THE DESIGN OF A WIND FARM WITH A HORIZONTAL AXIS WIND TURBINE FOR AN AGRICULTURAL FARM

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Abstract
This paper aims to design, using The Analysis Software of Clean Energy Project RETScreen International, of a wind power plants with installed capacity of 20MW, equipped with horizontal axis wind turbines for an agricultural farm.

Key words: horizontal axis turbine, wind farm

INTRODUCTION

Since European policy for renewable energy, we decided to design and implement a mini wind farm in an agricultural farm for the following reasons:

- by delivering energy to the national energy system and receiving the green certificates, we will have a new line of business that can help farmers in the years with poor results ,
- from the park, we will feed the pumping station for irrigation,
- if power is interrupted from the national energy system, we will have the energy we have produced

Our agriculture farm has 800 hectares, part of which will be used for the wind farm.

Through this project we prove the profitability of installing a mini wind farm, although the Romanian Government by Governmental Decision No. 994/11.12.2013 reduced the number of the given green certificates.

MATERIAL AND METHOD

In order to design and adopt of optimal variant from a financial point of view, we will use The Analysis Software of Clean Energy Project RETScreen International. We will use Method 2, a type specific for the analysis software of RETScreen International**.** This method involves calculating the wind farm achieved, in four steps, namely:

- technical sizing calculation;
- the power model;
- calculation of emissions;

- economic calculation, consisting of
  - cost analysis;
  - financial analysis.

RESULTS AND DISCUSSION

Wind farm design equipped with a horizontal axis wind turbine is presented in table 1.

Constructive-functional data for the wind turbine NORDEX N80 – 100m is presented in table 2.

Table 1

Wind farm with a horizontal axis wind turbine

Loss vortex effect 1.0%	Uncorrected energy production 9,559 MWh
Loss on the blades 1.0%	Pressure coefficient 0.977%
Various losses 2.0%	Temperature coefficient 1.016
Availability 98.0%	Total production of energy 9,484MWh
Utilization factor 40.8%	Loss coefficient 0.94%
Electricity delivered to the system 71,414 MWh	Specific yield 1,776kWh/mp
Delivered electricity price 65$/MWh	8 Horizontal axis wind turbine NORDEX N80 – 2.5MW - 100m

Table 2

Technical data on the wind turbine NORDEX N80 - 2500kW – 100m

Rated	2.5MW
Cut-in wind speed	3 m/s
Cut-out wind speed	25 m/s
Height of axis of rotation	100m
Turbine rotor diameter	80m
The area swept by the turbine	5,027mp
Form Factor	2
Power density	0.03mp/kW
Number of blades	3
Speed control	Variable via microprocessor
Gearbox construction	Combined spur / planetary gear
Generator construction	Double-fed asynchronous generator
Control center	PLC controlled
Voltage	660 V
Distance control	Remote controlled surveillance system
Manufacturer	Nordex Energy GmbH
Wind turbine price	1,950,300 $

Power curve for the wind turbine NORDEX N80 - 2500kW – 100m is presented in figure 1.

Technical, economic and financial data is presented in table 3.

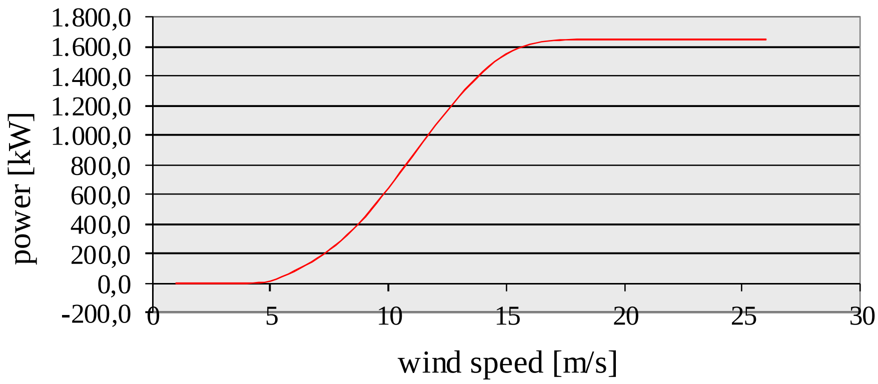

Fig. 1. Power Curve for the wind NORDEX N80 -2500kW – 100m

Table. 3

Horizontal axis wind turbines NORDEX N80–2,5MW–100m

Feasibility Study	330,000 $
Development	880,000 $
Engineering	890,000 $
Electricity production system	24,175,000 $
Balancing system and various	5,453,969 $
Total initial cost	33,574,086 $
Annual maintenance costs	819,995 $
TOTAL COST	34,394,081 $
Savings and total annual revenues	4,641,939 $
Electricity delivered	71,414 MWh
Income from electricity delivered	4,641,939 $
Net GES reduction	29,526 tCO_2/year
Net GES reduction-25 years	738,143 tCO_2
IRR after taxing their capabilities	17 %
IRR after taxing assets	4.7 %
Simple payback period	8.8 years
Net Updated Value (NUV)	9,170,348 $
Electricity production cost	61.16 $/MWh
Payback period	4.4 years

Assessment of the wind farms designed using the updated methods of cash-flows is presented below.

a. Analysis based on a Net Updated Value (NUV)

From an economic perspective, the Net Updated Value (NUV) of a series of cash-flows, both incoming and outgoing, is defined as the sum of the present values of the individual cash-flows of that entity.

If future cash-flows are input and cash-flow is the purchase price, the NUV is effectively the UV of future cash-flows minus the purchase price. NUV is a central tool of discounted cash-flow and is a standard method for using the time value of money to appraise long time projects. NUV can be defined as "the amount of difference" between low amounts: input and output cash. It compares the current value of money with the updated value of money in the future, and it is considered as a sequence of cash-flows and an updated rate or discount curve.

Net Updated Value (NUV) of the project emphasizes the expected impact of the project on the company's value. Projects with positive NUV are considered that will increase the company's value. Rules for evaluation based on NUV specifies that all projects with a positive NUV should be accepted. If NUV is positive, the project is acceptable as the revenues are sufficient to obtain the benefit of determining initial capital return before the end of the life of the investment. If NUV is zero, return on invested capital is achieved at the end of its life and investment is much less attractive. In the analysis based on the Net Updated Value, in case of projects with positive NUV, there should be accepted the project with the highest NUV value.

The project to be supported is the wind farm with installed capacity of 20MW, equipped with 8 horizontal axis wind turbine type NORDEX N80 - 2.5MW - 100m, NUV = 9,170,348 $.

b. Analysis based on Internal Rate of Return (IRR)

Represents an indicator of economic efficiency, based on the difference between the effect and economic effort, determines the update rate, called the internal rate of return (IRR) for updated net income is zero:

$$\sum_{t=1}^{T} \frac{H_t - C_t}{(1-IRR)^t} = 0 \qquad (1)$$

IRR is that update factor for which updated revenues equal updated costs or, cash-flow is equal to zero.

The value of the indicator IRR is determined by linear interpolation, using integers. The value obtained by linear interpolation is larger than the real one due to the fact that the variation curve of the IRR is convex.

Investment is feasible if: $\mathrm{IRR} \geq \mathbf{a}$, so, for the energy field (a = 10 %), the feasibility is provided by :

$$\mathrm{IRR} \geq \mathbf{10\%} \qquad (2)$$

After calculating the IRR for many projects, they are classified by the size of the IRR, cost-effective options are those for which the IRR is greater than the normal rate of return in terms of economic data ($\geq 10\%$).

In case of the wind farm projects discussed above, based on previous data we have the IRR after taxing their own capacities equals 18.9%.

The project to be supported is the wind farm with installed capacity of 20MW, equipped with 8 horizontal axis wind turbine type NORDEX N80 – 2.5MW - 100m, for which the IRR after taxing their own capacities is equal to 18.9%.

The constructive-functional and economic analysis shows that for the installed capacity of 20MW, the optimum design and execution of a wind farm is that with horizontal axis wind turbines NORDEX N80 – 2.5MW – 100m.

CONCLUSIONS

The software RETScren International allows economic and technical design of the wind power plant with installed capacity of 20 MW and the optimal solution is to equip its axis wind turbine of horizontal type NORDEX N80 – 2.5MW - 100m, NPV = 9,170,348 $.

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