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Predication of wind energy potential generation in Geryan – Libya

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Abstract:

A wind energy assessment is an integrated analysis of the potential wind energy resources of a particular area. Such an assessment begins with an understanding of the general wind patterns of the area, and progresses to the collection and analysis of wind data. Wind energy is an indirect form of solar energy. Between 1-2% of the solar radiation that reaches the Earth is converted into energy in the wind. This study focused on the wind energy and wind assessment in four different location area in Geryan City. This study provides background information about wind power and its resource, including a review of available data, which were obtained from the representative meteorological stations. For each location, long term time series of 3 hourly measured wind data were used; the wind data had been recalculated to represent the actual wind speed at hub height. The mean wind speed, the Weibull distribution, annual energy and annual capacity factor were calculated for each site. The annual energy and annual capacity factor calculation are based on specification of wind turbine as efficiency (V60- 850kw), This study indicates that wind energy is available in some sites in Libya, and Geryan zones locations Four has an acceptable power, annual energy and high capacity factor.

Key-words: Wind Energy, predication, Potential, Natural Resources, Geryan - Libya.

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

توقعات إمكانيات توليد طاقة الرياح في مدينة غريان – ليبيا.

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الملخص:

تقييم طاقة الرياح هو تحليل متكامل لموارد طاقة الرياح المحتملة في منطقة معينة. يبدأ مثل هذا التقييم بفهم أنماط الرياح العامة في المنطقة، ويتقدم إلى جمع وتحليل بيانات الرياح. طاقة الرياح هي شكل غير مباشر للطاقة الشمسية. يتم تحويل ما بين 1-2٪ من الإشعاع الشمسي الذي يصل إلى الأرض إلى طاقة في الرياح. ركزت هذه الدراسة على تقييم طاقة الرياح والرياح في أربعة مواقع مختلفة في مدينة غريان – ليبيا. قدمت هذه الدراسة معلومات أساسية حول طاقة الرياح ومواردها، بما في ذلك مراجعة البيانات المتاحة، والتي تم الحصول عليها من محطات الأرصاد الجوية التمثيلية. لكل موقع، تم استخدام سلاسل زمنية طويلة المدى من بيانات الرياح المقاسة كل (3) ساعات؛ تم إعادة حساب بيانات الرياح لتمثيل سرعة الرياح الفعلية عند ارتفاع المحور. يتم حساب متوسط سرعة الرياح وتوزيع وايبول والطاقة السنوية وعامل السعة السنوية لكل موقع. يعتمد حساب الطاقة السنوية وعامل السعة السنوية على مواصفات توربينات الرياح بفاعلية (V60- 850 كيلو وات)، وتشير هذه الدراسة إلى أن طاقة الرياح متوفرة في بعض المواقع في ليبيا، وأن منطقة مدينة غريان الرابع لديه طاقة مقبولة، وطاقة سنوية وعامل القدرة عالية.

الكلمات الدالة: طاقة الرياح, التنبؤات, الامكانيات، الموارد الطبيعية, غريان–ليبيا.

1. Introduction

Global population is increasing daily. The population growth in developing countries is more rapid than in industrialized nations. As

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

a result of this population growth and developmental activities, the energy demand is also increasing. Growing energy demand and environmental consciousness have re-evoked human interest in wind energy. The wind is the fastest growing energy source in the world today [1].

Energy is one of the crucial inputs for socio-economic development. The rate at which energy is consumed by a nation often reflects the level of prosperity that it has achieved. The global energy demand is met from a variety of sources. Fossil fuels consisting of coal, oil, and natural gas, but unfortunately, these fossil fuels are finite resources and will be completely exhausted one day or the other, hence, while our energy demand is increasing day by day, the available resources are depleting. This will definitely lead us to the much discussed energy crisis. However, the crisis may not be an imminent reality as the time scale may prolong due to discoveries of new resources. Here comes the significance of sustainable energy sources like wind. The wind is an environment friendly and economically viable source of energy which can be tapped in a commercial scale [1,2].

The most critical factor influencing the power developed by a wind energy conversion system is the wind velocity. Due to the cubic relationship between velocity and power, even a small change in wind speed can result in a significant change in power. The speed and direction of wind at a location vary randomly with time. A part from the daily and seasonal variations, the wind pattern may change from year to year, even to the extent of 15 to 35 per cent. Hence, the behavior of the wind at a prospective site should be properly analyzed and understood [1-3].

This article is considered as an extension to the study of the Four zones in the city. The estimating wind characteristics is the first essential step to evaluating a wind energy project. The based on information about all aspects of the implementation and operation of the project. Therefore, necessary to have detailed knowledge of the wind to select the suitable wind turbine for a certain zone and to estimate its performance accurately. Various parameters need to be

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

known of the wind, including the mean wind speed, directional data, variations about the mean in the short term (gusts), daily, seasonal and annual variations, and variations with height. These parameters are highly site specific and can only be determined with sufficient accuracy by measurements at a particular site over a sufficiently long period.

The article outlines physical phenomena that are related to the characteristics of the wind for the selected areas. However, as knowing that, the cost of wind energy development depends sensitively on the nature of the wind resource. Hence, any detailed evaluation of wind energy economics requires a series of wind assessment studies.

2. Wind Assessment

A wind energy assessment is an analysis of the potential wind energy resources of a particular area. Such an assessment begins with an understanding of the general wind patterns of the area, and progresses to the collection and analysis of wind data. The wind speed increases with the height above the ground. Due to, the frictional drag of the ground, vegetation and building [2,3]. It is clear that any plans to harness the wind must take into account these variables. Because the cost of wind energy development is sensitive to the nature of the wind resource. More detailed evaluation of wind energy economics requires a series of wind assessment studies. At the most advanced stages, computer simulations of wind flow can be used to determine wind turbine micro-sitting.

After the region has been selected for assessment, it is necessary to collect the wind data (wind speed and direction). A complete wind resource assessment involves a dense network of anemometers (wind monitoring stations) recording continuous wind data for at least one year. Since such wind monitoring efforts are time consuming and costly, wind researchers often obtain data sets that have been previously recorded. Several sources may be helpful in obtaining existing meteorological databases. For examples, climate change stations, renewable energy stations, and geology stations

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

[3,4]. The researcher had focus on areas likely enhanced wind speeds [3-6]. In this article, the data were recorded at height 30 meters continuously using a cup generator anemometer for all stations of each area. Table 1 shows samples of the mean monthly wind speed data for the year of (2019).

TABLE 1. Mean monthly wind speed (Meter/Sec)

Months / Zones	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Geryan 1	5.99	6.87	7.79	6.98	7.98	7.12	6.76	5.69	5.43	5.74	5.57	6.77
Geryan 2	6.50	6.85	8.04	7.20	7.61	7.32	6.78	6.23	5.79	6.34	6.52	6.86
Geryan 3	5.76	6.98	7.67	7.67	7.66	6.67	6.74	6.21	5.67	5.89	6.10	6.91
Geryan 4	6.65	7.12	7.94	7.43	7.67	7.98	7.95	7.49	7.53	7.12	6.74	7.91

3. Analysis of wind regimes

The next step in the wind resource assessment is to analyze the wind data set to determine patterns in the magnitude, duration and direction of the wind. The Mean wind speed (Vm) is the most commonly used indicator of wind production potential where defined as:

$$V_m = \frac{1}{N}\sum_{i=1}^{N} V_i \tag{1}$$

Where: N is the sample size, and V_i is the wind speed recorded for the i^{th} observation.

The wind speed at surface is zero due to the friction between the air and the surface of the ground. The wind speed increases with height most rapidly near the ground, increasing less rapidly with greater height. At a height about 2 km above the ground the change in the wind speed becomes Zero. The vertical variation of the wind speed, the wind speed profile, can be expressed by different

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

functions [4,5]. Two of more common functions which have been developed to describe the change in mean wind speed with height are based on experiments and are given below.

- Power exponent function

$$V(z) = V_R\left(\frac{z}{z_r}\right)^{\beta} \qquad (2)$$

Where: Z is the height above ground level, V_R is the wind speed at the reference height Z_r above ground level, V(z) is the wind speed at height z, and β is an exponent which depends on the roughness of the terrain. A typical value of β might be 0.1 .

- Logarithmic function

$$\frac{V(z)}{V(10)} = \frac{\ln\left(\frac{z}{z_0}\right)}{\ln\left(\frac{10}{z_0}\right)} \qquad (3)$$

Where V(10) is the wind speed at 10 m above ground level and z_0 is the roughness length. The parameters β and z_0 for different types of terrain are shown in Table 2.

TABLE 2. Roughness' of different terrains

Type of terrain	Roughness class	z_0(m)	β
Water areas	0	0.001	0.01
Few surface features	1	0.12	0.12
Farmland with buildings and hedges	2	0.05	0.16
Farmland with many trees, forests, villages	3	0.3	0.28

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

Both functions can be used for calculation of the mean wind velocity at a certain height, if the mean wind velocity is known at the reference height [5,6]. In this study we used the power exponent function during the calculation and choose the value for β which equal 0.12.

4. Wind statistics

In the previous literate shows that a wind speed distribution can typically be described in terms of the Weibull distribution. The equation of the non-cumulative Weibull distribution is:

$$p(\mathrm{V}) = \frac{k}{C}\left(\frac{\mathrm{V}}{C}\right)^{k-1} \exp\left\{-\left(\frac{\mathrm{V}}{C}\right)^{k}\right\} \qquad (4)$$

While the cumulative Weibull distribution is:

$$P(\mathrm{V}) = \exp\left\{-\left(\frac{\mathrm{V}}{C}\right)^{k}\right\} \qquad (5)$$

Where: k is the shape parameter and C is the scale parameter. Finding a best fit Weibull distribution is a convenient way to approximate a continuous wind speed distribution from the discrete observed values. In addition, this method is also useful in that the wind regime of an area can then be described using only the two Weibull parameters, k and C.

The parameters C and k for the Weibull frequency distribution can be found by plotting ln V against ln(-ln(P(V)), where ln is the logarithm to base e, and fitting a straight line to the points. The slope of the line is equal to k and C is equal to exp(ln V), or V, where ln(-ln(P(V)) is zero. This technique is based on taking logarithms of cumulative Weibull distribution twice

5. Annual energy and capacity factor

The annual energy yield has been ccalculated of a wind turbine that is a fundamental importance in the evaluation of any project.

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

The long-term wind speed distribution is combined with the power curve of the turbine to give the energy generated at each wind speed and resulting in the total energy generated throughout the year. It is usual to perform the calculation using 1m/s wind speed bins as this gives acceptable accuracy [7-10]. The annual energy expressed mathematically as:

$$\text{Energy} = \sum_{i=1}^{i=n} H(i)P(i) \qquad (6)$$

Where: H(i) is the number of hours in wind speed bin i and P(i) is the power output at that wind speed.

Another measure is the load or capacity factor, defined as the ratio of the actual energy generated in a time period to the energy produced if the wind turbine were run at its rated power over that period [10-12]. For example:

$$\text{Annual load factor} = \frac{\text{energy per year (kWh)}}{\text{rated power (kW)} \times 8760} \qquad (7)$$

There are several similar measures of power plant performance. To avoid confusion when comparing the performance of wind plant, the precise definitions of availability or load factor should be clearly understanding [13-14].

6. Results and Discussion

To determine the Weibull frequency distribution, and the Weibull cumulative distribution, it is necessary to determine the scale parameter (*C*), and the shape parameter (*k*). Figure 1 shows the technique that used to determine these parameters for Geryan 4 (as a sample), the values of scale parameter is *C* = 9.34 m/s.

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

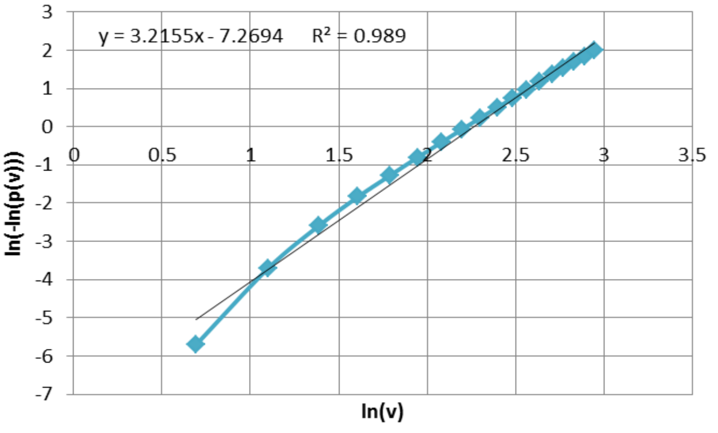

Figure 1. Weibull parameters for Geryan zones

While the slope of straight line is the value of shape parameter which is k = 3.23, and the cumulative Weibull distribution for Geryan 4 is as shown in Figure 2. The values of the shape parameters, scale factors, probability and the annual mean wind speed for all locations are shown in Table 3. And the mean wind speed and the wind speed of maximum frequency for Geryan 4 are indicated in Table 4 below.

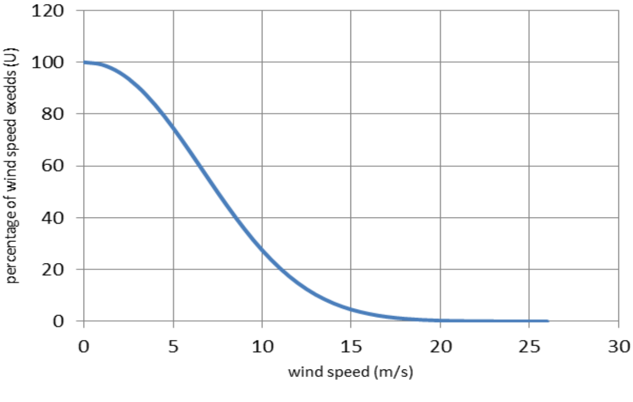

Figure 2. Cumulative Weibull distribution for Geryan zones

Table 3 shows the value for the probability of wind speed, which is drawn by using the values of scale and shape parameters with Equation (4), from this histogram. It is clear that the wind speed that has maximum frequency is 6.31 m/s in Geryan 1 (Profitability = 13.78 %), 6.50 m/s in Geryan 2 (Profitability = 13.53 %), 6.70 m/s in Geryan 3 (Profitability = 13.66 %), and 7.21 m/s in Geryan 4 (Profitability = 12.54 %).

TABLE 3. Performance of the areas under study

Variables / Zones	Scale parameter C (m/s)	Shape parameter K	Probability (%)	Annual mean wind speed
Geryan 1	5.5835	3.1199	13.78	6.31
Geryan 2	8.9768	3.0912	13.53	6.70
Geryan 3	8.6479	3.0828	13.66	6.50
Geryan 4	9.3410	3.2301	13.84	7.21

The annual mean wind speed can be estimated from the histogram of the probability of wind speed by taking the summation of multiplying each wind speed. In it is profitability, the mean wind speed is 7.21 m/s in Geryan 4. The calculations of the annual energy and capacity factor for each site are based on the data of Ventis v 60 wind turbine, which has a rotor diameter of 60 meters and a rated power of 850 kW.

The Figure 3 shows the annual energy for Geryan 4 which the maximum, annual energy 2187.34 MWh in, while the minimum one is 1434.12 MWh in Geryan 1. From these values it seems that this type of wind energy turbines is suitable for most of the Geryan City area, but still the Geryan 4 is highest zone has very high values. However, The final result values are summarized in the Table 4.

TABLE 4. Results of the areas under study

Factors / Zones	Wind speed of maximum frequency	Annual energy MWh	Annual capacity factor (%)
Geryan 1	7.18	1434.12	19.30
Geryan 2	7.82	1877.50	26.10
Geryan 3	7.10	1743.58	24.15
Geryan 4	7.98	2187.34	30.02

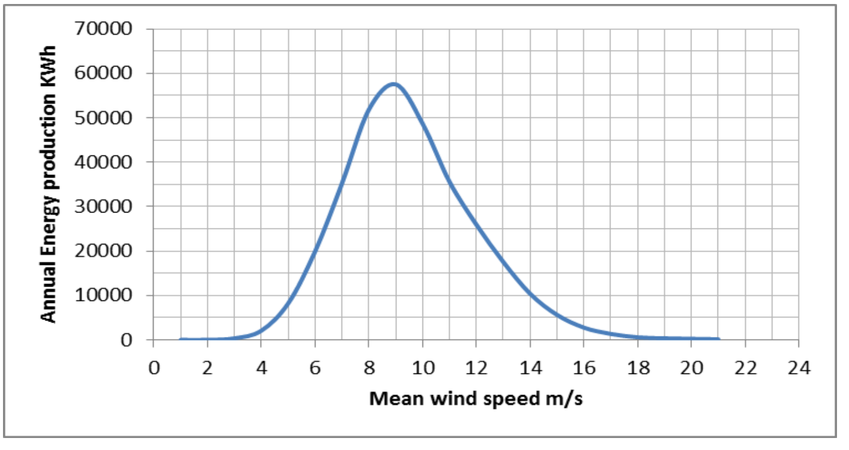

Figure 3. Anual energy for Greyan zones (4) based on 850 KW

7. Conclusion

The article in this study has discussed potential of wind energy as assessment an integrated analysis of the wind energy resources of a particular Greyan city zones. The article has conclusion that:

1. The wind data of this study has indicates the possibility of utilizing wind energy in electricity generation for the four regions in Geryan zones.
2. In Geryan 4 has the maximum annual energy and capacity factor while Geryan 1 has the minimum annual energy and capacity factor.

تم استلام الورقة بتاريخ: 15 / 6 /2023م وتم نشرها على الموقع بتاريخ: 30 / 7 /2023م

3. Existing data resources indicates that the mean annual wind speed of 7.21 m/s at Geryan 4 with theoretical capacity factor exceeding 30 %. These values indicate that Geryan could generate 2187.34 kWh.
4. More modern wind measuring equipment and advanced software should be available to increase the accuracy of the efficiency of the energy.
5. The entire country should be examined to detect the fields proper for the establishment of wind turbine farms, and public initiatives should start establishing wind energy farms in the selected areas.

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