COMPARATIVE ANALYSIS REGARDING THE ENERGY AND THE FUNCTIONAL PERFORMANCES OF SMALL WIND TURBINES WITH VERTICAL AND HORIZONTAL AXIS

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Abstract

This paper includes a comparative study of the two types of turbines, namely the turbine with a vertical axis V2500 and the turbine with a horizontal axis H2500 (project), which have an energy power at terminal of 2500 VA, speed λ_0 =3, the area exposed to the wind of 7,5 m^2 and the revolution at the installing point of 250 rpm and a peripheral speed of approximately 20-30 m/s) , as well as the calculation of the energy balance for the turning to account of the wind energy with the help of these wind assemblies.

Key words: wind turbines, energy evaluation, wind power, reference curves

INTRODUCTION

The comparative analysis has focused on the energy evaluations of each separate assembly. Based on these, the functional performances of the two turbines have been established. The adimensional curves have been constructed $C_P = f(\lambda)$, where these curves of reference present the association of the characteristic number λ with the maximum power value C_P. For estimations of the energy production, we have analyzed the energy curves of the turbines with vertical and horizontal axis previously presented.

MATERIAL AND METHODS

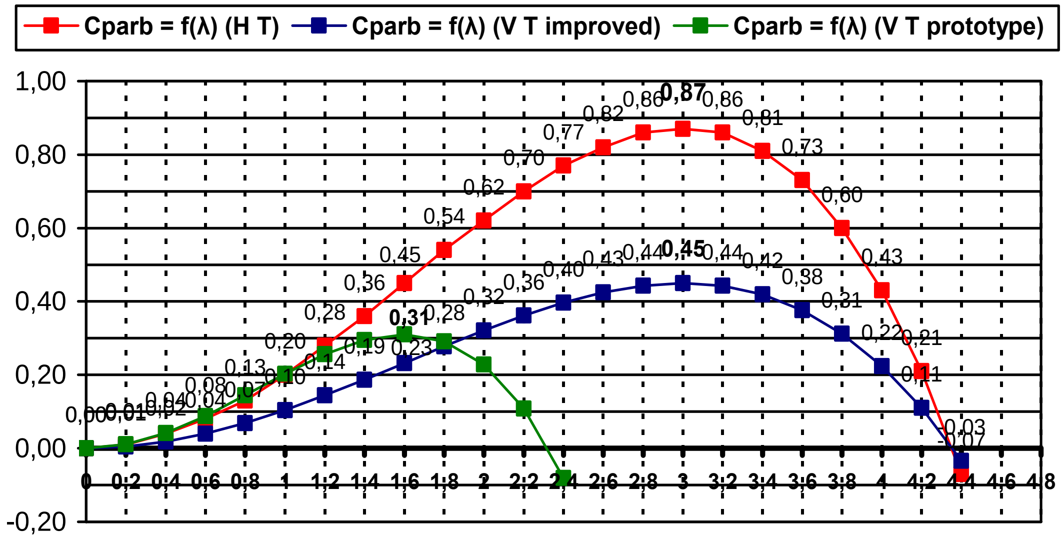
There is made a comparative analysis based on the results yielded by the calculations. There will be compared: the vertical turbine V2500 and the horizontal turbine H2500:

- adimensional curves - V2500 – $C_{Pmax} = 0{,}45$, $\lambda = 3$;
  - H2500 – $C_{Pmax} = 0{,}87$, $\lambda = 3$;
- exploitation curves: - V2500 – $P_{arb} = f(v)$; $n = f(v)$;
  - H2500 – $P_{arb} = f(v)$; $n = f(v)$;
- energy curves: - V2500 – ET = f(v); EE = f(v_{med});
  - H2500 – ET = f(v); EE = f(v_{med})

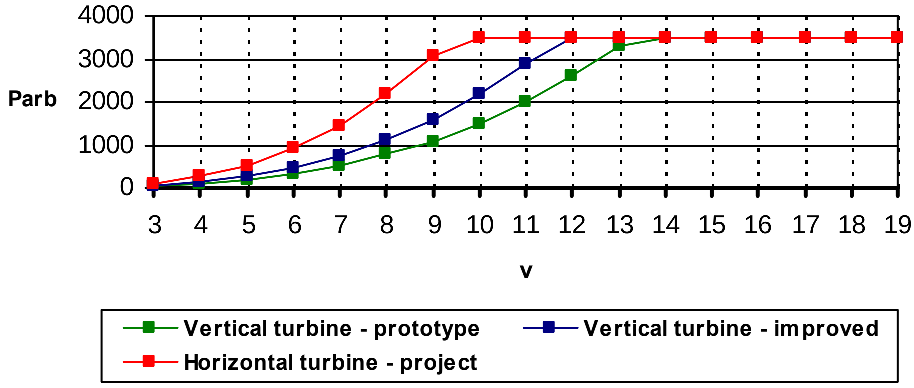
Conclusion: In the comparative analysis of the vertical and horizontal turbines it has been introduced also the graphical representation of the vertical wind turbine prototype (tested in the wind tunnel), characterized by $C_P = 0{,}31$, $\lambda = 1{,}6$ – as a reference element regarding the designing results.

RESULTS AND DISCUSSIONS

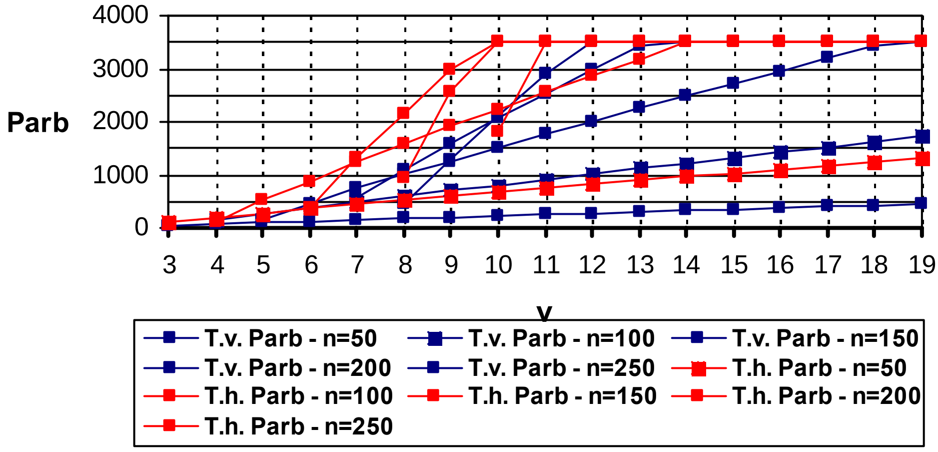
a) The adimensional curves (of the two types of turbines) allow the construction of the exploitation curves defined through the area exposed to the air blown by the rotor of the turbine (S) and the mode of operation (n). The characteristic number λ is the same for both turbines (vertical and horizontal). The association of the characteristic number λ with the maximum power value C_P, allows a maximization of the energy produced by the turbine, when this functions under optimum conditions C_{Pmax} şi λ_0.



b) <u>The exploitation curves</u> serve the evaluations of the annual energies, which are correlated with the areas exposed to the wind and the rotations of the turbine. We can notice from the figure that the horizontal turbine in comparison with the vertical one, accomplishes power P_{arb} = 3500 at speed v =10 m/s, which is a smaller value than that of the vertical turbine, where v = 12 m/s.

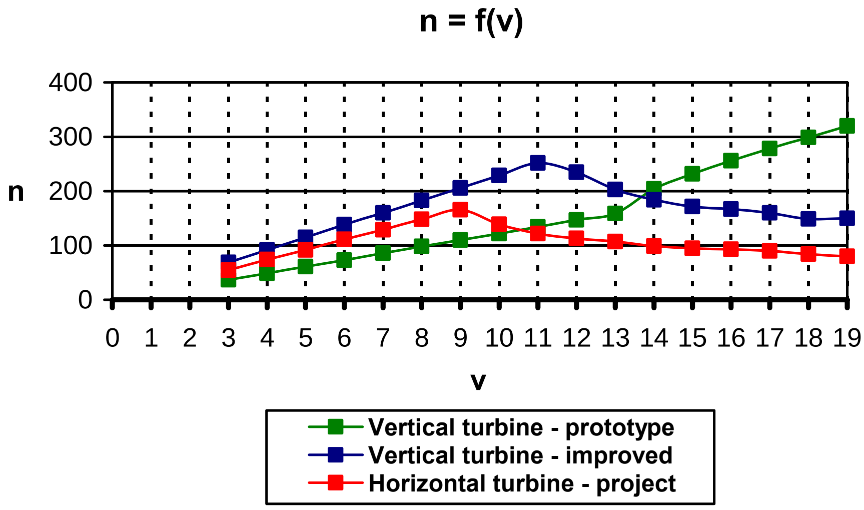


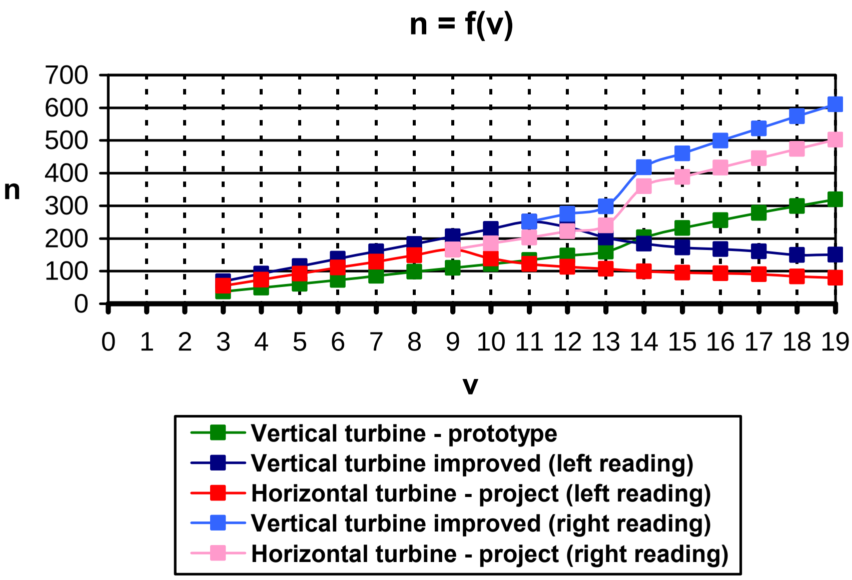
There is represented superimposed, in detail, the P_{arb} = f(v) correlation graphic for five revolutions values of the two previously analyzed turbines. It is shown also in this graphic the fact that the horizontal turbine, vs. the vertical one, achieves for each revolution higher values of the power at the axis, in smaller wind speeds.



Next, we present the dependence of the revolution according to wind speed, n = f(v), for the analyzed turbines (vertical and horizontal). It can be noticed from the representations that the horizontal turbine is more efficient than the vertical one because at smaller revolutions it reaches the values of the indices defined in the calculation for the obtaining of the axis energy.

There are represented two graphics in the same correspondence, witch are presenting two possible calculi situations; first of the graphics presents the situation in witch the correspondence $C_P = f(\lambda)$. There is stood out the very large number of revolution performed; for the turbine optimal use by decreasing the n revolution, the readings of the λ coefficient was made according to the power coefficient C_P in the left side of the graphic. The second graphic presents both λ coefficient reading possibilities, by the growing corresponding bifurcation appearing in the graphical representation, respective by the decrease of turbine revolution. In both representations there has been configured the shape of the n = f(v) curve also for the prototype turbine.





c) Comparison of energy curves. The synthesis of the energy balance for the two turbines (at a location with an average speed of 4...7 m/s) is presented in the following tables:

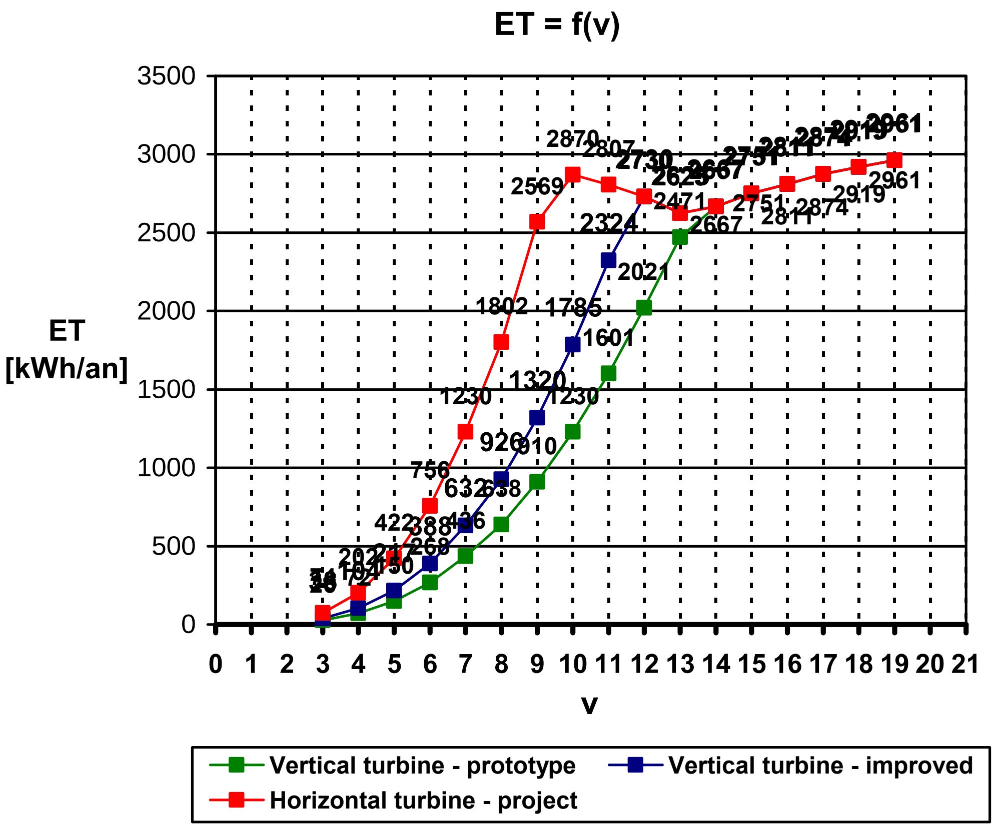
The vertical turbine – $\lambda = 3$, $C_{Pmax} = 0{,}45$

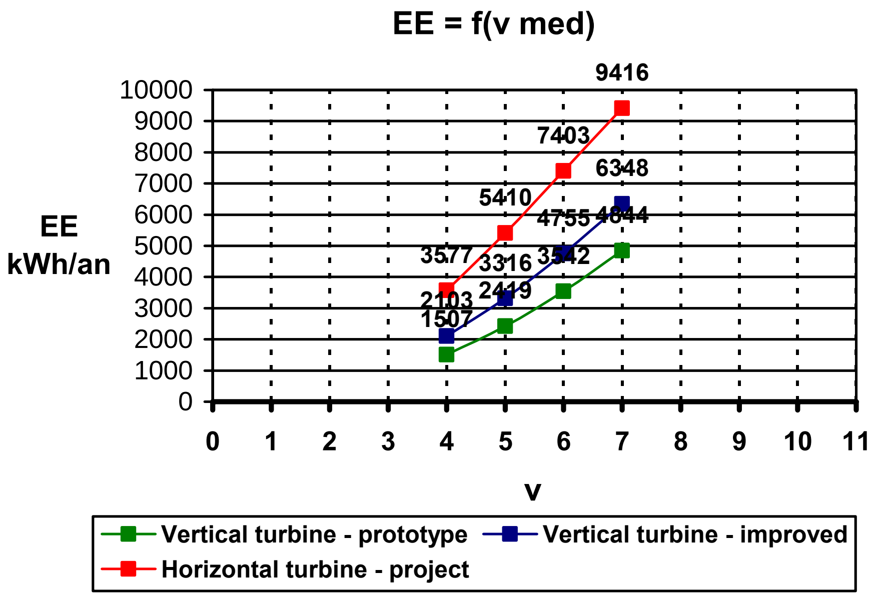
v_{med}	4	5	6	7
ET	2607	4110	5900	7895
EE	2103	3316	4755	6348

The horizontal turbine – $\lambda = 3$, $C_{Pmax} = 0{,}87$

v_{med}	4	5	6	7
ET	4419	6668	9125	11627
EE	3577	5410	7403	9416

There is presented the comparison between the energy curves of the two turbines which are graphically represented for the energy at the axis of the turbine and the electrical energy produced by the two turbines, depending on the wind speed.


ET = f(v)
ET
[kWh/an]
v
Vertical turbine - prototype
Vertical turbine - improved
Horizontal turbine - project


EE = f(v med)
EE
kWh/an
v
9416
7403
6348
5410
4755
4844
3577
3316
3542
2103
2419
1507
Vertical turbine - prototype
Vertical turbine - improved
Horizontal turbine - project

CONCLUSIONS

A first conclusion is that from the dependence $P_{arb} = f(v)$, determined on a large interval of wind speeds, the horizontal turbine is more efficient in the process of exploitation than the vertical one, being able to reach the required powers at lower wind speed.

It can be seen that the assembly with horizontal axis yields an annual energy production, at a location which allows a medium speed of 4...7m/s and favorable variability, bigger than the assembly with vertical axis, which, under the same conditions of medium speed , yields a smaller annual energy production ($EE=f(v_{med})$)

The horizontal turbine is yet again the most representative from both points of view: the the production of more axis energy, as well as the production of more electric power in an energetical system. ($ET=f(v)$).

Thus, we have accomplished the review of some objective criteria of comparison, based on scientifical, technical and economical analysis, which have been subordonated to the general aim of increasing the efficiency of low power wind assemblies.

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