J. Basic. Appl. Sci. Res., 3(4)654-662, 2013
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Practicability to Install Wind Turbines in Mazandaran Province

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ABSTRACT

Wind energy is one of the most important available energies at ground level. Today, we are capable to change wind energy to electricity. In comparison with the fossil fuel energy, wind energy has been exploited widely due to expanded availability, stability; reduce air pollution and economical aspects. Thereby, this study aims to consider and assess the rate of availability of various regions in all over the Mazandaran Province to take advantage of wind energy. In this regard, hourly data about speed and direction of wind is gathered primarily during the statistical period, then enjoying available software, some other information such as annual wind graph, speed diagrams, statistical distributions and at last, density of wind energy in above mentioned regions is analyzed. The findings of this study showed that due to quantitative and qualitative situation of winds, there is no possibility to produce electrical energy through technology of turbines in the region – instead of some parts in Balade Noor – from economical viewpoint.

KEYWORDS: Wind, Potential of Wind Energy, Vibul parameters, Mazandaran.

1. INTRODUCTION

Among all other types of energy resources, using wind energy is the cheapest, the most appropriate and maybe the most effective method to produce and optimize energy. Fossil resources of energy are mortal and on the other hand, wind energy is pollution free and cheap-to-produce, so it is important to recognize and consider the potential of wind energy in various regions of the country.

Assessment of wind resources in a region is a key or critical parameter to perform wind energy production with wind turbines. Available energy through wind current is proportional with the cube of wind speed. This means that if the wind speed doubles, the produced energy by turbine or available potential energy will be increased eight times.

Generally, annual average of wind speed more than 5 m/s is required and essential for application goals such as production of electricity and establishment of required electricity current. Although less than 5 m/s wind speed may be enough to charge batteries or to pump water. Density of wind power is a suitable method to assess potential of wind energy and its unit is watt/m^2. Density of wind power is a factor to show the amount of required available energy in any region to be changed to electrical energy by turbines. Density of wind power is defined and categorized based on two factors: speed of wind and height. Many studies have been done about potentiometery of wind energy in different points around the world. Meanwhile, Spain, Germany, India and USA have had the most possible operation with wind energy due to their vast land and high knowledge and technology. In 2010, the Europe reached to produce 40000 MW electricity by wind power.

In 1994, two units of wind turbines with 500 KW capacities were installed in Manjil and Roodbar regions in Islamic Republic of Iran to produce electricity from renewable wind energy. In following and regarding the advantages of produced electricity of wind energy in Iran, it was arranged to produce 500 MW of consumption electricity of the country from renewable energies. At present, the Organization of New Energies of Iran has two wind power plants under construction in Binalood with 30 MW output and in Manjil with 100 MW output. Many researchers have been done so far about the possibility to use potential of wind energy for different geographical regions and very valuable results have been obtained. In Gliboloy region in Turkey, by means of wind speed data, the function of density of wind probability is defined as a comparison between ten different functions. To do this, three fit goodness tests and graphical methods were done to obtain the best function. The considerations in Kotabia in Bangladesh showed that eastern and southern borders of this region can be sufficient to produce electricity by means of small turbines in 30 meters height. The monthly and annual wind atlas was drawn by WASP software in 50 meters height and annual speed of wind was calculated as 5.1 to 5.8 m/s and density of wind energy was assessed as 200 Watt/m^2 for winds in 50 meters height or higher in Korabia region. Potentiometery of wind energy in Jarandagh region in Takestan City of Qazvin Province in Iran showed that the region is completely appropriate to produce electricity from

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wind power and is classified in class 6. The region is located at the following of wind tunnel of Manjil and enjoys a suitable wind current.

MATERIALS AND METHODOLOGY

Hourly data and wind speed average of synoptic stations in Mazandaran Province are referred in this study to assess potential and density of wind energy. In primary studies to consider wind speed, at first, hourly data was extracted from stations and then, extracted data was analyzed by professional software for primary potentiometery, and it was considered that except for Baladeh Noor, Amirabad of Behshahr and Siah-Bisheh of Chaloos, the other parts had no mentionable wind current. So, the complementary studies were done over these three regions. Station of Baladeh is located on 68.51° eastern longitude and 36.12° northern latitude. The height of this station from the level of the sea is 2120 meters. Station of Amirabad is located on 53.22° eastern longitude and 36.51° northern latitude. The height of this station is 20 meters lower than free waters. Station of Siah-Bisheh is located on 51.18° eastern longitude and 36.15° northern latitude. Similar to Baladeh Station, this station is a mountain station and is located on the height of 1856 meters. Three above mentioned stations have not dislocated physically since they have been constructed. In this paper, potentiometery of wind is calculated by Vibul distribution, recorded statistics of aerology and WRPLOT and Windographer softwares.

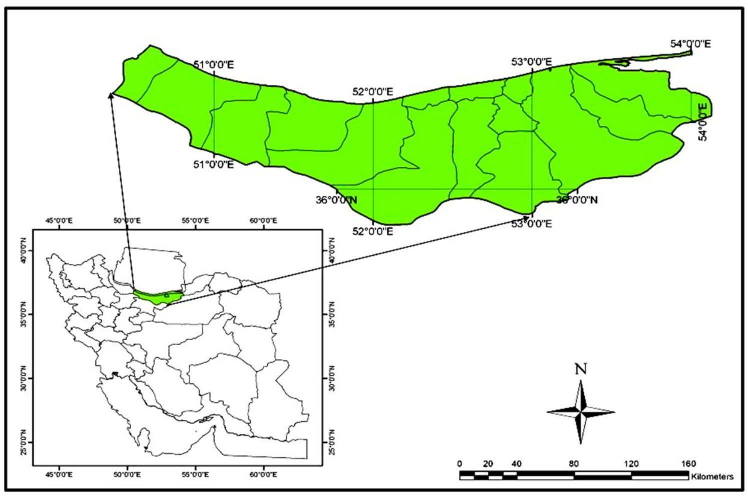
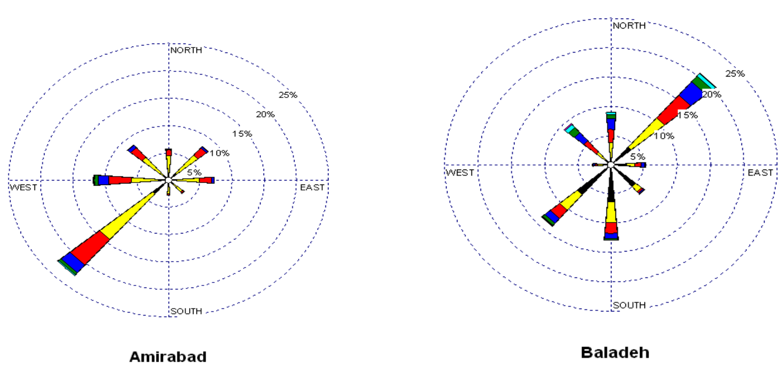


Figure 1: Position of Mazandaran Province in Iran

Analysis and Findings of Study

Considering wind graph of the station

Wind graph of each station shows the situation, direction and speed of the wind in various directions and speed levels. Figure 2 illustrates annual wind graph of synoptic stations of Baladeh, Amirabad and Siah-Bisheh.



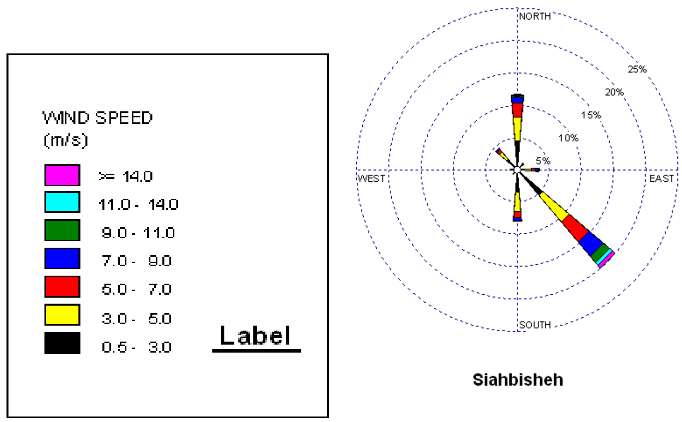


Figure 2: Annual wind graph of in question stations

The direction of prevailing wind is an important factor to arrange and install turbines and to establish wind farms. It should be mentioned that prevailing wind is the wind which has the highest blowing rate in desired region. Wind graph of Baladeh shows that the direction of prevailing wind and the maximum achievable energy is in north-east direction (0-90°) which includes about 28% of the wind in Baladeh region. During 19.38% of the entire year, the air of region is calm and static and there is no wind. In fact, there is appropriate wind blow during 80% of the year which is a positive parameter of the region. In Amirabad coastal station, the direction of prevailing wind and the maximum achievable energy is in south-west direction (180-270°). North wind (0-30°) is in second position and about 28% of blowing wind is reported in Amirabad Harbor. Continuous blowing of wind, sometimes hard and sometimes weak, during the entire year is an important feature of the region. Generally, there is a wind in about 71% of year. In synoptic station of Siah-Bisheh, it can be analyzed according to wind graphs that prevailing wind is in southeast direction during the statistical period (90-180°) and north wind (0-30°) is in second place which includes 43% of all blowing wind in Shiah-Bisheh. In more than 50% of the entire year, there is wind blowing which is appropriate in the first stage to establish wind turbines. The most speed of the wind is recorded in this direction (southeast) which should be considered while installing wind turbines in wind farms to take the maximum advantage of wind energy.

The trend of wind speed in stations

Figure 3 shows that the most speed of the wind occurs in winters in Siah-Bisheh region and the least speed occurs in summers. Totally, the wind speed is maximum in February (3.6 m/s) and it is minimum in July (1.5 m/s) in the height of 10 meters. Explaining variation of wind speed during different months and seasons has an important role.

Figure 3: Average monthly speed of the wind during statistical period and in 10 meters height in Siah-Bisheh Station.

Figure 4 illustrates average monthly speed of the wind in Amirabad region and indicates that average speed is higher in summer. The wind speed is maximum in July (3.6 m/s) and it is minimum in January (2.4 m/s) in this region. Totally, there is a wind speed higher than 3 m/s during 6 months per year.

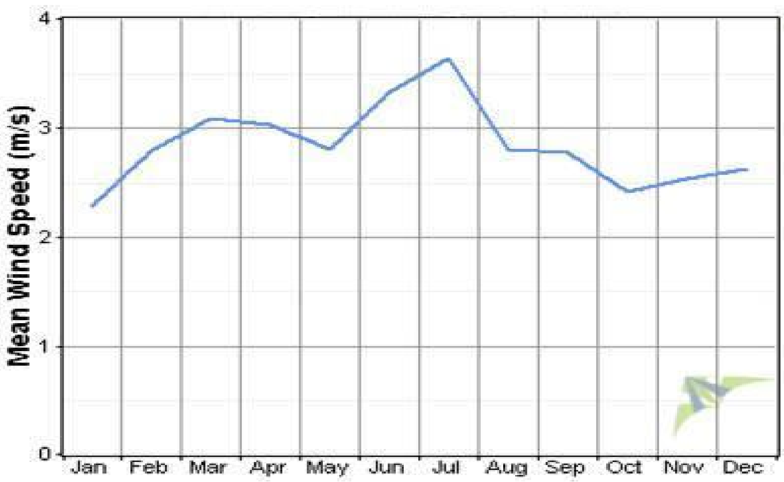


Figure 4: Average monthly speed of the wind during statistical period and in 10 meters height in Amirabad Station

Baladeh region has higher average speed in comparison with two other stations and the maximum wind speed is about 4 m/s in April and the minimum average monthly speed is about 3.2 m/s in the end of autumn (November and December) (figure 5).

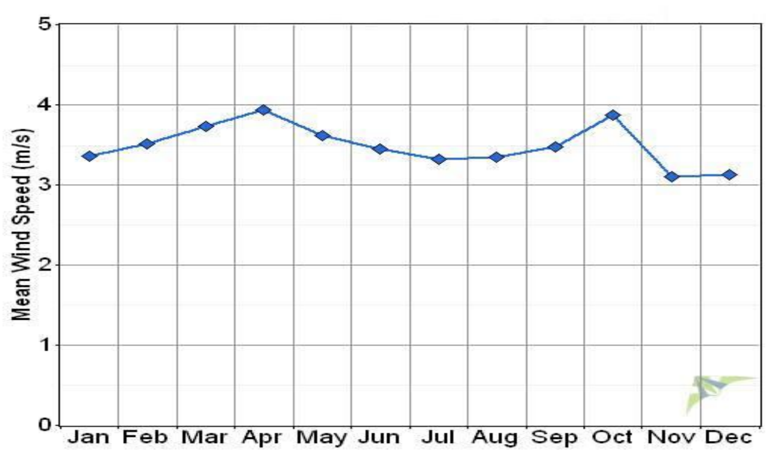


Figure 5: Average monthly speed of the wind during statistical period and in 10 meters height in Baladeh Station

Vibul distribution function and calculation of its parameters

Vibul distribution has two parameters which are used to distribute amplitude of wind speed. Vibul statistical distributions calculate wind regime in the region. Using such these statistical methods is a simple way to anticipate electrical energy output from a convertor system of wind energy. In analysis of wind energy, vibul distribution shows probability of wind density. The analysis of wind speed is done by means of the function of wind speed probability density in this study which is achievable by equation 1.

$$f(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} exp\left(-\left(\frac{v}{c}\right)^{k}\right), (k > 0, v > 0, c > 1)$$

Where c is the parameter of the degree of vibul in m/s and k is the parameter of the dimensionless figure of vibul. Basically, parameter c refers to wind abounding of the region and parameter k indicates that how wind distribution reaches its maximum level. Average speed ($\bar{v}$) and variance (δ^2) of data will be calculated to assess parameters c and k of vibul.

$k = \left(\frac{\delta}{\bar{v}}\right)^{-1.086} (1 \leq k \leq 10)$ and $c = \frac{\bar{v}}{\Gamma(1+1/k)}$ so the average wind speed is $\bar{v} = \frac{1}{n}\sum_{i=1}^{n} v_i$ and variance of recorded speed of the wind can be calculated by $\delta^2 = \frac{1}{n-1}\sum_{i=1}^{n}(v_i - \bar{v})^2$.

There are various methods to calculate standard parameters and figure of vibul function. “Least square assessment” is one of these methods which is referred by foreigner researchers. This method is performed by cumulative probability function.

Table 1 represents the amount of parameters k and c for vibul least square distributions for above mentioned stations.

Table 1: Parameters k and c about vibul least square distributions for above mentioned stations in the height of 10 meters

Station	Sum of vibul distribution	
	K	$(m.s^{-1})$c
Baladeh-Noor	1.3	4.6
Amirabad	1.45	3.5
Siah-Bisheh	1.02	2.7

Having parameters of the figure and (k,c) scale and also available speeds, the quantity of the function of vibul continuous probability is illustrated as a diagram in figures 6 to 8 in order to compare with real data.

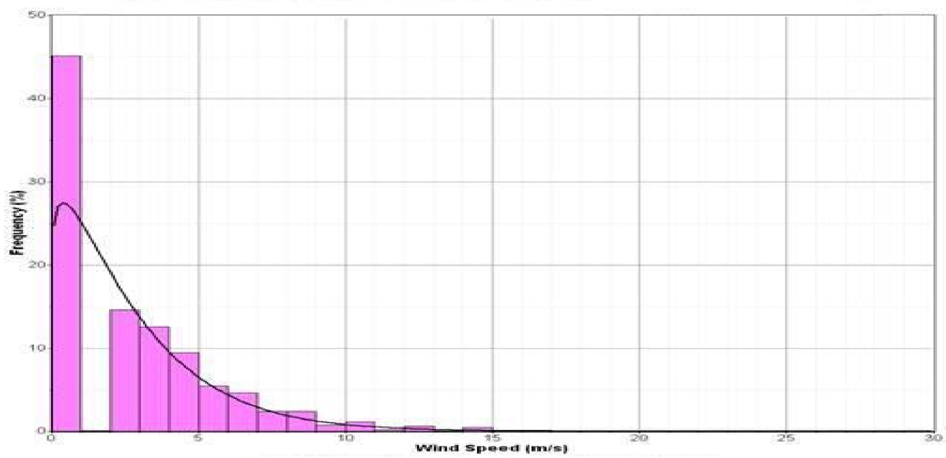


Figure 6: The histogram of amplitude and diagram of vibul distribution for Siah-Bisheh Station

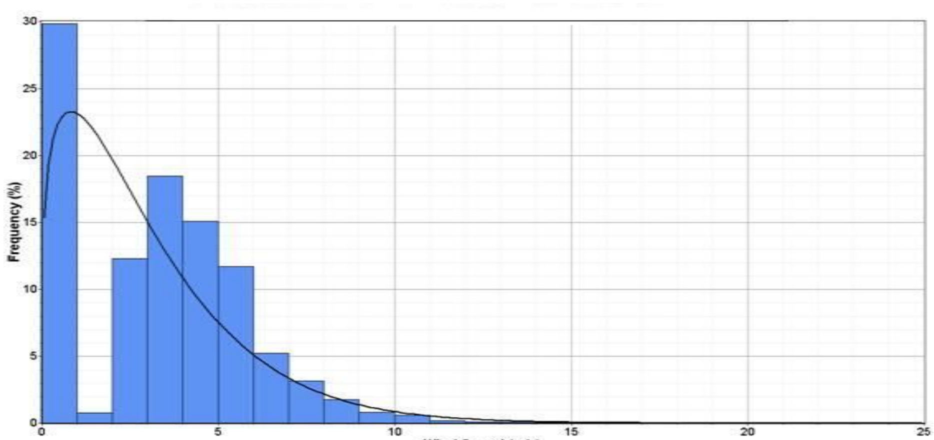


Figure 7: The histogram of amplitude and diagram of vibul distribution for Amirabad Station

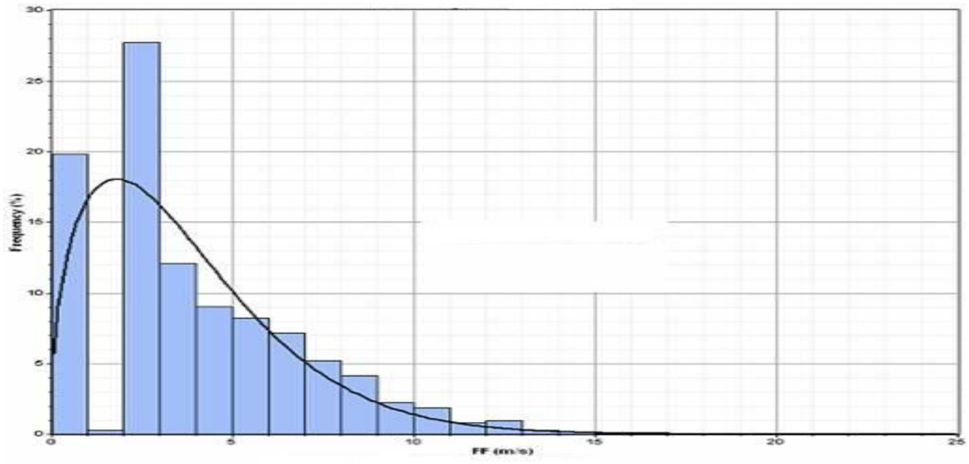


Figure 8: The histogram of amplitude and diagram of vibul distribution for Baladeh Station

Calculations of Wind Energy

Having quantities of average wind speed and parameters c and k, it is possible to assess the situation of synoptic stations from viewpoint of wind energy potential. The first step to consider wind energy for a region is to calculate wind power density (WPD). WPD will be achieved by $\frac{E}{A} = \frac{1}{2}\rho c^3 \Gamma\left(\frac{k+3}{k}\right)T$, where Γ is Gamma function, c and k are vibul parameters, ρ is density of standard atmosphere in 15^{o} C degree and 1 atmosphere pressure (1.225 kg/m^3) and $\overline{T}$ is average monthly temperature in Kelvin. According to equation 6 and the units of area, it can be concluded that wind energy density of a region is completely related to parameters of vibul function. Studies show that the most under operation turbines around the world are installed in the height of 30 to 50 meters. So, it is essential to consider the trend of changes of wind energy toward height. Figures 9 to 14 represent the trend of changes for density of wind energy in various heights of stations. This quantity is 79, 84 and 120 $watt/m^2$ respectively for Siah-Bisheh, Amirabad and Baladeh stations in the height of 30 meters and is 98, 108 and 147 $watt/m^2$ in the height of 50 meters.

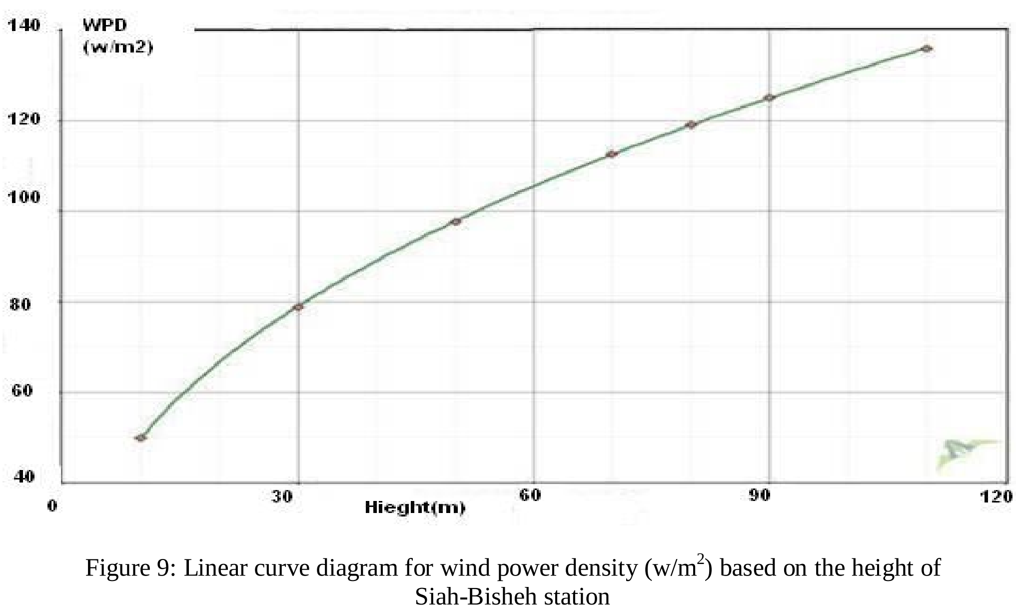


Figure 9: Linear curve diagram for wind power density (w/m^2) based on the height of Siah-Bisheh station

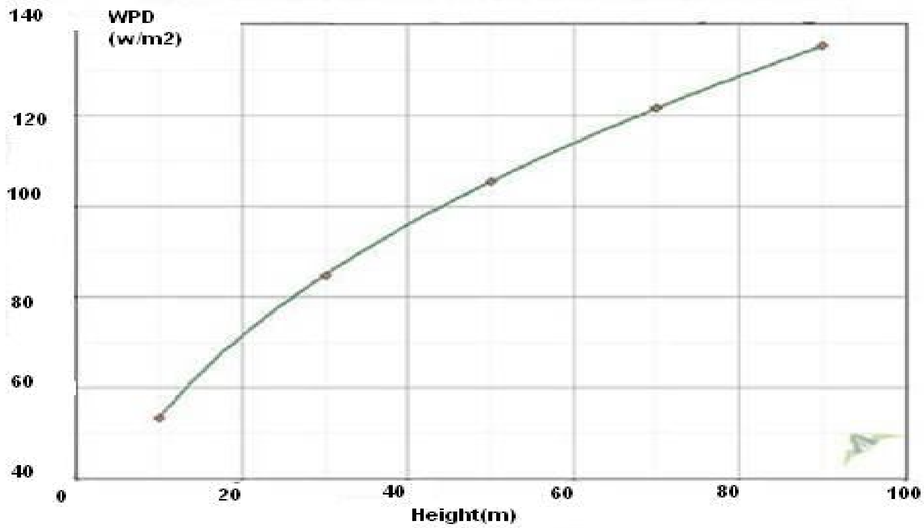


Figure 10: Linear curve diagram for wind power density (w/m^2) based on the height of Amirabad station

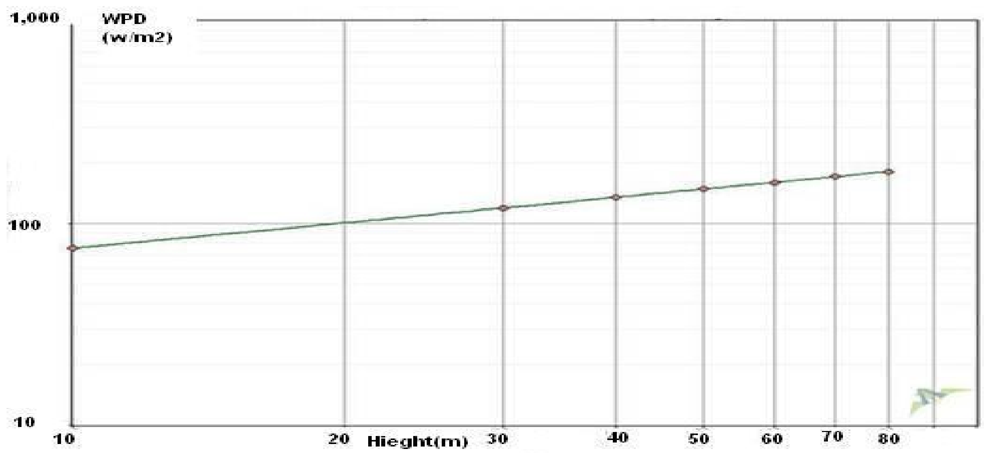


Figure 11: Logarithm curve diagram for wind power density (w/m^2) based on the height of Baladeh station

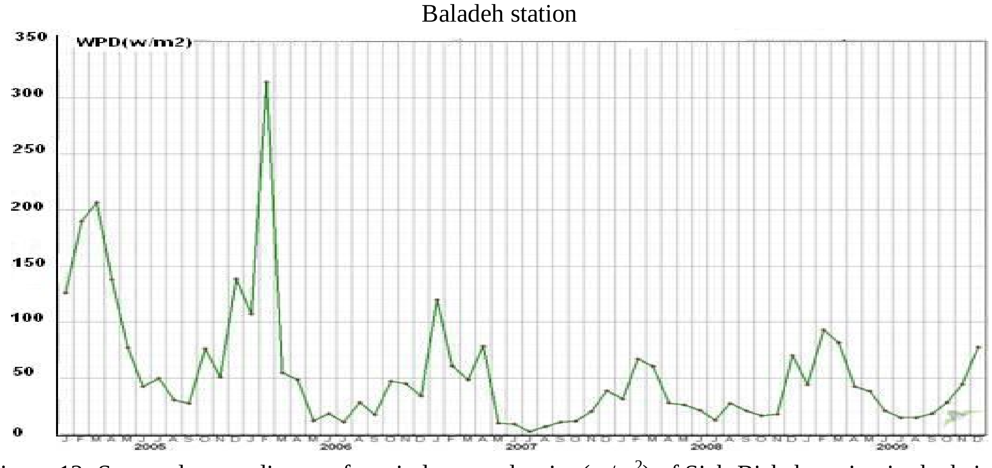


Figure 12: Seasonal curve diagram for wind power density (w/m^2) of Siah-Bisheh station in the height of 50 meters during time period

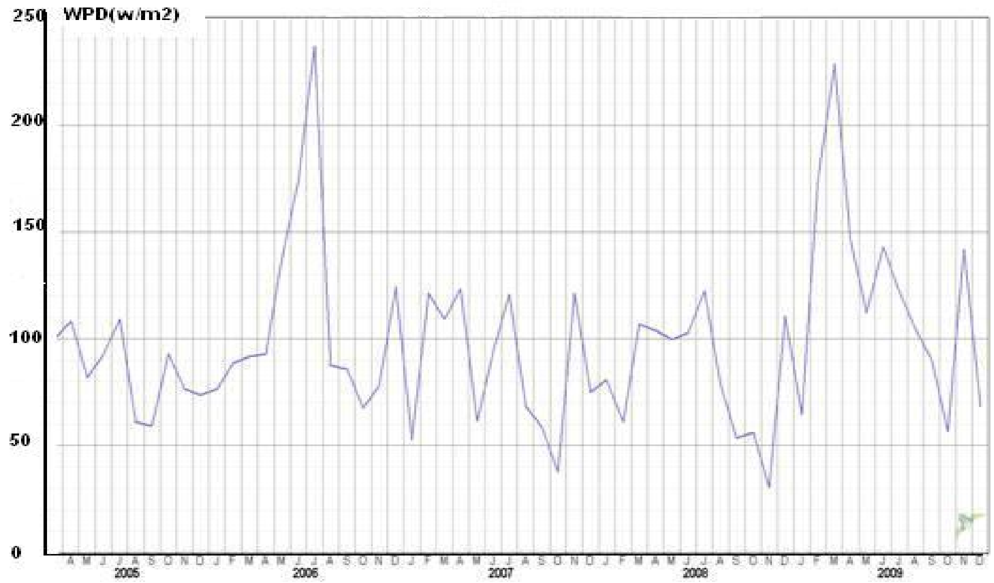


Figure 13: Seasonal curve diagram for wind power density (w/m^2) of Amirabad station in the height of 50 meters during time period

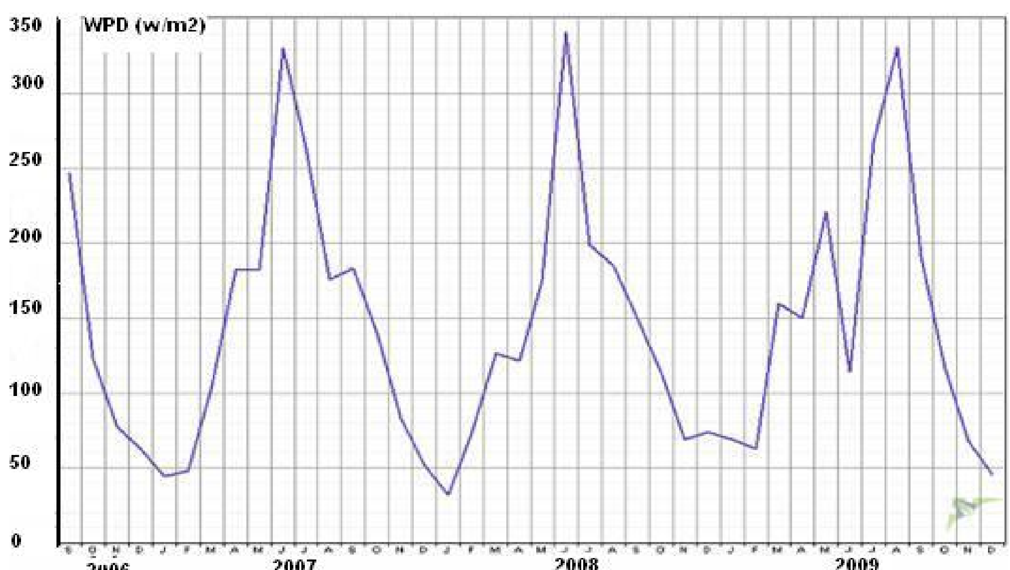


Figure 14: Seasonal curve diagram for wind power density (w/m^2) of Baladeh station in the height of 50 meters during time period

RESULTS AND DISCUSSION

Statistical considerations showed that Baladeh station of Noor has the highest percentage of wind, speed average and energy density (147 W/m^2) among all under consideration stations. Of course, seasonal studies about wind blow show that the highest density of wind power is for hot months and during June and July with a power more than 300 w/m^2. This quantity may decrease up to 200 W/m^2 at the beginning of spring (figures 11 and 14). In other words, Baladeh region has a situation from average to good from the beginning of spring to the beginning of autumn and is assessed as an appropriate region for various operations of wind energy. Coastal station of Amirabad located on the east of Mazandaran is in second position with energy density of 108 W/m^2 in the height of 50 meters especially during hot season. The balance of the region will reach 200 W/m^2,so Amirabad region is assessed as a windy region (figures 10 and 13). In mountain station of Siah-Bisheh of Chaloos the most wind power density (W/m^2) is in the late autumn to middle of winter (November to February) with an average power between 100 and 150 W/m^2. In other words, Siah-Bisheh has the most wind blowing in the entire year from the beginning of autumn to the middle of winter (figures 9 and 12).

Quantitively, the average wind speed of under consideration regions is less than required standards to install wind turbines; so at present, there is no possibility to produce electricity power in a wide range through the technology of wind turbines by average wind speed. In addition, the quality of prevailing winds across the province doubles the problems to produce electricity due to inappropriate continuation of wind blowing and changes of direction.

It is essential to recognize wind tunnels in some parts of Baladeh Noor retion during summer which there relatively good wind is blowing. It is also required to install and operate automatic anemometer stations to have a better recognition of windy points. Although the region is classified in class 1 regions (weak) according to global standards from the level of quality and wind energy, but an relatively appropriate wind is blowing during summers. Meanwhile, establishment of small wind turbines may provide enough power for agriculture, for charging batteries and other operations.

Hope to have further developments in the technology to create modern turbines in wind farms, it is expected to produce electricity power in the future in some parts of the regions due to enjoying relative potential of wind energy.

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