WIND ENERGY POTENTIAL STUDY IN SAN QUINTÍN, BAJA CALIFORNIA

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ABSTRACT

This work shows a study of the wind characteristics, taking into account its direction and speeds, of the city of San Quintín, Baja California. The analysis is based in the information obtained from the local weather station, for an evaluation period from 2004 to 2007. Weibull statistical parameters were calculated and wind roses were generated for each month, to observe temporary wind variations and, specially, sea breezes. Additionally, the estimated mechanical energy extracted from the wind was calculated, usable energy and electric energy produced by a wind turbine of small power. These estimations were compared against a simulation made using the HOMER software for the same wind conditions and same turbine. Such results may be useful to extract wind energy in the zone, where there are seven locations that do not have electric energy.

Key words: wind, sea breezes, energy, wind power.

1. INTRODUCTION

Wind power is one of the fastest growing sources of renewable energy in the world, it is estimated that for 2020 it may contribute to a reduction in CO_2 emissions by more than 10 million tons, 1.5 million ton a year [1]. In Mexico the area with the biggest development potential for 2012 is concentrated in the states of Oaxaca (2,600 MW) and Baja California (1,400 MW) [2]. In the state of Baja California the wind resources for the generation of electric energy are concentrated mostly along the Sierra Juarez, especially in the Rumorosa Zone [2]. In 2009 the wind farm La Rumorosa started operations, having an installed capacity of 10 MW, developed by the Government of the State of Baja California. In addition, there are wind farms in development in this zone, being the most important those of the Companies Unión Fenosa/Zemer Energia (400-1000 MW), Fuerza Eólica/Clipper WindPower (300 MW) and Sempra Generation (250-1000 MW) [2].

The wind power generation potential for rural applications that not been studied in detail, there are maps such as the one from the National Renewable Energy Laboratory made for rural applications like that one shown in figure 1.

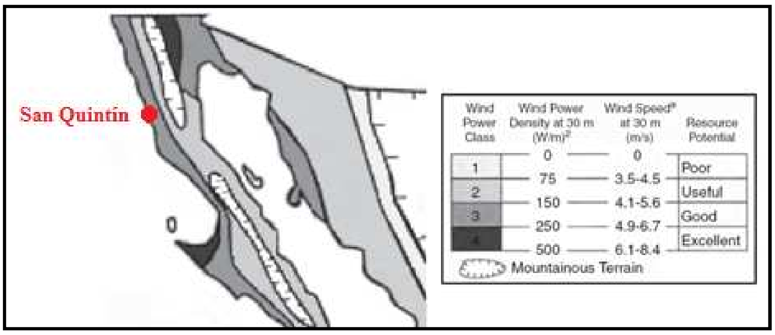
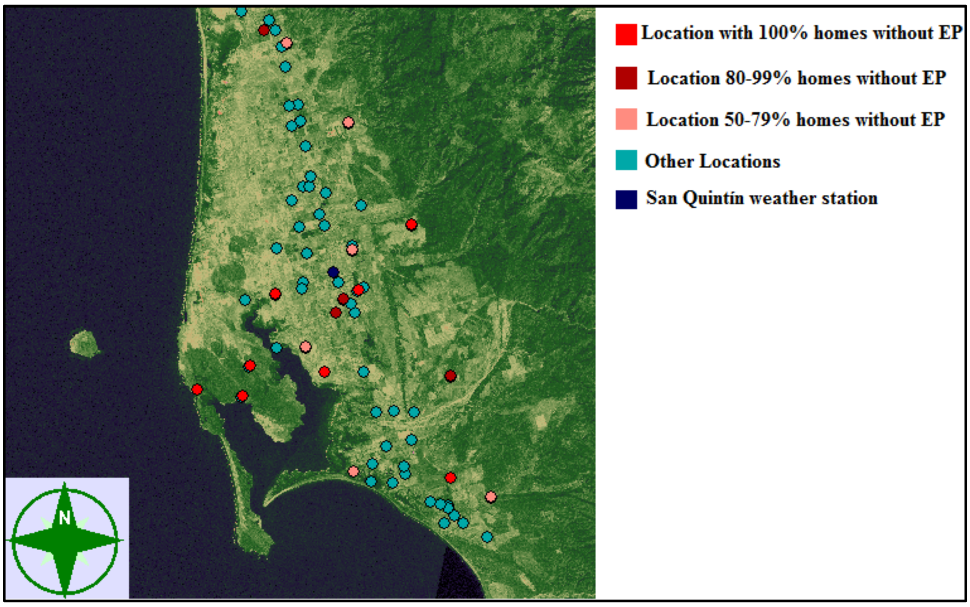


Figure 1. Mexico Wind Resource Assessment Project, NREL, modified [3].

In the northern zone of the Pacific Coast, where San Quintín is located, according to the map the wind resources for rural applications are “good”.

San Quintín is a city with a population of 5,021 people [4], and concentrated on its outskirts there are several rural localities that do not have electricity, Figure 2. This work shows the wind resource assessment in this city, the data was collected from the San Quintín weather station database for the years 2004 to 2007. Data was obtained from the *Comisión Nacional del Agua* (National Water Commission).



EP: Electric Power

Figure 2. San Quintín geographic location and rural localities on its outskirts.

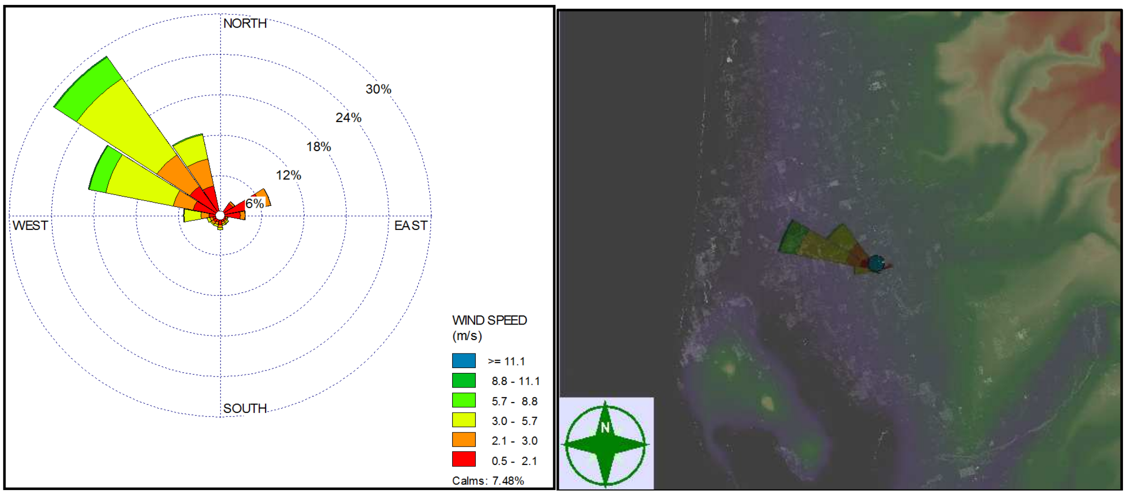
2. WIND RESOURCES ASSESSMENT

The City of San Quintín is very close to the sea; therefore the development of sea breezes could be seen in the wind roses, due to the shift in the direction mainly in the winter time. At the Baja California Pacific Coast, the rise in the sea surface temperature during summer originates a thick fog which does not allow the development of sea breeze and its typical persistence. During winter, there is a sea and land breeze circulation anomalously well- developed in the coast [5].

Table 1. Characteristics of the Assessment Site

Latitude	30°31'54.00"N
Length	115°56'13.00"W
Height above sea level	32 msnm
Height Anemometer	10 m
Distance to sea	9 km
Evaluation period	4 years

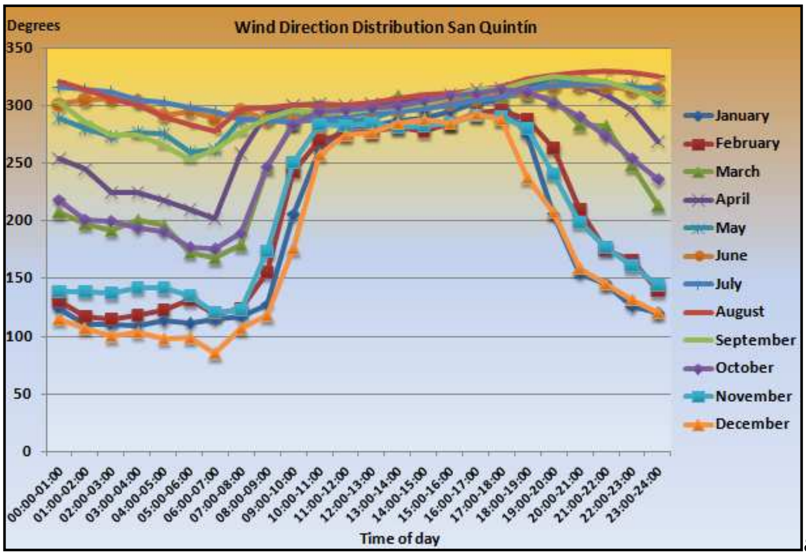
The wind is defined by two essential parameters: its direction and speed. The assessment of these two parameters over a period of time lead to the elaboration of the so-called *wind rose*. The software used to develop the wind roses was WRPLOT. Next, the wind rose for the 2004 to 2007 period is shown for San Quintín, and the monthly wind roses for that period on Appendix A.



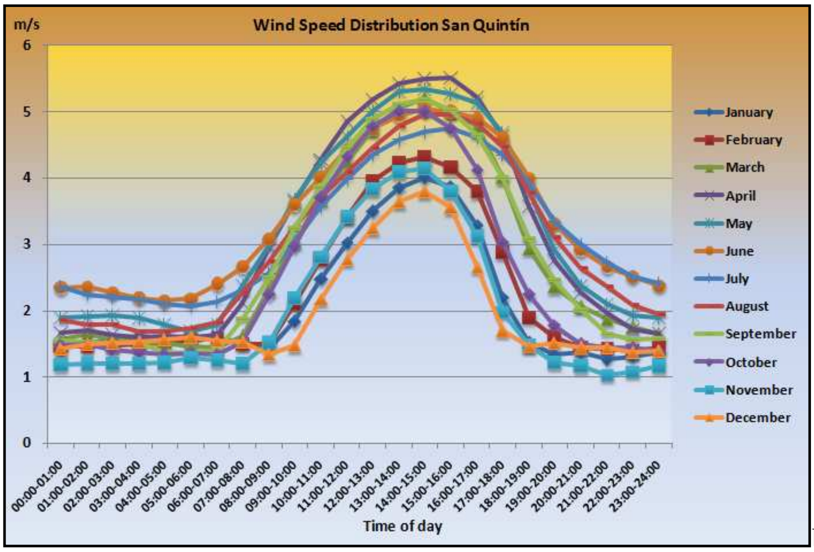
a) b)

Figure 3. a) San Quintín Wind Rose and b) Wind rose on a Digital Elevation Model.

The predominant wind direction is northwestern with 66% and northeast with 15%, the latter percentage belongs to the wind direction shift, that occurs during winter due to the sea breezes development. Figure 4 shows the daytime distribution of the wind direction and the speed increase observed during the assessment period. It is clearly shown in a) that during winter there is a sea breeze very developed note the shift in the wind direction. It is clearly shown in b) the wind speed increases during the morning from 6:00 am, wind begins to blow, peaking at 14:00 hours all year long and the wind speed begins to decrease approximately from 18:00 hours.



a)



b)

Figure 4. a) Hourly Wind Direction and b) Hourly Wind Speed.

Note that during the night when the land breeze occurs, wind direction oscillates between 50 and 100 degrees depending on the month, and during the day the wind direction changes completely between 250 and 340 degrees, that is, when there is sea breeze the wind blows from the northwest. As previously observed in the wind roses, 66% of the wind blows in the northwestern direction, that is when the best wind speeds occur, and that is during the day.

3. WIND STATISTICS

Usually for the statistical representation of wind the Weibull probability distribution is used, with two parameters: the scale parameter *c* and the shape parameter k. Were calculated parameters k and c, and the Minitab software was used to create the Weibull distribution.

Weibull distribution were estimated for each year, it was observed that there were two neutral years 2005 and 2006, for that assessment period, due to the fact that the wind had a very similar mean speed. It was observed that in 2004 there was a decrease in the winds due to the fact that that year the El Niño–Southern Oscillation phenomenon occurred significantly, which originates a weakening of the coast winds, occurring every 2 to 7 years. El Niño has a maximum seasonal change zone in the North Pacific on the surface that extends from the southern end of Baja California and connects with the groundwaters of Baja California [7].

Therefore by having knowledge of this phenomenon we can deduce what years will not have much wind energy production in the zone near the coast. Figure 4 shows the Weibull probability distribution for the assessment period in San Quintín.

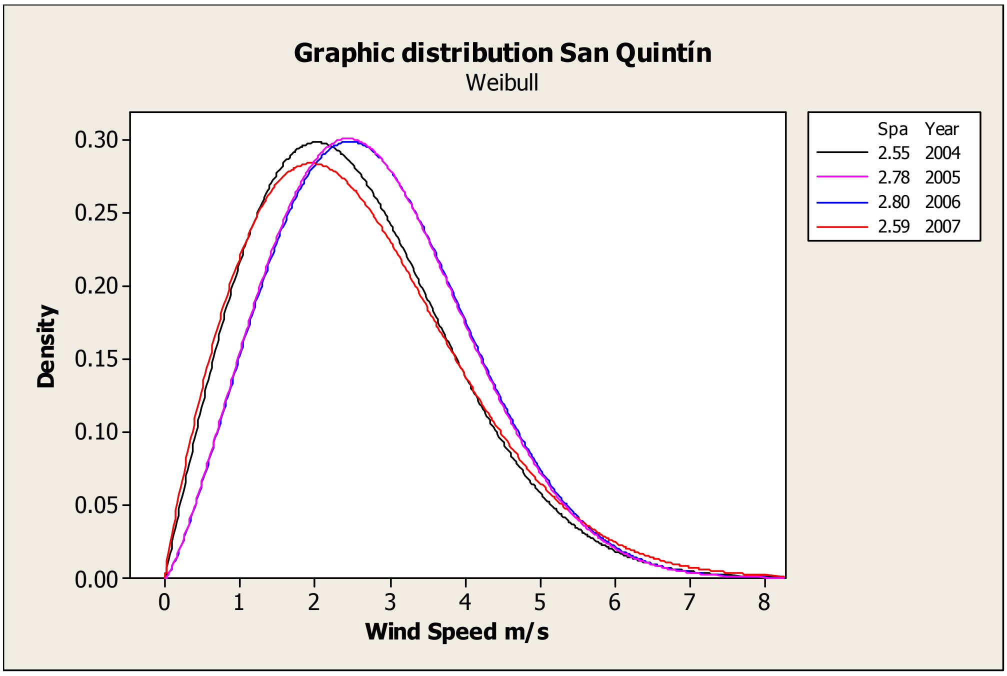


Figure 5. Weibull Distribution in San Quintín.

4. WIND USABLE ENERGY

A calculation was made to estimate the maximum extractable energy from the wind that equals the amount of mechanical energy that can be extracted. According to the Betz limit the amount of energy available from the wind that can be usable (59.3 % turbine and propeller efficiency upper limit, the efficiency of the actual wind turbines is about half of that value). And the amount of energy that can be generated through a wind turbine with an efficiency of 30% [6].

- Wind extractable power $W_{max} = \frac{1}{2} \rho v^3 A$ (1)
- Available power $W_{aprov} = W_{max} \cdot 0.593$ (2)
- Real power for a wind turbine $W_{real} = W_{max} \cdot \eta_{windturb}$ (3)

Table 2. Aerogenerator Technical Characteristics

Aerogenerator	Bournay
No. of blades	2
Diameter	2 m
Nominal power	600 Watts
For turn on	3.5

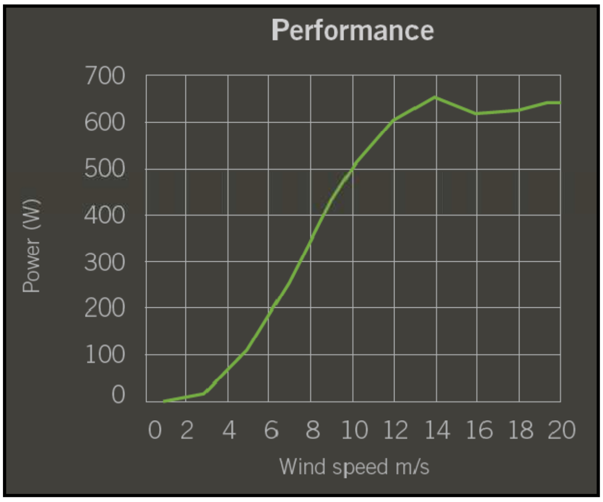


Figure 6. Wind power curve.

5. RESULTS AND DISCUSSION

A room temperature of 25 °C for all the year was used to calculate the power and the daily hourly average for each year. The power decrease for the year 2004 for the El Niño Period was clearly observed in the calculations, which observed 36 kW below the other years. It can be observed that even if the mean speed for 2007 is low, there is no much difference in the calculation of the actual power for the rest of the years as opposed to 2004. In Figure 6 the hourly distribution of the maximum extractable energy from the wind is shown having a peak hour at 14:00 hours, the power that can be usable and the power that would be produced by a turbine during the four years of the assessment.

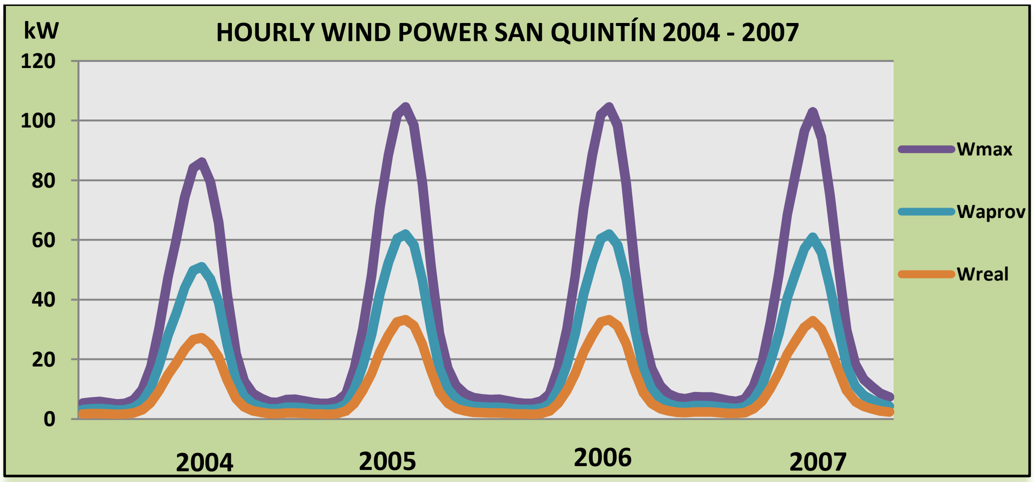


Figure 7. Maximum, Real and Usable Power for San Quintín.

A monthly wind speed distribution chart was made to observe the wind power generation behavior for each month, where it can be clearly visualized a major production of wind power from March to June, during the rest of the summer there is a strong decrease, that increases again in September and October.

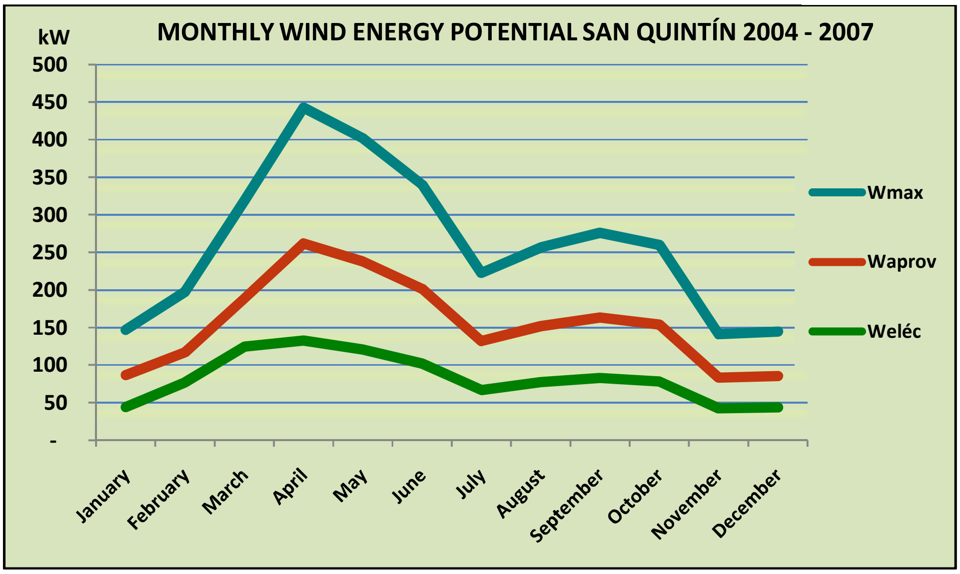


Figure 8. Monthly Power Dsitribution in San Quintin.

A simulation was run using HOMER Software, with the wind speed monthly averages only. The electric power estimation was obtained with the hourly average values, which is a major resolution to calculate the power. The following chart for the assessment period was obtained.

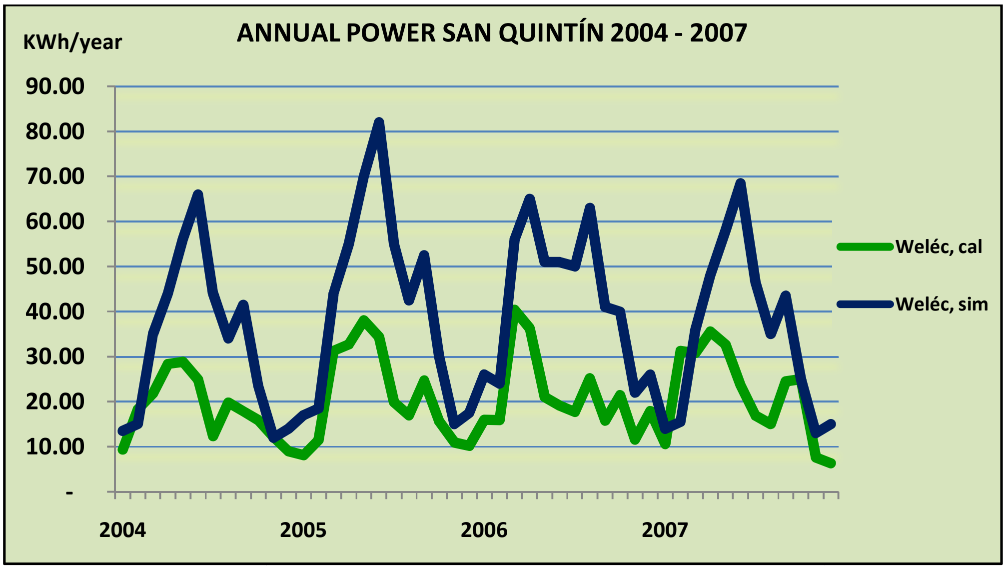


Figure 9. Comparisons between the Power Calculation Made and the Power Simulation.

As shown in Figure 9, the behavior pattern is similar since both used wind speed averages; the only difference is that the power calculation was made using daily hourly averages and the other used monthly averages that is why the first one has more data resolution. It is worth mentioning that there were some gaps in the anemometric data, therefore a data interpolation in those gaps was made.

The production of estimated wind energy is shown in the following chart and it can be observed how in 2004 there is not much production, year that was affected by the el El Niño phenomenon.

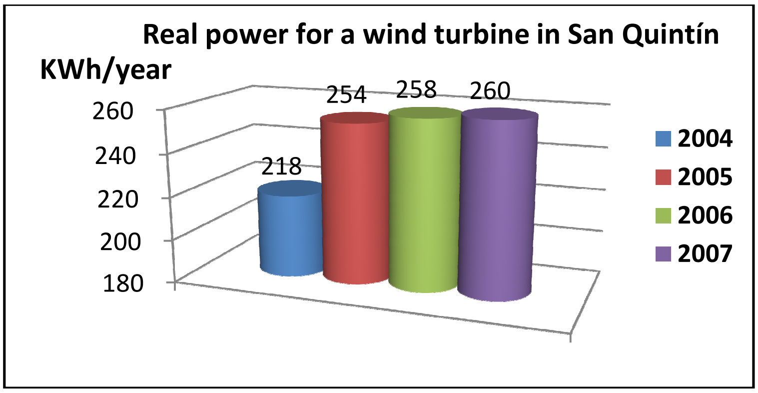


Figure 10. kWh production of a Small Power Aerogenerator.

If we used a residence of a rural locality as a reference that requires energy for the following basic services:

1.- 5 light bulbs
2.- 1 Refrigerator
3.- One evaporative cooler (only during summer)
4.- 1 fan (only during summer)
5.- 1 blender
6.- electric shower (only during winter)
7.- 1 T.V.
8.- Sewing machine

The average year energy consumption of this residence is 866 kWh and taking into account the average wind energy generation during the assessment period in San Quintín, approximately 30 % of the removable energy will be covered if an aerogenerator with the above described characteristics is used.

6. CONCLUSIONS

San Quintín has a good wind energy resource for rural applications, since, according to the estimations for a residence with basic services, it can cover 30% of the energy requirements with wind energy. If it were used only for lightning and an entertainment unit it could support a one year's supply.

The implementation of small power aerogenerators must be develop for those zones where there are wind resources and there are residences that do not have electric power. This way the cost of electric transmission networks and substations would be reduced, in addition to avoid CO_2 atmospheric emissions and would help people have electric power in their homes.

7. ACKNOWLEDGEMENTS

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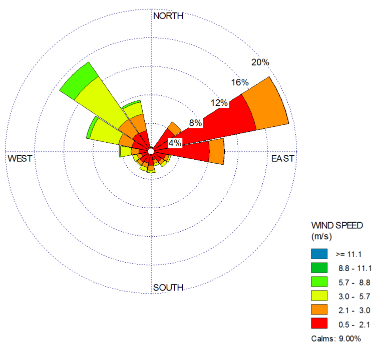
9. APPENDIX A

The monthly wind rose for the 2004 to 2007 period is shown for San Quintín.



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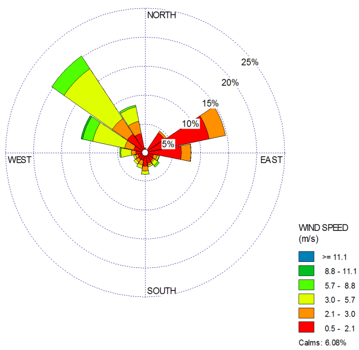

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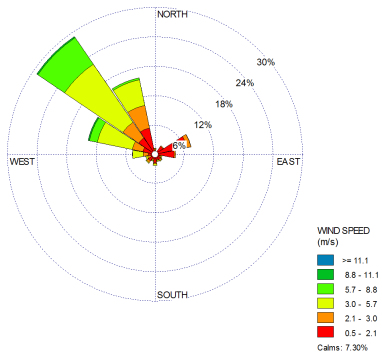

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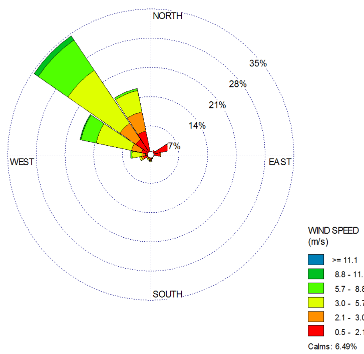

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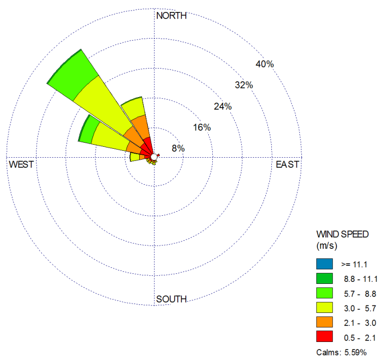

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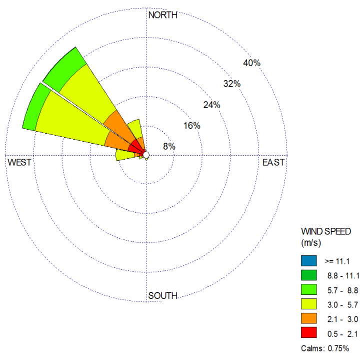

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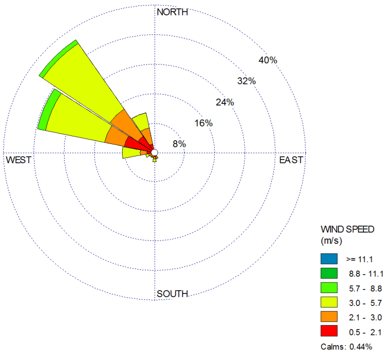

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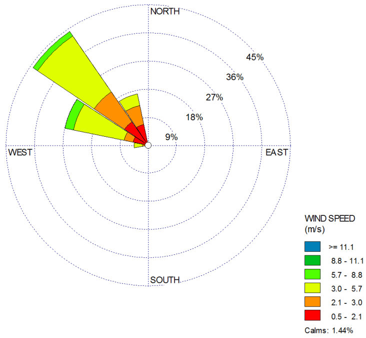

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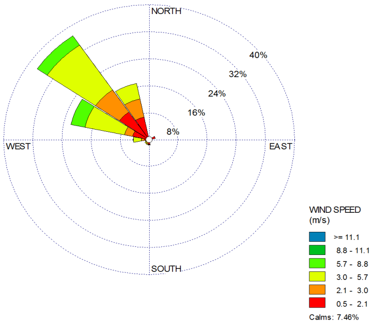

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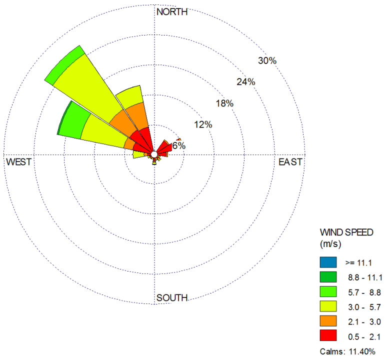

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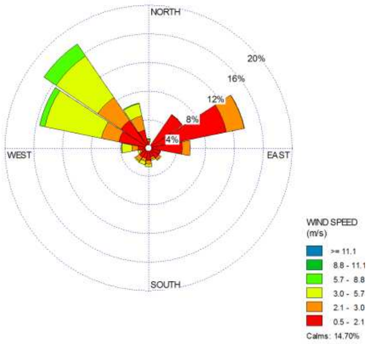

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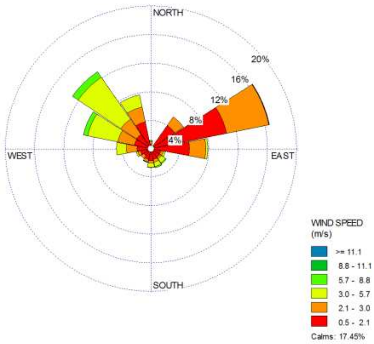

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