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RESEARCH ARTICLE - Atmospheric

Weibull Distribution Modified Using Fourier transformation

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Abstract

The newest energy source that is non-depleting, affordable, and easy to harness by various users is wind energy. One of the possible locations in Iraq for wind energy generation is Al-Shihabi area, since there is a big lack of information regarding the power of at this location, additional studies and researches of wind are crucial. A precise planning and execution of any wind energy project requires a shared understanding of the behavior of the wind. This paper's goal is to explore the potential for wind energy in Al-shihabi area, which is located south of Wassit, Iraq. Because of this, wind data were gathered for a year between December 2014 and December 2015 at heights of 10, 30, and 50 meters, in 10-minute intervals. After that, for the examination of datasets (the weibull-probability distribution function was conducted in order to evaluate of the wind energy power, and the Fast-Fourier-Transform was employed for spectral analyses. Giving spectral analysis for the data, the average yearly wind speed at 50 m was 6.84 m/sec, and the peak wind speed was 185921.078 -m/sec/12hour at a frequency of (2 Hz) at that height throughout night hours. And for the lowest values of wind speed was about 95161.3369-m/sec/12hour for the (2 Hz) frequency at that height throughout night hours. The wind was blowing faster in the morning than it was at night. While the predominant wind directions in the region were from the north-northwest and west-northwest.

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Keywords:Wind energy; Wind Speed; Spectral distribution; Fourier series; Weibull distribution.

1. Introduction

To meet the rising demand, energy is produced in large quantities from a variety of sources, which is accomplished by upgrading large-scale power projects. Coal and water were both resources that were abundantly available at the time, and they were both used in a lot of early power projects to generate electricity. Modern advancements have primarily focused on nuclear power in the latter half of the 20th century. As a result of the enormous demand, coal and oil reserves are known to be depleting, which has a negative impact on the environment. This type of behavior is not sustainable because the world's resources are being depleted faster than they can be replenished [1] [2]. This necessitated the establishment of a search for new, modified types of energy production technologies. The world has recently shifted to using clean energy, like biomass, solar photovoltaic, wind, tidal, and hydro, which are rapidly top up to meet the rising global demand for electricity [3]. The goal of the current research is to determine the features of wind for Iraq in -Wassit-Governorate-Al-Shihabi city in which is located in the Southern of-Iraq from December 2014 until December 2015. The implementation of a zero-map development was accomplished for Iraqi areas, which classified (Al-Shihabi) to be one of the most promising sites for the purpose of gathering wind energy. Mohammed [4][5] defined a selection of locations as a good setting for wind power generation.[6]

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2.Study area

Study location is situated at Iraqi lands at coordinate of (32.51°N 45.82°E) and a (22-M above sea level), in Wassit-Governorate which is roughly about 173 kilometers from Baghdad-the capital. Al-Shihabi location of choice is shown in Figure 1 to be to the south of Wassit governorate. The Tigris River flows through this area, passing close to a run of an irrigated-farmland features, creating a very dry-desert landscape for about northeast direction. The region is known for its dry, desert climate, which experiences summertime highs of over 40°C. The topography is flat with a few minor rough spots, and rainfall is sparse and concentrated in the winter. Because it is an open area without any barriers, the geographic location allows the wind to potentially reach high values, and table (1) lists specific distinguishing characteristics for the Al-Shihabi region. [7][8][9]

Table 1. The study area's characteristics [10,11].

Height-level (meter)	(Ū-mean wind speed in m per s)	Standard Deviation(S.D.)	The median for data	Minimum speed.(m per s)	Maximum speed.(m per s)
(10m)	(4.601)	(3.100)	(4.123)	(0.345)	(17.531)
(30m)	(6.133)	(3.413)	(5.901)	(0.383)	(19.520)
(50m)	(6.842)	(3.810)	(6.501)	(0.391)	(24.502)

Fig1. The chosen area of study.[12]

2. Materials and methods

Datasets were sorted out, and the Weibull distribution was estimated, and then it was linked with the Fourier transformation. The wind data used are the speed and direction for one year at intervals of 10 minutes for three-different heights levels that's (10- 30 and 50 m), which is collected from a meteorological mast in Al-Shihabi area.

2.1. The Weibull distribution:

Weibull-(probability density function), which is frequently applied inorder to explain the behavior for the wind-speed frequency distribution, is one of numerous probability-density-functions that can be employed to define distribution of the wind-speed at a particular site. The Weibull distribution has an acceptable level of precision, making it the best option among the others. The benefit of this method is that the average wind density at a given location can be quickly and clearly defined [6]. To describe the probability-density-function for the wind-speed we use. Equation-1 [13][14]:

$$F(xi) = \frac{k}{A}\frac{(xi-g)^{(k.-1)}}{A}.\exp\left[-\left(\frac{(xi-g}{A}\right)\right]^{K.} \quad (1)$$

Where $F(xi)$ is (the probability-distribution) in (W/m^2) for the considered wind-speed value (v) , The Weibull-shape-parameter (A.), and the scale-parameter (k.) as well as the location-parameter (g.), utilized in the indication of site's potentials for wind energy generation.

2.2. The wind direction:

In wind evaluation studies, state the governing direction of wind speed is essential because it makes clear the impact of the region's geographical features on the wind. As indicated by table 1, wind speed at heights of about (10m and 30m and 50m) is shown along by associated winds direction. [15][16][17]

2.3. The wind spectrum:

It's possible to depict the wind speed as follows [stationary process that is Gaussian and stochastic as well], the spectral-analysis process of the wind-speed is explained theoretically. This is how it can provide the distribution fit for the wind-energy-power at each of the frequencies points through the constructing of the spectrum of wind-speed from time series data-points; this is primarily a conversion method from time-domains of the wind-speed data values used to frequency-domains for the exact-same dataset values, that is to be successfully carried out employing (the-Fast-Fourier-Transform the-FFT). [9.] Below is schemed graph that shows the values of energy for the wind speed-components by every frequency-points that is produced by multiplying and plotting a set of wind speed data points with respect to frequency.[18] [19][20]

3. .Results and discussion

The data sets was recovered from a (met mast - metrological towers) using the sensors positioned at the met masts for at minimum one-year period for each 24-hours wind records for the chosen location of analysis for the wind speed at Al-shihabi location from December 2014 to December-2015. at an interval

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of a 10- minute on the [10-m and 30-m and 50-m] heights levels equally for the morning-time-hours and night-time-hours. 10-min-datas values had to be readjusted every day for the morning and evening hours, as well as at the specified heights (10, 30, and 50 m). After conducting a statistical analysis, creating a Weibull-distribution, and finishing the-wind-rose-scheme, the process of Spectral-analysis through means of the [FAST-FOURIER-TRANSFORM the-FFT] was introduced.

3.1. **The statistical analysis:**

The data must be statistically analysed to create very comprehensive representation of the wind-speed characteristics at chosen location, with the findings shown in table 2.

The Mean winds-speed: maximum mean-values of daily wind-speed data for night-time-hours has been valued to be 7.02418 m/s at the 50 m height level, while the maximum value-points of daily averaged of wind-speed in the morning-time-hours was valued to be 6.40127000 m per sec for the 50 meter. This is confirmed by looking at table 2, which shows that max. values of the data points for wind-speed-data was at height of 50 m because at this height level because the surfaces roughness has no-more present, whereas minimum daily-wind-speed value points that's in the 10meters height-levels since study's area that's owns features of flat-topography and a dry-deserts climate and a great temperature's-records with little rains-fall, the roughness create a significant impact on decreasing the wind speed. Looking through the solar heating's impacts of the sun-plant that has a significant impact on wind-speeds. Since the averaged-wind-speed for the morning-time-hours found to be 5.01512 (m per sec) meanwhile in night-time-hours it was stated as (4.843012 m per sec), it's obvious that in morning-time-hours have greater-values than that for night-time-hours.

Table2 .the parameters of statistical process for the wind-speed datasets

Morning-Time-Hours								
Height-levels (meters)	Mean wind speed-Ū (m per sec)	Max.value AND Min.value	The-Range	The-Median	The-Standard deviation(S.D.)	The-Skewness	The-Kurtosis	The-Confidence level(95%)
10	5.11242	14.51569 & 0.66305	13.852	4.539	2.99	0.841	0.148	0.307
30	6.07019	16.42069 & 0.8443	15.576	5.573	3.273	0.815	0.11	0.336
50	6.40127	17.25791 & 0.67	16.587	5.78	3.465	0.773	0.014	0.356

Night hours								
10	4.16404	10.87069 & 1.11819	9.752	3.793	1.912	1.078	1.053	0.196
30	6.1427	13.1168 & 1.17333	11.943	5.85	2.239	0.541	0.169	0.23
50	7.02418	14.54164 & 0.71875	13.823	6.785	2.715	0.303	– 0.256	0.279

3.2.The Weibull distribution results:

Table 3 summarizes the results of achieving the Weibull probability function, which suggests that real distribution data is accurately fitted by the Weibull distribution. Table 3 lists the shape parameter (k) for Weibull function and scale parameter (c) ,which were calculated for each height level.

Table3. the shape and scale parameters for the Weibull distribution.

Morning hours		
Height Levels (m)	Weibull Scale parameter -A (m/s)	Weibull Shape parameter- A
10	5.772	1.808
30	6.874	1.975
50	7.245	1.962
Night hours		
10	4.714	2.314

30	6.886	2.935
50	7.890	2.797

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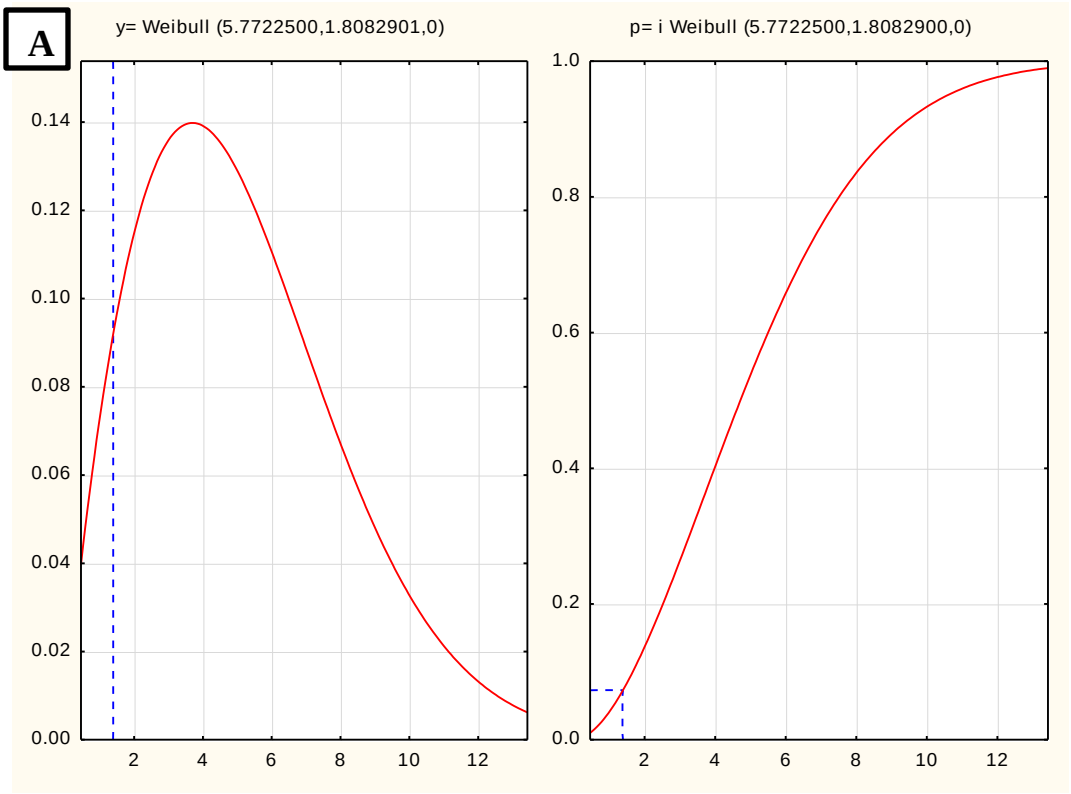

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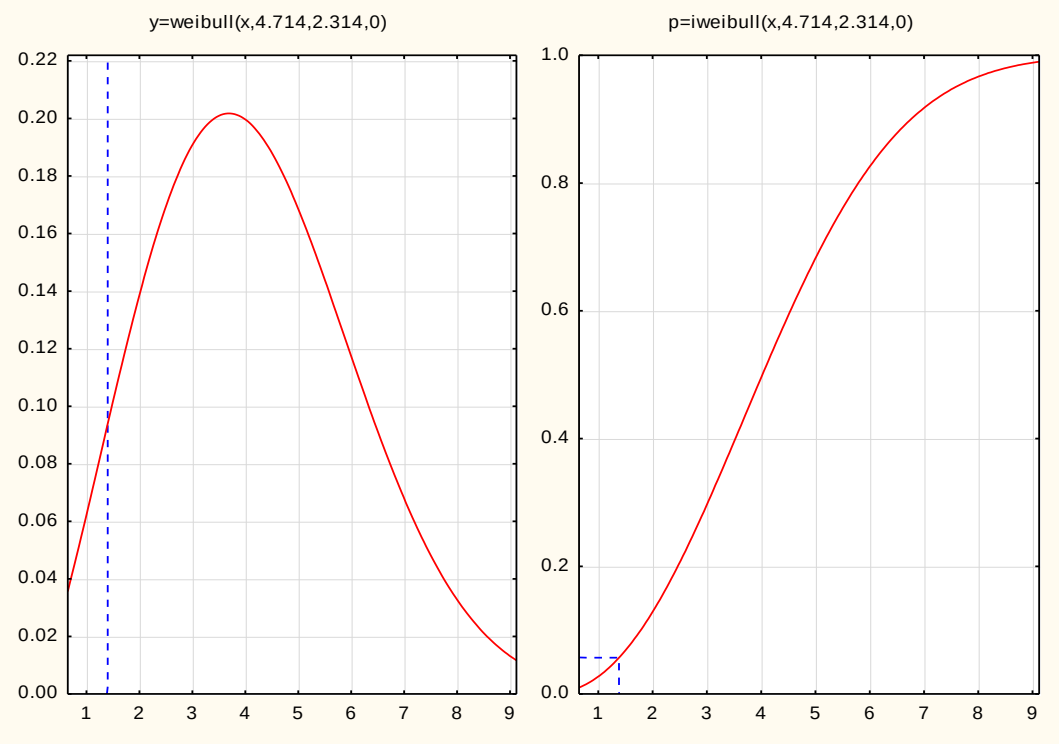

Fig2. The-Weibull-distributions. for the 10-meters throughout (A.) morning-times (B) night-times.

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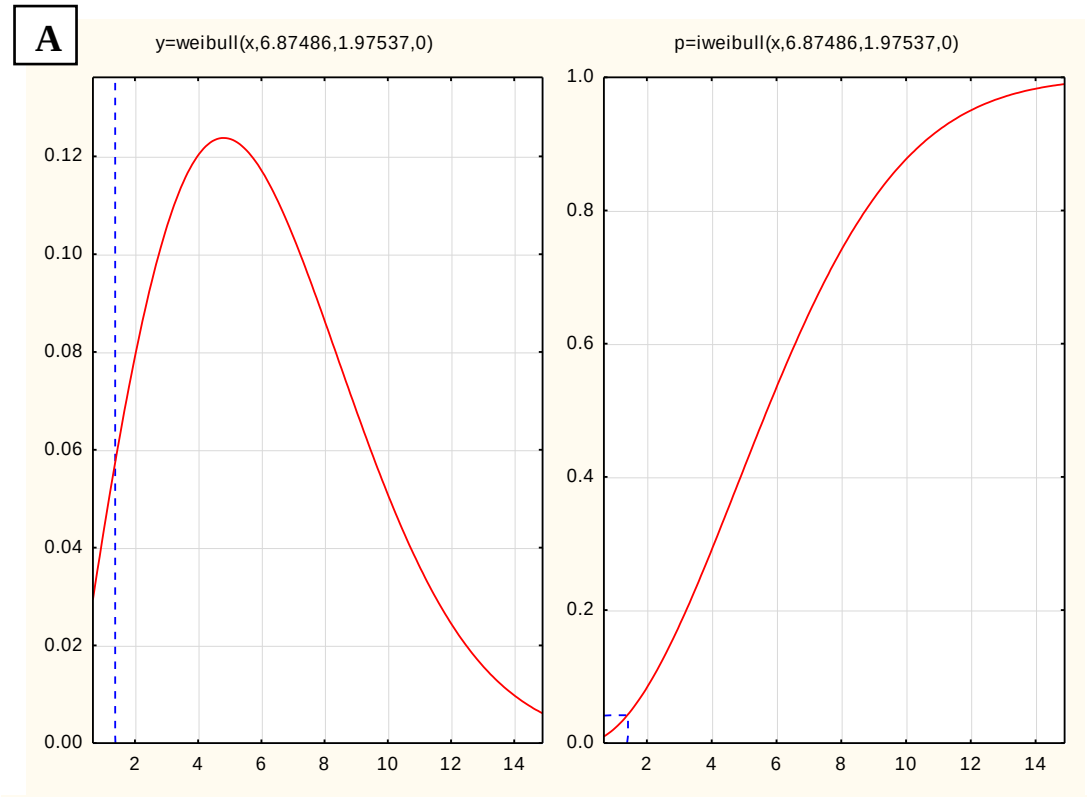

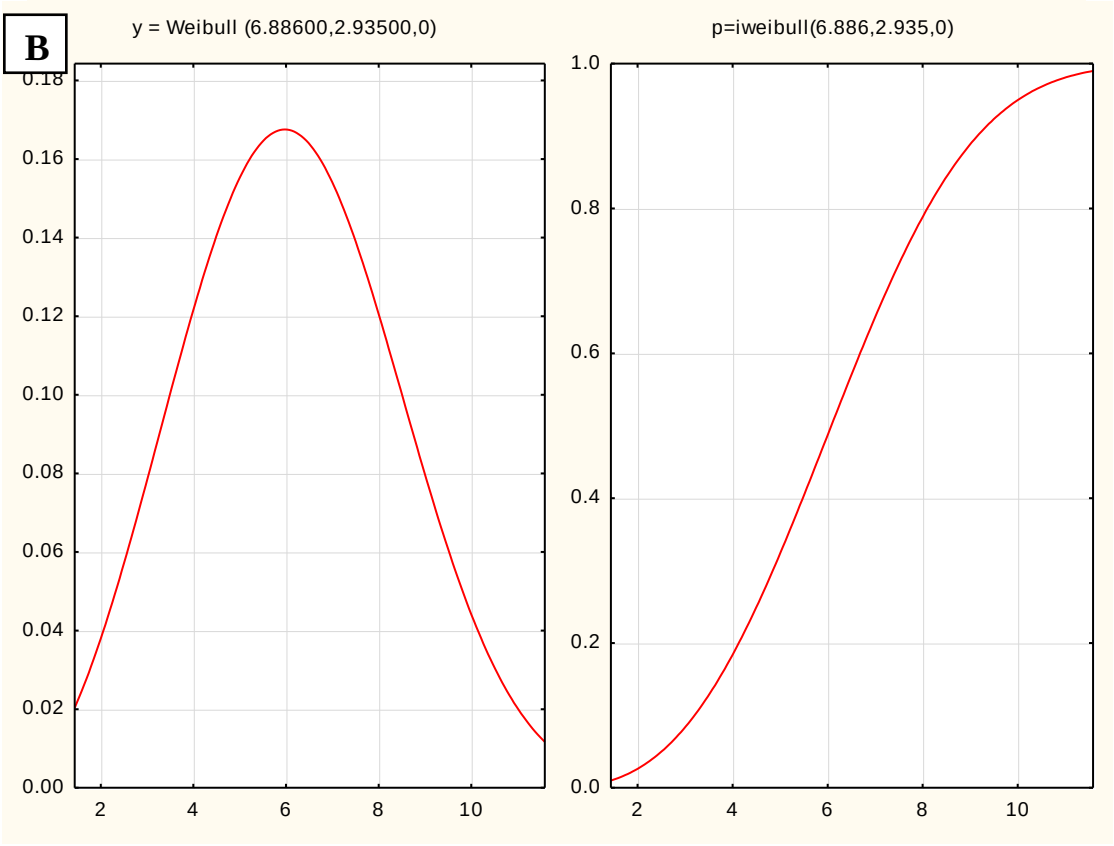

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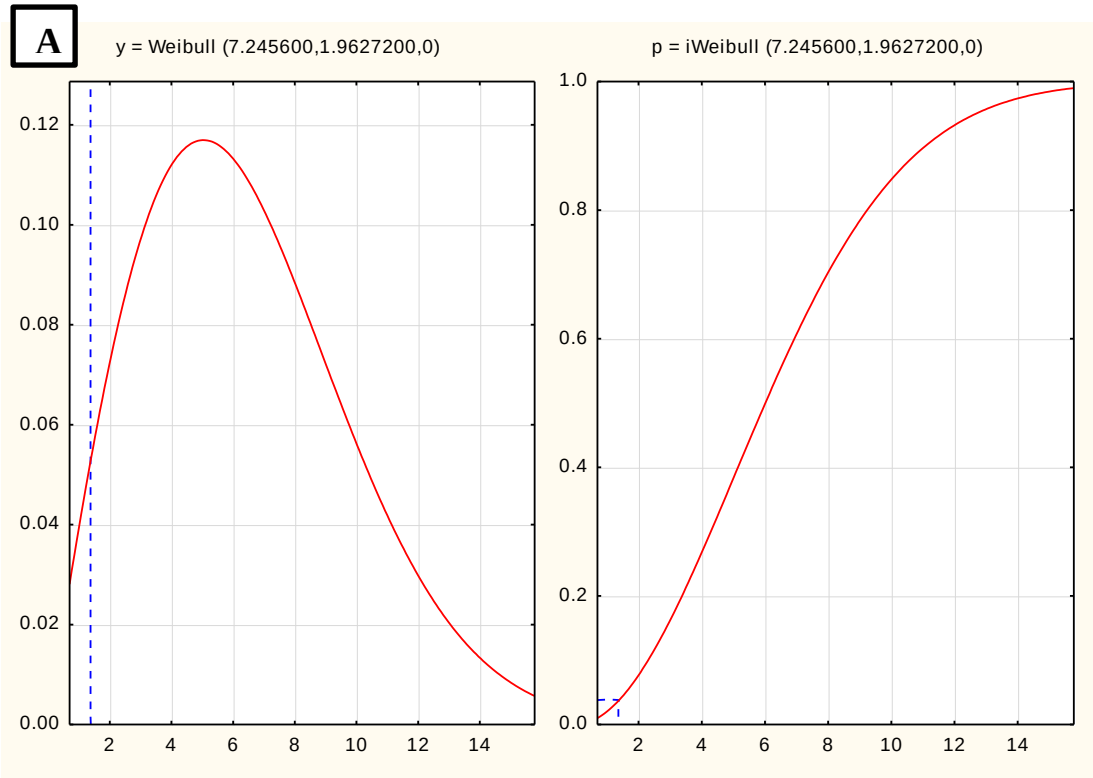
Fig.3. The-Weibull-distributions. for the 30-meters throughout (A.) morning-times (B) night-times.



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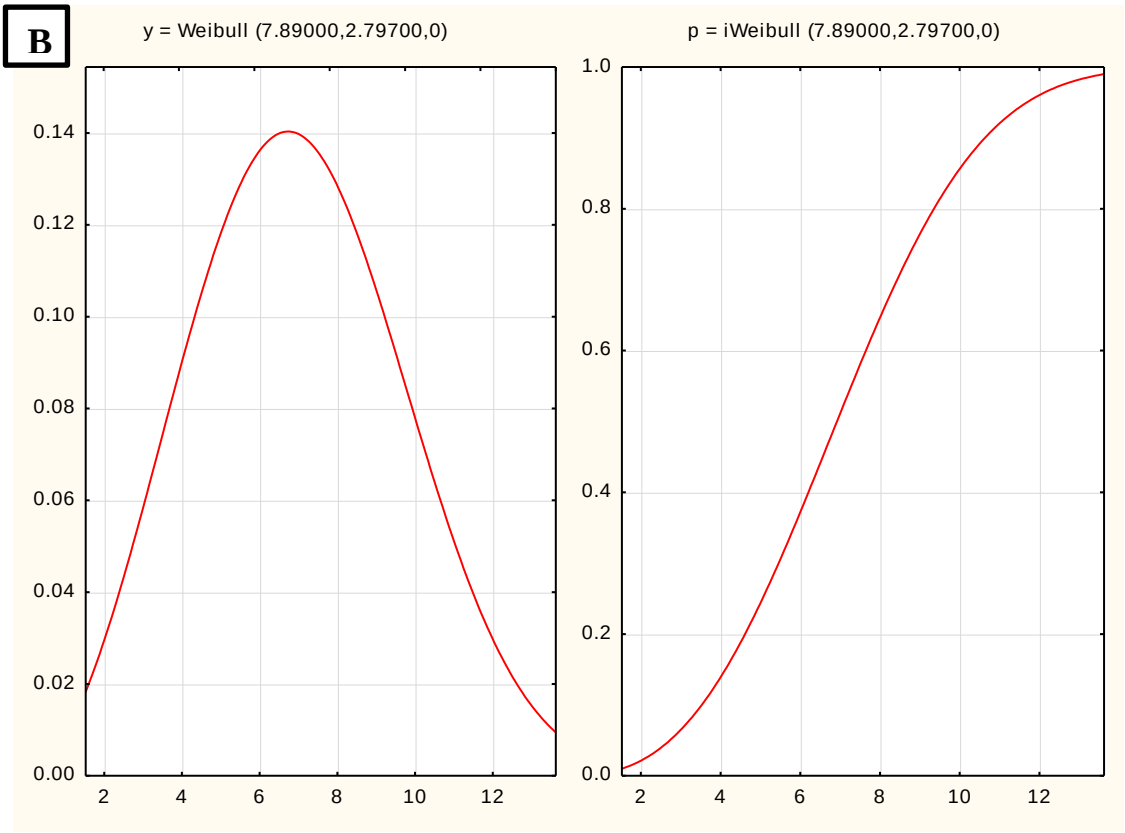

Fig4. The-Weibull-distributions. for the 50-meters throughout (A.) morning-times (B) night-times.

3.3. The wind rose:

A wind rose scheme was created to display the direction and speed of the wind at various elevation levels and during the day and night. The following plots shows that for wind-speeds in the heights-levels about 10-meters maximum value 28.39342 m/s was at the 280°.-300°. Whereas in about 30-meters height max.value of the wind-speed-data found to be in the sector 280°.-300°. equals [28.3749600 m per sec] meanwhile lowest value for the wind-speed lays in sector 180°.-200°. that was [1.47496 m per sec], directions sector which experienced greatest wind-speeds values ranged between 280°.-300°. That had valued about [28.3934200 m per sec]. However, at 50 meters, the wind speed extended from 1.27005 m/s at 200° -220° to 28.66478 m/s at 300° - 320°. At this location, the dominant wind direction was precisely in North.- West. At exactly in the west.-northwest. sector also the north.-northwest. Sector donated as (WNW, -NNW,), whereas moderate winds-directions found to be in South-West and West.-southwest. Donated as (SW.-WSW.).

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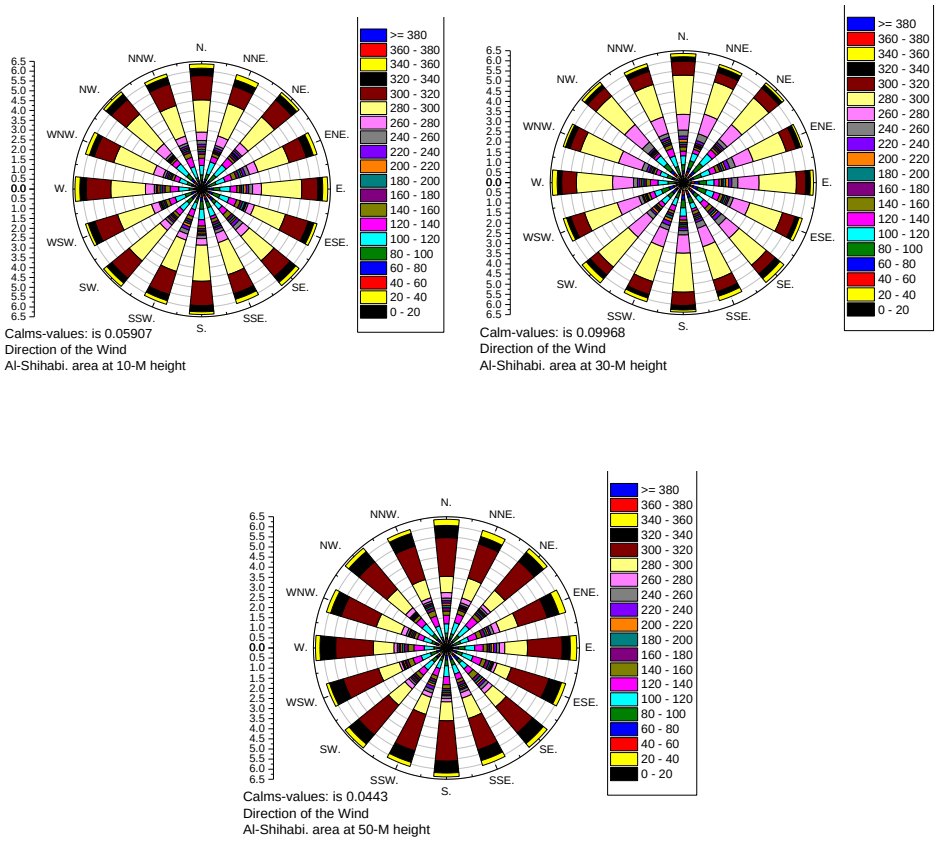

Fig5. Wind rose plot for the three height levels 10-m, 30-m and the 50-m.

3.4. **Time-series schemes:**

Schemes of daily values time-series has been charted in on the way to look at overall development in the speed values of the wind, and it is found to be about (7.02418900 meter per second) represents greatest values for the 50-meter at night-time hours while (4.16404200 m per second) represents lowest-value for the 10-meters height.

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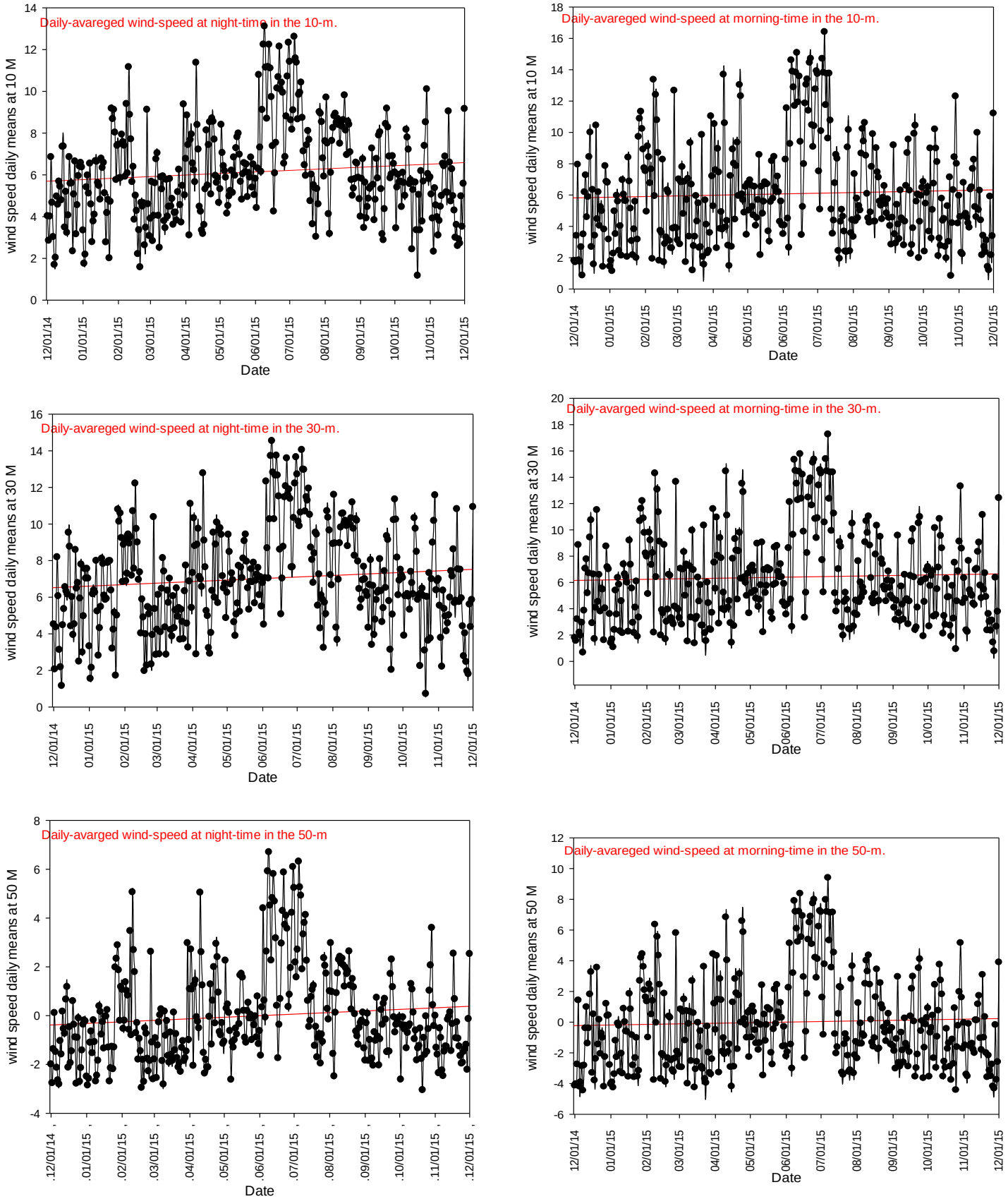

Fig6. Time-series plots in the morning-time hours and the night-time hours at 10m, 30m,50m.

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3.5.The Spectrum:

(The [Fast-Fourier-Transform FFT]) has been considered for time-series analysis for the acquired dataset values in order to calculate the 'power-spectral-density' ['PSD'] ,named the wind spectrum. The power-spectrum for the speed parameter of the wind has been created in Al-Shaabi. area for daytime and night time in the selected height-levels that's (10m, 30m and 50 m). An analysis of the peaks values indicates that the greatest value of [spectral-density-**SD**] in Al.-Shaabi which equals (185912.07801 m./s./12-hour) in (2-Hz) frequency level for the height level (50-m) above sea during night times, while the value (95161.336900 m./s./12-hour) was the lowest for (2-Hz) frequency level in 10-meters height-level throughout night times.

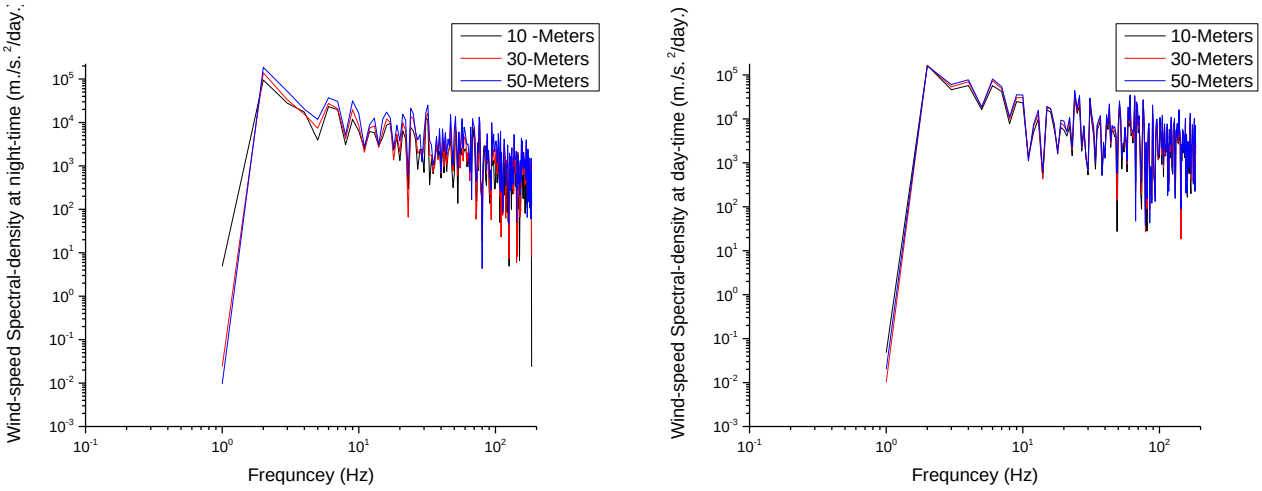

Fig7. Spectrum of the wind-speed in the 10m, 30m and 50m at night-times and morning-times.

4. Conclusion:

Wind power potentials in the Al-Shihabi area were described by analyzing wind datasets at heights of 10, 30, and 50 meters above the ground. The findings are as follows:

The wind speed is greater in the morning than it is at night, averaging 6.40127 m/s at a height of 50 m, with a standard deviation of 3.465.

The data attained from the actual measurements exhibits a good agreement with the Weibull distribution function at (10m, 30m, 50m) height levels.

wind-rose plots indicated that the two main wind directions are north-northwest and west-northwest.

For the heights of 10, 30, and 50 meters, the spectral density peaks for Al-Shihabi show that there is a greater agreement during the day than at night.

According to this analysis of wind data at the Al-Shihabi location, there is a reasonable amount of potential for conducting wind power assessments.

Finding alternative energy sources is necessary since energy is essential to both social and economic development. In the Al-Shihabi area, the study's findings support the use of wind energy.

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