Plant Archives Vol. 20, Supplement 2, 2020 pp. 657-663 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

SITE ASSESSMENT OF RAZZAZA AND NATURAL RESERVE SITES IN THE SOUTH OF IRAQ, STUDY AND COMPARISON WITH THE IRAQI WIND ATLAS (IWA)

Ahmed B. Khamees[1], Khalid S. Heni[2], Wasan T. Mousa[3]
[1]Wind Energy Dept., Ministry of Science and Technology, Baghdad, Iraq, ahmedbader63@yahoo.com
[2]Wind Energy Dept., Ministry of Science and Technology, Baghdad, Iraq, Khalid_heni@gmail.com
[3]Wind Energy Dept., Ministry of Science and Technology, Baghdad, Iraq, wasanmousa@yahoo.com

Abstract

Site assessment has been carried out to evaluate wind speed and power density in Najaf Natural Reservation in Najaf provenience and Razzaza site in Karbala provenience, both are located in the south of Iraq. The results have been compared with The Iraqi Wind Atlas (IWA) that produced previously depending on the data of (NASA). Metrological data of one year (2016) has been collected with time interval of 10 minutes for 10, 30, and 50 meters' heights. The data has been collected from two meteorological masts installed at the mentioned sites. These data were analyzed by using WAsP program. The results of WAsP obtained by using (real data) were better than results of (IWA), which are showing clear increment in mean wind speed and power density at the two sites. Therefore, real data must be obtained to get true and reliable wind atlas, not only in Iraq but anywhere around the world.

Keywords : Najaf Natural Reservation (NR), Site assessment, Razzaza, Iraqi Wind Atlas (IWA), Meteorological mast, meteorological data, WAsP.

Introduction

The world is going seriously toward exploit and develop the technologies of the field of renewable energy, to produce electric power used in different tasks of the life. A lot of instruments, equipment, and programs are developed in this field. This development allows getting the best benefits from the available natural resources of the renewable energy. Iraqi wind atlas (IWA) has been carried out depending on certified satellite meteorological data by NASA. The IWA has been designed especially for Iraq as GIS maps to show the distribution of wind speed, power density, the wind rose, and Weibull parameters at any location in Iraq for three heights above ground, 30m, 50m, and 100m. In this work, two sites were selected as the region of interest. The first site is located at Al-Razzaza Lake (Razzaza) in Karbala province, with coordinates of N: 32 41.346 E: 43 54.469. On the other hand, the second one is located at the natural reserve (NR) in Al-Najaf province with coordinates of N: 31 40.921 E: 44 18.330. A meteorological mast (met mast) is a lattice metal tower of 50 m height is installed in each of the selected locations. Each of the two installed masts has meteorological sensors of wind speed and wind direction; these sensors fixed at three levels on every mast, 10 m, 30 m, and 50 m. It is possible to achieve site assessment in each location by using the real data of wind speed and direction that is recorded every 10 minutes for one year for each met mast. These data were analyzed by using WAsP program for the three levels 10 m, 30 m, and 50 m. The results of the analyzed data have been compared with those of IWA to test the reliability of the two software, to choose the best one for the future work.

Theoretical Part

Wind energy is clean, renewable, and sustainable; it is becoming quite popular compared to other renewable energy sources such as solar, biomass, tidal and wave Nathan David (2013) and F. Fazelpour (2015). Many countries worked in this field, as development and investment. From 1992 onwards, renewable energy has become a top priority for the governments of all the European countries due to the increasing global concerns about climate change Md.M.E. Moula (2013). To get the benefits of wind energy, wind turbines must be installed in suitable sites to harvest the wind energy and convert it into electrical energy S. Bibek and P. Kaushik (2010) and E.I. Konstantinidis and P.N. Botsaris 2016.

Installing individual wind turbines or wind farms may depend on the surface roughness of the land and the average wind speed values as well as the frequency of the speeds on the site. Flat area with no obstacles is strongly wanted to install wind turbines to keep laminar wind flow as well as an obvious magnitude of wind speed Scottish Natural Heritage (2009) and Torben Reichstein *et al* (2019). The site of higher values of wind speeds is the best to install wind turbines. That means that high wind power (P) can be generated as can be cleared in the following relation I. Daut (2012) and Chowti *et al.* (2018):

$$P=1/2\ \rho A V^3 \qquad \dots (1)$$

Where ρ is the air density (kg/m^3), A is the swept area of the wind turbine (m^2), V is the wind speed value (m/s).

A primary study, investigation, and assessment must be achieved before installing wind turbines on a chosen site. This assessment includes land use, surface roughness, wind availability as well as wind direction and its frequency over the year. To get the best and accurate method to measure the wind speed, meteorological masts have to be installed in the desired sites to record various meteorological data Asian Development Bank -ADB- (2014) The number and height of the measurement masts should be adjusted to the complexity of the terrain as with increasing complexity W. Langreder (2010). The measurements can be done by fixing the suitable sensors at different heights on the mast. The criterion for determining wind-energy potential is based on a simple set of parameters, including average wind-energy density W/m^2, annual hours of wind speed above 6 m/s, and annual hours of wind speed above 3 m/s Sh. Singh (2006). By installing a large number of masts in a wide area in the middle and south of Iraq, the records of wind speed and direction, as well as other meteorological data for each site, will be obtained. The obtained data can be drawn in GIS map, to determine the sites that have superior wind speeds. These sites will be efficient if they have flat surfaces and with no obstacles, which resulted in laminar wind flow F. Ben Amar (2013), with accepted speeds. Iraqi Wind Atlas (IWA) has been achieved previously by using data from NASA for three levels 30m, 50m, and 100m, as shown in Figures 1, 2 and 3 respectively. Hourly data from June 2003 to June 2012 has been used to carry out the IWA and published on the website of IRENA IRENA, Global Atlas http://irena.masdar.ac.ae/# (2013). The figures 4 and 5 show the wind rose in each of the natural reserves (NR) and Razzaza at: a: 30m, b: 50m. The actual data which measured by the installed masts in each site will be analyzed and compared with the IWA to determine the difference between them. It is expected that the actual data has the higher values because it represents the field situation without any processing. . The percentage of the expected increment in wind speed can be calculated using any related formula Ummul Khair *et al* (2017). A study of the similar case shows a difference between the measured and predicted monthly values were within the range of 0.01 to 0.69 m/s S. K. Khadem (2004). WAsP (Wind Atlas Analysis and Application Program) N.G Mortenson (2011), has been used which is a standard tool typically used for sitting the appropriate locations for the construction of wind turbines toproduce electric power S. M. Ali *et al.* (2014) and Ahmed E. Ghitas *et al.* (2016).

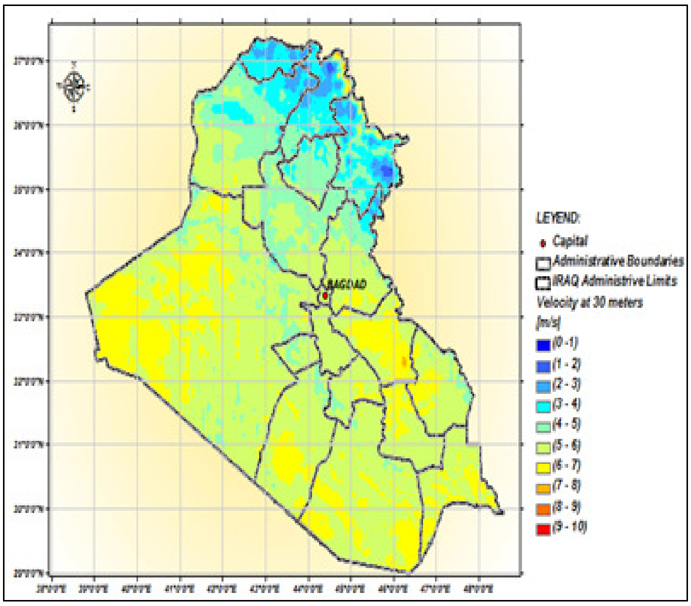


Fig. 1: Wind map of Iraq at 30m (IWA).

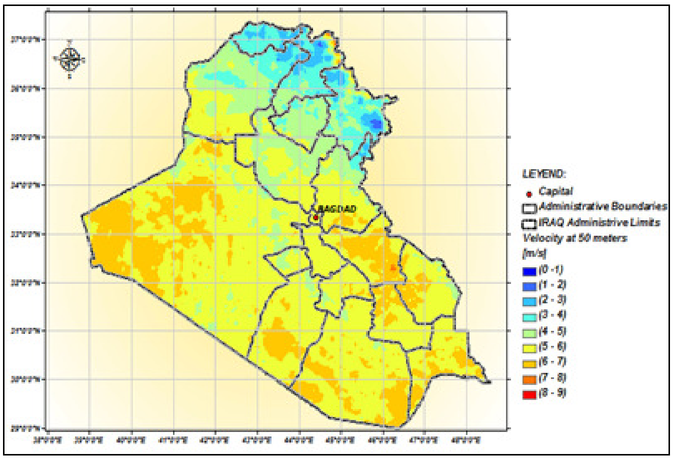


Fig. 2: Wind map of Iraq at 50m (IWA).

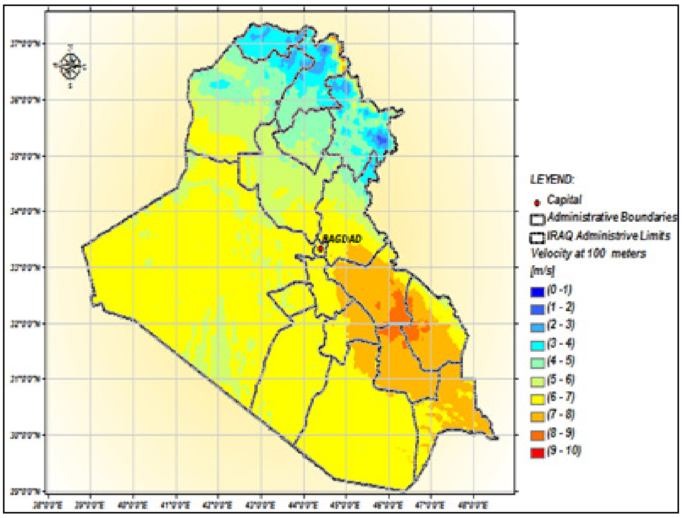
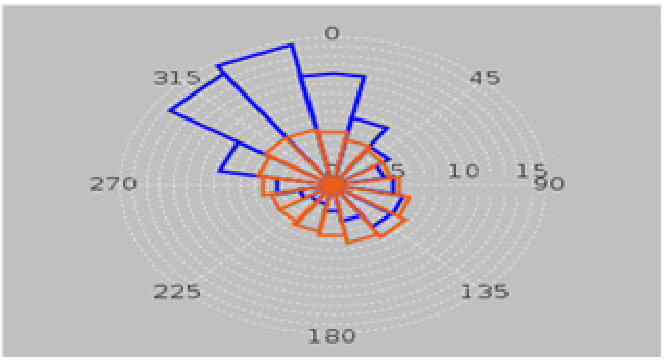
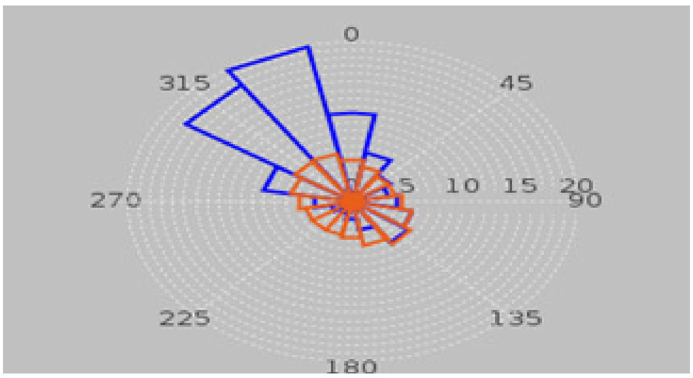


Fig. 3: Wind map of Iraq at 100m (IWA)



(a)

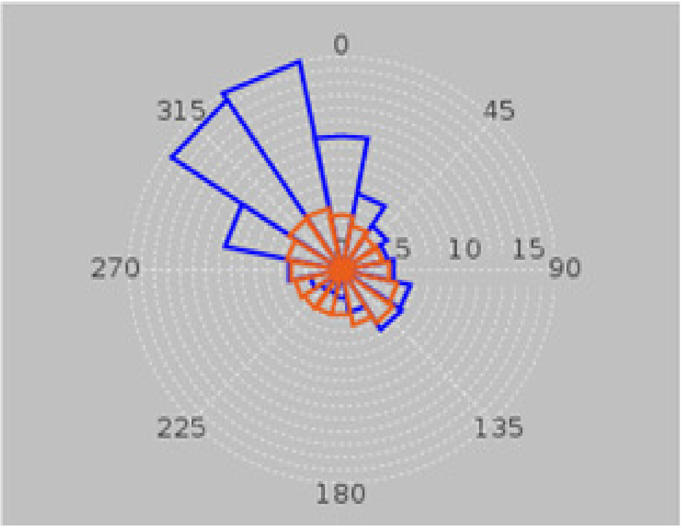


(b)

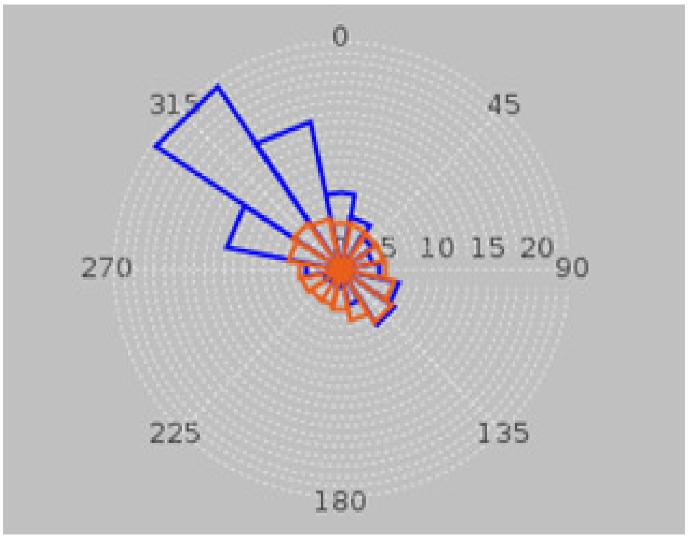
Fig. 4: Wind rose at the natural reserve (NR) at:

a: 30m, b: 50m.

The wind speed (orange), wind frequency (blue)



(a)



(b)

Fig. 5: wind rose at Razzazaat: a: 30m, b: 50m.

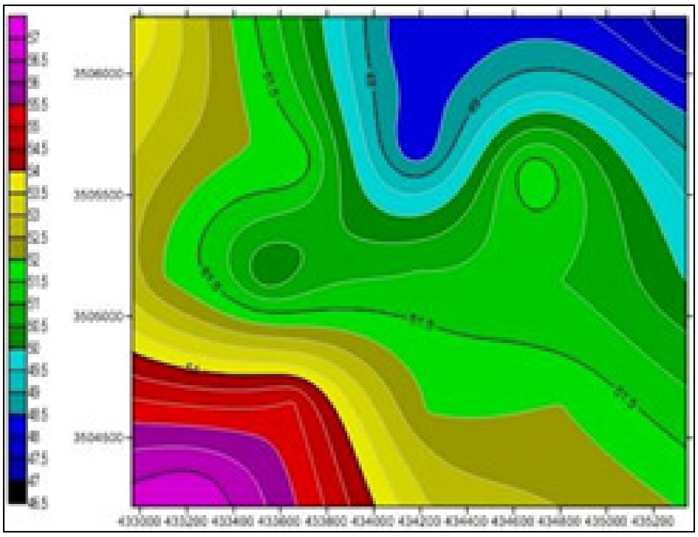
The wind speed (orange), wind frequency (blue).

Materials and Methods

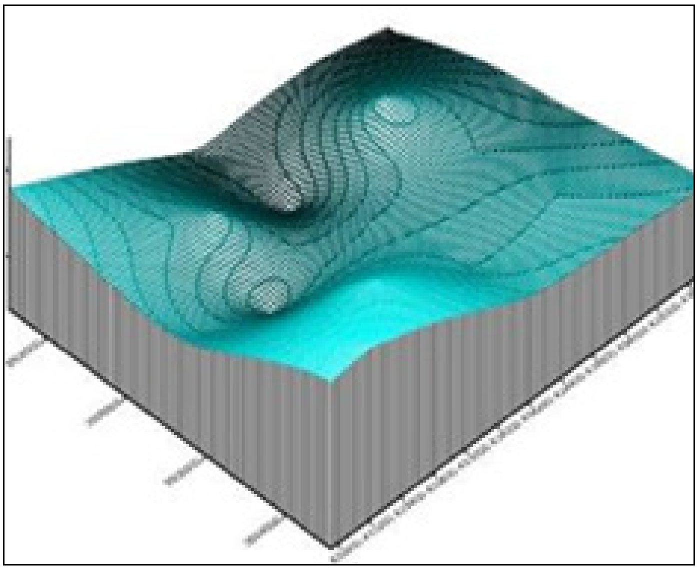
Mean wind speed, and power density has been estimated for each site at three heights 10m, 30m, and 50m by using the actual data which is logged by the installed mast at each site. The results are compared with IWA maps.

Surface Features:

The two selected sites have an almost flat surface with no obstacles. Figures 6 and 7 illustrate the surface shape in each site in 2-dimensions and 3-dimensions for the natural reserve (NR) and Razzaza, respectively. Slight acceptable variations found in the surface elevation of the selected sites. The existed variation in the natural reserve (NR) surface was about 9 meters while it is about 17 m in Razzaza. Therefore, the Value that has been adopted in this research for the roughness length is 0.03 m with roughness class of 1 according to the global Roughness Classes and Roughness Length Table.



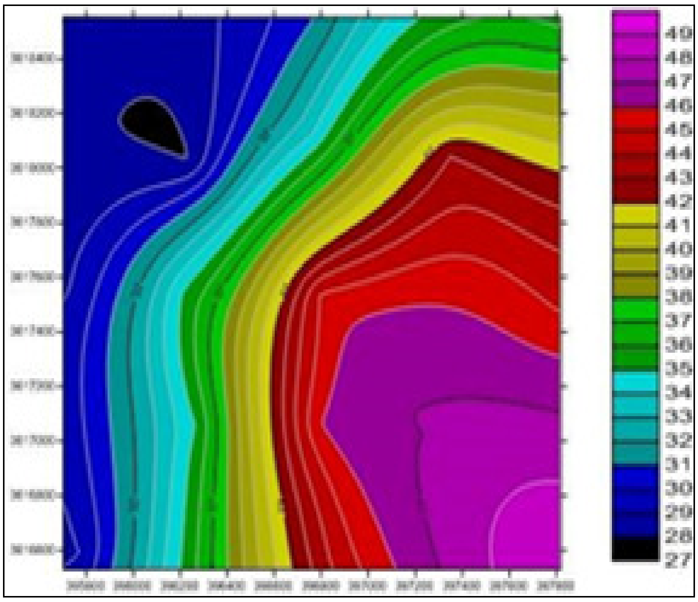
(a)



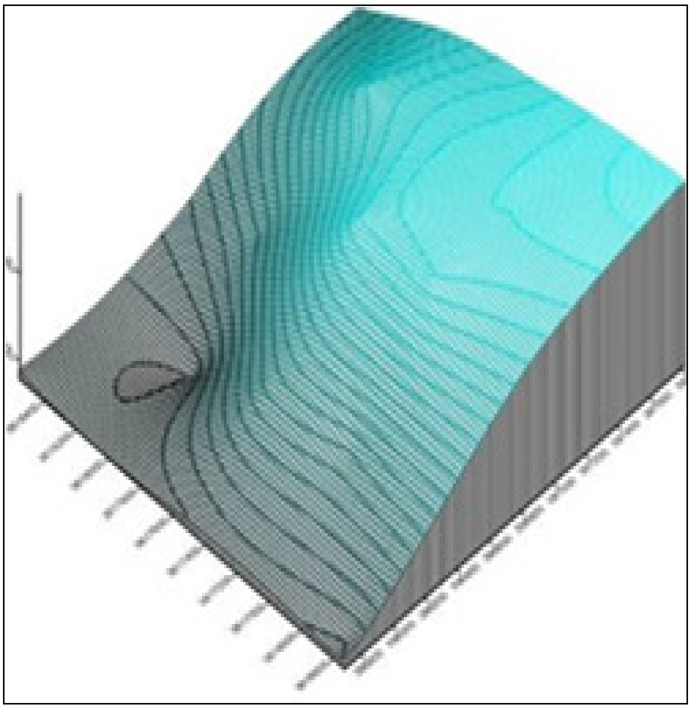
(b)

Fig. 6: The surface shape of (NR).

a: 2-dimensions, b: 3-dimensions.



(a)



(b)

Fig 7: The surface shape of (Razzaza). a: 2-dimensions, b: 3-dimensions.

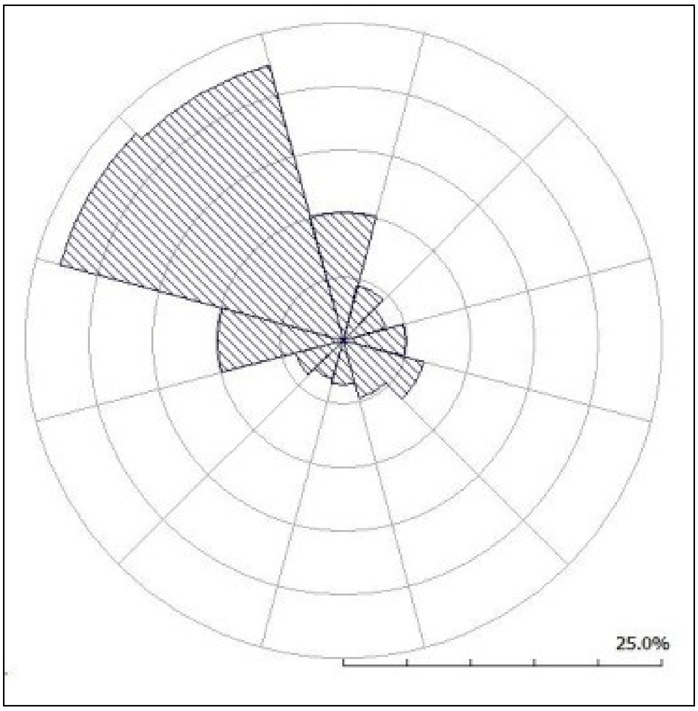


Fig. 9 : Windrose at 10m in Razzaza.

After analyzing the received data by using WAsP, curves of wind frequency, Weibull Parameters (A and k), average wind speed, and estimated power density were obtained, for each site on three heights 10m, 30m, and 5m, as shown in Figures 10, 11, 12, 13, 14, and 15.

Results and Discussions

By using the received data from both masts, wind roses have been drowning for each site at 10m height. Almost wind direction is not affected by height at each site because no turbulent exists in the upper heights, which means laminar wind flow. The figures 8 and 9 show the wind rose at 10m, in NR and Razzaza, respectively.

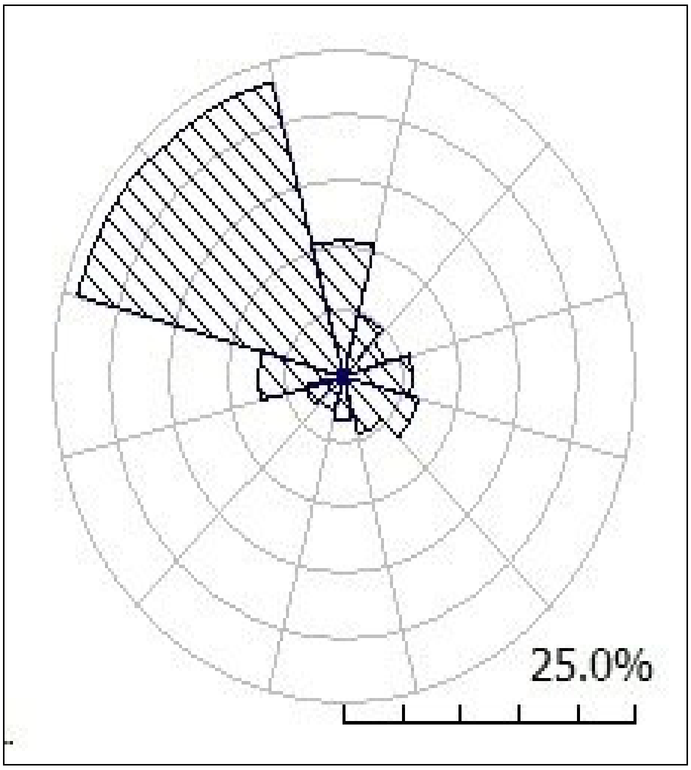


Fig. 8: Windrose at 10m in NR.

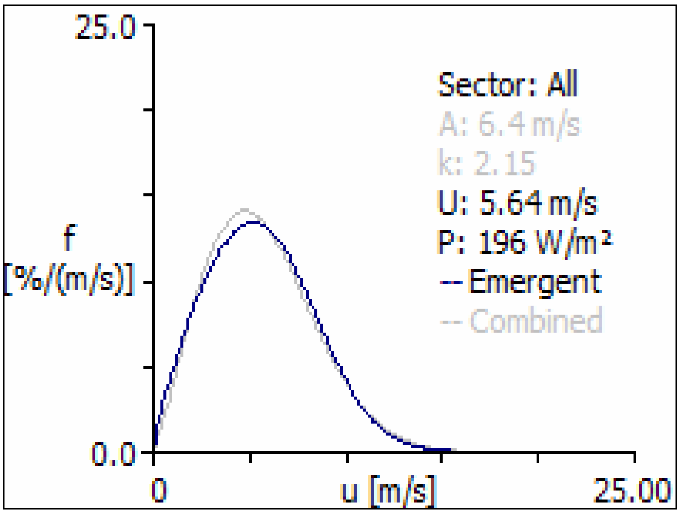


Fig. 11: Wind frequency at (NR) for 30m height.

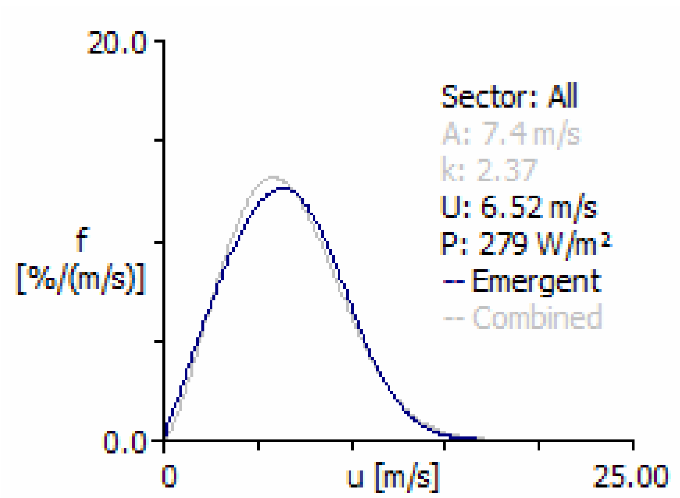


Fig. 12: Wind frequency at (NR) for 50m height.

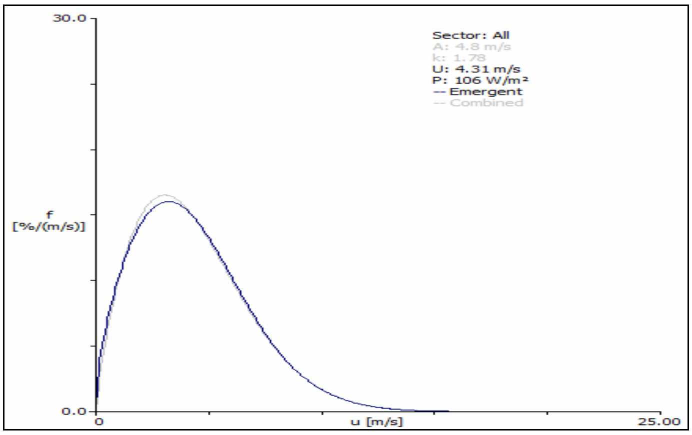


Fig. 13: Wind frequency at (Razzaza) for 10m height..

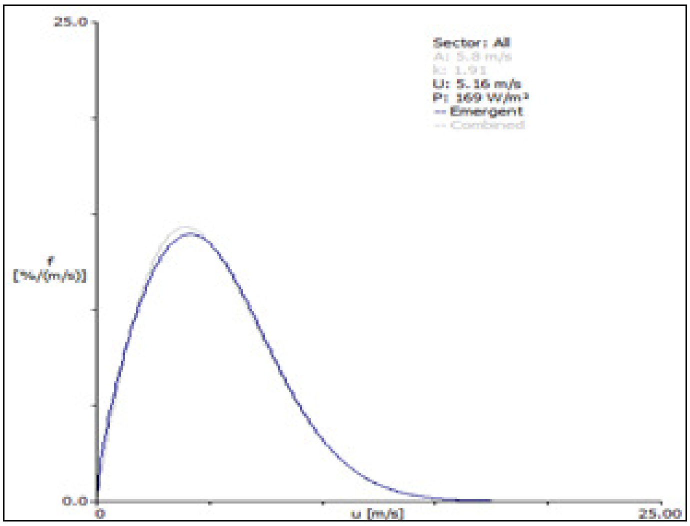


Fig. 14 : Wind frequency at (Razzaza) for 30m height.

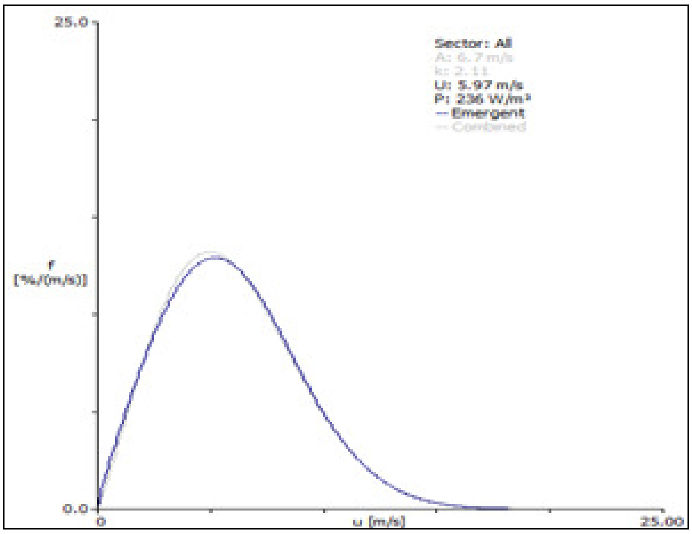


Fig. 15 : Wind frequency at (Razzaza) for 50m height

The results of wind speeds and power densities that estimated by WAsP and IWA, for the studied sites have been listed in Tables 1, 2, 3 and 4 to make a comparison between the two methods. The wind speed and power density for 10m height are not listed in Table as they are not available in the IWA. However, the comparison made between the heights 30m and 50m only. The percentage of the increase in wind speed has been calculated by using the following equation:

$$\text{Percentage } (\%) = \frac{\text{WAsP} - \text{IWA}}{\text{IWA}} \qquad \text{.... (2)}$$

Where WAsP means the average wind speed obtained by using WAsP program.

IWA means the average wind speed illustrated in the Iraqi Wind Atlas.

Tables 1 and 2 show a significant difference between the two used methods of estimation: WAsP and IWA, the real calculations that achieved by using WAsP (actual data) giving higher values of wind speeds at 30m (V30) and 50m (V50) than those estimated by IWA. There is a clear increasing in wind speed percentage. The increasing percentage in the NR is 10.59% at 30m and 20.74% at 50m while it is 7.5% at 30m and 24.11% at 50m in Razzaza..

Table 1 : Comparison of average wind speed at 30m and 50m in NR by WAsP and IWA.

Wind speed estimation	**V10(NR) m/s**	**V30(NR) m/s**	**V50(NR) m/s**
By WAsP	4.72	5.64	6.52
BY IWA	-	5.10	5.40
Increasing in wind speed (%)	-	10.59	20.74

Table 2: Comparison of average wind speed at 30m and 50m in Razzaza by WAsP and IWA.

Wind speed estimation	**V_{10} Razzaza m/s**	**V_{30} Razzaza m/s**	**V_{50} Razzaza m/s**
By WAsP	4.31	5.16	5.97
BY IWA	-	4.80	4.81
Increasing in wind speed (%)	-	7.50	24.11

As a result of wind speed increment, power density increases, too. Tables 3 and 4 show the results estimated by using each of WAsP and IWA in both sites at 30m and 50m height. At the NR, the power density which is estimated by WAsP is about 49.24% higher than that which is estimated by the IWA at 30m height, while it increased about 74.37% at 50m height. At Razzaza site, power density increased about 40.83% at 30m height and about 139.24% at 50m height.

Table 3: Comparison of power density at 30m and 50m in NR by WAsP and IWA

Power density estimation	$P.D_{10}$ (NR)W/m^2	$P.D_{30}$ (NR)W/m^2	$P.D_{50}$ (NR) W/m^2
By WAsP	122	197	279
BY IWA	-	132	160
Increasing in power density (%)	-	49.24	74.37

Table 4: Comparison of power density at 30m and 50m in Razzaza by WAsP and IWA.

Power density estimation	$P.D_{10}$ Razzaza W/m^2	$P.D_{30}$ Razzaza W/m^2	$P.D_{50}$ Razzaza W/m^2
By WAsP	106	169	378
By IWA	-	120	158
Increasing in power density (%)		40.83	139.24

The previous calculations of wind speed and power density that estimated by WAsP showing a featured result, in comparison with those estimated in the IWA. This may be due to the nature of the analyzed data. In addition to that, the data which used in the IWA program were hourly records while the data of WAsP were recorded for every ten minutes. The actual data from each mast in the studied sites gives a real indication for all meteorological elements; it a real indication for all meteorological elements; it represents all the effects of the field.

Conclusions

The average wind speeds that calculated by WAsP using real data (data from the meteorological mast) at different heights at the two selected sites are greater than those estimated in the IWA. The power density at both sites that estimated by WAsP was greater than those estimated by IWA.

It can be seen clearly from the calculations of each wind speed and power density that WAsP was superior to IWA in the results. This because WAsP takes real data.

The wind direction is almost the sameon both sites at the levels 30m and 50m.The reason for that, there is no existence of obstacles, which allowing laminar wind flow with no turbulent.

References

Ahmed, E.; Ghitas, A.A. and Yasser, A. Abdel-Hadi, (2016). An Assessment of Wind Energy Potential as a Power Generation Source in Helwan, Journal of Clean Energy Technologies, 4(6): November 2016 .

Ali, S.M.; Shaban, A.H. and Resen, A.K. (2014). Integrating WAsP and GIS Tools for Establishing Best Positions for Wind Turbines in South Iraq", International Journal of Computer and Information Technology, 03(03): May 2014.

Amar, F.B. and others (2013). International Renewable and Sustainable Energy Conference (IRSEC), Transposition of wind measurements to a standard site of open area roughness at a height of 10m above ground level", IEEE, 318-321.

Asian Development Bank (ADB) (2014). "Guidelines for Wind Resource Assessment: Best Practices for Countries Initiating Wind Development", ADB, Philippines, 5-15.

Bibek, S.; Kaushik, P. (2010). A Study of Wind Energy Potential In India, Department of Electrical Engineering National Institute of Technology, Rourkela, India, 17-18.

Daut, I.; Razliana, A.R.N.; Irwan, Y.M. and Farhana, Z. (2012). A Study on the Wind as Renewable Energy in Perlis, Northern Malaysia", Energy Procedia, 18: 1428–1433.

Fazelpour, F.; Soltani, N. and Rosen, M.A. (2015). " Wind resource assessment and wind power potential for the city of Ardabil, Iran", Int. J Energy Environ Eng., 6: 431–438.

International Renewable Energy Agency, Global Atlas, http://irena.masdar.ac.ae/# .

Khadem, S.K.; Ullah, S.M.; Ghosh, H.R. and Hussain, M. (2004). WAsP Analysis for Wind Energy Assessment over Kutubdia Island, World Renewable Energy Congress VIII (WREC 2004), Colorado, USA.

Konstantinidis, E.I. and Botsaris, P.N. (2016). IOP Conf. Ser.: Mater. Sci. Eng. 161012079 .

Langreder, W. (2010). Wind resource and site assessment, Ch. 2, WIT Transactions on State of the Art in Science and Engineering, Vol. 44: WIT Press, UK.

Mortenson, N.G.; Landberg, L.; Troen, I. and Petrson, E.L. (1993). Wind atlas analysis and application program (WAsP)," Vol.2, user's guide, Riso national laboratory, Roskidle.

Moula, M.E.; Maula, J.; Hamdy, M.; Fang, T.; Jung, N. and Lahdelma, R. (2013). Researching social acceptability of renewable energy technologies in Finland, International Journal of Sustainable Built Environment, 2: 89–98.

Nathan, D.; Nzewi, O.N.; Onuora, K.C. and AbioyeAyodejiOpeyemi, (2013). Alternate power source: Wind Turbine", Quest Journal of Electronics and Communication Engineering Research(JECER) 1(1): 01-09.

Scottish Natural Heritage (2009). "Siting and Designing windfarms in the landscape", V1, UK.

Singh, T.S.; Bhatti, D.P. Kothari (2006). A Review of Wind-Resource-Assessment Technology, Journal of Energy Engineering, 1(8): 132.

Torben Reichstein *et al*, (2012). Investigation of Laminar-Turbulent Transition on a Rotating Wind Turbine Blade of Multi Megawatt Class with Thermography and a Microphone Array, Energies 2019, 12, 2102.

Ummul Khair *et al*, (2017). Forecasting Error Calculation with Mean Absolute Deviation and Mean Absolute Percentage Error, IOP Conf. Series: Journal of Physics: Conf. Series 930: 012002.