Journal of Sustainability Science and Management
Volume 11 *Number* 2, December 2016: 39-48

ISSN: 1823-8556

EFFECTIVENESS OF INCENTIVES FOR WIND ENERGY: MODELS AND EMPIRICAL EVIDENCES FROM AN ITALIAN CASE STUDY

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Abstract: This study refers to "grid parity" to describe the point in time at which an investment project on renewable energy based on wind power will produce electricity for the same cost to ratepayers as traditional technologies. That is when the new technology can produce electricity for the same cost as the electricity available on a utility's transmission and distribution "grid". Our aim is to verify technical-energy-economic feasibility study of systems based on wind power. We evaluate the economic performance of an investment project in a hypothetical wind farm with an installed capacity of 1 Megawatt (MW) in Italy. In our model, the cost-building threshold of the wind farm in order to have a profitability project is computed by using a sensitive analysis. The obtained results underline the importance of incentives to support wind power in Italy because grid-parity presently cannot not achieved in absence of interventions.

Keywords: Renewable energy, wind energy, grid parity, regulation by incentives.

Introduction

After the Fukushima Daiichi nuclear meltdown of three of the plant's six nuclear reactors, international studies went on revealing that, over the next ten years, energy investments in the order of € 1 trillion are needed. Changes in productions and economic context oblige European States to choose among several energy projects. These choices will be felt over the next 30 years and more (European Commission, 2010). In this contest, Germany is rapidly becoming one of our model countries for proving transitions to a renewable energy economy can be done. Germans have a special word for it -"Energiewende", or energy transformation - which aims to power the entire country by renewable resources by 2050. A clear methodology to evaluate the economic value of each energy project is provided in this paper to help policy makers and investors to enable these decisions. Moreover, the economic value of an energy project is the consequence of country-specific effects that should be included in the model. In Europe, and particularly in Italy, there are country-specific regulatory frameworks (and incentives) able to support the use of renewable energy and especially wind energy. Furthermore, European experience suggests that a feed-in tariff offers more cost-effective support than a tradable green certificate, because it is less risky and allows these capital-intensive projects to be viable with a lower cost of capital (Green & Vasilakos, 2011; Haas *et al.*, 2011; Hiroux & Saguan, 2010).

In addition, in the case of renewable energy investment projects, given their long life expectation, there is considerable uncertainty regarding their economic viability, which is connected to the evolution of the cash flows that depend on the production cost and price of electric power, as well as other regulatory factors, e.g., subsidies on production, generation and commercialization requirements (Monjas-Barroso & Balibrea-Iniesta, 2013; Muzathik *et al.*, 2012). Several papers studied the investment projects in renewable energy. Among the others, Campisi *et al.* (2015), Sgroi *et al.* (2014), Squatrito *et al.* (2014) investigated the energy and economic performance of photovoltaic systems in Italy; Monjas-Barroso & Balibrea-Iniesta (2013) conducted a comparative study in three countries (Denmark, Finland and

Portugal), evaluating an investment project on renewable energy based on wind power. Kjærland (2007) studied an investment in hydropower in Norwegian and Muzathik *et al.* (2012) analyzed renewable energy resources in Malaysia. Blanco (2009) evaluated the generation costs of wind energy investments in Europe, both onshore and offshore; Biondi and Moretto (2015) analyzed the solar grid parity in Italy using real options. All these studies underline the importance of public policy to help the industry of renewable energy to develop the supply chain, and to continue to incentive the electricity produced in order to reduce the construction costs and margins can fall. Respect to these studies, this paper wants to evaluate the investment in a small wind farm in Italy. Moreover, using a sensitive analysis, we evaluate the cost-building threshold of our wind farm.

The paper is organized in two parts: first section is devoted to quantify energy performance of a wind farm, which can be used to generate electricity for different applications. A suitable analysis is performed in order to quantify available wind energy for different type of installations, taking into account the installation locations chosen. Then, in the second part of the paper, the net present value of the investment project, taking into account the different options stemming from the different regulatory frameworks, is computed (Campisi *et al.*, 2015). This led us to assess the value of investment opportunities and to find out the relation between price level of electricity, incentives and optimal timing of investment decisions. In fact, the investments in energy systems are often irreversible, but it is possible to increase their flexibility expanding new products, reducing the scale, changing the inputs and outputs and abandoning or postponing the phases of the project.

Moreover, we evaluate the impact of public incentives on the hypothetical wind farm analyzed, which is composed by an installed capacity of 1MW (about 50 medium-small wind turbines).

Notice that the choice of installing small size turbines could help stakeholders to choice the optimal plant size within a single-choice procedure or to investigate economic reinforcements in the adoption of paired interventions to reach grid parity in a multiple-choice procedure (Campisi *et al.*, 2015).

The Italian Context

Generally, the electric power companies have to perform daily bids to sell their electricity in markets. The matching and intersection of supply and demand allows to set the price of electricity. Thus, the intersection is able to demonstrate the price of electricity in a market.

In order to promote renewable energy in Italy, the remuneration of wind power is provided by means of a feed-in tariff system. This involves a reward for the production of electricity from renewable sources. The feed-in tariff is the establishment of a single regulated tariff, which includes a premium, conventionally expressed in euros per megawatt hour. The problem with feed-in tariffs is the need to set the tariff at an appropriate level, and the risk that it will be too generous, creating excessive rents, or too mean, stifling development (Green & Vasilakos, 2011). Previous experiences with feed-in tariff systems have shown several advantages in comparison to trading schemes for the following reasons:

(i) a feed-in tariff system is easy to implement and can be revised to account for new technologies;

(ii) administration costs are usually lower than for implementing a national trading scheme (Haas *et al.*, 2011).

In Italy, after a starting period during which the renewable energy production was mainly supported by using a green certificates scheme, from 2009, the renewable energy is supported by using a feed-in tariff system. As a consequence of incentives, renewable energy generation substantially increased - by 23 Terawatt-hour (TWh) from 2008 to 2013 (Clò *et al.*, 2015). According to the last available data, wind energy represents about 5.31% of the total Italian electricity net generation (Terna, 2013), with an installed power generation capacity of about 14,881Gigawatt-hour (GWh). Italy installed a large capacity of wind plants and the stimulus effect of Italian programs (such as other European countries) has helped to develop the wind technology, leading to falling costs and increasing efficiency. This means that producers can seriously consider building wind plants that can produce electricity close to grid parity, which is they can produce electricity for the same cost as the electricity available on the market.

The last scheme was determined in 2012 by Ministerial Decree (D.M.) 06.07.2012 and it is based on the laws on support of renewable energy production n.79/1999, n.78/2010, n.28/2011. The last scheme is also known as "Tariffa omnicomprensiva". For wind power, there are differences in tariff according to the size of the farm (GSE, 2015). In Table 1, the different tariffs are reported.

Moreover, this established scheme may also provide an extra-premium, which supplements the defined tariff of electricity. In the current study, we do not consider such extra premium, considering the tariff of electricity reported in Table 1 as the only price of selling electricity from wind farm.

General Characteristics of the Project

The investment project is a hypothetical on-shore wind farm with an installed capacity of 1MW. It is not a specific project but rather a generic project of a common type of wind farm. The farm is composed by 50 wind turbines and the model chosen is JIMP 20 kW. Then, we are assuming a small type of turbine.

In the case of a real investment project, the process would begin with the location of a construction site, the compilation of meteorological data and preliminary measurements of wind speed. In our case, we hypothesize an average wind speed of 4.85 m/s on a tower of 18 m and we estimate the production by using a software simulation. In such case, we assume a Weibull distribution following Ibrahim *et al.* (2014), obtaining the results reported in Table 2. Then, the net annual production of energy of a wind turbine is about 30,500 Kilowatt-hour (kWh).

As the wind farm plant is constituted by up to 50 wind turbines, if we multiply the annual output of a wind turbine by the number of turbines that make up the plant, we obtain an overall annual output of about 1,500 MWh. With reference to investments in wind energy we must consider the presence of uncertainty in all the cycle of life. Uncertainty will affect the

Table 1: Regulated tariff for electricity generated by wind plant in Italy

	Power	**Life expectancy of the turbines**	**Regulated tariff "Tariffa omnicomprensiva"**
Type of plant	**Kilowatt (kW)**	**years**	**€/Megawatt-hour (MWh)**
	1<P≤20	20	291
	20<P≤200	20	268
	200<P≤1000	20	149
	1000<P≤5000	20	135
On-shore	P>5000	20	127
	1<P≤5000	25	176
Off-shore	P>5000	25	165

Source: Terna (2013)

Table 2: Simulation for the annual electric output of a wind turbine (20 kW)

WIND TURBINE (20kW)

Producibility with connection to the electricity grid at low voltage

Inputs	Results
Average wind speed (m/s) = 4.85	Hub average wind speed (m/s) = 5.46
Weibull K = 2.00	Air density factor = 0%
Site altitude (m) = 0	Average output power (kW) = 3.48
Wind shear = 0.20	Daily energy output (kWh) = 83.60
Anemometer height (m) = 10.00	Annual energy output (kWh) = 30,514
Tower height (m) = 18.00	Monthly energy output = 2,543
Turbulence factor = 10.00%	Percent operating time = 72.2%

Weibull Performance Calculations

(m/s)	Power (kW)	Wind probability (f)	Net kW @ V
1	0.00	5.18%	0.000
2	0.00	9.57%	0.000
3	0.21	12.57%	0.027
4	0.64	13.91%	0.089
5	1.45	13.68%	0.198
6	2.64	12.25%	0.323
7	4.19	10.11%	0.424
8	6.26	7.75%	0.485
9	8.91	5.55%	0.494
10	12.22	3.72%	0.454
11	16.13	2.34%	0.377
12	20.94	1.38%	0.290
13	20.94	0.77%	0.161
14	20.94	0.40%	0.085
15	20.94	0.20%	0.042
16	20.94	0.09%	0.020
17	20.94	0.04%	0.009
18	20.94	0.02%	0.004
19	20.94	0.01%	0.001
20	20.94	0.00%	0.001
Totals		**99.55%**	**3.483**

Source: Own elaboration

cash flow structure as consequence of changes in the production costs and price of electricity, subsidies and other regulatory aspects.

The hypothesized wind farm under investigation, however, would generate cash flows from its implementation until the end of the average life expectancy of the turbines; the average life expectancy is estimated at 20 years. We estimate that the construction of the wind farm is expected in the year 2016, with the start-up date the following year.

To evaluate the profitability of the investment as well as its sustainability, the following parameters are taken also into consideration: total cost required to build the system; annual running and maintenance costs annual insurance cost; amortization; Weighted Average Cost of Capital (WACC); Corporate Income Tax.

The following values were assumed:

- the total cost for building the farm is estimated at €1,248,750 [€/kilowatt-peak (kWp) 1,250]; this cost is based on market values;
- operation, maintenance and insurance costs is estimated at 50,000€/year;
- about the sources of financing, we assume a 20% of the investment as equity and the remaining (80%) as debt following other studies (Campisi *et al.*, 2015); so, the amount of equity is about €249,750 and the debt (bank loan) is about €999,000;
- according to the Italian civil law, amortization is assumed equal to 4.5% of the building cost in the first year (2015); 9% of the building cost for the following 10 years (from 01/2016 to 12/2025); and the remaining is accounted in the last period (2026);
- WACC is set to be equal to 5%, according to the market values and previous studies (Campisi *et al.*, 2015; Monjas-Barroso & Balibrea-Iniesta, 2013);
- Corporate Income Tax is estimated at 27.5% of Earnings Before Interests and Taxes (EBIT) and it is assumed to be constant over the period examined (Morea, 2005).

Methodology

Methodologically, the calculation of the Net Present Value for investment projects, incorporating the regulatory framework, involves three stages:

(a) identification of the regulatory frameworks;

(b) estimation of cash flows for the projects;

(c) estimation of the uncertainness for the projects.

For the evaluation of profitability and solvency of the project, a number of indicators were taken into consideration: Net Present Value (NPV), Internal Rate of Return (IRR), Debt Service Cover Ratio (DSCR), Loan Life Cover Ratio (LLCR), Average Debt Service Cover Ratio (ADSCR) and Average Loan Life Cover Ratio (ALLCR). See Campisi *et al.* (2014), Gatti (2012), Campisi & Costa (2008), Thusen & Fabrychy (1993) for a review.

To define the acceptance of a project, the following conditions were used:

$$NPV > 0$$
$$IRR > WACC$$
$$ADSCR > 1$$
$$ALLCR > 1$$

The Weighted Average Cost of Capital is the rate that a company is expected to pay on average to all its security holders to finance its assets. The WACC is commonly referred to as the cost of capital of the firm. It represents the minimum return that a company must earn on an existing asset base to satisfy its creditors, owners, and other providers of capital, or they will invest elsewhere. Companies raise money from a number of sources: common stock, preferred stock, straight debt, convertible debt, exchangeable debt, warrants, options, pension liabilities, executive stock options, governmental subsidies, and so on. Different securities, which represent different sources of finance, are expected to generate different returns. The WACC is calculated taking into account the relative weights of each component of the capital structure. The more complex the company's capital structure, the more laborious it is to calculate the WACC. Then, companies can use WACC to see if the investment projects available to them are worthwhile to undertaken (Campisi & Nastasi, 1993).

Results

The calculation of cash flows is obtained from EBITDA (Earnings Before Interests, Taxes and Amortization): the annual revenue minus the annual operating expenses gives the earnings before interest, taxes, depreciation and amortization. In order to proceed in this assessment, we must add to these annual benefits the amortization of fixed assets, and subtract the annual payment of debt. The annual revenues are obtained by multiplying the net electricity produced (Table 2) on the sale price of electricity (Table 1), assuming both constant over time.

Then, if we subtract from EBITDA the annual amortization and the interest on debt, we obtain the earnings before interest and taxes (EBIT). And from the latter, if we subtract the corporate taxes, we finally obtain the profit after tax.

The values of cash flows represent the input for the net present value analysis. A discount rate equal to the WACC (5%), is applied to the project.

The first line in Table 3 shows the results of the financial analysis for the wind farm under analysis. Although we obtain positive values of available cash flow for the whole period of analysis (20 years), the net present value (NPV) is negative (and equal to -58,493€) and the average debt service coverage ratios is out the range of admissibility (both ADSCR and ALLCR are less of 1); furthermore, the internal rate of return (IRR) is less than WACC. Based on such values of NPV, ADSCR, ALLCR and IRR, the investment project in the analyzed wind farm must be rejected.

In order to evaluate what is the acceptable investment cost, we proceed in calculating the cost building threshold of our wind farm (Campisi *et al.*, 2015; Campisi *et al.*, 2001). The results are reported in Table 3, where it is shown a threshold for the recovery of the investment equal to 1,201,669€(-3.77% respect to the starting cost); for such value, NPV=0 and IRR=WACC. Moreover, for a cost of building the wind farm less than 1,051,669€ (-15.78% respect to the starting cost), the project can be considerable acceptable for the indicators defined above (ADSCR, ALLCR > 1).

Table 4 shows the details of the financial analysis for the threshold value when NPV=0.

Table 3: Financial analysis and threshold cost for the profitability of the investment

Cost of building the wind farm (€)	Equity (€)	Installment (€)	WACC (%)	NPV (€)	IRR (%)	ADSCR	ALLCR
1,248,750	249,750	80,162	5.00	- 58,493	4.17	0.89	0.74
1,228,750	245,750	78,878	5.00	- 33,645	4.52	0.91	0.77
1,201,669	**240,334**	**77,140**	**5.00**	**0**	**5.00**	**0.95**	**0.80**
1,151,669	230,334	73,930	5.00	62,120	5.92	1.02	0.88
1,101,669	220,334	70,721	5.00	124,239	6.87	1.10	0.95
1,051,669	210,334	67,511	5.00	186,359	7.87	1.18	1.04
1,001,669	200,334	64,301	5.00	248,479	8.93	1.27	1.13
951,669	190,334	61,092	5.00	310,598	10.05	1.38	1.23

Source: Own elaboration

Table 4: Financial analysis for the threshold value when NPV = 0

	2016	2017	2018	…	2035	2036
	t = 0	t = 1	t = 2	…	t = 19	t = 20
Net annual energy production (MWh)	0	1,500	1,500	…	1,500	1,500
Investment (€)						
Cost of building the wind farm	1,201,669	-	-	…	-	-
Coverage (€)						
Equity	240,334	-	-	…	-	-
Debt	961,335	-	-	…	-	-
Installment	-	77,140	77,140	…	77,140	77,140
Incomestatement (€)						
Total revenues		22,350	22,350	…	22,350	22,350
Total costs		50,000	50,000	…	50,000	50,000
EBITDA		17,350	17,350	…	17,350	17,350
Amortization		54,075	108,150	…	0	0
Net operating margin		119,425	65,350	…	173,500	173,500
Interest on debt		48,067	46,613	…	7,172	3,673
EBIT		71,358	18,737	…	166,328	169,827
Corporate tax		19,623	5,153	…	45,740	46,703
Profit after tax		51,735	13,584	…	120,588	123,124
Cash flow (€)						
EBITDA		173,500	173,500	…	173,500	173,500
Corporate tax		19,623	5,153	…	45,740	46,703
Cash flow available for debt service		153,877	168,347	…	127,760	126,797
Interest on debt		48,067	46,613	…	7,172	3,673
Repayable capital		29,073	30,527	…	69,968	73,467
Installment		77,140	77,140	…	77,140	77,140
Available Cash flow		76,737	91,207	…	50,620	49,657
NPV (€)	0					
IRR (%)	5.00%					
DSCR	-	0.99	1.18	…	0.66	0.64
LLCR	-	1.00	1.00	…	0.65	0.64
ADSCR	0.95					
ALLCR	0.80					

Source: Own elaboration

Financial and Economic Performance

This paper aims to evaluate the economic performance of an hypothetical small wind farm without State incentives. To reinforce previous analysis, we take into consideration in this section, the effect of variations in the capital asset by means of numerical simulations. Therefore, we run several simulations using a range of values of WACC between 3% and 7%, as reported in Table 5. In particular, this analysis has been conducted adopting a building cost equal to 1,051,669€, which corresponds to the acceptance of the project, as reported in the previous section.

The results are summarized in Table 5 and they demonstrate that the changes of WACC produce relevant changes in the indicators (Campisi *et al.*, 2014). In addition, these results confirm the reliability of the analysis: the worst results are obtained with the highest values of WACC (6% and 7%); in such cases in the ALLCR index is reduced by about 0.15and 0.27, while ADSCR is reduced by about 0.15 and 0.28.

Conclusion

This paper has applied economic analysis to a wind farm investment in Italy, in order to evaluate the profitability of such investment without State incentives. On the basis of our findings we can infer that grid-parity is not achieved by the analyzed wind farm and it is still need to incentive this renewable energy. For this reason, in the next years, the development of wind energy will depend from the wholesale energy prices, from the financial framework and from investment costs. In particular, this study claims that the significant reduction of the initial investment costs will be the main force for the development of wind energy because wind energy is a capital-intensive technology. Other authors underlined such topic: Hiroux and Saguan (2010) asserted that more market signals are needed to give right incentives for reducing wind integration costs but should not undermine the effectiveness of support scheme, encouraging investment and limiting capital costs. These authors underlined the importance of the selection of wind sites, the improvement of maintenance planning, the combination with other technologies and the transparency of the support schemes as key point to promote an efficient integration of large amounts of wind power into the system. Blanco (2009) showed that the generation costs of wind energy have increased in the past years, driven by a combination of rising prices of raw materials and an increase in the demand for wind turbines. For such reason, structural changes of the energy industry and other external variables may be unexpected and market measures that increase investment certainty need to be put into practice.

The results on grid parity are in line with previous studies (Blanco, 2009; Biondi & Moretto, 2015; Campisi *et al.*, 2015) and they underline that grid parity is still not achieved in Italy.

Table 5: Results of sensitive analysis

Cost of building the wind farm (€)	Equity (%)	Installment (€)	WACC (%)	NPV (€)	Δ NPV (€)	Δ NPV (%)	IRR (%)	ADSCR	ALLCR
1,051,669	20.00	56,551	3.00	276,682	+ 90,323	+48.47	9.11	1.55	1.31
1,051,669	20.00	61,907	4.00	232,618	+ 46,259	+24.82	8.52	1.35	1.20
1,051,669	20.00	67,511	5.00	186,359	-	-	7.87	1.18	1.04
1,051,669	20.00	73,351	6.00	137,999	- 48,360	-25.95	7.17	1.03	0.89
1,051,669	20.00	79,416	7.00	87,643	- 98,716	-52.97	6.41	0.90	0.77

Source: Own elaboration

In this paper we also provided a reliable methodology for investors and policy-maker to evaluate an investment project in renewable energy. From this point of view, this approach should be considered an integrated system that could be used to evaluate different projects of renewable energy investments. Moreover, the present study makes it possible to identify the real difference between the actual price of wind energy and what it should cost in order to be economically independent, not considering any government incentives. A limitation of this study is that only a type of wind farm in considered, by keeping constant the size of the wind farm. Further research is currently produced to measure the cross fertilization effect deriving from the adoption of multiple sources of renewable productions using cost benefit analysis. In the energy security area, it can be considered that natural gas and renewable energy are building blocks for a robust domestic energy economy.

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