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Research Note

Determination of Wind Potential in some Regions of Algeria

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P A P E R I N F O

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A B S T R A C T

This paper aims to determine the wind potential in two regions of Algeria according to months, seasons, and entire years. An attempt is made to participate to the update of the wind map in this country, by using the collected hourly data during a period of more than thirty years. The Weibull function is employed to perform the wind data analysis. Two regions are considered: Ilizi and Oran, which are located in the southeast and northwest of Algeria, respectively. The values of the Weibull parameters, average power density, and mean velocity are employed to achieve the statistical analysis. At the height of 10 m from the ground, the obtained results revealed that the highest annual average rate of 6.5 m/s occurred at the city of 'Illizi'. It was also found that the city of 'Es-senia' has a middle potential of wind with an annual mean velocity of 3.5m/s. Furthermore, it was observed that the spring season is the most windy season for both regions.

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INTRODUCTION

Wind energy potential, in Algeria possess the 5th rank among African countries [1]. In the past decades, the wind energy has become very competitive with the technologies of conventional power generation. This renewable energy has proven to be reliable and cost-effective. Algeria is known by its great potential in the wind energy. The interest of the wind farm in Adrar located in the Southwest Network of Algeria which was discussed by Hocine et al. [1]. Many researchers investigated the potential of wind power generation via theoretical and experimental approaches [2]. Abid et al. [2] focused on wind power technology for domestic use. The drtail on performance of technologies involved in wind power is discussed in literature [1–3]. The establishment of Atlas wind maps provided a useful knowledge in this context, citing for example the work of Chellali et al. [4], who studied the characteristics of the region of Hassi R'mel. The determination of wind resources at different regions in this country provided additional and valuable information [5–8].

The objective of this work is to contribute to the update of the wind map in Algeria. For this purpose, and analysis of the wind resource in two regions in Algeria is performed. The study is achieved by using meteorological data according to the wind velocity. An estimation of the average velocity and power density is provided. The measurements are taken for different months, seasons, and years.

The wind speeds at the height of 10 m above the ground were measured every hour by using "NCDC Climate Data Online" [9].

SITES SELECTION AND WEATHER DATA

Sites presentation

The first region under investigation "Illizi" is located in the southeast of Algeria, north of Tassili n'Ajjer, about a hundred kilometers from Libya. The second region studied "Oran" is a harbor city of the Mediterranean Sea, situated in the northwest of Algeria, at 432 km from the capital Algiers [8]. The geographic locations of both regions are shown in Figure 1.

Details on the position of each region under investigation are provided in Table 1. The measurement period is also given for both cases.

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(a) (b)

Figure 1. Geographic location of the cases studied in the Algerian map, (a) region of Ilizi, (b) region of Oran Analysis of wind velocities [8]

TABLE 1. Geographical coordinates of the regions studied

Region	Region code (AWS)	Longitude (°)	Latitude (°)	Altitude (m)	Measurement Period
Illizi	606400	+008.623	+26.724	+0541.9	01/01/1987-31/12/2017
Es senia	609400	-000.621	+35.624	+0089.9	01/01/1949 - 01/10/2019

MODELS OF WIND ANALYSIS

Weibull statistics

The distribution of the wind velocity is needed for the estimation of the potential of wind energy at any region. The distribution of Weibull is the most used approach [10]. It is given as follows:

$$f(v) = \left(\frac{K}{A}\right)\left(\frac{v}{A}\right)^{K-1} e^{-\left(\frac{v}{A}\right)^{K}} \quad (1)$$

where $f(v)$ is the probability to observe the wind speed, V is the wind speed (m/s), K is the parameter of the shape of Weibull (dimensionless), A is the parameter of scale of Weibull (m/s).

Various methods are available to estimate the distribution of Weibull parameters [11]. The maximum likelihood method is employed in this paper for its efficiency [12].

The parameters of Weibull K and A are given as:

$$K = \left[\frac{\sum_{i=1}^{n} v_i^K \ln v_i}{\sum_{i=1}^{n} v_i^K} - \frac{1}{N}\sum_{i=1}^{n} \ln v_i\right] \quad (2)$$

$$A = \left(\frac{1}{N}\sum_{i=1}^{n} v_i^K\right)^{\frac{1}{K}} \quad (3)$$

where N is the number of non-zero wind velocity and v_i is the non-zero wind velocity at a time i. The use of the values of Weibull parameters allows us to calculate the average wind velocity V_m [13]:

$$V_m = A \cdot \Gamma\left(1 + \frac{1}{K}\right) \quad (4)$$

where Γ is the gamma function.

Density of the wind power

The wind power may be determined by the following expression [14]:

$$P(v) = \frac{1}{2} \cdot S \cdot \rho \cdot V_m^3 \quad (5)$$

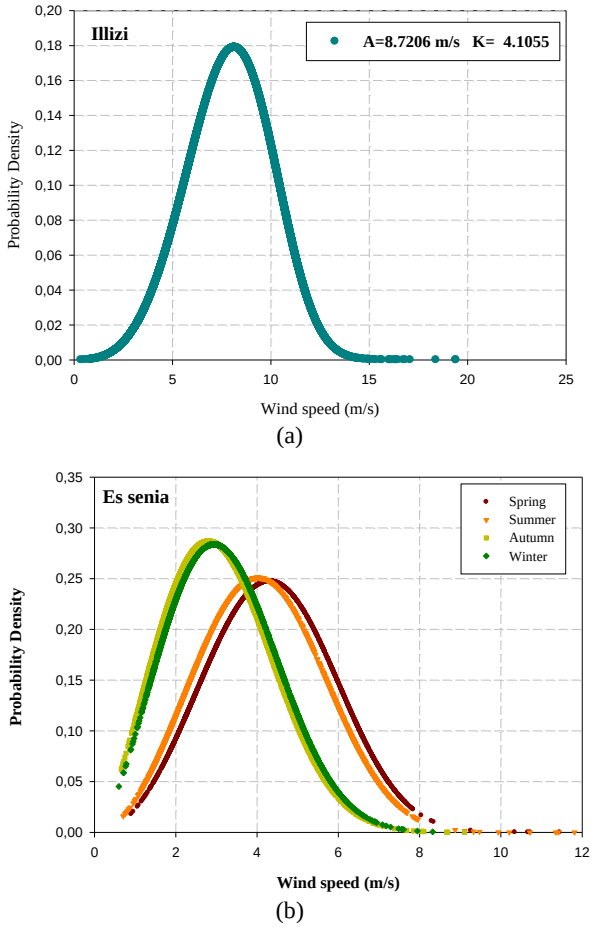
where ρ is the air density (kg/m^3).

The density of wind power for a site may be calculated as follows:

$$\frac{P}{S} = \frac{1}{2} \cdot \rho \cdot A^3 \cdot \Gamma\left(1 + \frac{3}{K}\right) \quad (6)$$

RESULTS AND DISCUSSIONS

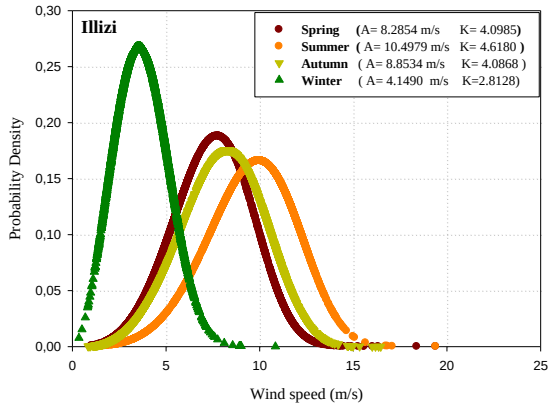
The seasonal distribution of Weibull parameters is given in Figure 3. As observed, all of the curves have a similar trend of wind velocities for the Weibull distribution. For the region of Ilizi, the wind velocity is higher than 20 m/s for all of the seasons, except for the winter season, where the speed range extends up to 10 m/s (Figure 3a). However, for the region of Oran, the wind velocity is higher than 12 m/s for the four seasons (Figure 3b).



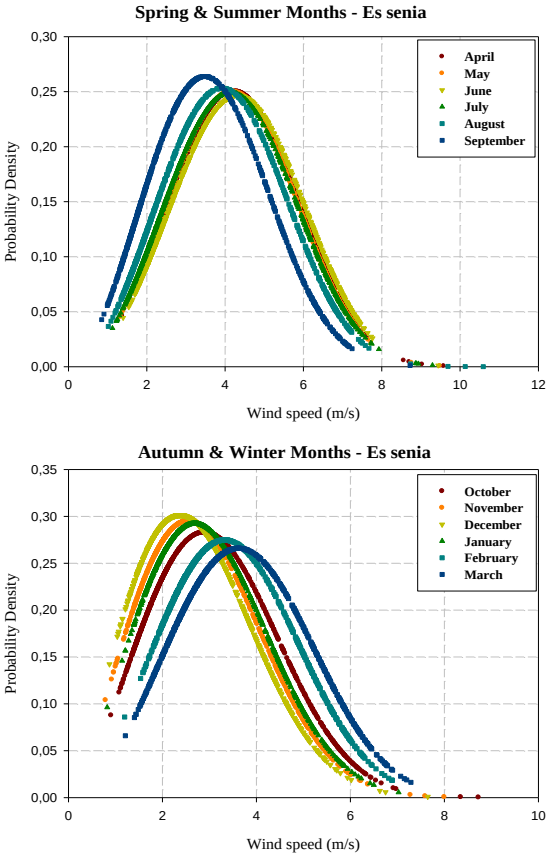
(a)

(b)

Figure 2. Annual distribution of Weibull parameters at 10 m of height, (a) Ilizi, (b) Oran



(a)



(b)

Figure 3. Seasonal Weibull wind distribution at 10 m of height, (a) Ilizi, (b) Oran

Region of Ilizi

For the region of Ilizi, Figure 4 presents the monthly and seasonal variation of both Weibull parameters during the period under investigation. The results show the most significant shape parameter equal to 4.7357 in June and 4.6180 in the summer season. However, the worst values of 2.6438 and 2.8128 are in January and the winter season, respectively, while the best scale parameter is reached in the summer months with the greatest value equal to 10.8272 m/s in June.

According to the data provided in Table 2, it is observed that the monthly mean wind speed at 10 m varies between 3.3759 m/s in December and 9.9641 m/s in June. Furthermore, the mean power density varies between 23.5655 W/m^2 in December and 605.9212 W/m^2 in June.

Region of Oran

The monthly and seasonal distributions of both Weibull parameters for the region of Oran are provided in Figure 5. The highest values of the shape parameter, which are equal to 3.0976 and 3.1008, are reached in June and the spring season, respectively. However, the worst values of 2.2465 and 2.4566 are observed in December and the autumn season, respectively, while the best scale parameter is obtained during the summer months (in June) with the highest value of 4.9014 m/s.

It is clearly observed that the monthly mean wind speed changes between 2.8132 m/s in December and 4.1356 m/s in June. Besides, the mean power density varies between 13.6364 W/m^2 in December and 43.3242 W/m^2 in June (Table 2).

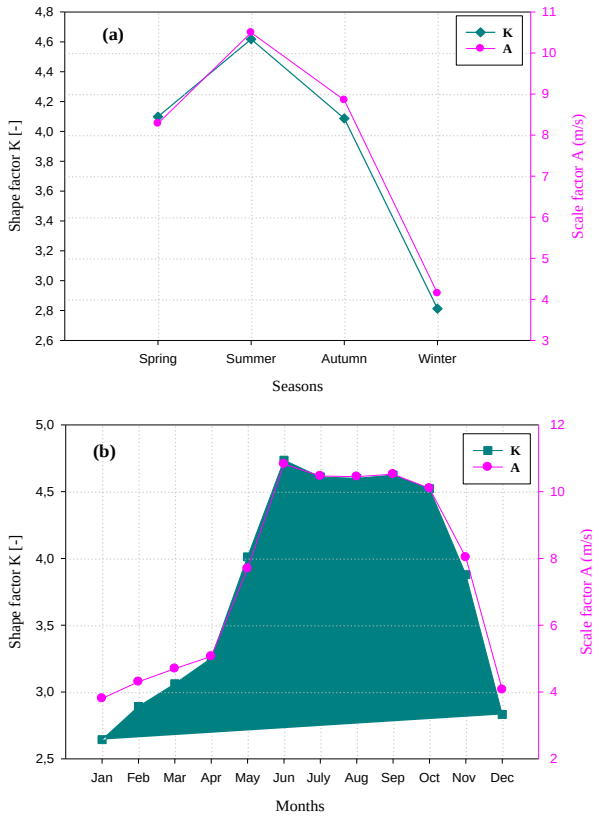


Figure 4. Weibull distribution parameters at a height of 10 m for the region of Ilizi, (a) Seasonal, (b) Monthly

TABLE 2. Monthly variations of the mean wind speed and power density at 10 m

	Ilizi		Oran	
Months	**V (m/s)**	**P (W/m²)**	**V (m/s)**	**P (W/m²)**
January	3.4193	24.4868	3.0331	17.0908
February	3.8984	36.2880	3.5130	26.5556
March	4.2444	46.8335	3.7068	31.1954
April	4.4385	53.5575	4.1166	42.7276
May	5.8818	124.6322	4.0208	39.8159
June	9.9641	605.9212	4.1356	43.3242
July	9.3411	499.2246	3.8791	35.7525
August	9.3239	496.4834	3.6421	29.5921
September	9.4649	519.3495	3.3446	22.9162
October	8.8551	425.2943	3.0323	17.0777
November	5.7445	116.1111	2.8940	14.8455
December	3.3759	23.5655	2.8132	13.6364

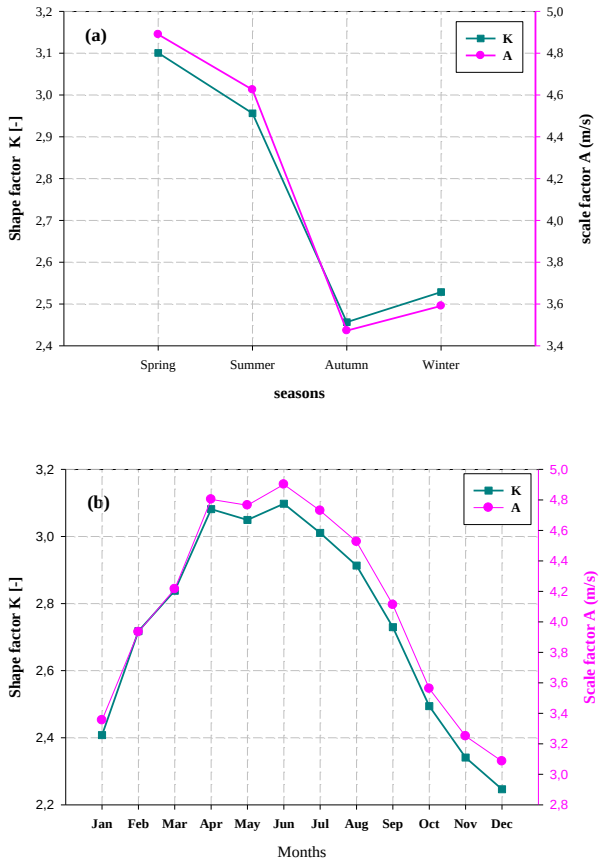


Figure 5. Weibull distribution parameters at a height of 10 m for the region of Oran, (a) Seasonal, (b) Monthly

CONCLUSION

For the country of Algeria, the monthly and seasonal Weibull parameters, density of the wind power, and mean velocity of the wind were determined to provide information about wind resources. A region from the southwest (Ilizi) and another region from the northeast (Oran) of Algeria were selected to achieve the study. Measurements of the wind characteristics were taken for a height of 10 m from the ground.

A strong relationship between the shape factor (*K*) and mean temperature of the air was observed, where the most prominent values were determined in the hot months for both regions. The minimal monthly cost of *K* was estimated to be 2.6438 in January, while the maximum value was equal to 4.7357 in June for the area of Ilizi. However, and for the area of Oran, the minimal and maximal monthly values of *K* were equal to 2.2465 and 3.0976 in December and June, respectively.

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Persian Abstract

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چکیده

این مقاله با هدف تعیین پتانسیل باد در دو منطقه الجزایر با توجه به ماه‌ها، فصول و کل سال انجام می‌شود. سعی شده است با استفاده از اطلاعات ساعتی جمع‌آوری شده در طی بیش از سی سال، در به روزرسانی نقشه باد در این کشور مشارکت شود. از تابع Weibull برای انجام تجزیه و تحلیل داده‌های باد استفاده شده است. دو منطقه در نظر گرفته شده است: ایلیزی و اوران که به ترتیب در جنوب شرقی و شمال غربی الجزایر واقع شده‌اند. مقادیر پارامترهای Weibull، میانگین چگالی توان و سرعت متوسط برای دستیابی به تجزیه و تحلیل آماری استفاده شده است. در ارتفاع ۱۰ متری زمین، نتایج به دست آمده نشان داد که بالاترین میزان متوسط سالانه ۶/۵ متر بر ثانیه در شهر "ایلیزی" رخ داده است. همچنین مشخص شد که شهر "Es-senia" دارای پتانسیل متوسط باد با سرعت متوسط سالانه ۳/۵ متر بر ثانیه است. علاوه بر این، مشاهده شد که فصل بهار برای هر دو منطقه بادگیرترین فصل است.