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Estimation of Electric Power Generation in Libya Using Processing Technology of Wind Energy (Sirte Case study)

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Abstract

Based on information regarding every aspect of the project's execution and operation, the estimation of wind characteristics is thought of as the first crucial stage in evaluating a wind energy project. Therefore, in order to choose the appropriate wind turbine for a given zone and to precisely predict its performance, extensive understanding of the wind is required.

The mean wind speed, directional information, fluctuations in the mean in the short term, daily, monthly, and annual variations, and variations with height are only a few of the elements that need to be known about the wind. These parameters are incredibly site-specific, and their accuracy can only be ascertained by measurements taken at a single place over an adequate amount of time. The study of wind energy and wind evaluation at a few chosen locations (Sirte City and Qaser AbuHadi) is presented in this paper, together with background information on wind power and its resource and an analysis of the available data from the representative meteorological station Sirte.

The wind data has been adjusted for each location to reflect the real wind speed at hub height. For each site, calculations are made to determine the mean wind speed, Weibull distribution, annual energy, and annual capacity factor.

Keywords: *Sirte, mean wind speed, wind data analysis, wind statistics, Profitability, Measurement.*

1. Introduction

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.[1] Winds result from an unequal heating of different parts of the Earth's surface, causing cooler dense air to circulate to replace warmer, lighter air.[2] While some of the sun's energy is absorbed directly into the air, most of the energy in the wind is first absorbed by the energy resources of a particular area. the usage of wind as a source of energy is increasing in different parts of the globe due to rapid technology advancement.[3] Wind energy utilization is also becoming competitive compared to traditional sources of energy. 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. This paper presented the detailed wind data analysis and wind availability at Sirte city which Located on coast of Mediterranean Sea in Libya.

2. Wind Energy In The World

591,549 MW had been installed globally at the end of 2018, an increase of 9.6% from the year2017. [4] In 2016, 2015, 2014, and 2013, the number of installations climbed by 54,642 MW, 63,330 MW, 51,675 MW, and 36,023 MW, respectively.

More than half of all new wind energy added since 2010 has occurred outside of the traditional markets of Europe and North America, primarily because to the ongoing economic growth in China and India. China installed 145 GW of wind energy by the end of 2015. [5] Nearly half of the additional wind generating capacity installed worldwide in 2015 was in China.

A number of nations have attained comparatively high rates of wind power penetration, including 39% of stationary energy output in Denmark, 18% in Portugal, and 16% in Spain[6]. 2010 saw 14% in Ireland [7] and 9% in Germany. [8] [9] As of 2011, wind energy was being used commercially in 83 different nations. [10] Scotland surpassed the milestone of having wind energy meet 100% of the nation's electricity demands in November 2018. [11] At the end of 2014, 3.1% of the world's electricity came from wind power.

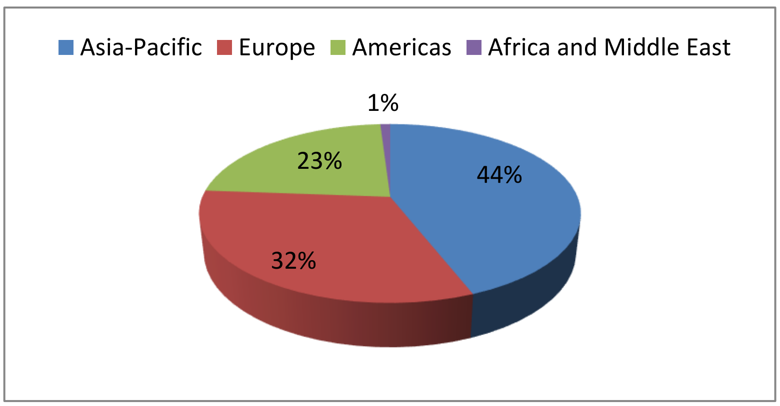

Figure. 1 Installed capacity by regions in 2020 (MW)

3. WIND ENERGY IN LIBYA

Fig. 2 shows the wind speed in some coastal cities. Figure 3 displays the typical wind speed at three different heights in various Libyan cities.

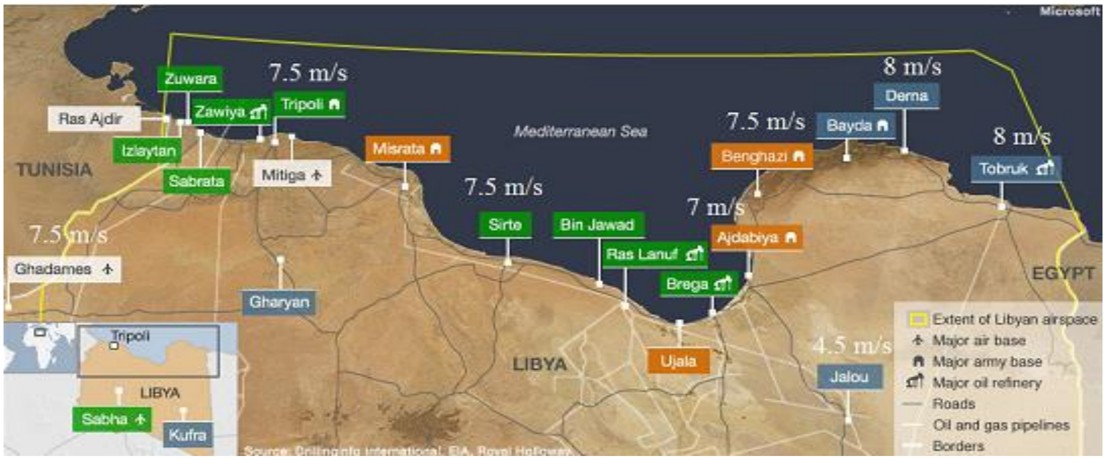

Figure. 2 The wind speed in coastal cities in Libya

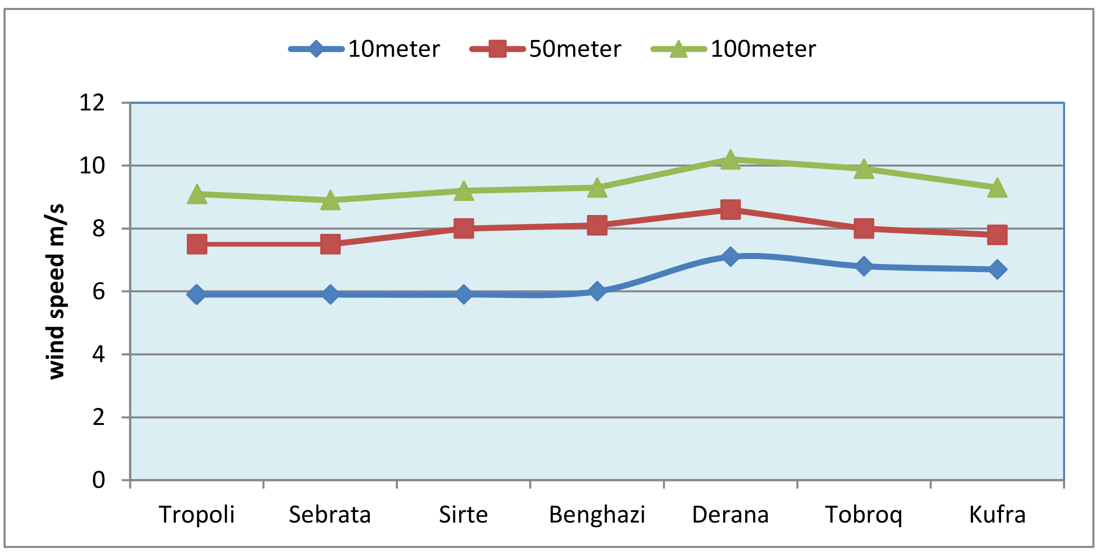

Figure.3 The monthly average wind speed in different cities in Libya

The Libyan plan for renewable energy is broken down into four fundamental stages. This proposal is on hold due to the unstable situation in Libya. Now in 2018, the volatility has prevented the 6% goal from being reached. Furthermore, there is no genuine desire to begin these undertakings. as an illustration of poor planning. The initial stage of the project, which runs from 2008 to 2012, involved constructing a 60 MW wind farm in Dernah. 37 wind turbines, each rated at 1.65 MW, make up the farm.

4. Wind assessment

Once a location has been selected for evaluation, information on wind direction and speed must be gathered. An extensive network of anemometers (wind monitoring stations) recording continuous wind data for at least a year is required for a thorough evaluation of the wind resource. Since these wind monitoring activities take a lot of time and money, wind researchers frequently use data sets that have already been collected.

To access current meteorological databases, a variety of sources may be useful. Airports and climatological stations, for instance, are likely to keep accurate records. If at all possible, spot measurements should be added to the already existing data sets. The researcher should concentrate on locations anticipated to have increased wind speeds when selecting places to study for possible wind development. The Sirte meteorological station provided the data used in this work; examples of these data are displayed in tables 1, 2.

Table 1. Monthly average wind speed for Sirte City (m/s)

Months	**2014**	**2015**	**2016**	**2017**	**2018**
Jan	5.189	5.932	6.128	5.651	5.825
Feb	5.210	5.650	6.472	5.872	5.983
Mar	4.982	5.329	5.450	5.825	5.493
Apr	5.621	5.438	5.826	5.275	5.710
May	5.873	5.628	5.914	5.369	5.901
Jun	5.816	5.819	5.541	5.681	5.042
Jul	5.820	4.908	5.573	5.827	5.173
Aug	5.625	4.981	5.329	5.736	5.630
Sep	5.981	5.012	5.127	5.481	5.305
Oct	5.941	5.142	5.351	5.295	5.361
Nov	6.815	5.871	5.715	5.871	5.947
Dec	6.826	6.003	5.983	6.091	6.023
Average	**5.808**	**5.476**	**5.700**	**5.665**	**5.616**

Table 2. Monthly average wind speed for Qasr AbuHadi (m/s)

Months	2014	2015	2016	2017	2018
Jan	5.287	5.992	6.258	5.681	5.872
Feb	5.127	5.680	6.262	5.894	5.963
Mar	4.867	5.352	5.480	5.883	5.481
Apr	5.712	5.491	5.616	5.251	5.763
May	5.793	5.647	5.934	5.311	5.951
Jun	5.906	5.831	5.821	5.673	5.073
Jul	5.769	4.924	5.613	5.845	5.190
Aug	5.702	4.993	5.629	5.763	5.662
Sep	5.998	5.102	5.377	5.497	5.374
Oct	5.971	5.171	5.491	5.292	5.821
Nov	6.888	5.889	5.842	5.851	5.817
Dec	6.896	6.035	5.894	6.231	6.093
Average	**5.826**	**5.508**	**5.768**	**5.681**	**5.671**

5. Data analysis

The analysis of the wind data set to identify trends in the wind's intensity, duration, and direction is the next phase in the wind resource assessment.

5.1. Mean wind speed

Mean wind speed (Vm) is the most commonly used indicator of wind production potential where defined as

$$\mathbf{V_m = \frac{1}{N}\sum_{i=1}^{N} V_i} \qquad (1)$$

Where,

N is the sample size, and Vi is the

For the ith observation, the wind speed was recorded. To build a histogram of the wind speed distribution when the sample size is big, it is helpful to group the wind speed data into intervals.

5.2. Vertical wind speed gradient

Because of the friction that exists between the air and the ground's surface, there is no wind speed there. Near the ground, the wind speed increases with height most quickly; as height increases, the rate of increase slows down. The change in wind speed stops changing at a height of around 2 km. Different functions can be used to express the wind speed profile, or vertical variation of the wind speed. The two more popular functions that have been devised to describe how mean wind speed changes with height are listed below.

5.3. Power exponent function

$$V(z) = V_R \, (Z/Z_r)^{\beta} \qquad (2)$$

Where z is the height above ground level, VR is the wind speed at the reference height zr 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 0.1.

5.4. Logarithmic function

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

Where z_0 is the roughness length and V(10) is the wind speed at a height of 10 meters. Table 3 show the β and z_0 parameters for different types of terrain.

Table 3 Wind speed parameters

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

If the mean wind velocity at the reference height is known, either function can be used to calculate the mean wind velocity at a specific height. In this study we used the power exponent function during the calculation and choose the value for β which equal 0.12.

6. Wind statistics

According to studies, the Weibull distribution can often be used to represent a wind speed distribution. The noncumulative Weibull distribution equation is:

$$p(V) = \frac{K}{C}\left(\frac{V}{C}\right)^{K-1} \exp\left\{-\left(\frac{V}{C}\right)^{K}\right\} \quad (4)$$

While the cumulative Weibull distribution is:

$$p(V) = \exp\left\{-\left(\frac{V}{C}\right)^{K}\right\} \quad (5)$$

The scale parameter is C, while the shape parameter is k. An easy technique to approximate a continuous wind speed distribution from discrete observed values is to find a best fit Weibull distribution. Additionally, the two Weibull parameters, k and C, can be used to define the wind regime of a region using this method.

When ln V is plotted against ln(-ln(P(V)), where ln is the logarithm to base e, the parameters C and k for the Weibull frequency distribution can be determined by fitting a straight line to the data points. Where ln(-ln(P(V)) is zero, the line's slope is equal to k, and C is equal to exp(ln V), or V. This method is based on twice taking the cumulative Weibull distribution logarithms.

6.1. Annual energy and capacity factor

In order to evaluate any project, it is crucial to calculate the annual energy yield of a wind turbine. The energy generated at each wind speed and, consequently, the total energy generated throughout the year, are determined by combining the long-term wind speed distribution with the power curve of the turbine. Since this provides adequate precision, it is customary to make the computation using 1 m/s wind speed bins. The yearly energy is mathematically stated as

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

Where P(i) is the power output at that wind speed and H(i) is the number of hours in that wind speed bin. The load factor, also known as the capacity factor, is another metric. It is the ratio of the energy produced during a given time period to the energy produced if the wind turbine had been operating at its rated power during that time. For instance,

$$\text{Annual load factor} = \text{Energy generated per year (Kwh)/Turbine rated power (Kw)}\times 8760$$

Power plant performance is measured using a variety of similar metrics. The precise definitions of availability or load factor should be understood in order to prevent confusion when comparing the performance of wind power plants.

7. Results and discussion

The scale parameter (C) and the shape parameter must be determined before the Weibull frequency distribution and Weibull cumulative distribution can be calculated (k). The method used to calculate these parameters for Sirte City and Qaser Abu-Hadi is shown in Figures 4 and 5. The values of the scale parameter were C = 6.09 m/s for Sirte City and C = 5.9 m/s for Qaser AbuHadi, while the value of the shape parameter was k = 1.92 for Sirte City and k = 1.89 for Qaser Abu-Hadi.

Figures 6, and 7 show the histogram for the probability of wind speed which drawn by using the values of scale and shape parameters with equation 4, from this histogram it's clear that the wind speed that has maximum frequency was 4 m/s in Sirte (Profitability= 13.8%), and 4 m/s in Qaser Abu-Hadi (Profitability = 13.6%), and the annual mean wind speed can be estimated from the histogram of the probability of wind speed by take a summation of multiply each wind speed in its profitability, the mean wind speed was 4.81 m/s in Sirte and 4.65 m/s in Qaser Abu-Hadi.

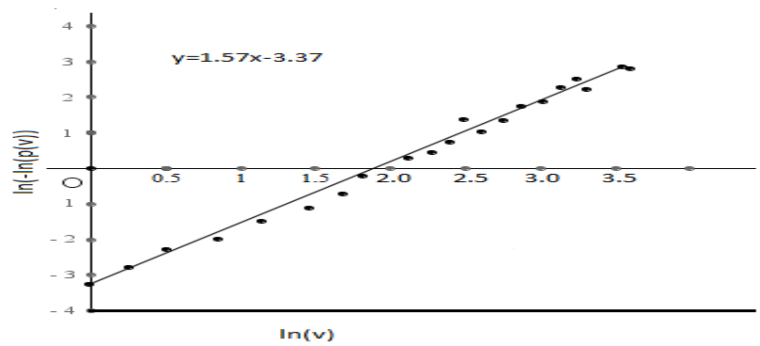

Figure. 4 Graphical determination of Weibull parameters Sirte city

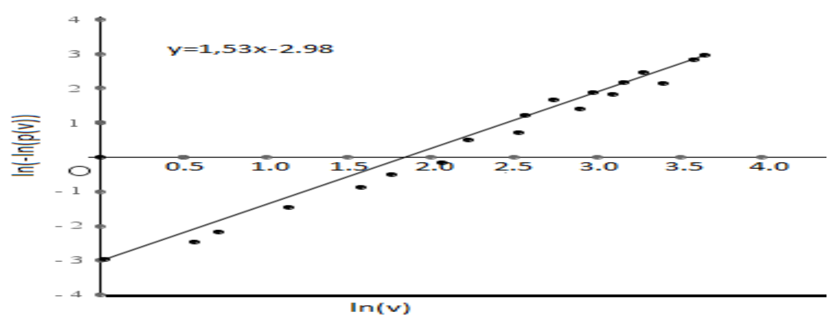

Figure. 5 Graphical determination of Weibull parameters for Qaser Abu-Hadi

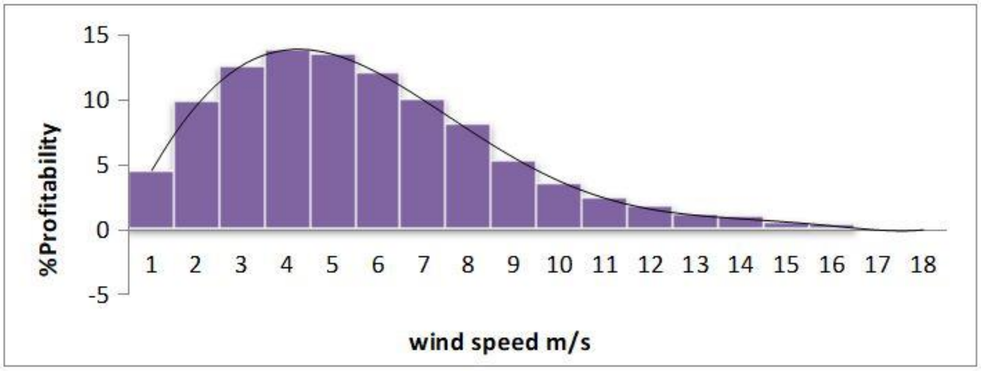

Figure. 6 Histogram and Weibull function for the probability of Sirte city

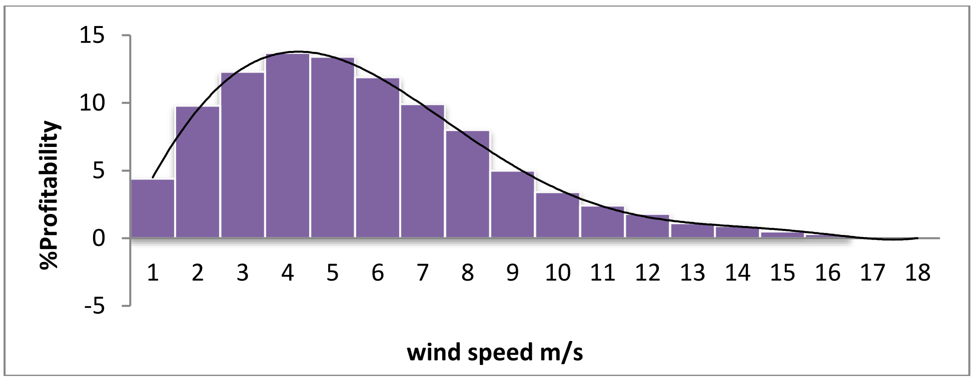

Figure. 7 Histogram and Weibull function for the probability of Qaser Abu-Hadi

The final results of calculations are summarized in table 4

Table 4 Performance of the Sirte City

Wind speed of max frequency(m/s)	4
Annual energy (MWh)	1156
Annual capacity factor (%)	15.3
Scale parameter C(m/s)	6.09
Shape parameter k	1.92
Annual mean wind speed(m/s)	4.81

Recommendations

Libya should start a subsidized plan and legislation for renewable energy that includes

(1) Raising public awareness of the immediate and long-term effects of electricity waste. Social media and TV channels can be used for this.

(2) Regulations and laws governing the use of low-wattage electrical equipment. This can be accomplished by enticing people to use energy wisely.

(3) Start the market for renewable energy with small- and medium-sized projects that focus on quick, easy, and straightforward installations.

(4) Encourage domestic and international investment in the Libyan electrical sector. The political stability of the nation heavily influences this point.

(5) Establish training and education initiatives to certify more people in the field of renewable energy technologies

Conclusions

The electric energy demand is predicted to expand extremely significantly in the coming few years; the excellent weather in Libya with a plentiful of land hold the promise to be one of the top countries in renewable energy production. This study demonstrates that the wind power has the good yearly energy and capacity factor so we should install the correct wind turbine in the city. Although Libya's location makes it the best place in the world to use renewable energy, the country still has a very low percentage of this technology. Large-scale grid-connected power generation via wind farms has a lot of promise. After oil and natural gas, Libya's wind energy resources can be a significant energy source. Resources for renewable energy present excellent chances for international cooperation and knowledge transfer. Both the energy production side and the energy consumption side can adopt energy efficiency. Libya has to start implementing an emerging strategy to strengthen its reliance on renewable energy. The resources in this sector will benefit if this effort is expanded to examine wind energy at other sites.

Acknowledgment

Sirte Meteorological Station.

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