OUTPUT OF ENERGY FOR TURBINES WITH VERTICAL AND HORIZONTAL AXIS

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Abstract
The aim of this paper is to review some objective criteria of comparison based on scientifical, technical and economic evidence, dependent on the general aim of expansion of aero-electric low-power assembly efficiency.
The comparative study between assemblies will focus on the energy evaluations of each and every assembly adjusted to a certain location, based on which the energy and functional performances of the two turbines will be established.

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

INTRODUCTION

The importance of the energy output of the assemblies for economic efficiency is materialized in an energy calculation based on a mathematical model regarding the system curves evaluation of turning to account of energy.

The proposals for this model have been differentiated for the two turbines (vertical / horizontal). This differentiation is based on comparisons of several vertical and horizontal axis turbines for which the results of the tests have been published.

MATERIAL AND METHODS

For the two types of assemblies of 2,5 kW we analyse the curves of exploitation : $P_e = f(v)$, where

P_e: energy at the terminal of the generator

v: wind speed

As a mode of exploitation we have considered a revolution adjustment in order to maximize power at powers under 3,5kW (at axis) and to fix a ceiling at this level. We allowed a short-lived overloading up to 3kW at the turbine axis. This ceiling and adjustment is conducted by means of a control system, using an invertor for connection to the electric network as well as for electrodynamic braking (for protection of assembly)

For the turbine with vertical axis we have accepted as basis of reference the characteristic adimensional curve attained in Canada and Ottawa during tests in wind tunnels.

RESULTS AND DISCUSSIONS

a) **The prototype turbine with vertical axis –** energy output

The calculation mode asks for designing a centralizing table, in which the following calculation relations have been used: $C_{P_{arb}} = a \cdot \lambda^{\alpha} - b \cdot \lambda^{\beta}$, $P_{arb} = f(n,v)$,

$P_{arb} = C_{Parb} \cdot \rho \cdot \frac{v^3}{2} \cdot S$, where S is the exposed area

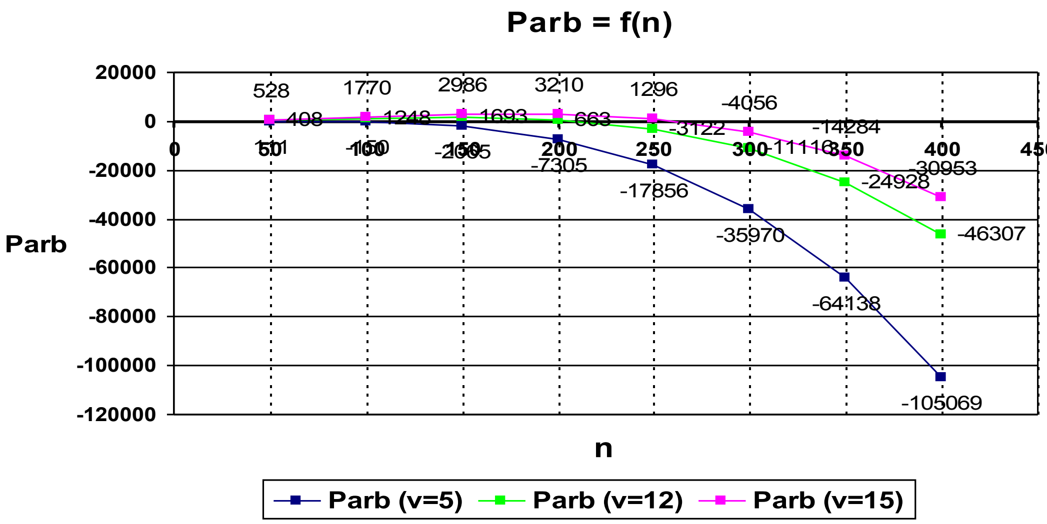
In the case of the vertical turbine $S = D \cdot H = 7{,}5 m^2$, where D = 2,5 m, H = 3

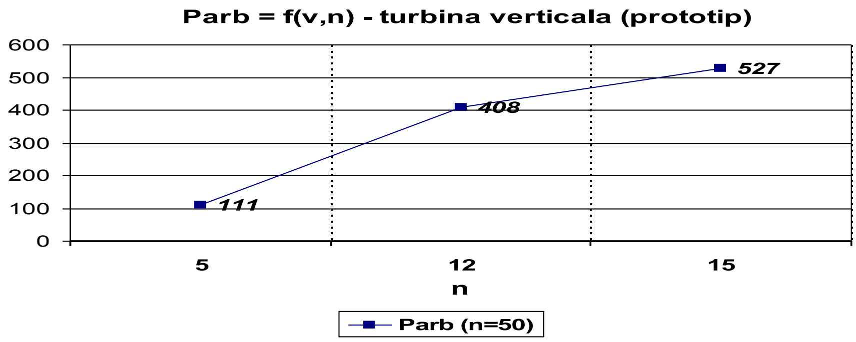
$\lambda = \frac{u_R}{v} = \frac{\omega \cdot R}{v}$; where $\omega = \frac{\pi \cdot n}{30}$, n being the turbine revolution (rpm.)

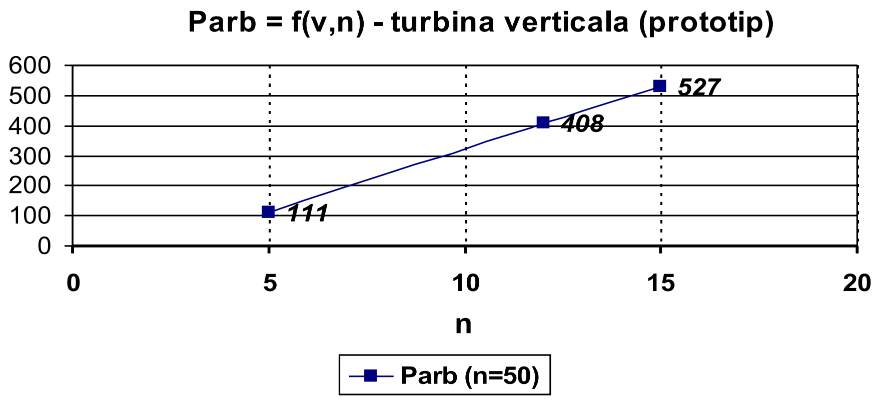
We have considered wind speeds v = 5, 12, 15 m/s.

The calculation results can be visualized in the following table:

v / **n**		**5**		**12**		**15**
	A	395,77		5471,08		10685,71
50	**λ**	1,31		0,55		0,44
	Cp	0,28		0,07		0,05
	Parb	110,59		407,56		528,04
100	**λ**	2,62		1,09		0,87
	Cp	-0,38		0,23		0,17
	Parb	-150,23		1247,73		1770,06
150	**λ**	3,93		1,64		1,31
	Cp	-5,22		0,31		0,28
	Parb	-2064,55		1692,92		2985,81
200	**λ**	5,24		2,18		1,75
	Cp	-18,46		0,12		0,30
	Parb	-7305,09		663,40		3209,57
250	**λ**	6,54		2,73		2,18
	Cp	-45,12		-0,57		0,12
	Parb	-17856,13		-3121,69		1295,70
300	**λ**	7,85		3,27		2,62
	Cp	-90,89		-2,03		-0,38
	Parb	-35970,01		-11116,22		-4056,18
350	**λ**	9,16		3,82		3,05
	Cp	-162,06		-4,56		-1,34
	Parb	-64138,04		-24928,32		-14284,44
400	**λ**	10,47		4,36		3,49
	Cp	-265,48		-8,46		-2,90
	Parb	-105069,4		-46306,8		-30953,2







b) The model turbine with vertical axis – energy output

The turbine presented in this paper is the second variant; as compared to the model of turbine measured in aerodynamic tunnel, it uses an original method of maximizing of the energy turned to account.

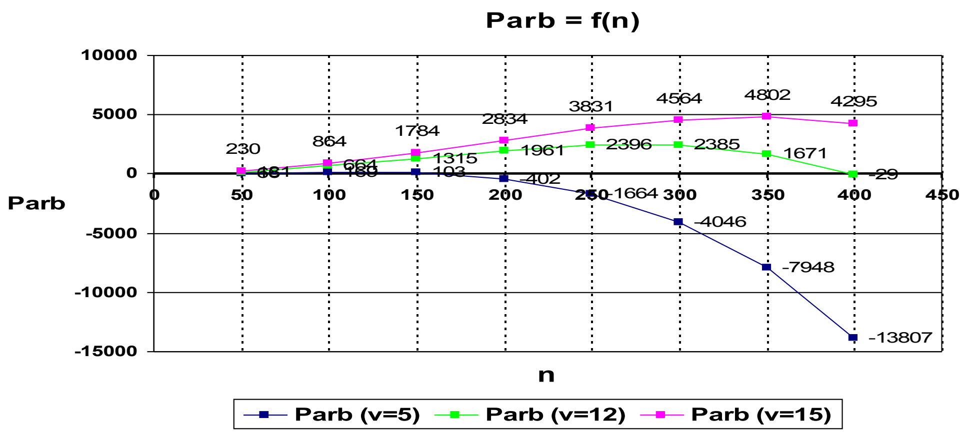
In the case of the vertical axis $S = D \cdot H = 7{,}5m^2$ where D = 2,5 m, H = 3

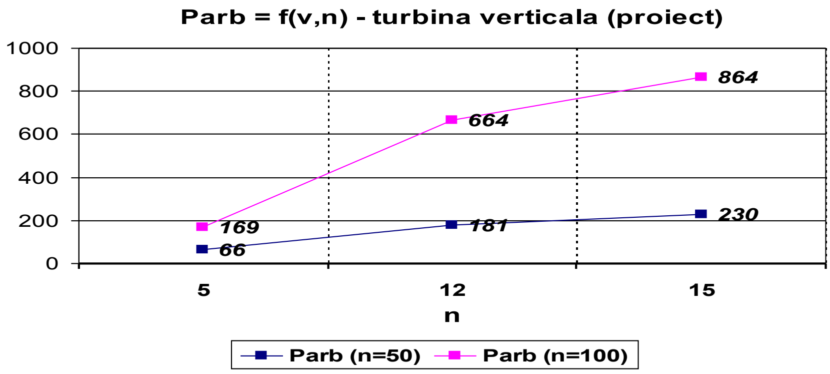
$$\lambda = \frac{u_R}{v} = \frac{\omega \cdot R}{v}\text{; where } \omega = \frac{\pi \cdot n}{30}\text{, n being the turbine revolution (rpm)}$$

We have considered wind speeds v = 5 , 12, 15 m/s, and the previously defined values for the turbine V2500.

The calculation results can be visualized in the following table:

n \ v		5	12	15
	A	395,77	5471,08	10685,71
50	**λ**	1,31	0,55	0,44
	Cp	0,17	0,03	0,02
	Parb	66,08	181,46	229,81
100	**λ**	2,62	1,09	0,87
	Cp	0,43	0,12	0,08
	Parb	169,03	664,31	864,22
150	**λ**	3,93	1,64	1,31
	Cp	0,26	0,24	0,17
	Parb	102,64	1315,46	1784,19
200	**λ**	5,24	2,18	1,75
	Cp	-1,02	0,36	0,27
	Parb	-402,09	1961,27	2834,40
250	**λ**	6,54	2,73	2,18
	Cp	-4,21	0,44	0,36
	Parb	-1664,27	2395,75	3830,61
300	**λ**	7,85	3,27	2,62
	Cp	-10,22	0,44	0,43
	Parb	-4046,14	2385,07	4563,69
350	**λ**	9,16	3,82	3,05
	Cp	-20,08	0,31	0,45
	Parb	-7948,37	1670,61	4802,31
400	**λ**	10,47	4,36	3,49
	Cp	-34,89	-0,01	0,40
	Parb	-13806,64	-28,87	4294,92





c) Turbine with horizontal axis – output of energy

The horizontal axis turbine designed in this paper is a first variant using an original method of maximizing the energy turned to account. Based on the known data and figures, for $\lambda_0 = 3$, a value close to the type of vertical axis turbine, we have obtained $C_{Parb\ max} = 0{,}87$.

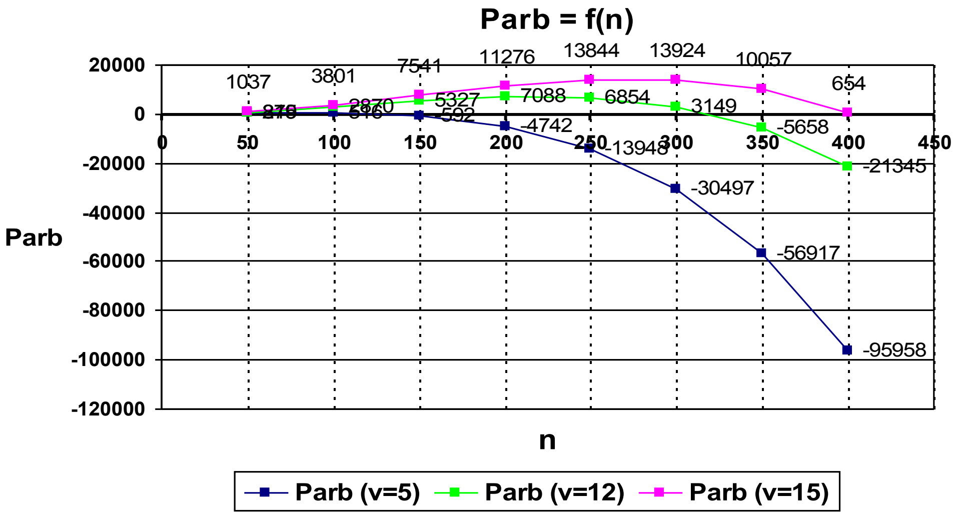
In the case of horizontal axis $S = \pi \cdot \frac{D^2}{4} = 7{,}5 m^2$, where D = 3,1 m

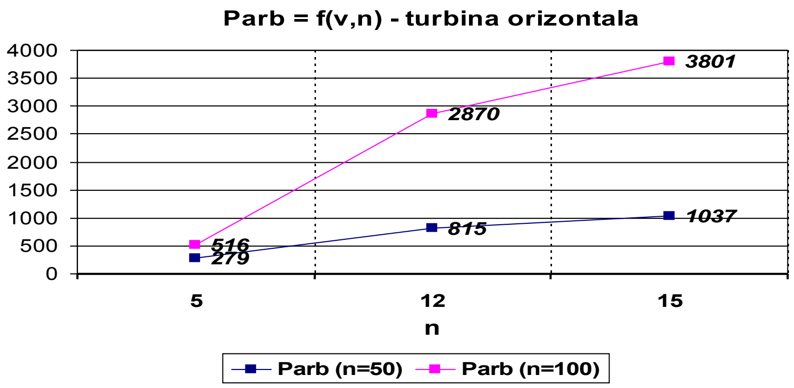
$\lambda = \frac{u_R}{v} = \frac{\omega \cdot R}{v}$, where $\omega = \frac{\pi \cdot n}{30}$, n being the turbine revolution.(rpm.)

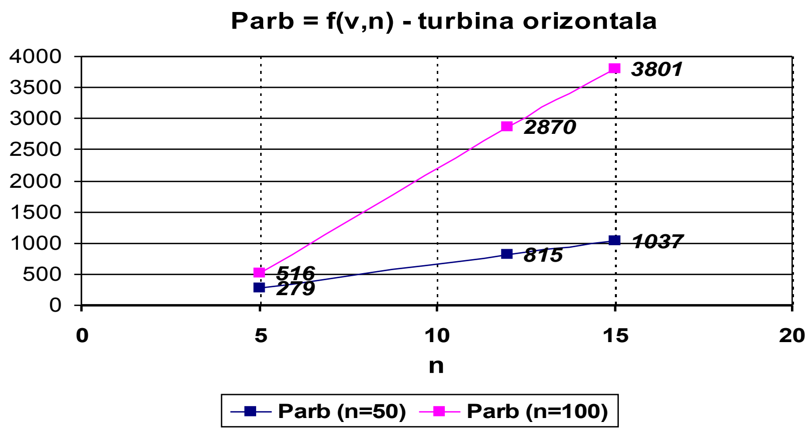
We have considered wind speeds v = 5, 12, 15 m/s, and the previously defined values for the turbine H2500.

The calculation results can be visualized in the following table:

n	**v**	**5**	**12**	**15**
	A	608,53	8412,34	16430,35
50	**λ**	1,62	0,68	0,54
	Cp	0,46	0,10	0,06
	Parb	279,29	814,60	1037,12
100	**λ**	3,25	1,35	1,08
	Cp	0,85	0,34	0,23
	Parb	515,70	2870,14	3801,23
150	**λ**	4,87	2,03	1,62
	Cp	-0,97	0,63	0,46
	Parb	-592,17	5326,58	7540,96
200	**λ**	6,49	2,71	2,16
	Cp	-7,79	0,84	0,69
	Parb	-4742,17	7087,97	11276,07
250	**λ**	8,12	3,38	2,71
	Cp	-22,92	0,81	0,84
	Parb	-13948,42	6854,18	13843,68
300	**λ**	9,74	4,06	3,25
	Cp	-50,12	0,37	0,85
	Parb	-30497,11	3149,50	13923,89
350	**λ**	11,36	4,73	3,79
	Cp	-93,53	-0,67	0,61
	Parb	-56917,03	-5658,40	10056,68
400	**λ**	12,99	5,41	4,33
	Cp	-157,69	-2,54	0,04
	Parb	-95958,07	-21344,58	654,41


Parb = f(n)
Parb
n
Parb (v=5)
Parb (v=12)
Parb (v=15)
1037
3801
7541
11276
13844
13924
10057
654
2870
5327
7088
6854
3149
-5658
-21345
-592
-4742
-13948
-30497
-56917
-95958


Parb = f(v,n) - turbina orizontala
n
Parb (n=50)
Parb (n=100)
516
279
2870
815
3801
1037


Parb = f(v,n) - turbina orizontala
n
Parb (n=50)
Parb (n=100)
516
279
2870
815
3801
1037

CONCLUSIONS

Considering the results obtained from the calculations regarding the output of energy for the three turbines, we present in a table the concentrated results which were analysed.

a) the vertical turbine (prototype- λ=1,6) $C_{P arb} = 0,31$

Obs: From the centralizing synthesis

- v = 5 m/s, for n = 50 rpm, λ = 1,31, $C_P = 0,28$, $P_{arb} = 110,59$
- v = 12 m/s, for n = 200 rpm, λ = 2,18, $C_P = 0,12$, $P_{arb} = 663,40$
- v = 15 m/s, for n = 250 rpm, λ = 2,18, $C_P = 0,12$, $P_{arb} = 1295,70$

b) the vertical turbine (project- λ=3) $C_{P arb} = 0,45$

Obs: From the centralizing synthesis

- v = 5 m/s, for n = 150 rpm, λ = 3,93, $C_P = 0,26$, $P_{arb} = 102,64$
- v = 12 m/s, for n = 350 rpm, λ = 3,82, $C_P = 0,31$, $P_{arb} = 1670,61$
- v = 15 m/s,for n = 400 rpm, λ = 3,49, $C_P = 0,40$, $P_{arb} = 4294,92$

c) the horizontal turbine (project- λ=3) $C_{P arb} = 0,87$

Obs: From the centralizing synthesis

- v = 5 m/s, for n = 100 rpm, λ = 3,25, $C_P = 0,85$, $P_{arb} = 515,70$
- v = 12 m/s, for n = 300 rpm, λ = 4,06, $C_P = 0,37$, $P_{arb} = 3149,50$
- v = 15 m/s, for n = 400 rpm, λ = 4,33, $C_P = 0,04$, $P_{arb} = 654,41$

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