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Novelty in Modifing the Weibull Distribution by Using Fast Fourier Transformation for Wind Energy Assessment

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ABSTRACT

Wind energy considered to be the most recent source of power that inexpensive, non-depleting, also simple for a variety of users to capture and employ. The location of Ali El Gharbi is one of the preferable sites for clean energy production in Iraq, however as there is a lack of information about the power exploration potentials at this place, more related researches and studies for wind power wind are fundamental. An accurate comprehension for the behaviour of the wind is required for the preparation and operation of every wind conversions to energy project.

The study is aimed at investigating the novelty in modifying the Weibull distribution by means of the Fast Fourier Transform with the purpose of estimate the possibility of wind energy harvesting in Ali El-Gharbi area of Ammarah, Iraq. The results from the modification of the Weibull distribution was a reduction in the value of the shape parameter for the new Weibull distribution which will lead to a smoother curve, the reduction of the shape parameter from about 5 to 1 implies a shift from the scenario where failures occur randomly and independently of the parameter. A second benefit of the modification was a reduction the time for calculation the Weibull parameters and PDF's with increasing the accuracy. As an outcome of the wind speed data values were recorded at a 10-minutes interval for a year starting from December 2014 till December 2015 at heights of 10, 30, and 50 meters. Subsequently, the datasets were examined by means of the Weibull probability distribution function (WPD) to assess wind energy production, and for the spectral part of the analysis was conducted by employing the Fast-Fourier-Transform. According to the spectral analysis for the data, the average yearly wind speed at 50 m was 6.134 m/sec, whereas highest wind speed recorded there during the day were about 17.011 , and the peak

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wind speed was 226236.282 m/sec/12hour at a frequency(2 Hz) at that height of 50 m all through night hours. And for lowest values of wind speed was about 115863.7 m/sec/12hour for the (2 Hz) frequency at that height throughout night hours. The blowing of wind was more rapidly in the morning than it was at night periods. While the main wind directions in the region were from the north-northwest and west-northwest.

الاصالة في تعديل توزيع ويبل باستخدام تحويلات فورييه السريعة لتقييم طاقة الرياح

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ملخص: تعتبر طاقة الرياح من أحدث مصادر الطاقة، فهي غير مكلفة ولا تستنزف ، كما أنها سهلة الاستخدام من قبل مجموعة متنوعة من المستخدمين. يعد موقع علي الغربي أحد المواقع المفضلة لإنتاج الطاقة النظيفة في العراق، ولكن نظرًا لوجود نقص في المعلومات حول إمكانات استكشاف الطاقة في هذا المكان، فإن المزيد من الأبحاث والدراسات ذات الصلة بطاقة الرياح أمر أساسي. يتطلب الأمر فهمًا دقيقًا لسلوك الرياح لإعداد ونصب اي مشروع من مشاريع استغلال طاقة الرياح. تهدف الدراسة إلى التحقيق في الاصالة في تعديل توزيع ويبل عن طريق تحويلات فورييه السريعة بهدف تقدير إمكانية حصاد طاقة الرياح في منطقة علي الغربي في العمارة، العراق. كانت النتائج المترتبة على تعديل توزيع ويبل انها اعطت قيمة منخفضة في قيمة معامل الشكل لتوزيع ويبل الجديد مما سيؤدي إلى منحنى أكثر سلاسة، ويعني انخفاض معامل الشكل من حوالي 5 إلى 1 تحولًا عن السيناريو حيث تحدث الأعطال بشكل عشوائي ومستقل عن المعامل او المتغير الذي يتم حسابه.

كانت الفائدة الثانية للتعديل هي تقليل وقت حساب معلمات ويبل وبيانات توزيع الاحتمالات مع زيادة الدقة. ونتيجة لذلك، تم تسجيل قيم بيانات سرعة الرياح بفاصل زمني قدره 10 دقائق لمدة عام بدءًا من ديسمبر 2014 حتى ديسمبر 2015 على ارتفاعات 10 و 30 و 50 مترًا. بعد ذلك، تم فحص مجموعات البيانات عن طريق دالة توزيع احتمالات ويبل (WPD) لتقييم إنتاج طاقة الرياح، وتم إجراء الجزء الطيفي من التحليل باستخدام تحويل فورييه السريع. وفقًا للتحليل الطيفي للبيانات، كان متوسط سرعة الرياح السنوية عند 50 مترًا 6.134 مترًا في الثانية، في حين كانت أعلى سرعة رياح مسجلة هناك خلال النهار حوالي 17.011 مترًا، وكانت ذروة سرعة الرياح 226236.282 مترًا في الثانية / 12 ساعة بتردد (2 هرتز) على ارتفاع 50 مترًا طوال ساعات الليل. وبالنسبة لأدنى قيم سرعة الرياح فقد بلغت حوالي 115863.7 متر/ثانية/12 ساعة للتردد (2 هرتز) عند ذلك الارتفاع طوال ساعات الليل. وكان هبوب الرياح أسرع في الصباح منه في فترات الليل. في حين كانت اتجاهات الرياح الرئيسية في المنطقة من الشمال الغربي والشمال الغربي.

الكلمات المفتاحية – طاقة الرياح؛ سرعة الرياح؛ التوزيع الطيفي؛ سلسلة فورييه؛ توزيع ويبل.

1. INTRODUCTION

The world is moving towards renewable energy therefore mostly for home use, renewable energy sources have the ability to produce comparatively clean energy, the production of wind power is anticipated to increase soon and has increased dramatically in many nations during the last ten years. Wind speed is the most crucial factor that needs to take into account while planning and researching wind power conversion systems. Green power sources are clean, environmentally friendly, and renewable, and do not emit harmful gases that pollute the environment, such as carbon dioxide and methane, and since their source are natural, they are not exhausted,[1] The total CO2 emissions were strongly related to oil prediction. Renewable energy generation and its technologies are many and different, as they are generated from wind energy, directly from the sun, from ocean energy, from energy generated in the ground, from biomass, from hydropower, or geothermal energy resources. The convective layer is a turbulent layer that affects the movement of horizontal winds and thus the generation of wind power finding a suitable place where the yearly wind speed is high to harvest high power is one of the essential topics in the field of the wind assessment before creating a wind farm.[2], [3]

Researchers analyzed the effect of disturbance intensity and concluded that there could be differences in the values of high and low disturbance intensity that may reach 3% of annual energy production, and there are also differences in annual energy production that may reach 4% between unstable and neutral conditions. Used the SAM software to evaluate wind energy through his research project Weibull parameters approximation for wind energy use in El Shihabi area. With the program, he was able to reach the best productivity in the study area's prevailing wind direction. In the present study, an investigation aim is to define the atmospheric stability conditions and atmospheric turbulence of the study area over many factors employed in the wind harvesting industry, and their connection to deviation in yearly energy production.[4]

The weibull distribution is a commonly used statistical model in various fields including reliability engineering, probability analysis, and density analysis. However, the standard Weibull distribution may not always accurately capture the complexity of real-world data, particularly when dealing with large datasets or data with deviations from the assumed model. To address these limitations, researches have been proposed modifications and extensions to the weibull distribution, aiming to enhance its flexibility and applicability.[5]

One such approach is the use of Fast Fourier Transformation to modify the weibull distribution. This novel technique has shown promising results in capturing the asymmetry and high similarity observed in the data distributions, such as those encountered in wind energy assessment and wind distribution function. The modified weibull distribution with FFT (Fast Fourier Transformation) offers greater flexibility in modeling a wide range of real-world data, including those with high skewness and kurtosis.

Modifying the Weibull distribution using Fast Fourier Transformation (FFT) can significantly enhance the accuracy of wind energy assessments in Iraq by providing a more precise representation of wind speed data. This approach allows for the generation of synthetic wind speed time series that closely mimic the statistical properties of actual wind data, which is crucial for reliable energy production forecasts by enhancing data generation since the phase-randomized Fourier transform model generates realistic surrogate time series that maintain the power spectral density of the original data, improving the fidelity of wind speed simulations [6] and also provides statistical descriptor accuracy This method ensures that the synthetic data aligns with the statistical descriptors of the target datasets, capturing nonstationary variations in wind speed, which is essential for accurate energy assessments, improved parameter estimation by employing maximum likelihood estimation on multiple time scales, the modified Weibull distribution can better reflect the temporal characteristics of wind speed, leading to more accurate energy output predictions[7] It can provide an error reduction since the accurate parameter estimation reduces potential errors in energy forecasts, as even minor inaccuracies in wind speed can lead to significant miscalculations in energy production.[8]

While the FFT modification offers substantial improvements, it is essential to consider the limitations of synthetic data, such as potential discrepancies between modeled and actual wind conditions, which may affect long-term assessments [9]

One promising opportunity for improving the weibull distribution is the incorporating of the FFT techniques. The Fast Fourier Transformation is a powerful analysis tool that can be employed to the wind speed analysis and transform data in frequency domain. This paper explores the novelty and potential benefits of using the Fast Fourier Transformation to modify the weibull distribution, with the goal of better capturing complex data patterns and improving model performance.

The location of the study sets in south of Iraq, Ali El-Gharbi city in which is located in Ammarah district and the data used here is from December 2014 until December 2015. The application of a zero-map improvement was accomplished for the Iraqi lands, which classified (Ali Al-Gharbi) to be one of the best favorable sites for the purpose of harvesting the wind energy.

2. STUDY AREA

Ali Al-Gharbi city located 110 km northeast of Amara province and 27 km away from the Iraqi-Iranian borders, at longitude and latitude (32.4617°N -46.6878°E), it is located at an altitude of 44 meters above sea level. the location with a hot desert climate hot and dry summer with temperatures exceeding 40°C, winters are moist with rainfall that's intensifies in the winter months with an averages of 177 mm per year. Being it an open area without obstacles, the geographical location lets the wind to reach potential high values, table (1) shows the specific features for the Ali El-Gharbi region. Field data was recorded from the meteorological station (Ali al-Gharbi) installed in the meteorological tower to monitors the wind speed and its direction, in addition to other secondary parameter (neglected in this study) such as relative humidity, pressure, radiation intensity, and rainfall, etc. at 10-minute intervals and at heights (10,30 - 50 meters) that approved by the Ministry of Iraqi science and technology, On the other hand, some atmosphere data (cloud cover data) are downloaded from the five models (ERA5) that return to the website of the European Centre for Medium-Range Weather Forecasts (ECMWF). The devises installed on meteorological tower constructed from (Stylitis-100) loggers from the Greek company (Symmetron), and sensors from the American company (Renewable NRG Systems), table 2 described sensor type, Country of Manufacture, Sensor Time Interval, Accuracy and Working Sensor Range. [3], [4]

Table 1. The study area's features [4].

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)
10	3.77	3.14	3.27	0.35	17.03
30	5.41	3.49	4.93	0.38	19.69
50	6.14	3.79	5.51	0.33	20.61

Table 2. Specifications of the sensors installed in Ali al-Gharbi meteorological tower [3], [10].

Sensor Type	Parameter	Country of Manufacture	Sensor Time Interval	Accuracy	Working Sensor Range
NRG #40C	Horizontal Component of Wind Speed	United States of America	10 minutes	± 0.15 m s-1	(0.33 m s-1) to (24 m s-1)

(Figure 1.) Illustrates the location of the study area on the map, and the meteorological tower at height 50m, which displays the sensors installed at three heights. Building a tower to monitor and evaluate weather parameters considered one of the projects that was funded by the Ministry of Science and Technology for scientific research (Iraqi government) under project of wind energy and the construction of wind farms mission, in Ali Al-Gharbi region, because it considered one of the most promising areas in terms of producing electrical energy using wind turbines. The current study is considered part of many academic studies that addressed possibility of wind power generation in this area, with a modified Weibull distribution technique.[3]

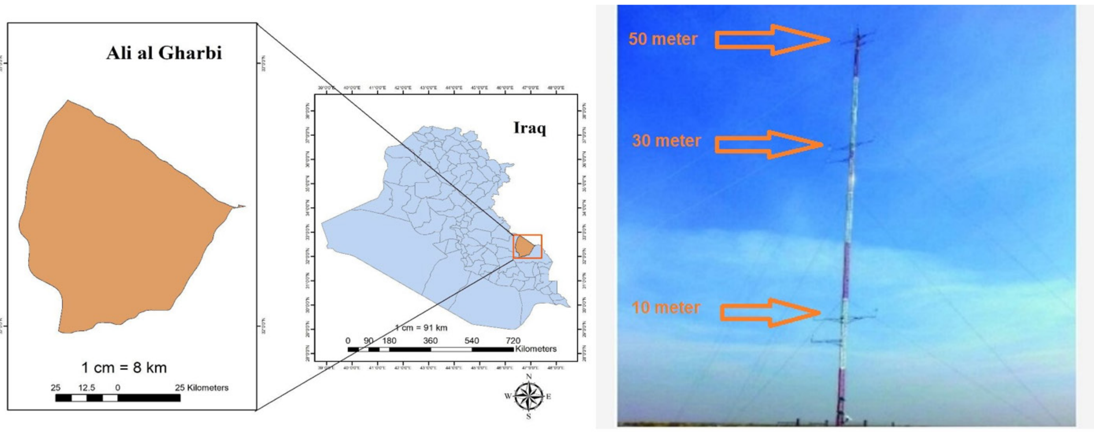


Figure 1. Shows location of the study area on the map, and the meteorological tower at height 50m, which displays the sensors installed at heights (10,30, 50m) [1], [11].

3. METHODOLOGY

For the analysis of wind speed and direction, the data need to be processed first and that is performed statistically by averaging the data on daily basis and divide each day into morning hour (6.00 AM – 6.00 PM) and night hours (6.00 PM – 6.00 AM).The data sets were rearranged and filtered using Excel software, first step was performing a statistical analysis for the data, after that the Weibull distribution was evaluated and the PDF was constructed , next we perform a spectral analysis by employing FFT and then we modified the Weibull distribution by linking it to the Fast Fourier Transformation. The time series and wind rose were plotted. The wind parameter data employed are recorded wind speed (WS) and recorded wind direction (WD) for one year of 2015 at intervals of 10 minutes for three-different heights levels that's (10, 30, and 50 m), that is collected from a meteorological mast located in Ali El-Gharbi region.

4. THE FAST FOURIER TRANSFORMATION METHOD

The Fourier analysis method was originally concerned with representing and analyzing periodic phenomena, via Fourier series, and later with extending insights to non-periodic phenomena, via the Fourier transform. A discrete set of frequencies in the periodic case becomes a continuum of frequencies in the non-periodic case; the spectrum is created. the Fast Fourier transform (FFT) is a set of rules that models a signal over a period of time (or space) and splits it into its frequency components. These components are single sinusoidal oscillations at diverse frequencies every one with their own amplitude and phase. One of the best shared approaches of spectral analysis is the use of the Fast Fourier Transform technique. In this routine a direct Fourier Transform is prepared of the data using an effective algorithm that makes use of the information that the length of the time series has been selected to be an integer power of two $M = 2^n$. Varied radix FFT's are also presented for which $Mch = 2^n\, 3^m\, 5^j$. In putting these techniques the total time series of length $N\Delta t$ is split into a series of smaller parts of length Mch. The spectra for these lesser parts can be averaged into a grand spectrum that owns some amount of statistical reliability. The FFT operates by decomposing an N point time domain signal into N time domain signals each composed of a single point. The second step is to calculate the N frequency spectra corresponding to these N time domain signals. Lastly, the N spectra are synthesized into a single frequency spectrum. Figure (2) shows an example of the time domain decomposition used in the FFT. Where a 16 point signal is decomposed through four stages. The first stage breaks the 16 point signal into two signals each consisting of 8 points. The second stage decomposes the data into four signals of 4 points. This pattern continues until there are N signals composed of a single point. An interlaced decomposition is used each time a signal is broken in two, that is, the signal is separated into its even and odd numbered samples [6], [12].

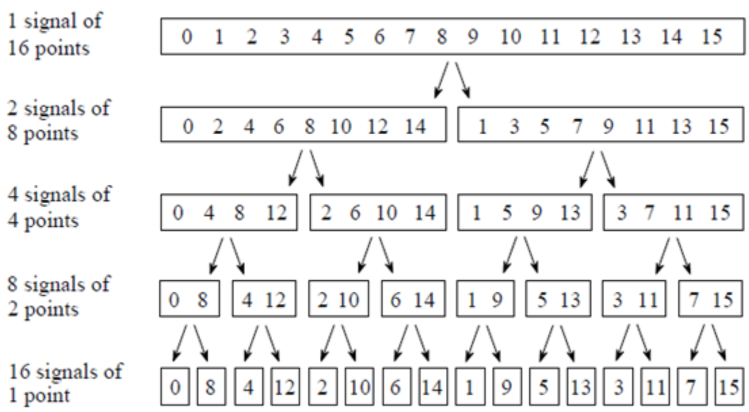


Figure 2. The FFT decomposition [12].

The Fast Fourier Transform formula used in the context of the spectral analysis is given by [6]:

$$F(n)=\sum_{i=0}^{N-1} x_i e^{-\frac{2\pi j}{N}nj} \tag{1}$$

Where x is the data point and N is the length of the series.

5. THE WEIBULL DISTRIBUTION

Modeling the probability distribution of various natural phenomena is a typical use for Weibull distribution, which bears the name of the Swedish physicist W. Weibull. This distribution was first used in the 1930s by Weibull in his research on the strength of materials under strain and fatigue. For more than fifty years, statisticians have been interested in various areas of statistics, as well as theoretical and methodological elements of the Weibull distribution. Countless academic articles possibly thousand has been done about that specific distribution, and studies on it is currently under examining. The Weibull distribution is without a doubt the statistical model that is employed the most frequently. Due to its many unique features that enable it to handle data from a variety of fields, There is many techniques employed to estimate the Weibull parameters (c and k).[13]

One of these techniques is the maximum likelihood method which is the approach most frequently used to estimate parameters. The Multilevel Modelling (MLM) is a good sample due to its many beneficial properties, which makes it a desirable choice to use. As the sample size grows, asymptotic consistency is indicated by the estimate getting closer to the true values [13]. Let the ($\nu_1,\nu_2,\nu_3 \ldots \nu_n$) to be a random sample size (n) that's taken from a PDF'(ν,θ) where (θ) is unknown parameter. The joint density of (n) random variables, which depends on the unknown parameters, is to be the likelihood-function for the random sample. The standard Weibull distribution function is performed and the maximum likelihood method is employed in the calculations of both the shape and scale parameters. Equation (1) for the shape parameter (k) [7], [8]:

$$k=\left(\frac{\sum_{i=1}^{n} v_i^k \ln(v_i)}{\sum_{i=1}^{n} v_i^k}-\frac{\sum_{i=1}^{n} \ln(v_i)}{n}\right)^{-1} \tag{2}$$

When the shape parameter (k) is given, the scale parameter (c) could be valued with equation (2):

$$C = \left(\frac{\sum_{i=}^{n} v_i^k}{n} \right)^{/k} \qquad (\ )$$

Since (v_i) is to be wind speed in any time step (i), and the (n) is to be the number of nonzero wind speed data points.
And the general equation for calculating the Weibull probability distribution is [5]:

$$F(x_i) = \frac{k}{A} \frac{(x_i - g)^{(k-1)}}{A} . exp\left[-\left(\frac{x_i - g}{A} \right) \right]^k \qquad (4)$$

Where $F(x_i)$ is (the probability-distribution) in (W/m^2) for the considered wind-speed value (v) .

6. 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, WS at heights of about (10 - 30 and 50m) is shown along by associated winds direction. [14]

7. THE WIND SPECTRUM

It's possible to depict the wind speed as follows stationary process that is Gaussian and stochastic as well], the spectral WS analysis process 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). [3]

8. RESULTS AND DISCUSSION

The data for the wind speed and direction were obtained from a (met mast) using the sensors positioned at the met mast for one year (Dec 2014- Dec 2015) for every 24 hours, for the selected study area (Ali Al-Gharbi) at three height levels (10, 30, and 50 m) at an interval of 10 minutes, this data had to be readjusted for morning time series and night time series in order to conduct a statistical analysis, after that the Weibull distribution was computed and the PDF's were plotted then the spectral analysis was performed by employing the FFT. The time series was constructed as well as the wind rose, finally the new values of the scale and shape parameters for the modified Weibull distribution were computed and PDf's were plotted.

8.1. The statistical analysis

The data must be statistically analysed to create very comprehensive demonstration of the WS characteristics at chosen location, with the findings shown in table 3.
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 level, while 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 3, which shows that max. values of the data points for WS 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 WS 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.

Table 3 .the parameters of statistical process for the wind speed datasets.

	Daytime								
Period	**Heights (m)**	**Mean (m/s)**	**Maximum & Minimum (m/s)**	**Range**	**Median**	**Standared deviation**	**Skwness**	**Kurtosis**	**Confidence level (95%)**
Daytime	10	4.26847	13.85986 & 0.00755	13.852	3.86	2.771	0.9985	0.583	0.284
	30	5.17901	16.0018 & 0.0126	15.989	4.754	3.077	0.9987	0.601	0.316
	50	5.60011	17.01194 & 0.01416	16.997	5.148	3.235	0.9840	0.582	0.332
Night time	10	3.21539	10.09528 & 0.42708	9.668	2.761	1.968	1.17	1.071	0.202
	30	5.18115	12.42569 & 0.44472	11.98	4.895	2.318	0.632	0.247	0.238
	50	6.13485	13.945 & 0.35105	13.593	5.840	2.7	0.451	0.108	0.277

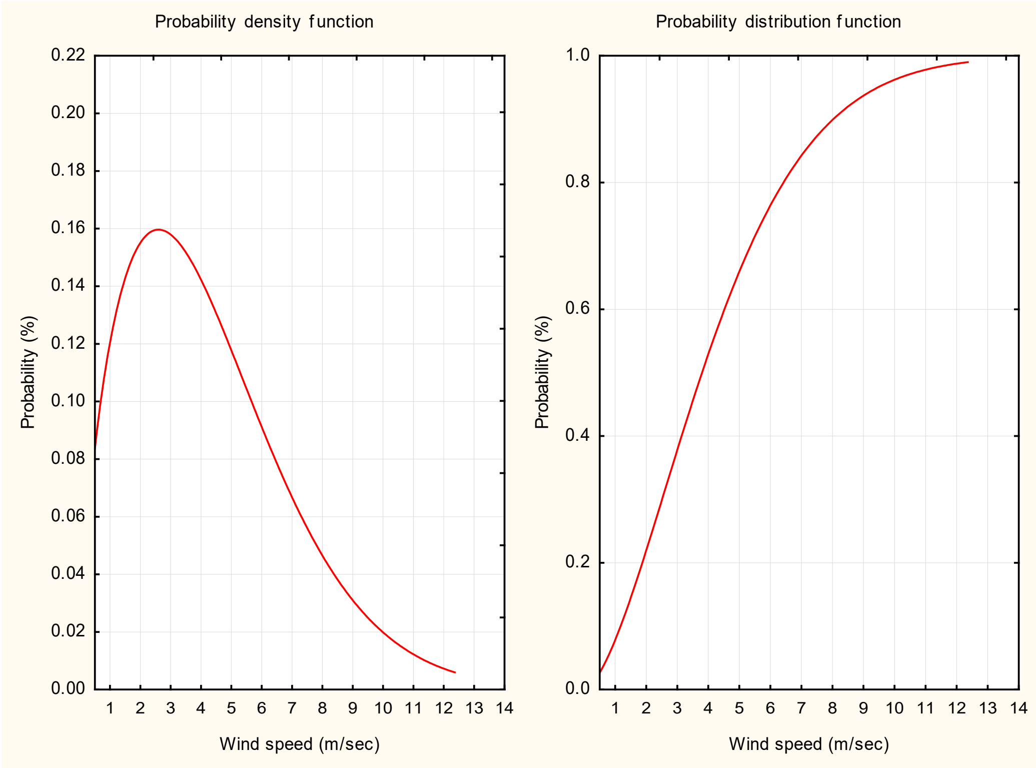
8.2. The Weibull distribution results

Table 4 summarizes the results of achieving the Weibull probability function, which suggests that real distribution data is accurately fitted by the Weibull distribution. The standard Weibull distribution function is performed and the maximum likelihood method is employed in the calculations of both the shape and scale parameters as shown in Table 4 which lists the shape (k) for Weibull function and scale (c) ,which were calculated for each height level.

Table 4. The shape k and scale parameters c for the used Weibull distribution.

Morning hours		
Height Levels (m)	**Weibull's Scale parameter-c (m/s)**	**Weibull's Shape parameter-k**
10	4.773	1.604
30	5.835	1.773
50	6.316	1.824
Night hours		
10	3.631	1.749
30	5.849	2.374
50	6.919	2.421

DAY



NIGHT

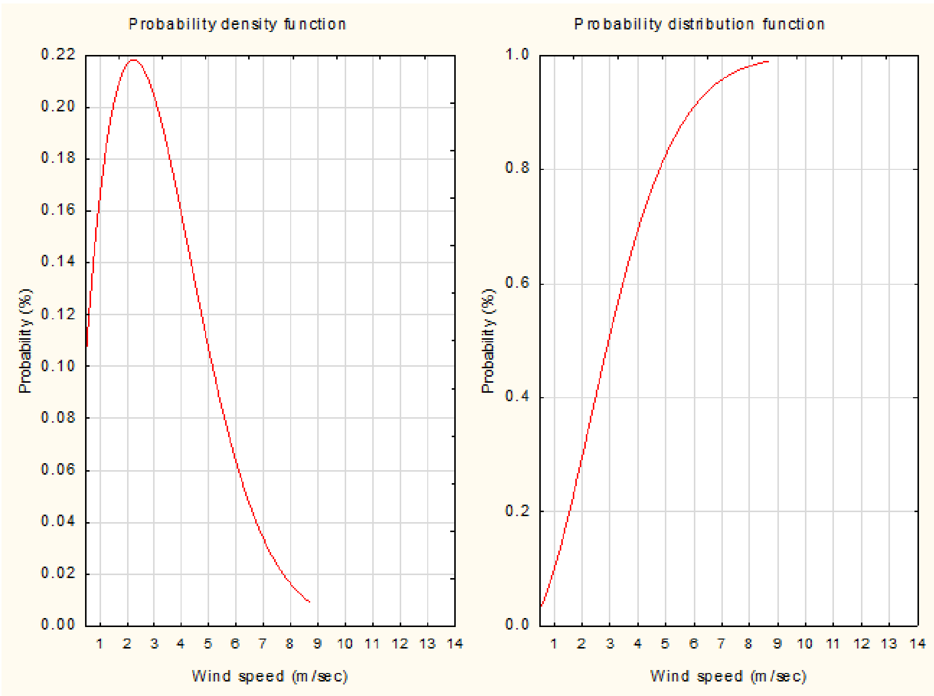
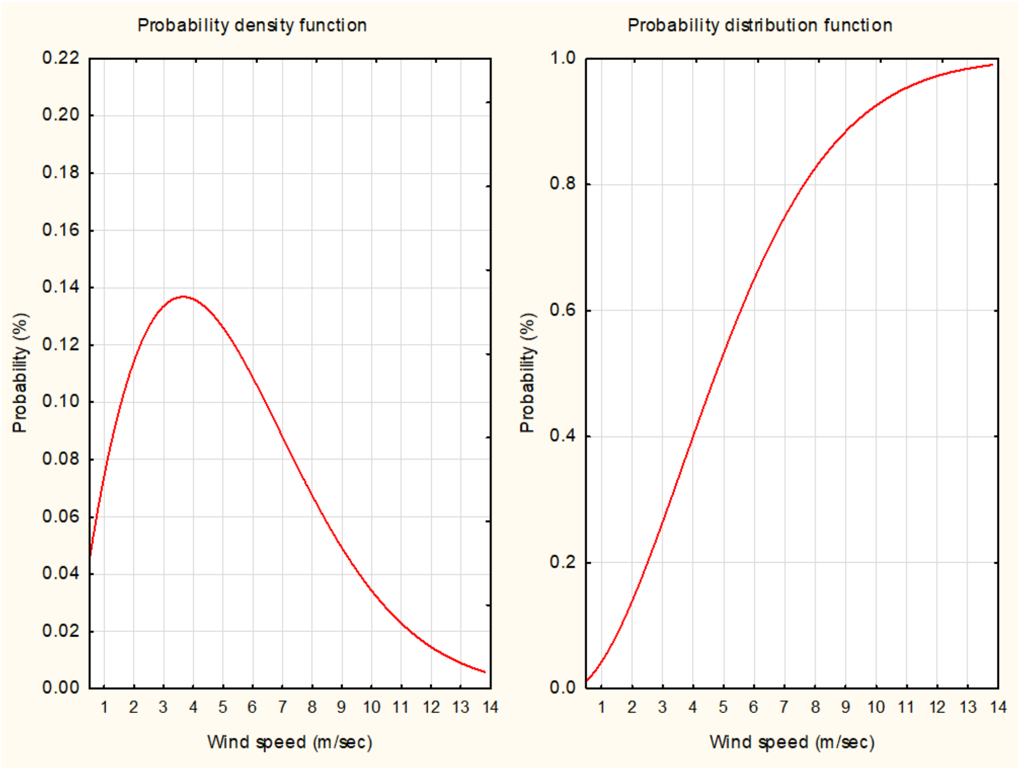


Figure 3. Weibull distribution for Ali al-Gharbi at 10 m during daytime and nighttime.

DAY



NIGHT

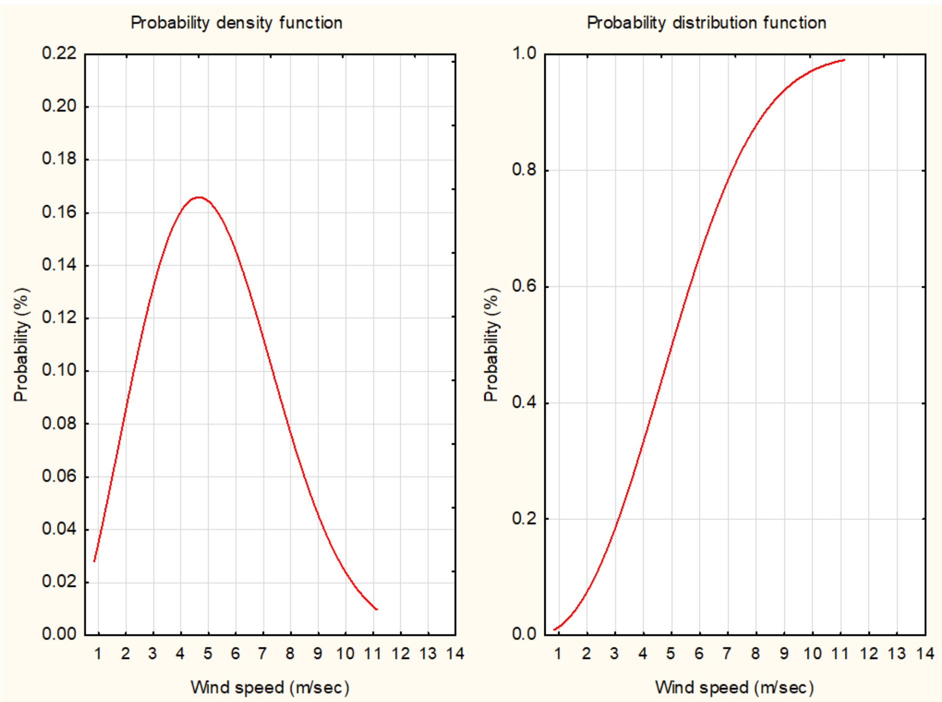
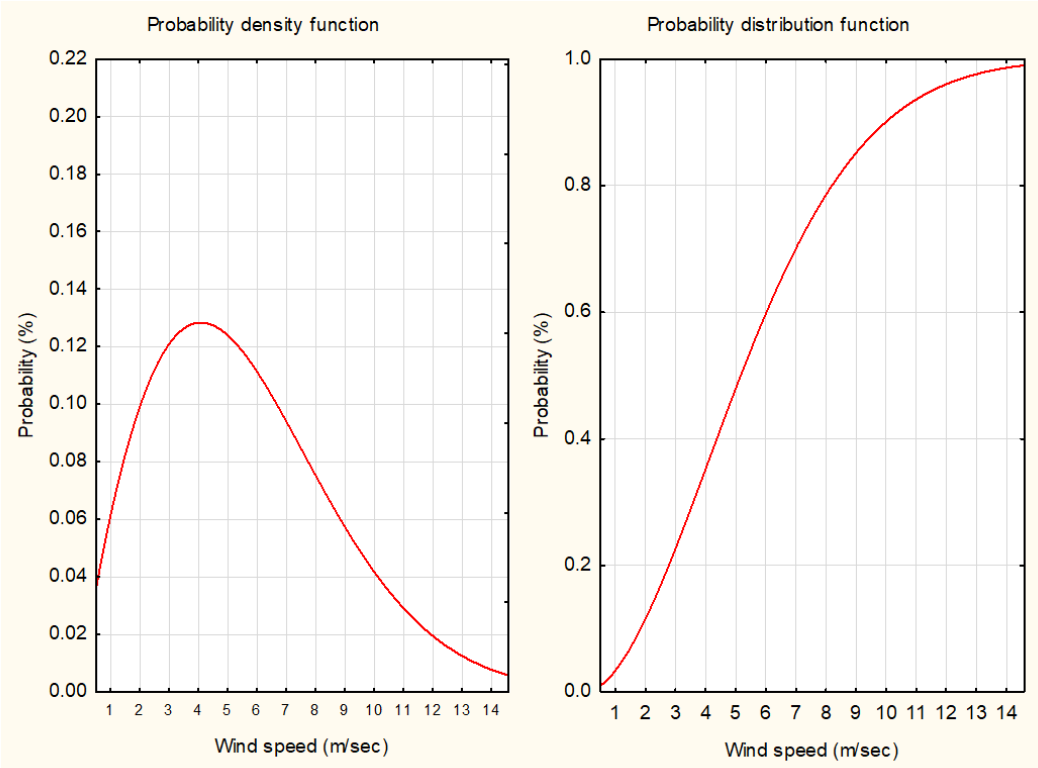


Figure 4. Weibull distribution for Ali al-Gharbi at 30 m during daytime and nighttime.

DAY



NIGHT

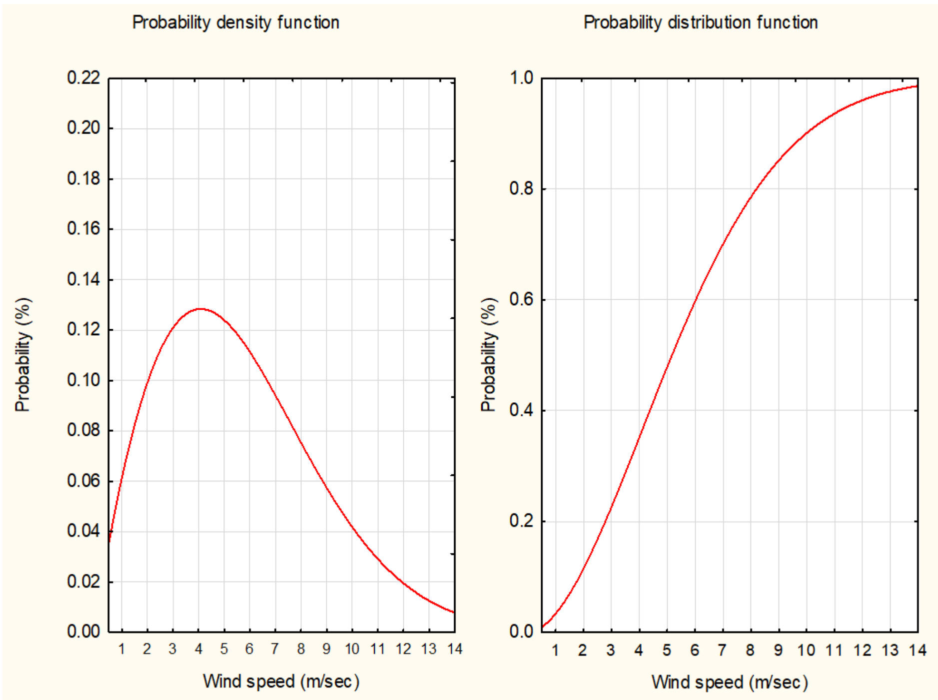


Figure 5. Weibull distribution for Ali al-Gharbi at 50 m during daytime and nighttime.

8.3. Weibull distribution modified using FFT

Considering the Weibull distribution mathematical background it's clear from the results that it's a non-periodic distribution and because of that the calculation process would be very long and therefore the accuracy would be low. A new technique method to modify the Weibull distribution using the Fourier transformation into a periodic distribution function and check for the accuracy of calculation as well. A ten minutes wind speed data sets are employed for the study area were processed as follows:

The resultant wind speed was calculated and corrected to the mean 10 minutes wind speed after that The Fast Fourier Transform applied using the Origin Pro 9.0 after that the Weibull distribution was performed using STATISTICA software where the shape and scale parameters where calculated using equation (2) mentioned before.

The examination of the results obtained show that: the highest scale parameter for Ali al-Gharbi site was (1.52206) at 50 m during the day time. While the lowest scale values at Ali al-Gharbi was (1.10755) for the night time at 10 m as shown in Figure (6-7-8).When it comes to the shape parameter the highest value at Ali al-Gharbi location is (2.26929) at 50 m during the day time and the lowest is (1.69946) at 10 m during the night time.

Compared table (4) with table (5) show that the modified method has reduced the shape parameter which is an important in the Weibull distribution since the shape parameter can change the shape of the curve and even alter the entire distribution.

A validation process has been conducted to determine the accuracy of the calculation procedure specified above using 100 values out of 356 values for each location by using the following formula (Woolmington, et al. 2013):

$$x = \frac{5 - slop}{2} \tag{5}$$

Where x is the data points, and it is found that the error due to rounding and sample size of about 4.2% for Ali al-Gharbi site.

Table 5. The values of shape k and scale parameters c for the modified Weibull distribution.

Morning hours		
Height Levels (m)	**Modified Weibull's Scale parameter-c (m/s)**	**Modified Weibull's Shape parameter-k**
10	1.40512	1.9224
30	1.45551	2.0186
50	1.52206	2.26929
Night hours		
10	1.10755	1.69946
30	1.13344	1.71521
50	1.24923	1.82936

DAY

NIGHT

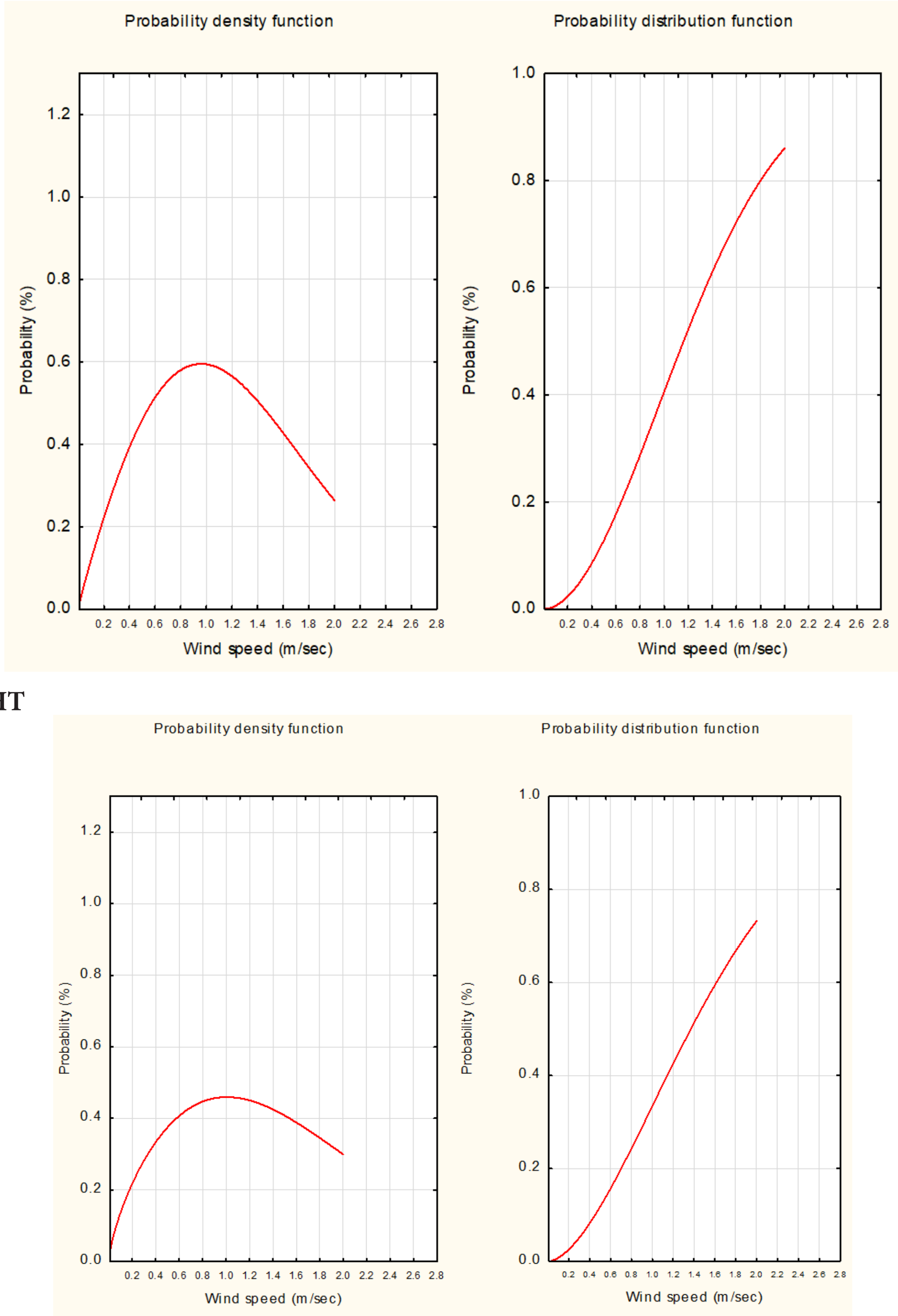
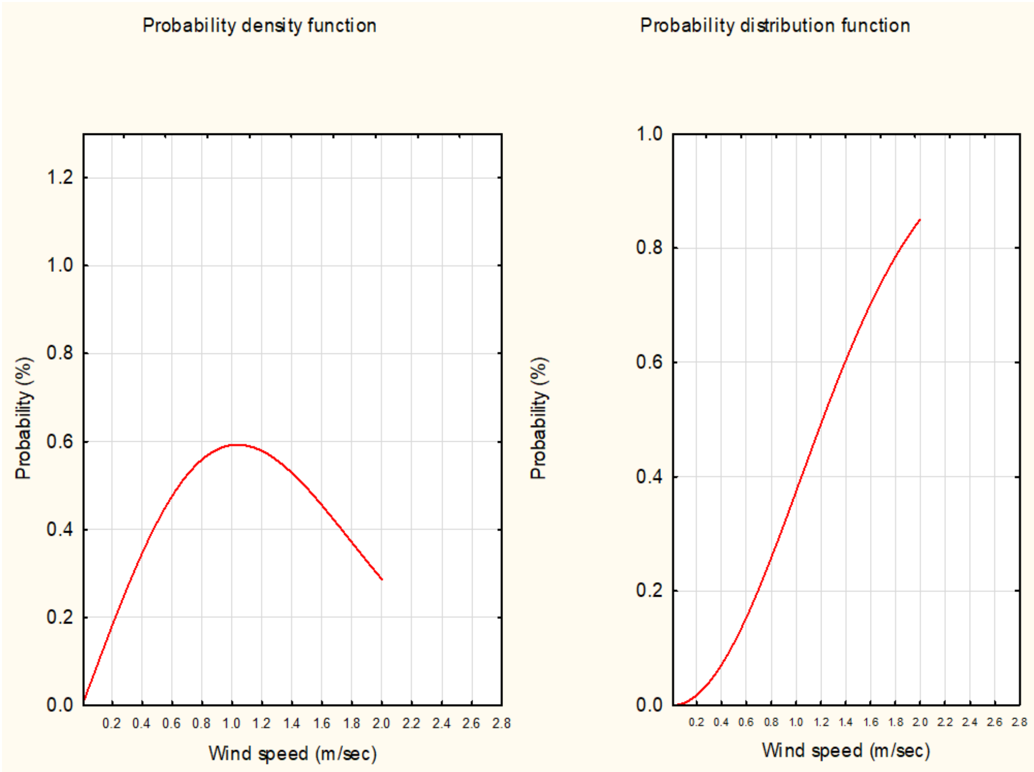


Figure 6. Modified Weibull distribution for Ali al-Gharbi at 10 m during day and night times.

DAY



NIGHT

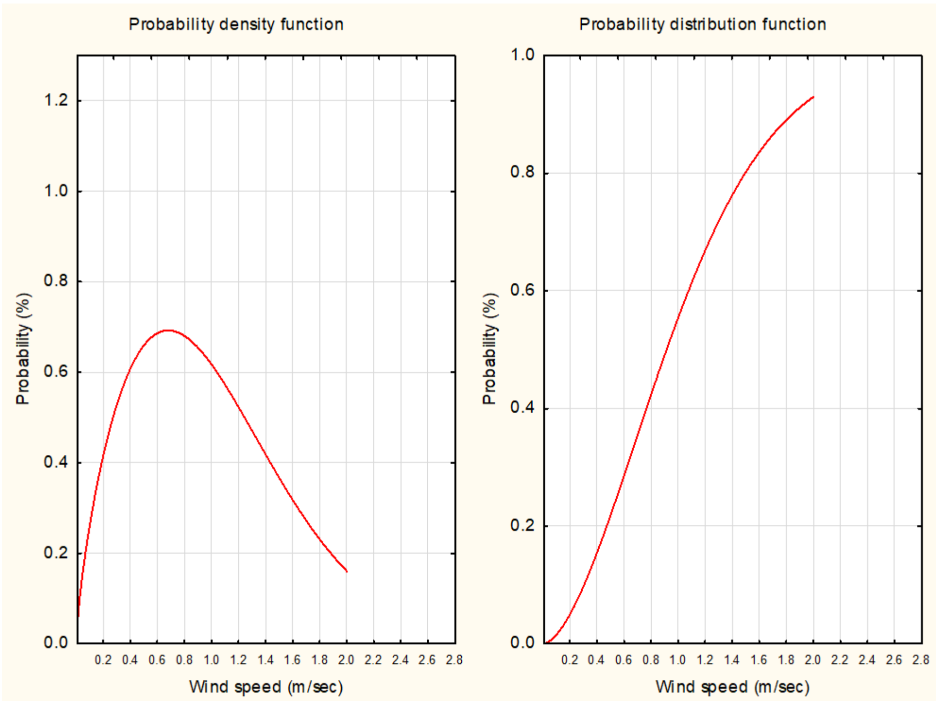


Figure 7. Modified Weibull distribution for Ali al-Gharbi at 30 m during day and night times.

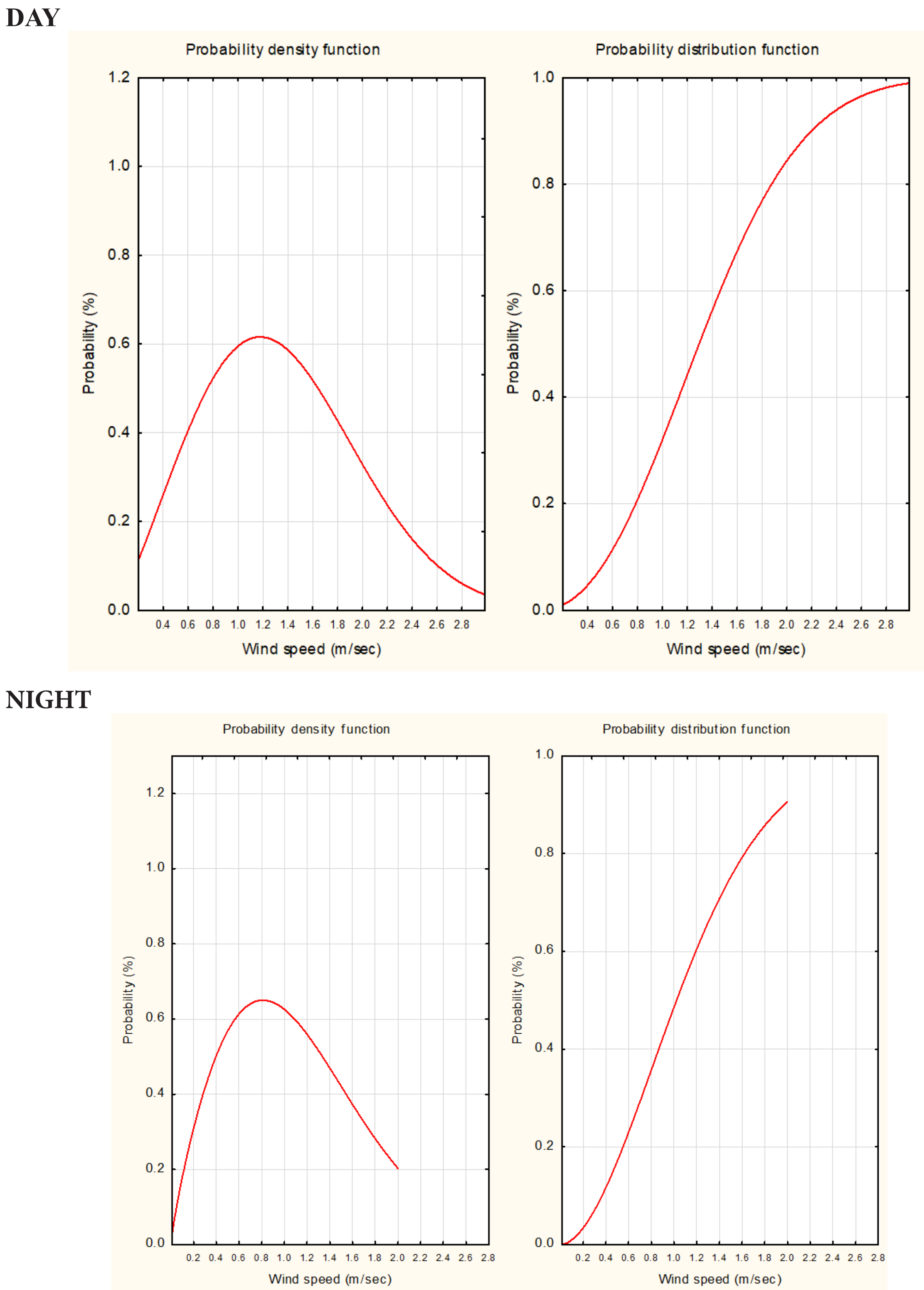


Figure 8. Modified Weibull distribution for Ali al-Gharbi at 50 m during day and night times.

8.4. The wind rose

A wind rose plots has been conducted using the Origin Pro9.0 program for the 10 minute data for daily means, Ali al-Gharbi locations for 12 months over the (10, 30 and 50 m) height levels, from the wind rose plots it's obvious that the dominant wind direction for Ali al-Gharbi the dominant wind direction is at the East –South East (ESE) specifically at the North and whiles the poorest wind direction is at the north as presented through Figure (9). The importance of knowing the wind direction is to determine the location of the wind turbine in order to face the wind and gain as much as possible of the wind speed value that is good for the wind energy production.

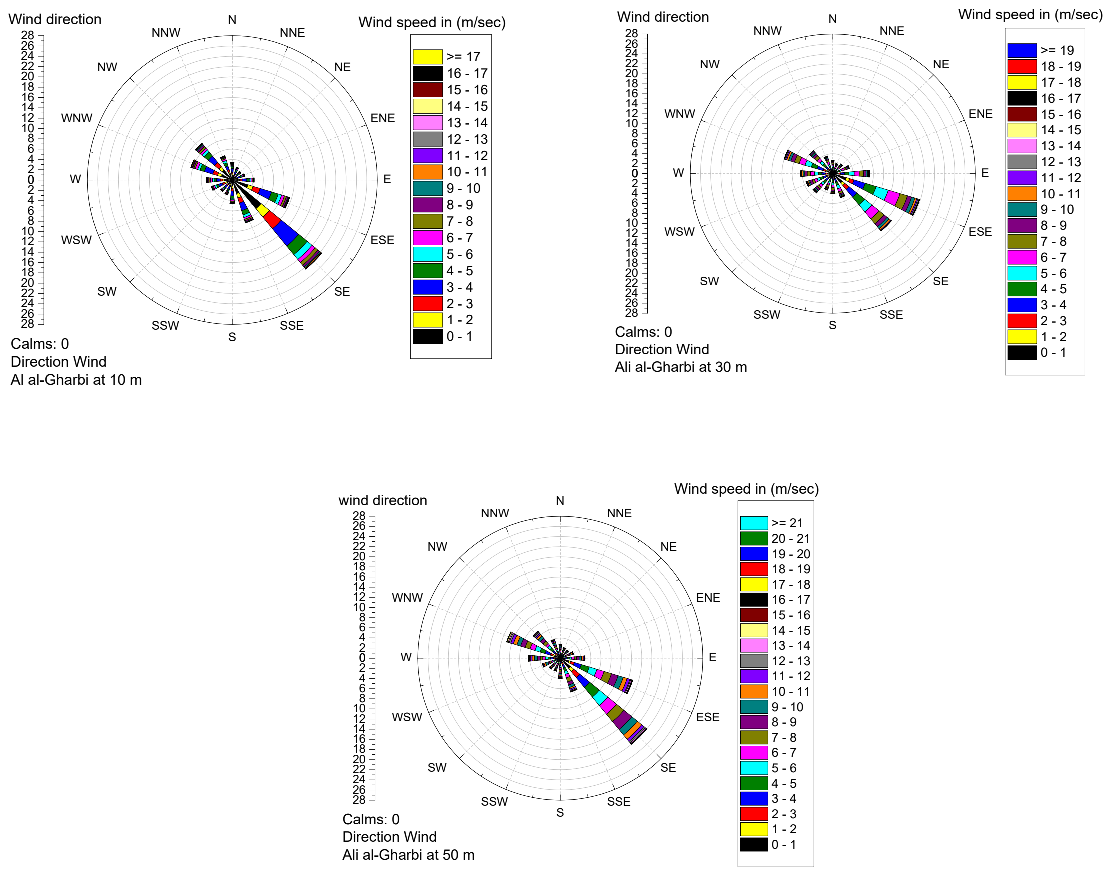


Figure 9. Wind rose plot for the three height levels 10-m, 30-m and the 50-m.

8.5. Time-series schemes

An averaged wind speed at day and night times for the period of (Dec 2014 – Dec 2015) was selected for the construction of the time series in order to show the general behaviour for the wind speed and from the result analysis it is found that the value (6.134852 m/sec) represents the highest value at 50 m during the night time whereas (3.215398 m/sec) represent the lowest value at 10 m during the night time at the chosen site , as shown in Figure 10.

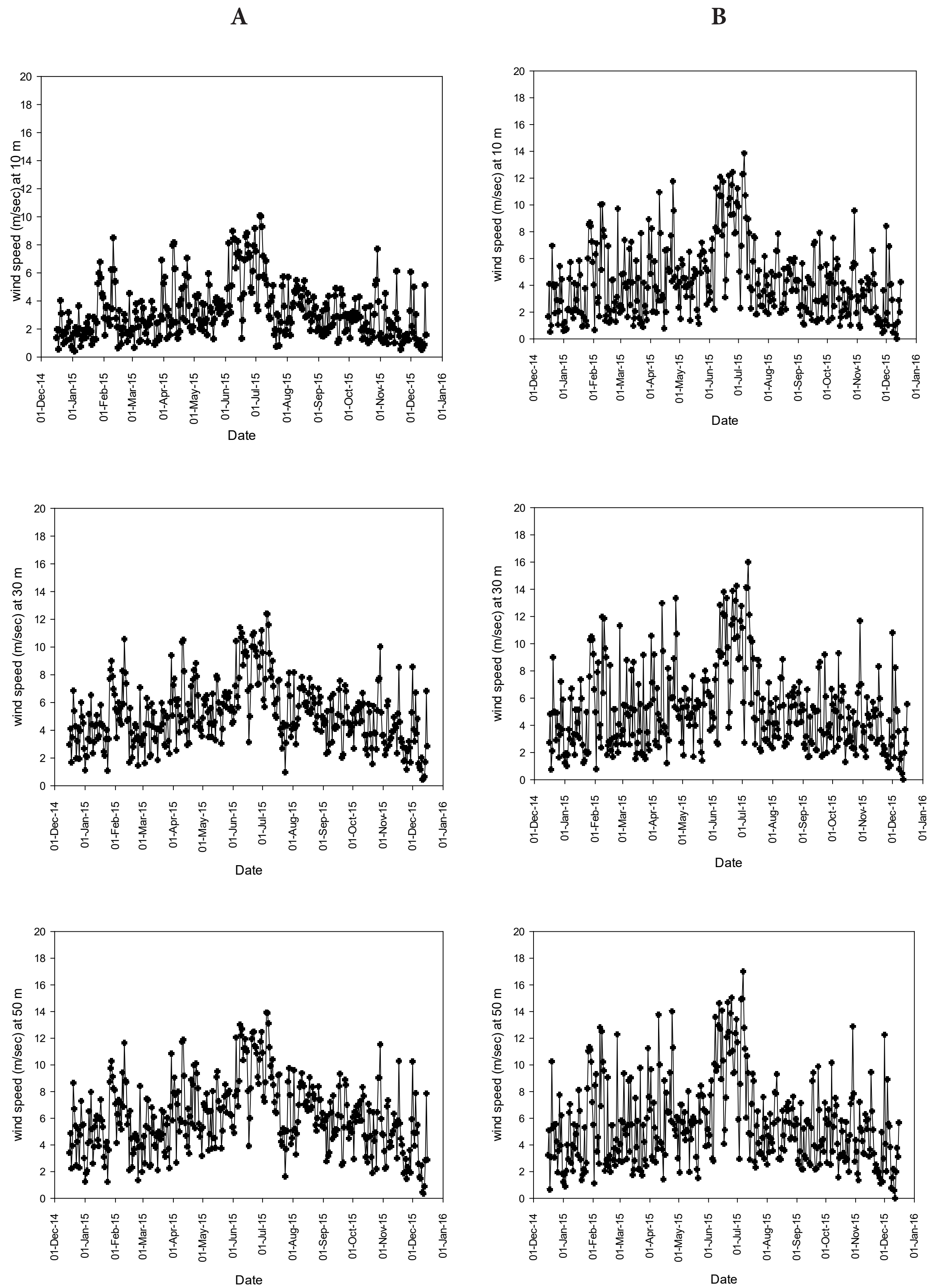


Figure 10.Time-series plots in the night-time hours (A) and the morning-time hours (B) at 10m, 30m,50m.

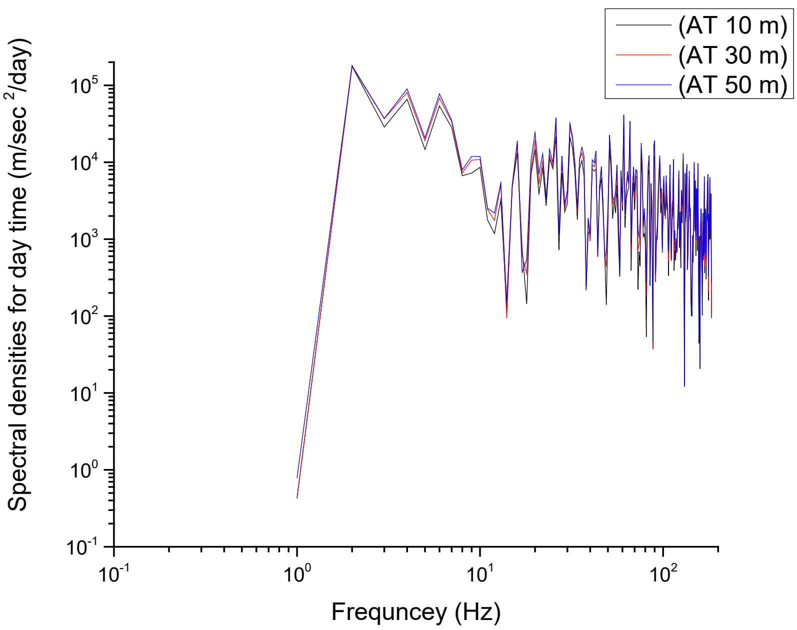
8.6. The Spectrum

The estimation of the wind speed spectra has been made by using the Fast Fourier Transform

(FFT).In order to obtain the power spectrum (the power spectral density –PSD) of the wind speed, the Fast Fourier Transform (FFT) of the time series for the collected data points is computed and using the Origin pro 9.0 software and through some mathematical calculations the power spectrum of wind speed is determined for Ali al-Gharbi region during both daytime and night time at three different height levels (10, 30 and 50 m) using a 10 minutes interval wind data. The strength of the periodic component is demonstrated by the spectrum. The peak of the spectrum indicate the energy level contained within the variable and from table (6) it's apparent that the higher the peak the higher the energy of wind. From the analysis of the peaks it is found that the highest spectral density for Ali al-Gharbi was (226236.282 m/sec2/Hz) at the frequency of (2 Hz) on the 50 m height level during the night time but the lowest is (115863.7 m/sec2/Hz) at the frequency of (2 Hz) at the 10 m height during the night time see Figure (11).

Table (6): Spectral density values for Ali Al-Gharbi during day and night times at three height levels.

Daytime		
Height level (m)	Spectral density peak ($m/sec^2/Hz$)	Frequency (Hz)
10	176935.055	2
30	176653.064	2
50	180694.914	2
Night time		
10	115863.7	2
30	172162.7	2
50	226236.282	2



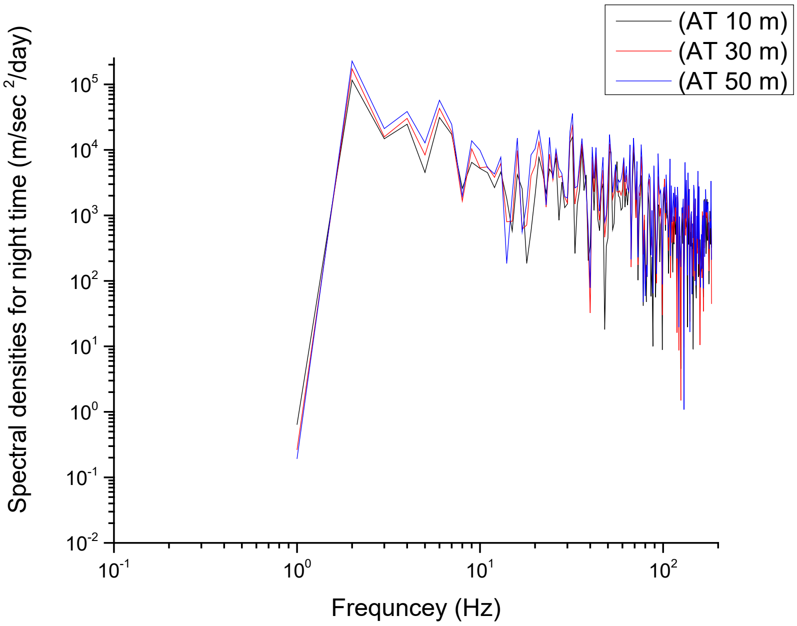


Figure 11. Spectrum of the wind-speed in the 10m, 30m and 50m at night-times and morning-times.

9. CONCLUSION

The use of wind parameter as a source of renewable energy has changed since it become a significant green energy source, the importance of this parameter is because it is available worldwide in the day time and night time through the year, The current study used a station far from the city to measure wind speed at heights of (10m, 30m and 50m) above ground level. In this study wind speed and direction were analyzed and an energy assessment was conducted, Weibull distribution was computed and then the distribution was modified by the use of the FFT in order to increase the calculation efficiency. The modification has changed the Weibull distribution from a non-periodic into a periodic distribution function making it less time consuming check for the accuracy of calculation as well, since the wind is a vary fluctuating parameter the new method is presented of developing the Weibull distribution and the Fourier series which can quantify the wind statistics in more accurate way. The new Weibull distribution plots show a smoothing in the curves since the shape parameter for the distribution has been altered and reduced. The reduction in the shape parameter from the values of about 5 to 1 suggest that the system or parameter being modeled is experiencing a significant shift in the nature of the failure time, leading to a less likelihood of failure as time progresses. The reduction of the shape parameter to about 1 will suggests that the failure time rate is constant over time. The employed spectrum method is consisted well with the measured data since it includes all of the data points and presented it in understandable way.

Energy is crucial when it comes to the social and economic improvement that's going to develop the quality of life in any place therefore results from this study can give an estimate for the energy production of a potential wind farm, as well as suitable approximations of day-to-day variable of wind speeds.

Authors contribution: Taghreed Ali Abbass: Data checked, processed, analyzed, and presented, Investigation, Writing-original draft; Amani I.Altmimi: Supervision, writing review, and editing.; , Monim H.aljboori: Supervision.

The data was processed, examined, and analyzed using (Microsoft Excel 2016), and the illustrations were produced using the (Origin 2024 program and sigmaplot software), by the author Taghreed Ali Abass.

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Data Availability Statement: Wind speed, direction, and temperature data for the year 2015 were obtained from the Iraqi Ministry of Science and Technology, Department of Renewable Energy, through the meteorological tower installed in the study area (Ali el-Gharbi) and stored in their repository.

Conflicts of Interest: The authors declare that there is no conflict of interest related to this article.

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