Journal of Education for Pure Science- University of Thi-Qar
Vol.9, No.2 (June, 2019)
Website: jceps.utq.edu.iq Email: jceps@eps.utq.edu.iq

DOI: http://doi.org/10.32792/utq.jceps.09.02.20

# Choosing Minimum Height for Continuing Operation wind Energy Generation Over Urban Cities

***Meena S. Hadad[1], Monaim H. Al-Jiboori[2]***

[1,2] Department of Atmospheric Sciences, College of Sciences, Al- Mustansiriyah University.

**Received 06/11/2017, Accepted 18/01/2018, Published 02/06/2019**



**Abstract:**

In this study, reference for the minimum height through which wind energy can be continuing over urban cities, the Mustansiriya University site located in the center of Baghdad. We were obtain with the data from the fast weather station responding to the building of the Department of Atmospheric Sciences University of Mustansiriya at 19 m high and the second station slow response data to determine the type of stability by knowing the length of Monin-Obukh and calculate the wind speed and rates for eight directions. Direction of speed Wind for the year 2016 depend on the available data in the days of awakening, measured the distance in the study area affected by roughness in order to know the lowest height of wind energy in the university and then calculated the wind power density at high altitudes that we found it .The measured of scale and shape parameters were also found according to Weibble distribution and the wind power density was compared in the normal way using Weibull distribution.

**Keywords:** wind energy, Internal Boundary layer, Fetch, Surface roughness length, Stability.

## Introduction

In recent times, there is considerable interest in the development of energy resources because Energy is an important requirement in life and it is part of the industry and technology. All developed and non-developed countries depend on the existence of energy either directly or indirectly [1].

As a result, society faces the challenge of meeting this continuous demand for energy. Therefore, it is clear that there is a relationship between energy consumption and pollution because the negative results so there must be a conversion from fuel consumption to the alternative or inventive energy resources such as (solar energy, flow energy). One of the least cost and suitable alternative resources is the energy of the winds.

In Iraqi cities which have a high wind speed that can be used to generate electricity, which is lacking for electricity in most of it Wind is a source of renewable energy where it is abundant, clean and easy to use. The historical monuments also show that the ancient Iraqis used this energy in prehistoric times and found a model of pottery for a sail boat. In 1915 Generators working on windmills were developed with a capacity of 25 Kw [2].

Al-Temimi, (2007), had estimated and assessment the wind power all over Iraq, (19) stations from different areas have been selected for the period of (1970 to 2000), the Weibull distribution function was used to analyze the wind data. The energy density was estimated due to Weibull function, the values of the annual shape and scale parameters were estimated for all stations. The Persistence of wind speed and direction, roughness length and 13the class was calculated. The given results reached a conclusion that the promising areas to install wind farms for electricity generation in Iraq are Telafar, Kut and Al-Hai [3].
Perez et al. 2004: Study on speed analysis Winds have come out with wind power during the day being better than night because the convection processes also made a recommendation not to rely on surface wind to exploit energy wind [4].

## 2. Theoretical basis

To get the height of internal boundary layer we use the following equation [5]:

$H_{ibl}/Z_0 = 0.3\,(X/Z_0)^{\alpha}$ … …. … .... …. ( s;

X: Is the distance between the search area and the city influential limits in the wind flow. $Z_0$: surfaces roughness length. : the power equal to about 0.8 for statically neutral condition, but is slightly smaller (0.6 to 0.7) in statically stable conditions, and larger for unstable (0.8 to 1.0).
The stability coefficient was calculated by using the longitudinal azimuth Λ length of Monin-Obukh [6]:

Λ= F Ŀ / @ₛ ÆŒ æ˝$̶ …. …. … … … …. ….. :t;

T: the average temperature in kelvin, u*: friction velocity, g: Accelerating gravity, k: Von-korman constant.
The wind changes exponentially with altitude, and the logarithmic equation is used to determine the velocity of the wind at different altitudes. The wind section can be represented by equation [٧]:

U (z٢) = U١ ( x̧ / x5 F̦… … … … …. ……. :u;

After we found the wind speed at different altitudes we can calculation the wind power density by the equation [8]:

92 &Ŀ 5/6 ØR7 …. …. …. …. … … …. (4)

Then we compared with Weibull probability density function, where scale parameter (A m/s) and shape (k), From the following equation:

Ŀ 5/6 O 7 @s E 7/i A.. …. …. .. …. :u;

: Gamma Function.
k : shape parameter.
A: scale parameter.

## 3. Site and Data

The first site is Atmospheric Science Building (ASB), College of Science, Al-Mustansiriya University located at northeast of Baghdad. This site is shown in Figure (1).
The devices used to achieve this work are fast response ultrasonic anemometer and Automatic weather stations.

The height of the Ultrasonic station is about 19m, this station have (air pressure, temperature, vertical components of wind). By using the equation (2) Monin-Obukh lenght to find condition of atmospheric stability: stable, unstable and neutral conditions. The total of what was received is 223 observe for 30 day shown in table (1).

Then used the data from automatic weather station to found the average wind speed were taken for observations at one hour to be monitored one per hour and the amount of observations are 24 monitored per day, depending on the number of observations available (1/1-10/11/2016) except two month because not availability at the start of the year and some months monitored a quarter of an hour and another month every hour and the total of what was received is 15591.

We used MATLAB and Excel in this study.

**Table (1): The dates, periods and no. of daily runs for stability and monnin-obukhov.**

| Data of observation (2016) | Periods (day) | Number of runs |
|---|---|---|
| 4-5-6 / Feb | 3 | 19 |
| 1-6-7-8- 23/ Mar | 5 | 17 |
| 8-9/ May | 2 | 8 |
| 15-22-24-25/ June | 4 | 36 |
| 5-7-8-9-10-13-14-15-22-23-27-28-30/ July | 13 | 116 |
| 2-5-6/ Aug | 3 | 27 |
| Total summation | 30 | 223 |

**Table (2): The runs of wind speed.**

| Wind speed | Runs of wind speed |
|---|---|
| 0-0.9 | 4053 |
| 1-1.9 | 4159 |
| 2-2.9 | 3672 |
| 3-3.9 | 2270 |
| 4-4.9 | 1038 |
| 5-5.9 | 97 |
| 6-6.9 | 165 |
| 7-7.9 | 78 |
| 8-8.9 | 49 |
| 9-9.9 | 10 |
| Sum | 15591 |

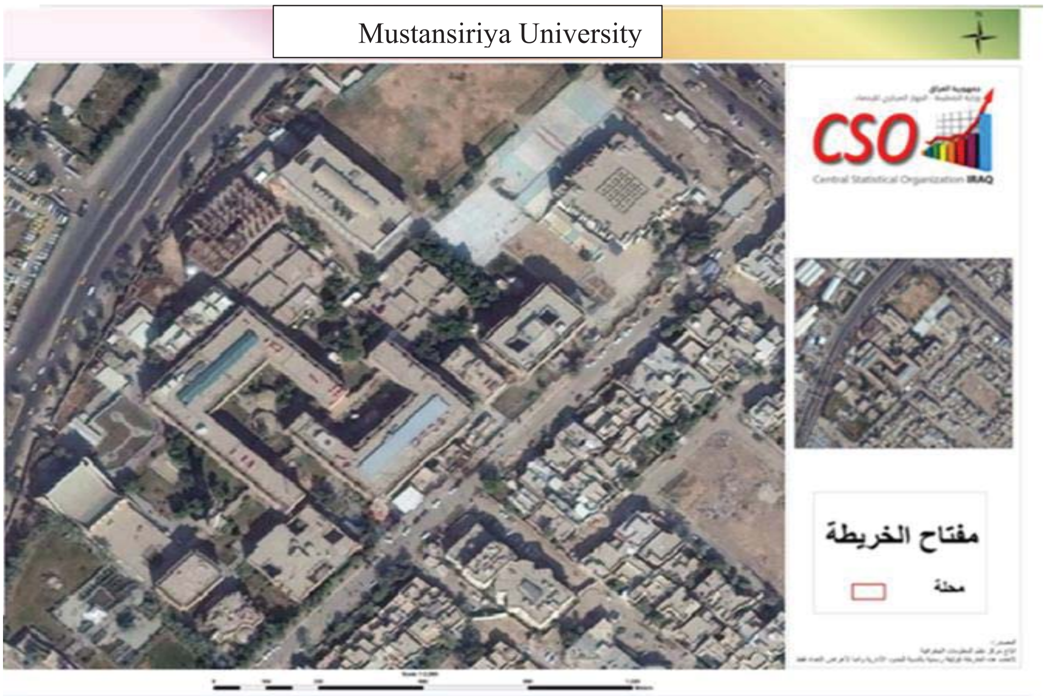



**Fig.(1): Map of Baghdad city on which the study sites Mustansiriya University[ 9 ].**

**Fig.(2): photo of the fast response anemometer, Gill sonic and the automatic weather station in (IBA)[ 9]**.

**4. Results and Discussion**

**4-1 wind speed frequency distribution**

We could make classification of the data taken from the automatic station by using the Matlab program at 10 interval as shown in table (3) and also used to know the wind speed rates for each period according to the classification to the initially identified, then we divided the data of wind speed in day and night to know the differs between these aims of day. Although highest frequencies of wind are in the first three intervals, the wind speed with values higher than 3 m/s has good frequencies that can move turbine blades to produce electricity.

**Table (3): The data of wind speed runs and average of wind speed.**

| Wind speed (m/s) | Wind speed average | Runs total |
|---|---|---|
| 0-0.9 | 0.6 | 4053 |
| 1-1.9 | 1.5 | 4159 |
| 2-2.9 | 2.4 | 3672 |
| 3-3.9 | 3.3 | 2270 |
| 4-4.9 | 4.2 | 1038 |
| 5-5.9 | 5.3 | 97 |
| 6-6.9 | 6.3 | 165 |
| 7-7.9 | 7.2 | 78 |
| 8-8.9 | 8.2 | 49 |
| 9-9.9 | 9.4 | 10 |
| Sum | | 15591 |

Wind speed values are obtained from (slow- response data) where each half hour or hour can be collected for year 2016 (depend to data available). It is important to know the different wind frequencies during the day, we used the data in the graph as shown in Fig.(3)which consists of two axis (horizontal and vertical) Speed is horizontal and its frequency is represented on the vertical axis where it is possible to know the speed of the most frequent wind within the specified periods. The wind speed required to run the turbine up to (4 m /s) and indicate the data is availability of this speed during the year, Statistical methods were used to calculate the percentage of wind speed and cumulative wind ratios ,the cumulative wind speed at (4 m /s) was approximately 98% . This rate is a good although this station is located in center of Baghdad and effect by building, trees and others elements roughness.

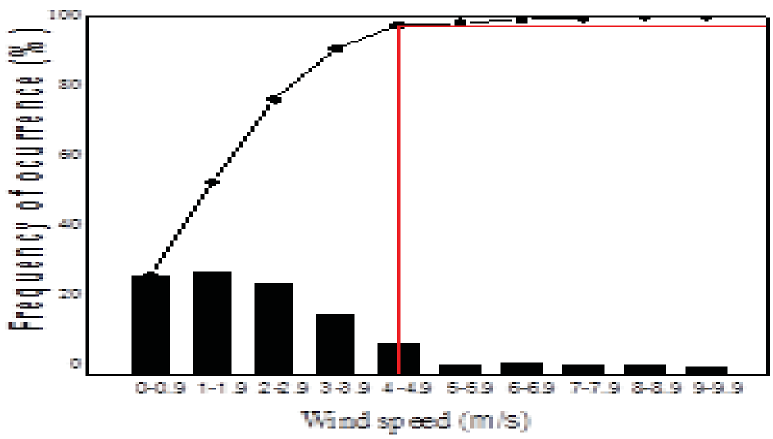
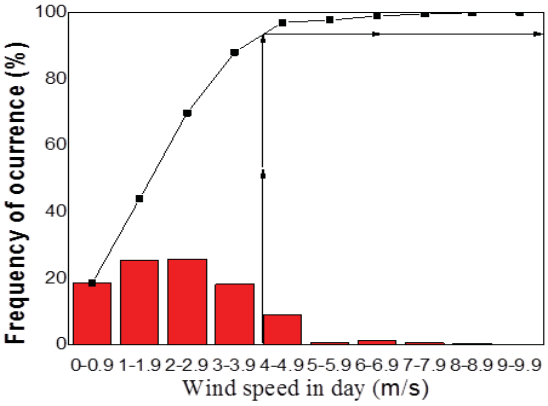
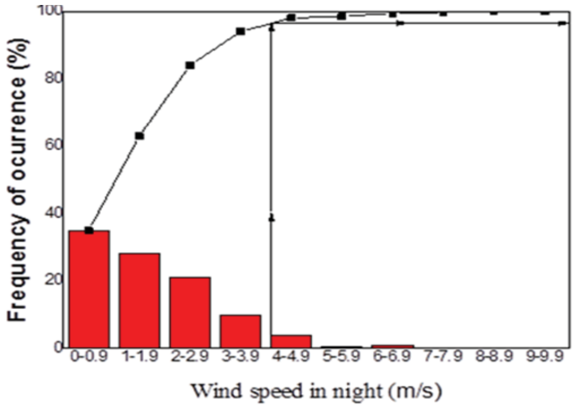



**Fig. (3): Wind speed with percentages of frequency and cumulative data.**

To know where the higher values of wind are availed at the day or at night .The wind data were separated up to these part. The wind frequency and its cumulative carve both times are presented in Fig. (4) (5).
It was found that the percentage of wind speed at (4 -4.9 m/s) is about ( 8.9%) which is useful for the Turbine runs , the cumulative ratio for the same period of wind speed is estimated at (96.9%).
Briefly wind speed values at day are more active and frequently from those at night. This is of course, belong to the sunrise in day which heat up the earth surface
nonhomogeneous.
While at night the percentage of wind speed within the period (4-4.9 m/s) is about (4%), the cumulative ratio for the same period of wind speed is estimated at (98%) show as (5).Which is a good proportion especially within the city of Baghdad which is characterized by the existence of buildings high and trees as a barrier to the wind.




**(4): Wind speed with percentages of frequency and cumulative data in day.**




**(5): Sam the Fig.(4) but in night.**

**4-2 Fetch**

To calculate fetch (x) from the university site at eight directions according to the regions depending on the change of the region roughness including height of buildings and trees and density of roughness buildings that work on the obstruction of the wind was taken into account and by using Google earth map to surrounding the study site .as show in the Table (3) and fig.(6).

**Table (3): Fetch measured from the map in eight directions.**

| Sector | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Direction | N | NE | E | SE | S |
| Fetch (km) | 1.5 | 1 | 1.6 | 2.1 | 4.3 |
| Sector | 6 | 7 | 8 | | |
| Direction | SW | W | NW | | |
| | | | | | |
| Fetch (km) | 3.6 | 4.7 | 3.2 | | |

The roughness of the university was considered as an approach to the roughness of the Bab al-Mu'adam area because it possesses the same characteristics buildings, while the study is limited in a short time and the data is not available therefore we used adopted this method which found that roughness is appreciated (1.2 m) [10].

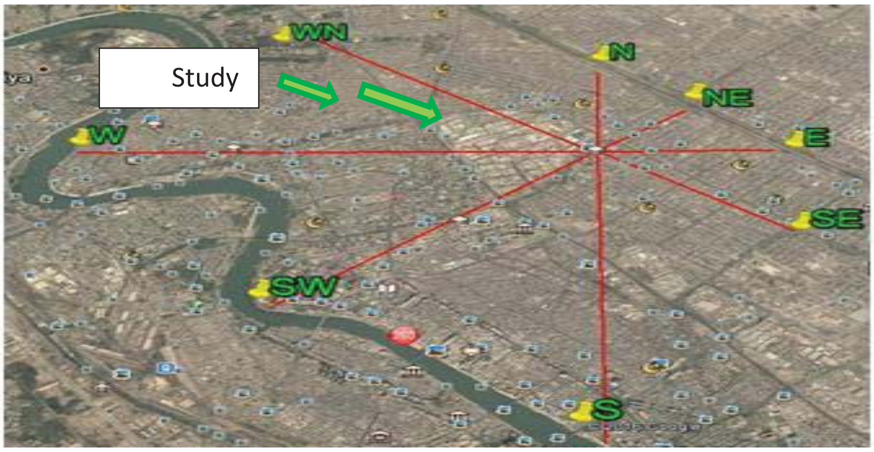



**Fig (6): fetch from 8 direction in study site [9].**

**4-3 Estimation the internal boundary layer height.**

By using Eq.(2) to find the IBL-H in the three state (unstable - neutral- stable), the stability values were initially taken as an average. The values of stability (α) were taken as an average at the three state (0.9-0.8-0.65 ) ,The lowest rate of height for the stable cases was (54.36m) shows in the table (3) and in sector (2-NE) Look less high neutral conditions the height (78m) which considered Appropriate to turbine to generated wind.

Table (7): Height of internal boundary layer (unstable- neutral-stable).

| Sector(◦) | Unstable | neutral | Stable |
|---|---|---|---|
| 1 | 108 | 108 | 37 |
| 2 | 153 | **78** | 28.4 |
| 3 | 223.7 | 113.8 | 38.6 |
| 4 | 298 | 114.1 | 46 |
| 5 | 569 | 251 | 73.5 |
| 6 | 484 | 217.7 | 65.5 |
| 7 | 1410 | 269 | 77.9 |
| 8 | 436 | 198 | 68 |
| Average | 460.21 | 168.7 | 54.36 |

**4-4 The relationship of stability with IBL**

In this section, we study the effect of the Monin-Obukhov length on the internal boundary layer height because in a previous section the stability was taken as an average. To obtain dimensionless local stability, it has been divided the height over Λ i.e. (z)/Λ .The stability values were classified to three ranges: Unstable

(- Z/Λ > 0.1), Neutral |∓ 0.1|, Stable (Z/Λ>0.1). To calculate the Monin-Obukhov length, we must find the velocity and the temperature and apply them in equation (2). In unstable condition we shown the relationship between stability and IBL-H, after we calculate {Z: 19m height of the station, Λ: Monin-Obukhov length (- Z/Λ > 0.1)} by depends on data in this case. We notes the direction (NE) is small and gradually be smaller but the direction (W) is large with IBL-H.

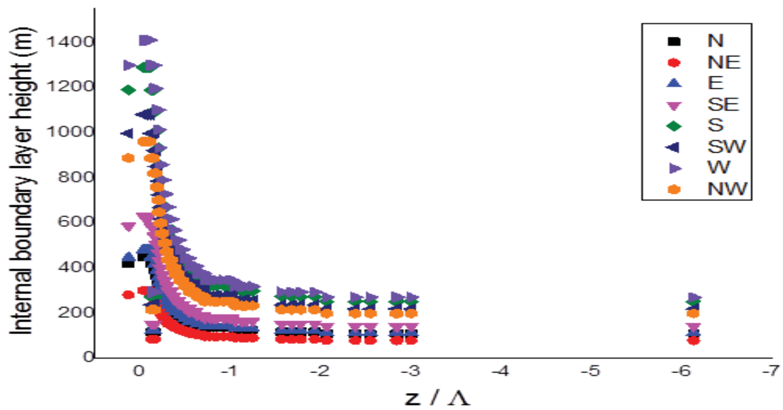



**Fig. (7): Internal boundary layer height with under unstable condition**

.

But in Stable condition (the stability values Z/Λ) on the x-axis and the internal boundary layer height values on the y-axis) we notice that there is an increase at the beginning with the stability and this increase is a few, in the Fig.(8) The lowest value at the direction (NE) while the higher value at the direction (W). Then the others direction was increase also with IBL-H. This increase in values is a linear relationship.

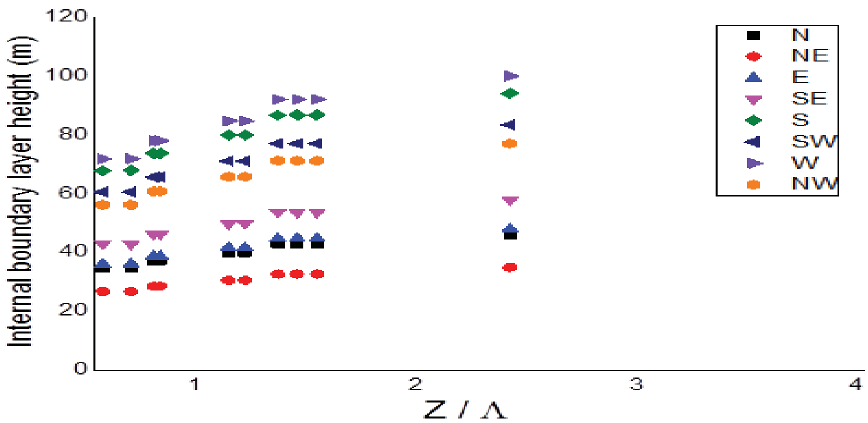



**Fig. (8): Same fig. (7) But in the stable conditions.**

**4-5 wind power density in the height (19 m).**

Using the wind speed calculated in the table above (3), and the value of Air density ( $\rho = 1.225\ kg/m3$) we calculated the wind speed density by eq.(3) as shown in the table ( 8 ), we notice that the intensity of the wind speed increases as the wind speeds increases ,When the wind speed is within a period (0-0.9 m ) it is ( 0.2 ), either the wind speed density is maximum when the wind speed is about (9-9.9 m) .

**Table (8): wind power density in different speed.**

| Wind speed intervals | WPD | Wind speed intervals | WPD |
|---|---|---|---|
| 0-0.9 | 0.2 | 6-6.9 | 150.8 |
| 1-1.9 | 2.1 | 7-7.9 | 232.3 |
| 2-2.9 | 8.3 | 8-8.9 | 333.4 |
| 3-3.9 | 21.1 | 9-9.9 | 513.6 |
| 4-4.9 | 46.3 | | |
| 5-5.9 | 91.2 | | |

**4-5 wind power density in IBL-H**

After we found the internal boundary layer height we can estimate the wind speed by the eq .(3) of low for height in three condition (unstable, neutral, and stable) and then we found the average of wind speed for this height. where the initial height of the station ($Z_{ref}$) is about 19 m and the second rise (Z) is estimated as in table (7), while the wind speed data ($U_{ref}$) obtained from the automatic weather station, Where the average of wind speed calculated at the maximum elevations did not exceed 25 m/s , which lead to a malfunction or defect in the work of the turbine and therefore the speed is suitable for the installation of a wind turbine.

Then we found wind power density in table (9) for three conditions by using (4). we notice the value of wind power density in neutral condition 41.95 ($w/m^2$) when average wind speed is about 4.04( m/s). The (WPD) proportional directly with the average wind speed, and we calculated shape, scale parameter , slandered deviation, to get wind power density by using Weibull destitutions .

**Table (9): wind power density in three condition and WPD by used Weibull destitutions.**

| Unstable | | Neutral | |
|---|---|---|---|
| | | | |
| Average wind speed (m/s) | WPD (w/m$^2$) | Average wind speed (m/s) | WPD |
| 1.07 | 0.79 | 1.03 | 0.70 |
| 2.66 | 11.92 | 2.55 | 10.52 |
| 4.21 | 47.50 | 4.04 | 41.95 |
| 5.76 | 121.44 | 5.53 | 107.25 |
| 7.48 | 266.14 | 7.18 | 235.03 |
| 9.38 | 523.63 | 9.00 | 462.42 |
| 11.51 | 968.81 | 10.64 | 764.85 |
| 13.29 | 1492.16 | 12.29 | 1178.01 |
| 15.00 | 2141.88 | 13.86 | 1690.95 |
| 17.32 | 3299.23 | 16.01 | 2604.64 |

| Stable | | By used Weibull distribution |
|---|---|---|
| Average wind speed (m/s) | WPD (w/m$^2$) | WPD |
| 0.91 | 0.47 | 0.19 |
| 2.24 | 7.18 | 2.14 |
| 3.56 | 28.63 | 8.58 |
| 4.87 | 73.19 | 22.34 |
| 6.32 | 160.40 | 45.97 |
| 7.92 | 315.58 | 89.69 |
| 9.37 | 521.96 | 154.35 |
| 10.82 | 803.93 | 229.08 |
| 12.20 | 1153.98 | 338.93 |
| 14.09 | 1777.52 | 509.28 |

## 5. Concluding remarks

Through data collection and analysis in according with the atmospheric conditions that accompanied the data recording by using different methods and equation to calculate IBL-H our study reached the following: By finding wind speed frequencies for the year 2016, according to the available data, the wind speed ratio is good. When the wind speed is between 4-4.9, the average speed is 4.2 and the frequency is 1038 times. The higher speed is Few are available, although this speed is measured from The station is located at Mustansiriya University in the center of the capital, meaning that it is affected by buildings and trees.

By taken the data from 'automatic weather station' was located .

The suggestion height in neutral condition to generate wind energy from Mustansiriya University is 78 meter.

**6. References:**

1- Shaw S., "Development and Validation of the Wind Energy Calculator (WEC) For Use As A Module in the Larger Complimentary Energy Decision Support Tool (CEDST) Project", M.Sc.Thesis, University of Guelph, 2012.

2-Al-Noori S., Al-sakini A., "The Possibility of Employing the Winds in Iraq in Producing the Electric Energy",M.Sc. Thesis ,University of Al-Mustansiriya.

3-AL-Temimi,2007:"WindEnergy Assessment in Iraq",Ph.D. Thesis, College of Science, Department of Atmospheric Sciences, Mustansiriya University.(Arabic)

4- Perez I.A. , Garcia M.A., Sanchez M.L., "Torre B.deAnalysis of Neight Variations of sodar-derived wind speeds in Northern spain", Journal of Wind Engineering and Industrial Aerodynamics 92:10,875-894,2004.

5-MathiasW. Rotach,1999: On the influence of the urban roughness sub layer on turbulence and dispersion, Atmospheric Environment journal 33 (1999) 4001-4008.

6-- Jasim,S.h.,,2008: " Calculation and Diagnose the Horizontal Wind Speed with Height over Baghdad City" ,M.Sc. Thesis, University of Al- mustansiriyah. (in Arabic)

7- Troen I., ″A High Resolution Spectral Model for Flow in Complex Terrain", Department of Metrology and Wind Energy, Riso National Laboratory, Roskilde, Denmark, 1989.

8- Mahyoub H. Albuhairi,2006, Assessment and Analysis of Wind Power Density in Taiz- Republic of Yemen, Ass. Univ. Bull. Environ. Res. Vol. 9 No. 2, pp. 13-21.

9-https://www.google.iq/maps/

10- Al.jiboori,M.,and A,G,Al-draji 2010: Aerodynamic Surface Roughness Length Of Baghdad City, Journal of Al-Nahrain University Voi.13,pp.96-102.