OBJECTIVE AND ANALYSIS OF WIND MEASUREMENT IN THE 50 M INSTRUMENTED METEOROLOGICAL TOWER TO PREDICT WIND ENERGY POTENTIAL

Sardar Maran P.[1], **Ponnusamy R.**[2]

[1]Research Scholar & Scientist, Centre for Earth & Atmospheric Sciences
Sathyabama University, Jeppiaar Nagar, Chennai, India

[2]Principal, Madha Engineering College, Madha Nagar, Kundrathur, Chennai, India
E-mail: sardarmaran@gmail.com, rponnusamy@acm.org

ABSTRACT

The renewable energy sources offer scope for power generation in dispersed mode and at the load points, thereby eliminating line loss. Moreover, they are eco-friendly and do not pollute the environment. Wind in India are influenced by the strong south-west summer monsoon, which starts in May-June, when cool, humid air moves towards the land and the weaker north-east winter monsoon, which starts in October, when cool, dry sir moves towards the ocean. During the period march to August, the winds are uniformly strong over the whole Indian Peninsula, except the eastern peninsular coast. Wind speeds during the period November to march are relatively weak, though higher winds are available during a part of the period on the Tamil Nadu coastline. This paper presents the analysis of real time wind measurement and the prediction of available wind potential in the 50 metre meteorological tower installed at Sathyabama University, Chennai, near east coastline of Tamil Nadu.

Keywords: Wind speed, Wind Energy, Meteorological Tower

I. INTRODUCTION

India's rapidly growing economy and expanding population make it hungry for electric power. In spite of major capacity additions over recent decades, power supply struggles to keep up with demand. [1] Electricity shortages are common, and a significant part of the population has no access to electricity at all. India's electricity demand is projected to more than triple between 2005 and 2030. [2] [3]

Wind is commercially and operationally the most viable renewable energy resource and accordingly emerging as one of the largest source in renewable energy sector. India has a good Potential of wind throughout the country. [5] [6] [8] After a few years of slow growth, the Indian wind power market is now back on track and witnessed significant growth in 2010. It comes in third behind China and the USA in terms of new installed capacity during 2010 at 2,139 MW, taking total capacity up to 13.1 GW. [11] [13] The states with highest wind power concentration are Tamil Nadu, Maharashtra, Gujarat, Rajasthan, Karnataka, Madhya Pradesh and Andhra Pradesh. (Global Wind Energy Council).

In 2010 the official wind power potential estimates for India were revised upwards from 45 GW to 49.1 GW by the Centre for Wind Energy Technology (C-WET). In India 10% of the total capacity of power generation will come from renewable energy sources by the 2012. Wind power in India has been concentrated in few regions, especially the southern state of Tamil Nadu, [14]-[19] which maintains its position as the state with most wind power represents 50% of India total wind power capacity. The cumulative achievement of wind power potential in Tamil Nadu as on 31st Oct 2011 is 6548 MW. (TEDA). National Installed capacity of the Wind farms has been contributed by Tamil Nadu is 61%.

II. STUDY AREA

Meteorological data have been used in several kinds of analyses with different goals. Meteorological towers are the platforms providing continuous in situ information within the lower atmospheric layer. Meteorological towers are the platforms providing continuous in situ information within the lower atmospheric layer called the Atmospheric Boundary Layer (ABL). Most often such towers are installed for basic research studies in the ABL. The 50 Metre tower at Sathyabama University has multilevel sensors for all the basic atmospheric parameters like wind speed and direction, temperature, relative humidity, pressure, rainfall and nuclear radiation. The meteorological tower is located at latitude 12° 52 N, longitude {80° 13 E with 4 m elevation.

III. DATA MODEL

A. Data Archival

The weather parameters data archived at various levels at 10 minutes interval of time. The available data is stored in a database automatically in the server. The following Table I shows the list of weather parameters at various levels with duration of archival.

List of Weather Parameters With Levels

Weather Parameters with Height	Forecast / Hour	
Temperature (50 m), Humidity (50 m), Wind (50 m), Pressure (50 m)	10 Minutes	1 Hour
Temperature (32 m), Humidity (32 m), Wind (32 m), Pressure (32 m)	10 Minutes	1 Hour
Temperature (16 m), Humidity (16 m), Wind (16 m), Pressure (16 m)	10 Minutes	1 Hour
Temperature (8 m), Humidity (8 m), Wind (8 m), Pressure (8 m)	10 Minutes	1 Hour
Temperature (2 m), Humidity (2 m), Wind (2 m), Pressure (2 m)		
Precipitation	10 Minutes	1 Hour

V. WIND DATA ANALYIS

A. Average Wind Speed

The Wind Speed data for two years (2010-2011) at different heights namely 50 m, 32 m, 16 m, 08 m and 02 m is taken for analysis and prediction. The monthly average wind is calculated and listed in the following Table II.

The following figure 1 shows the average wind speed in meter per second for the year 2010. The wind speed is increasing from the ground level to higher level according to the height of the tower. It is clearly identified the wind speed is gradually increasing from the month of March to May.

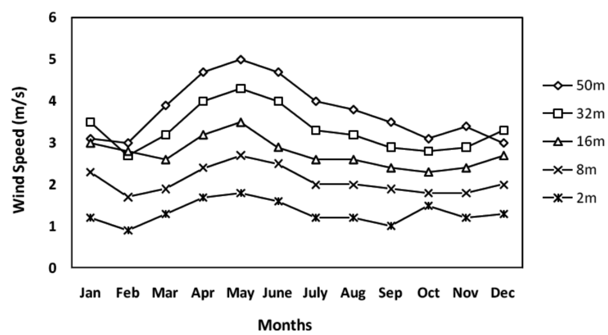

Fig. 1. Average Wind Speed at different heights (2010)

The average wind speed for the year 2011 is depicted in the followind figure 2. Compared to the year 2010 the wid speed increased at all levels from the month of April to June and decay upto the month of October. The relative humidity is slightly higher between April to June of 2011 will cause the wind

TABLE II. MONTHLY AVERAGE WIND SPEED (m/s) DATA FOR THE YEAR 2010-2011

Year	Height in meter	Months											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	50	3.1	3.0	3.9	4.7	5.0	4.7	4.0	3.8	3.5	3.1	3.2	2.1
	32	3.5	2.7	3.2	4.0	4.3	4.0	3.3	3.2	2.9	2.8	2.9	3.3
	16	3.0	2.8	2.6	3.2	3.5	2.9	2.6	2.6	2.4	2.3	2.4	2.7
	08	2.3	1.7	1.9	2.4	2.7	2.5	2.0	2.0	1.9	1.8	1.8	2.0
	02	1.2	0.9	1.3	1.7	1.8	1.6	1.2	1.2	1.0	1.5	1.2	1.3
2011	50	3.9	3.2	3.0	3.3	4.2	5.3	4.8	3.7	3.4	2.8	3.6	3.5
	32	3.7	3.0	2.9	3.2	4.0	4.4	4.0	3.4	3.3	2.4	3.3	3.4
	16	3.0	2.6	2.4	2.7	3.3	3.7	3.4	2.8	2.7	1.9	2.6	2.7
	08	2.3	1.9	1.9	2.1	2.6	2.9	2.7	2.2	2.1	1.5	2.0	2.0
	02	1.4	1.1	1.1	1.2	1.7	2.0	1.7	1.4	1.2	0.8	0.6	0.4

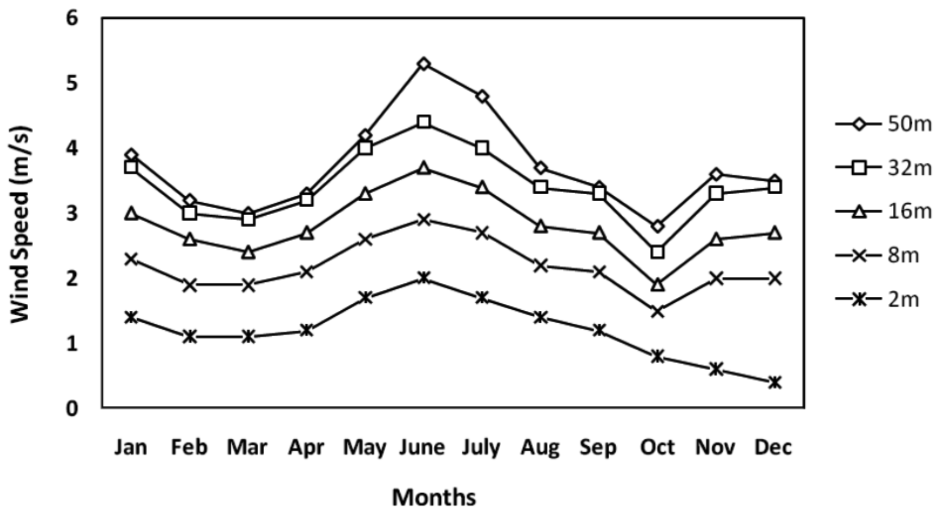

Fig. 2. Average Wind Speed at different heights (2011)

speed much higher when compared to the year 2010. On the other hand, under humid weather conditions, the high humidity of the air cause the evapotranspiration rate to be lower. The effect on evapotranspiration of increasing wind speeds. The average wind speed is also increased beyond 5 m/s.

B. Severe Cyclonic Storm Laila – May 17-21, 2010

The severe cyclonic storm "Laila" formed over southeast Bay of Bengal during 17-21 May 2010 and crossed Andhra Pradesh coast near Bapatla between 1630 and 1730 hrs IST of 20th May 2010. It caused wide spread rainfall with scattered heavy to very heavy falls and isolated extremely heavy falls over coastal Andhra Pradesh leading to flooding in low lying areas. The highest wind speed during this cyclone is shown in in Figure 3.

C. Severe Cyclonic Storm Thane – Dec 29-31, 2011

The very severe cyclonic storm THANE over southwest Bay of Bengal moved west-southwestward and lay centered at 0530 hrs IST of 29th December 2011 near latitude 12.30 N and longitude 83.00 E,

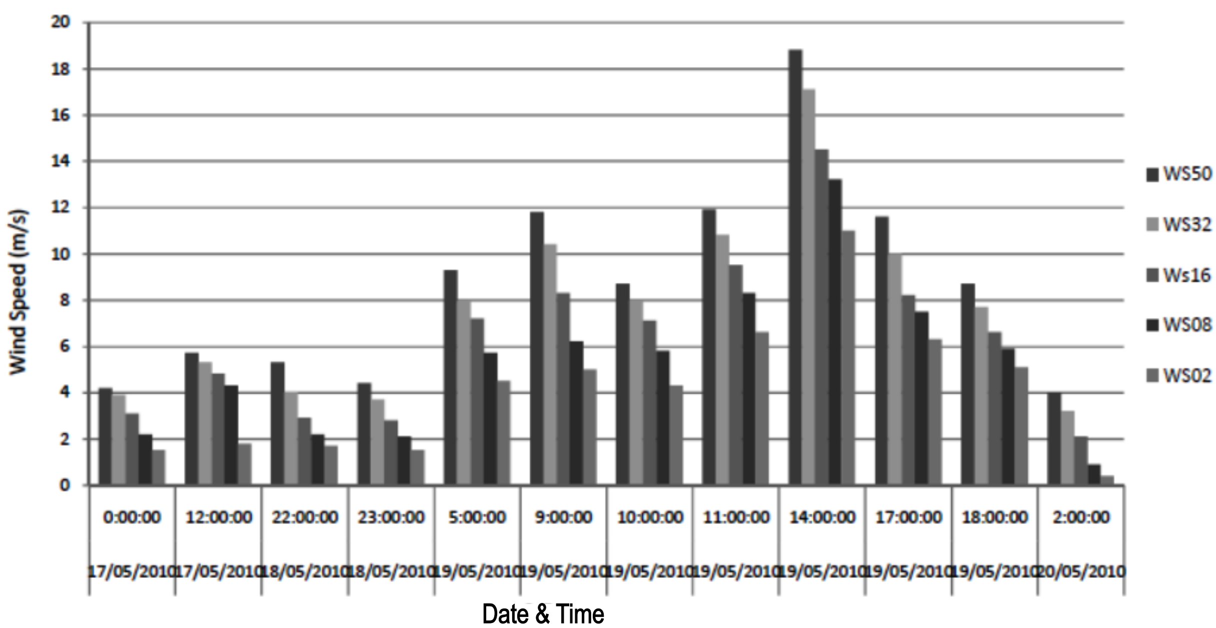

Fig. 3. Maximum Wind Speed on cyclonic storm Laila

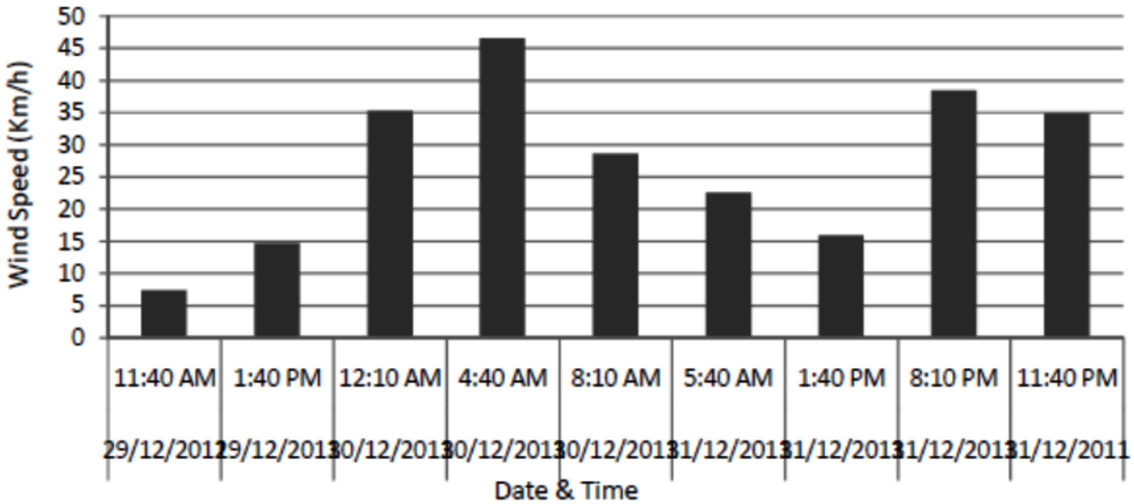

Fig. 4. Maximum Wind Speed on THANE cyclone, Dec 2011

about 300 km east-southeast of Chennai (Tamilnadu) and 480 km north-northeast of Trincomalee (Sri Lanka). The system is likely to move westwards and cross north Tamil Nadu coast between Nagapattinam and Chennai, close to Puducherry around morning of 30th December 2011. The maximum wind speed attained in the morning at that time is shown below in figure 4.

V. WIND ENERGY PREDICTION

The construction of wind turbine is economically viable depends on the quality of wind resource. Generally, average annual wind speeds of at least 4.0-4.5 m/s (14.4 – 16.2 km/h; 9.0-10.2 mph) are needed for a small wind turbine to produce enough electricity to be cost-effective. The meteorological factors like wind speed and air density greatly influence the wind power generation. The available wind power at the wind turbine in watts is given by

$$P_{\min} = \frac{1}{2}\rho A V^3$$

where ρ is the air density in kg/m^3, A is the swept area of wind turbine in m^2, and V is the wind speed in m/s. Air density at a given temperature in degree celcius and pressure in hPa is calculated as 11.4952 kg/m^3. The swept area of the turbine is be calculated from the length of the turbine blades using the equation for the area of a circle. Of these variables, the wind speed has a major influence on win turbine power output since the power output varies with cubic value of wind speed. The air density variation during different period of a year and at different location is lessed compared to the wind speed variation. The wind turbine power production capacity is mainly affected by wind speed variations during the seasons of a year.

he mean annual wind speed with indicated value of wind resource is listed in the Table II.

TABLE II. Mean Annual Wind Speed

Annual Wind Speed	Indicated Value of Wind Resource
< 4.5	Poor
1.5 - 5.4	Marginal
5.4 ≤ 6.7	Good
> 6.7	Exceptional

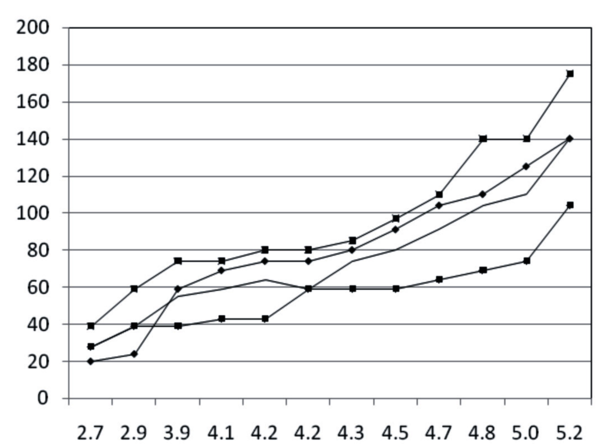

Fig. 5. Monthly Average wind speed (m/s)

From the monthly average wind speed is used to shows the variation of monthly power generation in kWh per KW for the period of years. The following fig. 5 shows the variation of monthly power generation in kWh per kW of installed capacity with the monthly average wind speed.

VI. CONCLUSION

Wind energy technology is currently making a significant contribution to the electric power generation systems in India. Now India is one of the leading countries in the world for the development and utilization of wind energy. According to the growth of wind energy India will achieved high potential in future. The present investigations showed that at 50 m height and above the ground level reach a good potential for wind energy. These areas seem to be very convenient for wind turbine installation.

VII. ACKNOWLEDGEMENT

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