Optimal Estimation of Critical Angle for the Wind Power (Energy) to Generate High Electrical Power in Baghdad City

تخمين الزاوية الحرجة المثلى لطاقة الرياح لتوليد أعلى قدرة كهربائية في مدينة بغداد

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Abstract

The wind energy is regarded one of the important renewed energies invested by man from ancient time to execute some of his works and he is still challenging and continuing in finding the best techniques to exploit as much as he could and consider them a new source for the renewed energy to meet his requirements. The aim of the research is to estimate the usability of the wind energy to get high efficient of electrical power in Baghdad city through the analyzing the impact of some explanative variables (Mean Temp. , High Temperatures , Time of High Temperatures Registration , Low Temperatures , Time of Low Temperatures Registration , Heat Degree Days , Cool Degree Days , Rain , Average Wind Speed , High Wind Speed , and Time of High Wind

Speed Registration) on the function of Dom. Dir. in the studied area in period (1/1/2009 – 31/12/2009) through transforming in angler form on the circumference of the presumptive circle starting with zero degree in front of the north pole with a clockwise to enabling of applied the Model of predicting optimal critical angle estimate/or obtaining the best electrical power through using the Multiple Linear Regression Model , which is for the first time as far (as we know). Some recommendations and suggestions were given.

Keywords: Wind power; Energy; Electrical power; Meteorology; Renewable Energy.

الخلاصة

تعتبر طاقة الرياح من الطاقات المتجددة المهمة التي استثمرها الإنسان منذ القدم لإنجاز بعض أعماله ولا يزال الإنسان متحدياً ومستمراً في إيجاد أفضل التقنيات لاستغلالها قدر الإمكان واعتبارها مصدراً جديداً للطاقة المتجددة لسد احتياجاته منها.
إن هدف البحث هو تخمين إمكانية تطويع طاقة الرياح للحصول على الطاقة الكهربائية المثلى في مدينة بغداد من خلال تحليل أثر بعض المتغيرات التوضيحية (ممثلةً بـمتوسط الحرارة ، أعلى درجة حرارة ، وقت تسجيل أعلى درجة حرارة ،درجة السخونة اليومية ، درجة البرودة اليومية ، منسوب الأمطار ، متوسط قياس سرعة واتجاه الرياح وفترة ذروتها) على سرعة واتجاه الرياح في منطقة الدراسة كل ساعة للفترة من 2009/1/1 ولغاية 2009/12/31 بعد تحويلها بصيغة الزاوية على محيط الدائرة الافتراضية بدءً بالزاوية صفر عند اتجاه القطب الشمالي وباتجاه عقرب الساعة وذلك تحقيقاً لتطبيق نموذج تقدير الزاوية الحرجة المثلى لطاقة الرياح للحصول على أفضل قدرة كهربائية بالانحدار الخطي المتعدد وهي لأول مرة (بحسب علمنا) ، كما أعطيت بعض التوصيات والمقترحات.

1. Introduction

The transformation of energy from forms provided by nature to forms that can be used by humans.

Over the centuries a wide array of devices and systems has been developed for this purpose [1]. Some of these energy converters are quite simple. The early windmills, for example, transformed the kinetic energy of wind into mechanical energy for pumping water and grinding grain [2].

Other energy-conversion systems are decidedly more complex, particularly those that take raw energy from fossil fuels and nuclear fuels to generate electrical power [3]. Systems of this kind require multiple steps or processes in which energy undergoes a whole series of transformations through various intermediate forms. Wind energy is an indirect form of solar energy. About 1 percent of the total solar radiation that reaches the earth is converted to the atmosphere into the energy of the wind [4].

Wind results from the difference in the heat of the earth and its atmosphere by the sun. Wind energy is renewable and poses no major environmental problems [5]. Wind energies as one of the most potential source of alternate energy that will be helpful to a great extent in connecting the gap between the energy demand and supply. Wind has a kinetic energy by virtue of the movement of large masses of air caused by different heat of the atmosphere by the sun. The energy can be utilized for performing mechanical and electrical works [6, 7]. A wind turbine must be able to function over very large variations in energy flux (Pw) accommodate typical variations in wind speed [8].

Wind speed in any given region is not constant, but varies over periods of variation, seasonal variation and yearly (Cycling) variation and in addition to irregularity variation. Great changes in wind speed can be encountered by a wind turbine [9]. The main source of variations in wind efficiency is how predicting the optimal /or critical Angle for the Wind Power (Energy) of wind turbines to Generate high Electrical Power [10]. In this research we gain a new procedure for attainment the preceding process through estimating the critical angle and its predicted region, which is for the first time as far (as we know).

2. Method and Apparatus

2.1 Method

The team of Meteorology Station measured the wind speed and direction, humidity and temperature every hour for the period from 1/1/2009 till 31/12/2009 by the weather station setup on a height of 50m over the building of the Atmospheric Sciences Department at the College of Science/Al-Mustansiriyah University. An example of a wind turbine, figure 1 showed a wind turbine of three bladed turbines which is the classic design of modern wind turbines.

Figure 1. Wind turbine of three bladed

2.2 Apparatus

Weather station (USA) consists of:

The anemometer measures wind direction (2.5 to 3 seconds) and wind speed (2.5 to 3 seconds).

Temperature sensor (- 40 to 150^{o}F) (- 40 to 65^{o}C).

Humidity sensor (50 sec to 1 min).

Solar radiation sensor (50 sec to 1 min).

Ultraviolet (UV) radiation sensor (50 sec to 1 min).
Data record.

3. Turbine Components

Horizontal turbine components include:
Blade or rotor, which converts the energy in the wind to rotational shaft energy; a drive train, usually including a gearbox and a generator [6]. A tower that supports the rotor and drive train. And other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment. Figure 2 represents turbine wind components:

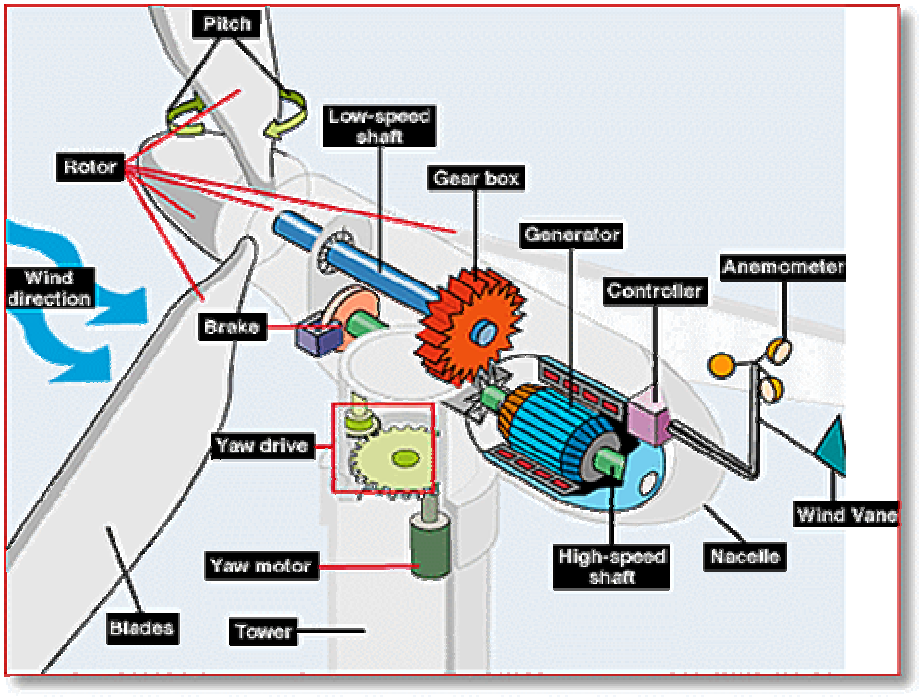

Figure 2. Represents turbine wind components

4. Statistical Methods

The suitable statistical methods were used in order to assess and analyze our results, they includes:
4.1 Descriptive Statistics

- Statistical Tables.
- Mean (Average value).
- Standard deviation.
- Standard error of mean.
- 95% confidence intervals for he mean values.
- Two extremes values (Min. and Max.) readings.
- Complete Correlation Coefficient of multiple linear functions.
- Determination Coefficient (R-Square) of multiple linear functions. And standard error of estimate.
- Durbin-Watson criteria of multiple linear functions.

4.2 Inferential Statistics

These were used in order to accept or reject the statistical hypotheses, they includes:

- Goodness of fit for multiple linear regression models by regression analysis of variance.
- Estimation and testing the significant of multiple linear regression equation of Dom. Dir. function.
- Estimation the Critical Angle (for the Wind Power (Energy) with 95% confidence limits (Predicted Values).

5. Results &Finding

5.1 Descriptive statistics of the studied data

Tables 1 to 11 represents the summary statistics of explanative variables of the studied function of Dom. Dir. (Mean Temp. , High Temperatures , Time of High Temperatures Registration , Low Temperatures , Time of Low Temperatures Registration , Heat Deg. Days , Cool Deg. Days , Rain , Avg. Wind Speed , High Wind Speed , and Time of High Wind Speed Registration) distributed along the studied period (2009) Per months in the Al-Mustansiriyah Meteorology Station.

The following discussions for the preceding tables would be summarizing the majority of grades in each of the studied explanative variables:

- Mean Temperatures: Table 1 showed that the majority of mean temperatures were focused from May to Sep. and in

overall the studied period along twelve months represented grand mean 26.117º ±9.421º. In addition to that Mean Temperatures ranged value was registered 26.8º .

- High Temperatures: Table 2 showed that the majority of High temperatures were focused from June to August and in overall the studied period along twelve months represented grand mean 31.304º ±10.108º. In addition to that High temperatures ranged value was registered 28.5º .
- Time of High Temperatures: Table 3 showed that the majority of Time of High temperatures were focused from July to August and in overall the studied period along twelve months represented grand mean 14.373 ±2.9856 (hrs.). In addition to that Time of High temperatures ranged value was registered 3.3(hrs.).
- Low Temperatures: Table 4 showed that the majority of Low temperatures were focused at Jan., Feb., and Dec. and in overall the studied period along twelve months represented grand mean 20.805º ±8.596º. In addition to that Low temperatures ranged value was registered 24.9º.
- Time of Low Temperatures: Table 5 showed that the majority of Time of Low temperatures were focused at Nov. and in overall the studied period along twelve months represented grand mean 6.5015 ±2.8257 (hrs.). In addition to that Time of Low temperatures ranged value was registered 2.14 (hrs.).
- Heat Deg. Days: Table 6 showed that the majority of Heat Deg. Days was focused at Jan. and in overall the studied period along twelve months represented grand mean 1.27 ±2.57. In addition to that Heat Deg. Days ranged value was registered 7.59.
- Cool Deg. Days: Table 7 showed that the majority of Cool Deg. Days was focused at Aug. and in overall the studied period along twelve months represented grand mean 8.89 ±7.40. In addition to that Cool Deg. Days ranged value was registered 18.63.

- Rain: Table 8 showed that the majority of Rain was focused at Nov. and in overall the studied period along twelve months represented grand mean 0.51 ±5.44 (mm.). In addition to that Rain range value was registered 4.35(mm.).
- Avg. Wind Speed: Table 9 showed that the majority of Avg. Wind Speed was focused at July and in overall the studied period along twelve months represented grand mean 1.916 ±0.984 (m/s). In addition to that Avg. Wind Speed ranged value was registered 1.35(m/s).
- High Wind Speed: Table 10 showed that the majority of High Wind Speed was focused at July. And in overall the studied period along twelve months represented grand mean 8.856 ±3.033 (m/s). In addition to that High Wind Speed ranged value was registered 4.029(m/s).
- Time of High Wind Speed: Table 11 showed that the majority of Time of High Wind Speed was focused at June and July. and in overall the studied period along twelve months represented grand mean 12.31 ±5.79 (hrs.) .In addition to that Time of High Wind Speed ranged value was registered 2.45(hrs.).

Table 1. Summary Statistics for Mean Temperatures along with period (2009) per months in the Al-Mustansiriyah Meteorology Station.

parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
MEAN TEMP	JAN.	29	10.221	3.679	0.683	8.821	11.62	2.9	16.5
	FEB.	27	15.733	1.839	0.354	15.006	16.461	12.4	19.3
	MAR.	31	18.574	2.766	0.497	17.56	19.589	11.3	23.7
	APR.	29	23.179	3.003	0.558	22.037	24.321	18.3	29.2
	MAY.	29	30.434	3.653	0.678	29.045	31.824	24.9	39.1
	JUN.	29	35.979	2.435	0.452	35.053	36.906	31.6	42
	JUL.	30	36.713	1.547	0.282	36.136	37.291	33.2	39.7
	AUG.	31	37.058	1.494	0.268	36.51	37.606	34.9	39.8
	SEP.	30	31.990	3.095	0.565	30.834	33.146	25	36.2

	OCT.	31	27.865	2.509	0.451	26.944	28.785	21.5	31.6
	NOV.	17	18.524	5.324	1.291	15.786	21.261	12.4	28.7
	DEC.	10	15.200	2.128	0.673	13.678	16.722	10.8	18.7
	Total	323	26.117	9.421	0.524	25.086	27.148	2.9	42

Table 2. Summary Statistics for High Temperatures along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
High Temperatures	JAN.	29	15.238	3.847	0.714	13.775	16.701	6.4	20.7
	FEB.	27	20.044	2.442	0.47	19.078	21.011	15.4	25
	MAR.	31	23.148	3.669	0.659	21.803	24.494	12.7	29.7
	APR.	29	28.272	3.426	0.636	26.969	29.575	22.9	36.2
	MAY.	29	35.972	4.182	0.777	34.382	37.563	27.8	43.9
	JUN.	29	41.021	3.029	0.562	39.869	42.173	34.3	47.3
	JUL.	30	42.043	1.983	0.362	41.303	42.784	37.9	45.6
	AUG.	31	43.703	2.401	0.431	42.822	44.584	39.9	48.8
	SEP.	30	37.82	3.617	0.66	36.469	39.171	29.5	42.9
	OCT.	31	33.716	3.526	0.633	32.423	35.009	24.4	38.4
	NOV.	17	21.847	5.164	1.253	19.192	24.502	13.6	29.9
	DEC.	10	19.05	2.887	0.913	16.985	21.115	11.8	21.8
	Total	323	31.304	10.108	0.562	30.198	32.41	6.4	48.8

Table 3. Summary Statistics for Time of High Temperatures Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Time of High Temperatures Registration	JAN.	29	13.905	3.8175	0.7089	12.4531	15.3573	0.5	16.25
	FEB.	27	14.898	1.1874	0.2285	14.4284	15.3679	10.75	16.25
	MAR.	31	12.629	4.9501	0.8891	10.8133	14.4447	0	16.75
	APR.	29	13.966	3.8895	0.7223	12.486	15.445	0.75	16.75
	MAY.	29	14.535	1.5364	0.2853	13.9501	15.1189	11.5	17
	JUN.	29	14.173	3.8179	0.709	12.7202	15.6247	1	17

	JUL.	30	15.467	1.0743	0.1961	15.0655	15.8678	13	17
	AUG.	31	15.226	1.5212	0.2732	14.6678	15.7838	13	22
	SEP.	30	14.667	0.8841	0.1614	14.3365	14.9968	13	16
	OCT.	31	14.774	1.2572	0.2258	14.313	15.2354	13	20
	NOV.	17	14.824	1.6292	0.3951	13.9859	15.6612	11	18
	DEC.	10	12.200	6.1968	1.9596	7.7671	16.6329	0	16
	Total	323	14.373	2.9856	0.1661	14.0462	14.6999	0	22

Table 4. Summary Statistics for Low Temperatures along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Low Temperatures	JAN.	29	5.776	3.688	0.685	4.373	7.179	-0.6	13.2
	FEB.	27	11.481	2.15	0.414	10.631	12.332	6.8	15.4
	MAR.	31	13.858	2.195	0.394	13.053	14.663	9.9	18.4
	APR.	29	18.131	3.045	0.565	16.973	19.289	14.1	25.2
	MAY.	29	24.89	3.18	0.59	23.68	26.099	18.9	32.6
	JUN.	29	30.09	2.296	0.426	29.216	30.963	25.9	35.9
	JUL.	30	30.713	1.597	0.292	30.117	31.31	26.7	34.1
	AUG.	31	30.029	1.332	0.239	29.54	30.518	27	32.1
	SEP.	30	25.957	2.781	0.508	24.918	26.995	18.9	29.6
	OCT.	31	22.126	1.91	0.343	21.425	22.826	17.7	25.7
	NOV.	17	15.371	5.957	1.445	12.308	18.434	6.9	28.7
	DEC.	10	11.44	1.79	0.566	10.159	12.721	8.6	13.7
	Total	323	20.805	8.596	0.478	19.864	21.746	-0.6	35.9

Table 5. Summary Statistics for Time of Low Temperatures Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
Time of Low Temperatures	JAN.	29	6.2328	2.2932	0.4258	5.3605	7.105	0	8
	FEB.	27	6.4815	2.2328	0.4297	5.5982	7.3647	0	10.25
	MAR.	31	6.1774	3.9148	0.7031	4.7415	7.6134	0	23.75
	APR.	29	6.0517	4.0275	0.7479	4.5198	7.5837	0	23.75

	MAY.	29	6.1810	3.6626	0.6801	4.7879	7.5742	0	23.75
	JUN.	29	6.0345	1.8609	0.3456	5.3266	6.7423	0	8
	JUL.	30	6.9000	0.8449	0.1543	6.5845	7.2155	6	10
	AUG.	31	6.8387	1.2675	0.2276	6.3738	7.3036	5	13
	SEP.	30	6.4333	1.3566	0.2477	5.9268	6.9399	0	8
	OCT.	31	6.6452	1.4271	0.2563	6.1217	7.1686	0	8
	NOV.	17	8.1765	5.992	1.4533	5.0957	11.2573	0	23
	DEC.	10	6.6000	2.8363	0.8969	4.5711	8.6289	0	9
	Total	323	6.5015	2.8257	0.1572	6.1922	6.8109	0	23.75

Table 6. Summary Statistics for Heat Deg. Days Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
HEAT DEG. DAYS	JAN.	29	7.59	3.50	0.65	6.26	8.92	2.10	15.40
	FEB.	27	2.78	1.43	0.28	2.21	3.34	0.10	5.70
	MAR.	31	1.36	1.05	0.19	0.98	1.75	0.00	3.90
	APR.	29	0.25	0.34	0.06	0.12	0.37	0.00	1.3
	MAY.	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JUN.	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JUL.	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	AUG.	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SEP.	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OCT.	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	NOV.	17	2.21	2.44	0.59	0.95	3.46	0.00	5.90
	DEC.	10	2.71	1.40	0.44	1.71	3.71	0.50	5.10
	Total	323	1.27	2.57	0.14	0.99	1.55	0.00	15.40

Table 7. Summary Statistics for Cool Deg. Days Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
COOL DEG. DAYS	JAN.	29	0.04	0.10	0.02	0.00	0.08	-	0.30
	FEB.	27	0.47	0.62	0.12	0.22	0.71	-	2.00
	MAR.	31	1.80	1.64	0.30	1.20	2.41	-	5.60

	APR.	29	5.07	2.81	0.52	4.00	6.14	0.30	10.90
	MAY.	29	11.30	3.42	0.63	10.00	12.60	5.10	16.70
	JUN.	29	16.21	4.07	0.76	14.67	17.76	4.10	22.50
	JUL.	30	18.10	2.22	0.41	17.27	18.93	10.90	21.40
	AUG.	31	18.67	1.57	0.28	18.09	19.24	16.10	21.50
	SEP.	30	13.69	3.11	0.57	12.53	14.85	6.70	17.90
	OCT.	31	9.57	2.51	0.45	8.65	10.50	3.20	13.30
	NOV.	17	1.48	2.17	0.53	0.37	2.60	-	6.80
	DEC.	10	0.23	0.23	0.07	0.06	0.40	-	0.70
	Total	323	8.89	7.40	0.41	8.08	9.70	-	22.50

Table 8. Summary Statistics for Rain Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
RAIN	JAN.	29	0.18	0.95	0.18	0.00	0.54	0.00	5.10
	FEB.	27	0.16	0.69	0.13	0.00	0.43	0.00	3.60
	MAR.	31	0.30	1.63	0.29	0.00	0.90	0.00	9.10
	APR.	29	0.16	0.68	0.13	0.00	0.42	0.00	3.60
	MAY.	29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	JUN.	29	0.01	0.06	0.01	0.00	0.03	0.00	0.30
	JUL.	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	AUG.	31	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	SEP.	30	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OCT.	31	2.16	11.72	2.11	0.00	6.46	0.00	65.30
	NOV.	17	4.35	17.46	4.24	0.00	13.33	0.00	72.10
	DEC.	10	0.03	0.09	0.03	0.00	0.10	0.00	0.30
	Total	323	0.51	5.44	0.30	0.00	1.11	0.00	72.10

Table 9. Summary Statistics for Avg. Wind Speed Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		

AVG. WIND SPEED	JAN.	29	1.697	0.971	0.18	1.327	2.066	0.3	3.7
	FEB.	27	2.022	1.082	0.208	1.594	2.45	0.1	4.5
	MAR.	31	2.152	1.346	0.242	1.658	2.645	0.6	5.8
	APR.	29	2.021	0.969	0.18	1.652	2.389	0.2	4.4
	MAY.	29	2.003	0.786	0.146	1.704	2.303	0.5	3.4
	JUN.	29	2.028	1.261	0.234	1.548	2.507	0.3	5.4
	JUL.	30	2.493	0.73	0.133	2.221	2.766	1.1	4
	AUG.	31	1.929	0.658	0.118	1.688	2.17	0.8	3.4
	SEP.	30	1.747	0.579	0.106	1.53	1.963	0.7	2.7
	OCT.	31	1.694	0.794	0.143	1.402	1.985	0.7	3.9
	NOV.	17	1.141	1.036	0.251	0.609	1.674	0.0	3.5
	DEC.	10	1.41	0.99	0.313	0.701	2.119	0.8	3.8
	Total	323	1.916	0.984	0.050	1.809	2.024	0.0	5.8

Table 10. Summary Statistics for High Wind Speed Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		
High Wind Speed	JAN.	29	7.503	2.414	0.448	6.585	8.422	4.0	13.9
	FEB.	27	9.344	4.033	0.776	7.749	10.94	3.6	21.5
	MAR.	31	9.668	3.32	0.596	8.45	10.886	5.8	17
	APR.	29	9.986	3.076	0.571	8.816	11.156	3.1	15.6
	MAY.	29	8.983	2.062	0.383	8.198	9.767	4.5	12.1
	JUN.	29	10.034	3.265	0.606	8.793	11.276	4.5	17.9
	JUL.	30	10.417	1.314	0.24	9.926	10.907	8.0	13.9
	AUG.	31	8.197	2.12	0.381	7.419	8.974	4.9	11.6
	SEP.	30	8.43	2.532	0.462	7.484	9.376	4.5	19.2
	OCT.	31	8.01	3.319	0.596	6.792	9.227	4.0	19.2
	NOV.	17	6.388	3.427	0.831	4.626	8.15	2.2	13.9
	DEC.	10	7.33	2.905	0.919	5.252	9.408	3.1	12.1
	Total	323	8.856	3.033	0.169	8.524	9.188	2.2	21.5

Table 11. Summary Statistics for Time of High Wind Speed Registration along the studied period (2009) per months in the Al-Mustansiriyah Meteorology Station.

Parameter	Month	N	Mean	Std. D.	Std. Error	95% Confidence Interval for Mean		Min.	Max.
						Lower Bound	Upper Bound		

Time of High Wind Speed Registration	JAN.	29	11.84	6.26	1.16	9.46	14.23	0.0	23.25
	FEB.	27	12.12	5.33	1.03	10.01	14.23	0.5	23
	MAR.	31	13.19	5.35	0.96	11.23	15.16	0.25	23.75
	APR.	29	11.37	7.51	1.39	8.51	14.23	0.0	23.25
	MAY.	29	13.10	5.42	1.01	11.04	15.17	2.0	23.75
	JUN.	29	13.10	5.40	1.00	11.05	15.16	0.0	23
	JUL.	30	12.13	5.49	1.00	10.08	14.18	0.0	22
	AUG.	31	10.65	5.89	1.06	8.48	12.81	0.0	18
	SEP.	30	13.07	4.80	0.88	11.27	14.86	0.0	23
	OCT.	31	12.77	5.68	1.02	10.69	14.86	0.0	23
	NOV.	17	12.35	6.24	1.51	9.14	15.56	0.0	23
	DEC.	10	11.30	7.45	2.36	5.97	16.63	0.0	21
	Total	323	12.31	5.79	0.32	11.67	12.94	0.0	23.75

5.2 Inferential statistics of the studied data

Since the studied random variable (DOM DIR) which categorized in sixteen nominal scales of wind direction by a clockwise (N , NNE , NE , ENE , E , ESE , SE , SSE , S , SSW , SW , WSW , W , WNW , NW , NNW) and for make possible to obtains a quantitative measurement scale for the preceding variable we transforming the directions through anglers of circle locations starting from zeroº degree at North Pole (N) location and closed with North-North West (NNW) at (337.5º) which indicated that the angler between each contiguity pairs equal (22.5 º) . That suggested transformations (By the Author) enable us to applying the Multiple Linear Regression Model which is the suitable statistical method to implement the objective of this work.

Linear Regression estimates the coefficients of the linear equation, involving the studied independent variables, (Mean Temp. , High Temperatures , Time of High Temperatures , Low Temperatures , Time of Low Temperatures , Heat Deg. Days , Cool Deg. Days , Rain , Avg. Wind Speed , High Wind Speed , and Time of High Wind Speed)that best predict the value of the dependent variable (DOM DIR) .

Tables 12 to 15 represents the estimates of inter model : Multiple R (Complete correlation) , R^2 (Determination coefficient) , adjusted R^2, Standard error of the estimate , Durbin-Watson test .Analysis-of-variance table(Goodness of fit for applying Multiple

Linear Regression Model- MLRM).Regression coefficients table, testing the significant of the regression coefficients. Also, Predicted values, and residuals.

The Complete correlation coefficient between the transformed (DOMDIR) and the studied explanative variables recorded highly significant correlation ship at P<0.000 which indicated that the choosing of that effectiveness variables would be successful to illustration /or explanation the changeability that occurrences in the wind's directions and Durbin-Watson test indicated that a non-correlated between had been occurred between error term and the explanative variables. In addition to that, the multiple regression analysis of variance indicated the highly fitness of MLRM to study and analyze this phenomena since (P-value of Regression ANOVA ≤ 0.000).

The significant of explanative variables for determinate wind direction were (Time of Low Temp. , HEAT DEG Days , and High Wind Speed) at (P< 0.05, P< 0.01 , and P<0.01) respectively , while the others parameters were recorded a non-significant effects on studied function (DOM DIR) at P> 0.05 . But in fact a meaningful effects had been occurred within a confidence levels by (Time of High Wind Speed , Time High Temp. , Rains , and Low Temp.) with not less than (83.9% , 83.6% , 80.1% , and 64.9%) respectively.

Finally, the Predicted Value of (DOM DIR) for obtaining the Optimal Estimation of critical Angle of Wind Power (Energy) represented (122.113º) with min. value (46.111º) and max. Value (261.485º). The preceding estimator showed too highly wide interval for the optimal /or critical angle and that explanations the disturbances of the studied effects on the predicated values. For illustration the preceding, figure 3 represents the region of wind predicated interval within the optimal direction/or critical Angle that estimating for the Wind Power (Energy) of propeller wind turbines to Generate high Electrical Power in Baghdad city.

Table 12. Some estimators of multiple regression analysis models for DOM DIR function.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
	0.434	0.188	0.16	70.74	0.208

a:Predictors : (Constant), TIME3, AVG WIND SPEED, COOL DEG DAYS, RAIN, HEAT DEG DAYS, TIME1, TIME2, HIGH1, HIGH2, LOW, MEAN TEMP

b:Dependent Variable: DOM DIR

Table 13. Analysis of variance of multiple regression analysis model for DOM DIR function (Goodness of fit – Model).

	S.O.V.	Sum of Squares	d. f.	Mean Square	F	Sig.
ANOVA	Regression	360889.2	11	32808.11	6.556	P=0.000 HS
	Residual	1556300	311	5004.18		
	Total	1917189	322			

a:Predictors: (Constant), TIME3, AVG WIND SPEED, COOL DEG DAYS, RAIN, HEAT DEG DAYS, TIME1, TIME2, HIGH1, HIGH2, LOW, MEAN TEMP

b:Dependent Variable: DOM DIR

Table 14. Multiple Linear Regression parameters estimates of DOM DIR function.

Regression Components	Un standardized Coefficients		Standardized Coefficients	t-test	Sig.	95% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	209.401	31.667	—	6.613	0.000	147.093	271.71
Mean temp.	1.818	8.393	0.222	0.217	0.829	-14.695	18.332
High temp.	-1.694	4.654	-0.222	-0.364	0.716	-10.851	7.464
Time high temp.	-1.974	1.414	-0.076	-1.396	0.164	-4.755	0.808
Low temp.	-4.201	4.494	-0.468	-0.935	0.351	-13.043	4.642
Time of low temp.	-3.265	1.456	-0.120	-2.243	0.026	-6.129	-0.400
Heat deg. days	-8.909	2.464	-0.296	-3.616	0.000	-13.757	-4.062
Cool deg. days	-3.26E-03	0.133	-0.001	-0.024	0.981	-0.266	0.259
Rain	0.954	0.74	0.067	1.288	0.199	-0.503	2.41
Avg. wind speed	-1.643	6.711	-0.021	-0.245	0.807	-14.848	11.561
High wind speed	6.45	2.202	0.254	2.929	0.004	2.117	10.784
Time of high wind speed	0.982	0.699	0.074	1.405	0.161	-0.393	2.357

a:Dependent Variable: DOM DIR

Table 15. Multiple Linear Regression predicted estimates of Critical Angular for DOM DIR function.

Prediction of the Critical angular					
Indicators	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value : DOM DIR	46.111	261.485	122.113	33.478	323
Residual	-143.462	229.066	0.00	69.521	323
Std. Predicted Value	-2.27	4.163	0.000	1.000	323
Std. Residual	-2.028	3.238	0.000	0.983	323
a:Dependent Variable: DOM DIR					

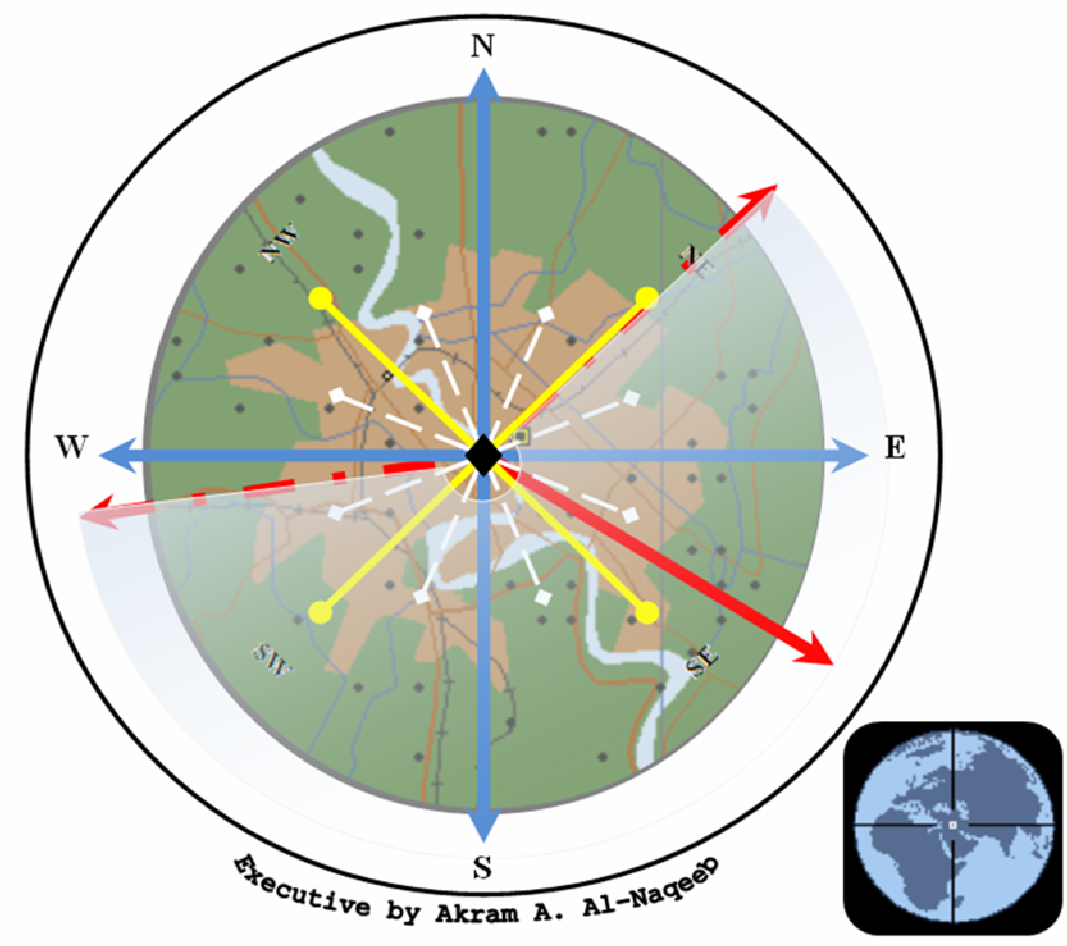

Figure 3. Predicted Optimal Estimations for Critical Angle of Wind Power (Energy) to Generate High Electrical Power in Baghdad City.

6. Conclusions

- The emergence and evolution possessing of wind-driven devices for obtaining highly efficient of electric power generation are briefly surveyed here through estimating the critical angle of the best propeller's directed in Baghdad city.
- The significant of explanative variables for determinate wind direction were presented at (Time of Low Temp., HEAT DEG Days, and High Wind Speed)respectively, while the others parameters were recorded a non-significant effects on studied function (DOMDIR).
- A meaningful effects had been occurred within a highly confidence levels by (Time of High Wind Speed, Time High Temp. ,Rains, and Low Temp.) yet a non-significant were recorded on studied function (DOMDIR).

7. Recommendations

- Necessarily Generalize the suggested transformation of the wind direction in measuring score (Quantitative random variable) which enabling to apply the Multiple Linear Regression Model which is the suitable statistical method to implement the objective of this work.
- Trying to apply this work in assessment the successfulness / or not the stand-up of propeller's wind turbines.

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