STUDY OF COMPARISON CRITERIA FOR WIND AGGREGATES SUBJECT TO A COMPARATIVE ANALYSIS

Dubău Călin Gavril*, Derecichei Laura

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

Abstract

Several comparison criteria are presented, based on which several comparative appreciations on the two wind aggregates may be performed, representing the main subject of the herein work. The comparative appreciations may be detailed, by making a complex analysis for each separate criterion, in this manner being monitored the efficiency of the adaptation process of wind aggregates to the requirements of hybrid systems.

Key words: comparison criteria, wind aggregates, comparative analysis.

INTRODUCTION

The study of comparison criteria for wind aggregates, subject to the comparative analysis, are based on several considerations regarding the wind regime, offer of placements, analysis of performances of wind turbines, estimates of the energy production and energy balances, conception of the assembly turbine generator, conception and protection of aggregate, confrontations with other technical achievements, quality tests on a model, etc.

MATERIAL AND METHOD

The study was accomplished in the Informatics Laboratory of University of Oradea, in the period 2010-2011.

1. Functional performances based on aerodynamic considerations – these selectively and synthetically arranged data allow comparative analysis with the purpose to choose for sizes which characterize the functionality of the system – turbine's diameter (D), type of turbine λ_0, maximum turation n_{max}.

2. Components' masses – important element in the comparative analysis because the net weight of the pallet and the material of which it is built are taken into account, the dimensions of support structure, which is conditioned by the assessment of radial forces given by the components' masses in the rotation movement, respectively of the cyclic ones given by the pallets aerodynamics.

3. Manufacture cost – is determined by several factors, that is the complexity and functionality of the system, of the aggregate's management, respectively of the protection measures for various extreme conditions; the decisions regarding all these elements lead to the idea that a modern technology, as well as any additional equipment mean additional costs.

4. Behaviour at vibrations – analysis of this phenomenon, which might occur at disbalances of masses in rotation movement or at mechanical flaws, determines weightening measures and static balancing of various subassemblies, in the conditions of the identification of disturbing frequencies of various components.

5. Assembling conditions – offer a multitude of possibilities in relation to the global geometrical and kynematic measurements of the turbine, positioning of the pallet towards the terrestrial speed field, conditions for starting the turbine and support devices for start-up, correlation with the electrical generator, and mechanisms for starting the aerodynamic breaking.

6. Sustainability – important quality index regarding the functionality of aeroenergy systems adapted to the specific requirements, materialized through the management and protection of the aggregate, control tests within the manufacture of turbine, conception of the assembly turbine-generator.

7. Protection against wind and overspeed – we start with the idea that the management system of the aggregate must ensure its correct functionality. In these conditions, the effect is the turbine overspeed, which may occur in the case of electric consumer release, as well as in the case of breaking the coupling between the turbine and the generator, and the comparison criterion starts from the system regular exploitation of the field.

8. Aesthetic aspects – the aesthetic aspects appear, following mainly the use of existing elements, by also observing the functionality of the system to the parameters for which it was designed; certain conclusions may be drawn by comparing these types of situations for the types of turbines.

9. Other considerations – are related to comparisons with other aggregates performed by important manufacturing companies, by following the product competitiveness in relation to these, the advantages offered, the exploitation options etc.

All these considerations may be detailed, making a complex analysis for each separate criterion, thus monitoring the efficiency of the adaptation process of wind aggregates to the requirements of hybrid systems, studied for the local energy systems.

RESULTS AND DISSCUSIONS

1. Functional performances of aggregates subject to comparative analysis:

Electric power installed at terminals	2500 VA
Turbine speed	$\lambda_0 = 2...3$
Area exposed to wind	7,5 m^2

Diversification of area	6 m^2 ; 4,5 m^2
Speed at the installation point	250 rpm
Peripheral speed	20 – 30 m/s
Position of the turbine axis: - vertical:	$A = H \cdot D$
- horizontal:	$A = \pi \cdot D^2/4$

2. The total mass of metallic structure of vertical aggregate is of approximately 90 kg, and of the horizontal one is of 120 kg. In these conditions the total mass of the vertical turbine (metallic support structure + 3 polyester pallets) is estimated at approximately 101 kg, and of the horizontal one at approximately 141 kg.

Table 1

Total mass of vertical and horizontal aggregate

Masses [kg]	Material	Vertical turbine	Horizontal turbine
Total turbine	OL/PAFS/Al	100,626	141,47
Pallets	PAFS	11,430 x 3	7,000 x 3
Spokes	OL/PAFS	6,700 x 6	–
Hub	OL	–	36,000
Axle + bearing	OL	16,173 + 6,820	–
Components	various	3,143	34,470
pillar (minimum)	OL	–	50,000

3. The structure of investment of an air-electric station takes into account the emphasis of manufacture costs, including assembling and start-up, installation costs on the placement and operation and maintenance costs.
Specific costs [kg/kW ; lei/kW]
Prices
Vertical aggregate 2117 €
Pallets 706 €
Spokes 524 €
Protection of the generator 86 €
Metallic support structure 686 €
Package 115 €
Price materials
Polyester 10-15 € / kg
Processed stainless steel 3 € / kg
Aluminum 3 € / kg
Steel 2 € / kg
Pillar 1.5-3.5 € / kg

4. Constant angular speed functioning shall be achieved at the moment:

$$M_m = M_{f_r} + M_\Delta + M_G \qquad (**)$$

If $M_m > M_{f_r} + M_\Delta + M_G$ => a diminuation packing which subsequently is corrected through the increase of breaking
If $M_m < M_{f_r} + M_\Delta + M_G$ => decrease of speed, which may be possibly compensated through the diminuation of $M_{f_r} \rightarrow 0$, or the situation may bring the system in the previous case.

5. At diversifications of the turbine for other placements, reference is made to two other dimensions of the diameter correlated to the average speed, maximum speed and installation speed, presented briefly under the following form:

Table 2

Diversifications of the turbine for other placements

Diameter D [m]	2	1,5
Wind average speed v_m [m/s]	5	6
Maximum speed n_{max} [rpm]	310	410
Installation speed v_i [m/s]	12	13

Based on these diversifications of the turbine dimensions, the performances required for turbines were identified in order to maximize the energy production [kWh/an].

6. By resuming the results obtained following the calculations regarding the energy production for the two turbines, the concentrated results are presented and shall be analyzed.

a) vertical turbine (project - λ=3)

$C_{P_{arb}} = 0,45$

$\alpha = 2$; $a = 0,11666$

$\beta = 3,5$; $b = 0,01283$

The maximum is $C_{P_{max} arbore} = 0,45$, and the place of maximum $\lambda_0 = 3$

v = 4 m/s : E = 2139 kWh/y
v = 5 m/s : E = 3396 kWh/y
v = 6 m/s : E = 4902 kWh/y
v = 7 m/s : E = 6581 kWh/y

b) horizontal turbine (project - λ=3)

$C_{P_{arb}} = 0,87$

$\alpha = 2$; $a = 0,2255$

$\beta = 3,5$; $b = 0,024805$

The maximum is $C_{P_{max} arbore} = 0,87$, and the place of maximum $\lambda_0 = 3$

v = 4 m/s : E = 4061 kWh/y
v = 5 m/s : E = 6369 kWh/y

$v = 6$ m/s : $E = 9032$ kWh/y
$v = 7$ m/s : $E = 11860$ kWh/y

7. In the analysis of the exploitation regime, the aggregate shall have two management fields that is the adjustable speed, respectively fixed speed, concentrated in the following chart:

Table 3

The analysis of the exploitation regime

Option	D = 2,5 m	D = 2 m	D = 1,5
Field of adjustable speed (power maximization)	$v = 3 \dots 9$ m/s	$v = 3 \dots 9$ m/s	$v = 3 \dots 9$ m/s
	n = 70-200 rpm	n = 90-250 rpm	n = 115-335 rpm
Field of fixed speed (restriction of the turbine's power)	$v > 9$ m/s	$v > 9$ m/s	$v > 9$ m/s
	n = 200 rpm	n = 250 rpm	n = 335 rpm
Protection at maximum speed n_{max}	$n_{max} = 250$ rpm	$n_{max} = 310$ rpm	$n_{max} = 410$ rpm

8. We wish to obtain aggregates with reduced dimensions, reduced masses, with manufacture and maintenance costs as low as possible. The turbine with horizontal axis is of three pallets airscrew, using a light resistance structure. The vertical axis turbine is of "Giromill" type, with three pallets and six spokes.

9. The 12 analyzed turbines, based on the original charts from the profile catalogues, are synthetically presented in the following table. Those dates, which are interesting for the elaboration of an assembly adapted for the studied turbines, were compared.

Table 4

The profile catalogues turbine analyzed

Aggregate code	P_{nom} [W]	D [m]	m [kg] rotor	$\frac{m}{P}$ [kg/W]	$\frac{m}{A}$ [kg/m^2]	n [rpm]	Exposed area A [m^2]	Peripheral speed u_R [m/s]
INCLIN 250	240	1,35	32	133	22,4	< 600	1,43	< 42,4
Yellow Sand	300	2,40	4	13,3	0,9	< 500	4,52	< 62,8
INCLIN 600	600	2,0	38	63	12,1	< 800	3,14	< 83,8
ESPADA	750	2,2	3,0	4	0,8	< 900	3,80	< 103,7
WHISPER H40	900	2,1	21,0	23	6,1		3,46	
WHISPER H80	1000	3,0	30,0	30	4,2		7,07	
PASSAT	1400	3,12	14,0	10	1,8	< 750	7,65	< 122,5
INCLIN 1500neo	1500	2,86	42,0	28	6,5	< 800	6,42	< 119,8
SG 280	1800	2,88	50,0	28	7,7	< 700	6,51	105,6
INCLIN 3000neo	3000	4,0	125	42	9,9	< 450	12,6	< 94,2
WHISPER 175	3200	4,5	70	21,9	4,4		15,9	
SG 500	5000	5,5	300	60	12,5	250	24,0	72

CONCLUSIONS

The conclusions of the comparative analysis are the following:

- the constructive form of turbines represents the data basis for comparative analysis specific to types of analyzed types of aggregates
- modern technologies, as well as any additional equipment means additional costs.
- behavior at open vibrations opens the possibilities of comparison between the wind turbines.
- the assembling conditions define the considerations which are the basis of comparative analysis.
- sustainability, as quality index, defines multiple comparison elements.
- the comparison criteria related to the phenomenon of normal exploitation of the system.

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