Comparative Study between Eight Statistical Laws Applied to Wind Energy. Application to Algeria

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Abstract

The wind is an inexhaustible resource, free and available everywhere. With water and wood, wind was one of the first natural resources that have been used to facilitate human life [1]. By mastering the wind, he was able to navigate and discover new lands or grind the beans with windmills. Today, wind power produces electricity [2].

When studying the wind, especially its speed, we find that they are not constant through time. We distinguish four categories of change:

- *Inter-annual:* the inter-annual variations arise for a period greater than one year.
- *Annual:* within one year, variations of wind speed can commonly occur.
- *Daily:* in tropical and temperate latitudes, big wind shifts may occur on a diurnal or daily time scale.
- *Short term:* changes in wind speed can also occur in small period of time (minutes, seconds).

The study of the temporal variation of wind speeds is important for any wind energy project and the choice of the period of the study will affects the accuracy of the results. To analyze and predict the frequency distribution of wind speeds during a certain period, statistical laws are used. The various

works reveal that the Weibull distribution with two parameters has been most successful in the wind energy field. In our study, we present seven other statistical laws used less than Weibull and make a comparison. Each law has its own parameters; we will use a parametric method to calculate them: maximum likelihood method [3].
The eight laws are:

- Weibull distribution with two parameters "W" [4]
- Rayleigh distribution with a parameter "R" [4]
- Inverse Gaussian distribution, two parameters "IGS" [5]
- Gamma distribution with two parameters "G2" [4]
- Gamma distribution with three parameters "G3" [6]
- Truncated Normal distribution with two parameters "NT" [7]
- Normal distribution of Square Roots to two parameters "NRC" [8]
- Log-Normal distribution with two parameters "LN" [4]

During the period of study, the possibility of having zero wind speeds cannot be overlooked. For that, and to consider them when they exist, we will use the concept of hybrid distribution introduced by Takle and Brown [9].
In order to apply our comparative analysis of the eight statistical laws, we had to choose localities and accurate wind profiles. Our choice fell on two regions in southern Algeria: Tindouf and El Golea. We recovered hourly data of about 29 years (1986-2015) wind speeds from the archives of CDO "Climatic Data Online" [10] to reconstruct an annual profile type containing 8760 hourly rates.
To assess the effectiveness of different laws, we use the RMSD test ("Root-Mean-Square Deviation"). For each speed v wind between v_{min} and v_{max}, the cumulative function calculated from the used law and the cumulative function Y(v) calculated from the data sample will be compared. Note that v_{min} and v_{max} are the extreme values of wind speeds of the selected profile. The results obtained are summarized in Figure 1.

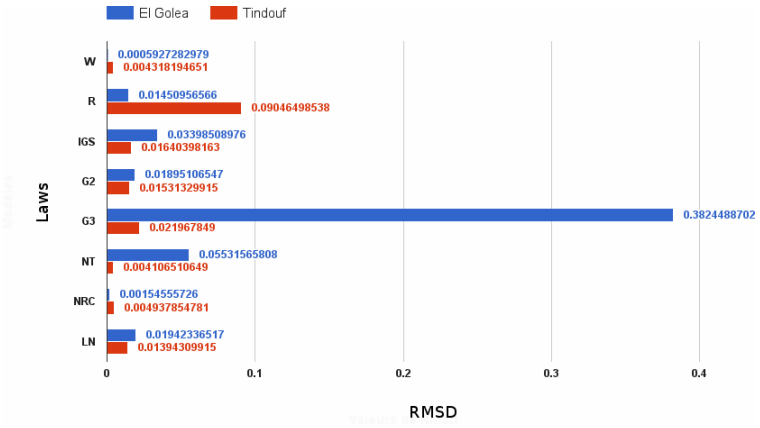

Figure 1. Values of RMSD

In analyzing the results, we note that:

- El Golea: With a value of RMSD = 0.593×10^{-4}, the Weibullwith two parameters (W) is thelaw that best represents the distribution of different frequencies of wind speeds in this region (Figure 2). The values of parameters characterizing this law are: k = 1.837 and c = 4.428 m/s
- Tindouf: With a value of RMSD = 4.106 x 10^{-3}, the Truncated Normal distribution with two parameters (NT) is the law that best represents the distribution of different frequencies of wind speeds blowing regime in this region (Figure 2). The values of parameters characterizing this law are: $\alpha = 5.504$ and $\beta = 1382$

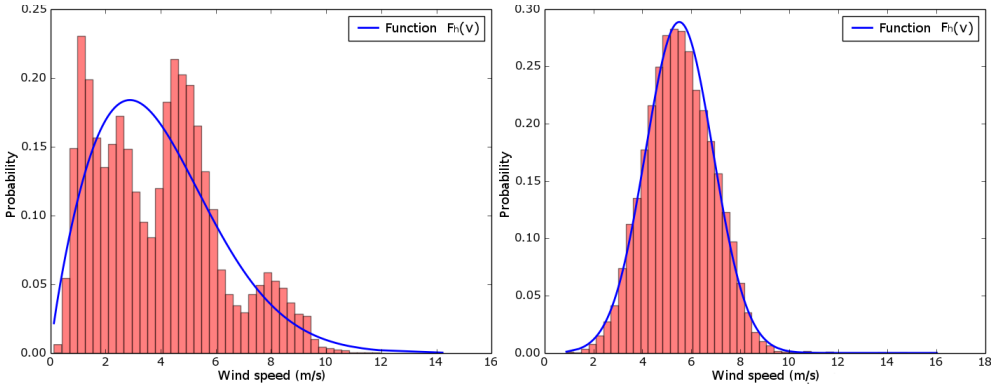

Figure 2. Weibull distribution, El Golea (left) and Truncated Normal distribution, Tindouf (right)

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