Investigation on Wind Power Generation for Different Heights on Bechar, South West of Algeria

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ABSTRACT

The wind energy is one of the most significant and rapidly developing renewable energy sources in the world and it provides a clean energy resource, which is a promising alternative in the short term in Algeria. The main purpose of this paper is to present, the wind potential in Bechar (Southwest of Algeria) and to discuss the potential for electricity generation based on the local weather data for different heights and typical wind turbine characteristics. A case studied investigation allows wind speed and wind power density to be obtained using different hub heights, and the annual power generated and annual operating hours by the wind turbine to be simulated.

I. Introduction

Limited reserves of fossil fuels and their negative impacts on the environment lead institutions, organization and governments to find out more efficient technologies and new and renewable energy resources to produce energy in the natural environment. Recently, wind energy is the growing energy source of energy in the world and wind power is one of the most widely used alternative sources [1]. The wind energy has been used for centuries for navigation and agriculture. Today, the use and the technology of the wind energy have been developing very fast. As of the end of 2002, total global wind generating capacity exceeds 31,000MW, and provides about 65 billion KWh of electricity annually [2]. Approximately, 6800 MW of new capacity were installed worldwide in 2002[3]. Generating capacity is mainly concentrated in just five countries using wind energy for their energy production as of the year 2004: Germany (39%), Spain (19%), the USA (16%), Denmark (7%), and India (7%), together account for 88% of the total [4]

In Saudi Arabia, Rehmane [5] performed a detailed analysis of wind speed terms of energy yield, effect of hub-height on energy yield, plant capacity factor, etc. In Hong Kong, Lin Lu and all [6] presented the Investigation on wind power potential on Hong Kong islands-an analysis of wind power and wind turbine characteristics, the wind speed and the wind power density to be obtained using different hub heights. Algeria has a vast uninhabited land area where the south (desert) represents the part with considerable wind regime. [7]

In Algeria, work on wind energy resource assessment dates back to 1976 when a wind atlas was developed by using wind speed data from 20 locations [8]. This atlas presented the monthly mean wind speed contour end frequency distribution for all the months during the year.

Dahbi et al [9] calculated the monthly and seasonally Weibull parameters for Bechar's site at 10m and found that the wind speed was well represented by the Weibull distribution function, based on wind speed data measured at 10 m height and collected along 12 years by the Algerian Meteorological Office. Arama FZ et al [10], compared the performances of energy produced by the use of two types of controllers (PI regulator and the neural network regulator (NN)) in order to control the wind power conversion system to compare their precision & robustness against the wind fluctuation and the impact on the quality of produced energy.

This Paper present the monthly wind speed and wind power density for different heights to assess the wind power potential for the site of Bechar (South Western of Algeria) which geographical coordinates are Latitude=31°62'N, Longitude=2°22'W, Altitude=811m [7]. The monthly power output of a wind turbine and the monthly operating hours for different tower height are calculated. Simulation is performed using Matlab software environment. Bechar (South West Algerian) in new valley was selected as the site under consideration in this work. It is based around an oasis of the Sahara Desert. A meteorological data collected (wind speed data measured at 10 m height) along 12 years by the Algerian Meteorological Office is used for analysis in this paper.

II. Mathematical Modelling and Simulation of the Wind Power

The mathematical model used for this study is presented in this section. There are three main factors that determine the power output of a wind turbine: wind speed distribution of selected site where wind turbine is installed, the tower height and power output curve of chosen wind turbine.

II.1. Wind Speed Variation with Height

Wind speed near to the ground changes, which requires an equation that predicts the wind speed at one height in terms of the measured speed at another height. For a wind turbine, it is also necessary to know the wind speed at its hub center. The most common expression is the power law, expressed as [6] :

$$v = v_0\left(\frac{z}{z_0}\right)^{\alpha} \tag{1}$$

Where v is wind speed estimated at desired height, z ; v_0 is wind speed measured at the reference height, z_0 ; α is the ground surface friction coefficient.

The exponent α varies with height, time of day, season, and nature of the terrain, wind speeds, and temperature. For relatively low heights from the ground, the values of alpha for typical classes are given in [11]. In this study, without specific site data, the one-seventh-power law ratio is applied [12].

II.2. The Average Power Output of the Wind Turbine

As different generators have different power output performance curves, the mode is also different. Using polynomial regression to define the power output curve of the chosen Fortis Espada 800 Watts wind generator, the following model describes the performance of the chosen wind generator [13]:

$$P_e(v) = \begin{cases} 0 & (v < 3) \\ 0.007.(v-6)^2 + 0.06(v-6) + 0.13 & (3 \le v < 8.5) \\ -0.005.(v-14)^2 + 0.04.(v-14) + 0.68 & (8.5 \le v < 20) \\ 0.0008.(v-22,4)^2 - 0.02(v-22,4) + 0.68 & (20 \le v \le 25) \\ 0 & (v > 25) \end{cases} \tag{2}$$

Where $P_e(v)$ en (kW) is the electric power output of the generator at a wind speed v(m/s).

II.3. The Operating Hours of the Wind Turbine

The cumulative distribution function can be used for estimating the time for which wind is within a certain velocity interval. Is can be calculated like follow [14]:

$$p(Vd < V < Vm) = (e^{-\left(Vd/c\right)^k} - e^{-\left(Vm/c\right)^k})tm \qquad (3)$$

Where V_d is the cut-in speed, V_m is the cut-of speed, *tm* is the monthly hours number, *k* is the Weibull shape factor and *c* is the Weibull scale factor.

II.4. The Monthly Power Output of The Wind Turbine

The monthly electric power output of the wind turbine is calculated by multiplying the monthly average power of the wind turbine by the monthly operating hours of the wind turbine for different heights. The results are given in figure 4.

III. Results and Discussion

The Fig.1 shows that the wind speed varies with height for different months. It is clear from the figure that wind speed is high from April to August, but very low in the autumn and winter months. The windy seasons in site of Bechar are spring and summer.

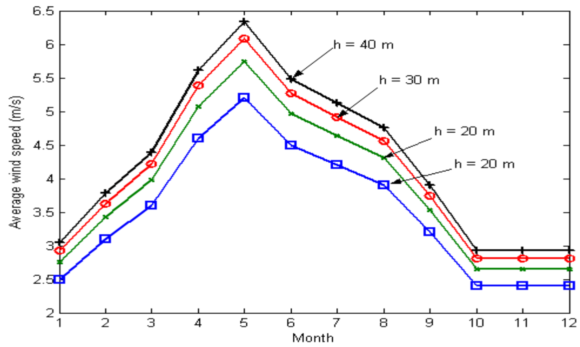

Figure 1. Monthly average wind speed

The monthly average power output of the wind turbine for different heights are presented in fig.2

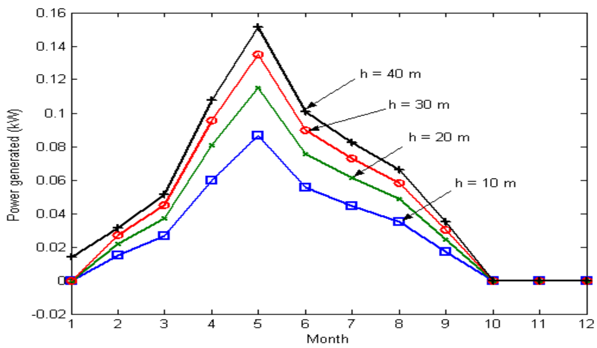

Figure 2. Monthly average power output of the wind turbine for different heights

It is clear from the figures that the mean wind speed and the monthly power generated are distinctive for different months. The highest power output is generated in Mai, while the lowest from October to December.

The tow curves have similar changing trend, but the rate of change is not the same. This is because, for the power density, it is determined not only by the mean wind speed bat also by the wind turbine characteristics.

For the FORTIS ESPAD 800 Watt wind generator, the cut-in speed is 3 m/s, and the cut-off speed is 25 m/s. for the four tower heights, the operating hours off the wind generator in a year can be calculated, as shown in figure 3.

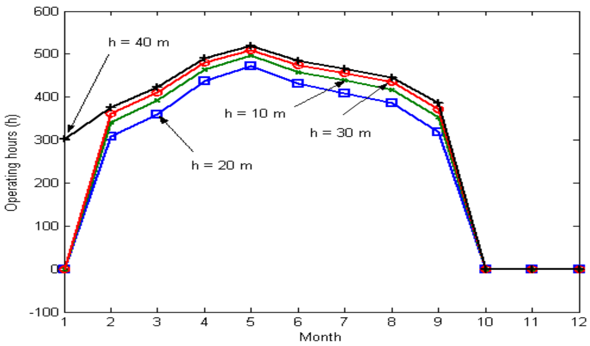

Figure 3.Monthly operating hours of the wind turbine for different height

It can be seen that, for different heights, the monthly operating hours of the wind generator are also different. For 10-m-high tower the monthly operating hours vary between 300 h and 460 h from February and September but is almost nil from October to January due to the fact that the wind speed is inferior than the cut-in speed of wind turbine generator.

For 40-m-high tower the monthly operating hours vary between 300 h and 520 h from January and September but is almost nil from October to December.

For the different heights, the maximum monthly operating hours is in May.

The monthly electric power output of the wind turbine is calculated by multiplying the monthly average power of the wind turbine by the monthly operating hours of the wind turbine for different heights. The results are given in figure 4.

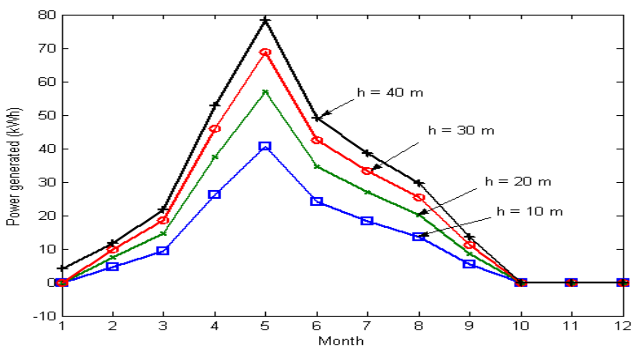

Figure 4. Monthly electric power output of the wind turbine for different heights

For 10-m-high tower the monthly power output of the wind turbine vary between 5 kWh and 40 kWh from February and September but is almost nil from October to January due to the fact that the wind speed is inferior than the cut-in speed of wind turbine generator.

For 40-m-high tower the monthly energy output of the wind turbine vary between 5 kWh and 40 kWh from January and September but is almost nil from October to December.

For the different heights, the maximum monthly energy output of the wind turbine is in May. For example, it reaches 80 kWh for 40 m high and 40 kWh for 10 m high.

The yearly energy generated is calculated for different heights. It reaches 141.9449 kWh for 10 m high, 206.9734 kWh for 20 m high, 255.3364 kWh for 30 m high and 299.2433 kWh for 40 m high.

The result shows that for each height, the energy generated is different. It increases with increasing tower height. Is important to notice that the power generated by a wind turbine is determined not only by wind speeds Weibull distribution (parameters c and k), but also by the characteristics of wind turbine.

IV. Conclusion

From the case study, it is found that the tower hub height of a wind turbine is an important parameter in power generation. More the tower is high more the hours operating and the power generated increases. When the height is 40 m the wind turbine can operate 520 h in May and can generate 80 kWh of electrical energy and 299.2433 kWh in a year. In the case of Bechar, it is fortunate that the windy season coincides with the high temperature seasons (45°-55°) which causes an increased demand for electricity could be covered by exploitation of wind energy. Therefore, accurate wind predictability and its correlation with electricity load demand may allow for a high penetration of wind energy and could make it an economically attractive supplement to diesel-fuelled power station. The most significant advantage of the wind energy is that it is produced by the source which is most unlikely to vanish as compared to other natural sources like coal, natural gas. Wind energy is safe for the environment because it does not produce chemicals like Carbon dioxide. So, it does not pollute air. It is recommended to undertake further studies to explore other locations in the south of Algeria and to develop this renewable energy resource.

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