Article **Journal Electrical Engineering**
December 2021, Vol.5 No.15 14-19

# Statistical analysis of the wind speed in Mazatlán Sinaloa

# Análisis estadístico de la velocidad del viento en Mazatlán Sinaloa

GALÁN, Néstor*†, OROZCO, Eber, MEJIAS, Nildia and MELLADO, Carlos

ID 1st Author: *Néstor, Galán*

ID 1st Co-author: *Eber, Orozco*

ID 2nd Co-author: *Nildia, Mejias*

ID 3rd Co-author: *Carlos, Mellado*

**DOI:** 10.35429/JEE.2021.15.5.14.19 Received July 20, 2021; Accepted December 30, 2021

**Abstract**

The wind speeds are analyzed in this article during the month of May in Mazatlan Sinaloa, Mexico. Starting from the first measurements obtained from the meteorological station installed at the Universidad Politécnica de Sinaloa. As measurements of wind speed were made at 10 m height, we want to know how the wind speeds are at 55 and 85 m, which are the hub heights of two different Enercon wind turbines. This study aims to determine the available wind resource and wind power density within the city at different heights. Contribution. The main contribution of this work is the management of statistical data to determine the wind resource available in the Mazatlan City.

**Mean wind speed, Standard deviation, Wind power, Mean wind power density**

**Resumen**

En este artículo se analizan las velocidades de viento presentes durante el mes de mayo en la ciudad de Mazatlán, Sinaloa, México. Partiendo de las primeras mediciones obtenidas de la estación meteorológica instalada en las instalaciones de la Universidad Politécnica de Sinaloa. Como las mediciones de la velocidad del viento se realizaron a 10 m de altura, se desea conocer las velocidades de viento que se tendrían a la altura de 55 y 85 m, que es la altura de dos bujes de aerogeneradores Enercon diferentes. Este estudio tiene como objetivo conocer el recurso eólico disponible y la densidad de potencia eólica al interior de la ciudad a diferentes alturas. Contribución. La contribución principal de este trabajo es el manejo de datos estadísticos para determinar el recurso eólico disponible en la ciudad de Mazatlán.

**Velocidad media del viento, Desviación estándar, Potencia eólica, Densidad media de potencia eólica**

**Citation:** GALÁN, Néstor, OROZCO, Eber, MEJIAS, Nildia and MELLADO, Carlos. Statistical analysis of the wind speed in Mazatlán Sinaloa. Journal Electrical Engineering. 2021. 5-15:14-19.

† Researcher contributing as first author.

## Introduction

Wind generation is currently the source of greatest use and growth among the other alternative sources of energy [1]. Wind energy has shown a certain superiority compared to traditional energy sources, which is why it is considered one of the most precious, clean, abundant, cheap, inexhaustible renewable energy sources that is also part of the environment [2].

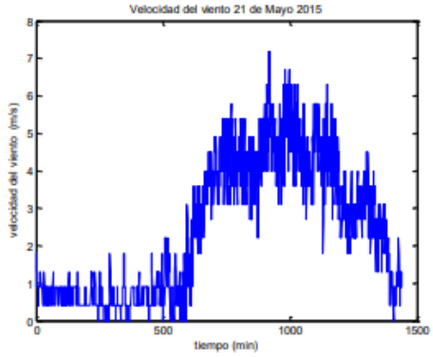
Wind energy is literally inexhaustible and abundant throughout the world, which can be used as a promising internal source of energy in several countries. More importantly, with the continuous development of new wind generation technologies, it has become a renewable energy source with the lowest generation prices [3].

Today, wind energy harvesting has been widely spread all over the world. In Mexico, there is an installed wind generation capacity of 1,677 MW in operation, 2,792 MW are about to come into operation soon and there is an estimated capacity of 1,594 MW of electricity generation in the process of construction. Foreseeing an installed wind generation capacity in the near future of 6,446 MW [4].

A weather station has recently been installed at the Polytechnic University of Sinaloa in order to obtain real data on the different natural resources in the area, which will help create a statistical database that will serve as a reference for the different projects and investigations that are being carried out. making the academic body of the Energy Engineering career from the solar and wind resource.

In this work, the wind speed measurements obtained during the month of May are analyzed. The values measured are with a sampling frequency of 1 min, and are averaged for one-hour wide intervals, with which a statistical treatment is performed defining the average (or stationary) speed and the standard deviation. Thus, laying the foundations for the evaluation of the wind resource of at least one year at different heights that is planned to be carried out at the University.

During the 24 hrs of sampling, a long period of calm winds has been observed, with only 8 hours of usable winds between 11:00 and 19:00 hrs (660 – 1,140 min), as shown in the graph. 1, it is for this reason that only this interval of hours will be taken for the evaluation of the wind resource.




**Graphic 1** Wind speed May 21, 2015

The article begins by dealing with what is related to the statistical data process of the wind speed, continuing with the statistical numerical analysis that is carried out on the speed to determine the power density and the available wind power, mentioning the methodology developed and the results obtained, as well as the conclusions.

*Statistical treatment of wind data*

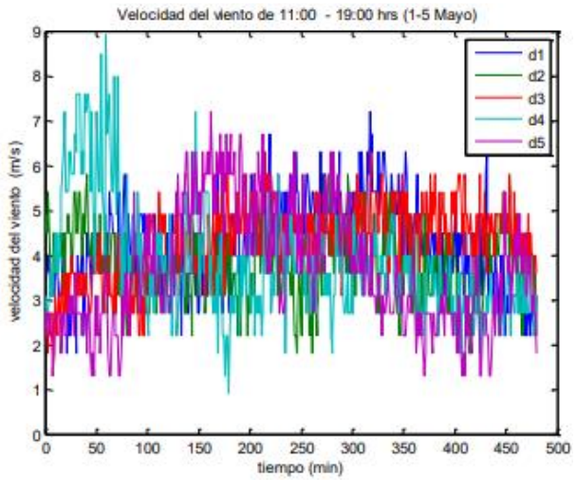
Several mathematical tools have been used for the analysis of wind speed data. Among these tools, the use of centralization parameters such as the arithmetic mean stands out:

Dispersion parameters such as standard or typical deviation for a set of N speed data:

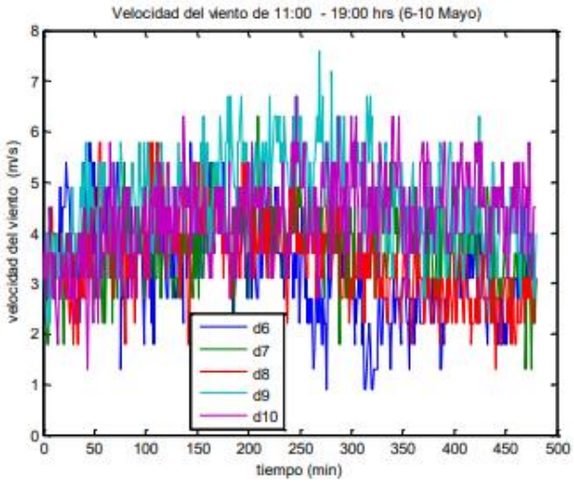
From where I saw is the speed shown in a minute.

These basic parameters will allow us to know the average speed and the standard deviation of the wind in intervals of one hour within the range of 11:00 – 19:00 hrs. of the month of May 2015, according to the data obtained with the meteorological station. The behavior of the wind speed in this month is shown in graphs from 2 to 7. To finally obtain the daily average values of the month.

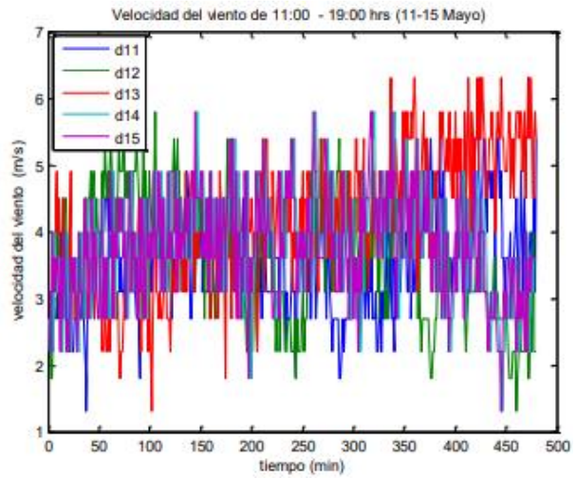
ISSN-2523-2517



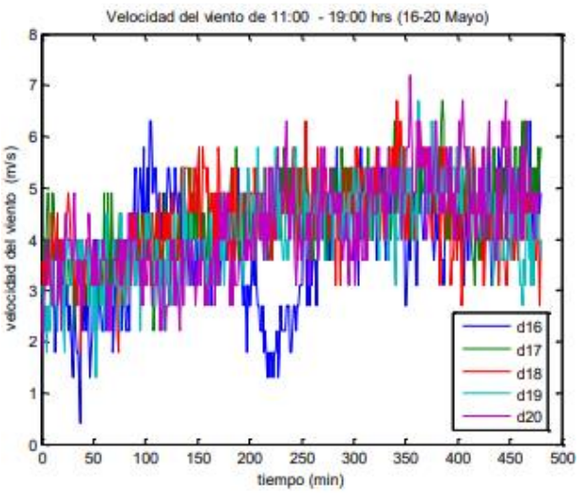

**Graphic 2** Wind speed May 1-5



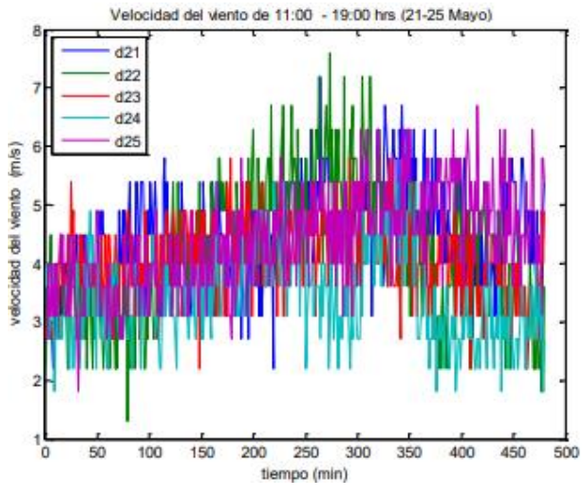

**Graphic 3** Wind speed May 6-10



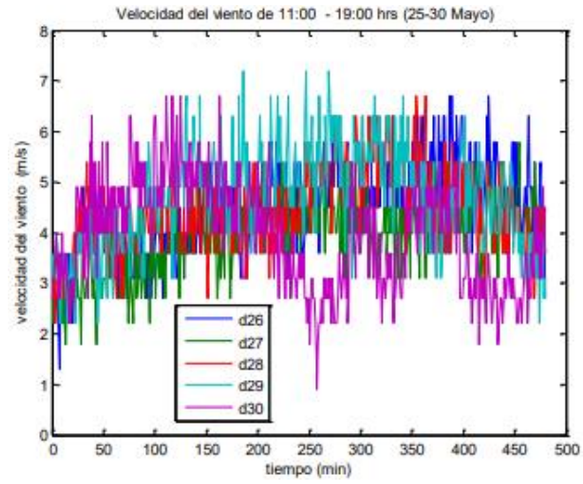

**Graphic 4** Wind speed 11-15 May




**Graphic 5** Wind speed May 16-20




**Graphic 6** Wind speed 21-25 May




**Graphic 7** Wind speed 25-30 May

## Statistical wind analysis

In addition to the mean wind speed and standard deviation, the statistical analysis includes the mean wind power density and the available wind power.

$$k = \left(\frac{\sigma}{\bar{v}}\right)^{-1.086}$$

These results of mean velocity and standard deviation will allow to estimate in a second work, the shape factor k,

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

and the scale factor c in (m/s) is,

From the Weibull Probability Density Function (PDF), which allows from the wind speed distribution to calculate its energy potential and the annual energy that a wind turbine can produce [5].

*The WTP is expressed as:*

The wind speed is measured at 10 m height (weather station location), so it is necessary to extrapolate the wind speed data to the hub height of the selected wind energy conversion system using the following power law expression:

Where, vw is the wind speed measured at height h,

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

$v_w$ is the wind speed at the height h, vw of the hub, the factor α depends on the type of surface roughness and atmospheric stability [6]. Numerically α is in the range of 0.1-0.3, adopting for wind-settlement terrain the value of 1/7.

| Máquina Eólica | Vo (m/s) | Vm (m/s) | Vn (m/s) | Pn (kW) | h (m) | Diámetro Rotor (m) |
|---|---|---|---|---|---|---|
| E-40-6.44 | 2.5 | 28 | 12 | 600 | 50 | 44 |
| E-66-18.70 | 2.5 | 28 | 12 | 1800 | 98 | 70 |

**Table 1** Technical data of two ENERCON wind turbines

**Figure 1** ENERCON wind turbine

The technical data of the ENERCON wind turbine are shown in Figure 1. This type of wind turbine has been selected to determine the wind speed at the hub height, this height corresponds to the type of machine that is specified in Table 1. In this case the hub height is at 50 m and 98 m above ground level [7].

The average wind power density (PD) expressed in Watts/$m^2$, at the installation site is calculated as:

$$P_D = \frac{P_w}{A} = \frac{1}{2}\rho\bar{v}_w^3$$

With the available wind power Pw in Watts:

$$P_w = \frac{1}{2}\rho A\bar{v}_w^3$$

Of which A is the swept area of the wind turbine in $m^2$, ρ is the air density (1,225 kg/$m^3$).

**Methodology to develop**

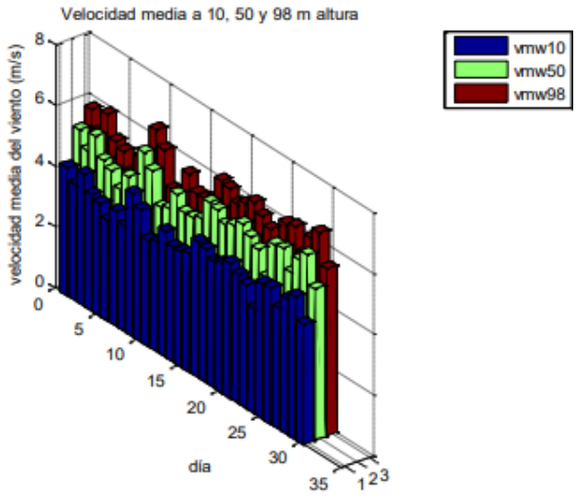
The daily mean wind speed and standard deviation are calculated based on measurements taken at 10 m height. These mean values are recalculated for 50 m and 98 m height.

ISSN-2523-2517

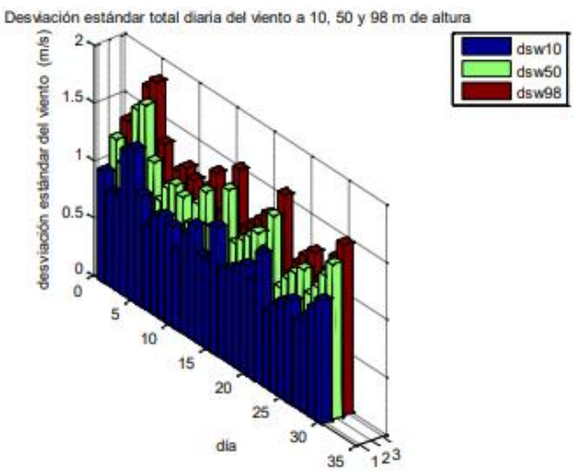
The average daily wind power density is obtained for the three proposed heights, 10, 50 and 98 meters. The swept area to determine the available wind power is obtained based on the diameters of the wind turbine rotors according to the hub height.

## Results

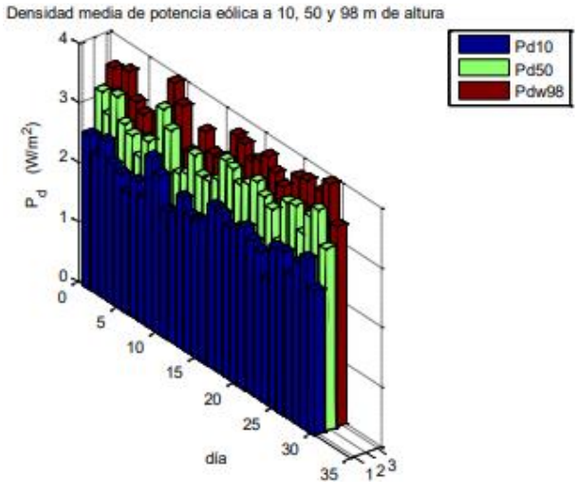
The results of mean wind speed, standard deviation, mean wind power density and available wind power in the city of Mazatlan Sinaloa, Mexico, at 10 m, 50 m and 98 m are presented in graphs 8 - 11.



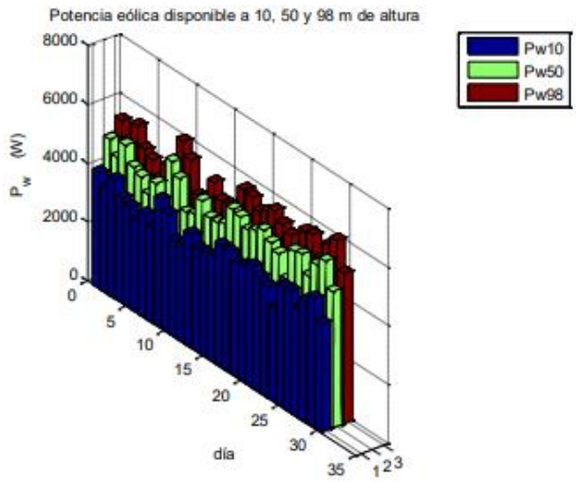

**Graphic 8** Average wind speed




**Graphic 9** Daily wind standard deviation




**Graphic 10** Average Wind Power Density




**Graphic 11** Available wind power

## Conclusions

The average usable wind speed is above 90 m height, in the interior of the city of Mazatlan, which is a wind speed influenced by the roughness of the terrain and very different from the wind speed in front of the sea. There is an interval of four four hours a day where the wind is above average, which influences This has a direct influence on the calculation of the available wind power since it is raised to the cube of the wind speed.

This is only the beginning of the treatment of data obtained with the meteorological station, hoping that in the course of a year the first annual average can be obtained and thus determine the complete Weibull distribution in order to determine the true energy potential existing in the city of Mazatlan Sinaloa, Mexico.

ISSN-2523-2517

**References**

Z. Lubosny, "Wind Turbine Operation in Electric Power Systems Advanced Modeling", Springer, 2003.

Chang TP. Estimation of wind energy potential using different probability density functions. Appl Energy 2011; 88(5):1848–56.

Wagner HJ, Mathur J. Introduction to wind energy systems: basics, technology and operation. Springer Science & Business Media;

2012. Subsecretaría de planeación y transición energética, SENER. http://www.energia.gob.mx/.

ISSN-2523-2517