Preliminary investigation study of wind energy at Tuz-Khormatu in Iraq.

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Abstract

The aim of the present work is an investigation of wind energy potential for construction a wind farm in (Tuz-Khormatu) in Iraq using the world wind map of RETScreen software. The wind data were obtained from RETScreen and Windographer programs for 15 years and eight months. Three wind turbines were selected from the library of the RETScreen and matched with wind data to assess the potential of the proposed wind farm at the selected site (Tuz-Khormatu).The wind turbine model (Enercon-33-50m,330KW) has the highest capacity factor 31.5% and the maximum wind energy from the wind farm 6874 MWh/year .

Keywords: RETScreen, Wind Turbine, shape factor, scale factor, wind energy, capacity factor.

1. Introduction

The potential of wind energy in Iraq has not been yet fully explored due to the lack of an accurate reliable and historical wind data at most of the regions in Iraq, so the data is insufficient to evaluate and select the suitable sites for the wind power project development. At present, a few numbers of sampling small scale wind turbines were erected by the ministry of science and technology in Iraq.

To developed more wind energy application; this work will assist in defining the promising site for wind projects for rural electrification in Iraq. The RETScreen software can be used to evaluate the energy production and savings, costs, and other aspects for various types of Renewable-energy and Energy Efficient Technologies (RETs)[1].

H. R. Hermannsson [2] made an examination of two computer programs for estimating wind energy, RETScreen and System Advisor Model (SAM), and compared to measured data from a wind farm. He found that the Wind speed and electrical production estimated by RETScreen underestimates the electrical production by 35% and SAM overestimates it by 26%.

S. Rehman [3] has studied wind farms of 30MW installed capacity at five coastal locations in Saudi Arabia by using RETScreen software. Among the five proposed areas, he found that the only two sites at Yanbo and Dhahran would be an economically feasible for the wind park development considering with 1500, 1000, and 600 kW machine.

In the present work, 6MW proposed wind energy project is supposed for rural electrification at (Tuz-Khormatu). RETScreen software 4 was used to demonstrate the energy modeling of proposed wind farm construction at that site.

2. Wind data source

The assessment of wind resource is the major process to evaluate the potentiality of wind energy of the candidate site. It is recommended to use direct measurements wind data to accurate assessment by tower masts to get long term data acquisition. However, in Iraq the available data is still not covering all the regions. Figure 1 shows the map of Tuz-Khormatu (35.31 latitude, 44.33 longitude).

An hourly wind data were downloaded for this site by using RETScreen at10 m above ground level (a.g.l) and the daily wind data were downloaded from Windographer at 50 m from January of 2000 to August of 2015 (15 years And eight months).

Fig.(1): Tuz–Khormatu map.

3. Wind power density

The wind power density at a site shows expected electrical energy produced by the wind turbine by using wind speed data for selected site. RETScreen calculate wind power using the input wind speed data and air density with a value of 1.225 kg/m³ with standard sea level pressure and a temperature of 15°C. The energy calculations were performed using RETScreen Software, more details can be found in many references [4, 5].

To obtain the Weibull parameters K_h and C_h at different hub heights of wind turbines by using the following equations [6, 7]:–

$$K_h = K_o * \left[1 - 0.0881 * \ln\left(\frac{h_o}{10}\right)\right] / \left[1 - 0.0881 * \ln\left(\frac{h}{10}\right)\right] \quad \text{.........(1)}$$

$$C_h = C_o * \left(\frac{h}{h_o}\right)^{\alpha} \quad \text{........(2)}$$

Where C_o and K_o are the scale and shape factors, respectively, at the measurement height h_o, and h is the hub height.

The losses of the wind turbines are expressed as coefficient (CL) in the following Eq. (3), specify array loss, airfoil loss and miscellaneous loss are specified in RETScreen models [4,5].

$$CL=(1-\lambda a)\times(1-\lambda s\&i)\times(1-\lambda d)\times(1-\lambda m) \quad \text{..........(3)}$$

Where,

, λa = Array loss, $\lambda s\&i$= Airfoil soiling and icing loss, λd = Downtime loss, λm = Miscellaneous loss. Table 1 shows the typical and the used values of losses parameters and the rate of electricity absorption which were used in as an input data in RETScreen [7].

Table 1: typical and the used values of losses parameters [7].

Type of losses	Typical value	Used value
Array loss	1–8%	2%
Airfoil soiling and icing loss	1 to 10%	1%
Downtime loss	2 to 7%	3%
Miscellaneous loss	2 to 6%	2.2%
Availability (absorption rate)	98–100%	98

The wind shear coefficient (n) was calculated for each month and the average yearly values were computed using the following equation (4)[8]:-

$$n = [0.37 - 0.088 \ln(c_o)] / \left[1 - 0.088 \ln\left(\frac{h}{10}\right)\right] \quad \text{.........(4)}$$

4. Wind turbine selection

Three wind turbines were selected from the library of RETScreen 4 program to study the proposed site which considers as poor site (class1) according to the classification classes of wind power densities of International Electro technical Commission (IEC61400-1) [9]. The power curve of these turbines is shown in Figure (2). these types of wind turbine can operate at 3m/s.

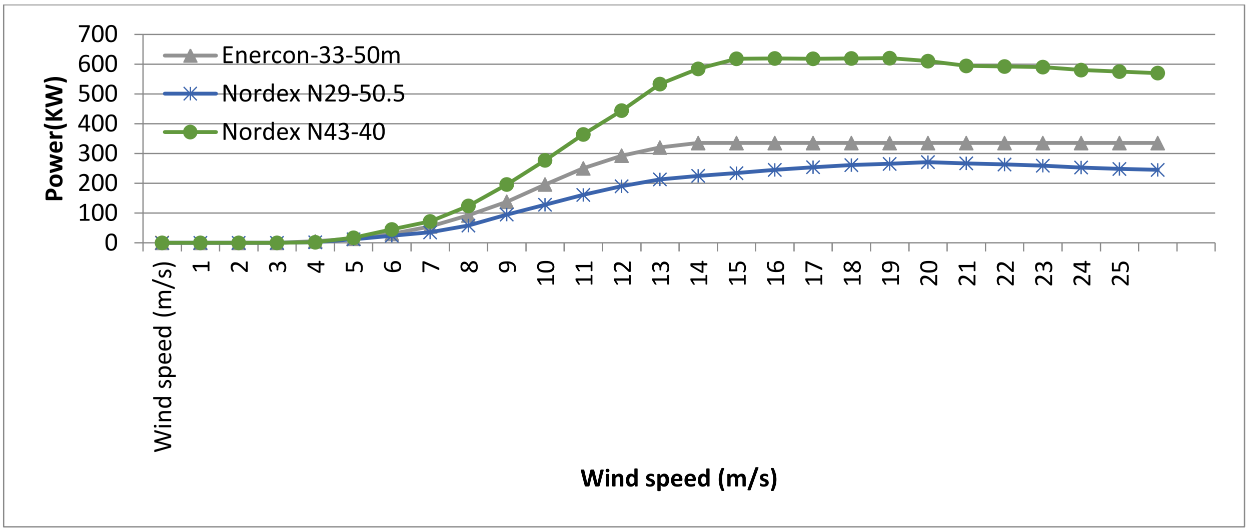

Fig. (2): Power curve of the selected wind turbines at Tuz-Khormatu site[8].

The gross energy production can be computed by the following Eq. [4,5,10].

EG=EU CH CT ... .(5)

Where, EU is the unadjusted energy production, and CH= P/P0 (P is the annual atmospheric pressure at the site and P is the standard atmospheric pressure of 101.3 kPa).

And CT = T0/T (T is the annual average absolute temperature at the site and T0 is the standard absolute atmospheric temperature of 288.1K).

The RETScreen computes the pressure adjustment coefficient and temperature adjustment coefficient automatically from online weather database. The capacity factor can be calculated as the ratio of the energy produced by wind turbine to the energy produced by the operating wind turbine at the rated power throughout the time period expressed in Eq.(6)[5,8].

CF=(EA/(Pr×T))×100 ....
(6)

In which, CF is the capacity factor, EA is the actual energy produced by the wind turbines, Pr is the rated power capacity of the wind turbines, T is the duration of operation in hours. In the models, the gross annual energy production (MWh) and the capacity factor were calculated for the selected wind turbines.

5. Results and Discussions

5.1. Wind data results

The monthly and annual average wind speeds were calculated from the original hourly and daily data from RETScreen and Windographer respectively. The monthly and annual average wind speeds at 10m and 50m are shown in Figure (3).

The average annual wind speed was found to be 3.145 m/s and 3.268 from RETScreen and Windographer at 10m respectively. At 50m, the average annual wind speed was found to be 5.0 m/s and 4.86 from RETScreen and Windographer respectively.

The largest values of wind speeds occur during the summer season, exceeding 6m/s at June month at RETScreen wind data. This is important to generate largest wind energy when maximum demand of electricity is needed while the lowest values were obtained during the winter months.

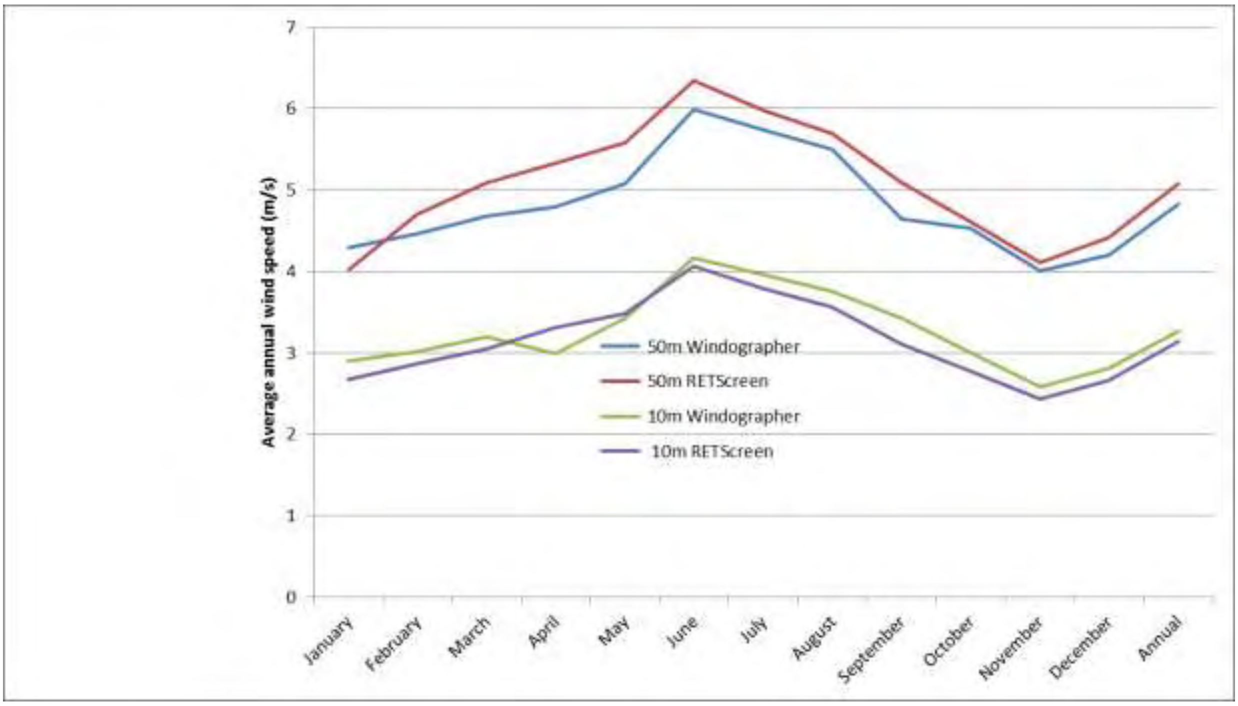

Fig. (3): Monthly and annual average wind speed graphs.

At 10m as shown in Table 2, the average monthly and annually values of the shape factor (k), yielded from RETScreen wind data reflect that the selected site changeable wind regime when k values less than 2.0 and stable when k values more than 2.0 with an average annual value of 2.26.The stable wind regime site will be more suitable for wind turbines erecting. It was found also that the k values from Windographer wind data were more than 2.0 at all months with an annual value of 3.108, which means more stability wind regime site. The values of scale parameter c is a function of wind speed and represents the breadth of wind distributions along with x axes, The higher scale parameter value, the windier the place is. The maximum values of scale parameter exceeding 4.0 m/s during the summer months when maximum wind speeds were obtained and the average annual values were3.66 m/s and 3.269 m/s from RETScreen and Windographer respectively.

Table 2: Weibull parameters values at 10m.

Month		Jan.	Feb.	March	April	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Ann.
RETS.	K_{10}	1.70	1.82	1.791	1.59	2.60	2.95	2.82	2.95	2.91	2.39	1.86	1.70	2.26
	C_{10}	3.24	3.38	3.591	3.34	3.86	4.66	4.44	4.20	3.84	3.38	2.91	3.14	3.66
Windog.	K_{10}	2.30	2.84	2.395	3.2	3.81	3.85	3.41	3.71	3.18	3.40	2.66	2.46	3.10
	C_{10}	3.26	3.38	3.60	3.34	3.79	4.59	4.40	4.15	3.82	3.34	2.90	3.16	3.26

The wind shear values were computed by using Eq.(4) at both 10m and hub height. The annual average values of wind shear were 0.32 and 0.33 at 10m from RETScreen and Windographer respectively as shown Figure (4), while this value decrease to 0.29 at 50m hub height. It is obvious as the wind speed increase with the altitude, the wind shear decreases and causing more wind energy harvesting at hub height level.

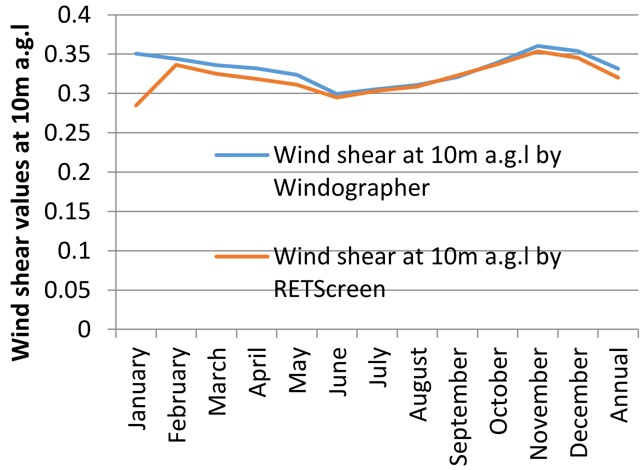

Fig. (4): Wind shear values at 10m.

5.2. Results related to selected wind turbines.

Three wind turbine models were selected and the wind speed characteristics at hub height of selected wind turbines shown in Table 3 and Figure (5). The average wind speed 5.07m/s at the height 50 m for both (Enercon−33, Nordex N29) and 4.7m/s for (Nordex N43) models, These wind speeds are not so high. Both shape and scale parameters were computed at hub height of the wind turbines using Eqs.(1 and 2) and these values are shown in the Figure (5).

Table 3: Wind speed characteristics at hub height of selected wind turbines.

Wind turbine model	Hub height (m)	Average annual Wind shear n_h	Average annual wind speed V_h	Average annual shape factor K_h	Average annual scale factor C_h
Enercon−33	50	0.297	5.077	2.633	5.923
Nordex N29	50.5	0.297	5.077	2.633	5.923
Nordex N43	40	0.291	4.707	2.574	5.492

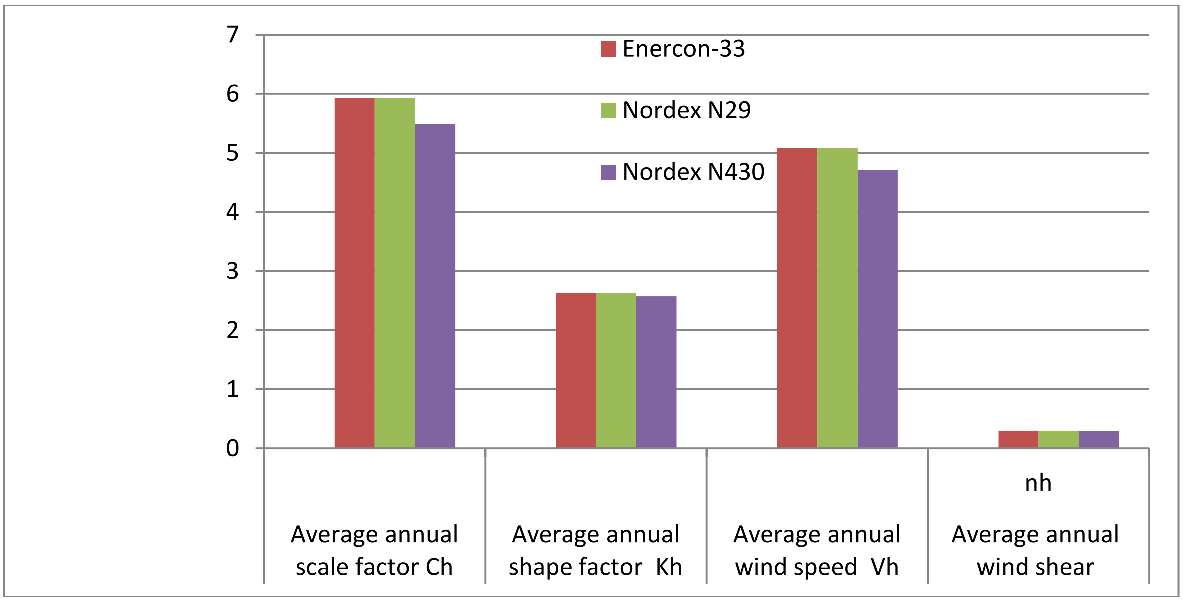

Fig. (5): Wind speed characteristics at hub height of selected wind turbines.

It was found that the results from RETScreen and Windographer software's were closely in their values, so the author neglects the results from Windographer and adopted only the results of RETScreen at all the next calculations.

To construct proposed wind farm at Tuz–Khormatu with a capacity of 6000KW,it was found needing for 19, 24 and 10 wind turbines from the selected models (Enercon–33, Nordex N29, Nordex N43) respectively.

The capacity factor (CF) of each wind turbine was recalculated with respect to RETScreen wind speeds frequencies.

As shown in Table 4,shows that the maximum CF is 31.5% for Enercon–33 wind turbine, hence, the highest capacity factor represents one of the indicators for assessing the performance of wind turbine, while the other two turbines (Nordex N29, NordexN43) have lower a capacity factor of 25.8%.

The calculated delivered energy from RETScreen using the Eqs.(3 and 5) is (6874MWh) from Enercon–33 wind turbines as shown in Table 4 and Figure. (6).

The yearly energy obtained from the wind turbine models (Nordex N29 and Nordex N43) were found with values of 5923MWh and 4138MWh respectively.

Table 4: Results of capacity factor and accumulated energy output for selected wind turbines.

Wind turbine model	No. of wind turbines	Rated Power Pr(KW)	Capacity factor CF	Total wind Energy of the wind farm/year (MWh)
Enercon–33	19	330	0.3151	6874
Nordex N29	24	250	0.2583	5923
Nordex N43	10	600	0.2583	4138

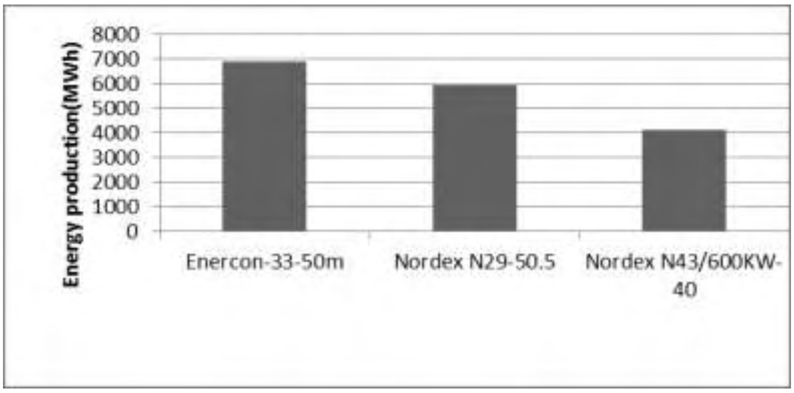

Fig. (6): Annual energy yielding from the wind farm.

6. Conclusion

In this proposed wind farm of 6MW capacity at Tuz-Khormatu site, it can be concluded that the wind turbine model (Enercon-33) with 19 units can produce electricity of 6874MWh/year that is because the highest capacity factor which was found as 31.5%, and represents one of the indicators for assessing the performance of the wind turbine.

From productivity point of view the wind turbine model (Enercon-33) represent the highest choice for constructing the proposed wind farm than the other two models Nordex N29 and Nordex N43, which their capacity factors were found as 25.83%.

The primary founding of wind speeds from RETScreen program shows that the case study site at Tuz-Khormato represent a low wind speed site and suitable for low wind speed wind turbine models.

7. Recommendation

For a reliable and accurate future work, the results from RETScreen will be required to check in comparison with on-site measuring data and observing the error percentage by setting up tower masts and measuring instruments of wind data in the proposed site and comparing the two results.

8. References

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