Aspects of the Design of Wind Power Plant with an Installed Capacity of 10MW at an Agritouristic Company - Choosing the Best from a Horizontal Axis and a Vertical Axis Turbine

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Abstract

This paper aims to design, using The Analysis Software of Clean Energy Project RETScreen International, of two wind power plants with installed capacity of 10MW, equipped with horizontal axis wind turbines, and vertical axis wind turbines respectively; we will choose the optimal technical and economic option.

Key words: horizontal axis turbine, vertical axis turbine, wind farm

INTRODUCTION

Since European policy for renewable energy, we decided to implement in a mini wind farm on a agritouristic company for the following reasons :
- by delivering energy to the national energy system and receiving green certificates, we will have a new line of business that can help us in the years with poor results,
- from the park, we will power the unit guesthouse in the agritouristic company,
- if power is interrupted from the national energy system, we have produced new energy for us.

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 green certificates received.

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.

Wind farm design equipped with a horizontal axis wind turbine are shown in figures 1-4.

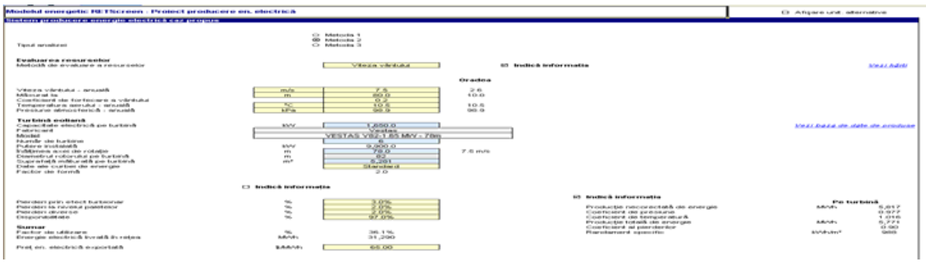

Fig. 1 Power Model

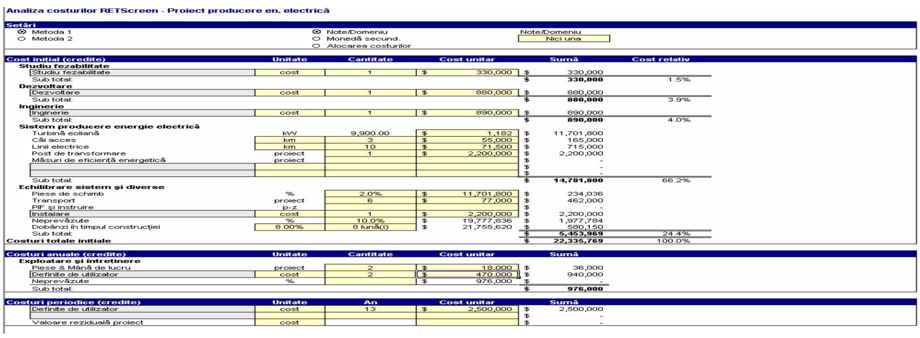

Fig. 2 Cost Analysis

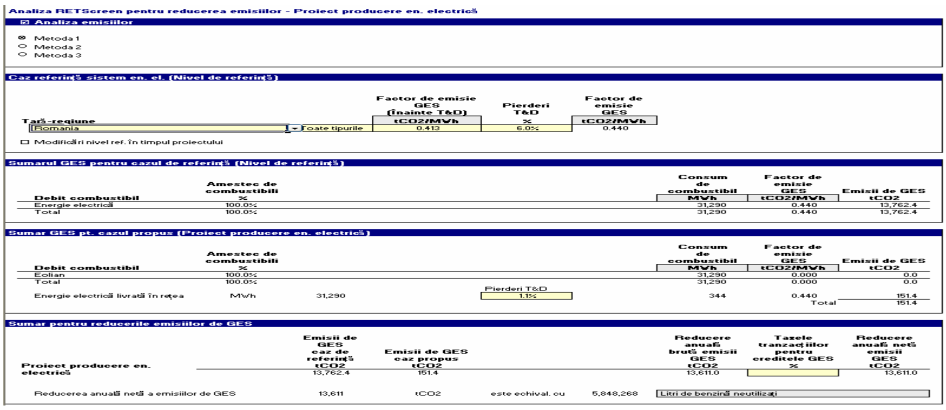

Fig. 3 Analysis of Emissions

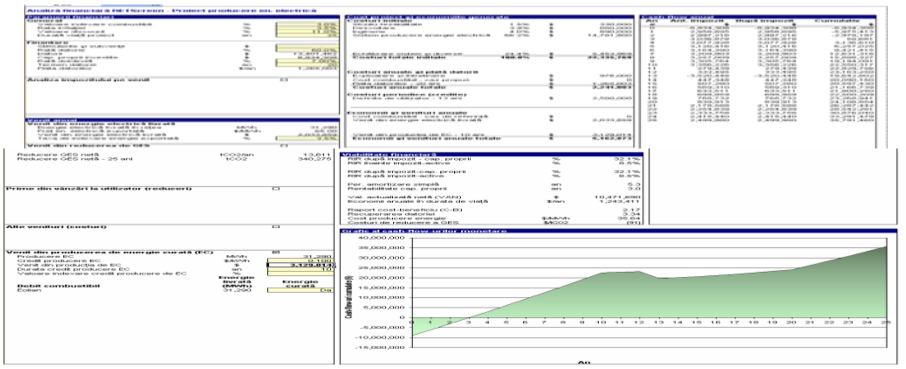

Fig. 4 Financial Analysis

Wind farm design equipped with vertical axis wind turbines are shown in figures 5-8.

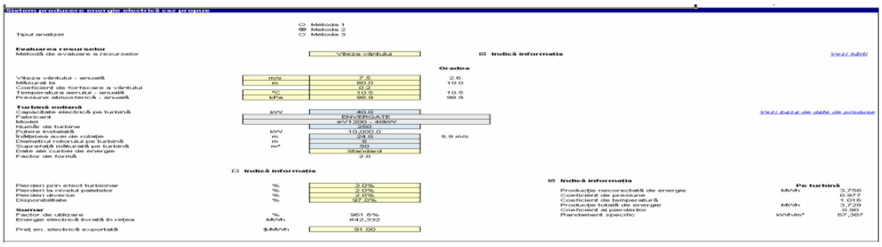

Fig. 5 Power Model

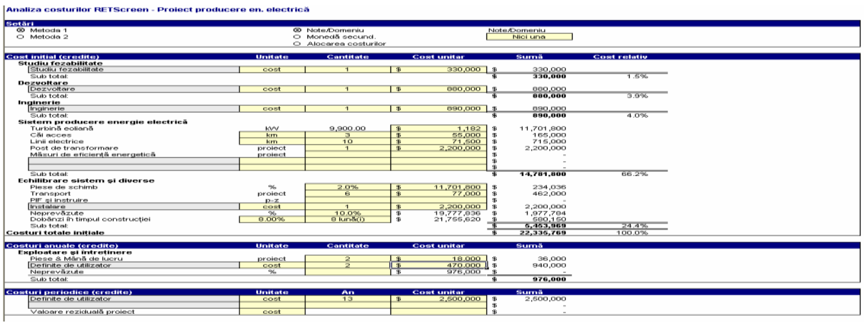

Fig. 6 Cost Analysis

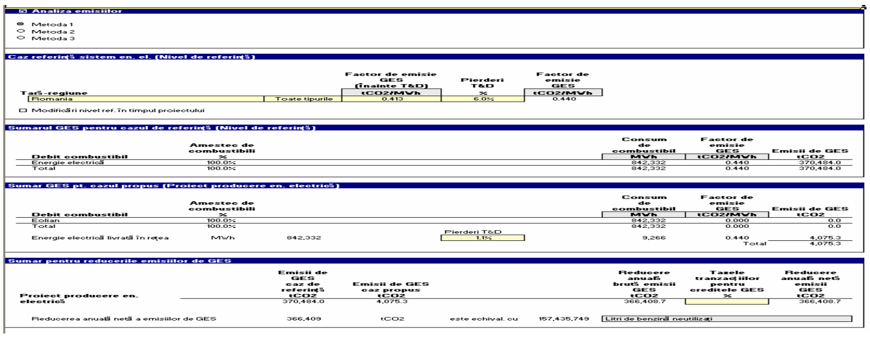

Fig. 7 Analysis of Emissions

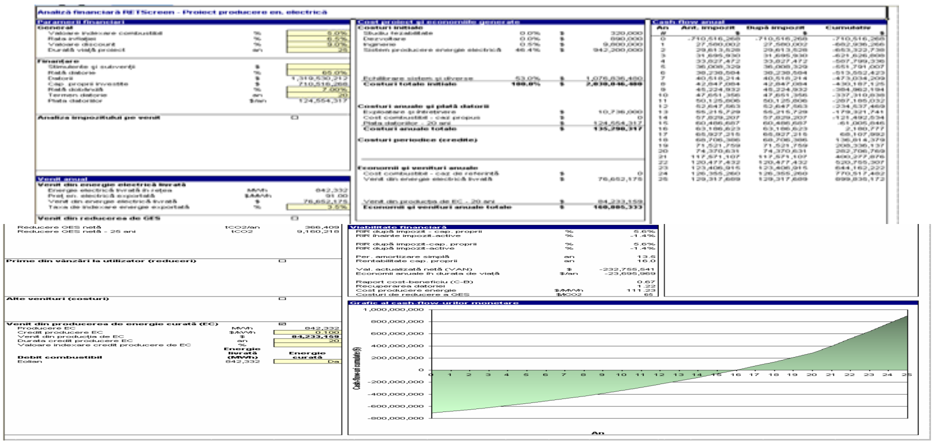

Fig. 8 Financial Analysis

Comparative analysis of the two wind farms with installed capacity of 10MW is made from two aspects.

Analysis in terms of building and function are presented in tables 1 and 2.

Table 1

Wind farm with a horizontal axis wind turbine

Loss vortex effect 3.0%	Uncorrected energy production 5,817 MWh
Loss on the blades 2.0%	Pressure coefficient 0.977
Various losses 2.0%	Temperature coefficient 1.016
Availability 97.0%	Total production of energy 5,771MWh
Utilization factor 36.1%	Loss coefficient 0.90
Electricity delivered to the system 31,290 MWh	Specific yield 988kWh/mp
Exported electricity price 65.0$MWh	
6 Horizontal axis wind turbine VESTAS V66-1,65MW-67m	

Table 2

Wind farm with a vertical axis wind turbine

Loss vortex effect 3.0%	Uncorrected energy production 3,758MWh
Loss on the blades 2.0%	Pressure coefficient 0.977
Various losses 2.0%	Temperature coefficient 1.016
Availability 97.0%	Total production of energy 3,729MWh
Utilization factor 961.7%	Loss coefficient 0.90
Electricity delivered to the system 842,332MWh	Specific yield 67,387kWh/mp
Exported electricity price 65.0$MWh	
250 Vertical axis wind turbine Enverge eV1200-40kW	

Analysis in terms of economic and financial are presented in table 3.

Table 3

Wind farm with an installed power of 10 MW

	Wind Turbine VESTAS V66–1,65MW–67m	Wind Turbine Enverge eV1200–40kW
Feasibility Study	330,000 $	320,000 $
Development	880,000 $	890,000 $
Engineering	890,000 $	9,800,000 $
Electricity production system	14,781,800 $	942,200,222 $
Balancing system and various	5,453,969 $	1,076,836,480 $
Total initial cost	22,335,769 $	2,030,046,480 $
Annual maintenance costs	976,000 $	10,736,000 $
TOTAL COST	23,311,769 $	2,040,782,480 $
Savings and total annual revenues	2,374,872 $	160,885,333 $
Electricity delivered	31,665 MWh	842,332 MWh
Revenues from electricity supplied	2,033,859 $	76,652,175 $
Net GES reduction	13,611 tCO_2/year	366,409 tCO_2/year
Net GES reduction-25 years	340,275 tCO_2	9,160,218 tCO_2
IRR after taxing their capabilities	32.1%	5.6%
IRR after taxing assets	8.5%	-1.4%
Simple payback period	5.3 years	13.5 years
Net Updated Value (NUV)	10,471,690 $	-232,755,541 $
Electricity production cost	35.64 $/MWh	111.23 $/MWh
Payback period	3 years	16 years

Chart of money cash-flows for both types of turbines is shown in Figures 9 and 10.

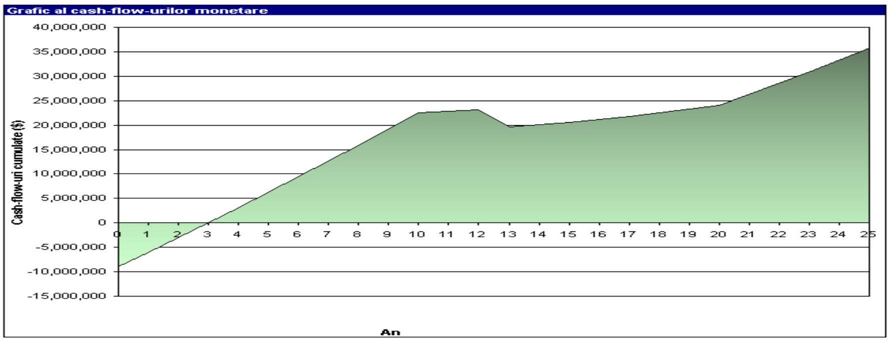

Fig. 9 Horizontal axis wind turbine VESTAS V66-1, 65MW-67m

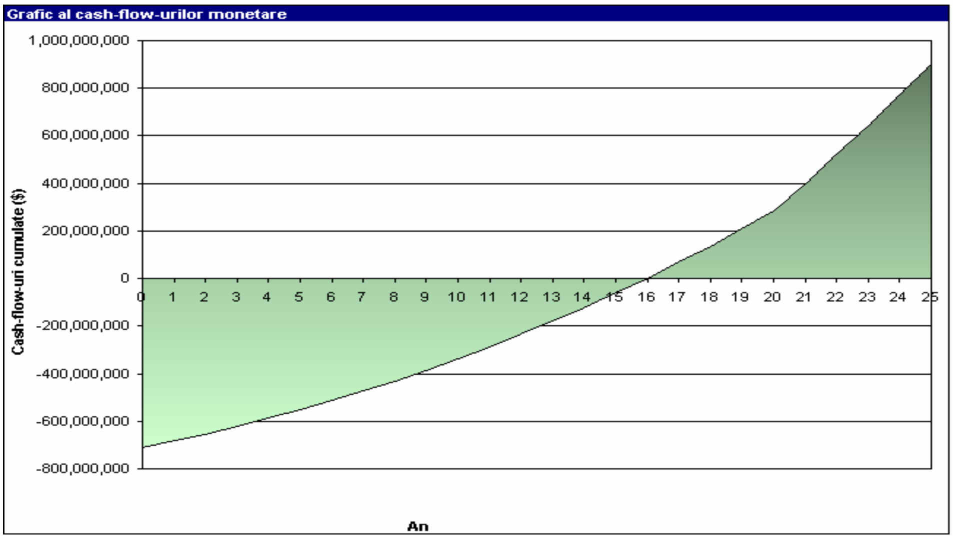

Fig. 10 Vertical axis wind turbine Enverge eV1200-40kW

Assessment of the wind farms designed is done using the following two methods.

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 specified 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.

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:

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

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: $IRR \geq a$; so, for the energy field (a = 10 %), the feasibility is provided by :

$$IRR \geq 10\% \qquad (2)$$

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 ($\geq 10\%$).

RESULTS AND DISCUSSION

Our analysis based on a Net Updated Value showed that projects of wind farms have:

- for the wind farm equipped with horizontal axis wind turbines VESTAS V66-1,65MW-67m, NUV = 10,471,690$.
- for the wind farm equipped with vertical axis wind turbine Enverge eV1200-40kW, NUV = -232 755 541$.

The project to be supported is the wind farm with installed capacity of 10MW, equipped with 6 horizontal axis wind turbine type VESTAS V66-1,65MW-67m, NUV = 10,471,690$.

In case of the two wind farm projects discussed above, based on previous data of Internal Rate of Return we have:

- for the wind farm equipped with horizontal axis wind turbines VESTAS V66 -1,65MW - 67m, the IRR after taxing their own capacities equals 32.1% ;
- for the wind farm equipped with vertical axis wind turbine Enverge eV1200 - 40kW, the IRR after taxing their own capacities is equal to 5.6%.

The project to be supported is the wind farm with installed capacity of 10MW, equipped with 6 horizontal axis wind turbine type VESTAS V66 -1,65MW - 67m, for which the IRR after taxing their own capacities is equal to 5.6 %.

The constructive-functional and economic analysis shows that for the installed capacity of 10 MW, the optimum design and execution of a wind farm is that with horizontal axis wind turbines VESTAS V66-1,65MW - 67m.

CONCLUSIONS

The software RETScren International allows economic and technical design of the wind power plant with installed capacity of 10MW and the optimal solution for this project, at agritouristic company, is to equip its axis wind turbine of horizontal type VESTAS V66 -1,65MW - 67m, NPV = 10,471,690$.

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