

POTENTIAL ENERGY EVALUATION FOR AL-SHEHABI LOCATION IN IRAQ (CASE STUDY)

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ABSTRACT

The development and sitting of wind energy conversion systems for electrical power generation and other applications in any site demands proper wind resource assessment of the project sites. This paper presents an assessment of wind resource for wind energy utilization in Al-Shehabi location. The wind data were obtained from weather station installed at the location. Then, Mathematical equation is used to get logarithmic profile at different heights. A contour map is drawn in 3D shape mode to get deep insight and general thought about the topographic shape surface. Weibull probability distribution function is calculated and plotted in order to assess mean wind speed, annual energy and Weibull parameters. Also, wind rose, speed rose and energy rose are included in this calculations. Finally, a wind resource map of 1km x 1km for interested areas drawn at Gamesa G114 wind turbine with hub heights of 120m and 114m rotor diameter is chosen to determine the output energy. Wind data analysis is performed for the proposed site using WAsP software, for data recorded at 10m height. The results show that the mean power density about 168 W/m², as a class-3 and satisfactory wind resource.

Keywords: wind speed, power density, WAsP, Weibull Distribution

1. INTRODUCTION

The most important factor in a wind energy project is a wind turbine site and predicting the economic success of the project. Understanding the wind resource is especially critical as the energy available in the wind varies as the cube of the wind speed. The wind is highly variable, both geographically and locally. Wind resource assessment is the most important step in planning a community wind project because it is the basis for determining initial feasibility and cash flow projections, and is ultimately vital for acquiring financing. Initial assessment of the site is fairly simple in most states with publicly available high resolution wind resource data. Recent advances in computer modeling and the internet have made public wind data sources easily accessible.

Wind Atlas Analysis and Application (WAsP) is the most commonly used modeling software for predicting wind climates and power productions from wind turbines. This model based on the wind atlas methodology; it calculates a "wind atlas" or "regional wind climate" based on measured wind data. The regional wind climate represents the raw wind data as a wind climate over an ideal terrain (perfectly flat with uniform surface roughness) – to remove local terrain effects. This process can be reversed to determine the wind climate at another site using the wind atlas [1]. Wind assessment software packages use statistical methods to represent the wind speed and direction, as a Weibull distribution and wind rose, respectively [2].

Ten minutes interval records for one year had been studied at different heights (10, 25, 50, 100, 200). The WAsP has been used to determine the Weibull Parameters, which are estimating the wind speed and wind potential. The wind power (P) is proportional to the third power of the wind speed (U), or [3]-[4]:

$$P = \frac{1}{2} \rho A r U^3 \quad (1)$$

where ρ is the air density, $A r$ is the swept area. Then, it is necessary to determine the value of the wind speed for power density calculations. Weibull distribution functions were used to simulate the frequency wind speed which is represented by the equation below [5]:

$$P(U) dU = \frac{K}{A} \left(\frac{U}{A} \right)^{(K-1)} e^{-\left(\frac{U}{A} \right)^K} dU \quad (2)$$

Where, A, is the scale parameter has the same wind speed unit and K is the dimensionless shape parameter. These parameters are estimated by different mathematical approaches. One of the simplest techniques needs to know U and σ , where U, is the mean value of wind speed, and σ is the standard deviation, then K and A parameter can be represented by the following equation as[6]-[7]:

$$A = \frac{U}{\Gamma(1+\frac{1}{K})} \quad (3)$$

$$\left(\frac{\sigma}{U}\right)^2 = \left[\frac{\Gamma(1+2/K)}{\Gamma^2(1+1/K)}\right] - 1 \quad (4)$$

Γ , represents a general Gamma function, and K can be evaluated explicitly as:

$$K = \left(\frac{\sigma}{U}\right)^{-1.086} \quad (5)$$

2. AREA OF STUDY

The feasibility and applicability of wind energy development depends on the physical characteristics of the study area and the wind resource. The region is located in the area between Maysan and Wasit. It is 112 km from Maysan, 85 km from Wasit, and about 220 km from Baghdad at position 32.77°N 46.70° E; Figure. 1 shows the location of chosen site in eastern region near the border between Iraq and Iran.



Figure 1 Iraq satellite image to indicate the area of study

3.METHODOLOGY

For any wind resource assessment, the wind speed and direction must be measured, and this often involves erecting a metrological mast (met mast) at a desired location, with instruments located at least one year for continuous wind measurements at the site. Data was obtained by cup anemometer at (10m) height throughout the year 2013. The first step in analyzing a site with WASP is to create an observed wind climate file (OWC). A separate tool, the OWC Wizard, can create a statistical summary to a site's wind climate based on a time-series of wind measurements. Using description of the topography and surface roughness which surround the place measurement site to convert the OWC into a wind atlas. This data is site-independent in a limited region surrounding the observation site. The wind atlas data set can be used then to deduce the wind climate at a specific site, using the descriptions of the terrain at the new site. The respective topography/roughness map was inserted, as well as a 'new wind atlas.' The OWC then added to this wind atlas. After calculations, it was then possible to export a wind atlas. With the wind atlases and maps created, it was then possible to start the WASP wind speed predictions. The wind turbine selected for this study was a Gamesa G114 with 2MW of installed power with rotor diameter of 114 m, cut-in wind speed of 3 m/s, and cut-out wind speed of 25 m/s and swept area 10.207 m². The methodology of this research is summarized in the diagram that has been shown in figure 2.

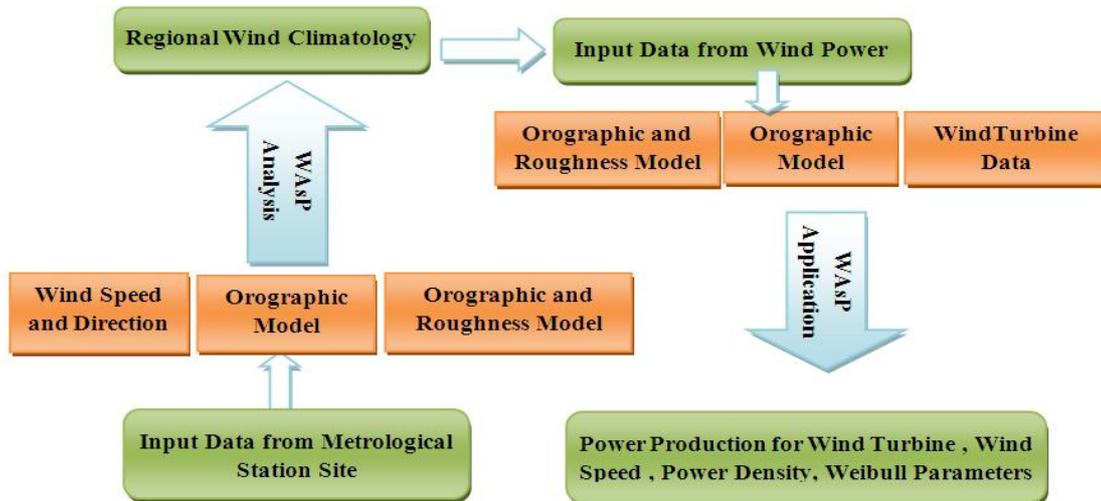


Figure 2 Diagram Represent research methodology

4. RESULTS AND DISCUSSIONS

The first step is creating the vector map that presents in figure 3, which shows the low roughness of the terrain. Vector map was established using Surfer and WASP Map Editor Softwares.

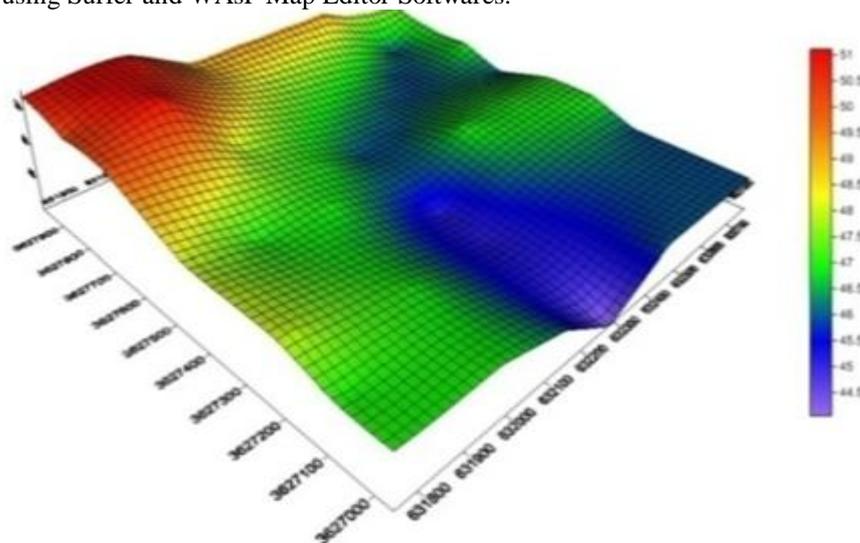


Figure 3 Vector map of topographic terrain for study area

The measured and Weibull distribution for wind speed is plotted for the actual measured data and presented in Figure 4.

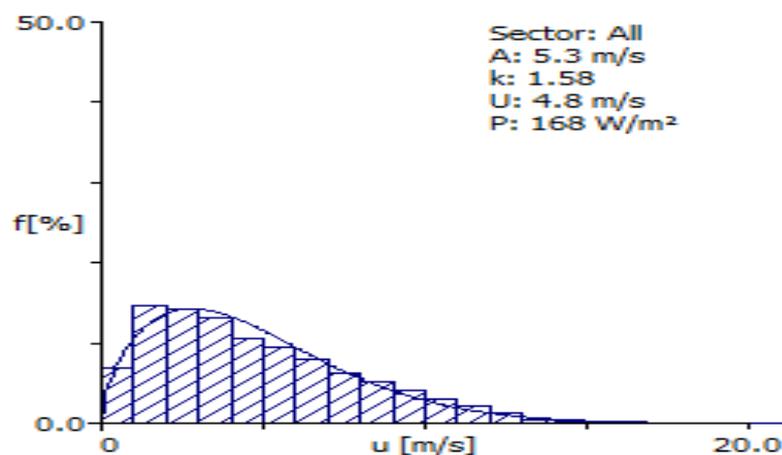


Figure 4 Weibull distribution

Figure 5 shows the frequency rose for the measured wind speed data, velocity rose and energy rose.

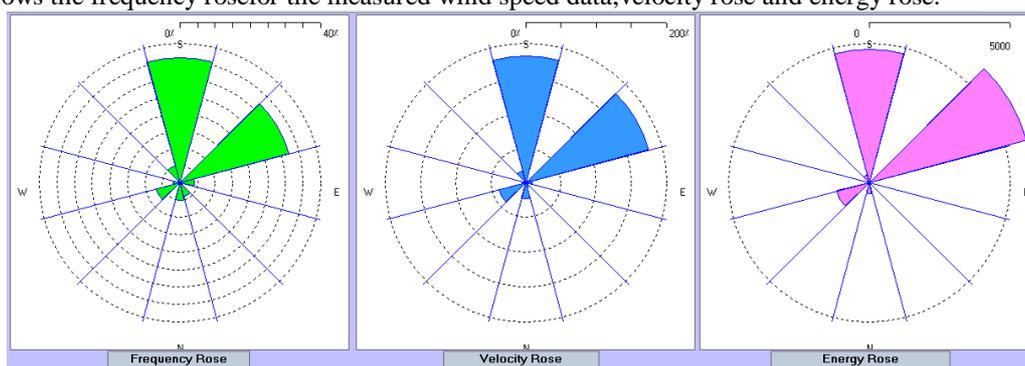


Figure 5 Represent frequency rose (left), velocity rose (middle), energy rose (right)

The mean wind speed estimation for the studied area at 120 m hub height can be shown in figure 6, for the 12 sector, which is varies between 7.83 to 8.00m/s.

Figure 7 presents the power density P (W/m^2) of the wind for all 12 sector and it is vary between 633 to 592 W/m^2 and the mean value U is 614 W/m^2 at 120 m hub height. Scale parameter A is 9 m/s and shape parameter K is 1.90. The Annual Energy Production (AEP) was calculated and present in figure 8, which varies between 9.890 to 9.715GWh with the mean value 9.805GWh.

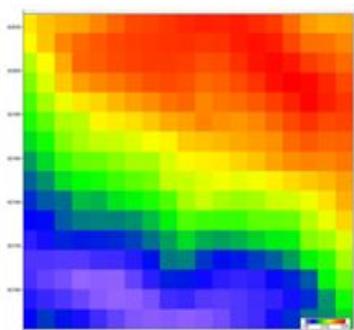


Figure 6 Mean wind speed

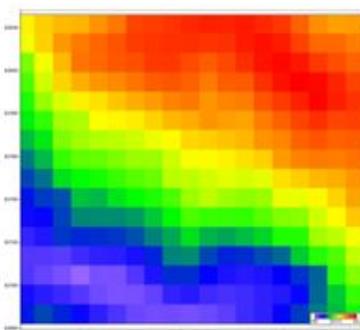


Figure 7 Power density

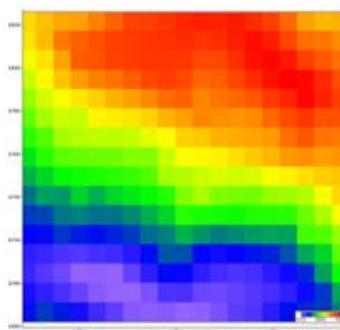


Figure 8 AEP

Sector-wise Weibull distributions for roughness length 0.03 mare calculated at five heights (10,25,50,100,200) m for each sector.

Table1: Present the statistics for each sector included mean wind speed (U), power density (P), Scale parameter (A) and shape parameter (K) at five heights and 0.03 surface roughness

Height	parameter	Sectors											
		10	30	60	90	120	150	180	210	240	270	300	330
10 m	A	5.7	6.3	6.2	1.8	1.9	2.0	4.4	6.1	6.2	2.4	3.1	4.6
	k	1.97	1.73	1.71	1.03	1.55	1.58	1.29	1.80	1.89	1.40	1.33	1.38
	U	5.07	5.58	5.54	1.75	1.71	1.76	4.07	5.41	5.50	2.21	2.89	4.25
	P	155	239	238	18	8	8	144	208	206	20	49	146
25 m	A	6.9	7.4	7.3	2.2	2.3	2.4	5.3	7.2	7.4	2.9	3.8	5.6
	k	2.13	1.81	1.78	1.10	1.67	1.70	1.37	1.90	2.00	1.51	1.44	1.46
	U	6.07	6.58	6.54	2.09	2.05	2.11	4.83	6.41	6.52	2.64	3.46	5.05
	P	246	372	371	27	12	13	217	325	323	30	74	223
50 m	A	7.9	8.4	8.3	2.6	2.7	2.7	6.1	8.2	8.4	3.4	4.5	6.4
	k	2.39	1.93	1.90	1.23	1.88	1.91	1.48	2.06	2.18	1.69	1.61	1.60
	U	7.02	7.46	7.41	2.41	2.37	2.44	5.51	7.31	7.44	3.06	4.00	5.77
	P	346	503	500	33	17	18	283	443	444	40	96	293
100 m	A	9.3	9.6	9.6	3.1	3.2	3.3	7.1	9.5	9.7	4.1	5.3	7.5
	k	2.56	2.08	2.05	1.31	2.01	2.04	1.59	2.22	2.35	1.81	1.72	1.71
	U	8.30	8.55	8.48	2.86	2.80	2.88	6.39	8.45	8.63	3.62	4.73	6.72
	P	544	703	696	48	26	28	399	641	651	62	147	421
200 m	A	11.4	11.3	11.2	3.7	3.9	4.0	8.4	11.3	11.6	5.0	6.5	9.0
	k	2.46	2.02	1.99	1.26	1.93	1.96	1.54	2.14	2.27	1.74	1.65	1.65
	U	10.13	10.00	9.91	3.49	3.42	3.52	7.60	10.01	10.27	4.42	5.77	8.02
	P	1019	1158	1145	94	49	52	704	1099	1129	117	280	751

5. CONCLUSION

The data presently available from ongoing measurements in Al-Shehabi station have been analyzed and evaluation made with the wind resource estimation program WASP. Wind speed is the most critical variable in determining the plant output, but no single wind speed can adequately represent the wind conditions for the entire wind plant. Measurements of a station have been used for the evaluation. It was found that the output power from Al-Shehabi site is considered as satisfactory -class 3. Thus, this location could be ideal for generating wind power because of reliable speed of the wind. At the hub height of 120 m, the estimated average wind speed is determined to be 7.96 m/s, and the maximum amount of wind power density is calculated to be 624 W/m².

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