Measurements and Analysis of Wind Characteristics in Northern Emirates for Wind Power Generation

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Abstract
Actual measurements of weather parameters are always essential for any future planning and developments of a region, UAE in specific is one of the world’s most emerging economies. For development, infrastructure and power sector reliable and accurate weather data is essential for the development of this region, multiple reliable and on-ground measuring weather stations are working in the southern emirates like Abu Dhabi and Dubai, on-ground weather stations are scarce in the northern emirates like Ras-Al-Khaimah and Umm-Al-Quwain, this paper discusses the actual wind measurements and its analysis for power generation in the industrial zone of Ras Al Khaimah.

Keywords: Wireless Sensor Network, Sensors, Named Data Networking, Decision coordination Priority, Wireless recharging, Energy replenishing.

INTRODUCTION
UAE is promoting the need for renewable energy sources to overcome the rapidly increasing energy demand and preserving its domestic oil reserve for future exports [1]. Out of the total power produced in UAE less than 1% is coming from renewable energy sources [2] resulting in second highest ecological footprint per capita in the world as per 2011 data [3]. However individual emirates are responsible to increase the share of renewable power production. Abu Dhabi expects to bring 1.6 GW of renewable power into the system by 2020 [2] which is around 7% of its total energy production. Dubai is expected to install 1 GW by 2030 in multiple phases 1% of its total energy production by 2020 and 5% of its total energy production by 2030. Resulting in a high demand for renewable energy sources available in this region solar obviously tops the list next is thermal but wind energy production is hard to find very few have taken initiative to go for it, probably the reason behind this is the wind profile in this region which is not so suitable for wind turbines to produce energy throughout the year, this paper discusses the wind data of 2010-2012 specifically 2010.

In the recent years many researchers have been investing their time and efforts to make a contribution in the process of moving the UAE to the next step regarding the country’s vision on sustainable energy resources by conducting researches on the following topics: green technologies adopted in the UAE, policies on implementing green technologies issued by authorities, solar energy potential in the region, weather conditions throughout the year in different locations and different ideas on how to expand the potential of sustainable energy in the future. The aim behind this work is to give a real measurement of wind data measured from the period from (2008-2012) in the northern part of the UAE which can help in investigating the feasibility of using wind turbines technologies in this location. M. Jamil et al. [5] studied the advantages and the disadvantages of using different renewable energy technologies such as photovoltaics, CSP, biomass energy, bio fuels and hydropower, also the different renewable energy projects conducted in the UAE were shown in the study. Abdul Waheed Bhutto et al. [6] made a review on the progress of utilizing different renewable energy resources in the GCC countries, the power grid between GCC countries was demonstrated, also major projects conducted through each of the GCC countries were shown and policies and regulations followed by the GCC countries were studied. Adel Juaidi [7] et al. assisted the production and consumption of energy in the UAE in numbers, an overview of CO2 emissions in the UAE was given, renewable energy resources and projects in the UAE were also assessed. M. Asif [8] made a trend on the growth of sustainable buildings in Saudi Arabia and in the UAE. Abdouleh et al. [9] studied the different policies used in the energy sector in the UAE, the study included recommendations regarding financial, fiscal, technological and environmental support. Mezher et al. [10] made a comparison between renewable energy policies followed by different countries worldwide in which it can be used by Abu Dhabi, the study contained lessons learnt from UK and Germany. The study demonstrated the costs and constrains of renewable energy in Abu Dhabi. M.D. Islam et al. [11] measured the direct beam radiation in Abu Dhabi for a complete year to get an actual view of the solar energy potential in Abu Dhabi, this paper focus is on wind data to check the possibilities for wind turbines.

EXPERIMENTAL SETUP
The weather station is located in the industrial area in Ras Al Khaimah, this location can have significant effect on the different parameters of the local climate, though wind velocity and direction are the least to be effected from this location. The climate in Ras-Al-Khaimah is hot and arid with hot summers and mild winters. Indian Ocean influence the climatic conditions of this region. In summer; May, June, July and August the weather is hot and humid, the average temperature in July is around 30-40 °C and in December the average temperature is around 16-25°C.
The weather data presented in this paper is from a Vantage Pro2™ (6162) Wireless weather station that includes two components; the Integrated Sensor Suite (ISS) Fig. 2 which houses and manages the external sensor array and the console which provides the user interface, data display and calculations. The ISS and Vantage Pro2 console communicate via an FCC-Certified, license free, spread-spectrum frequency hopping (FHSS) transmitter and receiver Fig. 3 the console may be powered by batteries or by AC powered adapter. Weatherlink™ software is used to interface the weather station with the computer, to log weather data and to update weather information on the internet. Passive shielding is included to reduce solar radiation induced temperature errors in the outside temperature sensor readings.

Data display categories are listed in alphabetical order
1) Barometric pressure 2) Dew point (calculated) 
3) Heat index (calculated) 4) Humidity 
5) Rainfall 6) Solar radiation (requires solar radiation sensor) 
7) Temperature 8) Ultra violet (UV) Radiation Index (requires UV sensor) 9) Clock. Resolution: 1 minute, time: 12 or 24 hour format (user-selectable), date: US or international format (user-selectable), accuracy: ±8 seconds/month, adjustments time: automatic daylight savings time (for users in North America and Europe that observe it in auto mode, manual setting available for all other areas) date: automatic leap year alarms: once per day at set time when active.

Wind
10) Wind chill (calculated) 11) wind direction 
Range: 0 – 360, display resolution: 16 points (22.5°) on compass rose, 1° in numeric display accuracy: ±3° 
Update Interval: 2.5 to 3 seconds, current display data: Instant (user-adjustable offset available) Current Graph Data: Instant; 10-min. Dominant; Hourly, Daily, Monthly Dominant Historical Graph Data: Past 6 10-min. Dominants on compass rose only; Hourly, Daily, Monthly Dominants 12) Wind Speed: Resolution and Units: 1 mph, 1 km/h, 0.4 m/s, or 1 knot (user-selectable).

DATA REDUCTION AND FORMATTING
The data reduction procedure is quite cumbersome as it has to deal with a very big and never processed raw database, from a station that has a large number of raw databases recorded since August, 2007 till date. The frequency of the records in the station is 5 minutes. As the records since its installation have never been reduced and assessed before, the amount of databases is very big. Furthermore, the databases have never been scanned for its clarity, correctness etc. There were plenty of unusual data recorded due to some technical fault in the instruments or installation or improper management. Those unusual/wrong data for all of the recorded variables have been identified and omitted, and the databases have been updated before heading for further assessment. The updated databases have been averaged according to the assessment requirement like hour-wise, week wise, day wise, month wise, year wise etc.
Table 1. Type of Data Recorded in File

<table>
<thead>
<tr>
<th>Type of Data Recorded in File</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Solar W/m²</td>
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<tr>
<td>Temp. °C</td>
<td></td>
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<tr>
<td>Hum. %</td>
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<td>Wind km/h</td>
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<td>Direction °</td>
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<td>Wind gust km/h</td>
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<tr>
<td>Rain mm</td>
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<tr>
<td>Baro. hPa</td>
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<tr>
<td>UV UV-I</td>
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DATA ANALYSIS
Following assessment carried out by Sujata reveals the wind turbine installation potential in the region for renewable electricity production. Therefore, the assessment is divided into five sections based on wind resource availability and the measurement limitation of the instrument for wind turbine operation. Similar to wind direction sensor, the wind speed sensor records a 5 minute wind speed occurrences. Figure 5 presents the monthly wind averages assessment for the year 2010, whereby it seems that most of the numbers of wind speed occurrences are mostly falling in the range of not suitable wind speed, i.e. no wind, 0.4<X<0 m/s and 2.2<X<0.4 m/s. Moreover, the number of wind speed occurrences falling in the marginal wind speed occurrences range is also having a good portion. Furthermore, the number of wind speed occurrences falling on the suitable speed range is covering a very small portion. Figure 6 presents the occurrences for monthly wind speed in total hours of a month and figure 7 shows the occurrences for monthly wind speed in percentage share basis, whereby it can be concluded that only 5% occurrences of the wind is falling in the suitable wind speed range for wind turbine installation. About 65% portions of occurrences of wind speed is in the not suitable range and around 30% occurrences of wind is in the marginal range.

Figures 8, 9 and 10 represent the assessment for June 2010 on a daily basis, by occurrence percentage, occurrence hours and percentage by share respectively. From all graphs it can be concluded that only 9% occurrences of the wind is falling in the suitable wind speed range for wind turbine installation. About 55% portions of occurrences of wind speed is in the not suitable range and around 30% occurrences of wind is in the marginal range.

Figure 5. 5 min. Wind Speed Occurrence percentage per Month during 2010.

Figure 6. 5min. Wind Speed Occurrence hours per Month during 2010.

Figure 7. Wind Speed Occurrence Percentage by share during 2010.

Figure 8. Wind Speed Occurrence percentage per day during June 2010.
Figure 9. Wind Speed Occurrence hours per day during June 2010

Figure 10. Wind Speed Occurrence by percentage share during June 2010

WIND DIRECTION
Having realized that wind can flow from any direction from 0 to 360° and it is very difficult to analyze all the number of occurrence wind from each direction within the whole range from 0 to 360°, first of all the 360 degree is divided in 16 number of sections having 20° for each section, that can be visible in the ensuing figures. The wind flowing from any degree range within the section is recorded as number of occurrence for that particular section. The number of occurrence is measured for each 5 minutes. In this context, the wind direction analysis is based on the total number of occurrence falling in the particular section. Figures 11 and 12 present the wind direction results for the year of 2010. Figure 11 shows that the number of occurrences for wind direction are maximum from North-West region which falls towards the coast side of the Arabian Gulf. Similarly, the figure shows that there is also a marked number of occurrences of wind just from the opposite direction to the sea shore, which falls South-East direction. Figure 12 is just the details of the analysis shown in Figure 11, whereby occurrences is divided for each month of the year. It can be observed by different colors for different months. Figure 15, presents the comparison of number of occurrences for wind direction for the year 2010, 2011 in the same picture. As depicted in the figure, the trend seems to be more or less repeating in both years, but when wind direction for 2010, 2011 and 2012 were compared in same picture Figure 16 the result is clearly visible that 2012 has a significant decrease in number of wind occurrence in the same region.

Figure 11. Average wind direction trend based on number of occurrences for the year 2010

Figure 12. Monthly average wind direction occurrences trend for the year 2010
CONCLUSION
Wind resource for power generation in Ras Al Khaimah, UAE has been studied for three years (2010, 2011 and 2012). Wind speed and wind direction has been recorded and analyzed for the three years, it was found that the wind resource for this particular region can’t be utilized for wind power generation due to low occurrence and low speed.

REFERENCES
[8] Asif, M. "Growth and sustainability trends in the buildings sector in the GCC region with particular
