

Wind Data Report
Peaks Island Wind Site
Peaks Island, Maine
Quarterly Report March 2011 to May 2011

Prepared by
The University of Maine
June 1, 2011



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Executive Summary

Wind monitoring equipment began operating at the Peaks site on August 23, 2010. The data contained in this report summarizes the wind data at the Peaks collected from March 2, 2011 through May 31, 2011. This report is a quarterly report for the Peaks site. The report includes wind shear coefficient. The results show that average wind speed at 30m is 3.91 m/s which are below the viable standard for commercial wind turbine operation of around 4.5 m/s continued monitoring is required to confirm these results.

Station Location

The monitoring tower is located at the Peaks facility. The site coordinates are 43.66083 latitude and -70.18655 longitude. Figure 1 shows the approximate location of the tower:

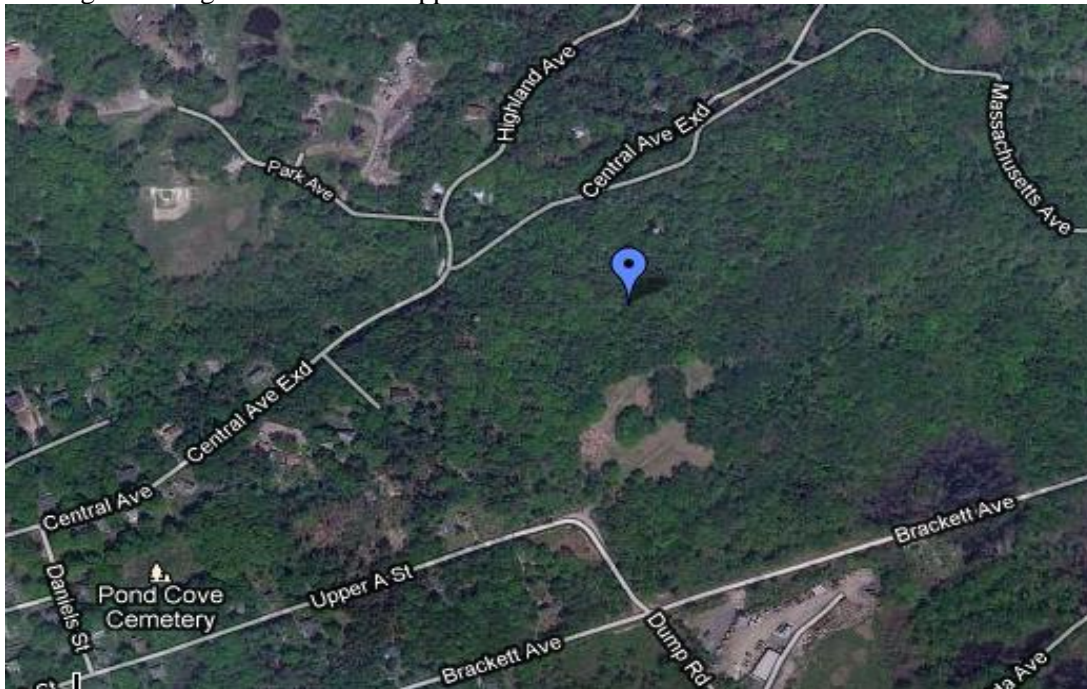


Figure 1 – Location of Tower

Instrumentation & Equipment

The 30m tower holds two separate NRG #40 anemometers, one at 30m and one at 20m. Wind direction is monitored only at 30m via an NRG #200 wind direction vane. Further, an NRG #110 temperature sensor with radiation shield is mounted a few feet above grade. The anemometers and wind vanes are mounted approximately 57” from the centerline of the tower. The data from the anemometers and wind vanes is provided to an NRG Symphonie data logger.

In summary, the tower consists of the following:

- NRG #110 temperature sensor with radiation shield
- Two NRG #40 anemometers with standard calibration
- NRG #200 wind direction vane
- Two booms to locate the monitoring equipment 57” from the tower centerline
- Simple lightning protection consisting of ground rod and ground conductor
- Guy wires at 120° and 80° from tower base with power driven anchors

Data Collection and Maintenance

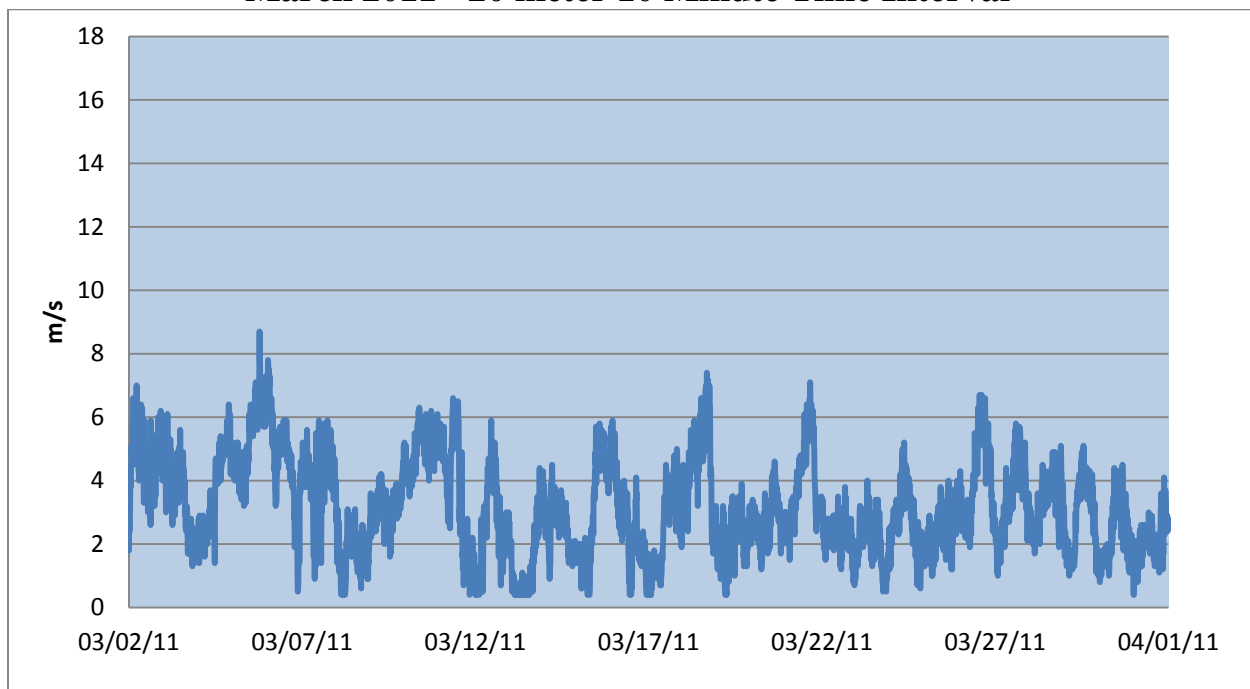
All data points from 03/02/2011 to 05/31/2011 were not recorded successfully. 144 data points were not properly recorded or transferred. This is less than 1% loss of data and does not impact the overall results.

Data Results

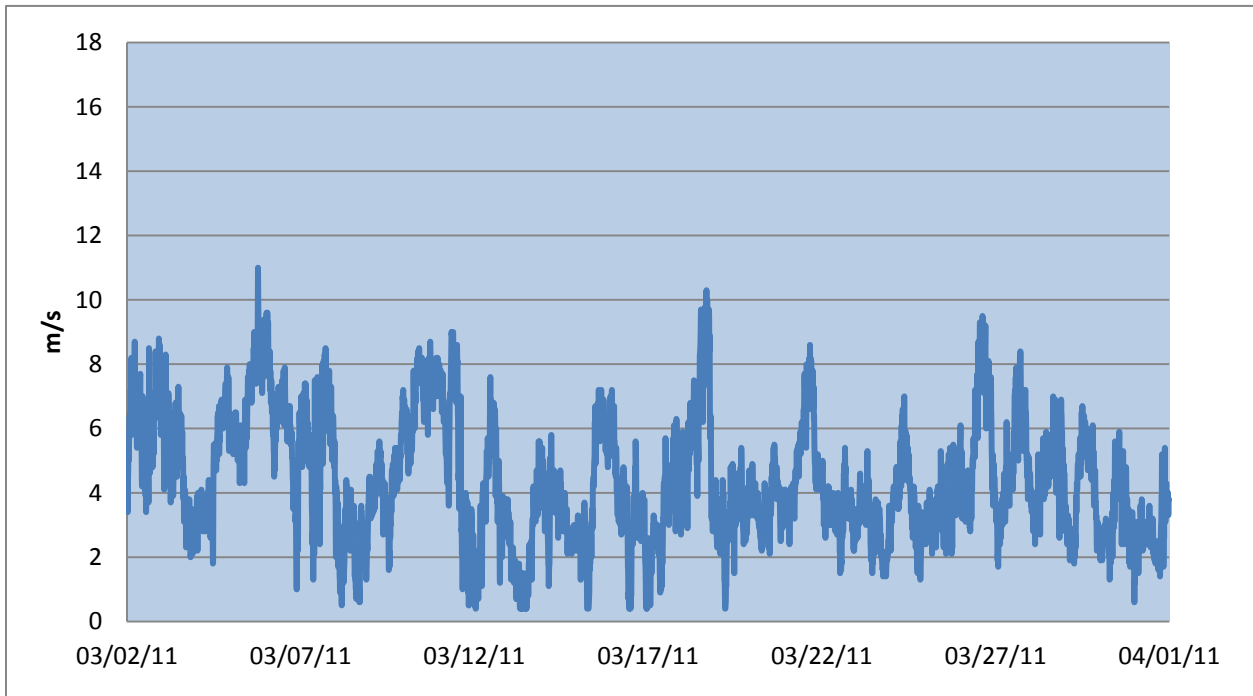
The average 30m wind speed for the entire monitoring period is 3.91 m/s. Standard commercial wind turbines have a nominal cut in speed of 4.5 to 5.3 m/s. The calculated average 30m wind speed at the site does not support the installation of a commercial scale turbine at 30m. However, new turbine designs that have lower cut in speeds are being developed and may be viable for this site in the future.

Time series data is useful to characterize variations in wind speed. The following figures identify the 10-minute time interval data for the site:

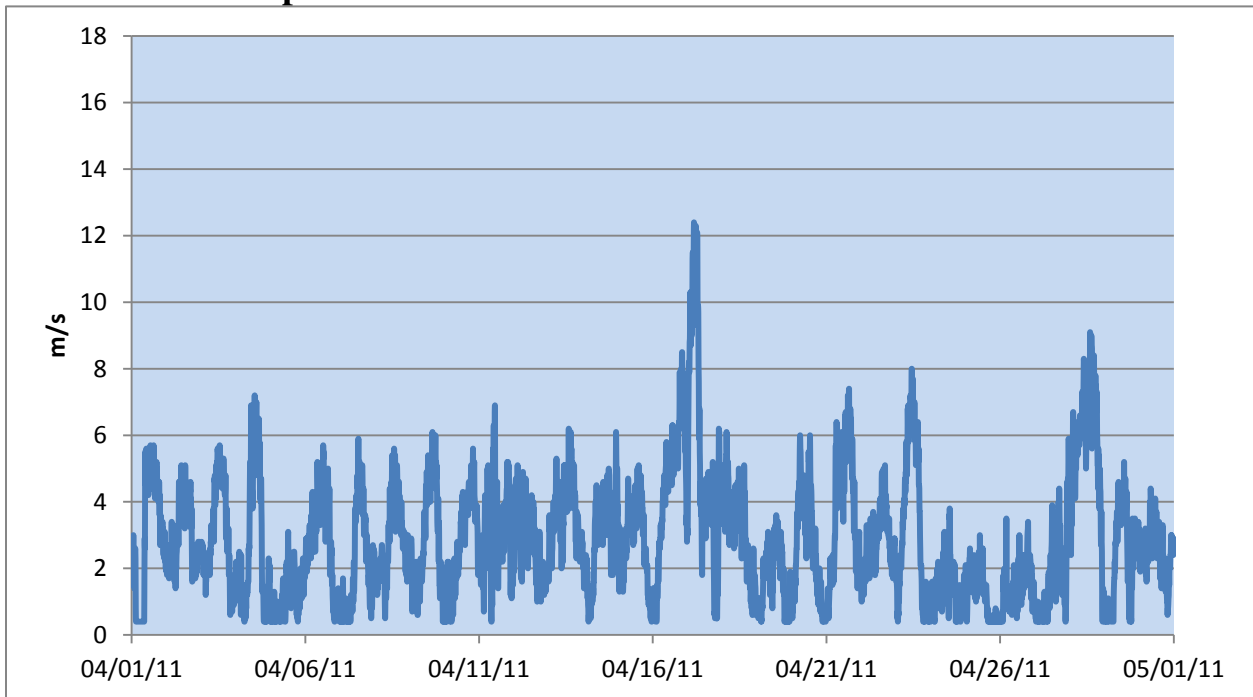
March 2011 - 20 meter 10 Minute Time Interval



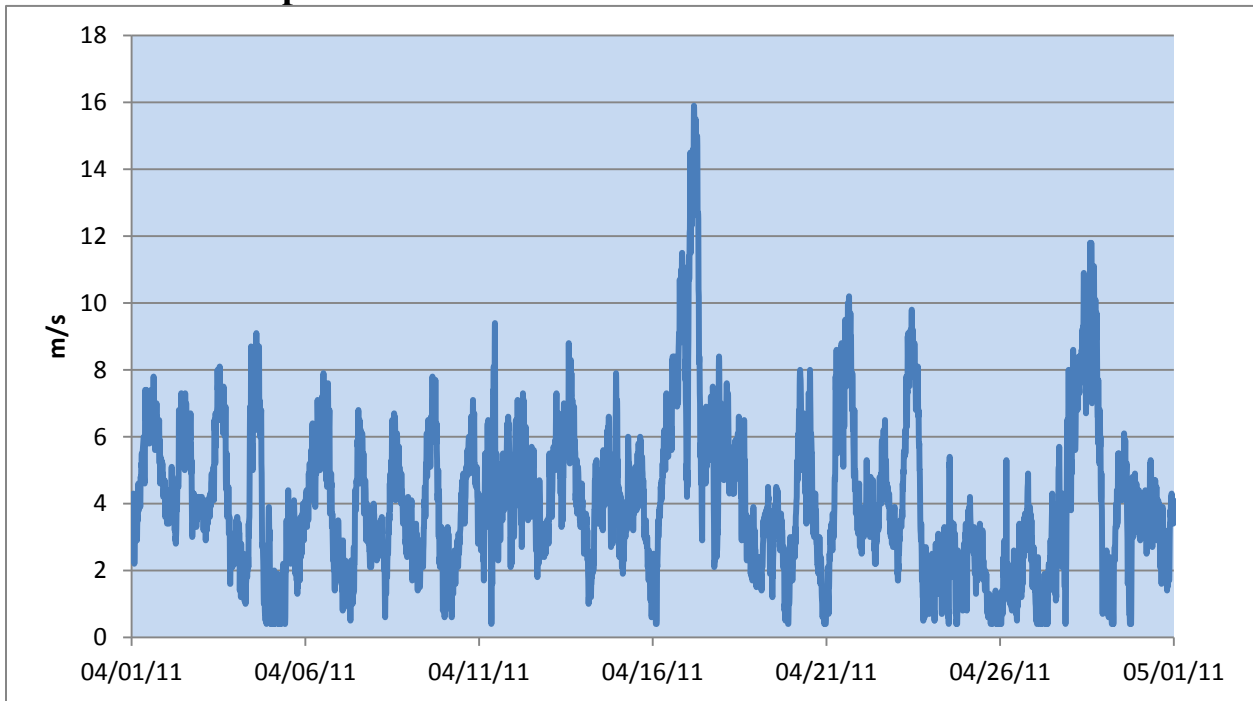
March 2011 - 30 meter 10 Minute Time Interval



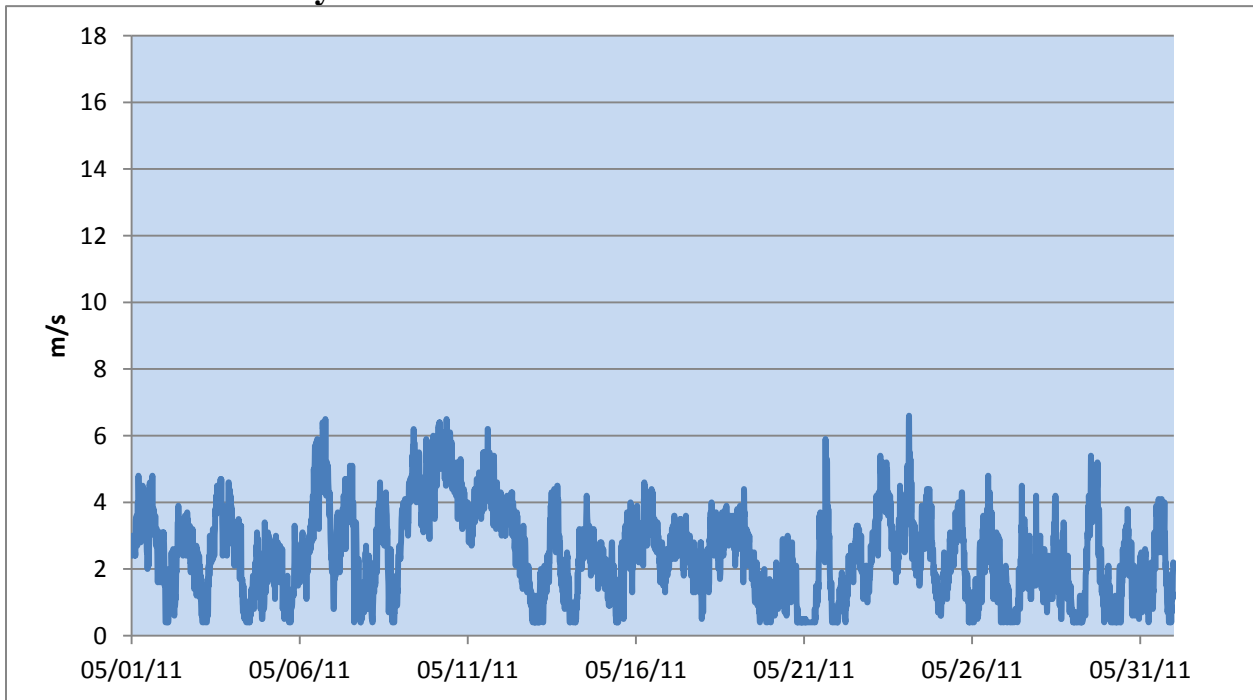
April 2011 - 20 meter 10 Minute Time Interval



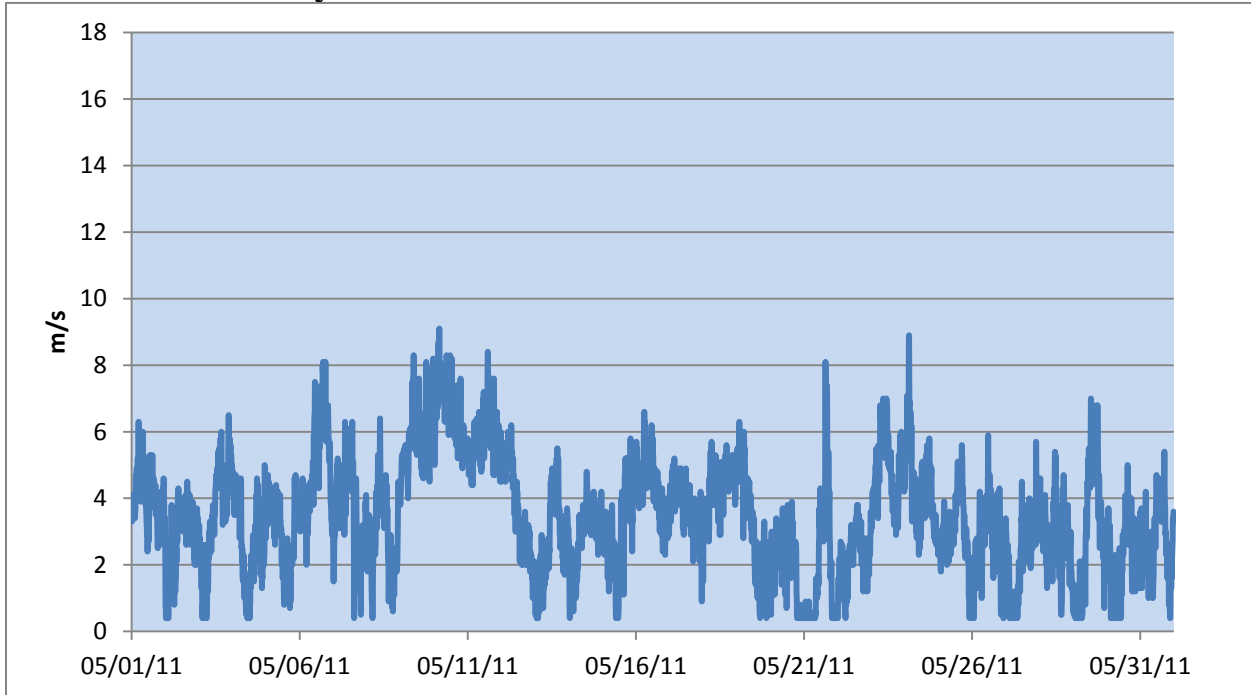
April 2011 - 30 meter 10 Minute Time Interval



May 2011 - 20 meter 10 Minute Time Interval

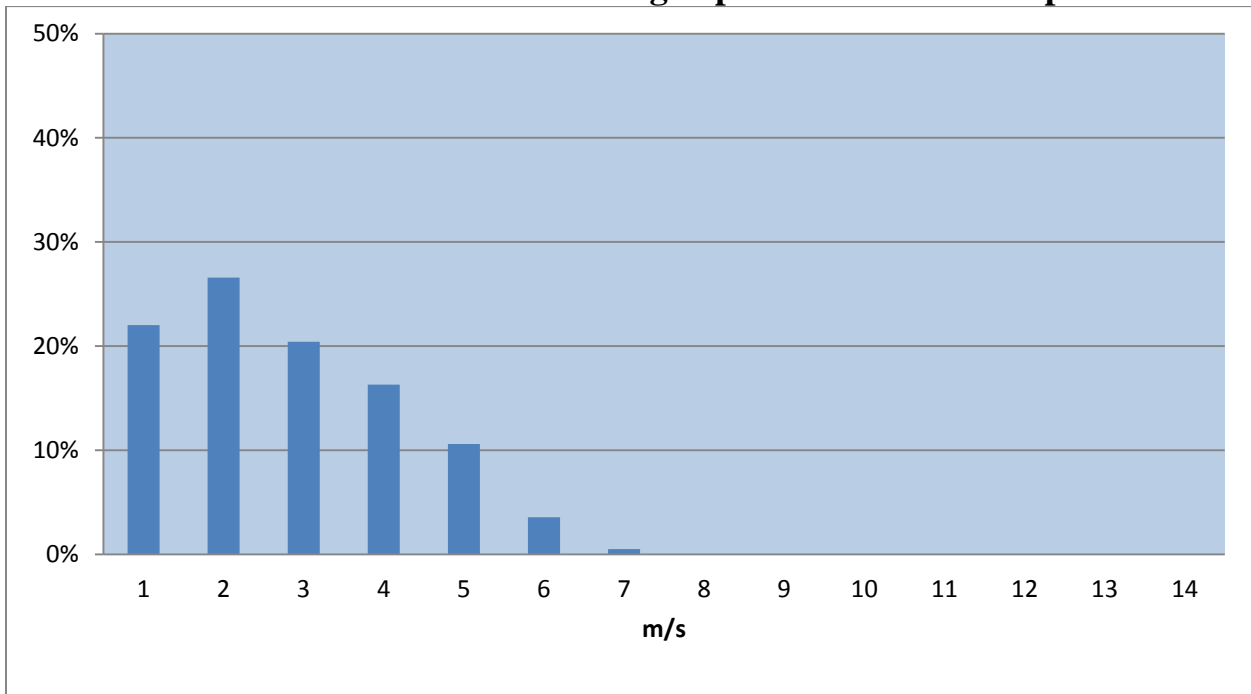


May 2011 - 30 meter 10 Minute Time Interval

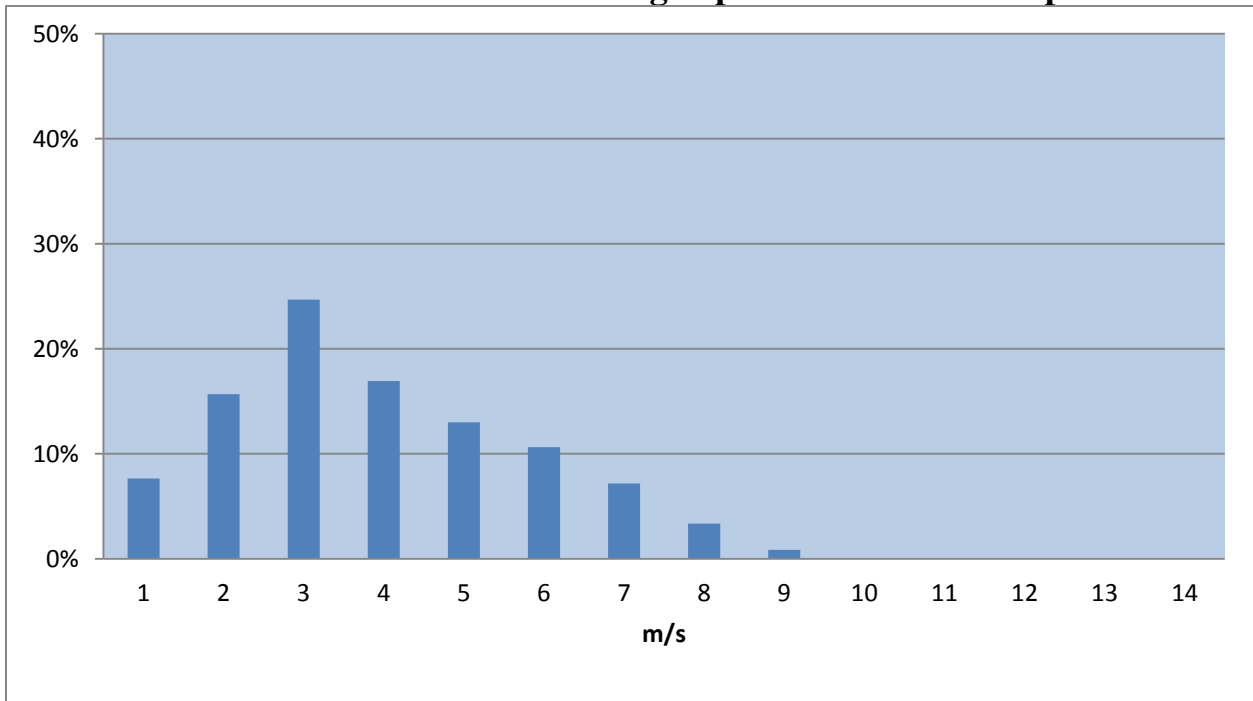


To estimate the anticipated output power for a particular site, forecasters develop equations based on probability. The analysis utilizes a Weibull Probability Density Function. To assist in the development of the probability density function, histograms depicting the percentage of time spent at a particular wind speed for each month are developed. The following figures are the histograms:

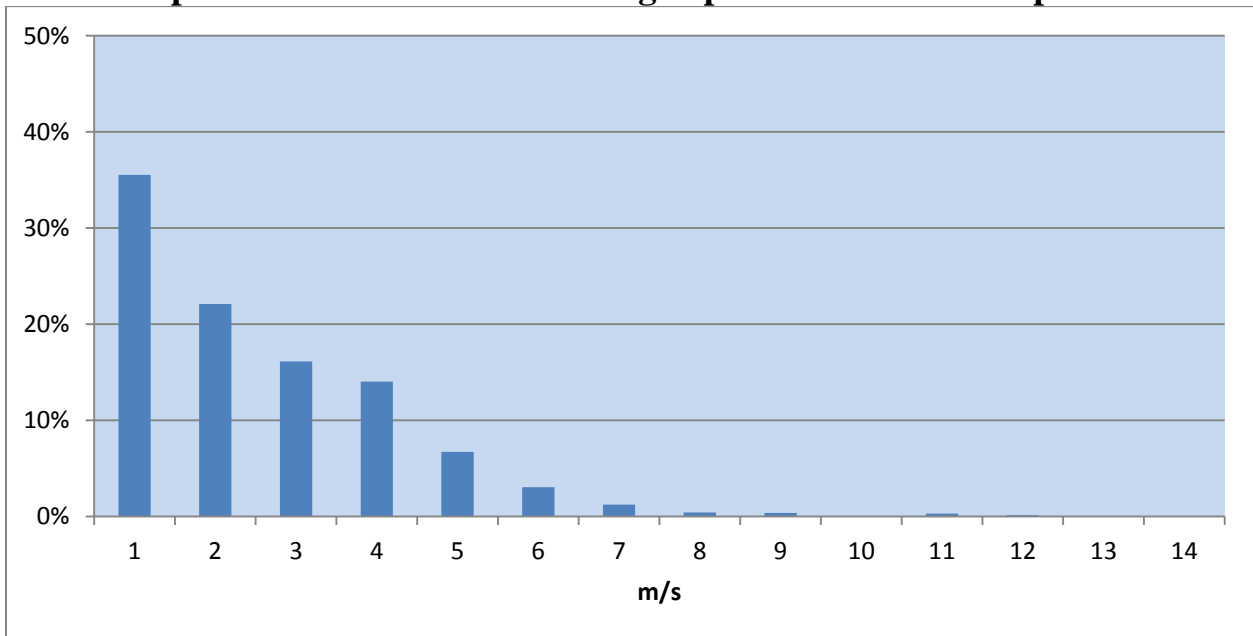
March 2011 - 20 Meter Percentage Spent at Each Wind Speed



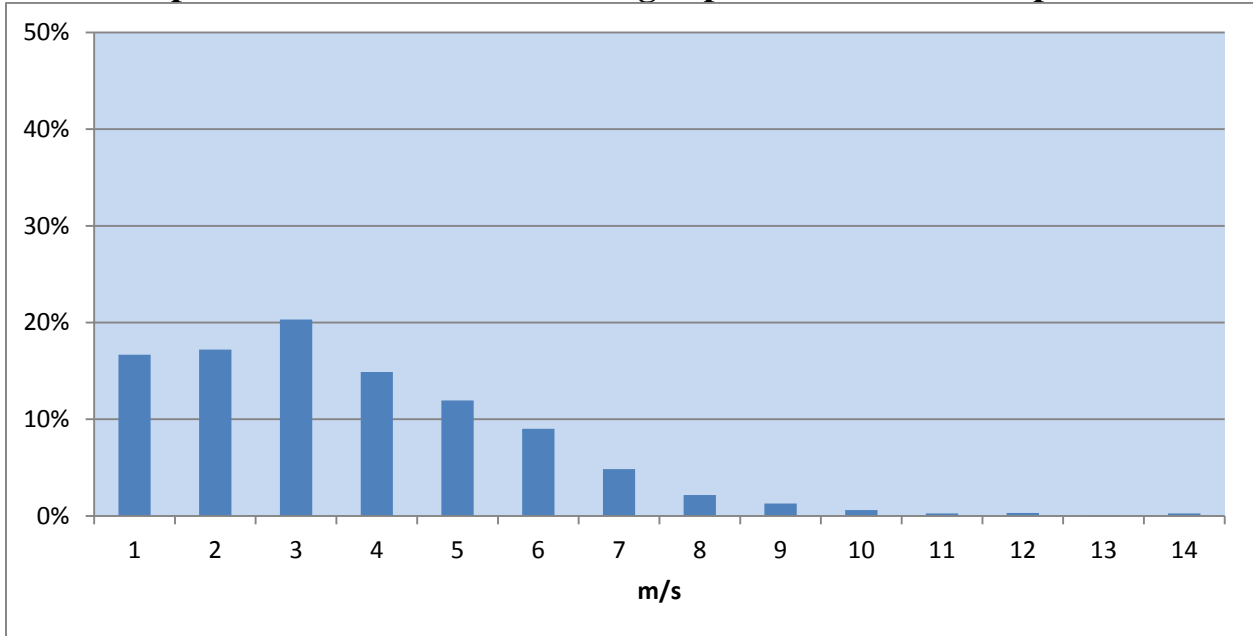
March 2011 - 30 Meter Percentage Spent at Each Wind Speed



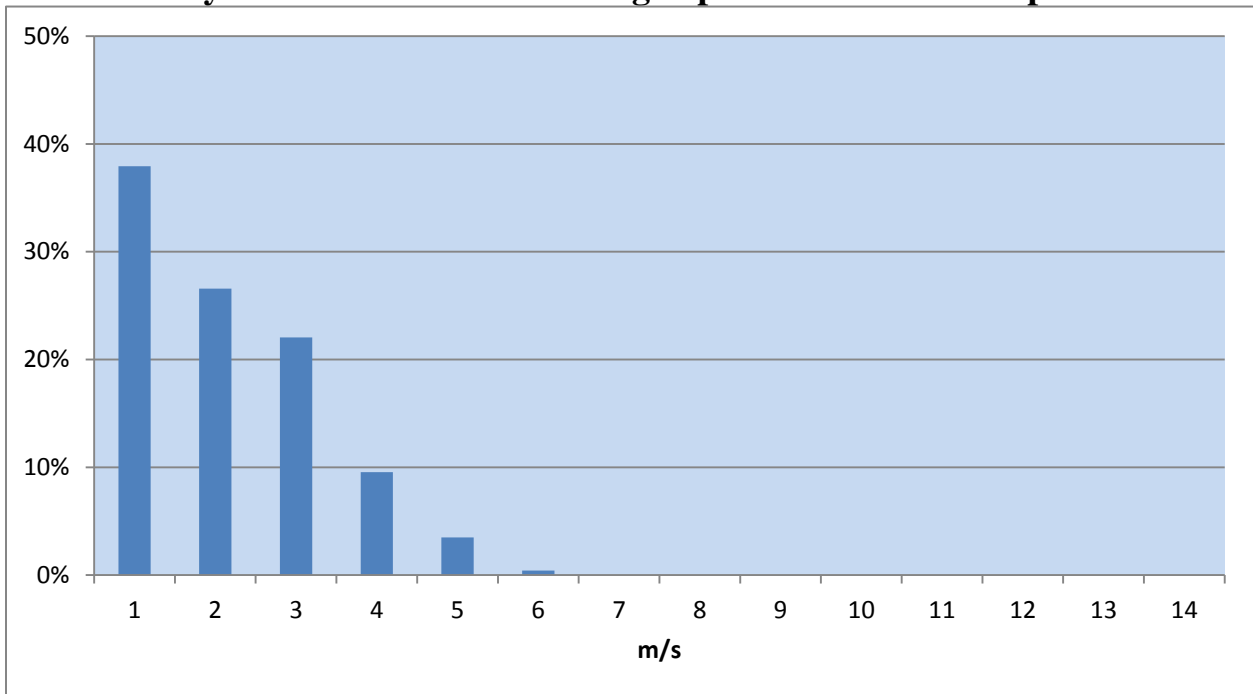
April 2011 - 20 Meter Percentage Spent at Each Wind Speed



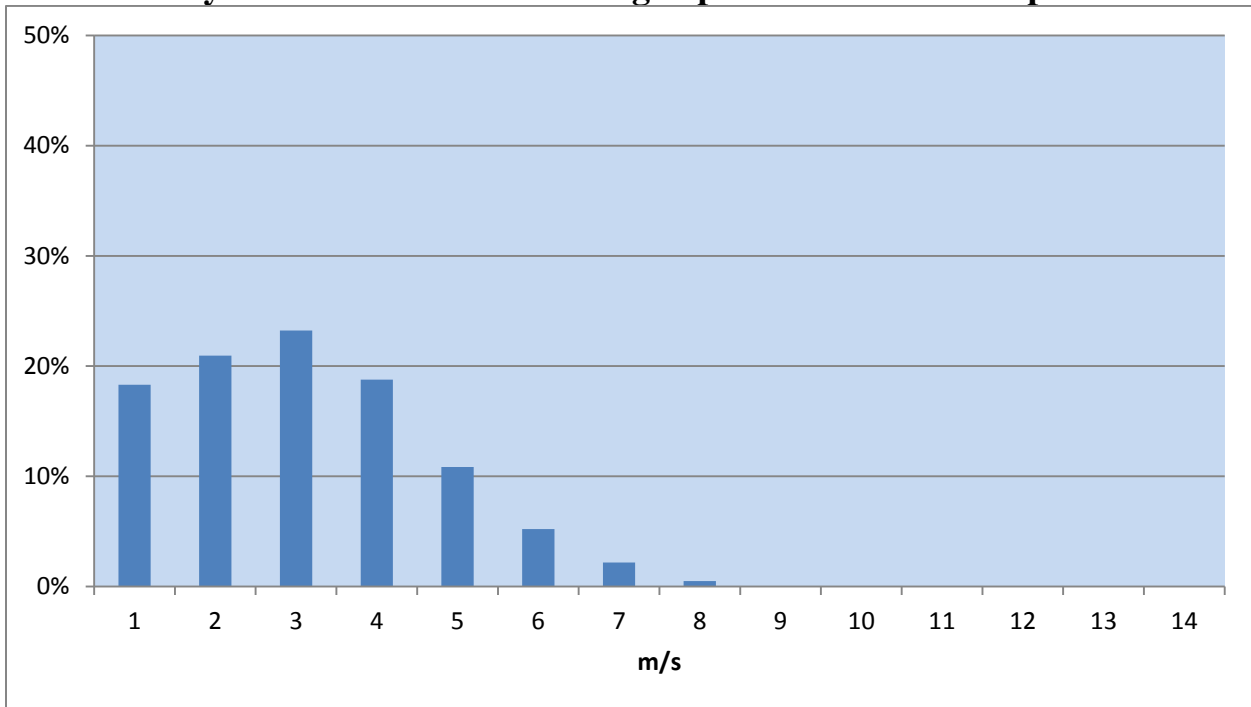
April 2011 - 30 Meter Percentage Spent at Each Wind Speed



May 2011 - 20 Meter Percentage Spent at Each Wind Speed

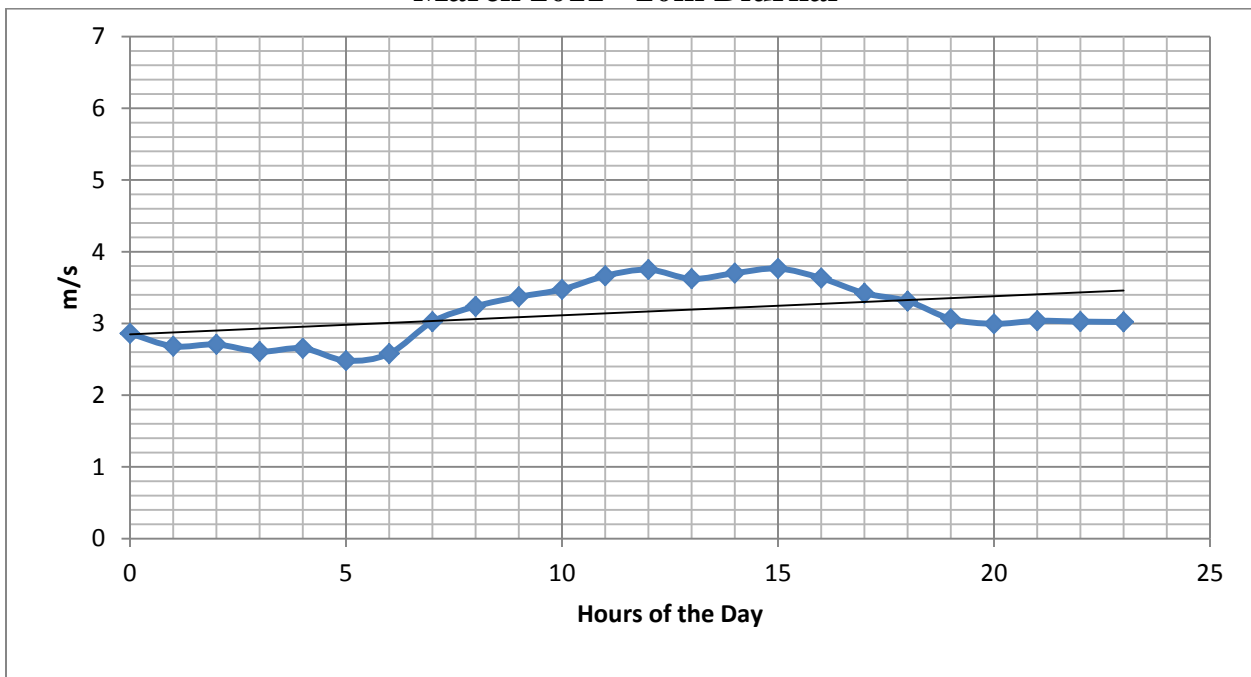


May 2011 - 30 Meter Percentage Spent at Each Wind Speed

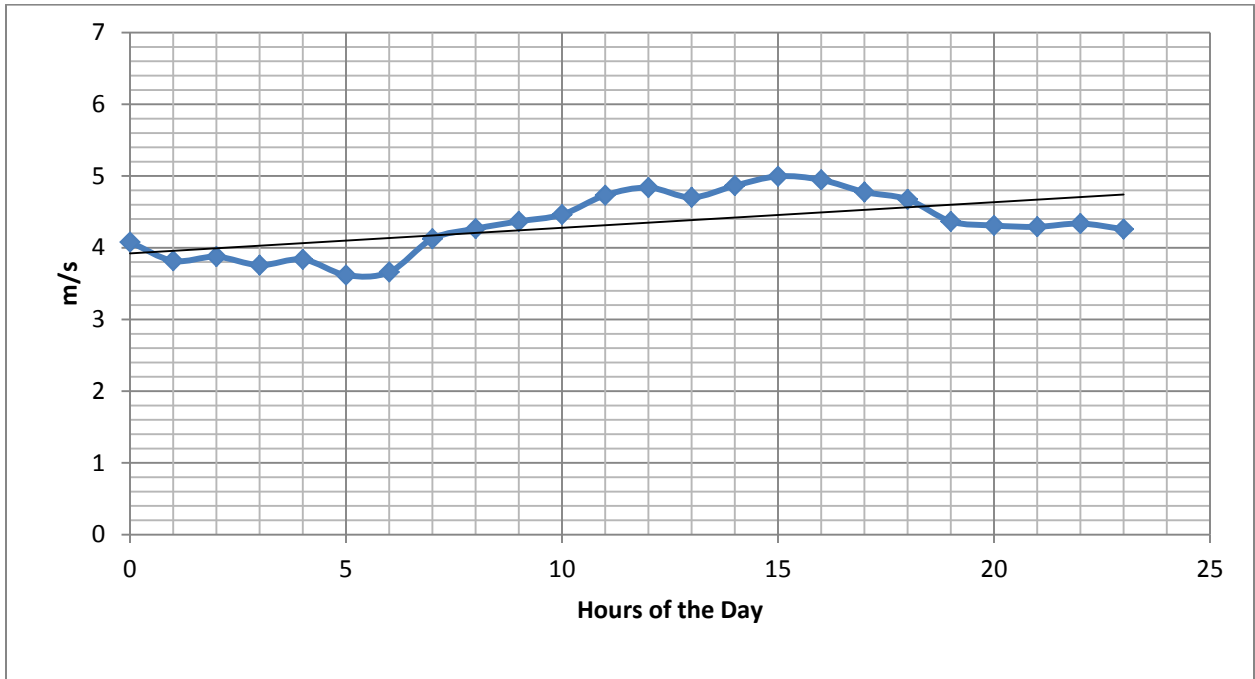


The following plots show the average wind speed each hour of the day. The data is useful to help energy forecasters match available energy from the wind with the demand on the electrical grid.

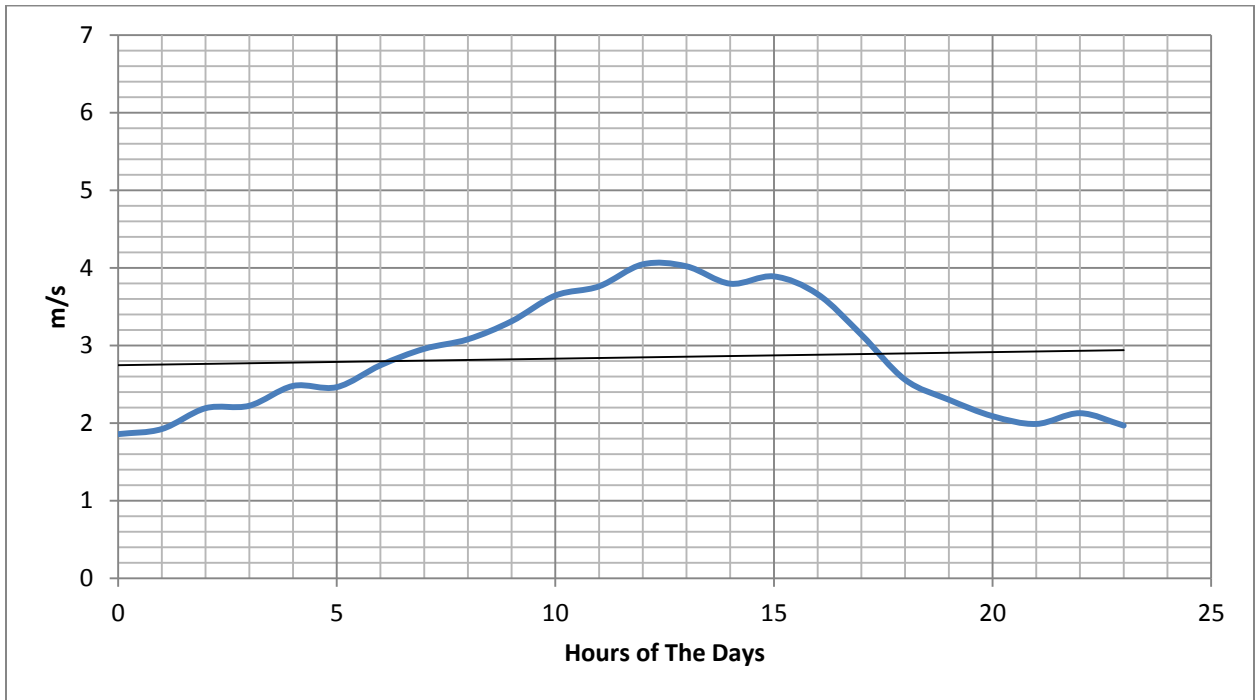
March 2011 - 20m Diurnal



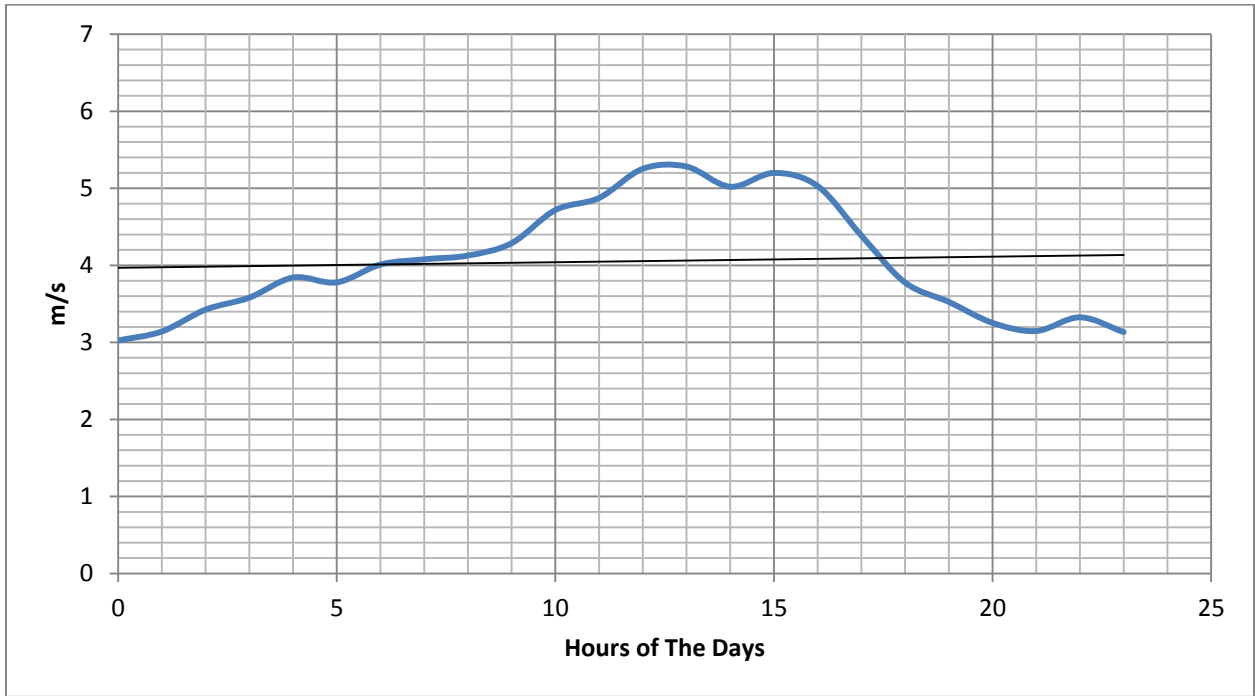
March 2011 - 30m Diurnal



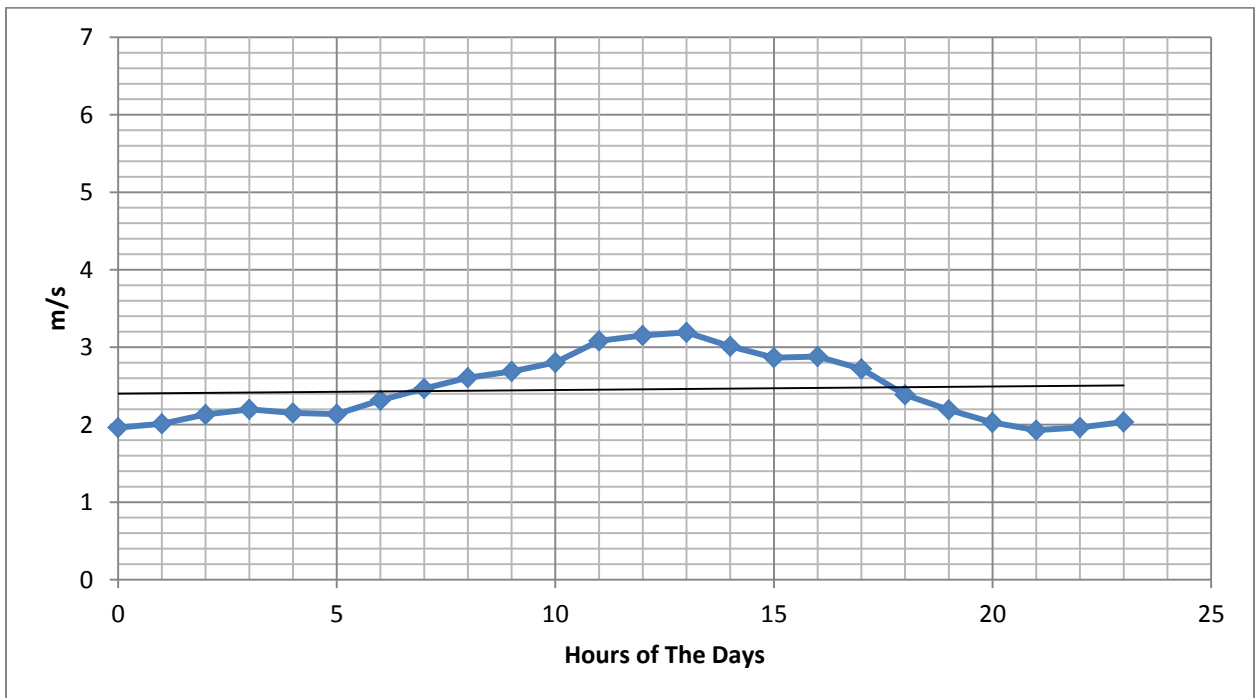
April 2011 - 20m Diurnal



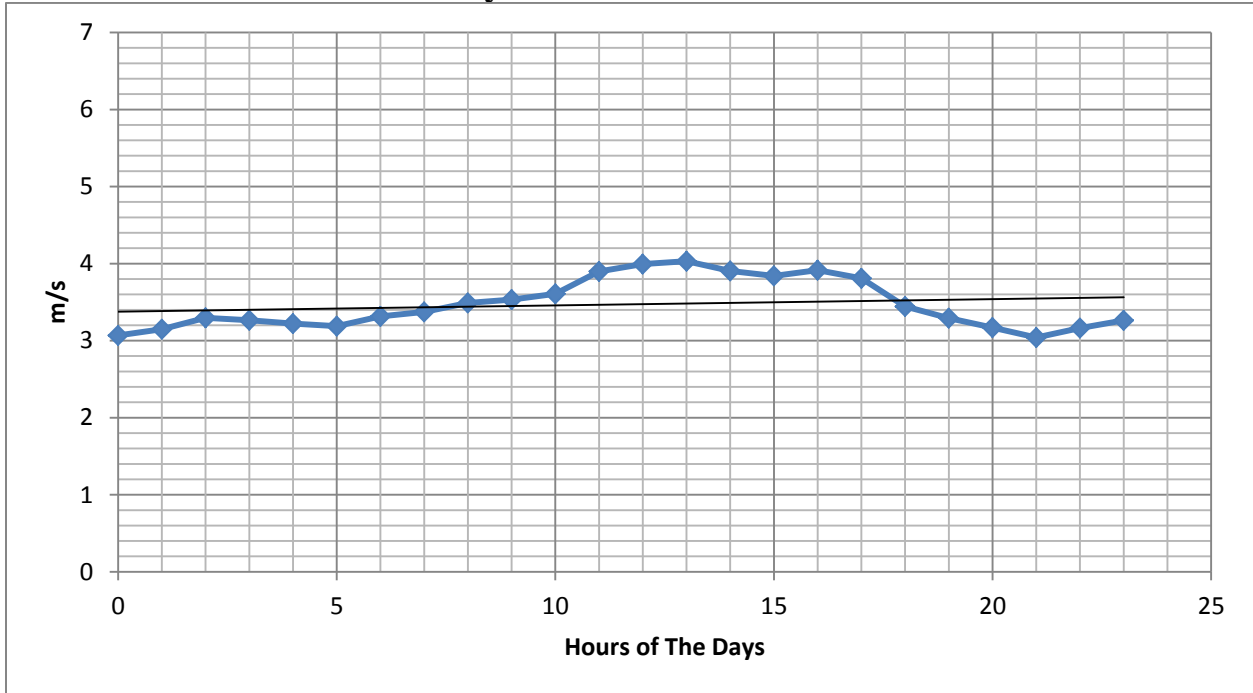
April 2011 - 30m Diurnal



May 2011 - 20m Diurnal

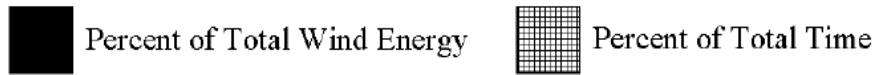


May 2011 - 30m Diurnal

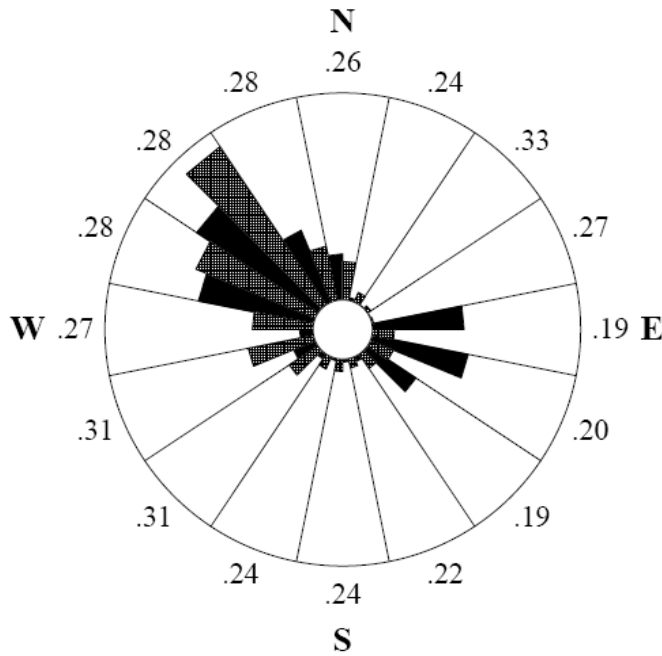


The normal direction of wind speed is useful when sitting a wind turbine. The following plots, termed wind rose, show the prevailing wind direction for each month. A legend identifying each of the plot style types is below.

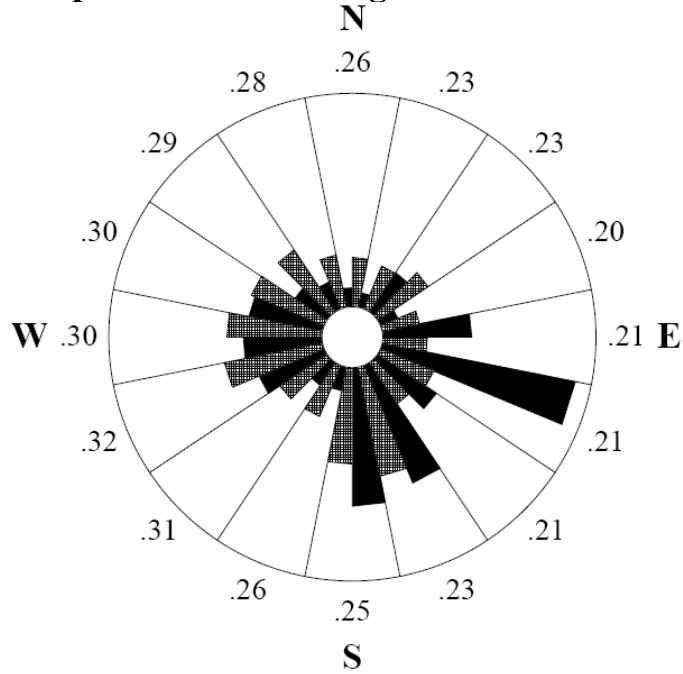
Wind Rose Legend



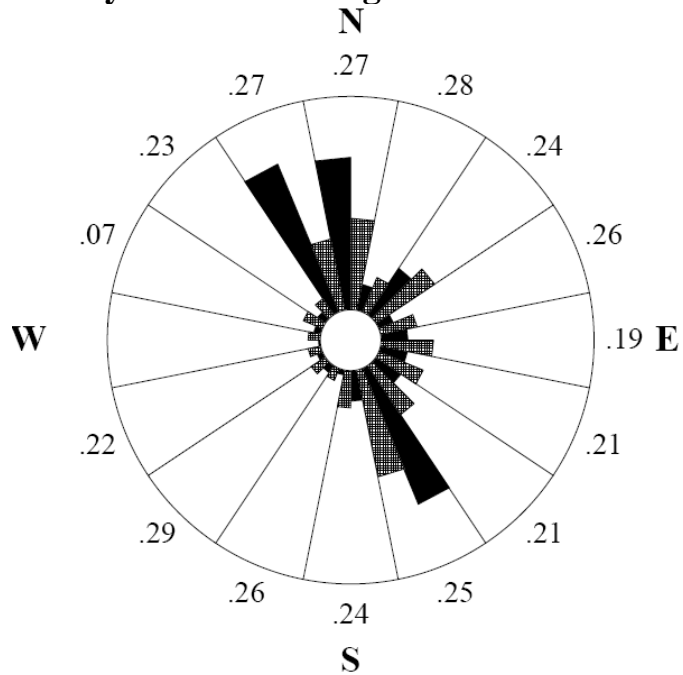
March 2011 Prevailing Wind Direction



April 2011 Prevailing Wind Direction

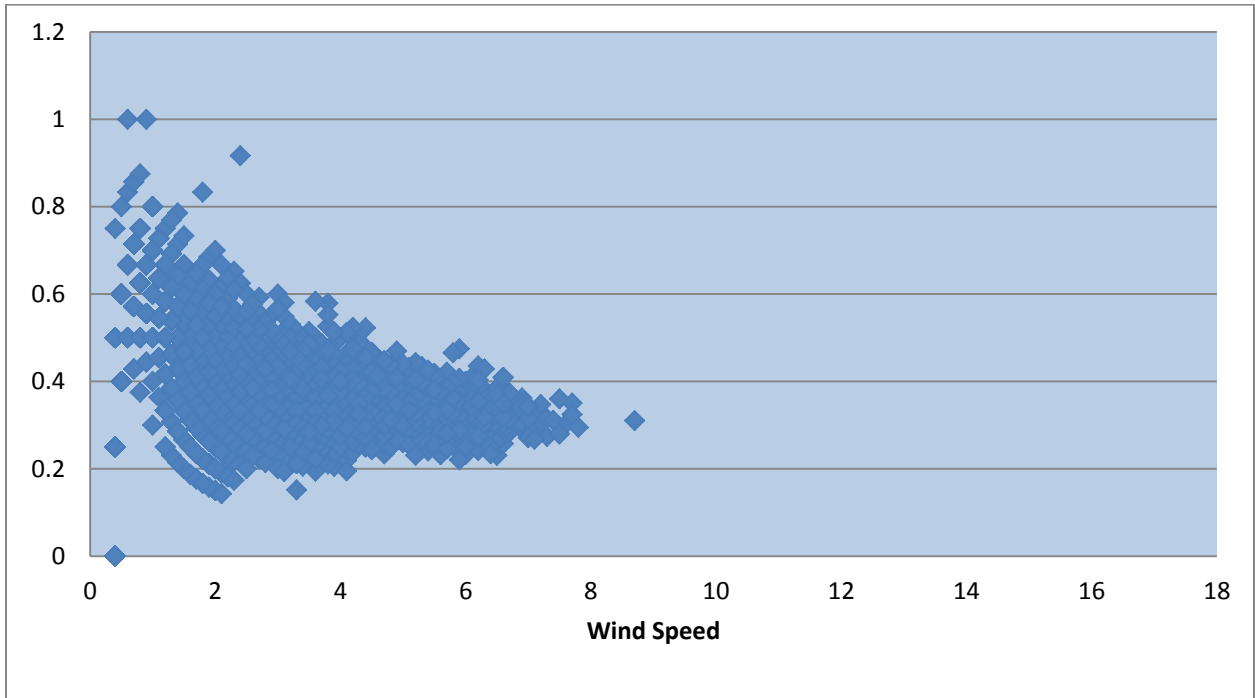


May 2011 Prevailing Wind Direction

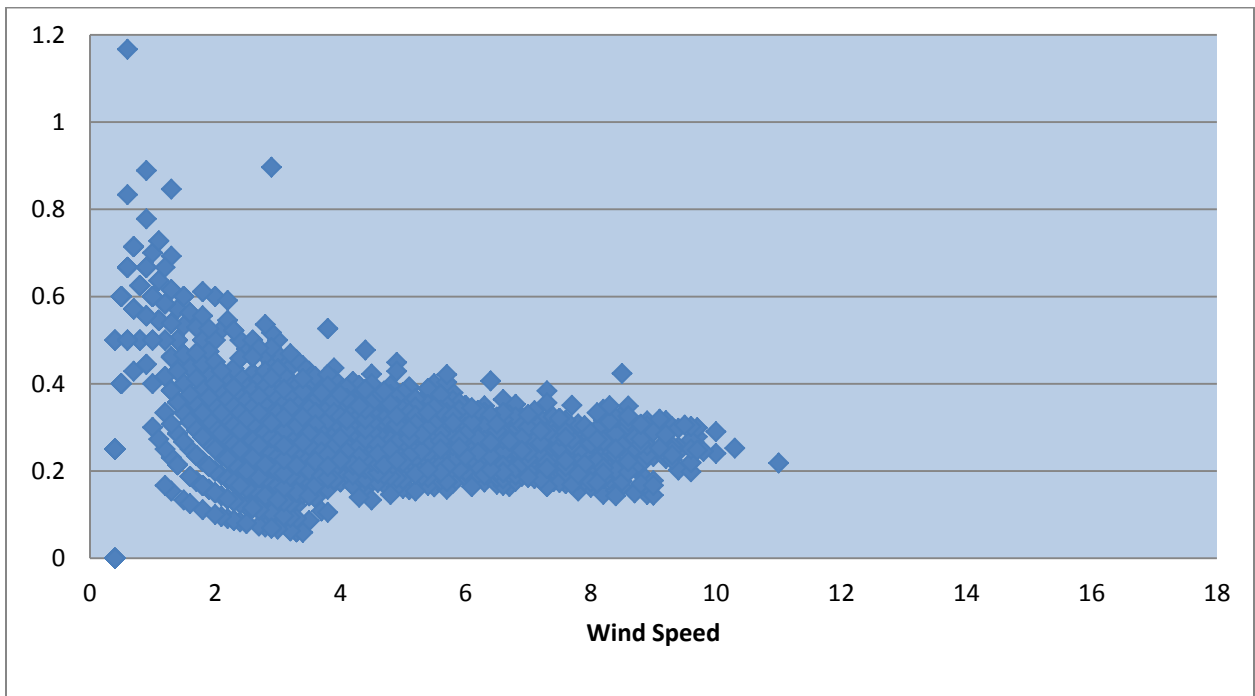


The final set of plots show the turbulence intensity. Turbulence intensity is calculated by dividing the standard deviation of the wind speed by the average wind speed and is plotted versus wind speed. It is used to determine the variation in wind speed that a turbine will see. Lower values of turbulence intensity translate to lower variations in mechanical loading.

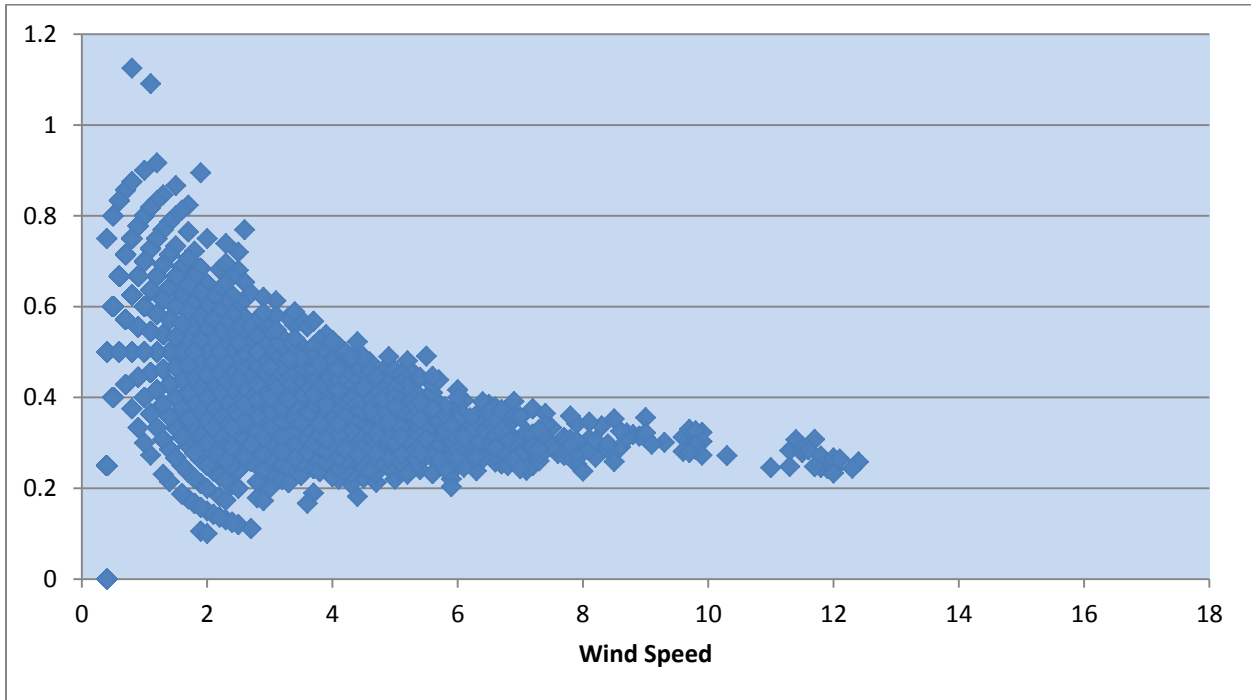
March 2011 - 20m Turbulence Intensity



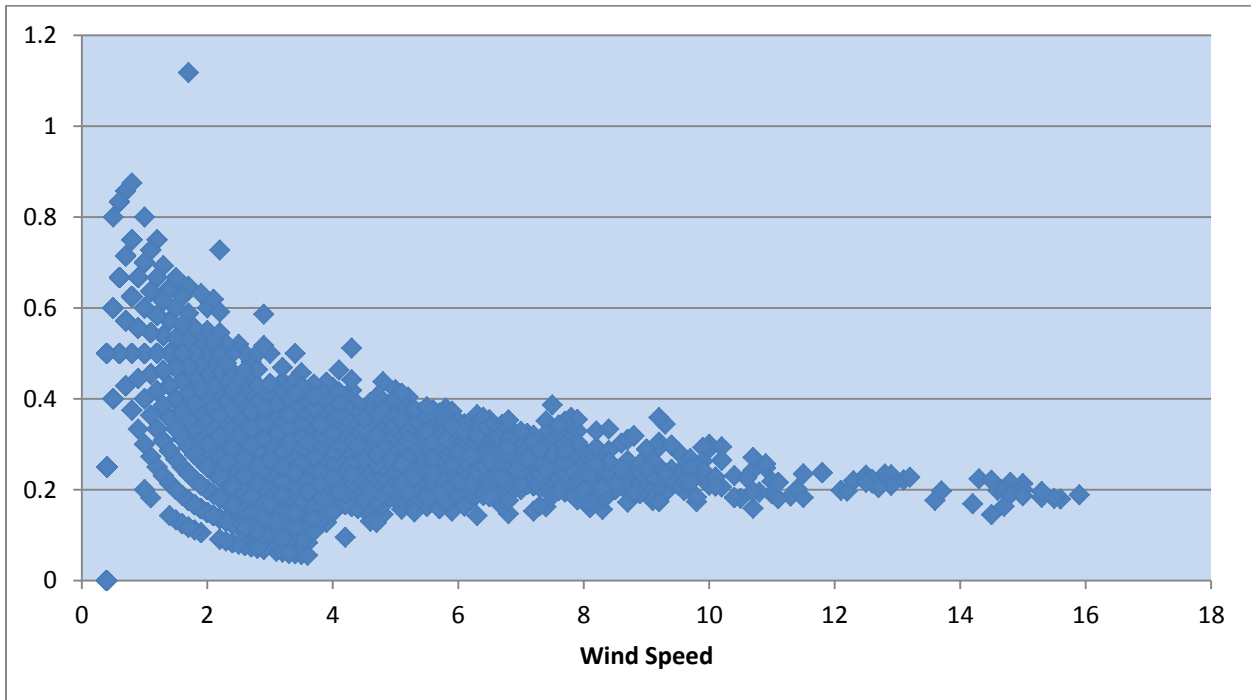
March 2011 - 30m Turbulence Intensity



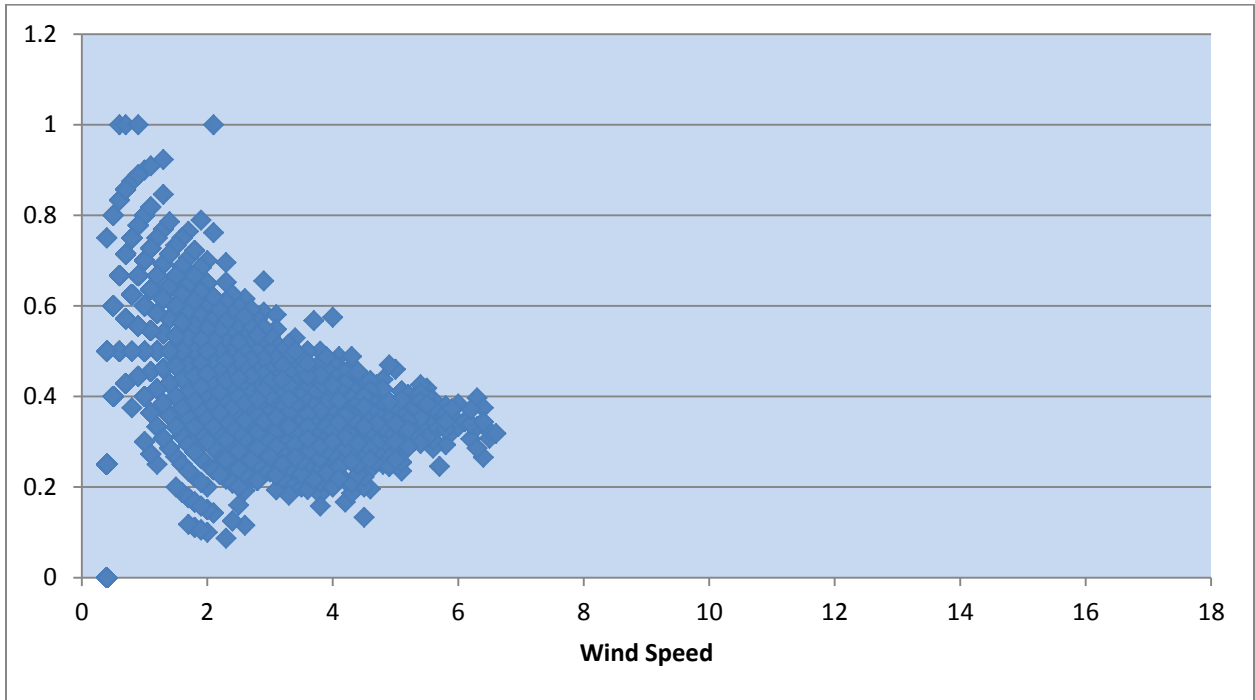
April 2011 - 20m Turbulence Intensity



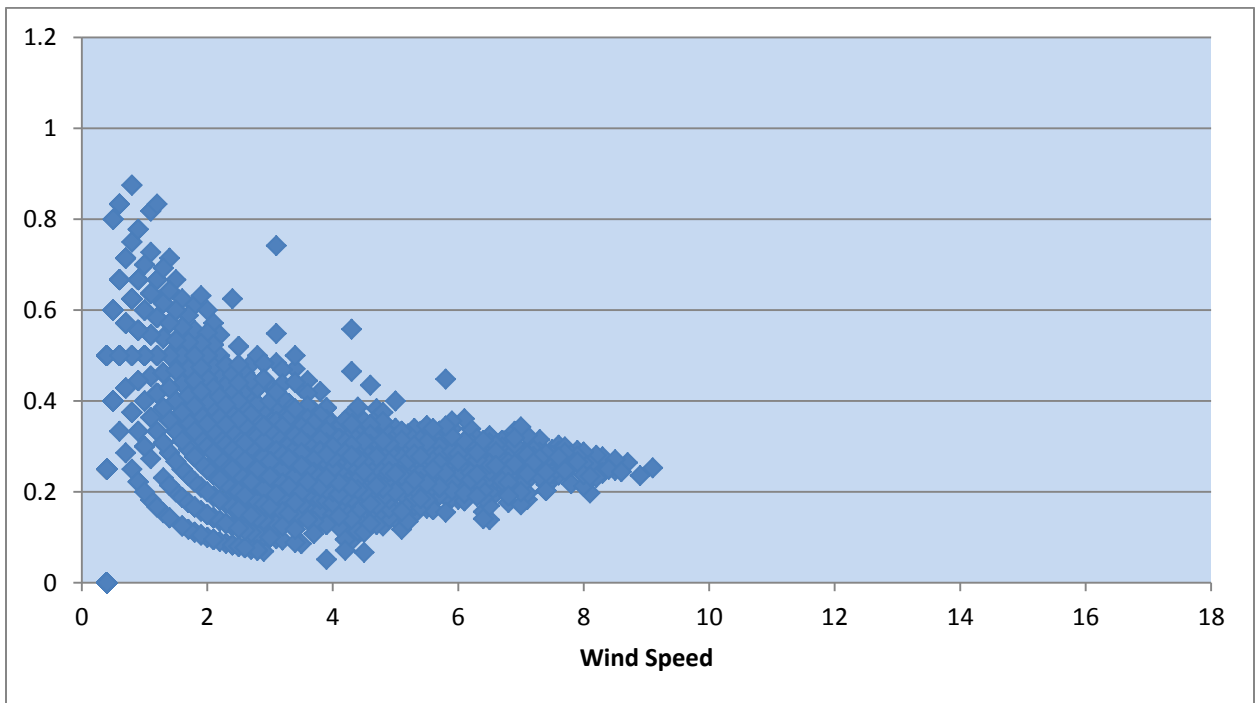
April 2011 - 30m Turbulence Intensity



May 2011 - 20m Turbulence Intensity



May 2011 - 30m Turbulence Intensity



Wind Shear

Wind shear is a measure of the rate of increase in wind speed as you increase the elevation. For wind developers, wind shear is important as it helps to determine the appropriate wind turbine hub height. The higher the value of shear, the faster the wind speed increases. This may result in lower hub heights to obtain required power production. Wind shear is determined using the wind anemometer at 30m and at 20m. Wind shear is a unit-less quantity. The calculation is as follows:

$$WS = \frac{\log\left(\frac{30m \text{ avg wind speed}}{20m \text{ avg wind speed}}\right)}{\log\left(\frac{30m}{20m}\right)}$$

Wind shear can be used to estimate the wind speed at a certain height using the following equation:

$$\text{Speed at height of interest} = \text{speed at known height} \left(\frac{\text{height of interest}}{\text{known height}} \right)^{\text{Wind Shear}}$$

Note that wind shear calculation is not a definitive method for calculating exact wind speed at a certain height. It is only an estimate. The following values of wind shear were calculated for each month:

Month	Wind Shear
March, 2011	0.845
April, 2011	1.038
May, 2011	0.909

Summary of Data

The following data is a summary of the data collected August 23, 2010 to May 31, 2011.

Month	30m Mean [m/s]	30m Max [m/s]	30m Turbulence Intensity	20m Mean [m/s]	20m Max [m/s]	20m Turbulence Intensity	Prevailing Wind Direction
Aug. 10	3.52	13.30	0.25	2.16	12.50	0.43	215
Sept. 10	3.42	14.00	0.27	2.29	12.90	0.42	199
Oct. 10	3.71	28.10	0.30	2.44	22.40	0.46	218
Nov. 10	4.08	16.60	0.27	2.75	23.10	0.42	245
Dec. 10	4.70	28.10	0.27	3.22	23.90	0.43	259
Jan. 11	3.66	21.70	0.28	2.52	19.30	0.43	273
Feb. 11	4.09	20.50	0.28	2.91	20.10	0.39	239
Mar. 11	4.38	20.90	0.28	3.19	16.30	0.38	206
Apr. 11	4.09	25.10	0.29	2.86	22.70	0.42	193
May. 11	3.47	16.70	0.28	2.45	16.70	0.42	169

Data Validation

The quality of data provided by the data logger is significant. The probability that all of the data is valid is low. As a result, it is necessary to check the data for errors or inconsistencies, to prevent invalid data from being included in the data analysis.

Expected Data Points

This refers to the number of data points that were expected to be recorded during a data collection period.

Actual Data Points

This refers to the number of data points actually recorded during the data collection period.

% Data Recovered

This calculation is used to determine the percentage of expected data points to actual data points recorded.

Min/Max Test

The Min/Max Test ensures that the data recorded is within the specified range of the instruments used at the site. The ranges used in the tests, were, 0 to 90m/s for wind speed, 0 to 4m/s for wind speed variation, 0 to 359.9°C for wind direction, and 60°C for temperature. If the data is not within the ranges of the related tests, the data is invalid and is flagged so. Data that is flagged invalid is removed before the analysis of the data is started.

Min/Max T Test

This test checks the variation of the data, using the wind speed and wind speed direction standard deviation. If the wind direction standard deviation is less than 0 degrees, or if the wind speed is less than 10 m/s and the wind direction standard deviation is greater than 100 degrees, or if the wind speed is greater than 10 m/s and the wind direction standard deviation is greater than 100 degrees, the data is in range. If the data does not pass this test the data is invalid and is removed before the data is analyzed.

Icing Test

The icing test is designed to find data that may be invalid due to conditions that cause the vane to be iced. It is determined by an average wind speed greater than 1m/s, a temperature less than 2°C, and a wind direction standard deviation less than 0.5m/s.

Hours Out of Range

The hours out of range are determined by the Min/Max and Min/Max T Test. This test flags data that falls outside of a specific range. The data that falls outside of the range determines the hours out of range.

Hours of Icing

The hours of icing are determined using the icing test. The test uses average wind speed, temperature, and wind direction standard deviation to determine what data to flag due to icing.

% Data Good

The percent of bad data is subtracted from the percent of the data recovered to determine the percent of good data.

March 2011 Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	%Data Recovered	Hours Out of Range	Hours of Icing	% Data Good
30m Wind Speed	4320	4320	100	0	0	100.00
30m Wind Speed SD	4320	4320	100	0	0	100.00
20m Wind Speed	4320	4320	100	0	0	100.00
20m Wind Speed SD	4320	4320	100	0	0	100.00
Wind Dir.	4320	4320	100	0	0	100.00
Temp.	4320	4320	100	0	0	100.00
Total	25920	25920	100	0	0	100.00

April 2011 Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	%Data Recovered	Hours Out of Range	Hours of Icing	% Data Good
30m Wind Speed	4320	4320	100	0	1.17	99.84
30m Wind Speed SD	4320	4320	100	0	0	100.00
20m Wind Speed	4320	4320	100	0	0	100.00
20m Wind Speed SD	4320	4320	100	0	0	100.00
Wind Dir.	4320	4320	100	0	0	100.00
Temp.	4320	4320	100	0	0	100.00
Total	25920	25920	100	0	1.17	99.97

May 2011 Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	%Data Recovered	Hours Out of Range	Hours of Icing	% Data Good
30m Wind Speed	4464	4464	100	0	0	100.00
30m Wind Speed SD	4464	4464	100	0	0	100.00
20m Wind Speed	4464	4464	100	0	0	100.00
20m Wind Speed SD	4464	4464	100	0	0	100.00
Wind Dir.	4464	4464	100	0	0	100.00
Temp.	4464	4464	100	0	0	100.00
Total	26784	26784	100	0	0	100.00

Total Data Collected From Aug 23, 2010 to May 31, 2011 Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	%Data Recovered	Hours Out of Range	Hours of Icing	% Data Good
Aug '10	7272	7272	100	0	0	100.00
Sept '10	25920	25920	100	0	0	100.00
Oct '10	26784	26784	100	0	0	100.00
Nov '10	25920	25920	100	0	0	99.98
Dec'10	26784	26784	100	0	1	99.98
Jan'11	26784	26784	100	0	47	98.95
Feb'11	24186	24186	100	0	0.17	100.00
Mar'11	25920	25920	100	0	0	100.00
Apr'11	25920	25920	100	0	1.17	99.97
May'11	26784	26784	100	0	0	100.00
Total	242274	242274	100	0	49.34	99.89