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Assessment of Wind Generation Potentiality and Site Matching of Wind Turbines in Algeria

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ABSTRACT

Wind data gathered at 10 m high is based on the atlas of the wind of Algeria established by the National office of the Meteorology runs 37 stations of measures. The data is used for a feasibility analysis of optimum future utilization of Wind generator potentiality in 14 sites covering all landscape types and regions in Algeria. A mathematical formulation using a two-parameter Weibull wind speed distribution is further established to estimate the yearly mean wind speed and the yearly average available wind energy flux for each site. Detailed technical assessment for the ten most promising potential wind sites was made using the capacity factor. The investigation was performed assuming twelve models of small, medium and big size wind machines representing different ranges of characteristic speeds and rated power suitable for water pumping and electric supply. The results show that small wind turbines could be installed in some coast region and medium wind turbines could be installed in the high plateau and some desert regions and utilized for water supply and electrical power generation, the sites having an important wind deposit, in high plateau we find Tiaret site's but in the Sahara there is some sites for example Adrar, Timimoun, In Amenas and In Salah, in these sites could be installed a medium or a big size wind turbines, provided the correct wind machine-site is selected.

Keywords: Wind energy; Wind characteristics; wind speed distribution; capacity factor.

1. Introduction

To seize the range of renewable energies in Algeria and the stakes considerable, it is suitable first of all, to remind the considerable and inexhaustible resources existing of these energies not yet exploited namely the exceptional solar layer which covers a surface of 2.381.745 km^2, with more than 3000 hours of sunniness per year and the existence of a wind and geothermic potential energy appreciable easily mobilizable. In addition, these energies are clean, renewable and are used where they are and their decentralized character is appropriate well at the scattered state of the zones with low density of population.

Consequently, they can contribute to the environmental protection and be regarded as an alternative resource to future of the energies conventional. These energies are for the future of the rural world and against its insulation for health and the supply water and electrical power generation, against deforestation and for telecommunications. What induces the stabilization of the populations on their origin places with promising prospects as for their living conditions. The ratification of the protocol of Kyoto and the law on the promotion of renewable energies within the framework of the durable development came to confirm the Algerian political good - will and the engagement of our country for the exploitation of these renewable natural resources and non polluting, thanks to an increased mobilization of the efforts of research and development for the control of the technologies implemented in the installations of conversion of the power renewable energies.

2. Topography of Algeria

Algeria is located in North Africa bordered north by the Mediterranean Sea (1200 km), east by Tunisia (965 km) and Libya (982 km), south-east by Niger (956 km,), south-west by Mali (1,376 km) and Mauritania (463 km), west by Morocco (1,559 km) and the Western Sahara (42 km). It geographical coordinates are represented by a latitude of 28º00´North of the equator and longitude of 3º00´ East of Greenwich. On the African continent, Algeria is after Sudan, the second-largest country with an area of 2 381 740 km², whose four fifths are occupied by the Sahara.

The regions (A), (B), (C) and (D) represent respectively the sites of the coast region, Atlas tellian, high plateau and Sahara

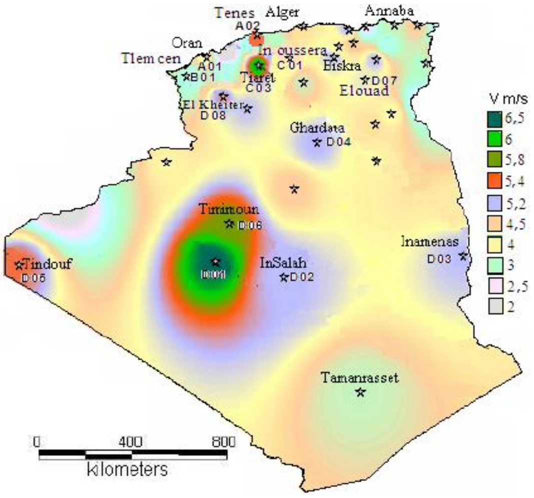


Fig.1. the distribution map of the wind in Algeria and location of the chosen sites and regions.

3. Wind distribution and available energy

In many cases, the Weibull probability density function allows to model the availability of wind energy for a specific region by means of the probability of occurrence of the wind speed. The Weibull and Rayleigh probability density functions are commonly used and widely adopted in wind power studies. It is important to keep in mind that Rayleigh is only a subset of Weibull probability density function. The Weibull probability density function is defined as, [1, 2, 3, 4, 5]:

$$f(V) = \frac{k}{c}\left(\frac{V}{c}\right)^{k-1} \exp\left(-\left(\frac{V}{c}\right)^{k}\right)$$

The cumulative distribution function of the velocity V gives us the fraction of time (or probability) that the wind velocity is equal or lower than V. Thus the cumulative distribution F (V) is the integral of the probability density function [3, 6]:

$$F(V) = 1 - \exp\left(-\left(\frac{V}{c}\right)^{k}\right) \quad (2)$$

f(V) is the function of the Weibull probability density (probability of observation of a wind speed)
k : is the shape factor of the Weibull law, describing the distribution of the winds velocity.
C : in m/s is the scale factor of the Weibull law, it is connected to the mean velocity by the shape factor k.
Therefore starting from the distribution of the Weibull law, one can appreciate speeds characteristic of the wind turbine and the average energy, which it can produce and the average energy of the site wind potential.

The models to assess the available wind potentiality during a period T for any site are given by the following expressions:
The available average power density Pd and the available average power P crossing the blades by using Weibull probability distribution is calculated as follows [1, 2, 5, 6]:

$$P_d = \frac{1}{2}\rho V_{3m}^3 \quad (3)$$

$$P = AP_d \quad (4)$$

A is the blades swept area.
ρ□ and V_{3m} are respectively the air mass density and the cubic mean velocity of the wind, V_{3m} is obtained by:

$$V_{3m}^3 = \int_0^\infty V^3 f(V)dV \qquad V_{3m}^3 = C^3\Gamma\left(1+\frac{3}{k}\right) \quad (5)$$

The average wind energy available in a given site during a period T is written:

$$Em = AEd \quad (6)$$

Ed is the average energy flux during the time T given by:

$$Ed = \int_T P(V)dt = \frac{1}{2}\rho\int_T V^3 dt = \frac{1}{2}\rho V_{3m}^3 T \quad (7)$$

The Weibull distribution function gives us:

$$Ed = \frac{1}{2}\rho T\int_0^\infty V^3 f(V)dV \quad (8)$$

$$Ed = \frac{1}{2}\rho T C^3\Gamma\left(1+\frac{3}{k}\right) = \frac{3}{2}\rho T\frac{C^3}{k}\Gamma\left(\frac{3}{k}\right) \quad (9)$$

4. Energy conversion model

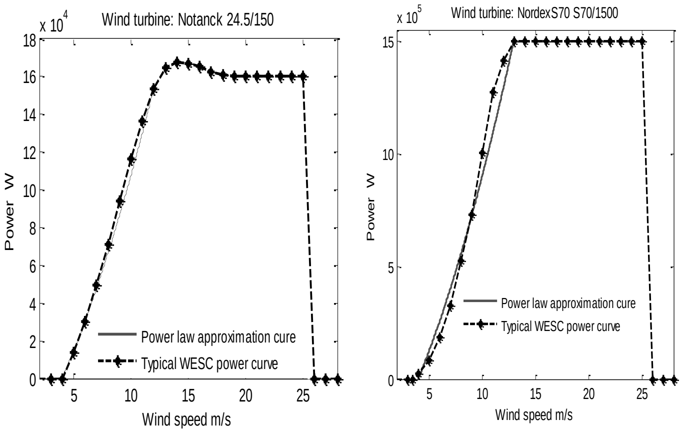
The model of energy conversion used for the evaluation of the wind turbine siting and potentiality is the linear model, which is given by a single equation relating electrical power output to wind power input by the following relation [1, 5]:

$$P = (\eta_{me}\eta_{el})Pa = 0.5\rho(Cp\,\eta_{me}\eta_{el})V^3 \quad (10)$$

$$P = 0.5\rho S\eta V^3 \quad (11)$$

Where Pa is the fraction of power extracted from the power in the wind and η is the global output of the system, which takes account various efficiency; electric (η_{el}), mechanics (η_{me}) aerodynamics (C_P).

As for the power curve model of a real wind turbine, it can be modelled by four parameters: the cut-in speed Vc, the rated speed Vr, the cut-off speed Voff, and the nominal power Pr [7, 8].



Figs. 2: Typical WECS power curve showing the theoretical power law approximation.

For the analysis of the available wind data in the chosen Algerian sites for wind turbines siting and potentiality. The analytical power law used is the following model appropriate to the turbine power curve of real machines is as follows (see Figs. 2):

$$P_2(V) = \begin{cases} 0 & V \le Vc \\ \dfrac{\Pr(aV^2 + bV + C)}{(Vr - Vc)^2} & Vc < V \le Vr \\ \Pr & Vr \le V \le Voff \\ 0 & \text{Otherwise} \end{cases} \quad (12)$$

The regression constants a, b and c, are related to the speed characteristic of the machine by the following relations:

$$\alpha = \frac{(\mathrm{Vr} + 2\mathrm{Vc})\mathrm{Vr}}{(-0.08Vc - 0.05Vr + 3.085)(Vr^2 - Vc^2)} \quad (13)$$

$$a = 2(1-\alpha),\; b = (1-a)Vr - (a+1)Vc,$$

$$\mathrm{C} = (\mathrm{Vc} - (1-\mathrm{a})\mathrm{Vr})\mathrm{Vc}$$

α is a dimensionless parameter, because the constants 0.08 and 0.05 have the dimension sm^{-1}
It is appropriate to simulate the power curve of a pitch-controlled wind turbine and to a lesser extent a stall- or a yaw-controlled wind turbine, which do not have a constant power range and thus neglects the power output exceeding Pr.

5.1 Average power output

The most straightforward and simple solution is to calculate the resulting power directly by using the probability density function. Since the probability density function f (V) represents the fraction of duration of wind speed, the average power output of a wind turbine can be defined as [5]:

$$P_{avg} = \int_{Vc}^{Voff} P(V)\,f(V)dV \quad (14)$$

$$P_{avg} = \int_{Vc}^{Vr} P(V)\,f(V)dV + \int_{Vr}^{Voff} f(V)dV \quad (15)$$

$$P_{avg} = \int_{Vc}^{Vr} P(V)F'(V)dV + \int_{Vr}^{Voff} f(V)dV \quad (16)$$

Using integration by parts, it can be further derived as:

$$P_{avg} = P(V)F(V)\Big|_{Vc}^{Vr} + \int_{Vc}^{Vr} P'(V)F(V)dV + \int_{Vr}^{Voff} f(V)dV \quad (17)$$

$$P_{avg} = P(V)F(V)\Big|_{Vc}^{Vr} + \int_{Vc}^{Vr} (2aV+b)F(V)dV + F(V)\Big|_{Vr}^{Voff}$$

The integral at Eq. (17) can be estimated by Simpson's three-eighths rule as:

$$P_{avg} = \Pr\left[-G(Voff) + \frac{1}{8}\left[\begin{array}{l} (1-a)G(Vc) + (1+a)G(Vr) \\ + (3+a)G\left(\dfrac{Vc+2Vr}{3}\right) \\ + (3-a)G\left(\dfrac{2Vc+Vr}{3}\right) \end{array} \right] \right] \qquad (18)$$

Where

$$G(V) = \exp\left(-\left(\frac{V}{C}\right)^{K}\right) \qquad (19)$$

P_{avg} as a function of six variables: k, C, Vc, Vr, Voff and Pr, Eqs. (18) and (19) give the final for the estimated average power output. G (Voff) can be ignored because the wind turbine has a relatively higher Voff, Eq. (18) can be simplified as:

$$P_{avg} = \frac{\Pr}{8}\left[\begin{array}{l} (1-a)G(Vc) + (1+a)G(Vr) + (3+a)G\left(\dfrac{Vc+2Vr}{3}\right) + \\ + (3-a)G\left(\dfrac{2Vc+Vr}{3}\right) \end{array} \right]$$

5.2 Pairing performance

The dimensionless capacity factor or so-called mean power coefficient is defined as the index of turbine–site pairing performance, and is denoted as PP [4]:

$$PP = \frac{P_{avg}}{\Pr} \qquad (20)$$

This can be interpreted as the power output effectiveness with respect to the nominal power. Furthermore, since the cost of the wind turbine is positively correlated to its nominal power, PP can also be an approximate measure of the power output of the unit cost, even though there is no proportionality between WECS cost and nominal power [6]. By substitution of Eq. (18) can be further derived as:

$$PP = \frac{1}{8}\left[\begin{array}{l} (1-a)G(Vc) + (1+a)G(Vr) + (3+a)G\left(\dfrac{Vc+2Vr}{3}\right) \\ + (3-a)G\left(\dfrac{2Vc+Vr}{3}\right) \end{array} \right] \qquad (21)$$

It should be noticed that in Eq. (21), PP is independent of Pr. Therefore, two wind turbines with the same Vc, Vr and Voff but different nominal power Pr get the same pairing performance at the same site. This is reasonable for performance-oriented cases because the turbine with larger nominal power is equivalent to the combination of several smaller turbines.

The capacity factor reflects how effectively the turbine could harness the energy available in the wind spectra. Hence, CF is a function of the turbine as well as the wind regime characteristics. Usually the pairing performance index is expressed on an annual basis and for a reasonably efficient turbine at a potential site may range from 0.25 to 0.4. A PP index of 0.4 or higher indicates that the system is interacting with the regime very efficiently.

5.3 Average energy output

Since Weibull probability density function is more accurately representing the wind speed variation, it will be used in calculate of the average electrical out put energy. The operation of the wind turbine is limited by the cut-in speed Vc and the cut-off speed Voff. Therefore, E can be given as [3, 4, 6]:

$$E_{avg} = T\int_{V_c}^{Voff} P(V)\, f(V)\, dV = TP_{avg} \qquad (22)$$

$$E_{avg} = T \Pr PP$$

The energy flux per unit area Es:

$$Es = \frac{T \Pr PP}{A} = 0.5\rho T \eta r Vr^{3} PP \qquad (23)$$

Where ηr is the rated output of the wind turbine given at the following equation:

$$\eta r = \frac{2\Pr}{\rho Vr^{3}} \qquad (24)$$

6. Sites chosen

The sites whose main wind data have been used in this work are presented in Table 1. Table 1 group the yearly mean parameters of Weibull probability distribution function and the yearly mean wind speed. The data were collected by Algerian Meteorological Department at a standard height of 10 m. All quantities in Table 1, however, were evaluated as yearly mean value over an entire period of 10 last years. The sites are aggregated in the four geographic regions, (A) coast region, (B) Atlas Tellian, (C) high plateau region and (D) Sahara region.

Table1: Main wind data of the sites at an elevation 10 m

Topographical Situation	**Sites**	**Symbol**	**R m**	**K**	**C m/s**	**Vm m/s**
coast	**Oran**	A01	0.01	1.26	4.10	3.81
	Ténès	A02	0.01	2.47	6.09	5.40
Atlas Tellian	**Tlemcen**	B01	0.01	2.02	4.29	3.80
high plateau	**In Oussera**	C01	0.08	2.03	5.00	4.43
	El Bayadh	C02	0.01	1.62	5.28	4.72
	Elkheiter	D08	0.01	1.85	5.25	4.66
	Tiaret	C03	0.02	1.58	6.90	6.19
Sahara	**Adrar**	D01	0.01	2.15	7.20	6.37
	In Salah	D02	0.02	1.78	6.01	5.42
	In Amenas	D03	0.02	2.01	6.16	5.46
	Ghardaïa	D04	0.03	1.65	5.60	5.00
	Tindouf	D05	0.00	1.98	6.20	5.49
	Timimoun	D06	0.01	1.89	6.5	5.76
	Elouad	D07	0.01	1.64	4.92	4.40

In the table 1, R is the Roughness factor of the land.

The Vertical extrapolation of Weibull parameters at an elevation more than 10 m is obtained by using the following formulas [9, 10, 11]:

$$C = C_1\left(\frac{Z_2}{Z_1}\right)^{m} \qquad (25)$$

$$m = \left(\ln\left(\frac{Z_g}{Zo}\right)\right)^{-1} + \frac{0.0881\ln(C_1)}{1-0.00881\ln(0.1Z_1)} \qquad (26)$$

$$k = k_1\left[\left(1-0.0881\ln\left(\frac{H}{Z_1}\right)\right)^{-1}\right] \qquad (27)$$

The obtained results are gathered in the Table 2.

Sites	H m	K	C m/s	Vm m/s	V3m m/s	P W
A01	24	1.36	4.62	4.22	6.19	145.91
A02	24	2.67	6.86	6.10	6.99	209.13
B01	24	2.18	4.83	4.30	5.65	110.82
C01	24	2.20	5.90	5.23	5.74	116.04
C02	24	1.75	5.95	5.30	6.89	200.56
C03	24	1.71	7.87	7.2	9.22	481.18
	70	1.90	9.05	8.02	10.12	635.25
D01	24	2.33	8.11	7.18	8.51	378.59
	70	2.59	9.21	8.18	9.44	470.97
D02	24	2.17	7.02	6.22	7.51	260.10
	50	2.34	7.74	6.86	8.12	328.55
D03	24	2.02	6.97	6.17	7.62	271.91
D04	24	1.78	6.44	5.73	7.40	248.61
D05	24	2.14	6.20	5.49	6.66	181.12

7. Models of Wind energy system conversion (WECS) 7.

Table 3: Main data of the twelve Wind Energy Conversion system models

Models	Wind turbines	Blade Nbrs	D (m)	Pr (kw)	Vc m/s	Vr m/s	Voff m/s
Model I	**LMW1003**	3	3	1	4.00	11.7	25
Model II	**Travers TI/6/2.1**	3	6	2.1	2. 5	8	30
Model III	**Repower**	3	13	11	3.00	9.5	25
Model IV	**EW50**	3	15	50	4.00	11.3	25
Model V	**BWCXL.50**	3	14	50	2.50	11.0	25
Model VI	**PGE50**	3	20	50	3.00	11.0	25
Model VII	**Notanck150**	3	24.5	150	4.00	12.0	25
Model VIII	**Norwin150**	3	24.6	150	4.00	12.3	25
Model IX	**ADES WIND TURBINE 200**	1	30	200	4.00	11.7	25
Model X	**Bonus1300**	3	62	1300	3.00	16.0	25
Model XI	**Nordex70**	3	70	1500	4.00	13.0	25
Model XII	**BHD FL-1000 IEC IIA GL IIA**	3	55	1000	3.50	13.5	25

Twelve models of wind energy generators are considered (see Table 3). The models chosen represent different ranges of characteristic speeds and rated power. In addition, they have different fields of application. The models (I) (II) (III), (IV) (VI) and (VII) are small size wind turbines, suitable for low energy needs (water pumping and/or electric supply) in remote areas, although their design, performance and environmental needs are quite different. The medium size Models (VII), (VIII) (VIX), however, is suitable for small electric networks or for grid connection and big size models (X), (XI) (XII).

8. Discussion of results

Fig. 3 shows the capacity factor curve, which depends only on kinematics parameters, concentrated mainly on the effect of Vc and Vr.

This figure displays the variation of the capacity factor versus cut-in speed to a constant rated speed and its variation according to the rated speed to a constant cut-in speed. These two curves indicate that the capacity factor obey to a decreasing law in both supposed cases. The maximum of the capacity factor versus cut-in speed to a constant rated speed is gotten for the lowest value of Vc and in the inverse case its optimum is obtained for the lowest value of the rated speed.

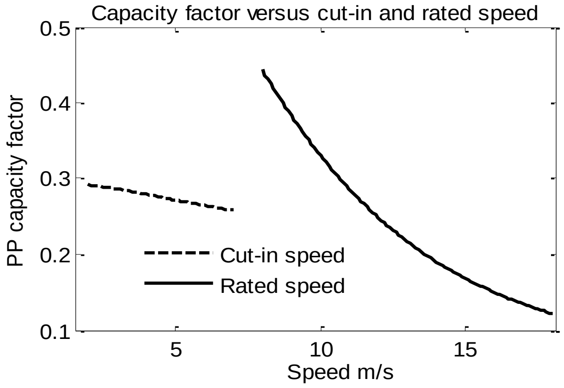
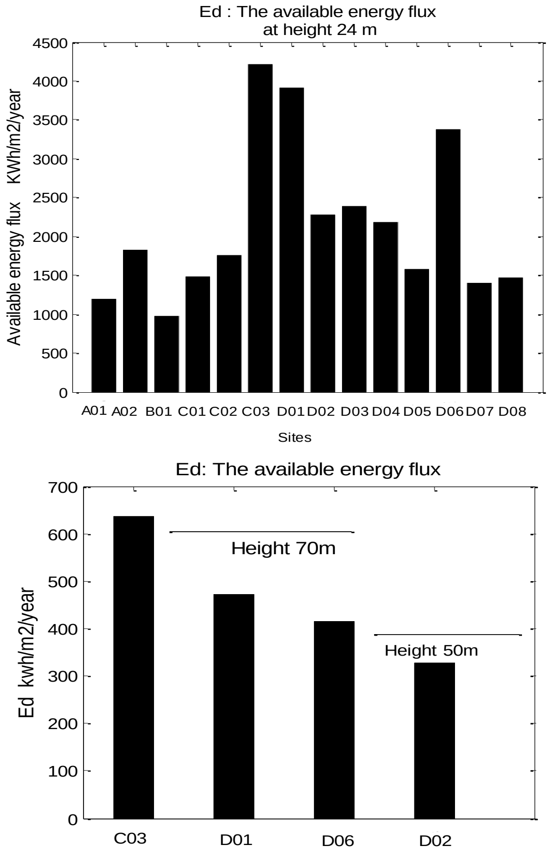


Fig.3: Capacity factor cut-in speed and rated speed versus

The Fig.5 shows the expected potential wind generation in the four regions, which is indicated by the average annual flux of the available energy in all the sites.



Figs.4: The available energy flux

Table 2 collects the main wind data for representative and promising sites of the four regions of Algeria. In this table, the yearly mean velocity at a various heights and the density of average power available of the wind of each site computed directly by the wind data presented in Table1. It can be seen that the yearly mean wind speeds at 24m elevation in some locations could reach as high as 6.10 and 5.30, 7.2 m/s in regions A02 and C, and 7.18, 6.22, 6.86, 6.17, 5.73 5.49 6.48 and 5.24 m/s in regions (D) respectively. However, the sites with high energy level, with available energy flux Ed proximate or higher than 2000 KW/m^2/year Fig.4, are limited to the locations; C03, D01, D02, D03, D04, and D06, in the majority are located in the Sahara.

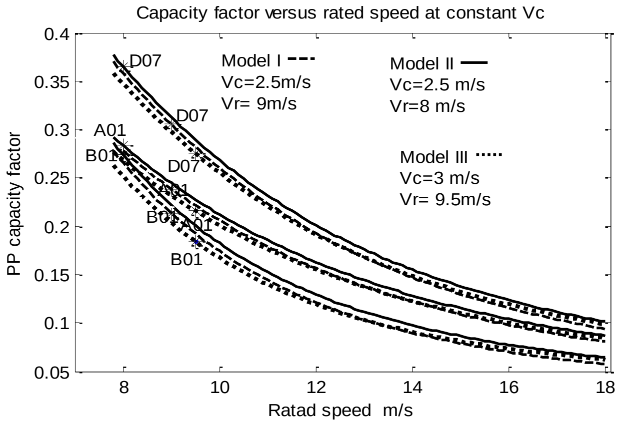


Fig. 5: capacity factor versus rated speed at constant cut-in speed

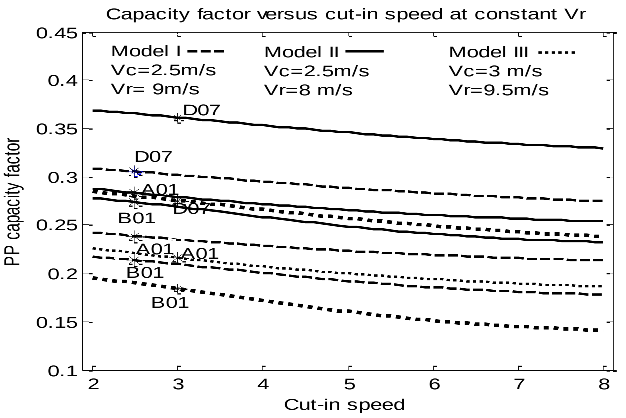


Fig. 5: capacity factor versus cut-in speed at constant rated speed

The sites A01, B01 and D07 are poor in wind energy; these sites have a low mean velocity lower than 5 m/s, their capacity factor given by the models (I) (II) and (III) of wind turbines are presented at the Fig.5. Such sites can deliver something only if the wind machine matches an optimal pairing performance, i.e. Vc is low, which takes place when Vr is low to have a good value of capacity factor higher than 25%. Although Vr and Vc of a wind turbine conversion system (WECS) are interdependent, ie, is mainly optimized by Vc. The machine being appropriate among the three models for these sites and which answers the criterion of optimization is the model (II) of wind turbine. The results of the matching of this wind turbine model with the wind distribution for the expected wind potential on the three sites are 0.2833, 0.2737 and 0.3681 of capacity factor respectively for the sites A01, B01, and D07. It has to be mentioned that the wind turbine generators has been assessed based on the highest capacity factor, ie, depends on the output wind energy.

The capacity factor of the representative promising sites against cut-in speed and rated speed aggregated by model of WECS is presented in Fig. 6 and Fig. 7. The operative data of each model are indicated in the captions. It is obvious that choosing the bad model for a site can be very penalizing. For example can be seen, at sites C01 and D02 model (IV) achieves a pairing performance 0.2273 and 0.3318, respectively and the wind energy flux per unit area and the wind energy output delivered by this model are respectively 479.89 KWh/m2/year, 84.80MWh and 736.37 KWh/m2/year, 122.99 MWh by comparing the values of both sites the model (IV) match well with the site D02 but not with the site C01.

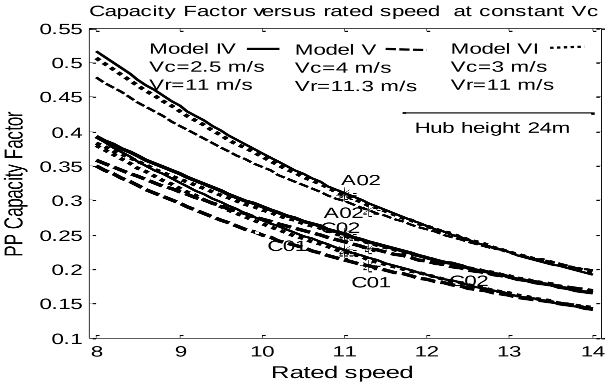


Fig.6a Capacity factor versus rated speed at constant cut-in speed

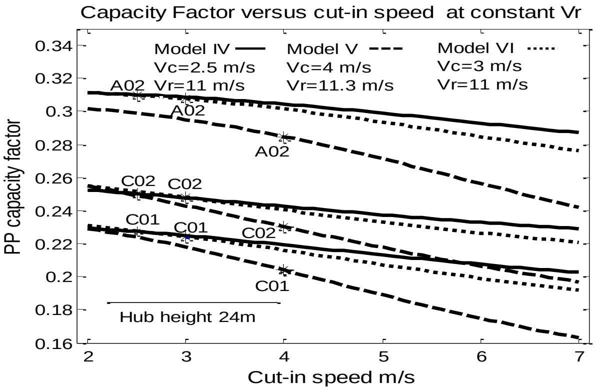


Fig.6b Capacity factor versus cut-in speed at constant rated speed

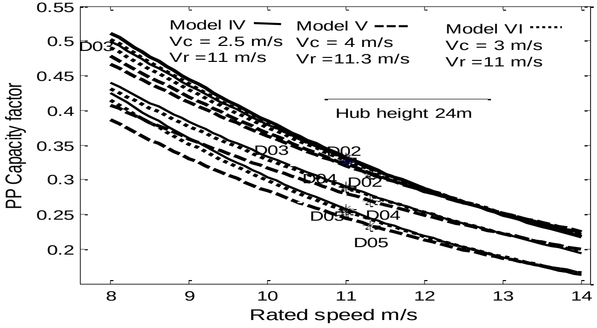


Fig.6c Capacity factor versus rated speed at constant cut-in speed

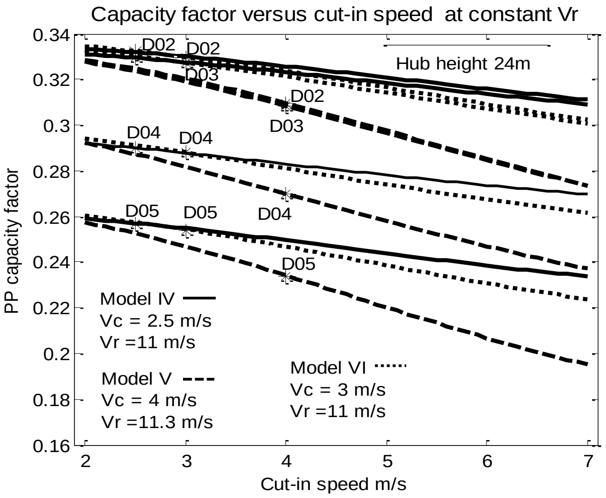


Fig.6d

Capacity factor versus cut-in speed at constant rated speed

Figs. 6: Capacity factor versus for the three models of WECS.

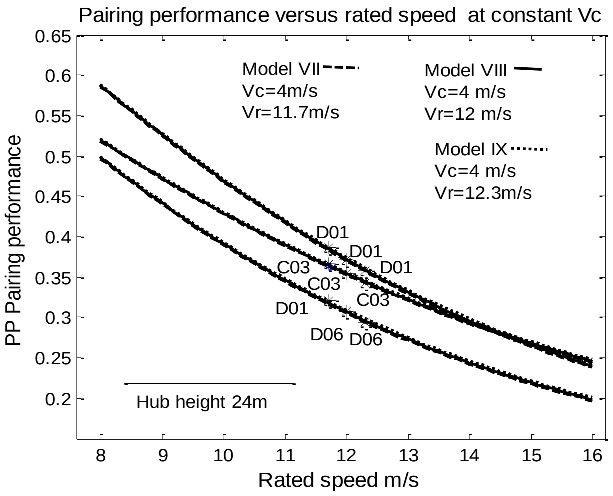


Fig. 7a

Capacity factor versus rated speed at constant cut-in speed

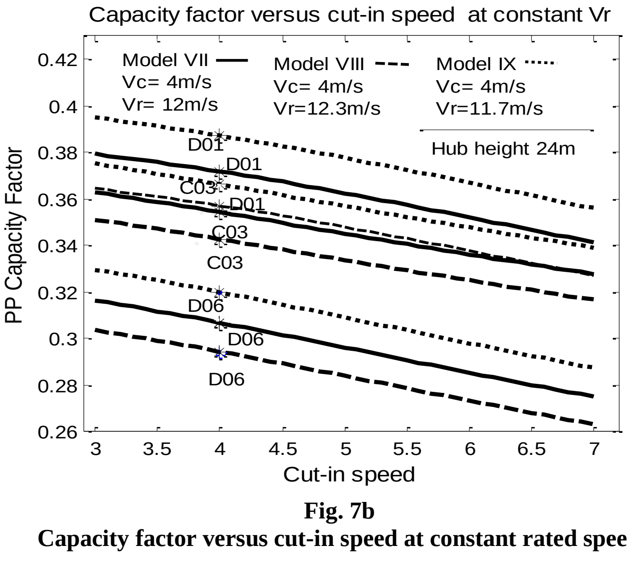


Fig. 7b

Capacity factor versus cut-in speed at constant rated speed

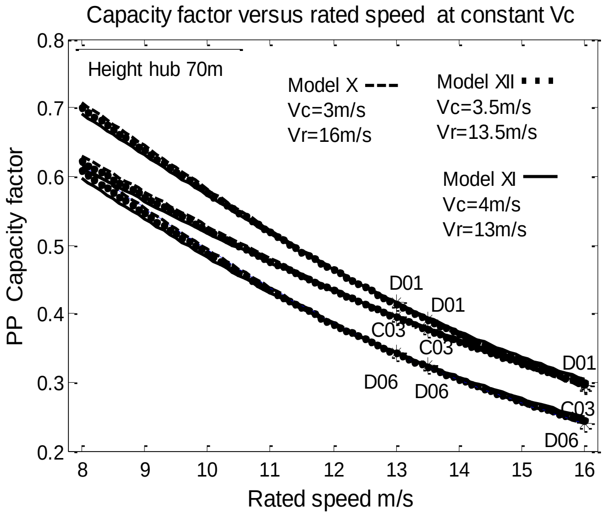
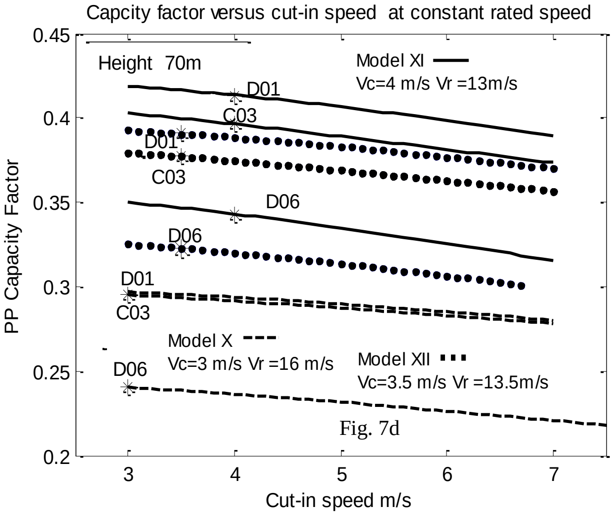


Fig. c

Capacity factor versus rated speed at constant cut-in speed



Capacity factor versus cut-in speed at constant rated speed

Figs. 7: Capacity factor of promising sites versus cut-in speed and rate speed for the six models of WECS.

The Figs. 6 and Figs. 7 show the capacity factor versus cut in speed to a constant rated speed and the versus rated speed to a constant cut in speed, to make easy the choice of wind turbine and the corresponding cut in and rated speed, which supply the best value of pairing performance PP.

The sites A02, C02, D02, D03, D04 and D05 are the sites with a medium wind speed more than 5m/s and exceed slightly 6m/s and moderate range of distribution following the Weibull parameters K and C. the PP index for each turbine – site pair marked on the figures of the each models of wind turbines. The pp index indicates that the three models of wind turbines (IV), (V) and (VI) interact effectively with the wind regime of the site A02, D02, D03 and D04 (Figs. 6a, 6b), but the sites C02 and D05 interact with the two models (IV) and (VI). Theirs meaningful energy per unit area and the output energy of the three models are shown at the (Figs. 8a and Figs. 9a).

The sites C03, D01 and D06 are of those with higher wind speed and widest range of distribution. It is easy to perceive from Table 2, and Figs. 7. That sites stands for the better candidates for wind energy utilization. These sites match with all the chosen wind turbines, except the model (X) of wind turbine deliver a low value of PP index at the site D06 because its rated speed is very large.

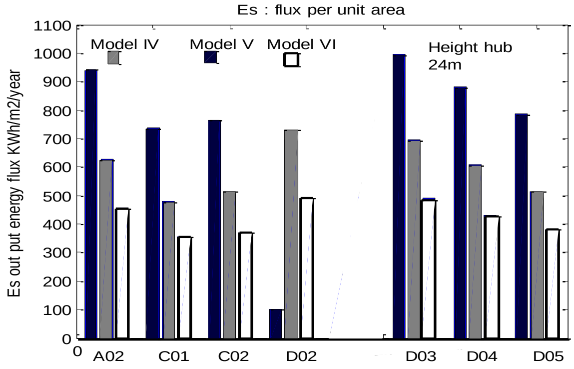


Fig. 8a

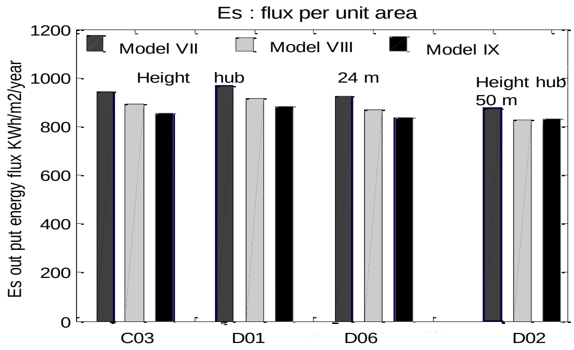


Fig. 8b

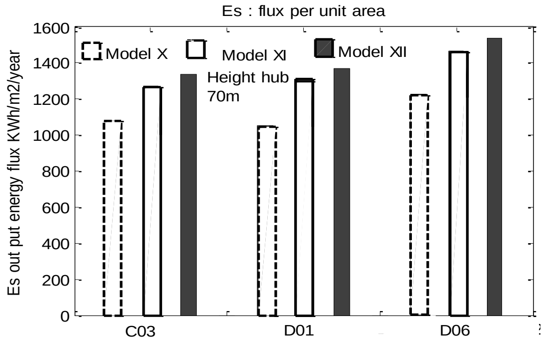


Fig. 8c

Fig. 8: Energy flux per unit area of the promising sites for the nine models of WECS

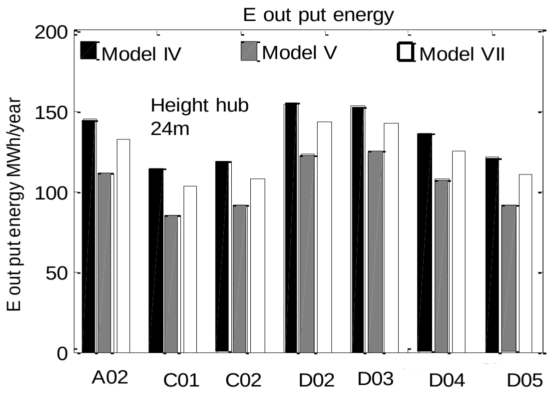


Fig. 9a

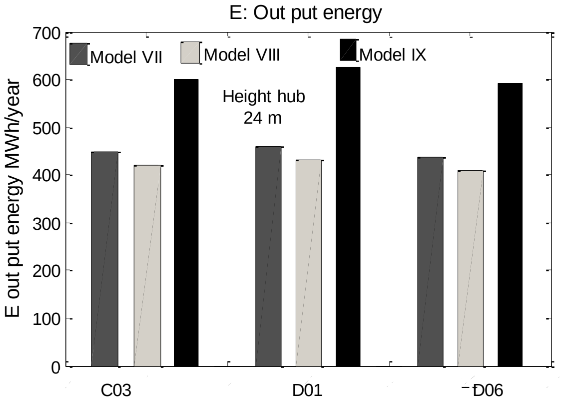


Fig.9b

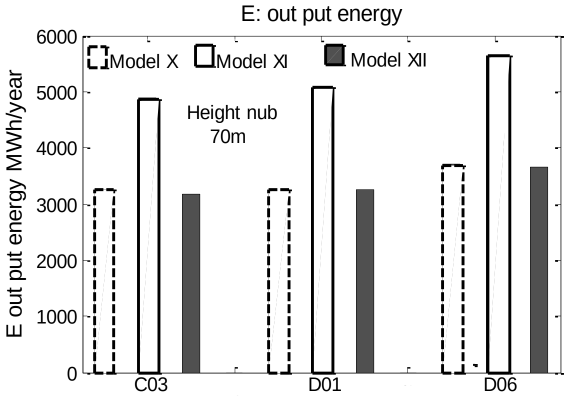


Fig. 9c

Fig. 9: Out put energy of the promising sites for the nine models of WECS.

The best results of the nine wind turbines models paired with the promising sites are grouped in the Table 4, which are shown on the figures (Figs.6 and Fig.7). These figures present the capacity factor of promising sites versus cut-in speed to a rated speed for the nine models of WECS.

Tables 4: The results

Sites		**A02**	**C02**	**D02**	**D03**	**D04**	**D05**
Model (IV)	**PP**	0.3101	0.2532	0.3318	0.3294	0.2900	0.2567
Model (V)	**PP**	0.2847	#	0.3097	0.3082	0.2699	#
Model (VI)	**PP**	0.3075	#	0.3298	0.3275	0.2879	0.2541

Sites		**C03**	**D01**	**D06**	**D02 (50 m)**
Model (VII)	**PP**	0.3543	0.3719	0.3069	0.3391
Model (VIII)	**PP**	0.3428	0.3572	0.2945	0.3249
Model (IX)	**PP**	0.3663	0.3873	0.3201	0.3541

Sites		**C03**	**D01**	**D06**
Model (X)	**PP**	0.2952	0.2928	#
Model (XI)	**PP**	0.3964	0.4165	0.3431
Model (XII)	**PP**	0.3772	0.3918	0.3229

These tables and the figures (Fig.7, Fig.8 and Fig.9) display that the models (IV), (V) and (VI) perform suitably with the sites except the site D05 is not paired with the model (V). But the medium wind turbines models (VII), (VIII) and (IX) are matched with all the sites C03, D01, D06 and D02 at 50 m elevation. The big size wind turbines models (X), (XI) and (XII) pair properly with the sites C03, D01 and D06 at elevation of 70m.

The best value of capacity factor and the corresponding cut-in speed and rated speed for the high wind generation potentiality sites in the three regions are outlined in Table 5 and Table 6. These sites can achieve high capacity factor from 0.28 to as much as 0.38 could be obtained by the small size wind turbines. The operational cut-in wind speeds vary from 2.5 to 3 m/s, which are pertinent to small and sized wind machines. For the medium wind turbine can get a capacity factor can reach 0.28 to 0.45, the corresponding cut-in speed vary 3 to 4 m/s and rated speed vary from 10.5 to 12.5 m/s.
It is seen that most of Algerian's landscape, can be used for wind energy generation by small and medium sized wind machines which can be used for water pumping and small electric networks or for grid connection. Moreover, a few sites in the north and in the south can be supplied with wind machines of typical rated power values of up to 150 kW to MW provided the right selection of wind machine and site is made.

8. Conclusion

The values of capacity factor range between the minimum and the maximum value according to the cut in speed and rated speed of the machine, which could be selected (Table 5 and 6).

Tables: Capacity factor corresponding to cut-in speed and rated speed for a high wind generation potentiality of the chosen sites.

Table 5: Small size

Sites		**A02**	**C02**	**D02**
Small size model of 50kw	Vc m/s	2.5-3	2.5	2.5-3
	Vr m/s	10-11	10-10.5	10-12
	PP	0.2886 0.3225	0.2600 0.2800	0.2801 0.3947

Table 6: Medium and big size

Sites		C03	D06	D01
Medium size model of 150-200kw	Vc m/s	3	3-4	3-4
	Vr m/s	10.5-11.5	10.5-12.5	10.5-12.5
	PP	0.2805 0.3313	0.3037 0.4259	0.3156 0.4528
	Vc m/s	3	3- 4	3-4
Big size model of 500-1300kw	Vr m/s	11-12	11-12.5	11-13
	PP	0.4145 0.4840	0.4529 0.5512	0.3846 0.5233

This study is based on the yearly data of wind at 10m elevation, from these data; the wind potential for the four regions in Algeria has been broadly assessed. The estimate of this potential to the different locations is determined by the evaluation of the available average power and the available average energy flow on the sites. On the other hand the index used for pairing of a wind turbine and site is the yearly capacity factor and energy out put achieved in all the sites, this study has led to the following conclusions:

The coast regions are presented by the site A02; the sites C01, C02 and D02, D03, D04, D05, D06, D08 represent respectively the high plateau regions and Sahara regions. These sites possess a medium wind deposit described by the moderate parameters of Weibull probability density function and yearly mean velocity (see Table1 and 2). These can shelter wind turbines of typical rated power values of up to 30 to 50kw or more at 24m elevation, if its specific speeds, cut-in speed and rated speed takes one value of the values given in the Table 5, supply the best pairing factor PP.

For the locations of Tiaret (C03) and Adrar (D01) and Timimoun (D06), these sites possess a strong wind potential, which is shown by the best parameters of Weibull probability density function and their yearly mean speed are between 6.96 and 7.2m/s at 24 m elevation, whereas at 70 m elevation the yearly mean speed reach between 7.61 and 8.18 m/s (see Table1 and 2). The wind turbines could be installed on these sites can have typical rated power values of up to 150 to 200kw (Table 4 and Figs. 7) at an elevation of 24m (Fig. 8 and Fig. 9), which deliver a best index matching site and wind turbine if the speeds characteristic belong to the interval given at Table 6. At high elevation these sites will become much more productive, can see the Table 4. Table 6 lists the values of the technical specification of the wind turbine speeds can be chosen for the installation on these sites, in order to perform and achieve the desired goal of provided energy.

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