Chapter 31
Onshore Wind Farms: Value Creation for Stakeholders in Lithuania

Marija Burinskienė, Paulius Rudzkis and Adomas Kanopka

Abstract With the costs of fossil fuel consistently rising worldwide over the last decade, the development of green technologies has become a major goal in many countries. Therefore the evaluation of wind power projects becomes a very important task. To estimate the value of the technologies based on renewable resources also means taking into consideration social, economic, environmental, and scientific value of such projects. This article deals with economic evaluation of electricity generation costs of onshore wind farms in Lithuania and the key factors that have influence on wind power projects and offer a better understanding of social-economic context behind wind power projects. To achieve these goals, this article makes use of empirical data of Lithuania's wind power farms as well as data about the investment environment of the country.Based on empirical data of wind power parks, the research investigates the average wind farm generation efficiency in Lithuania. Employing statistical methods the return on investments of wind farms in Lithuania is calculated. The value created for every party involved and the total value of the wind farm is estimated according to Stakeholder theory.

31.1 Introduction

Continual population and economic growth has meant increased energy consumption worldwide. From 2004 to 2008, the world population grew by 5 %, whereas the gross energy production increased by 10 %, and the yearly CO_2

M. Burinskienė (✉) · P. Rudzkis
Vilnius Gediminas Technical University, Saulėtekio Avenue 11, 10223 Vilnius, Lithuania
e-mail: marija.burinskiene@vgtu.lt

P. Rudzkis
e-mail: paulius.rudzkis@gmail.com

A. Kanopka
Mykolas Romeris University, Ateities Street 20, 08303 Vilnius, Lithuania
e-mail: adomas.kanopka@gmail.com

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emission increased by 10 % [9]. If such tendencies continue, the IEA predicts that, by 2030, energy demand worldwide will have increased by approximately 60 %, and carbon dioxide emission will have increased by 62 %.

Wind energy is expected to play an important role in the future. By 2020, approximately 180 GW of both onshore and offshore wind power, corresponding to 10–15 % of all energy produced in EU power installations, could be generated in the European Union alone. As estimated by the Global Wind Energy Council [7], in 2020, approximately 16 % of electricity consumed worldwide will be generated by wind energy.

In Lithuania wind power is one of the most rapidly growing technologies of renewable energy. As opposed to 2009, in 2010, the generation of electricity in wind power plants in Lithuania grew by 43 % which corresponded to 3.9 % of all electricity generated in the country. The amount of electricity generated in hydro power plants in Lithuania is small in comparison, and, moreover, the usage of hydro resources is limited due to the flat landscape.

In the last decade, a variety of models have been developed for analyzing long-term trends in renewable and wind energy costs and payback periods necessary for the return of the investments for wind farms [1, 8, 20, 22]. A usual way to look at the long-term cost trend is by applying the concept of the experience curve, which analyses the cost development of a product or a technology as a function of cumulative production, based on recorded data. The experience curve is not a forecasting tool based on estimated relationships; it merely points out that if specific trends continue to prevail in the future, then we may see the proposed decrease. However, some of these models use incompatible specifications, not all of which can be compared directly. Experience curves for wind energy have been presented in scientific papers [10, 17]. As a rule, the price for wind energy is determined by calculating the direct value. However, wind farms create not only direct, but also indirect value, which refers to their social value and the price and properties of inferred resources. Consequently, it is necessary to ensure that both the evaluation and the development of wind power projects are performed in the economically most optimal fashion.

This paper attempts to contribute to a better understanding of how to substantiate wind power projects economically.

The objective of the article is: to evaluate the implementation costs and the created value of onshore wind farms in Lithuania, to identify key factors that have an influence on wind power projects, and to contribute a better understanding of the social-economic context behind wind power projects.

The expected outcomes of this study are:

- improving the evaluation of wind power plant investment projects in Lithuania by analyzing their investment environment and prospects
- identification of the total economic value and distribution of value shares to stakeholders.

To achieve these goals, empirical data about Lithuania's wind power farms as well as data about their investment environment have been collected.

Technological development plays a major role in decreasing the overall cost of wind energy; the growing demand raises the price of power generation units in the short run. The wind energy generation costs have increased by 20 % in the past 3 years, due to the rising prices of key raw materials and an unexpected surge in the demand for wind turbines, following the approval of favorable support policies in large markets, such as those of the USA, China, and the second round of European Member States [1]. For the reasons mentioned, in this article, we refer to the financial and technical characteristics of the already existing wind farms.

The empirical analysis presented in this paper is based on the data provided by the operator of the largest wind farm (30 MW) in the Baltic countries and owner of the closed joint stock company "Vėjų̧spektras," which has an extensive experience in developing wind energy projects. Its wind power farm consists of 15 E-70 model power turbines, manufactured by German Enercon, GmbH; the installed capacity of each turbine is 2 MW. The wind power farm is located in the seaside area, which is recognized as a location, commercially viable for the development of wind power farms. Therefore, the data about this farm is a suitable basis for an analysis of the value and costs of wind energy in the seaside area.

Methods: This article carries out a financial analysis, a Cost-Benefit analysis, and a Discounted Cash Flow analysis. The Cost-Benefit analysis (CBA) is an analytical method applied by businesses and governments in order to determine whether the economic net benefit, brought by a project or a public sector program, outweighs the costs [2, 18]. CBA makes use of a set of widely adopted methods for evaluating investments, which include the Discounted Cash Flow (DCF) method. The DCF method helps estimate the current value of an investment by discounting projected future revenues and costs.

31.2 The Efficiency of the Wind Resources of the Lithuanian Onshore Area in Generating Electricity

The most important factor affecting the profitability of investments in wind energy is the local wind resource. Differences in wind speed explain most of the differences in the costs per kWh between specific countries and projects. The development of wind energy in Lithuania has less favorable natural conditions than in Latvia and Estonia [24]. This is determined by a short stretch of the coastal line in Lithuania. The deeper into the continent goes to measure wind speed and the effectiveness of wind power plants, the more they tend to decrease [14].

A number of UNDP supported studies have been conducted in order to identify wind energy resources in Lithuania [19]. The wind speed measurement data (m/s) obtained at 10 m above ground level by Hydro meteorological stations has led to a conclusion that the wind speed in Lithuania is insufficient for the development of industrial wind energy production. Measurements of wind speed, conducted in 1996–1997, showed that in the seaside area, at 50 m above ground, wind speed reaches 7.4 m/s [23] while Lithuania average is 2.52–4.55 m/s. The regional nature of wind energy is thus obvious; however, adequate technological improvements as well as simply increasing the height of wind turbine towers allow for exploiting the entire territory of Lithuania.

Multi-year wind measurements conducted in the coastal area of Lithuania between 1995 and 2003 revealed that, in Klaipeda's region, near Giruliai district, the average wind speed was 6.4 m/s. During different seasons, the wind speed can vary by up to 50 %, but the average annual speed measurements differ only slightly.

The most favorable conditions for developing wind energy in Lithuania can be found along a 50 km stretch of the coastal line [11, 15]. To determining a correct micro location of each individual wind turbine successfully is thus crucial for the economic success of any wind energy project. The most attractive territories for installing power plants are the Baltic Sea and the Curronian lagoon, where the average wind speed is 8 m/s.

One of the biggest technical problems posed by wind energy development, compared to traditional forms of energy generation, is the dependence of wind power on atmospheric stability. Consequently, the exact amount of wind produced electricity cannot be predicted for every particular time period, which causes problems in terms of system control and the balance between the demand and supply of electricity. Unlike with traditional power generating technologies, electricity production in wind farms cannot be unclearly calculated, and efficiency rates vary according to a geographic location and to winds prevailing there at any particular period of time. However, the production of electricity by a wind generator installed in a specific location is a stationary random process. Therefore, the average efficiency of a wind generator and its potential errors can be statistically evaluated, referring to historical data.

As can be seen in Fig. 31.1, the monthly fluctuations in the efficiency of the wind farm are sufficiently large. During the investigation period, the average farm efficiency was about 0.238. To evaluate possible limitations of calculating average efficiency and to construct a confidence interval, the standard error of estimate should be taken into account.

Having evaluated the confidence interval for the average efficiency of the wind farm, it can be said with 95 % probability that, in the long run, the average efficiency of a wind turbine should be between 0.208 and 0.269. In this case, 1 kW of installed capacity should produce from 1.82 to 2.36 MWh of electricity on the average.

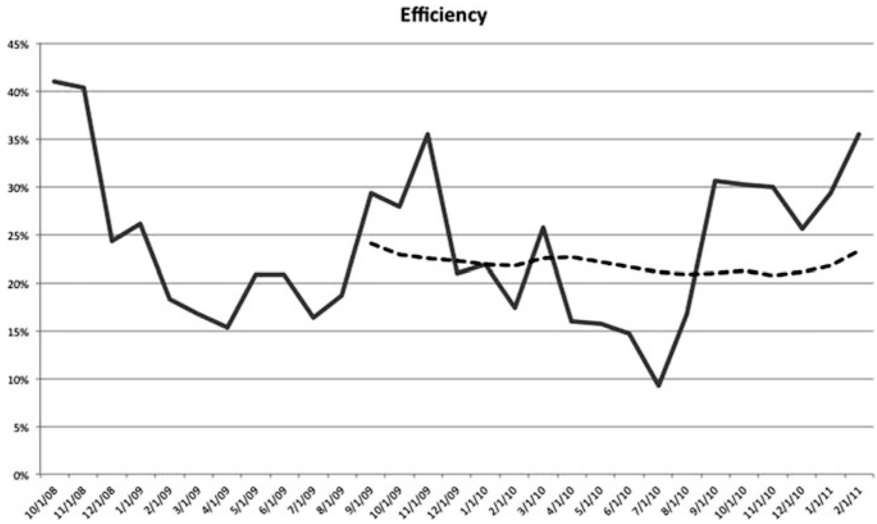

Fig. 31.1 The average efficiency dynamics of a wind farm. *Note* the data is obtained from a wind farm consisting of 15 wind generators, where the installed capacity of one power generator is 2 MW

31.3 The Components of Investments in Onshore Wind Energy in Lithuania

There are four groups of parameters that influence wind power costs: 1—capital costs, 2—operation and maintenance costs, 3—the amount of electricity produced, 4—the discount rate and economic lifetime of the investment.

Investments in electricity generation are directly related to electricity production; therefore, they are quite clearly defined [12]. On the other hand, investments in infrastructure, which involves environmental impact assessments, roads, and so on, are unique in each case; such investments are typically smaller when developing a larger wind power farm. In this article, the assessment is made, taking a 30 MW (15 × 2 MW) wind farm as an example.

The major part of the investment (approximately 90 %) in developing a wind farm is allocated to the power generator, whereas the infrastructure is given only approximately 10 % of the total amount of costs.

Taking into consideration the average estimate of the efficiency of wind energy, we can predict the average income of a wind farm. Wind power produced in Lithuania is subsidized: wind produced electricity is purchased for 81.1–107 euros/MWh; moreover, pollution-reducing projects receive Emission Reduction Units (ERUs), which can be sold on the market. Thus the revenue of a wind farm consists of two parts, both of which are related to the performance ratio, and ERUs also depend on market prices. Empirical assessment of the wind farm data can be constructed in the lower and upper limits of the average annual income:

$$P((\overline{E} - t * SEM) * 8.76 * (p + 0.626 * \overline{ERU}) \\ < R < (\overline{E} + t * SEM) * 8.76 * (p + 0.626 * \overline{ERU})) = 0.95 \quad (31.1)$$

P—random probability, *SEM*—the standard error of the mean, t—Student's distribution value, $\overline{E}$—efficiency of the sample mean, *p*—power purchase price, $\overline{ERU}$—projected average market price of ERUs, *R*—average annual revenues.

According to the formula (31.1), we can estimate the average annual income of the lower and upper limits. Based on the estimates of the wind farm average efficiency 1 kW of installed capacity per year should produce from 1.82 to 2.36 MWh of electricity, with 95 % probability. Assuming that one ERU will cost about 6 euro in the long run, the average gross revenues should be between 165 and 214 euros, approximately 177.4 euros on the average.

The average investment for 1 kW of installed capacity should be expected to be approximately 1561 euros. Therefore, if the term of the bank loan is 20 years and the interest rate is 5.5 %, according to the annuity method, the payment to the bank should consist of about 131 euros per year, while the Cost of Goods (rent, insurance, maintenance, etc.) should be about 23.7 euros and management costs (salaries and other expenses)—about 5 euros. Looking at the total costs imposed on 1 kW installed capacity, the largest part of the cost is bank payments, which account for approximately 83 % of the total sum, meanwhile the Cost of Goods, together with operating expenditure, constitute only about 17 %. Consequently, changes in interest rates have the biggest impact on the general cost and thus can substantially influence the profitability of the project itself. Assuming the interest rate to be 5.5 %, and the loan period to be 20 years, the total annual cost is estimated to be approximately 160 euros.

The current value of the project depends on the cash flows that will be generated in the future. Referring to the above calculations, over the next 20 years, the average annual income of the wind farm should be between 165 and 214 euros, while the average annual expenses would be approximately 160 euros. Consequently, the average annual cash flow should be within the range between 5 and 54 euros. The total present value of the project can be evaluated, using the discounted cash flow method.

In calculating the current value, estimated cash flows and the 20-year period of time as indicated above will be taken into account, standard 5 % discount rate is used, which is slightly lower than the aforementioned interest rate. The residual value of the project should be divided into two parts: that of the infrastructure and of the power generator. In this article, the residual value of the infrastructure after 20 years is equaled to 161 euros, the initial amount of the investment. It is assumed that the average value of the infrastructure will increase the size of the discount rate, and the investment in the generator is measured, taking into consideration the receipt of benefits; therefore, the amortization is not depreciated. The residual value of the generator should be viewed, assuming the probability that the generator does not wear out completely in 20 years and can be used longer.

Taking into consideration the aforementioned assumptions and the formula (31.1), the average value of the project at the moment can be calculated to fall within the range of 92.2 and 663.5 euros/kWh or approximately 377.8 euros/kWh on the average.

However, if a wind farm is evaluated as a commercial project not subsidized by the state, one which is expected to produce electricity for sale on the market, the situation changes significantly. In 2011, the average price for electricity on Lithuania's power market was about 48 euros/MWh, whereas wind energy was purchased for around 81 euros/MWh. Generating electricity in the wind power-station costs from 68 to 88 euros/MWh (from 160 euros/2.36 MWh to 160 euros/1.82 MWh). Thus wind energy is purchased for a price approximately 68 % higher than the market price. Using the DCF method, the interval of the net present value of state subsidies (NPVs) can be calculated. Therefore, the net present value of the state's subsidies for new wind farms should be between 751 and 973 euros per 1 kW of installed power. Consequently, the value of state subsidies is significantly higher than the benefits of the project developers. From the point of view of a consumer, when the value estimation is based only on the cost-benefit basis, wind power becomes commercially unattractive. However, it is also clear that the development of wind energy creates indirect benefits, such as encouraging production, reducing pollution, etc. Therefore, it is necessary to assess the impact of wind power more generally, taking into consideration not only its prices and cash flows, but also its created value for all the parties involved.

31.4 Indirect Wind Energy Costs and Value: Stakeholders' Perspective

When evaluating the projects for the development of wind farms, the overall impact of the development on all the parties involved should be taken into consideration. No detailed analysis or assessment of societal and environmental costs and benefits of renewable energy has been conducted yet. The theoretical and conceptual basis for evaluating the impact of wind power on the involved parties is provided by the stakeholder theory (SH). The concept of stakeholders was formulated by Freeman in 1984: "any group or individual who can affect or is affected by the achievement of the organization's objectives" [6]. This concept is ambiguous and has been debated.

SH theory sees an organization as a complex system and analyses it according to descriptive, instrumental, and normative aspects. The descriptive approach mainly focuses on the interests of the stakeholder group. The instrumental approach allows for an investigation of stakeholders' connections within and with an organization and their consistency, while the normative approach considers stakeholders' legally defined interests [3]. Thus, the SH theory helps not only to define the organizational goals, but to take into account the interests of the SH group [4].

The SH theory distinguishes between five groups of stakeholders: the owners (shareholders), employees, customers, suppliers, and a society at large. All these groups are important for an organization, its survival and development. Producing electricity differs from conventional businesses, but interested parties are similar overall. The electricity sector can be divided into the following groups: the country's economy, producers, consumers, society, and suppliers. These groups have very different roles and weight in developing wind generated energy value, and for this reason, these should be assessed for each group separately at the beginning of a new project.

Producers—in this article, producers are seen as project developers, who organize the construction of a wind farm and operate it. The value of the producers can be defined very simply, through future cash slurry. According to the DCF method, the producers can be said to be creating value which ranges between 92.2 and 663.5 euros, depending on the actual efficiency of a wind farm.

Consumers—the largest consumers of electricity are legal entities, whose main interest is in lowering the price. The direct benefits of providing electricity to the customers are measured by their willingness to pay for the power. Increasing the production of wind energy has negative impact on consumers, and the impact of new wind energy projects can be estimated to range between 751 and 973 euros/kW.

Society—the public benefits of wind energy can be defined as environmental friendliness and creation of work places. Wind energy is green energy, which reduces environmental pollution. Public benefits of wind energy (apart from consumption) can be seen through emissions trading scheme (ETS), the environmental value of a new wind power plant (using the DCF method) ranges from 142 to 184 euros per 1 kW of installed capacity.

The assessment of society benefits in terms of work places created during the development of a project is a complex undertaking. There is a widespread opinion in scholarly literature that operational costs of fossil fuel technologies, along with societal and environmental costs, are less competitive economically than those of wind power technology [5, 13, 16, 21, 25].

Suppliers—in this article, suppliers are seen as a balance of power system controllers and the guarantor of the power reserve. The production of wind energy is volatile, so wind energy has negative impact on the electricity system and requires additional reserves. However, this effect is difficult to measure because wind energy is but a small part of all electricity production and requires almost no supplementary costs, but even a small increase in them makes it more difficult to balance the system and ensure the reserve.

The country's economy—one of the interested parties in this case is the state, whose value is perceived based on the country's economy. The development of wind energy has systematic impact on any country's economic development, because it affects foreign trade, creates jobs, develops technologies, encourages the production, etc. The benefits on the country's economy are difficult to assess because they depend on a number of complex factors. In each country, the impact of the development of wind farms on the national economy should be assessed and modeled separately, taking into account such factors as unemployment, GDP structure, etc. This requires a complex analysis, which will not be carried out in this article.

Taking into consideration to the interested parties listed above, it is possible to estimate the total created value of a new wind farm. To simplify the process, let us assume that all the interested parties are equally important. In addition, only the value of only two of the interested parties overlaps directly. This is because producers receive the benefits from ERU, and the public gets the benefits of reduced pollution. General value can be calculated:

$$GV = G + V + VP + T + E - v^{*} = 378 - 862 + 163 + T + E - 98 \qquad (31.2)$$

Here G—the value of producers, V—the value of consumers, VP—the value of the public, T—the value of suppliers, and E—the value of the country's economy.

As the estimate (31.2) shows, according to the SH theory, a new farm with 1 kW installed capacity depends on two non-assessed values, that of the suppliers and that of the country's economy. According to the estimate, it can be stated that the total value will be positive if the created value for the country's economy is larger than the harm done to suppliers by at least 419 euros.

31.5 Conclusions

1. The most efficient fair wind resources in Lithuania are found along the coastal line of the Baltic Sea. Measurements show that the most favorable conditions for developing onshore wind energy in Lithuania exist in the stretch of about 50 km along the coastal line.
2. Having evaluated the confidence interval of the average efficiency of a wind farm, with the 95 % probability in the long run, the average efficiency of a wind turbine should be between 0.208 and 0.269, and 1 kW of installed capacity should produce from 1.82 to 2.36 MWh of electricity on the average.
3. A financial and economic analysis of investment projects reveals that the return on investments in wind farms in Lithuania is estimated to range between 92.2 and 663.5 euros (per 1 kW of installed capacity), depending on the efficiency of wind turbines.
4. While determining the value of wind energy generated for different SH groups, it was revealed that the state subsidies are higher than the producers' value and that the total value of wind energy will be positive if the created value for the country's economy will be at least 419 euros higher than the harm done to the suppliers.
5. Most of the arguments presented in scholarly literature support an opinion that operational costs of fossil fuel technologies, along with societal and environmental costs, are less competitive economically than those of wind power technology.

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