International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 12, December-2014

Analysis of Wind Speed Data in East of Libya

Abdelkarim A. S, D. Danardono, D. A. Himawanto, Hasan M. S. Atia
Mechanical Engineering Department,
SebelasMaret University,
Jl. Ir. Sutami 36ASurakarta
Indonesia

Abstract: **In this paper wind speed characteristics had been studied in Al-fattaih-Derna east of Libya that was based on wind data in 2003. This investigation is for one year wind data measured in 2003 at a height of 50 m, the annual mean wind speed at the site was 8.21 m/s.Weibull distribution results had been used to accomplish the analysis, the two parameters of the Weibull statistics were found to lie between $2.39 \leq k \leq 5.77$ and $5.36 \leq c \leq 7.8$, respectively.. The possibilities were high because of 8010 hours are available with reasonable wind velocity values varied between 3-23 m/s, which is equal to 92.47 % of the year. With the shortage in power in Libya, this location conceder recommended and promising, to partly cover the problem of power ,as renewable energy resource.**

Keywords: Average wind velocity, Weibull distribution, East of Libya.

1. INTRODUTION

Energy demands have been increased rapidly all over the world. It becomes real threat to the environments with increasing production levels. Wind energy available potentials on land and off-shore estimated by 72 TW which is more than five times the current energy consumptions for the whole world in all form [1]. Recent prediction study shows that in 2014 the global electric wind capacity will stand at 409 GW instead of 158 GW in the end of 2008 with growth rate of 20.9% [2]. In Europe approximately 20% of electricity comes from renewable sources around 5.3% are from wind energy, under the term of EU's renewable energy directive the share will increase in 2020 up to 34% including 14% from wind energy as total European production [3].

In Libya the situation is more dramatic, a country which has plenty of fossil fuel and natural gas enough to sale power not only to meet with its own demands, it is been found with a serious energy crisis. At least for the past 15 years Libyan community has been busy thinking about this problem which makes life harder for Libyans. To cover the demands Libya always needs neighboring countries to cover the shortage in power and sometimes these countries won't be able to supply Libya in certain situations. Like if these countries need their extra power for their own peak loads or for strategic plans of these countries. Power plants capacities in Libya are not enough to produce energy to meet with the country's demands. It might be possible to starts some projects to increase power production, some power plants could be built in few years and surely with the suitable energy management power problems would be solved. In the other hand we are going to face different kind of problems too, fossil fuel and natural gas are not clean energy sources. The production processes for these kinds of sources will have negative impacts on environments. Usually such a production comes with high levels of emissions like carbon dioxide (CO_2) plus other emissions which are unfriendly with the environments. In some areas these emissions would exceeds the limits and become real dangerous. This is usually comes with this kind of power production and with nuclear power production the danger is higher even if the production gives more power.

Most of the developed countries utilized mixed power production systems. Mostly the production divided into several systems with different forms and it could be like the following: power plants using conventional resources, fossil, gas or nuclear, plus renewable energy resources. This is what most of the developed countries come to because it would be possible to get the power needed and also to reduce the damages in the environment as much as possible.

2. ENERGY SITUATION IN LIBYA

Electricity in Libya has critical situation, and recently become real crisis. Either at homes or public utilities, with the same production levels which remains the same values almost for the past decade, in the other hand demands increasing every year which aggravate the problem. Libyan Energy makers and government organizations expect that demand for electrical power will double by 2014 and it will be more than two and half by the end of the year 2020.According to power production levels [4] , the statistics shows that Libya consider a small country because Libya's population is around 6.5 million, even though Libya has Africa's highest electricity consumption Per capita which was 4.60 kWh in the year 2009 [5]. The problem in Libya is that demands are always higher than power production. Based on last statistic for the Libyan authorities in 2012 total energy produced is 33.980 GWH, with an increase of 4.37 % compared to 2010. And total power produced by all types of power plants exist in Libya 2012 is 6,798 M Watt. Furthermore and from studies that have been made by the ministry of electricity, energy demands in 2017 with natural growth will stand at 48.497 GWH. While energy demands with developments projects included will be up to 87.935 GWH [4]. It's quite simple to realize that the country needs much work, in order to overcome the shortage in problem. Good strategic planning is required from the authorities to build new projects in order to increase the capacity of power production. Its better if these projects are mixed power production sources which in reality Libya never been utilized it before. For example, nuclear power plants or renewable energy power plants. Libya considers rich country with renewable energy resources especially solar and wind energy, which is clear from the global maps available of solar energy resources, and from some studies [5]. It's quite simple to notice that large parts of empty areas in Libya are rich with solar energy. Wind energy has acceptable potentials with velocity varied between 5-10 m/s. The long coast of the country is almost 1900 km, that means long offshore wind farms with high possibilities for wave and tidal energy even its not high [5].

Renewable energy is not reliable to solve the problem of power right now, but it can supports the demands and more important to reducing problems such as global warming and pollutions, which really harmful to the environment. It should be priority in all government's plans, for the future of next generations.

3. WIND ENERGY IN LIBYA

Wind energy in Libya consider in the early days. Utilizing wind farms to produce energy is not familiar in Libya. Some of renewable energy resources have been used in very limited range, like utilizing solar energy for heating systems in certain areas in the country, especially if electricity supplements are not available at that area. But for wind energy it's quite rare to see wind turbines. Few turbines could be found working as individual rotors to supply some facilities, for example radio stations or radars in rural areas. Based on some published documents some areas like Al-fattaih in east of Libya and Al-magron in west of Libya and Jbalzaltan in west of Libya famous with windy weather most of the year, and wind resources are sufficient enough to encourage for a study for wind energy harvesting project [5]. The wind farm that will be calculated in this research will be the first one at the east of the country. There is need for a clear strategy and time plan to take this field forward in the future of Libya.

4. METHOD

Wind data in this study came from two "sources" first the Libyan's Renewable Energy Council, and second Libyan National Electricity Company in eastern region. The one which analyzed in the study was the one which came from Libyan's Renewable Energy Council. The data was from (2002-2004) three years data, each ten minutes recorded with four intervals. The 2003 data was Chosen because it was complete for 12 months, while records of 2002 and 2004 had missed some month's records. Changing the format from four interval records each ten minutes to hourly records was done to make it easier to calculate and make the analysis. The data used here was captured at 50 meter height. Using monthly mean wind speed in such a study is mostly used, because it's available for most locations or easy to estimate as the case in this study.

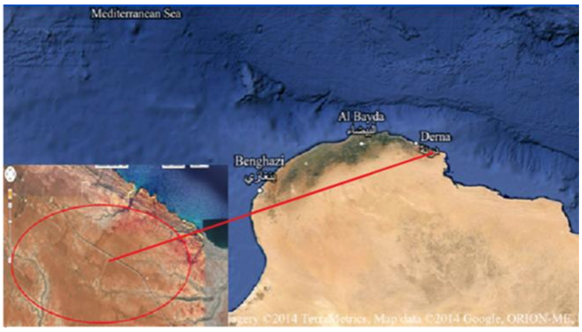

Figure 1 View of the studied location AL-fattaih-Derna

The geographical location of the selected site:
Al-fattaih-Derna located at east of Derna city eastern region of Libya, 47 km east of the city of Derna which conceder far enough to bulid wind energy project, as the requirement for minimum distance if the height of the turbine is greater than 50 m, but does not exceed 100 m, the minimum distance requirement is (1.5-2) km [7]. The location is with following geographical Latitude (N) 32° 40' - Longitude (E) 22° 51' - Altitude (m) 173.

Wind data have been used for monthly mean wind speed monthly and annual calculations. That was the first thing to do, calculations made by using equation (2), which is the actual average wind velocity if power calculation will be followed the analysis. Usually this is the case in most analysis investigations

$$Vm = \frac{1}{n}\sum_{i=1}^{n} Vi \qquad (1)$$

$$Vm = \left[\frac{1}{n}\sum_{i=1}^{n} Vi^3\right]^{\frac{1}{3}} \qquad (2)$$

Where V is the wind velocity and n is the number of wind data. However, for wind power calculations', averaging the velocity using equation (1) is often misleading,by calculating the average using equation(1), we are underestimating the wind power potential by 20 %. For wind energy calculations, the velocity should be weighed for its power content while computing the average. Thus, the average wind velocity is given by equation(2).The weighted average expressed in equation(2) should be used in wind energy analysis[6]. After average wind velocity calculated the next step is using Weibull probability distribution function method for data analysis.

The two parameters Weibull probability distribution function method [6]is widely used in analysis studies and recommended because it gives the best accuracy is the Weibull and Rayleigh distribution models. In or order to start this kind of method, two parameter need to determine. And the parameters are scale factor (*k*) and shape factor (*c*). In this method the variation in wind velocity is characterized by two functions, the probability density function and the cumulative distribution. The probability density function f(*V*) indicates the frequency or the probability of the wind at a given wind speed V, while the related cumulative distribution function F(V) of the velocity V gives the probability that the wind speed is equal to or lower than V, or within the range of given wind speed.

The Weibull probability density function is given by the following equation[6]:

$$F(V) = \left(\frac{k}{c}\right) \exp\left[-\left(\frac{V}{C}\right)^K\right] \quad (3)$$

Where $f(V)$ is the probability density function:,k = scale factor , c = the shape factor ,
v = wind velocity m/s.

Cumulative distribution *F(V)* is given by equation[6]:

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

Some methods are available to determine the parameters. To estimate the parameters of the Weibull wind speed its possible by applying a method like, the maximum likelihood method or the moment method also graphical method. The parameters of Weibull were calculated using another method which is the standard deviation method [6].This method gives better results than other method also more simple. Furthermore there is no requirement for more details in wind data which is usually not easily available for academic studies. the standard deviation σ is given by the expression [6]

$$\sigma = \sqrt[2]{\frac{\sum_{i=1}^{n}(Vi - Vm)^2}{n}} \quad (5)$$

Where *Vm* is the mean wind velocity, *V*i is hourly wind speed.

The shape factor *K* determined from the following equation [6]:

$$K = \left(\frac{\sigma}{Vm}\right)^{-1.086} \quad (6)$$

to determine the scale factor c is by using the equation [6]:

$$C = \frac{Vm * K^{2.3374}}{0.184 + 0.816 K^{2.73855}} \quad (7)$$

Determining the two factors will lead to the final results after applying the equations (1) and (2) with the data. Finally these results will be used to draw both Weibull probability distribution and cumulative annual distribution functions curves, as in figures 4 (a) & 4(b).

5. RESULTS AND DISCUSSION

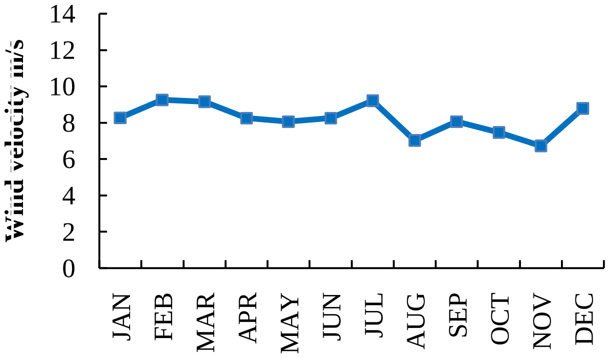

Figure 2 Annual average wind velocity

TABLE 1 annual wind velocity

Wind velocity m/s	Hours per year
0-1	42
1-2	209
2-3	408
3-4	702
4-5	959
5-6	1082
6-7	1051
7-8	1140
8-9	1105
9-10	739
10-11	521
11-12	386
12-13	202
13-14	125
14-15	79
15-16	44
16-17	25
17-18	22
18-19	10
19-20	2
20-21	5
21-22	1
22-23	1

Data was transform from four interval average wind speed records, into hourly wind speed records, to be able to start the analysis and finding location's wind characteristics. Results of monthly average wind speed are showing in figure 2. Average wind velocity calculations had been made by equation(1) and the results plotted in figure 2. At the location the highest mean wind speed was in February 9.26 m/s, where the lowest was in November 6.72 m/s.

Location's annual average wind speed was 8.21 m/s. this is a good sign and it might indicate that the location has the potentials for harvesting wind energy. Before coming to such a final result and make any decision about the location potentials, there should be a clear knowledge about how much time wind will blow with reasonable wind speed, that is why table 1 was important, and there is counting for each range of wind speed values, how many hours any wind speed was occurred per year. Table 1 also shows how many hours that wind speed will be between the cut-in speed and the cut-out speed of most commercial turbines, usually available commercial turbines work from 3-25 m/s.

most frequent wind speed during the year were between 7-8 m/s with 1140 hours. A lot of information could be read from table 1 as well about wind speed duration time, which might help with turbine chosen, if wind energy project will be set at the location. Definitely impossible
July shows that most frequent wind speeds are towards medium and high wind speed during the month, while November shows most frequent wind speeds towards low wind speed, which might bethe reason in power calculations for highest and lowest annual power produced.

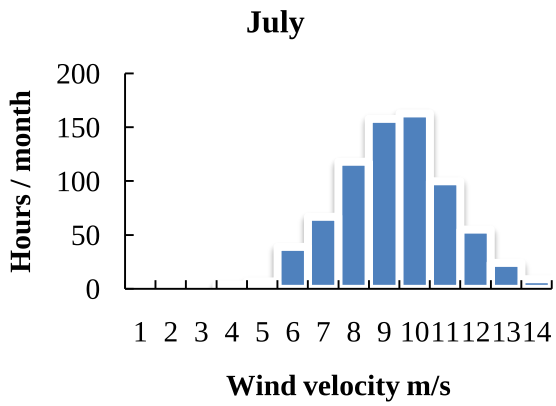

Figure 3 July wind speed distribution

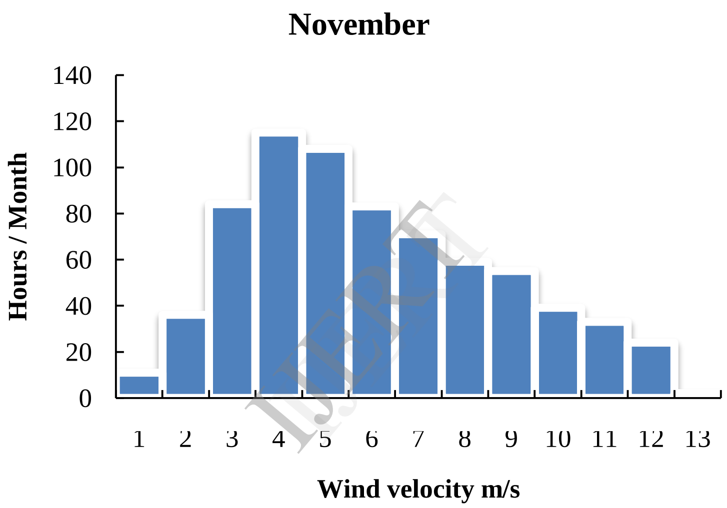

Figure 4 November wind speed distribution

Most of the year wind velocity distribution shows different results, but both July and November were as mentioned above.

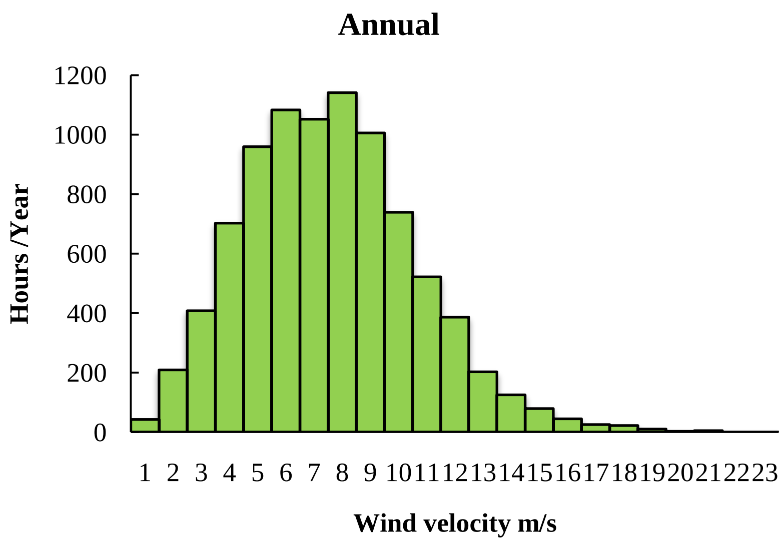

Figure 4 annual wind speed distribution

5.1 WEIBULL DISTRIBUTION RESULTS

Table 2 Weibullparameters

Weibull Parameters	σ	k	c
Annual	3.19	2.79	6.57
Jan	3.17	2.83	6.59
Feb	4.12	2.4	7.8
March	4.09	2.39	7.74
April	3.28	2.72	6.67
May	3.27	2.66	6.57
Jun	2.41	3.81	5.88
Jul	1.83	5.77	5.57
Aug	2.42	3.17	5.36
Sep	3.08	2.86	6.4
Oct	3	2.68	6.06
Nov	2.94	2.45	5.63
Dec	3.56	2.66	7.15

First part of finding weibull probability is computing the weibull, parameters for the whole year by using the equations(1, 2, 3), which will give the above table 2. That is used to draw the Weibull distribution for each month and also annual Weibull distribution profile.

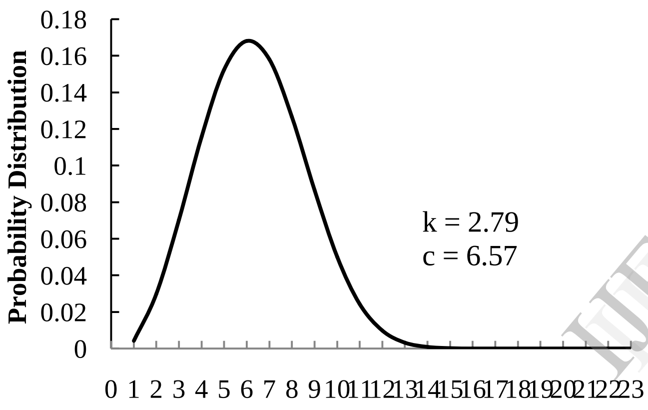

Figure 5 (b) Annual cumulative distribution

Both figure 4 and figure 5 (a) shows that most frequent wind speed varied between 5-8 m/s, as it will be the most probability that wind will blow with this speeds. Apparently table 1 also shows similar information, wind speed will be mostly around these values during the year, and nevertheless distribution is more accurate when it comes to power calculation as wind speed is different from month to another.

The probability density function is used to illustrate the fraction of time for which given wind speed possibly prevails at a location. As expected, from data wind speed values, the peak of the density function frequencies of the entire site towards the higher values of mean wind speed. It should be remarked that the peak of the probability density function curve indicates the most frequent velocities. It can be observed from Figure 5(a) that the most frequent wind speed expected in Al-fattaih-Derna is 7.5 m/s, the range from 7-8 m/s was the highest frequent one by1140 hoursper year. Also it can be further observed that Al-fattaih-Derna has the highest spread of wind speed because of its altitude 173 m and almost consider no obstacles directly on the sea. The cumulative probability distribution at the study location Figure 5(b)shows a similar trend. The cumulative distributionfunction can be used for estimating the time forwhich wind speed is within a certain speed period. For wind speeds greater or equal to 8 m/s, Al-fattaih-Derna has frequencies of about 76.46%, and it can be derived from this analysis that the wind resource in this part of Libya can be evaluated mostly good wind resource. The monthly mean wind speed varies between 6.72 m/s in November and 9.26 m/s in February.

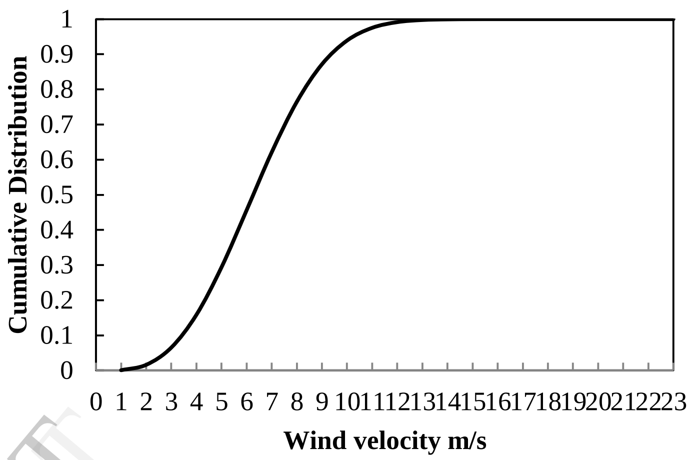

Figure 5 (b) Annual cumulative distribution

6. CONCLUSIONS

This study shows that wind potential in the selected location in the eastern part of Libya were investigated. The findings from this study can be noted and summarized as follows:

1. The annual mean wind speed Al-fattaih-Derna is 8.21 m/s.
2. Most of the year there will be energy harvesting, if wind energy system build at the location. Because of annual wind speeds peak and 8101 hours wind speed was between 3–23 m/s, as in table 1.
3. Wind characteristics shows that from February to July wind speeds were enough to say that summer season which usually has the peak loads would be partly covered.

REFERENCES

1. Archer, C.L. and M.Z. Jacobson, Evaluation of global wind power. Journal of Geophysical Research: Atmospheres (1984–2012), 2005. **110**(D12).
2. Wind, G.G., Report. Global Wind Energy Council; 2010. 2009.
3. Association, E.W.E., Pure Power-Wind energy targets for 2020 and 2030. 2011: EWEA.
4. http://www.gecol.ly/aspx/Statistics.aspx.
5. Mohamed, A., A. Al-Habaibeh, and H. Abdo, An investigation into the current utilisation and prospective of renewable energy resources and technologies in Libya. Renewable Energy, 2013. **50**: p. 732-740.
6. Sathyajith, M., Wind energy: fundamentals, resource analysis and economics. 2006: Springer.