Economic Research-Ekonomska Istraživanja

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rero20

Sustainability, investment strategy, and governance: evaluation of wind energy sector in North-West Spain

Raquel Fernández-González, Félix Puime-Guillén, Nataša Tandir & Francisco Rodríguez de Prado

ECONOMIC RESEARCH-EKONOMSKA ISTRAŽIVANJA
2023, VOL. 36, NO. 3, 2183420
https://doi.org/10.1080/1331677X.2023.2183420

Sustainability, investment strategy, and governance: evaluation of wind energy sector in North-West Spain

Raquel Fernández-González[a], Félix Puime-Guillén[b]*, Nataša Tandir[c] and Francisco Rodríguez de Prado[d]

[a]Department of Applied Economics, ERENEA-ECOBAS, Faculty of Economics and Business, University of Vigo, Vigo, Spain; [b]Department of Business, Faculty of Economics and Business, University of A Coruña, Coruña, Spain; [c]Management Department, Faculty of Economics and Social Sciences, International Burch University, Sarajevo, Bosnia and Herzegovina; [d]Department of Financial economics and accounting, Faculty of Economics and Business, University of Vigo, Vigo, Spain

ABSTRACT

Climate change is one of the greatest challenges humanity faces globally. For this reason, governmental efforts to reduce emissions of polluting gases have multiplied in the last decade. Against this panorama, petroleum companies have adopted a strategic policy focused on energy diversification, intending to contribute to sustainable development. In the case of Spain, wind energy has been one of the renewable energies that have attracted the most investment from petroleum companies. In particular, this trend is especially acute in Galicia (a region located in the northwest of Spain), since its biophysical conditions and, above all, its institutional framework for the promotion of photovoltaic energy has aroused the interest of petroleum companies. The objective of this article is to perform a feasibility analysis of an average wind project in Galicia. through the calculation of the initial investment, the necessary financing, and the preparation of balance sheets and profit and loss accounts. For this purpose, the methodology used is based on the preparation of a feasibility plan, through which the necessary investment is analyzed and the flows of receipts and payments generated by the company are considered. In this way, this analysis is intended to be useful for companies that are considering the appropriateness/inappropriateness to carry out this type of investment. The results show a high internal rate of return, which indicates the high profitability of the project.

ARTICLE HISTORY
Received 2 June 2022
Accepted 7 February 2023

KEYWORDS
Wind energy; climate change; sustainability; economic-financial analysis

JEL CODES
Q00; Q28; G18; P18

1. Introduction

Climate change governance has been consolidated in the European Union (EU) over the last decade. From the approval of Directive 2009/28/EC to the adoption of the Green Deal, the EU has led the new institutional strategy to achieve climate neutrality

CONTACT Félix Puime-Guillén felix.puime@udc.es
*Universidade da Coruña, Campus Industrial de Ferrol, Department of Business, Faculty of Economics and Business, Ferrol, 15403, A Coruña, Spain.

(Montanarella & Panagos, 2021). A major challenge in the transition to a fossil fuel-free economy is to find the balance between energy security and environmental sustainability (Bórawski et al., 2019). Achieving this objective is a priority for the EU because, on the one hand, access to energy at a competitive price has a positive socio-economic impact and, on the other hand, it is essential to address the environmental degradation risk (European Commision, 2019).

The International Energy Agency (IEA) has recommended that investments in fossil fuels be progressively reduced to eliminate net CO2 emissions by 2050. This should be accompanied by a reduction in coal (-90%), oil (-75%), and gas (-55%) production (IEA, 2021b). At the same time, the promotion of renewable energy is essential in the climate change industry (Kang et al., 2021). For this reason, the implementation of renewable energy projects is increasingly being promoted through investment and institutional actions. However, although in the economic scenario of developed and underdeveloped economies there is a growing drive towards energy transition, there are several commercial, technological, and regulatory barriers that complicate market access. Among the most widespread difficulties are: 1) the incompleteness of the energy institutional framework; 2) the difficulty of accessing financing; 3) the high uncertainty about the feasibility and complex bureaucracy involved in setting up a project; 4) the opposition of local communities to the implementation of the project (Olleik et al., 2021).

However, some of these barriers are of relatively minor importance for an established oil and gas company (OGC), where access to financing and the completion of complex administrative processes can be overcome with a variety of tools at their disposal. While the general trend for OGCs to invest in renewables begins after 2005, and averaged about 1% of the reinvestment of their revenues (Hunt et al., 2022), after the Covid-19 pandemic intensifies. The declining competitiveness of OGCs, due to rising operating costs, increasing energy demand, and falling costs of renewable energy production materials, have encouraged the diversification policy of the petroleum major firms. In addition, these factors are compounded by the reputational benefits of OGCs (Pinkse & van den Buuse, 2012).

The world's largest oil companies, Royal Dutch Shell, ExxonMobil, Chevron, Total, BP, Eni, Petrobras, PetroChina, Saudi Aramco, or Equinor, have made large capital allocations to renewables (Pickl, 2019). Considering that 60% of the OGCs market corresponds to the transportation sector (Hunt et al., 2022), and the widespread introduction of electric vehicles and the ban on the sale of combustion-engine cars are a reality in the medium term, OGCs failing to invest in renewable energy will undermine their survival. In addition, the promotion of green hydrogen as a fuel is also a challenge for the petroleum sector.

Wind energy is one of the renewable energies in which petroleum companies have invested the most. In 2020, 11,782 MW of new onshore wind power capacity were installed in Europe, with the Netherlands (1,979), Germany (1,650) Norway (1,532), and Spain being the main countries where the most wind farms were installed (IEA, 2021a; Wind Europe, 2021, pp. 2021–2025). In Spain, Galicia (a region located in the northwest of the Iberian Peninsula) is one of the leading regions in terms of accumulated installed capacity and number of wind turbines (Copena et al., 2019).

In Galicia, wind energy has continuously increased its contribution to the Galician primary energy mix: in 2000, 27 wind farms had an installed capacity of 577 MW. In 2006, production had increased fivefold, to 2,585 MW, distributed among 110 wind farms. In 2020, 186 wind farms have a total installed capacity of 3,922 MW (EGA. Asociación Eólica de Galicia, 2021). The remarkable expansion of wind power in Galicia is due to a set of factors of heterogeneous nature. Among the most relevant variables are the good quality of the Galician wind resource, the technological development process responsible for substantially increasing the efficiency of wind turbines, and the positive performance of public administrations. Regarding the last factor, the complementary regulations approved by the national and regional governments promoted a favorable scenario for the implementation of wind farms and created a highly attractive retribution scheme for private initiative, attracting important Spanish petroleum companies (Fernández-González et al., 2023).

The strong development of this sector has been studied by the Academy from different approaches. Several studies have analyzed the legal framework of the wind energy sector in Galicia (Copena et al., 2019, 2019; Fernández-González et al., 2022a; Iglesias et al., 2011; Simón et al., 2019), the socio-economic impact of this industry (Castro-Santos & Puime Guillén, 2020; Fernández-González et al., 2022b; Perez & Ramos-Real, 2009; Varela-Vázquez & del Carmen Sánchez-Carreira, 2015), and the technological evolution of the operation of wind farms (Du et al., 2019; Filgueira et al., 2009; Rodriguez et al., 2002). However, the financial analysis applied to wind projects in Galicia is not common.

The objective of this paper is to analyze the feasibility of a wind farm in Galicia. Thus, it will facilitate decision-making on investment/disinvestment in wind energy by oil companies. The feasibility analysis, applied in this case study, is structured in different phases. The first stage consists of detailing the initial investment, the working capital requirements of the project, and the long and short-term financing. Subsequently, balance sheets and interim income statements are prepared, and finally, the internal rate of return is calculated for each of the facilities to determine the profitability of this project. To make this analysis as representative as possible, the characteristics of the wind farm analyzed are following the average project of the regional public calls for proposals in Galicia. However, the case study analyzed in this article is located outside a protected natural area, a characteristic not always observed in wind energy projects in Galicia. This factor is relevant because, even though Galicia is immersed in a new wind boom since 2019, the rate of projects rejected by the regional public administration is high and this is mainly because the refused projects are intended to be developed in protected natural areas.

2. Wind energy in Galicia

Galicia ranks second in Spain as the region with the highest renewable energy production in 2020 (Red Electrica Española, 2021). This is due, in part, to wind energy, since Galicia is the third most important region in Spain in terms of accumulated wind power (3,829 MW), which represents a market share of 14% (IDAE, 2021). In fact, in 2019, more than 4,000 wind turbines were in operation in Galicia, distributed between 153 wind farms, 16 singular wind farms (promoted and managed by local entities), and 41 mini-wind farms (with a power of less than 100 kW) (Inega: Instituto Enerxético de Galicia, 2021). As a consequence of this considerable expansion, Galicia is the Spanish region with the highest level of wind energy intensification, with an average of 113 kW/km2, while the Spanish average is 45 kW/km2. This means that more than a third of Galician municipalities have installed a wind farm (Figure 1) (Copena & Simón, 2018).

The two main factors that have positioned Galicia as a regional wind energy powerhouse are: (i) the biophysical and geographical conditions and (ii) the institutional framework implemented by the regional government of Galicia (Matti & Consoli, 2015). Regarding the environmental conditions in Galicia, this region is located in one of the main European routes for the entry of squalls and frontal systems throughout the year. For this reason, the nature of the wind presents few changes in the climatic seasons (Bokde et al., 2019). Considering that, with the technology available in 2020, territories with a wind speed of 6 m/s or more can have a wind resource that can be used at a height of 80 m, then 47.8% of Galicia's surface area can be used for wind farms (Figure 2). This percentage is double the Spanish average (23.4%) (IDAE, 2020).

The second factor that has boosted wind energy production in Galicia is the institutional framework. In Galicia, the management of wind energy production is based on a system of multilevel governance, whereby the national and regional governments share the competencies of the resource. The Spanish Constitution of 1978, still in force, states in its article 149.1°.25 that it is the central government that has the competences to establish the bases of the energy regime in Spain. However, the approval of the legislation, management, and concession of the use of the wind resource corresponds to the pertinent Spanish region, as long as this use does not affect another

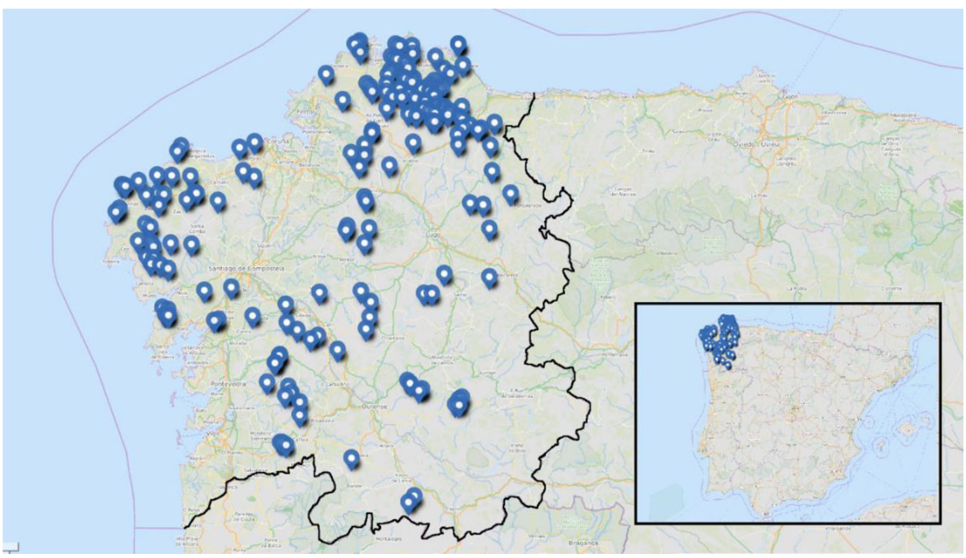

Figure 1. Wind farm locations in Galicia. Source: Own elaboration. Data from (OEGA: Observatorio Eólico de Galicia, 2021).

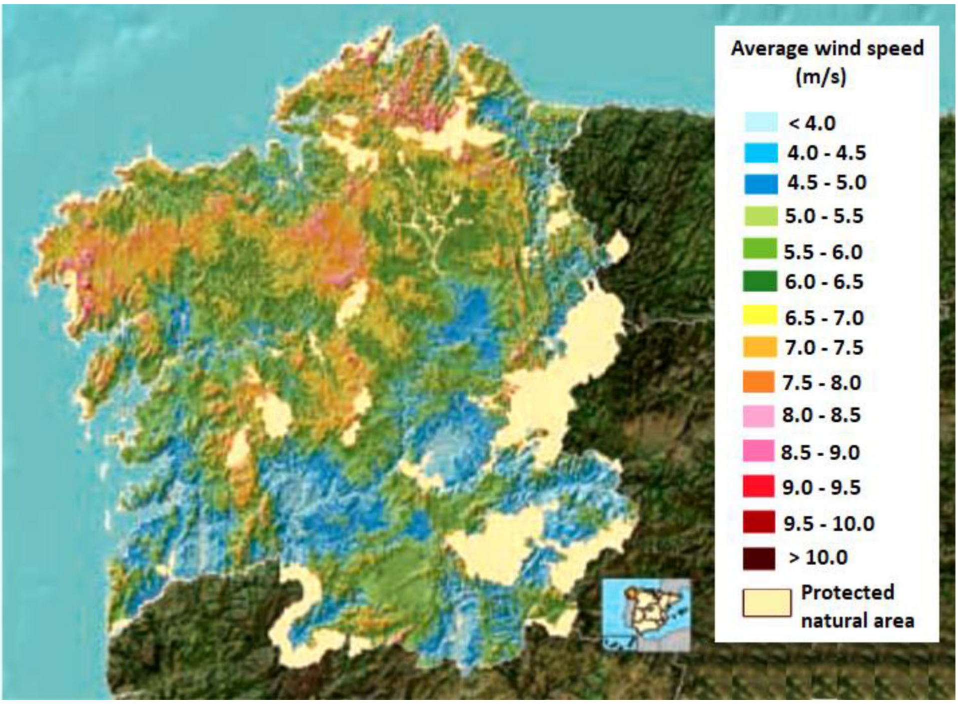

Figure 2. Average wind speed and protected natural areas in Galicia. Source: Own elaboration. Data from (IDAE, 2021).

territory in which it does not have jurisprudence (BOE, 1978). Thus, the Statute of Autonomy of Galicia, which is the basic institutional rule of this region, grants exclusive competence over the installation, distribution, and transmission of energy to Galicia through article 27.13° (Ley Orgánica 1/1981, de 6 de abril, de Estatuto de Autonomía para Galicia, 1981).

Although the transfer of competencies took place in 1981, it was not until 1995 that the regional government of Galicia approved the first regulation on wind energy, which was followed by the Galician Wind Energy Sector Plan (PSEG) in 1997. As a result, between 1998 and 2002 this region increased its wind energy production capacity sixfold. Despite being renewable energy, the first phase of wind energy development in Galicia generated a negative environmental impact. This is explained by the implementation of wind farms in protected natural areas. The 1997 PSEG established that there was no conflict between the installation of wind turbines and the protection of natural areas and, in the reform of the PSEG, in 2002, the compatibility of wind farms with protected areas was expressly approved by classifying the development of this sector as 'public utility' (Xunta de Galicia, 2002). The impact of these measures is quantified in the existence of 54 wind farms in Red Natura 2000 areas, that is, 39% of the installed wind power capacity (OEGA, 2020).

This anomaly was corrected in 2007 with the approval of Decree 242/2007, which established a ban on the implementation of wind farms in the Natura 2000 Network. From 2000 to 2007, the average annual increase rate of installed wind power in

Galicia was 27.2%, while this same rate between 2008 and 2018 is less than 1% (Red Eléctrica de España, 2020a). The stagnation of this industry is not only due to the restriction of protected areas as possible installation sites, but also to the economic crisis that has affected Spain since 2007, and to the cancellation of the national Feed in Tariff system for renewable energy in 2012 (Fernández-González et al., 2021).

The end of this period of stagnation and the return to the path of growth in the sector began in 2019. The reasons were that, at the national level, 4,100 MW of wind power was awarded through public auctions in 2017. This auction process is since the Spanish Government, faced with the possible failure to meet the target of 20% of the production of the energy mix coming from renewable energies set out in Directive 2009/28/EC, approved urgent measures to comply with the European goal. The actual installation of the allocated MW was postponed until 2019, the last year for connecting renewable installations to the grid. However, only 1,976 MW were connected, less than half of the allocated capacity. Galicia was the region where most projects were commissioned, representing 63.2% of all MW awarded (Table 1). The reason that caused Galicia to lead the new wind energy boom in Spain lies in the fact that, in addition to presenting suitable biophysical conditions, the regulatory changes carried out by the regional government of Galicia attracted investors. Law 5/2017, to promote the implementation of business initiatives in Galicia cataloged wind energy as a 'sector of special interest' and endowed administrative procedures for wind installations with more agility.

In the last three years, Galicia is undergoing a new expansion in the installation of wind energy. These investments mainly come from large petroleum companies such as Endesa, BP, Naturgy, Repsol, or Shell. As a consequence of this strategy, spending on oil and gas production by these companies will remain at pre-Covid-19 levels. In contrast, the resources allocated to buy or improve their assets in renewable energy projects will reach between 5-7% of total resources.

3. Materials and methods

3.1. Data

The Viability Plan presented in this article focuses on the analysis of a generic wind farm located in Galicia, the installation and implementation of which will take place in 2021. The data corresponding to this project has been obtained through the information provided by an engineering consultancy with extensive experience in the sector. This consultancy has provided the quantification of the technical aspects of an average wind energy installation in Spain, both financial-economic and fiscal.

One of the main goals of this article is that the results of the analysis will be of relevance to -makers. For this reason, a case study has been selected in which the company analyzed presents the characteristics of the average Spanish wind farm. After reviewing the wind energy projects in Galicia, which are available for public consultation on the website of the Ministry for the Ecological Transition and the Demographic Challenge, the following characteristics have been determined for our case study wind farm (Ministerio para la Transición Ecológica, 2021):

Table 1. Installed energy capacity in Spain and Galicia.

		Spain (MW)	Galicia (MW)	Galicia as a % of Spain total
2010	Non-renewable energies	69,975.00	6,514.00	9.30
	Renewable energies (except wind energy)	41,797.00	5,045.00	12.08
	Wind	20,203.00	3,285.00	16.30
	TOTAL	104,479.00	10,949.00	10.50
2011	Non-renewable energies	69,050.00	6,596.00	9.60
	Renewable energies (except wind energy)	15,412.00	1,142.00	10.00
	Wind	20,763.00	3,287.00	15.80
	TOTAL	105,225.00	11,025.00	10.50
2012	Non-renewable energies	67,996.00	6,199.00	9.10
	Renewable energies (except wind energy)	16,675.00	651.00	9.95
	Wind	22,618.00	3,313.00	14.60
	TOTAL	107,288.00	10,665.00	9.90
2013	Non-renewable energies	67,977.00	3,304.10	8.30
	Renewable energies (except wind energy)	17,063.00	654.00	10.30
	Wind	23,001.00	3,320.00	14.40
	TOTAL	108,041.00	10,915.00	10.10
2014	Non-renewable energies	67,659.00	3,304.18	8.46
	Renewable energies (except wind energy)	17,140.00	1,193.00	10.23
	Wind	23,020.00	3,334.00	14.50
	TOTAL	107,819.00	11,005.00	10.20
2015	Non-renewable energies	54,830.00	3,854.00	10.50
	Renewable energies (except wind energy)	28,060.00	3,807.00	12.55
	Wind	23,029.00	3,334.00	14.50
	TOTAL	105,919.00	10,995.00	10.40
2016	Non-renewable energies	53,898.00	3,841.00	10.78
	Renewable energies (except wind energy)	28,073.00	3,809.00	12.50
	Wind	23,064.00	3,334.00	14.50
	TOTAL	105,035.00	10,984.00	10.50
2017	Non-renewable energies	53,406.00	3,837.00	10.74
	Renewable energies (except wind energy)	28,085.00	3,814.00	12.50
	Wind	23,057.00	3,343.00	14.50
	TOTAL	104,549.00	10,994.00	10.50
2018	Non-renewable energies	52,922.00	3,837.00	10.82
	Renewable energies (except wind energy)	28,142.00	3,852.00	12.60
	Wind	23,149.00	3,412.00	14.70
	TOTAL	104,212.00	11,101.00	10.70
2019	Non-renewable energies	52,532.00	3,834.00	10.94
	Renewable energies (except wind energy)	31,451.00	3,911.00	15.10
	Wind	24,306.00	3,804.00	15.60
	TOTAL	108,289.00	11,549.00	10.70

Source: Own elaboration. Data from (Red Eléctrica de España, 2020b).

- Location in a communal forest, outside any protected natural area, that involves the payment of rent.
- 11 wind turbines.
- 2,700 hours of estimated usable wind hours.
- 3,465 MW.
- 20 years of service life.

3.2. Methodology

For any investor, renewable energies are an attractive business. This is because there is a growing market with high profitability derived from assured sales and known tariffs stipulated by law (Gutiérrez-Pedrero et al., 2020). However, undertaking an investment project involves committing factors or resources to a specific activity for the duration of the project. These assets can be investments in technical fixed assets or fixed assets for the period, also called minimum working capital investments, which are necessary for the normal development of production (Elie et al., 2021).

The benefits derived from the project are initially unknown. Therefore, uncertainty must be reduced, to encourage entrepreneurship, by developing models that allow reliable estimates of the results of the company. The feasibility analysis is an appropriate methodology for this purpose since its effectiveness is directly related to the ability to incorporate into our analysis all the variables that affect the investment and all its possible scenarios.

Therefore, through the feasibility plan, the investment is analyzed from a financial point of view, considering the flows of receipts and payments generated by the company (Bonifaci et al., 2016). However, this is not easy, because it is necessary to determine the real cost of the investment, the duration of the investment, the possible outflows of funds, and, finally, the inflows of funds to the company. Thus, the previous phase of research on the business is fundamental for the analysis of any investment project.

For the formulation of the financial statements, research work has been carried out to determine the key variables for the estimation of each of the elements that integrate each financial statement (Zafirakis et al., 2013). The conclusion is that the following variables are critical in the elaboration of the business plan for our case study:

1. Formation expenses.
2. Installed power.
3. The price paid for each kW installed.
4. Elements of the installation.
5. Useful life of the elements.
6. The percentage of borrowed funds as a percentage of liabilities.
7. The percentage of equity over liabilities.
8. kW/h generated.
9. Tariff regime.
10. Interest rates.

These variables, properly defined, provide the initial balance sheet, the income statement and the cash flow generated. Based on these parameters, the EOAF will be elaborated, permitting the estimation of the Internal Rate of Return (IRR) for the project and the shareholders. Therefore, once the key variables are known, we can establish the Balance Sheet with the following structure (Table 2):

Where each equity item is calculated as follows:

- Non-Current assets: Sum of the amount of installed power, the price paid for each kw, and the nature of the elements that are part of each installation.
- Current Assets: Sum of average customer balance and average cash balance.
- Total assets: Sum of non-current assets and current assets. Its amount is equal to Total Liabilities.
- Current Liabilities: average balance of the Suppliers

Table 2. Balance sheet structure.

Initial assets	Equity and liabilities
Land and Natural Assets	Capital Contributions
Technical Installations	Total Stockholders' Equity
Other Facilities	Loans
Machinery	
Other Property, plant, and equipment	Total Non-Current Liabilities
Accumulated Depreciation	
Total Non-Current Assets	Suppliers
Customers	
Treasury	Total Current Liabilities
Total Current Assets	
Total assets	Total liabilities

Source: Own elaboration.

Table 3. Structure of an income statement.

Operating income	kW/h generated
	Premium
Maintenance costs	Insurance premium
External services	Agent-Seller Cost
	Cost of the energy forecasting system
Wages and salaries	
Tributes	
Incorporation and First Establishment Expenses	
Various	
Depreciation and amortization charge	
Operating Results	
Financial expenses	
Income before taxes	
Taxes	
Net income	

Source: Own elaboration.

- Non-Current Liabilities: financial obligations not expected to be paid within one year.
- Net Equity: Difference between the above items of Liabilities and Total Liabilities.

Also, from the information obtained from the key variables of the sector, it is possible to estimate an Income Statement with the following structure (Table 3).

- Turnover: Kw/h generated per year valued at the selling price per kW according to the applicable tariff system.
- Maintenance costs: Estimated amount per kWh generated per year by the installation.
- External services: Sum of national/regional taxes applied to wind energy generation, land rental, maintenance costs, and commissions of the energy selling agent.
- Wages and salaries: Estimated based on the collective industry agreement.
- Taxes: Estimated based on installed capacity.
- Incorporation and first establishment expenses: Fixed amount established in the analysis according to the capacity and number of wind turbines.
- Various: other costs not included in the above categories
- Depreciation: estimated based on the service life of each piece of equipment and installation.

- Operating income: Difference between revenues and expenses.
- Income before taxes: Difference between operating results and financial results.
- Net profit: Profit from business activity after deducting all expenses (including depreciation and taxes) from total income.

Based on the information provided by the Balance Sheets, the Income Statements, and the estimated Cash Flow, it is possible to elaborate on the Statement of Source and Application of Funds for the different fiscal years. This statement provides the Cash Flow available to shareholders. Cash flow to investors is the income available to shareholders after deducting investment in assets, operating cash requirements, financial charges, and debts (Montes & Martín, 2007). Cash flow is one of the most relevant financial indicators to determine the capacity of the company to generate liquidity (Erfani & Tavakolan, 2020).

In addition, another important indicator is calculated in this analysis. To study the profitability, the IRR for shareholders is calculated. For this purpose, the following variables are used: the service life of the plant, cash flow of the shareholders, liquidation value of the company, and capital contributions (Himri et al., 2020). The mathematical expression of this calculation is:

$$IIR = \sum_{n=1}^{Service\ \ life} \frac{Shareholders\ \ Cash\ \ flow}{(1+IIR)^{N}} + \frac{Liquidation\ \ value}{(1+IIR)^{Service\ \ life}} - Capital\ \ contributions \tag{1}$$

4. Results

To prepare a business plan for a wind farm, it is necessary to start from a quantifiable hypothesis, which allows calculations to analyze the feasibility and profitability of the project.

4.1. Balance sheet structure

The first step in the feasibility analysis of the company is to determine the financial resources required to undertake the investment. For this purpose, the following variables are calculated: tangible fixed assets, expenses, and payments for the establishment of the wind farm, investment in working capital, and the sources of financing required for this project.

Concerning tangible fixed assets, it is necessary to establish the installations required for the correct operation of the project. In this case, the wind farm consists of 11 wind turbines, with a capacity of 3,465 MW, the electrical installation, and the adaptation of the terrain necessary for its proper operation. In addition, an electrical evacuation line and the interconnection substation are required.

The estimated investment in fixed assets amounts to approximately €36.79 million, including the €32.2 million costs of the wind farm and the €4.59 million cost of the interconnection of the wind farm. In this analysis, it is considered that the initial installation will be performed during the period of one year (Year 0). Table 4 provides details of the investment required for the wind farm based on the information provided by the engineering consultancy.

The costs and payments for the establishment of the wind farm, during the period of the investment, are required to finance the incorporation and first establishment costs, which amount to €0.45 million. In addition to the above amounts, it is required to finance the Value Added Tax (VAT) of the investment and the financial costs associated with the start-up of the project (Table 5). Considering all the above items, the investment in the first year is approximately 4.58 million euros:

As for the investment in working capital, the company must finance this type of necessary initial capital. This is since both customer collections and supplier payments are made within 90 days. In turn, the working capital is financed from the shareholders' equity and the credit policy.

Regarding the sources for project financing, in this article, it is considered that part of the investment is made with equity (which would constitute capital stock). In this case study, the capital stock of the company is 11.04 million euros, which represents 30% of the total investment. The remaining 70% of the investment is made through a long-term loan used to pay for the investment, another short-term loan to finance the VAT, and a credit facility needed to cover cash flow shortfalls (Table 6). This last external resource, the credit facility, is necessary to finance the cash mismatches during the first five years and to finance the VAT on the investment until the VAT is refunded by the Spanish State Tax Administration Agency.

Table 4. Types of investments required.

Investment	Concept	Value (€)
Terrain	Construction of accesses to the wind farm	258,176.13
	Earthworks for roads	1,046,021.72
	Earthworks for footings	559,023.82
	Earthworks for platforms	921,993.45
	Land restitution	447,793.05
	Foundations and screeds	982,342.98
	Drainage, piping, and signaling	374,648.85
		4,590,000.00
Technical facilities	Medium voltage grid	255,426.48
	Grounded grid	127,508.51
	Communication grid	114,258.10
	Interconnection center	1,963,381.34
	Voltage measuring unit	61,417.19
		2,521,991.62
Other facilities	Aero transformer station type OL +1 L + 1P (x11)	**658,056.52**
Machinery	Wind turbines (x11)	**28,924,451.86**
Other fixed assets	Individual and collective protection equipment	95,500.00
	Total	**36,790,000.00**

Source: Own elaboration.

Table 5. Financial expenses at the beginning of the activity of the company.

Concept	Value (€)
VAT of investment in fixed assets	1,930,000
Interest in the construction period	2,580,000
Interest in credit policy	190,000
Interest in VAT financing	190,000

Source: Own elaboration.

Table 6. Terms and conditions of external financing resources.

	Long-term loan	Credit facility
Amount	€25.7 mill.	€3.7 mill.
Interest rate	5% /year	5% /year
Provisionpla	During the first year of the project	During the first 5 years of the project
Period	15 years	5 years
Shortage	24 months from the beginning of the construction of the wind farm	
Interest payment	Quarterly	Quarterly
Depreciations	Quarterly	
Opening commission	1%	

Source: Own elaboration.

4.2. Income statement

The analysis performed in this sub-section focuses on the calculation of the income statement of the project through the operating accounts and cash flow forecasts. The calculations are presented below, and the results can be consulted in the annexed tables. All the calculations made in the forecasts of this investment project have been carried out adopting a time horizon of 20 years of operation, since this is the estimated service life of the wind turbines, with year 0 being the period of realization of the investment.

The first step in the analysis of the economic-financial forecasts of the project, through the profit and loss account, is the calculation of the provisional operating accounts. For this purpose, an estimate of the operating costs, financial revenues and expenses, corporate income tax, and the operating cash flow of the company will be made.

Regarding revenues, it is expected that they will start to be generated at the beginning of period 1, once the investment is completed. The reason for this is that revenues are expected to be generated from the production of 123,035 MWh/year of wind energy, which is equivalent to 3,228 hours of operation at the nominal power of the wind farm (38.11 MW). In addition, to complete the temporal analysis, several assumptions have been made. The first assumption is that there will be a constant increase in the price of energy, 1.5% per year, throughout the service life of the wind farm. The second assumption is that the price per MWh will be €43 in year 1 and that the payment of the invoiced energy will be made in 90 days.

Another item in the provisional operating accounts is the operating costs. This item includes all costs related to the operation, maintenance, reconditioning, and exploitation of the wind farm. Operating, maintenance, and reconditioning costs are those that include the maintenance of the entire wind farm infrastructure, from the payment of land rental and insurance to the replacement of parts and equipment necessary for the operation of the wind turbines. The following costs are established for the calculation of the provisional operating accounts (Table 7):

In addition to these items, the provisional operating accounts are composed of three other elements. The first of these is the financial income and expenses. The interest chargeable for each of the years is calculated by multiplying the interest rate of remuneration (2%/year) by the final cash balance of the previous period. The second item is the corporate income tax, which is obtained by applying a rate of 25% to the result of ordinary activities. Finally, the third item is the operating cash flow, which is calculated by adding the depreciation and the result after tax.

Table 7. Cost of the provisional operating accounts.

Cost type	Cost evaluation
Billing cost per production	3.5 €/MWh (years 1 and 2) 6 €/MWh (year 3) 7% of turnover (years 4-20)
Other additional operating and maintenance costs	1,3% of annual production
Depreciation of the wind power farm	Depreciated at a constant rate over 15 years
Management and administrative costs	2% of annual production
Land rental	3.000 €/MW (year 1) 3.000 €/MW + 2% annual (years 2-20)
Insurances	84.805€/ year
Wind power production fee	45.100 €/year
Tax on electricity generation	7% of annual generation turnover

Source: Own elaboration.

The income statement is also composed of cash forecasts. This item includes project establishment costs (incorporation and registration costs), investment in working capital, interest on financial expenses due to the construction of the wind farm, profits, and dividend payments.

4.3. Evaluation

Once the amount of the initial investment and the cash flows generated by the investment project are calculated, it is possible to estimate the economic internal rate of return (IRR). The IRR is the discount rate that equates the market price of the net asset with the present value of the expected stream of its operating cash flow, which provides a measure of the profitability of the project.

For this case study, two IRRs will be calculated considering 20 years. On the one hand, the IRR of the project has been calculated, which represents the profitability of the project in the strict sense, without considering the necessary financing and the financial costs. In this case, the IRR of the project is 8.92%. On the other hand, the IRR of the capital is 14.68%. This type of IRR evaluates the flow of income generated by the project (the cash generated each year and the dividends received by the shareholders) against the equity provided by the shareholders.

5. Conclusions

Wind energy is a non-polluting and sustainable resource that promotes the achievement of a European economy that is less polluting and respectful of the planet, seeking to guarantee a sustainable future for the next generations. The use, for decades, of wind energy has made it possible to test its effectiveness and identify the ideal locations for this type of installation. Nowadays, we have instruments that allow us to know and measure the characteristics and strength of the wind for a specific geographical area. Within the Spanish geography, Galicia has suitable climatic characteristics for wind energy which, together with the policies implemented by the regional government, have boosted this sector.

These characteristics have attracted investment from large petroleum companies that, given the change in the energy paradigm, have diversified their business. Increasingly, the portfolio of projects of the OGCs has included those related to renewable energy. In this way, this sector has benefited from its commercial expertise and resource readiness to create synergies to drive the energy transition. At the same time, petroleum companies are improving their corporate image in a scenario in which their business model has been challenged by society's growing environmental concerns.

Certainly, the institutional framework for renewable energy is an essential factor that has differentiated Galicia from other Spanish regions. During the last decade, the FIT system, the high availability of space, and the streamlining of bureaucratic procedures or public subsidies have attracted large oil companies, which sought to diversify their business. Currently, Galicia is immersed in a dynamic process to increase the installed capacity of wind energy in its territory. However, some of the conditions that led to the great development of the sector at the beginning of the 21st century have changed. Even so, its legal framework is still solid and, together with its favorable natural conditions, continues to attract investors. After defining the composition of the model, where a number of variables can be used to obtain the cash flows resulting from the operation of a wind farm, a feasibility study is carried out. In this way, by relating the cash flows to the initial investment, it is possible to calculate and compare how the values of the parameters change in order to determine the final value of the project. In this article, a financial valuation has been carried out to determine the degree of viability of a wind power project in Galicia. For this purpose, the critical elements of the activity have been defined, since, from the values obtained for a series of variables, such as installed power, useful life or tariff regime, the future profitability of a specific installation can be predicted. Based on the data obtained for the variables, we can elaborate on the forecast financial statements, which provide a priori knowledge of the expected profitability resulting from the investment decisions.

This is the main contribution of the analysis: the execution of a model that makes it possible to obtain the cash flow generated from the activity before making the investments. Determining the necessary investments, the financial expenses, and the conditions of the external financial resources, the cash flows are calculated, and finally the IRR. In this way, simulations are carried out with a high degree of sensitivity to know how changes in the values of such decisive variables, such as the kWh price or the interest rate, can fluctuate and how they can affect the profitability of the project. The adaptability of the methodology used in this article makes it easier for investors to make decisions by comparing the initial disbursements made in any project with the cash flows generated during the useful life of the project.

Therefore, in this work, the IRR of the capital (as a measure of the profitability expected by the investors) has been calculated. The result obtained for the estimated IRR, calculated using the cash flows of the shareholders through the 20 years of service life, shows a measure of the theoretical profitability that will be obtained by those who invest in this type of facility. In our case study, the IRR is 14.68%. This profitability is very high, especially if we compare it with the profitability associated with other renewable installations, such as those dedicated to photovoltaic energy or biomass. Furthermore, in regions such as Galicia, with low solar radiation and where hydropower from river storage is beginning to be questioned due to its associated environmental impact, wind energy is an option for OGCs to reduce the carbon intensity of their activities and move towards the energy transition.

Despite the rigorousness that characterizes this analysis, it also has limitations. On the one hand, the feasibility analysis has been carried out for a wind farm that fits the average characteristics of the projects submitted to the regional public calls for proposals in Galicia, but this does not mean that it represents all the wind projects in Galicia. Each of them has its own characteristics that must be considered before making an investment, so although the level of representation of this case study is high, it is not complete. On the other hand, the study period of this analysis is 20 years, which represents a medium-term time horizon. Although temporal variations have been considered for the financial and economic parameters used in the calculation of the return on investment, it would be necessary to revise the calculations in view of the external macroeconomic fluctuations that have arisen in recent months. The war in Ukraine, the generalized increase in inflation, the energy crisis and the changes in the monetary policy strategy in Europe, create a new economic scenario in Spain. The increased uncertainty may change both the parameters used in the analysis and affect investors' decision-making.

Author contributions

Conceptualization, R. F-G.; methodology, R. F-G.; validation, R. F-G, N.T., F.P.G. and R. F-G.; formal analysis, R. F-G and N.T.; investigation, R. F-G.; resources, N.T and F.P.G. and F.R.P.; data curation, F.P.G.; writing—original draft preparation, R. F-G. and N.T.; writing—review and editing, R. F-G., F.P.G. and F.R.P.; visualization, F.R.P. and N.T. All authors have read and agreed to the published version of the manuscript.

Disclosure statement

No potential competing interest was reported by the authors.

Funding

This research has been funded by the Consellería de Cultura, Educación e Ordenación Universitaria of the Xunta de Galicia in Spain the postdoctoral grant ED481B2018/095 and the following grants: ED431C2018/48 and ED431E2018/07. In addition, this publication is part of the Spanish R&D&I project RTI2018-099225-B-100, funded by MCIN/AEI/10.13039/501100011033/and FEDER 'A way of doing Europe'. The authors are also grateful for the valuable contributions made by Juan Carlos López Rodríguez.

ORCID

Raquel Fernández-González http://orcid.org/0000-0001-5356-2793
Félix Puime-Guillén http://orcid.org/0000-0001-7341-9134

References

BOE. (1978). *Constitución Española*. https://www.boe.es/buscar/act.php?id=BOE-A-1978-31229

Bokde, N. D., Feijóo, A., Al-Ansari, N., & Yaseen, Z. M. (2019). A comparison between reconstruction methods for generation of synthetic time series applied to wind speed simulation. *IEEE Access*. *7*, 135386–135398. https://doi.org/10.1109/ACCESS.2019.2941826

Bonifaci, P., Copiello, S., & Stanghellini, S. (2016). The methodological framework of feasibility study to support strategic planning. *Procedia - Social and Behavioral Sciences*, *223*, 45–50. https://doi.org/10.1016/j.sbspro.2016.05.287

Bórawski, P., Bełdycka-Bórawska, A., Szymańska, E. J., Jankowski, K. J., Dubis, B., & Dunn, J. W. (2019). Development of renewable energy sources market and biofuels in The European Union. *Journal of Cleaner Production*, *228*, 467–484. https://doi.org/10.1016/j.jclepro.2019.04.242

Castro-Santos, L., & Puime Guillén, F. (2020). Comparison of wave energy and offshore wind. In M. Shahbaz & D. Balsalobre-Lorente (Eds.), *Econometrics of green energy handbook: Economic and technological development* (pp. 211–220). Springer International Publishing. https://doi.org/10.1007/978-3-030-46847-7_10

Copena, D., Pérez-Neira, D., & Simón, X. (2019). Local economic impact of wind energy development: Analysis of the regulatory framework, taxation, and income for Galician municipalities. *Sustainability*, *11*(8), 2403. https://doi.org/10.3390/su11082403

Copena, D., & Simón, X. (2018). Wind farms and payments to landowners: Opportunities for rural development for the case of Galicia. *Renewable and Sustainable Energy Reviews*, *95*, 38–47. https://doi.org/10.1016/j.rser.2018.06.043

Du, P., Wang, J., Yang, W., & Niu, T. (2019). A novel hybrid model for short-term wind power forecasting. *Applied Soft Computing*, *80*, 93–106. https://doi.org/10.1016/j.asoc.2019.03.035

EGA. Asociación Eólica de Galicia. (2021). *El Sector en cifras*. EGA. Asociación Eólica de Galicia. https://www.ega-asociacioneolicagalicia.es/el-sector-en-cifras/

Elie, L., Granier, C., & Rigot, S. (2021). The different types of renewable energy finance: A Bibliometric analysis. *Energy Economics*, *93*, 104997. https://doi.org/10.1016/j.eneco.2020.104997

Erfani, A., & Tavakolan, M. (2020). Risk evaluation model of wind energy investment projects using modified fuzzy group decision-making and Monte Carlo simulation. *Arthaniti: Journal of Economic Theory and Practice*. https://doi.org/10.1177/0976747920963222

European Commision. (2019, octubre 23). *EU climate action and the European Green Deal* [Text]. Climate Action - European Commission. https://ec.europa.eu/clima/policies/eu-climate-action_en

Fernández-González, R., Arce, E., & Garza-Gil, D. (2021). How political decisions affect the economy of a sector: The example of photovoltaic energy in Spain. *Energy Reports*, *7*, 2940–2949. https://doi.org/10.1016/j.egyr.2021.05.021

Fernández-González, R., Puime-Guillén, F., & Panait, M. (2022a). Multilevel governance, PV solar energy, and entrepreneurship: The generation of green hydrogen as a fuel of renewable origin. *Utilities Policy*, *79*, 101438. https://doi.org/10.1016/j.jup.2022.101438

Fernández-González, R., Puime-Guillén, F., Pérez-Vas, R. (2022b). The new wind energy boom in Spain: Are large companies once again dominating the market? In S. A. R. Khan, M. Panait, F. Puime Guillen, & L. Raimi (Eds.), *Energy transition* (pp. 135–163). Springer Nature. https://doi.org/10.1007/978-981-19-3540-4_5

Fernández-González, R., Puime-Guillén, F., & Vila-Biglieri, J. E. (2023). Environmental strategy and the petroleum industry: A sustainability balanced scorecard approach. *Journal of Petroleum Exploration and Production Technology*, *13*, 763–774. https://doi.org/10.1007/s13202-022-01543-9

Filgueira, A., Seijo, M. A., Munoz, E., Castro, L., & Piegari, L. (2009). Technical and economic study of two repowered wind farms in Bustelo and San Xoán, 24.7 MW and 15.84 MW respectively. In *International Conference on Clean Electrical Power* (pp. 545–549). https://doi.org/10.1109/ICCEP.2009.5211998

Gutiérrez-Pedrero, M.-J., Ruiz-Fuensanta, M. J., & Tarancón, M.-Á. (2020). Regional factors driving the deployment of wind energy in Spain. *Energies*, *13*(14), 3590. Art https://doi.org/10.3390/en13143590

Himri, Y., Merzouk, M., Kasbadji Merzouk, N., & Himri, S. (2020). Potential and economic feasibility of wind energy in south West region of Algeria. *Sustainable Energy Technologies and Assessments*, *38*, 100643. https://doi.org/10.1016/j.seta.2020.100643

Hunt, J. D., Nascimento, A., Nascimento, N., Vieira, L. W., & Romero, O. J. (2022). Possible pathways for oil and gas companies in a sustainable future: From the perspective of a

hydrogen economy. *Renewable and Sustainable Energy Reviews*, *160*, 112291. https://doi.org/10.1016/j.rser.2022.112291
IDAE. (2020). *Análisis del recurso. Atlas eólico de España estudio técnico per 2011–2020*. https://www.idae.es/sites/default/files/documentos/publicaciones_idae/documentos_11227_e4_atlas_eolico_a_9b90ff10.pdf
IDAE. (2021). *Estudios, informes y estadísticas*. https://www.idae.es/informacion-y-publicaciones/estudios-informes-y-estadisticas
IEA. (2021a). *European Union 2020. Energy Policiy Review*. https://iea.blob.core.windows.net/assets/ec7cc7e5-f638-431b-ab6e-86f62aa5752b/European_Union_2020_Energy_Policy_Review.pdf
IEA. (2021b). *Zero by 2050: A roadmap for the global energy sector*. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf
Iglesias, G., del Río, P., & Dopico, J. Á. (2011). Policy analysis of authorisation procedures for wind energy deployment in Spain. *Energy Policy*, *39*(7), 4067–4076. https://doi.org/10.1016/j.enpol.2011.03.033
Inega: Instituto Enerxético de Galicia. (2021). *Balance energético de Galicia | Publicaciones*. http://www.inega.gal/publicacions/balanceenerxetico/publicacion_0007y.html
Kang, S. J., Lee, S., & Lee, S. J. (2021). Impacts of environmental agreements on bilateral trade of climate industry. *Energies*, *14*(21), 7277. https://doi.org/10.3390/en14217277
Ley Orgánica 1/1981, de 6 de abril, de Estatuto de Autonomía para Galicia, Pub. L. No. Ley Orgánica 1/1981, BOE-A-1981-9564 8997. (1981). https://www.boe.es/eli/es/lo/1981/04/06/1
Matti, C., & Consoli, D. (2015). The emergence of wind energy in Spain: A review of the policy mix. In *The economics of knowledge, innovation and systemic technology policy*. Routledge.
Ministerio para la Transición Ecológica. (2021). *Gobierno de España—Sede Electrónica*. https://sede.miteco.gob.es/portal/site/seMITECO/navServicioContenido#
Montanarella, L., & Panagos, P. (2021). The relevance of sustainable soil management within the European green deal. *Land Use Policy*, *100*, 104950. https://doi.org/10.1016/j.landusepol.2020.104950
Montes, G. M., & Martín, E. P. (2007). Profitability of wind energy: Short-term risk factors and possible improvements. *Renewable and Sustainable Energy Reviews*, *11*(9), 2191–2200. https://doi.org/10.1016/j.rser.2006.03.009
OEGA. (2020). *Parques eólicos en Red Natura*. https://observatorio.eolico.webs.uvigo.es/2021/05/24/parques-eolicos-en-red-natura/?lang=es
OEGA: Observatorio Eólico de Galicia. (2021). *Energía eólica en Galicia*. https://observatorio.eolico.webs.uvigo.es/energia-eolica-en-galicia/?lang=es
Olleik, M., Auer, H., & Nasr, R. (2021). A petroleum upstream production sharing contract with investments in renewable energy: The case of Lebanon. *Energy Policy*, *154*, 112325. https://doi.org/10.1016/j.enpol.2021.112325
Perez, Y., & Ramos-Real, F. J. (2009). The public promotion of wind energy in Spain from the transaction costs perspective 1986–2007. *Renewable and Sustainable Energy Reviews*, *13*(5), 1058–1066. https://doi.org/10.1016/j.rser.2008.03.010
Pickl, M. J. (2019). The renewable energy strategies of oil majors – From oil to energy? *Energy Strategy Reviews*, *26*, 100370. https://doi.org/10.1016/j.esr.2019.100370
Pinkse, J., & van den Buuse, D. (2012). The development and commercialization of solar PV technology in the oil industry. *Energy Policy*, *40*, 11–20. https://doi.org/10.1016/j.enpol.2010.09.029
Red Eléctrica de España. (2020a). *REData—Aldia*. https://www.ree.es/es/datos/aldia
Red Eléctrica de España. (2020b). *REData—Potencia instalada | Red Eléctrica de España*. https://www.ree.es/es/datos/generacion/potencia-instalada
Red Electrica Española. (2021). *Informe del Sistema Eléctrico Español 2020* (p. 100). https://www.ree.es/sites/default/files/publication/2021/06/downloadable/inf_sis_elec_ree_2020_0.pdf
Rodriguez, J. M., Fernandez, J. L., Beato, D., Iturbe, R., Usaola, J., Ledesma, P., & Wilhelmi, J. R. (2002). Incidence on power system dynamics of high penetration of fixed speed and

doubly fed wind energy systems: Study of the Spanish case. *IEEE Transactions on Power Systems*, *17*(4), 1089–1095. https://doi.org/10.1109/TPWRS.2002.804971

Simón, X., Copena, D., & Montero, M. (2019). Strong wind development with no community participation. The case of Galicia (1995–2009). *Energy Policy*, *133*, 110930. https://doi.org/10.1016/j.enpol.2019.110930

Varela-Vázquez, P., & del Carmen Sánchez-Carreira, M. (2015). Socioeconomic impact of wind energy on peripheral regions. *Renewable and Sustainable Energy Reviews*, *50*, 982–990. https://doi.org/10.1016/j.rser.2015.05.045

Wind Europe. (2021). *Wind energy in Europe. 2020 Statistics and the outlook for 2021–2025*. https://windeurope.org/intelligence-platform/statistics/

Xunta de Galicia. (2002). *Modificación del Plan Sectorial Eóico de Galicia*. http://www.inega.gal/sites/default/descargas/enerxia_galicia/242-d-memoria.pdf

Zafirakis, D., Chalvatzis, K. J., Baiocchi, G., & Daskalakis, G. (2013). Modeling of financial incentives for investments in energy storage systems that promote the large-scale integration of wind energy. *Applied Energy*, *105*, 138–154. https://doi.org/10.1016/j.apenergy.2012.11.073