VERTICAL AXIS WIND TURBINE POWER RATING

Dubău Călin*

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea, Romania, e-mail: calin_dubau@yahoo.com

Abstract

The paper presents the selection and evaluation of wind turbine dimensions that depend both on the optimal correlation of two speed ranges and the turbine site. Is it about maximizing the annual energy production taking into account any possible restrictions, presenting solutions for turbine wheel in comparison with other supply on the market.

Key words: wind turbine, energy production, start-up speed

INTRODUCTION

Choosing the optimal dimensions depend on the optimal correlation of two speed ranges, namely:

- Operational range between start-up speed and commissioning speed
- Speed range provided by the site.

Usually it is about maximizing the annual energy production. At this goal one could add any possible restrictions (noise, disturbing pattern, appearance, etc.).

As a conventional rule one opts to set commissioning speed at about twice the annual average speed at the wind turbines site.

It is obvious that most of the time a plant unit operates at partial power ranging between (0 and P_i) and very little time over the value of v_i.

MATERIAL AND METHOD

The parameters defining the pattern are the diameter (D) and the height of the blades (H).

The exposed area is A = D. H

The power ratio at turbine shaft is: $P_a = C_{Pa} \cdot \rho \cdot \frac{v^3}{2} \cdot D \cdot H$

Where:

ρ: air density depends on height above sea level and air temperature.

v: air speeds depend on time and site elevation

C_{Pa}: depends on the specific number ($\lambda = \frac{circumferential \cdot speed}{wind \cdot speed}$)

The commissioning point is a pair of parameters (P_{ai}, v_i) for which the system is dimensioned accordingly. P_{ai} is the maximum output that system can operate in.

The maximum output coefficient is selected at power and speed levels which are lower than those used for commissioning purposes. This strategy favours outputs at partial loads. The specific rating value λ_o is associated to this end scale locus of the power coefficient. At speeds exceeding the commissioning speed, some power should be dissipated in order to prevent exceeding the installed capacity.

RESULTS AND DISSCUSIONS

Considering the restrictions (wind turbine location i.e. on a house, aesthetics), we put forward the following wheel turbine variants:

Version 1: A = 3 m^2 (solution adapted to average speed of 5-6 m/s)

Version 2: A = 4.5 m^2 (solution adapted to average speeds of 4 to 4.5 m/s)

Version 3: A = 7.5 m^2 (solution adapted for average speed < 4 m/s).

The optimum ratio H / D can be analyzed in a feasibility study.

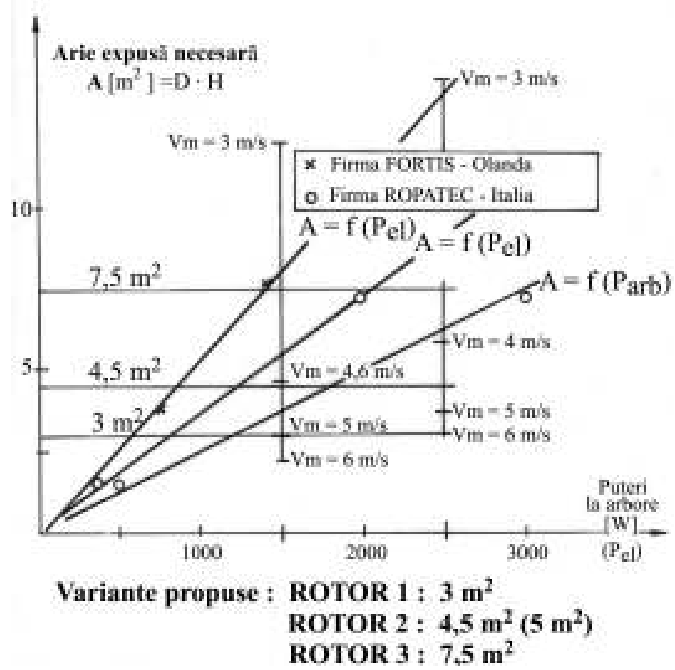

Fig. 1

Legend:

Arie expusă necesară – Exposed area required

Firma FORTIS - Olanda – FORTIS Company - Netherlands

Firma ROPATEC Olanda – ROPATEC Company – Italy
Variante propuse – Versions
ROTOR - TURBINE WHEEL

Comparisons between supplies available on European market:

Table 1

FORTIS Company (Netherlands) - horizontal axis

Installed capacity	Commissioning speed	Exposed area
750 W	15 m/s	3.8 m^2
1400 W	15 m/s	7.65 m^2
4000 W	15 m/s	19.63 m^2
10.000 W	12 m/s	38.50 m^2

Table 2

ROPATEC Company (Italy) - vertical axis

Installed capacity	Commissioning speed	Exposed area
500 W (at shaft) 350 W (power)	14 m/s	1.5 m^2
3000 W (at shaft) 2000 W (power)	14 m/s	7.25 m^2
6000 W (at shaft) 4000 W (power)	14 m/s	7.25 x 2 m^2

The plant unit analyzed in this paper is configured in two versions as follows:

Table 3

1.5 kW shaft plant unit

V_m [m/s]	Speed range (available site)	v_i	Exposed area required
3	0 - 8 m/s	8 m/s	12 m^2
4	0 - 11 m/s	11 m/s	4.6 m^2
5	0 - 13 m/s	13 m/s	2.8 m^2
6	0 - 14 m/s	14 m/s	2.2 m^2

Higher speeds occur very rarely and the related issues are dealt with at protection covers.

The turbine output was considered C_{PiT} = 0.4 hoping to achieving a high performance turbine. Standard density is 1.225 k/m^3.

Table 4

2.5 kW shaft plant unit

V_m [m/s]	v_i [m/s]	Exposed area required
3	9	14 m^2
4	12	5.9 m^2
5	14	3.7 m^2
6	15	3.0 m^2

CONCLUSIONS

Annual gross output is modest and one should explore ways to increase it to the desired level (i.e. 2,000 kWh / year).
Ways to achieve this increase are as follows:

a. Choosing the turbine type ($\lambda 0$) out of analyzed versions;
b. Choosing the size of the exposed area from the variants surveyed;
c. Correlating the generator output with the turbine output;
d. Opting for more favourable sites.

For the options that need to be made based on this study and the conclusions listed herein the theme for turbine design and the prerequisites for the power generator unit can be developed. Preparatory elements for this project were made during the preparation of this study. The most urgent is the way (c) consisting in correlating the outputs of the two units by maximizing the performance of products ($C_p * \eta_G$).

REFERENCES

1. Bej A., 2003, Wind *Turbines*, Timişoara Polytechnic Press, ISBN 973-625-098-9, Timişoara, Romania.
2. Dubau C., 2005, *Modern methods regarding the determination of the functioning characteristic curve for a pipe-line network*, Analele Universității din Oradea, Fascicula Construcții și Instalații Hidroedilitare, ISSN 1454-4067, vol. VIII.
3. Dubau, C., 2007, *The Utilization of Micro-Wind Assemblies within Complex Systems*, Timişoara Polytechnic Press, ISBN 978-973-625-408-6, Timişoara (In Romanian, Ph. D. thesis).
4. Dubau C., 2009, *Comparative study regarding the energy of turbines with vertical and horizontal axis,* Annals of DAAAM International Vienna & Proceedings, ISSN: 1726-9679, January 1, pp. 1819.
5. Gyulai, F., 2000, (a), *Contributions on horizontal axis wind turbine theory*, Proceedings of the 5th International Conference on Hydraulic Machinery and Hydrodynamic, Oct. 2000, Timişoara, Romania.
6. Gyulai,, F., 2000, (b), *Vocational Training in Sustainable Energy* – Course Wind Systems.
7. Gyulai F. & Bej, A., 2000, *State of Wind Turbines in the End of 20th Century and Proposals for Romanian Options*, Buletinul Ştiinţific al Universităţii „Politehnica„ Timişoara, Romania, Tom 45(59), ISSN 1224-6077.
8. Gyulai F.; Bej, A. & Hentea, T., 2000, *Contribution to aerodynamic optimization of horizontal axis wind turbines for mountain sites*, ENERGEX'2000, Proceedings of the 8th International Energy Forum and the Conference of the International Energy Foundation, Las Vegas, USA.
9. ILIE V., ALMAŞI L., NEDELCU Ş., (1984), Utilizarea energiei vântului, Editura Tehnică Bucureşti, pp. 118-120
10. SPERA D. A., 1994, Wind turbine technology – Fundamental concepts of wind turbine engineering, ASME PRESS, New York