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Wind assessment network at North of Yucatan Peninsula

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Abstract

In order to increase the use of the winds as energy sources is essential to study the periodical patterns of the wind resources by means of high quality data obtained from measurement stations, specially configured to evaluate the energy available in the winds. The present work shows the preliminary results of the network of ultrasonic wind sensors which were installed by the Autonomous University of Yucatan at the North region of the Yucatán Peninsula. Located in the tropical region at the Eastern of Mexico, the study area had been studied previously just by means of the wind data from the local meteorological stations. The developed network is formed by six towers between 40m and 50m height located around the main parts of the North of Yucatan Peninsula. The preliminary result shows a highly directional behaviour of the winds with better wind resources at the sites on the coast line.

Keywords: Wind resource, Diurnal wind behaviour, Frequency distribution, Wind roses

1 Introduction

Among the most effective options of environmental friendly energy source is the wind power. The “Global Wind Energy Council” reported an increase of 32% in the annual market for wind energy in 2006, with over 15,000 MW of new capacity installed worldwide [1]. México, one of the most promising countries for wind energy development, doubled its installed capacity in the same year with systems installed mainly in the Isthmus of Tehuantepec.

A key role in the process to increase the use of the winds as a source to produce electricity, as well as to make more reliable the estimation of the energy produced, is the study of the periodical patterns of the wind resources by means of high quality data with measurement stations specially configured to evaluate the energy available in the winds [2, 3].

The winds as mechanical force to pump water have been used in the Yucatan Peninsula over the last 100 years in diverse applications. The question about whether the potential of the winds is also able to produce electricity has been raised during the last years by politicians, industrialists, academics and the local community in general. Thus, the Autonomous University of Yucatán began a research program to study the wind characteristics at the North-West of Yucatan Peninsula with the financial support of the Government of the Yucatan State and using mainly the tower facilities of a national mobile phone service provider. The presented research shows the preliminary results obtained with a measurement network of six stations which were configure, installed and operated by the University of Yucatan in the North region of the Yucatán Peninsula, as can be seen in the Figure 1 below.

Figure 1. Digital elevation map for Yucatan Peninsula maps with the station locations.
The geographical coordinates for each measurement site and the measurement heights have been listed in the Table 1, along with the station ID that will be used in the rest of the paper.

Table 1. Geographical coordinates and measurement heights.

<table>
<thead>
<tr>
<th>Station ID</th>
<th>Geographical Coordinates</th>
<th>Heights [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZM</td>
<td>21°23' N, 88°53' W</td>
<td>20 &amp; 40</td>
</tr>
<tr>
<td>TCP</td>
<td>21°19' N, 89°23' W</td>
<td>20 &amp; 50</td>
</tr>
<tr>
<td>CHM</td>
<td>21°16' N, 89°44' W</td>
<td>20 &amp; 40</td>
</tr>
<tr>
<td>TZM</td>
<td>21°09' N, 88°08' W</td>
<td>20 &amp; 50</td>
</tr>
<tr>
<td>FIUADY</td>
<td>21°02' N, 89°38' W</td>
<td>20 &amp; 50</td>
</tr>
<tr>
<td>CEL</td>
<td>20°52' N, 90°23' W</td>
<td>20 &amp; 50</td>
</tr>
</tbody>
</table>

Located in the tropical zone at the Eastern of Mexico, the study region had been studied previously just by means of the wind data from the local meteorological stations, usually at 10m height.

2 Materials and Methods

The measurement network has a central point at the Energy laboratory to monitor, download and process all the measured data. In this site, it was also installed a measurement tower which can be seen in Figure 2.

Figure 2. Central measurement tower installed at the University site.

The measurement network was completed with another five remote stations which were installed on Mobile Phone towers around the main parts of the North of Yucatan Peninsula. An example of the two types of tower used in the remote measurement sites is shown in Figure 3.

Figure 3. Example of the remote tower configurations used in the network.

Two ultrasonic wind sensors, an atmospheric pressure sensor and two ambient temperature sensor were installed in each measurement station. Figure 4 and Table 2 show the image and the main parameters of these sensors. In this paper just the results of the wind sensors will be reported.

Figure 4. Images of the sensors installed on each measurement station.

Table 2. Main technical characteristic of the sensors

<table>
<thead>
<tr>
<th>Characteristics / Sensor</th>
<th>Measurement Range</th>
<th>Resolution</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gill WindSonic Anemometer (Wind Speed)</td>
<td>0 – 60 m/s</td>
<td>0.01 m/s</td>
<td>±2%</td>
</tr>
<tr>
<td>Gill WindSonic Anemometer (Wind Direction)</td>
<td>0 – 360º</td>
<td>1º</td>
<td>±3º</td>
</tr>
<tr>
<td>CSI 108 (Air Temperature Sensor)</td>
<td>-5ºC to 95ºC</td>
<td>0.1ºC</td>
<td>±0.2ºC</td>
</tr>
</tbody>
</table>

A data-logger and a mobile modem were configured to download remotely the stored data on daily basics. The installation heights of the wind and temperature sensors on the measurement towers were shown in Table 1.
As can be seen in Table 1, the higher sensor couldn’t be installed at the same height in each station, for that reason in the following sections the measurement heights will be referenced as Low (for 20m) and High (for 40m o 50m). Each data-logger measured data every one second and stored the ten minutes and the daily averages of every measured parameter.

3 Results

3.1 Wind directional behaviour

The first measurement year was compiled and the results for the measurement at the higher height will be reported in this paper. Figure 5 presents the directional pattern of each site by means of a 16 sectors wind rose. Each wind rose presents the relative amount of wind available in each direction and the wind speed distribution in the ranges of 3, 6 and 9 m/s.

![Wind rose example](image)

Figure 5. Wind roses for each station

As can be appreciated from the wind roses of DZB, TCP and CHM in Figure 5, the winds present a similar directional distribution in this particular sites located on the most Eastern region of the study site. Thus, the wind patterns for the diurnal cycles as well as the wind speed frequency distribution will be grouped considering this fact in the next sections.

3.2 Wind diurnal behaviour

The hourly averages for the full day over the study period have been computed to produce the behaviour of the winds along the hours of a day. Figure 6 presents the diurnal behaviour for DZB, TCP and CHM which has a maximum above the 7.5 m/s in the afternoon between 15:00 and 17:00 hours.

![Diurnal wind speed and direction](image)

Figure 6. Diurnal behaviour of the wind speed and wind direction to DZB, TCP and CHM.

The patterns of the diurnal wind direction reveal that the increment in the wind speed described above is produced by the winds coming around the North-East direction, in the cases of DZB, TCP and CHM, see Figure 6.

In the cases of the others study sites; TZM, FIUADY and CEL, the diurnal behaviour of the wind speed and wind direction, showed in Figure 7, present in general the same trends of the others study sites with a peak in the wind speed around the 16:00 hours produced mainly by winds coming from the North-East directions. With some oscillations in the morning, the wind speed is around 1m/s higher
in CEL than in FIUADY. TZM presents wind speeds patterns between the ones described for CEL and FIUADY.

The wind direction patterns presented in Figure 7 shows that in the morning until 11:00 the winds come between the North-East and the East directions for TZM and FIUADY sites while for CEL site the winds come from around the South-East direction in the same period of time. Approximately after 11:00 in the morning, the winds begin to change their directions to the North-East until the 17:00 hours when them begin to return to the directions they had previous 11:00 in the morning.

3.3 Wind speed frequency distribution

The wind speed values measured over the whole study period were classified every 1m/s interval for each site. Thus, the amount of measurements for each interval (also known as bin) was normalized to obtain the frequency in which each wind speed interval is present.

Figure 8 and Figure 9 present the wind speed frequency distributions for each study site at the two measurement heights, namely Low (for 20m) and High (for 40m or 50m, see Table 1). It can be observed that TZM and FIUADY sites present a frequency distribution which decreases more abruptly after 4.5m/s indicating that there will be less wind available at higher speeds. These two sites are the more inland located sites and the High height was 50m in both cases. It is important to notice even DZB and CHM sites in which the High height was just 40m the behaviour described for TZM and FIUADY sites were not present.
Finally, using the WindPro software from Riso Laboratory with the frequency distributions shown in Figure 8 and Figure 9, the Weibull parameters [4-6] were computed as well as mean wind speed and the wind shear parameter for each study site, see Table 3.

Table 3. Weibull parameters and computed mean wind speed and wind shear for each site.

<table>
<thead>
<tr>
<th>Sites</th>
<th>c [m/s]</th>
<th>k</th>
<th>Mean Wind Speed [m/s]</th>
<th>Wind shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>DZB</td>
<td>7.02</td>
<td>2.347</td>
<td>6.221</td>
<td>0.262</td>
</tr>
<tr>
<td>TCP</td>
<td>7.379</td>
<td>2.745</td>
<td>6.566</td>
<td>0.1845</td>
</tr>
<tr>
<td>CHM</td>
<td>6.861</td>
<td>2.641</td>
<td>6.097</td>
<td>0.2522</td>
</tr>
<tr>
<td>TZM</td>
<td>5.942</td>
<td>3.004</td>
<td>5.306</td>
<td>0.3968</td>
</tr>
<tr>
<td>FIUADY</td>
<td>5.092</td>
<td>2.463</td>
<td>4.516</td>
<td>0.4247</td>
</tr>
<tr>
<td>CEL</td>
<td>6.671</td>
<td>2.623</td>
<td>5.927</td>
<td>0.1882</td>
</tr>
</tbody>
</table>

4 Conclusions

An operational network of ultrasonic wind sensors to measure the relevant wind parameters has been installed, tested and it is operational to fully evaluate the wind characteristic and its potential as a source of Energy in the Yucatan Peninsula over the next years. The preliminary results presented have shown that the sites located on the shore line have better wind resources; among them DZB, TCP and CHM presented mean wind speed over 6m/s.

Acknowledgements

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