future wind generation in order to benefit from state support, leaving the remaining sales to be realised according to the terms obtained on the market or in CPPAs.

The arguments in favour of involving financial resources in wind projects regard continuous increases between the 2019-2022 period in electricity prices as well as demand and consumption, which are important elements affecting return rates on invested capital. The reasons result from the beneficial economic situation and pressure on environmental protection, as well as sustainable development (Zioło, Filipiak, Bąk, & Cheba, 2019). On the one hand, mechanisms are being implemented to financially discourage conventional energy producers from emitting carbon dioxide and harmful substances into the atmosphere, while on the other, financial support for building zero-emission renewable energy generations are observed. These factors make it the most dynamically developing technology in the domestic energy sector due to the pursued policy and taking the wind potential in Poland into account.

The presented analyses have allowed to prove that the financial support systems for the production of energy from renewable sources translate into an increase in the profitability of wind investments, the intensification of which stimulates the expansion of the energy potential. Support mechanisms characterised by stability in determining electric energy sales prices have stronger impact on the achievement of the expected return rate and the period of return on expenditure than market prices listed on the Polish Power Exchange. Both investors and credit rating institutions prefer the stability of income for long-term investments in order to limit the price risk. Stock prices are characterised by a greater scale of fluctuations and, as a result, an increased risk of not achieving the assumed revenues. Therefore, it should be recognised that financial support systems are, currently, an important factor in the development of wind investments in Poland. At the same time, the sector of wind energy sources in Poland, in order to fully utilise its potential, requires necessary changes in law, allowing for the dynamisation of new investments.

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