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Technical possibility assessment of creating wind power station at Soltanieh zone of Zanjan province

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ABSTRACT
Due to increasing expansion of energy consumption and also the decrease and tendency towards ending fossil energy reserves, the current energy cycle needs to use alternative energy specially wind energy, because it's considerably cheaper than other recycling sources. The present research investigates suitable possibility of exploiting wind energy to create wind power station in Soltanieh zone of Zanajn province by considering technical cases. Some researches have been carried out on possibility assessment, measurement and comparison of power density. In technical possibility investigation, several turbines were investigated to calculate obtainable annual energy capacity coefficient of each turbine. Then these were compared to select the best type of turbine. According to the results, wind turbine owned by Vestas Company, model V100, rated power of 1800 kW and capacity coefficient of 33.1% was selected as the best turbine.

KEYWORDS: Weibull distribution function, wind turbine, Soltanieh, wind power density, technical possibility investigation.

1. INTRODUCTION

Today the impressive development of science and technology has led to comfort and welfare of human life. So, this development caused some new problems for humans including environmental contamination, extensive climatic changes on earth and so on [4].
Specifically oil and its derivatives are vital and assist the country in some cases, and non-optimal consumption of these products leads to inevitable losses [1,2]; therefore experts and researchers are looking for sources that gradually replace fossil fuels. Fossil fuels cause more environmental contamination; on one hand, by burning fossil materials, toxic gases enter into environment and lead to human respiratory problems and on the other hand, concentration of these gases in the atmosphere prevents the exit of heat from

around the earth and this increases weather temperature and intensive climatic changes on earth. This phenomenon is called greenhouse effect. If increasing weather temperature continues according to current trend, it will be almost impossible to return it to the previous condition. The best solution that most scientists suggested is to prevent growing trend of these harmful gases. Specialists believe that if we use clean energies such as wind, solar and geothermal energy etc. rather than energies derived from fossil fuels, then environmental contamination and dangers related to it will be prevented. On the other hand, fossil fuels such as oil, gas and coal will finally end through ending these fuels, human civilization depending directly on energy will lead to new and big challenges. This affair resulted in industrially developed countries take other available energies especially recycling energies on the nature into consideration. Before using recycling energies, they should be studied and investigated more. Gradually, a set of recycling energy undertakes larger portion within world's energy supply. Among recycling energies, wind energy is paid more attention due to its lower complete cost compared to other types of recycling energies. Wind energy, like other sources of recycling energy, is always available from expanded geographical spread [3]. Wind energy has fluctuating and alternative nature and doesn’t have constant movement. It is thousands of years that human beings have used little part of wind energy by windmill. This energy was extensively used before industrial revolution as a source of energy but at the period of industrial revolution, fossil fuels due to cheapness and high safety were replaced by wind energy. At this time, old wind turbines weren’t more competitive with the market of oil and gas energy, so during years between 1973 and 1978, two big oil shocks influenced energy economy resulted from oil and gas. In this way, energy produced by wind turbines was improved in comparison to world rate of energy price [5]. Then, several researches and laboratory centers and institutions around the world investigated different technologies for using wind energy as a big energy source [6,7].

Also this crisis created some tendencies toward usage of wind energy to produce electricity connected to network, pump water and supple electricity energy at distant areas. During some recent years, environmental problems and difficulties related to climatic changes of earth due to using sources of fossil energy have caused these tendencies to continue intensively. Increasing extension of energy need and limitation of fossil sources, increasing environmental contamination resulting from burning these sources, discussion on warming weather and greenhouse effect, downpour of acidic rain and making CO_2 balance necessitate to save fossil fuels and use recycling energy sources. Among recycling energies, wind energy has been one of economical ways of generating electricity that doesn’t lead to environmental contamination and also it’s mortal [8].

According to available statistics, generatingelectricity energy can prevent the spread of nearly one kilogram CO compared to fossil fuels power stations. Generally, replacing energy of wind electricity by energy of electricity produced by fossil fuel PowerStation can decrease spread of greenhouse gases.

2.THEORETICAL BACKGROUNDS OF RESEARCH

To model wind velocity, there are several functions such as Gaussian, Railey and Weibull, so that according to different investigations, it was proved that Weibull function is more compatible with wind data and more compatible with wind specifications of zone and also this function is used as software's possibility investigation at dominant algorithm. This function draws wind frequency value per distinct velocity duration by series. Weibull distribution function is stated as the equation I.

$$p(v) = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)^{2}\right] \quad (1)$$

Where, p (v) indicates frequency density (m/s) or Weibull possibility function; V indicates wind velocity (m/s), K is shape factor (dimensionless) a C is scale coefficient (m/s).

These values are obtained by two ways. First one is obtained by experimental relations that were provided by Justus in 1978 and it is as follows:

$$k = \left(\frac{\sigma_u}{v}\right)^{-1.036} \quad (2)$$

Where, σ_υ and $\overline{V}$ are standard deviration and average velocity, respectively. And also standard deviation is obtained by the following formula:

$$c = \frac{\overline{v}}{r\left(1+\frac{1}{k}\right)} \quad (3)$$

$$\sigma_u = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(v_1-\overline{v}\right)^2} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(v_1^2-n\overline{v}\right)^2} \quad (4)$$

Also another relation was presented by Larsen in 1983 as follow:

$$\frac{c}{v} = \left(0.568 + 0.433 / k\right)^{\frac{1}{k}} \quad (5)$$

Having K from equation (2) can calculate value C by equation 5.

By obtaining these two factors, we can model wind at a zone.

Based on high volume of wind data at Soltanieh zone, it's possible to obtain Weibull parameters by using software. The software which is used at this research for calculating and simulating turbines, is called Windgrapher.

3. ANALYSIS OF WIND DATA

At this part, the results derived from primary data by Windgrapher software, are presented as follow:

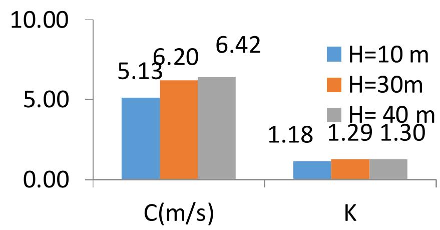

Fig.1. Weibull parameters of Soltanieh zone at top heights

4. CALCULATION OF WIND ENERGY

Power obtained by wind is calculated by equation (6) as follow:

$$p = \frac{1}{2} c_p \rho A V \tag{6}$$

In equation (6), P is weight (Density), A indicates cross section swept by router blades, V is wind velocity and C_p is power coefficient that is the percent of wind energy converted to mechanical energy. Another relation that is used for obtaining wind class at one zone, irrespective of type and size of wind turbine, is wind power density or WPD. Wind power density is obtained through equation (7).

$$wpd = \frac{windpower}{Area} = \frac{1}{2} c_p pv \tag{7}$$

By considering that wind velocity isn't constant value and its random variable, in equation (7), instead of wind velocity value, we replace Weibull consistent function.

$$wpd = \int_0^\infty \frac{1}{2} c_p \rho v^3 pd(v) d(v) \tag{8}$$

Where, pd (v) is Weibull distribution function at equation (1).

Capacity factors consist of ratio of exit average power of turbine to nominal power of turbine. In order to calculate this factor, wind turbine power must be available.

As mentioned before, calculations related to Weibull distribution function and determination of wind class of one zone were done by Wind-grapher software, and results of wind class were presented at table.2.

Table.1.Power density and wind class in Soltanieh

Power density at 50 m w/m2	Wind
462	4

According to results of table (1), Soltanieh zone has power density of 462 m/s at high 50 m, based on standards of wind energy valid. It's located within a good area.

5. TECHNICAL POSSIBILITY INVESTIGATION

The most important thing to for evaluate wind power at one zone technically is to determine wind class of zone. By considering that wind is a random and unpredictable process, in order to calculate wind class of a zone, modeling wind for different zones should be done by using statistical functions and ways. Since produced wind power equals third wind power, negligible mistake at wind velocity parameters will follow considerable mistakes in the results of possibility investigation. Therefore, the importance of accuracy is prominent in wind velocity. Since wind velocity is random for doing research on possibility investigation, in order to obtain acceptable results based on wind energy world association, taking data from wind velocity should be done at time periods of 10 minutes, 3 minutes, and current high of erection of wind turbines. Therefore, wind data of new energy organization (Sana) that were measured at time period of 10 minutes and heights 10, 30 and 40 meters, were employed.

6. SIMULATION OF DIFFERENT TURBINES

Although optimal power which was calculated from economical point of view for turbines in Iran, is 1.5 to 2 MW, and also on the other hand using turbines with high power suitable for improving technology and achieving high yield is important, because wind system at each zone and power curve of every turbine is specific, in order to obtain accurate value of power and capacity factor of every turbine, we must simulate turbines one by one for different zones.

Output power, obtainable energy and capacity factor of 16 turbines with power 1500 to 2000 kW simulated and calculated at software Windgrapher, are presented at table.2 as follow:

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Table.2.Summary of simulation results for different turbines

	Hub	Hub Height	Time At	Time At	Mean Net	Mean Net	Net Capacity
	Height	Wind Speed	Zero Output	Rated Output	Power Output	Energy Output	Factor
Turbine	(m)	(m/s)	(%)	(%)	(KW)	(KWh/yr)	(%)
AAERA-1500-70	65	6.5	30.13	12.27	371.4	3253802	24.8
AAERA-2000/71	65	6.5	39.02	6.78	409	3582926	20.5
DeWind D8.2	80	6.76	24.01	4.55	430.7	3773128	21.5
Ecotecnia 80	80	6.76	28.83	8.64	447	3915613	26.8
Ecotecnia 80 2.0	80	6.76	27.93	4.96	494.1	4328226	24.7
Enercon E82	78	6.73	7.49	13.45	579.3	5074704	29
GE1.5s	64.7	6.49	29.37	9.19	332.2	2909904	22.1
Nordex S77/1500Kw	80	6.76	34.76	10.23	420.4	3683108	28
REpower MD70	80	6.76	33.38	10.66	394.2	3453452	26.3
Sinovel SL1500/70	65	6.5	25.04	12.27	367.6	3220094	24.5
Suzlon S.88/2000	80	6.76	28.71	15.52	576.8	5053096	28.8
Unison U88	80	6.76	21.78	11.43	523.1	4582748	26.2
Vensys 77-1500Kw	85	6.84	28.6	14.99	449	3933326	29.9
Vetas V100-1.8MW	80	6.76	29.32	13	596.2	5222836	33.1
Vetas V82-1.65MW	80	6.76	29.38	9.43	469.9	4116660	28.5
Vetas V90-2.0MW	80	6.76	28.65	10.25	582	5098368	29.1

Table.3.Detailed results of simulation of Vestas V100-1.8MW turbine in Soltanieh zone

Month	Valid Data Points	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (KW)	Mean Net energy Output (KWh/yr)	Net Capacity Factor (%)
Jan	4453	6.1	30.95	9.93	477.2	355013	26.5
Feb	4026	7.83	18.01	16.17	735.9	494555	40.9
Mar	4460	9.79	20.29	23.09	779.2	579706	43.3
Apr	4320	8.3	18.54	18.5	759.5	546806	42.2
May	4464	7.28	25.18	17.34	670.5	498836	37.2
Jun	4214	7.63	25.01	20.36	688.7	495873	38.3
Jul	4546	7.39	23.21	18.81	714.3	531453	39.7
Aug	4460	6.19	33.79	12.15	585.5	435580	32.5
Sep	4022	4.75	44.26	5.57	385.1	277264	21.4
Oct	4314	5.4	36.95	5.91	486.4	361873	27
Nov	3448	4.59	43.74	1.91	397	285821	22.1
Dec	3187	4.74	37.78	2.89	359.6	267517	20
Overall	49914	6.76	29.32	13.2	596.2	5222836	33.1

As you see in table 3, value of obtained load coefficient for different turbines changes from 20.5% to 33.1%. This change is due to variation in power curve and also cut-in velocity (the velocity level through which turbines starts to generate power). By considering load coefficient it is possible to rate generated average power to turbine's nominal power, so this coefficient will be a suitable index to assess technically. Based on the table, the highest generated load coefficient is related to turbine Vestas V100 with load confident of 33.1%.

7. CONCLUSION

Based on results, technical evaluation of wind electricity generation at Soltanieh zone shows that this zone is suitable for creating wind power station and regarding wind class, it is located in a good area. Simulation and estimation of Windgrapher software showed that the best type of turbine for this zone is turbine Vestas V100-1.8MW with factor coefficient of 33.1% and annual generation of energy with 5222836 kW per year. Also this research shows that when trend of study of possibility assessment is done accurately and completely before creating wind power stations, specially the most suitable turbine and the best environmental conditions are selected, it will be possible to solve technical and financial problems imposed due to lack of doing study possibility assessment on wind electricity projects. It should be noted that increasing wind turbine size will decrease complete cost. On the other hand, by reducing gas reserves and deleting subsidence of oil products, fuel cost at gas and thermal power stations will decrease, so in the future this affair will lead to justification of wind power stations compared to gas and thermal power stations. Also wind power stations occupy only one percent of overall farm surfaces and the remaining 0.99 is used for agriculture and animal husbandry. Human attractions and view of wind energy systems that are exposed to propel observation, is one more benefit of wind energy that is considered as a sample of clean energy. Also when calculating factors, gas steam turbine yields and other parameters were investigated at the same conditions and also the products of best companies creating turbines were considered as the basis for comparison.

However, specific characteristics of wind energy systems include: high maneuver for exploiting at each capacity and size (from several watts to several (Mega Watts) and modularity of wind power stations and also supply electricity needed for distant areas and supply drinkable, agricultural and drainage water from low depth for nurturing aquatic creatures. Also, one index of constant expansion on countries is variety at types of generating energy that makes smooth use of recycling energies including wind energy and adding it to the basket of energy can improve constant development in our country.

REFERENCES

[1] Jain, Amit, Pramod Kumar Singh, and Kumar Anurag Singh (2011). "Short term load forecasting using fuzzy inference and ant colony optimization." Swarm, Evolutionary, and Memetic Computing. Springer Berlin Heidelberg, 626-636.

[2] Pourmahmood, Mohammad, Mohammd Esmaeel Akbari, and Amin Mohammadpour. "An efficient modified shuffled frog leaping optimization algorithm." *Int. J. Comput. Appl* 32.1 (2011): 0975-8887.

[3] European Wind Energy Association. The economics of wind energy. EWEA, 2009.

[4] Loue, Sana (1992). "Access to health care and the undocumented alien." Journal of Legal Medicine 13.3: 271-332.

[5] Hoogwijk, Monique, Bert de Vries, and Wim Turkenburg (2004). "Assessment of the global and regional geographical, technical and economic potential of onshore wind energy." Energy Economics 26.5: 889-919.

[6] Kaldellis, John K., and D. Zafirakis (2011). "The wind energy (r) evolution: A short review of a long history." Renewable Energy 36.7: 1887-1901.

[7] Kostakis, Vasilis, Michail Fountouklis, and Wolfgang Drechsler (2013). "Peer production and desktop manufacturing: The case of the Helix_T wind turbine project." Science, Technology & Human Values: 0162243913493676.

[8] Satkin, Mohammad, et al. (2014). "Multi criteria site selection model for wind-compressed air energy storage power plants in Iran." Renewable and Sustainable Energy Reviews 32: 579-590