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ASSESSMENT OF WIND CONDITIONS IN ASSIUT CITY, EGYPT USING LONG-TERM WIND MEASUREMENTS

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ABSTRACT

Present paper discusses the performance of an irreversible regenerative The present study investigates the wind conditions in Assiut city, Egypt through the determination of the shape and scale parameter of the Weibull function. The two Weibull parameters are used to estimate the exceedance probability that reflects the ventilation effectiveness of the incident wind. In addition, the Weibull parameters are employed to estimate the wind power density and the available wind energy in Assiut city. The measured wind data covers a period of five years, ranging from 2006 to 2010. The study results show that; the numerical values of the shape and scale parameters are varying over a wide range. The shape parameter varied from 1.8 to 4.57 and the scale factor ranged from 3.74 to 6.38 m/s. In addition, the estimated wind potential for energy generation in Assiut city show that the electricity generation may not be economic since the available wind energy is less than 200 kWh/m2/year.

KEYWORDS: Exceedance probability, Weibull parameters, Wind energy

1. INTRODUCTION

In building industry, it is important to assess the wind conditions of the construction site, since the wind conditions control the air quality within the pedestrian domains of these sites. The wind conditions may strongly affect the dispersion of pollutants around buildings at the pedestrian level. Consequently, demonstration of a satisfactory wind environment is required to ensure a reasonable level of air quality for inhabitants, as demonstrated by Lam and To (2006) [1] and Bady *et al.* (2008) [2].

There are many analytical functions that can represent the wind velocity distribution. One of these functions is the Weibull distribution function. It is one of the most commonly used distributions in reliability engineering because of the many shapes it attains for various values of the shape parameter. It can therefore model a great variety of data and characteristics. Different values of the shape parameter can have marked effects on the behavior of the distribution. Similarly, the scale parameter determines the range of the distribution of the applied wind.

Over the last few decades, many researchers have used Weibull distribution function to represent the measured wind data. Justus *et al.* (1976) [3] applied the Weibull and log-normal distribution to wind speed data from more than a hundred stations of the

USA National Climatic Centre and concluded that the Weibull distribution rendered the best fit. Stevens and Smulders (1979) [4] obtained the values of the shape parameter (*k*) and the scale factor (*c*) using five different methods; method of moments, method of energy pattern factor, maximum likelihood method, Weibull probability and the use of percentile estimators. The comparisons of these analytical findings had indicated that no significance discrepancies between the results from the different methods were observed. Gupta (1986) [5] carried out work on estimating the annual and monthly Weibull parameters for five locations in India and these revealed two parameters which varied over a wide range. Rehman *et al.* (1994) [6] studied the Weibull parameters for ten different locations in Saudi Arabia and they concluded that wind data were well represented by the Weibull density function. Garcia *et al.* (1998) [7] carried out a case study on the performance of two different functions; the Weibull distribution and the log-normal distribution. The work indicated that both approaches fitted the data well. Jamil *et al.* (1995) [8] estimated the wind energy density and other wind characteristics in a solar site in Iran with the help of Weibull probability density function. They concluded that the Weibull function is a useful tool for wind energy density estimation but it is not quite appropriate for fitting the wind data of low mean speed with short-term measurements. Isaac and Jospeph (2000) [9] calculated the two parameters of a Weibull density distribution function for three different locations in Hong Kong, based on long-term wind data consisting of thirty years (1968–1997). Celik (2003) [10] studied the wind energy potential in Turkey using the Weibull and Rayleigh functions. He found that the Weibull function is better than the Rayleigh function in fitting the monthly wind data.

The objective of the present study is to assess the wind conditions in Assiut city, Egypt, based on the mean wind data through the estimation of the Weibull parameters. In addition, a preliminary investigation of the wind power density and wind energy potential in Assiut city is carried out to estimate the wind energy potential. Moreover, an economic analysis is done using the present value of money method to estimate the cost of a kWh of energy produced by the chosen wind energy conversion system.

2. WEIBULL DISTRIBUTION

There are many analytical functions that can represent the wind speed distribution. One of these functions is the Weibull distribution function. The Weibull distribution is expressed mathematically as (Weibull W. (1951)) [11]:

$$P(v) = A \times \exp\left\{-\left(\frac{v}{c}\right)^k\right\} \quad \text{where } k > 0 \text{ and } c > 0 \tag{1}$$

where, $P(v)$ is the probability of exceeding a certain reference velocity, A is the relative frequency of occurrence, v is the measured wind speed (m/s), k is a dimensionless shape factor and c is a scale factor with units of speed (m/s). The three parameters A, k and c are closely related as:

$$A = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} \tag{2}$$

The Weibull distribution has a cumulative distribution function of the form:

$$M(v) = 1 - \exp\left[\left(-\frac{v}{c}\right)^{k}\right] \tag{3}$$

Taking the natural logarithm of both sides of Eq. (3), gives:

$$\ln\{-\ln[1 - M(v)]\} = k \ln v - k \ln c \tag{4}$$

The observed wind speeds can be divided into N speed intervals: 0 - v_1, v_1 - v_2… v_{N-1} – v_N. These intervals have frequencies of occurrences f_l, f_2 . . . , f_N, and cumulative frequencies M_1, M_2……., M_N respectively, where:

$$\left.\begin{aligned} M_1 &= f_1 \\ M_2 &= M_1 + f_2 \\ M_3 &= M_2 + f_3 \\ &.... \\ M_N &= M_{N-1} + f_N \end{aligned}\right\} \tag{5}$$

By plotting $X = \ln\{v\}$ against $Y = \ln\{-\ln[1 - M(v)]\}$, then Eq. (4) transforms to the linear form:

$$Y = a + bX \tag{6}$$

A straight line is fitted to the points where its slope is b. Thus, the Weibull parameters c and k may be computed from the following relations:

$$c = \exp\left(-\frac{a}{b}\right) \tag{7}$$

$$k = b \tag{8}$$

3. WIND POWER AND WIND ENERGY ESTIMATES

To estimate wind power, the scale parameter c and the shape parameter k are used according to the following relation (Weibull W. (1951)) [11]:

$$p = \frac{1}{2}\rho\, c^3\, \Gamma(1 + \frac{3}{k}) \tag{9}$$

where p is the wind power per unit area (kW/m^2), ρ is air density (kg/m^3) and Γ is the Gamma function that can be determined as:

$$\Gamma(z) = \int_0^{\infty} x^{z-1}\, e^{-x}\, dx \tag{10}$$

The wind energy output depends on the following parameters: (1) the overall turbine efficiency, (2) the cut-in and cut-out wind speeds, (3) the rated wind speeds and the duration of each wind speed regime, T_i, (4) the height at which the turbine is installed. Most modern wind turbines are usually installed at a height of 25 m; hence the wind speed at 25 m can be found using the equation:

$$\frac{u}{u_o} = (\frac{z}{z_o})^{\alpha} \qquad (11)$$

where u is the wind speed at the turbine hub height, z = 25 m, u_o the wind speed at the reference height, z_o = 10 m, and α is an index depends on surface roughness and atmospheric stability. Numerically, it lies in the range 0.05-0.5, with the most frequently adopted value being 0.14 (widely applicable to low surface roughness and well exposed sites). Using this value for α, the measured values of wind speed can be extrapolated to 25 m, the hub height of the wind generator.

Wind energy estimates are determined using the following relation [12]:

$$E = \eta C_{\mathrm{p}} \frac{1}{2} \rho \sum_{i=1}^{N} (v_i^3 T_i) \qquad (12)$$

where E is the available wind energy (kWh/m^2.month), v_i is the midpoint wind speed for the i-th interval (m/s), T_i is the corresponding duration of the wind speed in the interval, $T_i = Tf_i / l00$, T is the number of hours in the month or in the year (i.e. T = 8760 h for a whole year), f is the percentage frequency distribution, η is the overall efficiency taken as 30% for the wind energy converter and C_p is the power coefficient with the value 0.405 [12].

4. DESCRIPTION OF WIND DATA MEASUREMENTS

Assiut governorate is one of the governorates of Egypt. It stretches for about 120 km along the banks of the Nile. The capital of the governorate is the city of Assiut. It has a latitude of 27.33 (27° 19' 60 N) and a longitude of 30.83 (30° 49' 60 E). Such location is situated 90 kilometers north east (66°) of the approximate center of Egypt and 365 kilometers south (188°) of the capital Cairo. Assiut has an area of 25,926 km^2 (which represents 2.6% of the total area of Egypt) and a population of around 3.5 million with a density of 119.6 people/km^2. Figure 1 shows a map of Egypt and the location of Assiut governorate.

Wind speed measurements were carried out by the meteorological station which is located in Assiut University campus at a latitude of 27^o 11' 7 N, and a longitude of 31^o 9' 53 E. The data was measured for a period of five years starting from 2006 to 2010 at a height of 10 m.

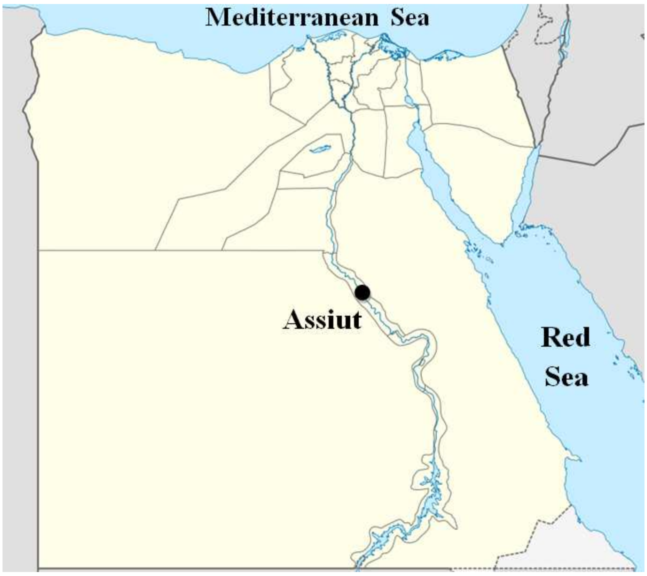

Fig. 1 Map of Assiut shows the location of the measurement site

Figure 2 shows the wind rose of Assiut city, drawn based on the mean wind data during the five years.

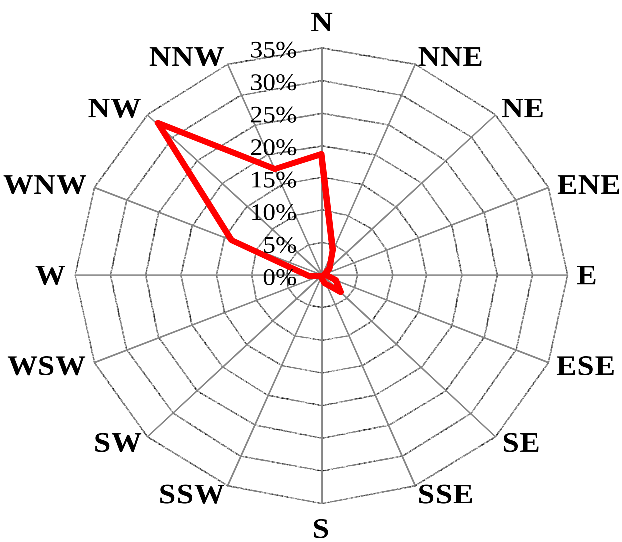

Fig. 2 Wind rose of Assiut city based on mean wind velocity (averaged over 1 hour)

The measured wind speed are divided into seven identified classes, which are: 0-2, 2-4, 4-6, 6-8, 8-10, 10-12, and 12-14 m/s. Table 1 presents the summarized wind data of Assiut city during the study period. Figure 3 shows histograms of the measured wind speed and wind direction frequency distributions, respectively, while the monthly average wind speeds during the five years is presented in Fig. 4.

Table 1 Summarized wind data (wind speed in m/s)

Wind direction	v_1 0 ~ 2	v_2 2 ~ 4	v_3 4 ~ 6	v_4 6 ~ 8	v_5 8 ~ 10	v_6 10 ~ 12	v_7 12 ~ 14
N	7.6%	10.9%	8.5%	21.9%	32.4%	23.8%	13.3%
NNE	3.3%	1.4%	50.4%	5.3%	5.0%	2.4%	0.0%
NE	3.3%	2.5%	0.7%	1.0%	0.0%	0.0%	0.0%
ENE	3.3%	0.3%	0.4%	0.0%	0.0%	0.0%	0.0%
E	4.3%	1.4%	0.3%	0.2%	1.2%	0.0%	0.0%
ESE	8.7%	5.8%	0.4%	1.0%	0.0%	0.0%	6.7%
SE	2.2%	5.6%	2.0%	2.4%	3.3%	2.4%	13.3%
SSE	1.1%	3.6%	0.7%	0.2%	0.0%	0.0%	0.0%
S	0.0%	0.6%	0.0%	0.2%	0.4%	2.4%	0.0%
SSW	1.1%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%
SW	0.0%	0.3%	0.0%	0.0%	0.0%	0.0%	6.7%
WSW	0.0%	0.0%	0.1%	0.4%	0.4%	2.4%	0.0%
W	8.7%	3.1%	0.5%	1.2%	1.2%	0.0%	0.0%
WNW	21.7%	22.0%	8.2%	9.9%	4.6%	2.4%	20.0%
NW	26.1%	29.5%	18.6%	35.7%	31.1%	38.1%	13.3%
NNW	8.7%	13.1%	9.4%	20.5%	19.9%	26.2%	26.7%
% of occurrence	5%	20%	31%	27%	13%	2%	1%

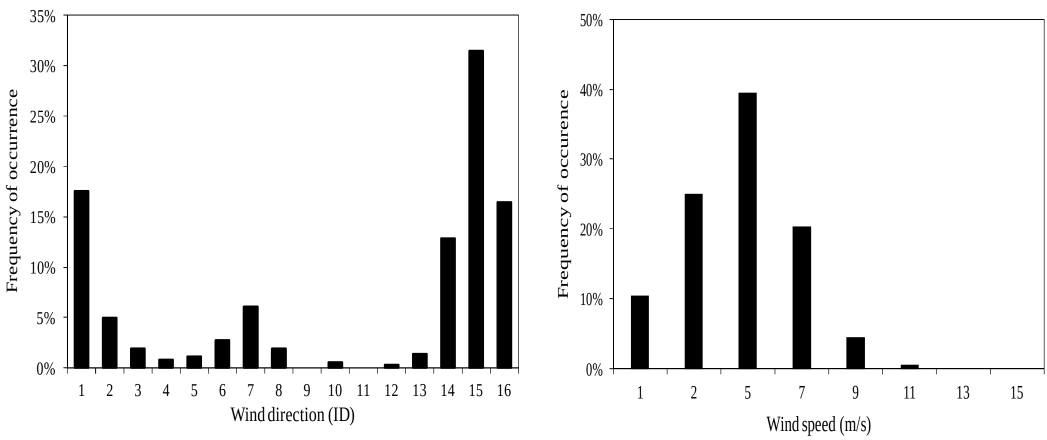

Fig. 3 Wind frequency histograms; wind direction (left), and wind speed (right).

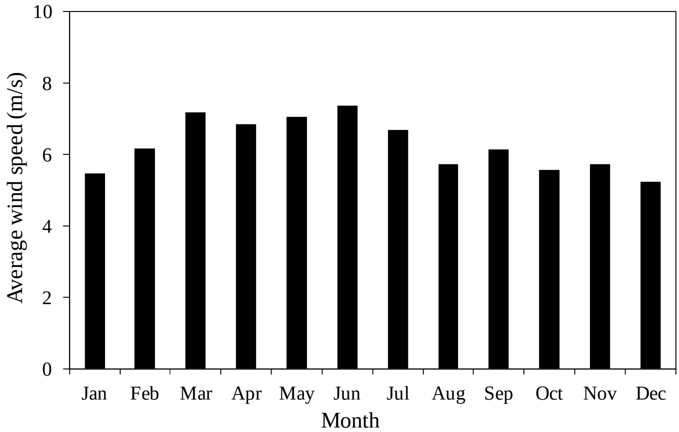

Fig. 4 Monthly average wind speeds in Assiut city during the study period.

As can be seen from Table 1, for 31 % of the time the wind blows, the wind speed ranges between 4 and 6 m/s, while for 27% of that, it ranges from 6 to 8 m/s. A histogram of the monthly average wind speeds is illustrated in Fig. 4. It is clear from the figure that; the average wind speed has the minimum value in December and the maximum value in June ranging from 5.2 to 7.3 m/s with an average of 6.25 m/s.

Table 2 presents the frequency of occurrence of the winds blowing from the considered 16 azimuth directions. From such table, some points arise:

- The mean wind speed during August is 5.72 m/s and it has the highest frequency of occurrence during the year; 58.1%, followed by 54.8% for mean wind speed 6.68 m/s at July, followed by 34.0% at 6.18 m/s during February.
- Accordingly, during these months peaks of mean wind speed occur at different days with an average value of 5.72-6.68 m/s which is above the cut-in values required for the operation of any wind turbine in Egypt.
- Since the minimum required wind speed for a wind park at 20 m height is about 3 m/s which is equivalent to 2.52 m/s at 10 m height in urban areas, a typical wind turbine can operate about 90% of all the time throughout the year. However, an analysis for the available wind energy is carried out later, to evaluate the wind potential for electricity generation in Assiut city.

5. RESULTS AND DISCUSSION

5.1 Monthly and Seasonal Weibull Parameters

The monthly values of Weibull parameters k and c are shown in Table 3, and represented graphically in Figs. 5 and 6, respectively.

The seasonally values of the Weibull parameters are presented in Table 4. The k and c values of the winter season represent the average value of k and c of December, January, and February months, while those of the spring season represents

Table 2 Monthly average wind speed and the frequency of occurrence for the 16 azimuth directions in Assiut from 2006 ~ 2010.

Month	v_{mean}	Percentage of occurrence of winds blowing from the following directions															
		349-11.5	11.5-34	34-56.5	56.5-79	79-101.5	101.5-124	124-146.5	146.5-169	169-191.5	191.5-214	214-236.5	236.5-259	259-281.5	281.5-304	304-326.5	326.5-349
Jan.	5.45	11.6	1.9	1.3	0.0	0.6	5.8	6.5	0.6	0.0	0.0	0.0	0.0	3.2	18.7	33.5	16.1
Feb.	6.18	11.3	0.7	0.0	0.0	2.1	5.7	7.8	2.1	0.0	0.0	0.7	0.7	2.1	13.5	34.0	19.1
Mar.	7.18	11.0	3.9	0.0	0.6	0.6	3.9	9.0	3.2	1.3	0.0	0.0	0.6	1.9	9.7	32.9	21.3
Apr.	6.83	19.3	5.3	2.0	0.0	0.0	2.0	6.7	3.3	0.7	0.0	0.7	0.0	1.3	12.7	28.7	17.3
May	7.05	23.2	3.9	2.6	1.3	0.6	1.3	2.6	0.0	0.6	0.6	0.0	0.6	1.9	8.4	32.9	19.4
Jun.	7.35	30.0	6.7	2.7	1.3	0.7	0.7	0.0	0.7	0.0	0.0	0.0	0.0	0.7	14.7	19.3	22.7
Jul.	6.68	12.3	1.3	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	16.8	54.8	13.5
Aug.	5.72	7.1	2.6	0.6	0.0	0.6	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	20.0	58.1	10.3
Sept.	6.13	25.3	4.0	2.0	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	0.0	1.3	14.0	30.0	20.7
Oct.	5.55	32.9	5.2	3.2	0.0	1.3	1.3	3.2	1.9	0.0	0.6	0.6	0.6	2.6	11.0	12.9	22.6
Nov.	5.72	19.3	7.3	3.3	1.3	1.3	0.7	2.7	0.7	0.7	0.0	0.0	0.0	4.0	14.0	28.7	16.0
Dec.	5.22	20.0	5.8	0.6	0.0	2.6	1.9	5.8	1.9	0.0	0.0	0.0	0.6	2.6	14.2	30.3	13.5
Annual mean	6.26	18.61	4.05	1.53	0.43	0.87	2.17	3.74	1.20	0.28	0.10	0.17	0.26	1.85	13.98	33.01	17.71

the average values of March, April, and May months. Similarly, the Weibull parameters values of the summer months represents the average value of June, July and August months, while the autumn season parameters represent the average values of September, October, and November months.

From Tables 3 and 4, the following points arise:

- The parameter k has a much smaller monthly variation than the parameter c.
- The shape parameter varies over a wide range from the minimum value of 1.70 in December to the maximum value of 3.73 in June, with an average of 2.71.
- The highest scale factor value is 6.59 m/s and occurred in June, while the minimum value is 3.98 m/s and occurred in December.
- The scale factor has low values during winter-autumn seasons and high values during the spring-summer periods.
- For the high values of k in spring and summer seasons, the majority of wind speed data tends to fall around the average wind speed value, where the average wind speeds at these seasons are high (v_{Spring}= 7.02 m/s and v_{Summer} = 6.58 m/s).

Table 5 and Fig. 7 show the variation of the Weibull parameters with the incident wind direction. As can be seen from the figure, the highest value of k (2.79) is found to occur with the direction WSW, while the lowest value of k (1.24) is found to occur with direction SSW. On the other hand, the highest value of the scale factor c (6.01) occurs when the wind blows from the north direction, and the minimum value of c (1.84) occurs with the wind direction ENE.

5.2 Weibull Distribution

A summary of the variation of scale factor, shape parameter and frequency of occurrence with the incident wind direction in Assiut city is shown in Fig. 8.

Figure 9 shows the velocity-based probability density distributions of the measured wind velocity. The figure has a wide span and a flat peak at a slightly higher wind speed. This indicates that wind conditions tended to concentrate more on the high wind speed. In addition, the maximum value of the probability density is 39 % and occurred in 2007, 2009 and 2010 at a wind velocity of 5 m/s, while the lowest density value is 31 % and occurred in 2006.

Figure 10 presents the cumulative probability distribution function, derived from the measured wind data of Assiut city, where the maximum value of the function occurred in 2009 and 2010 and the minimum occurred in 2006 and 2007.

Table 3 Average values of *k*, *c* and *v*.

Month	*c*	*K*	*v*
January	4.18	2.04	5.45
February	5.13	2.22	6.17
March	6.15	2.68	7.18
April	5.26	2.11	6.83
May	5.91	2.64	7.05
June	6.59	3.73	7.35
July	5.66	3.02	6.68
August	4.75	2.53	5.72
September	5.12	2.94	6.13
October	4.28	2.04	5.55
November	4.31	2.16	5.73
December	3.98	1.70	5.22

Table 4 Seasonal long-term *k*, and *c*.

Month	*c*	*k*	*v*
Spring	5.77	2.48	7.02
Summer	5.66	3.09	6.58
Autumn	4.57	2.38	5.80
Winter	4.15	1.97	5.47

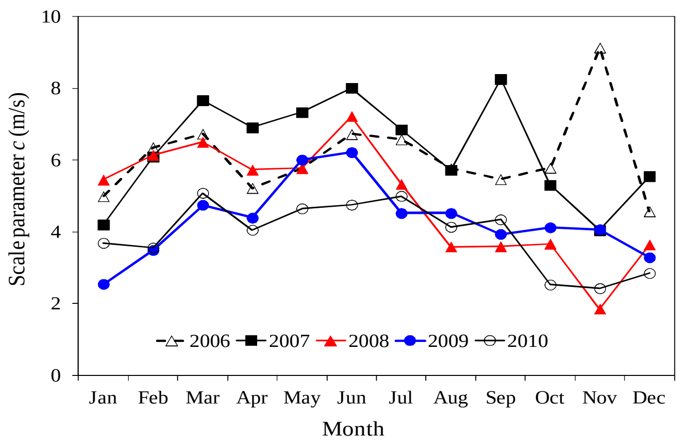

Fig. 5 Monthly variation of the scale parameter *c* during the study period.

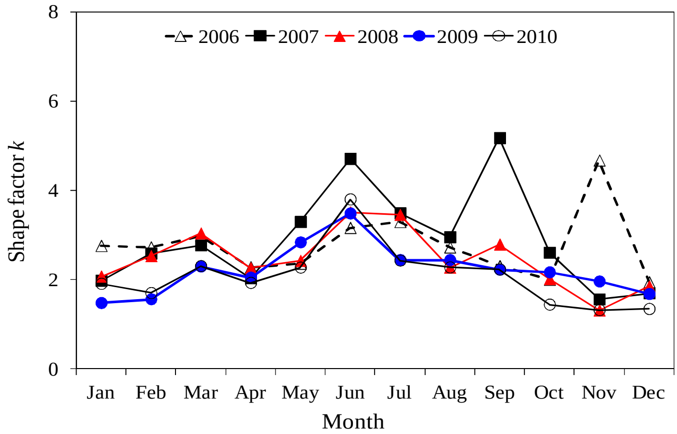

Fig. 6 Monthly variation of the shape factor *k* in Assiut city during the study period.

Table 5 Weibull parameters for the sixteen azimuth directions.

Direction	Direction ID	*c*	*k*
N	1	6.01	2.29
NNE	2	5.75	2.08
NE	3	3.72	1.78
ENE	4	3.02	1.37
E	5	2.98	1.43
ESE	6	2.67	1.45
SE	7	4.67	2.26
SSE	8	3.46	1.99
S	9	4.15	2.14
SSW	10	2.24	1.24
SW	11	4.48	2.31
WSW	12	5.28	2.79
W	13	2.71	1.50
WNW	14	3.63	1.94
NW	15	4.36	2.27
NNW	16	4.68	2.46

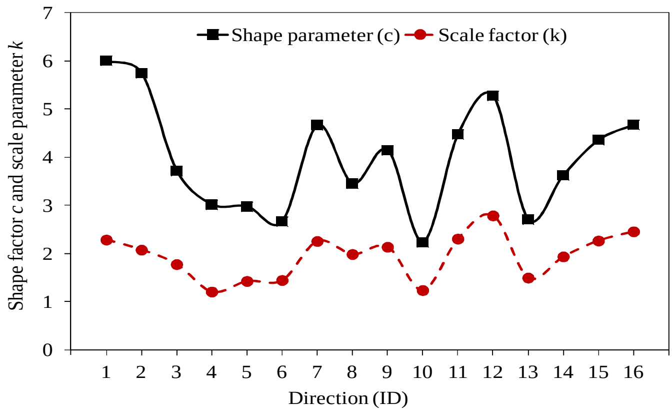

Fig. 7 Variation of scale factor and shape parameter with wind direction.

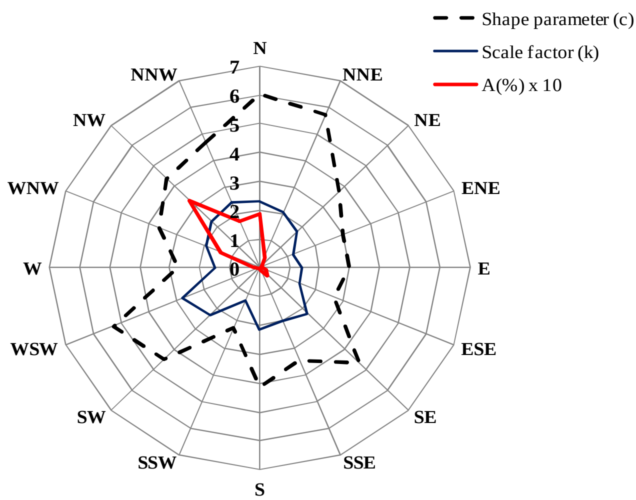

Fig. 8 Summary of the variation of scale factor, shape parameter and frequency of occurrence with the incident wind direction.

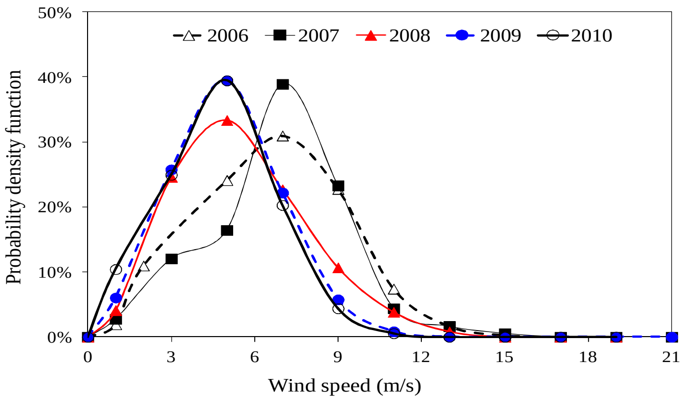

Fig. 9 Velocity-based probability density distributions for the study period.

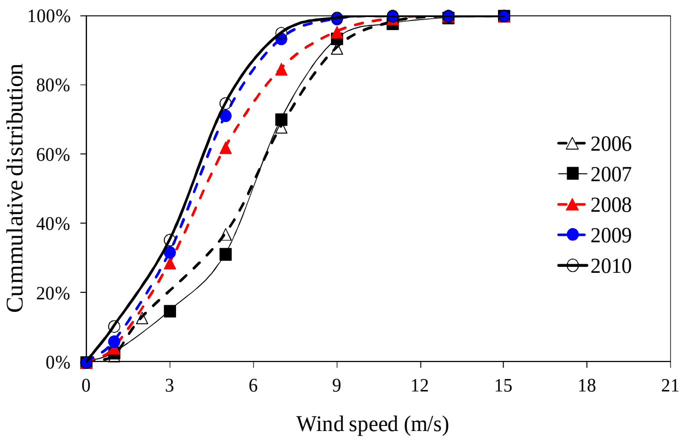

Fig. 10 Cumulative probability distributions for the study period in Assiut city.

5.3 Wind Power and Energy

The mean monthly wind power density in a vertical plane perpendicular to the wind direction is shown in Fig. 11 and summarized in Table 6. Similarly, the available wind energies that could be extracted from rotors of unit area at a height of 25 m above ground for Assiut city are calculated using Eq. (12). The results are depicted in Fig. 12 and summarized in Table 6. The annual wind energy and wind power density are also calculated in Table 7.

From Table 6, one can see that; the mean energy density over Assiut city ranges from 12 to 467 W/m^2. In addition, the maximum available energy density over Assiut city at 50 meter above ground level ranges from 3.6 to 82.7 kWh/m^2/year. According to these values, the expected power from wind in Assiut city may not be economic since its value is less than 200 kWh/m^2/year. However, an economic analysis is carried out in the following section, based on the conditions of Assiut city.

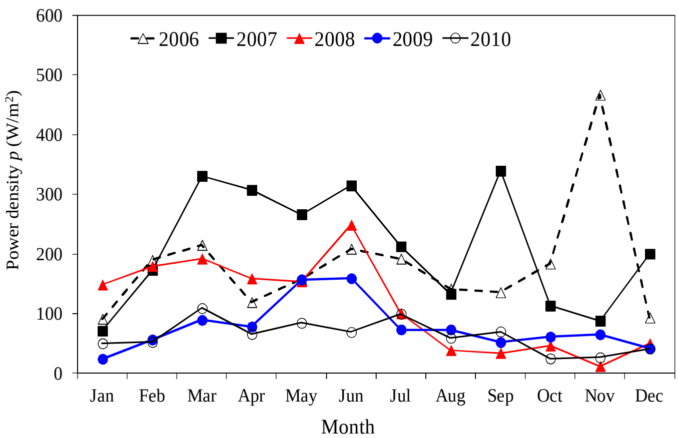

Fig. 11 Monthly power density in Assiut city during the five years.

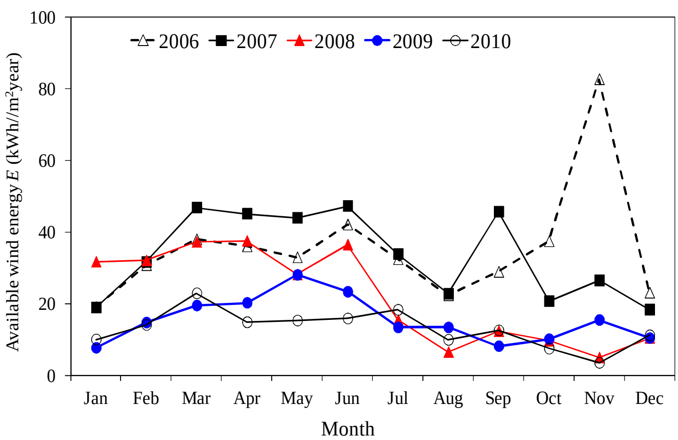

Fig. 12 Monthly available wind energy in Assiut city during the five years.

Table 6 Monthly wind power density and available wind energy in Assiut city.

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2006	*P*	91.54	190.23	215.45	119.46	157.53	208.91	192.23	141.83	135.92	184.14	467.0	93.61
	E	19.15	30.86	38.10	36.12	33.05	42.20	32.54	22.45	28.98	37.54	82.74	23.16
2007	*P*	71.36	173.30	331.00	307.31	266.50	314.94	212.88	133.29	339.51	113.59	88.38	200.58
	E	19.05	31.76	46.92	45.20	44.06	47.36	33.96	22.85	45.81	20.79	26.59	18.45
2008	*P*	148.86	179.69	192.39	159.20	154.13	248.99	100.64	38.97	34.01	46.60	12.23	50.42
	E	31.80	32.19	37.35	37.64	28.21	36.56	15.53	6.61	12.45	9.74	5.06	10.54
2009	*P*	24.40	56.71	89.48	78.56	157.44	159.37	73.57	73.57	52.34	61.53	65.38	42.19
	E	7.78	14.84	19.59	20.34	28.13	23.43	13.47	13.47	8.24	10.22	15.56	10.50
2010	*P*	50.35	52.52	109.34	65.98	84.74	69.28	99.87	59.58	70.26	25.02	26.80	41.45
	E	10.10	14.17	22.99	14.92	15.40	15.96	18.39	10.01	12.65	7.55	3.58	11.26

Table 7 Annual power density and available wind energy in Assiut city.

Year	p (W/m^2)	E (kWh/m^2.year)
2006	183.15	35.57
2007	212.72	33.56
2008	113.85	21.97
2009	77.87	15.46
2010	62.93	13.08

5.4 Economic Analysis

The present value of money method is applied to estimate the cost of a kWh of energy produced by the chosen wind energy conversion system. In order to calculate the present value of costs (PVC) of electricity produced per year, following expression is used under the following assumptions [13, 14, 15, 16]:

(1) Investment (I) includes the turbine price plus its 20% for the civil work and connection cables to the grid (other connections).
(2) Operation, maintenance and repair cost (C_{omr}) is considered to be 25% of the annual cost of the turbine (machine price/life time).
(3) The interest rate (r) and inflation rate (i) are taken to be 15% and 12%, respectively.
(4) Scrap value (S) is taken to be 10% of the turbine price and civil work.
(5) The lifetime of the machine (t) is assumed to be 20 years.

The present value of costs (PVC) is [13]:

$$PVC = I + C_{omr}\left(\frac{1+i}{r-i}\right)\times\left[1-\left(\frac{1+i}{1+r}\right)^t\right] - S\left(\frac{1+i}{1+r}\right)^t \qquad (13)$$

Consider the case in which a wind turbine of 10 m rotor diameter operates in Assiut city. According to Table 7, the average annual output energy of the turbine is 10.2 MWh/year. The price of a commercial scale wind turbine of the given annual capacity is about $2,000,000.

The estimation of the costs for one kWh of energy produced from the above turbine, to operate at Assiut station has been done under the mentioned assumptions with using Equ. (13).

If we consider such price, then:

The unit price is $2,000,000, the cost of civil work (20% of the price) = $400,000.
The investment I = $ 2,400,000, and the operation, maintenance and repair cost C_{omr} = $2,000,000/20×0.25 = $25,000. The scrap value, S = $2,400,000×0.1 = $240,000, where $r = 0.15$ and $i = 0.12$.

Using all these values in Equ. (13), we get: PVC = $2,641,781.

Since the annual output of the turbine is 10.2 MWh/year, the total output power over 20 years = 20×10200 MWh. Therefore, the specific cost per kWh = 2641781/ (20×10200) = 13 $/kWh.

Accordingly, the expected cost per kWh does not encourage the construction of wind farms at Assiut city. Such price for electricity generation is not a competition price at the wind energy world market.

6. CONCLUSIONS

In this study, the Weibull two-parameter function was estimated in order to investigate the wind characteristics in Assiut city, Egypt based on the wind data over a period of 5 years from 2006 to 2010. The two Weibull parameters were used to estimate the exceedance probability that reflect the ventilation performance of the incident wind. In addition, the two parameters were employed to estimate the wind power density and the available wind energy in Assiut city during the study period. The study results showed that:

- The wind in Assiut city is predominantly North-East (NE) throughout the year. The NE seems the only wind direction to be considered when designing high-density building arrays, regarding wind ventilation performance and air quality considerations.
- The mean wind speed in Assiut city is 6.2 m/s at a height of 10 m. The minimum required wind speed for a wind park in urban areas to operate is about 2.52 m/s (at 10 m height). Accordingly, a typical wind turbine will operate about 90% of all the time throughout the year in Assiut.
- The numerical values of the shape and scale parameters for Assiut are varying over a wide range. The shape parameter varied from 1.8 to 4.57 and the scale factor ranged from 3.74 to 6.38 m/s.
- The expected power from wind in Assiut city may not be economic since the available wind energy is less than 200 kW.h/m^2/year.

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تقييم ظروف الرياح في مدينة أسيوط باستخدام قياسات المدي الطويل

تبحث هذه الدراسة ظروف الرياح في مدينة أسيوط من خلال تحديد قيم معامل الشكل و معامل القياس في دالة فيبول. والقياسات المستخدمة في الدراسة هي لخمس سنوات من 2006 وحتي 2010. وقد استخدم معاملي الشكل والقياس في تقييم كفاءة الرياح في عملية التهوية من خلال حساب احتمالية الزيادة. بالاضافة لذلك فقد تم استخدام معاملي الشكل والقياس في حساب قدرة الرياح علي توليد الكهرباء في مدينة أسيوط. وقد بينت نتائج الدراسة أن قيم معاملي الشكل والقياس تتغيران لمدي كبيرحيث وجد أن معامل الشكل يتراوح من 1.8 الي 4.57 م/ث. و بالنسبة لقيم معامل القياس وجد أنها تتراوح من 3.74 الي 6.38. وبالنسبة لقدرة الرياح علي توليد الكهرباء في مدينة أسيوط وجد أنها لن تكون أقتصادية حيث ان قيم الطاقة أقل من 200 كيلووات ساعة للمتر المربع في السنة.