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THE COMPARATIVE ANALYSIS OF WIND POWER PLANTS (WPP) USING EFFICIENCY IN ABSHERON PENINSULA CONDITIONS OF THE REPUBLIC OF AZERBAIJAN

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Abstract- Wind power plants are significant component of power production as well as one of the major renewed energy sources in the world. Some countries have entered in a number of new installed wind power capacities. The efficiency analysis of using Wind Power Plants (WPPs) with equal capacities but different design speeds values in Absheron Peninsula conditions is given in this paper.

Keywords: Energy Generation, Wind Power Plants, Renewable Energy Sources, Weibull Distribution.

I. INTRODUCTION

Last decade the renewed power sources continue to strengthen their positions in world power engineering. Today one of the major renewed energy sources in the world is the wind power. This direction develops first of all in the areas with high wind power potential, availability of the roads for wind power plants delivery, the access to electric power system.

Electric power generation on the basis of wind power is a significant component of world power production. The annual electric power production by all installed to the end of 2008 year wind power plants in the world constituted 260 TWh, which corresponded to more than 1.5% of world electric power consumption [1].

According to input into operation within 2009 year new capacities China became world leader, where a capacity of national electric power engineering was increased by 100%.

The 13 GW of new electric power capacities were input into operation within only one 2009 year and, thus, its total installed capacity have been brought to 25.1 GW. The second and third places have been occupied by the European Union countries and the USA, having connected to power networks accordingly about 10.5 GW and 10 GW.

Within 2009 year the countries: Spain (24% - 2459 MW), Germany (19% - 1917 MW), Italy (11% - 1114 MW), France (11 % - 1088 MW) and Great Britain (10% - 1077 MW) have entered in a number of leader countries of Europe on new installed wind power capacities.

Wind power development in the European Union was promoted by EU member states policy, directed at stimulation of renewed power sources. This policy covers some financial stimulus, including investment grants and reduced rates, the ecological component of renewed power sources is also considered.

According to the prognosis of European Wind Power Association (EWPA), by 2010 year only wind power will allow to reduce the hotbed emissions to volume of 1/3 of EU obligations, according to Kioto report. The set by Association for Europe purposes are the follows: 75000 MW of wind power capacities by 2010, 180000 MW - by 2020, 300000 MW - by 2030 [2].

II. DEVELOPMENT OF WIND POWER ENGINEERING IN AZERBAIJAN

Azerbaijan Republic possesses the considerable hydro carbonic resources, but faces considerable ecological problems. Using the powerful alternative energy sources in Azerbaijan Republic, particularly the wind power, will allow besides the great fuel economy (up to 1 million ton in a year) at thermal power plants to reduce sharply an amount of harmful waste, emitted into atmosphere.

Importance and urgency of alternative power sources development have been confirmed by the "government program about necessity of alternative and renewed kinds of power using in Azerbaijan Republic". Reliable estimation of local wind potential is the most important factor, which determines the efficiency of wind power plants using. Generally for its estimation it is necessary to carry out continuous observation at a site of prospective wind power plants installation within not less than a year.

Therefore, the observations of weather stations are used; those give an opportunity to obtain some average statistical indexes for this site and should serve as the basis for wind power plant building problem solution [3]. Within last years the wind characteristics study results on the basis of continuous wind speeds records in Gobustan (height 40) were obtained.

The main delaying factor for wide wind power utilization is the high investment cost at initial stage: WPPs own cost, design and capital expenditures with taking into account local specific conditions. It is necessary to note for all this, that in wind power field the investment cost for each kilowatt power and 1 kWh of electric power production cost constitute presently up to 2000 US$/kW and 0.15 US$/kWh accordingly.

III. PROSPECT OF THE USING WPP TYPE VESTAS AND SINOVEL FOR ABSHERON CONDITION

In this paper the electric power generation volume of Vestas V90 - 3 MW and Sinovel SL110 - 3 MW WPPs' types with the same wind generators' hub heights equal to 90 m in the conditions of Absheron zone is considered and analyzed. It is necessary to note, the measurements of wind characteristics in Gobustan have been carried out at 40 m height, and hub height of above WPPs is 90 m, therefore according to empirical formula [3, 4]:

$$V_{90} = V_{40}\left(\frac{h_{90}}{h_{40}}\right)^{\alpha}$$

where

V_{90} - wind speed at 90 m height;

V_{40} - initial wind speed at 40 m height;

h_{90} - 90 m height;

h_{40} - 40 m height;

α - index, showing the dependence of yearly average wind speed on altitude, which for Absheron is in the range of 0.15-0.25 [5].

Wind speeds measurements at a height of 40 m were carried out in the period of from April 1999 to March 2000 year. Regime of wind speeds measurements is 10 minutes, for simplification 1 hour averaging have been implemented and 8760 hourly average wind speeds values have been obtained. For mentioned period the daily, monthly and yearly average wind speeds have been also calculated. Analysis of average wind speeds' calculated data shows, that all these values within investigated period are in a range of from 7.77 m/s to 10.7 m/s, yearly average wind speed is 9.51 m/s, which confirms the possible high efficiency of WPPs using in considering region.

Results of wind speeds recalculation from 40 m height to 90 m with $\alpha = 0.20$ are shown in Table 1. It is known that wind speeds data can be smoothed by Weibull 2-parameter distribution function, which for investigated height of chosen region is shown in Figure 1.

According to obtained data of average daily wind speeds at specified height and available data table of investigated WPPs types power characteristics the 24-hour power calculation and, accordingly, a quantity of electric power, produced by everyone WPP, have been carried out.

IV. ENERGY GENERATION BY WPP TYPE VESTAS AND SINOVEL FOR ABSHERON CONDITION

Total values of possible electric power production for a year of Sinovel SL110-3 MW WPP which constitutes ~12 million kWh (net) are shown in Figure 2, and of Vestas V90-3 MW with output of ~10 million kWh are shown in Figure 3.

By the obtained results, it is possible to draw the conclusions that electric power output of Sinovel SL110-3 MW WPPs is 19% more than of Vestas V90-3 MW in Absheron conditions. The number of hours of Sinovel rated power output will approximately make up 4100 hours, while for Vestas it is about 3500 hours. Analyzing the frequency of wind speed occurrence we find out, that the most often met wind speeds are in the limits of from 5 m/s to 12 m/s and accordingly the bulk of produced electric power (Sinovel SL110-3 mW - 68%, Vestas V90-3 mW - 63%) corresponds to these wind speeds.

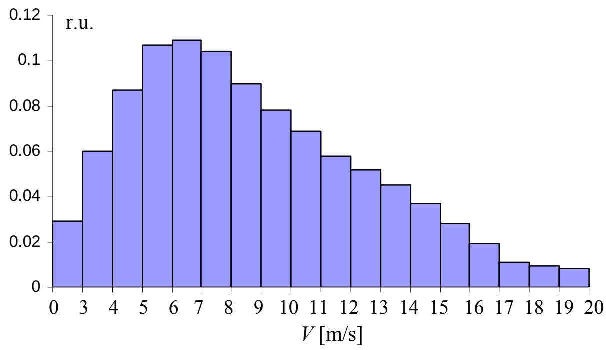

Figure 1. Graph of distribution Weibull

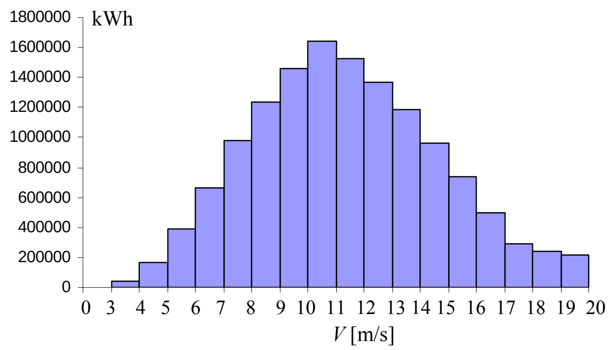

Figure 2. Generation of electrical energy by plant Sinovel

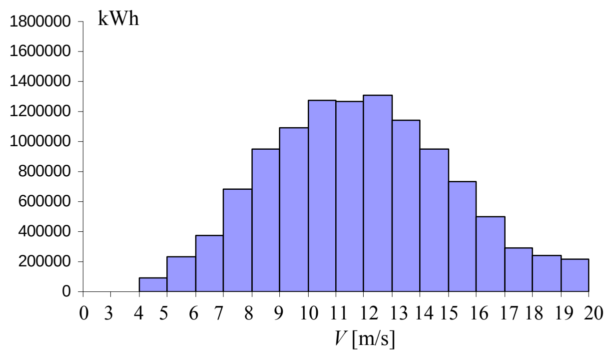

Figure 3. Generation of electrical energy by plant Vestas

Table 1. Results of wind speeds recalculation from 40 m height to 90 m with $\alpha = 0.20$

Days	Daily average wind speeds by α = 0.20											
	1999 year									2000 year		
	April	May	June	July	August	September	October	November	December	January	February	March
1	8.20	6.72	9.19	7.84	4.06	6.41	5.94	11.28	10.03	7.17	10.62	8.36
2	11.30	6.01	14.0	4.41	8.46	6.59	3.93	7.00	13.72	7.93	8.17	8.50
3	6.99	10.41	6.13	4.80	7.26	17.36	2.53	4.34	6.86	4.34	13.29	6.66
4	8.66	7.96	9.17	11.6	3.79	16.71	3.50	2.82	17.84	9.78	12.38	9.20
5	7.15	15.10	11.4	9.94	10.63	7.59	4.69	9.54	12.56	13.08	13.20	6.34
6	15.75	10.46	5.47	5.43	15.64	7.89	9.44	9.16	16.74	13.83	6.14	12.0
7	9.68	16.52	7.21	6.67	20.35	3.02	5.34	4.54	10.77	13.67	16.11	18.4
8	5.36	13.71	6.54	8.73	13.52	4.49	4.72	7.63	10.44	7.23	4.97	15.6
9	5.36	6.52	4.09	5.16	10.70	4.10	6.28	16.68	15.22	5.83	10.89	5.10
10	5.34	3.87	4.74	4.46	7.44	14.24	9.28	19.19	12.93	5.08	8.34	15.9
11	5.80	3.95	5.15	5.49	8.95	8.20	10.86	7.13	14.49	5.43	5.90	14.6
12	12.10	12.40	12.4	16.1	7.03	7.83	12.80	8.07	6.96	7.02	11.94	12.2
13	5.49	8.44	13.9	6.72	12.43	6.56	7.26	10.28	5.19	4.35	7.30	10.5
14	12.63	15.97	13.9	5.39	13.21	7.93	10.24	13.44	3.13	2.14	7.94	13.8
15	4.93	7.09	18.1	5.57	7.63	10.22	12.27	8.31	6.52	4.42	12.09	6.94
16	5.79	10.61	7.96	7.60	9.01	14.34	16.62	16.08	11.09	4.70	10.81	11.3
17	7.34	8.15	4.82	3.55	6.08	11.84	9.26	13.58	10.58	8.41	9.94	14.1
18	5.17	16.70	5.72	5.74	8.23	5.19	12.70	3.87	5.99	17.05	5.80	11.3
19	9.16	8.41	3.89	7.84	7.47	9.75	13.91	11.74	10.37	20.19	12.60	14.4
20	13.31	15.74	5.96	11.4	9.68	14.43	4.83	12.91	8.27	10.04	12.28	12.6
21	4.89	5.80	12.2	13.8	5.90	13.29	7.82	5.46	16.78	13.62	10.01	12.9
22	8.63	7.15	13.5	16.6	3.75	15.39	12.58	7.01	9.76	17.04	14.85	14.5
23	9.61	7.92	6.84	15.8	3.92	7.56	11.58	4.75	19.08	13.72	9.04	10.5
24	4.05	9.19	6.63	14.1	7.89	7.53	8.41	15.51	7.33	9.10	17.30	7.46
25	5.65	8.29	8.81	9.14	16.91	3.60	11.31	10.22	6.72	19.21	8.14	7.59
26	3.47	6.27	6.46	9.94	13.75	4.62	7.52	10.91	7.48	18.36	7.89	9.44
27	4.83	12.10	7.50	6.48	14.96	3.32	11.57	13.47	7.02	14.88	10.18	13.6
28	5.92	11.34	10.8	7.27	14.05	9.66	15.78	5.21	19.68	8.83	17.84	7.69
29	8.04	10.46	8.63	9.28	15.71	11.07	6.72	9.88	10.90	2.41		7.56
30	12.51	9.68	6.62	6.12	12.44	10.09	3.13	8.04	11.67	11.87		8.53
31		15.50		7.09	6.06		8.82		9.22	9.93		3.79
Monthly average wind speeds	**7.77**	**9.95**	**8.60**	**8.40**	**9.90**	**9.03**	**8.76**	**9.60**	**10.82**	**10.02**	**10.57**	**10.7**
Yearly average wind speeds	**9.51**											

V. CONCLUSIONS

The results shown that collecting Absheron conditions for the WPP's type among the WPPs in equal capacities and different design wind speed values, it is necessary to determine the generation of each WPP, and then comparing the effect of production increase with capital investment for each of observed WPPs.

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BIOGRAPHIES

Rauf Ismail Mustafayev was born in Baku, Azerbaijan in 1939. He graduated from Moscow Agrotechnical University (Moscow, Russia) on the specialty of electrician engineer in 1964 and awarded the Ph.D. degree in Azerbaijan State Oil Academy (Baku, Azerbaijan) in 1972. He defended his thesis on "Dynamic Modes of Electromechanical Converters of Operating to Power Network Wind Power Plants" theme and was awarded the Doctor of Technical Science degree in Moscow Institute of Power Engineering (Moscow, Russia) in 1990. Currently, he is a Professor of Power Engineering and head of "Wind Power" laboratory in Azerbaijan Scientific Research Institute of Energetic and Energy Design (Baku, Azerbaijan). He is also an academician of International Academy of Electrotechnical Sciences (Moscow, Russia). He is the author or coauthor of many papers (above 170) in journals and international conference proceedings.

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