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Evaluation of Wind Resources and Energy Potential at ESSENIA National Airport in Oran, Algeria

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ABSTRACT

Before setting up a wind energy system, an assessment of the site's potential must be carried out. The aim of this study is to evaluate the wind resources and energy potential in the ES-Senia region of Oran. This study used data based on 3-hour wind speed over a period ranging from 2013 to 2023, where the Weibull probability function was selected as the prediction function. The Weibull parameters: shape and scale parameters k and c respectively, were estimated based on the maximum likelihood method at the height of 10m and 50m. Power densities were too estimated at the height of 10m and 50m using the extrapolated Weibull parameters. The highest values of wind speed and the monthly power density were observed in June with 6.3160 (m/s) and 154.3216 ($W\ m2/$) respectively at the height of 50m.

Keywords: Energy evaluation, Energy potential, Weibull Distribution, Wind data, Wind Power Density.

1. Introduction

Renewable sources have received considerable attention in energy production because of demographic growth and the environmental pollution caused by traditional energy production systems, and also because of the urgent desire to explore the possibilities of exploiting energy sources [1, 2]. Over the last few decades, wind power has become a relatively less expensive, more efficient and ecologically friendly source of energy [3]. Algeria being the largest country in Africa, gives us the choice of several favorable sites such as Oran, which is a harbor city of the Mediterranean Sea, it is exposed to the wind throughout the year. Before any wind turbine installation, a precise study of wind speed is essential. The purpose of this work is the determination of wind speed distribution for different heights based on the wind speed history of past years, and the monthly power

2. Methodology

This study assesses the potential for harnessing wind energy at the ESSENIA national airport on the ORAN coast. It uses a 3-hour data ranging from 2013 to 2023. We estimate wind energy potential using the Weibull function, relying on two key parameters from the wind speed distribution: a dimensionless shape parameter (k) and a scale parameter (c in m/s).

$$f(v) = \left(\frac{k}{c}\right)\left(\frac{v}{c}\right)^{k-1} e^{\left(\left(-\frac{v}{c}\right)^{k}\right)} \quad (1)$$

We then employed the maximum likelihood method to calculate these two parameters.

$$k = \left(\frac{\sum_{i=1}^{n} \ln(v_i)}{\sum_{i=1}^{n} {v_i}^{k}} - \frac{\sum_{i=1}^{n} \ln(v_i)}{n}\right)^{-1} \quad (2)$$

$$c = \left(\frac{1}{n}\right)^{\frac{1}{k}} \left(\sum_{i=1}^{n} {v_i}^{k}\right)^{\frac{1}{k}} \quad (3)$$

This allowed us to obtain the monthly wind power density

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$$P(v) = \frac{1}{2}\rho S v^3 \quad (4)$$

$$P = \frac{1}{2}\rho c^3 \Gamma\left(1 + \frac{3}{k}\right) \quad (5)$$

3. Results and Discussion

The monthly distributions of the average wind speed observed over 3 hours at the height of 30, 40 and 50m of the studied site are shown in Figure 1. We found some variability in the wind speed distribution and in the minimum and maximum wind speed values. At a height of 50 m, the wind speed varies between 4.6284 m/s and 6.3160 m/s, which shows a good consistency in wind behavior.

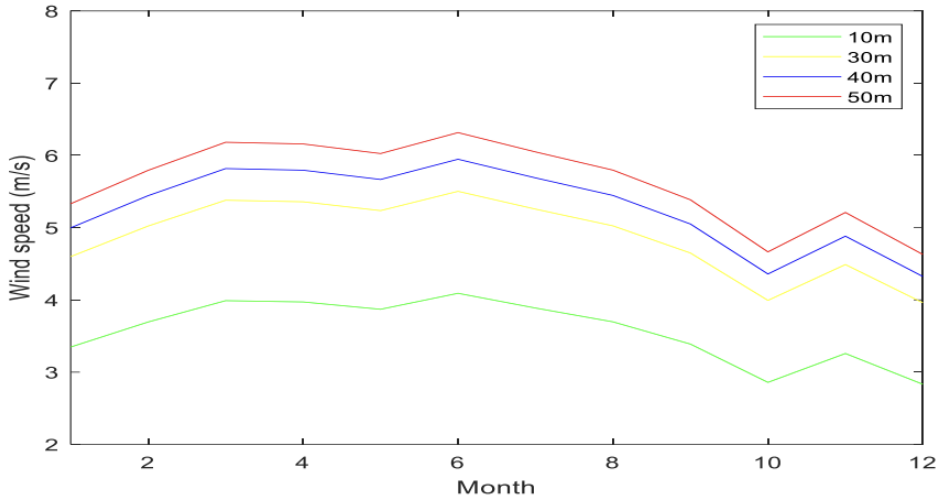

Figure 1: Monthly average wind speed at the height of 10, 30, 40 and 50 m.

The Weibull parameters in this study are calculated using the maximum likelihood method. According to the calculations, the shape and scale parameters have the values 1.61782 and 6.05469 (m/s) respectively at the height of 50m. Figure 2 shows Weibull probability density functions at the height of 50m.

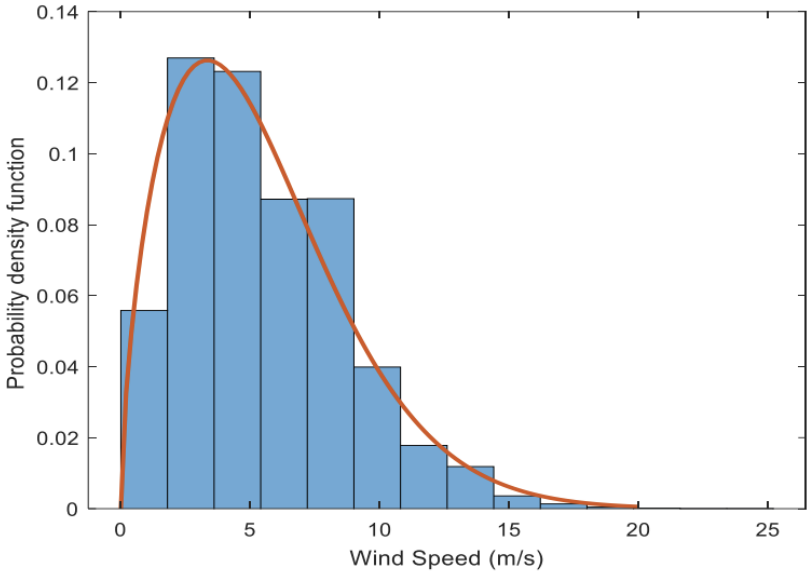

Figure 2: Weibull probability density functions and actual wind data at height 50 m.

4. Conclusions

The monthly variations in wind speed and power density at different heights were studied in this paper. It

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revealed that:

- The highest wind speeds in ESSINIA are identified in the summer period at the height of 50m, more specifically in June with the value of 6,3160 (m/s).
- The scale and shape parameter of the weibull distribution was calculated using maximum likely-hood method, and found to be 6.05469 (m/s) and 1.61782 respectively.
- The power density has reached its maximum at the height of 50m with the value of 154.3216 (W/m^2)

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