RESEARCH ARTICLE OPEN ACCESS

Calculating Wind Farm Production in Al-Shihabi (South Of Iraq) Using WASP

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ABSTRACT
The Wind Turbine farms are becoming popular in the renewable energy world. In this research, the ***Wind Atlas Analysis and Application Program (WAsP)*** *has been used to estimate wind power density in Al-Shihabi (south of Iraq). All statistical operations on data series are obtained from Field data collected from the wind measurement towers which installed by the Science and Technology Ministry at Kut city south of IRAQ at three heights (10, 30, 50 m). The wind turbine selected for this study to be installed in the wind farm are* ***Bonus-300kw, 600kw*** *The Annual Energy Production (AEP) has been calculate which varies between (746.990 - 759.446 MWH) at 30 m and it s varies between produced AEP (1.576 - 1.600 GWh) at 50 m ,this site classified as (class-1).*

Keywords: Wind farm, WAsP, Power density, Al-Shihabi

I. INTRODUCTION

From the beginning of industrial Revolution that directed by using the fuel widely like (oil, coke, natural gases and derivate material) that considered the main source of inject atmosphere by large amount of pollution gases and carbon dioxide and also nitrogen oxide which played big role increase earth and its atmosphere temperature which known as Global warning the problem of environment pollution became effected .To find alternative solution for future years to present another source of energy with longer age and less damaging for environment that takes from which is the renewable energy with all kinds (hydro, solar, wind, geothermal) .[1]

The power potential of wind is determined by its speed and the power varies as the cube of the wind speed. Wind is defined as the movement of air caused by pressure differences in the atmosphere as a result of temperature gradients. It is greatly affected by the local physical features like the landscape, obstacles such as buildings and vegetation cover. Accuracy in measuring wind speed is of fundamental importance in the assessment of wind power potential [2]. The computer software called the Wind atlas analysis and application program, WAsP, is the standard tool for wind energy assessment [3,4]. The program has been successfully used to predict wind energy resource for both offshore and onshore wind turbine candidate sites. The aim of this study is to find optimum locations for wind turbines in Al-Shihabi located on the south of Iraq and identify the optimum type of turbine to be used to designed wind farm at the study area location.

II. WIND ATLAS METHODOLOGY

Global and regional models cannot be used for studying winds for energy applications. The integration grid in those models is too coarse (about 200 km or more) for studying the detailed properties of winds at such scale. Meso and Micro Scale models are therefore the models that should be considered here two basically conditions, boundary conditions (orography and roughness of the earth's surface), and the initial conditions (local processes requires wind and air temperature values).[5]

III. THE WASP PROGRAM

A successful and widely used model in studying the wind micro-climate for energy application purposes is the Wind Atlas Analysis & Application Program (WAsP) developed by Riso National Laboratory of Denmark. The ideal model however, is one that addresses microscale and mesoscale processes jointly. One of the models, which used this approach, is the model known as KAMM; (KARLSRUHE ATMOSPHERIC MESOSCALE MODEL).

The model calculates the mesoscale wind field by using the synoptic scale circulation and taking the effects of roughness, obstacles and orography into account. In the second half of the cycle, WAsP uses KAMM products to estimate the microscale wind field needed for evaluating wind energy.[5]

IV. STUDY AREA

The study area is Al-Shihabi located in the south-east of the Kut city south of Iraq at longitude (46.42) and latitude (32.88) which almost characterized by flat topography and few roughness, as shown in figure (1).

Fig (1) Al-Shihabi study area

V. THE DATA

Field data has been collected from the wind measurement towers which installed by the Science and Technology Ministry at south at Kut city in IRAQ at three heights (10, 30, 50 m), as shown in Figure.(2).

Fig (2) Towers of the Science and Technology Ministry in Al-Shihabi

The collected wind data were made up as time series and frequency statistics based on the available observed of speed and wind directions recorded for every 10 minutes intervals for the year 2015. Some statistics details (Mean Speed. Stander Deviation, Median, Minimum and Maximum) for the data shown in table (1)

Table (1) some statistics details at three heights

Height (m)	M.S (m/s)	S.D.	Med.	Min. (m/s)	Max. (m/s)
10	4.60	3.10	4.12	0.34	17.53
30	6.13	3.41	5.90	0.38	19.52
50	6.84	3.81	6.50	0.39	24.50

VI. RESULTS AND DISCUSSION

The data has been analyzed using WAsP, to get a statistical summary. The mean wind speed, k and A parameters of Weibull distribution and the power density for the location at (30, 50 m) has been achieved, table (2, 3). Wind rose of the location; it is divided into 12 sectors, each one represents 30^o, The wind rose for the heights (30, 50m) respectively, it is evidence that the dominate wind direction at 330^o , which means North West direction, then power density has the majority value for this direction, Figure(3)

Table (2) Regional wind climate summary for the location at (30 m)

Sector Number	Sector angle (°)	Frequency (%)	Weibull-A (m/s)	Weibull-k	M.S (m/s)	E (W/m²)
1	0	4.5	3.5	1.85	3.07	37
2	30	4.1	4.1	1.91	3.61	58
3	60	3.4	4.9	1.89	4.35	102
4	90	8.3	8.2	2.33	7.26	391
5	120	8.2	7.2	2.07	6.34	288
6	150	3.6	4.8	2.08	4.28	89
7	180	2.3	3.8	1.71	3.35	52
8	210	2.3	3.5	1.57	3.14	48
9	240	4.3	4.4	2.04	3.90	68
10	270	24.9	7.6	2.81	6.77	278
11	300	28.4	8.5	2.17	7.56	468
12	330	5.9	5.2	2.17	4.60	105
All					6.13	280

Table (2) Regional wind climate summary for the location at (50 m)

Sector Number	Sector angle (°)	Frequency (%)	Weibull-A (m/s)	Weibull-k	M.S(m/s)	E(W/m²)
1	0	5.1	4.7	2.06	4.12	80
2	30	3.0	3.9	1.60	3.45	62
3	60	2.6	4.1	1.52	3.68	81
4	90	6.5	7.5	1.99	6.68	351
5	120	11.4	8.6	2.27	7.60	458
6	150	5.5	5.7	1.92	5.09	161
7	180	2.5	4.3	1.47	3.89	101
8	210	1.9	4.1	1.27	3.85	126
9	240	2.3	3.8	1.57	3.44	63
10	270	5.7	5.2	2.04	4.65	115
11	300	38.4	9.6	2.75	8.57	571
12	330	15.1	7.8	2.50	6.89	316
All					6.84	372

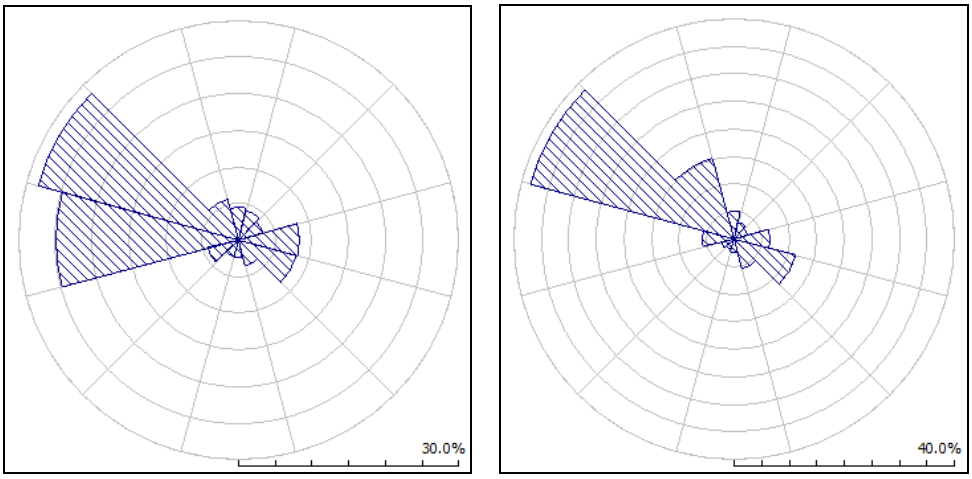

Fig. (3) The wind rose for the heights (30, 50m) respectively

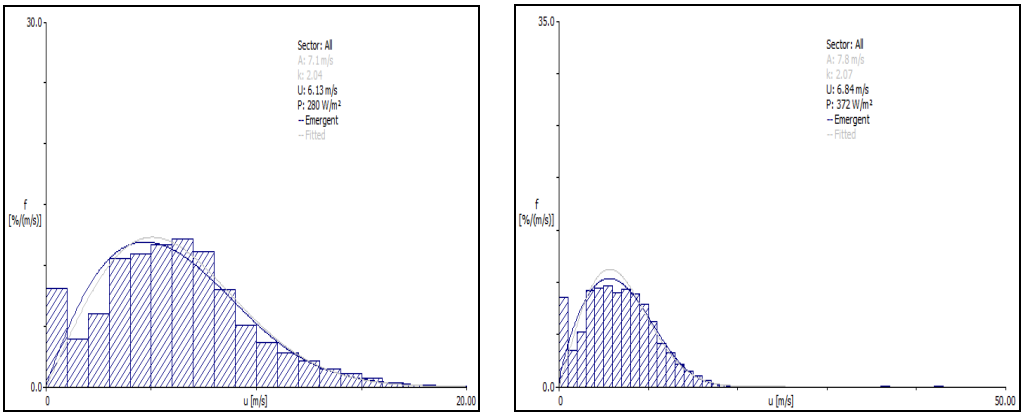

Fig. (4) Wind frequency distribution at height (30,50 m) respectively

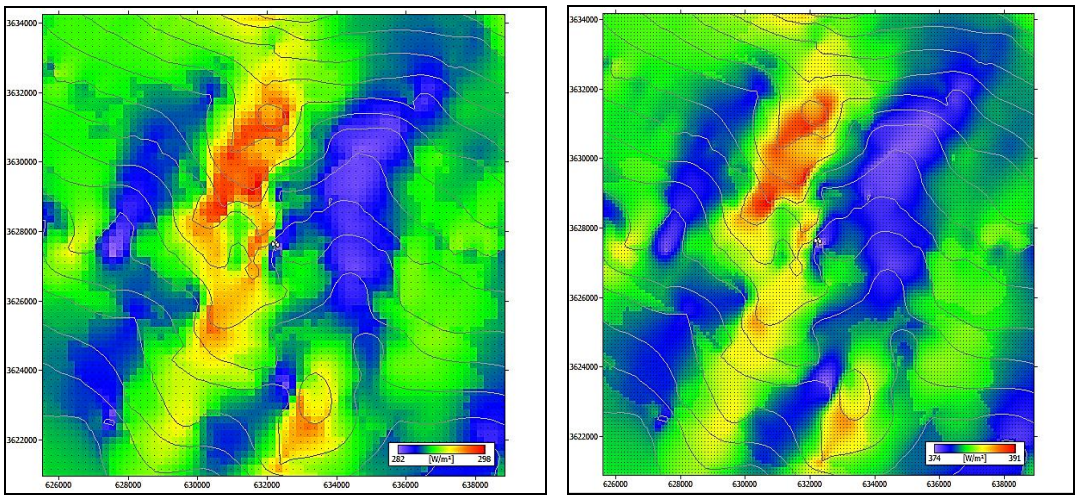

Fig.(5) The wind power density distribution at height (30,50 m) respectively

Wind Farm Installed at height (30, 50 m)

The wind turbine selected for this study to be installed in the wind farm is a **Bonus-300kw, 600kw** it has a blade diameter 33-44m, cut-in wind speed of 3 m/s, and cut-out wind speed of 25 m/s. The **Bonus-300kw, 600kw** has the following specification; it is a pitch regulated, upwind turbine with active yaw and a high speed rotor with three blades. The medium size of this turbine is suitable for powering large farms; its energy capture is exceptionally good across a wide range of wind speeds, installed on 30-40 m hub height for maximum energy capture, withstanding harsh conditions, and of design life exceed 20 years.

The Annual Energy Production (AEP) has been calculate in (MWh) in for the 12 sectors of study area and illustrated in figure-6. As it is obvious, the produced AEP varies between 746.990 MWh to 759.446 MWH, the mean value 752.966 MWh at 30 m, table (3).

Table (3) The wind farm results from WAsP by using **Bonus-300kw** at 30 m

Site desc.	X-location (m)	Y-location (m)	Elev. (m)	Speed (m/s)	Gross AEP (MWh)	Net AEP (MWh)	Wake Loss (%)
Turbine1	631146.2	3629894.0	55.0	6.24	760.667	748.020	1.66
Turbine2	631613.3	3629831.0	54.8	6.24	759.593	746.990	1.66
Turbine3	631094.4	3629427.0	54.0	6.24	760.180	747.516	1.67
Turbine 4	631447.2	3630900.0	56.9	6.24	760.212	759.446	0.10
Turbine 5	630689.2	3629076.0	52.4	6.24	760.531	759.064	0.19
Turbine 6	630658.4	3629489.0	53.2	6.24	760.025	755.307	0.62
Turbine 7	631602.9	5630381.0	55.7	6.23	757.249	747.855	1.24
Turbine 8	631073.6	3630433.0	56.2	6.24	761.236	757.487	0.49
Turbine 9	630627.3	3629956.0	54.3	6.23	759.137	755.011	0.54
All					6838.830	6776.696	

The Annual Energy Production (AEP) has been calculate in (GWh) in for the 12 sectors of study area and illustrated in figure-6. As it is obvious, the produced AEP varies between 1.576 to 1.600 GWh, the mean value 1.588 GWh, at 50 m, table (4).

Table (4) the wind farm results from WAsP by using **Bonus-600kw** at 50 m

Site desc.	X-location (m)	Y-location (m)	Elev. (m)	Speed (m/s)	Gross AEP (GWh)	Net AEP (GWh)	Wake Loss (%)
Turbine 1	630089.9	3628783.0	50.3	6.91	1.594	1.590	0.24
Turbine 2	631665.9	3631095.0	57.5	6.93	1.603	1.600	0.18
Turbine 3	630230.0	3627697.0	48.9	6.90	1.592	1.589	0.17
Turbine 4	631000.5	3628783.0	51.5	6.90	1.593	1.589	0.28
Turbine 5	631806.0	3630009.0	54.8	6.91	1.596	1.593	0.20
Turbine 6	631806.0	3628923.0	52.3	6.90	1.594	1.585	0.53
Turbine 7	631210.6	3627662.0	48.0	6.88	1.583	1.576	0.46
Turbine 8	632751.6	3630219.0	54.2	6.89	1.588	1.579	0.61
Turbine 9	630895.4	3629869.0	54.7	6.92	1.599	1.595	0.21
All					14.342	14.296	

When designing farm of wind's turbines, the best locations for erecting each turbine must be decided. In our present project the sites of turbines have been selected in corresponding to the site of the towers. As mentioned above, the adopted type of the wind turbine was **Bonus-300kw, 600kw**. For each decided turbine site. As shown in figures (6)

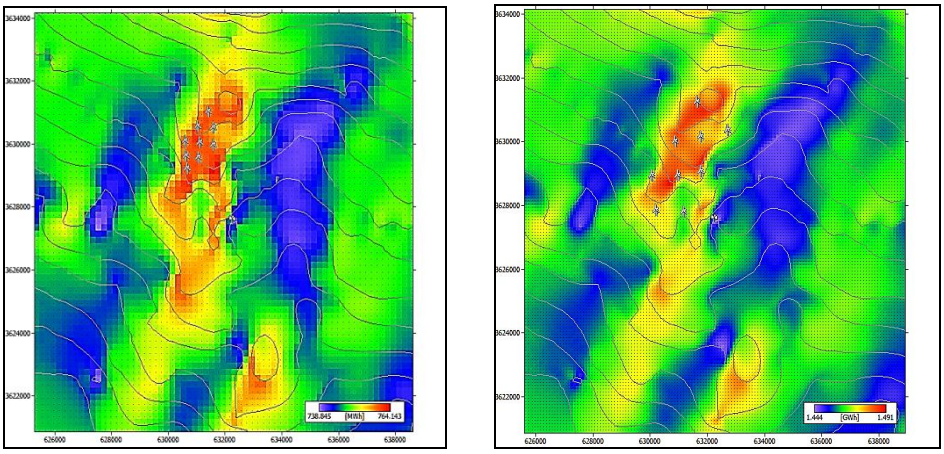

Fig.(6) The wind farm sites with wind turbines **Bonus-300kw, 600kw** at heights(30,50 m) respectively

VII. CONCLUSION

The study area is Al-Shihabi one of promising area south of Iraq at height 30,50 m with mean wind speed ranges (6.13- 6.84m/s) .The results of WAsP shows that the wind power density ranges (280-372 W2/m) ,by using two type of wind turbines and put up wind farm with nine turbines , results 6776.696 MWh-14.296 GWh. This site classified as (class-1)

VIII. REFERENCES

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