

Wind Data Report
Peaks Island Wind Site
Peaks Island, Maine
Quarterly Report December 2010 to February 2011

Prepared by
The University of Maine
March 7, 2011



Notice and Acknowledgements

This report was prepared by the University of Maine and is sponsored by Efficiency Maine. The opinions expressed herein do not necessarily reflect those of Efficiency Maine or the State of Maine. Reference to any specific product, service process, or method does not constitute an implied or expressed recommendation or endorsement of it.

The University of Maine, Efficiency Maine, and State of Maine make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods or other information contained, described, disclosed or referred to in this report. The University of Maine, Efficiency Maine, and the State of Maine make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage directly or indirectly resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

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 December 1, 2010 through February 28, 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 4.15m/s..

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:

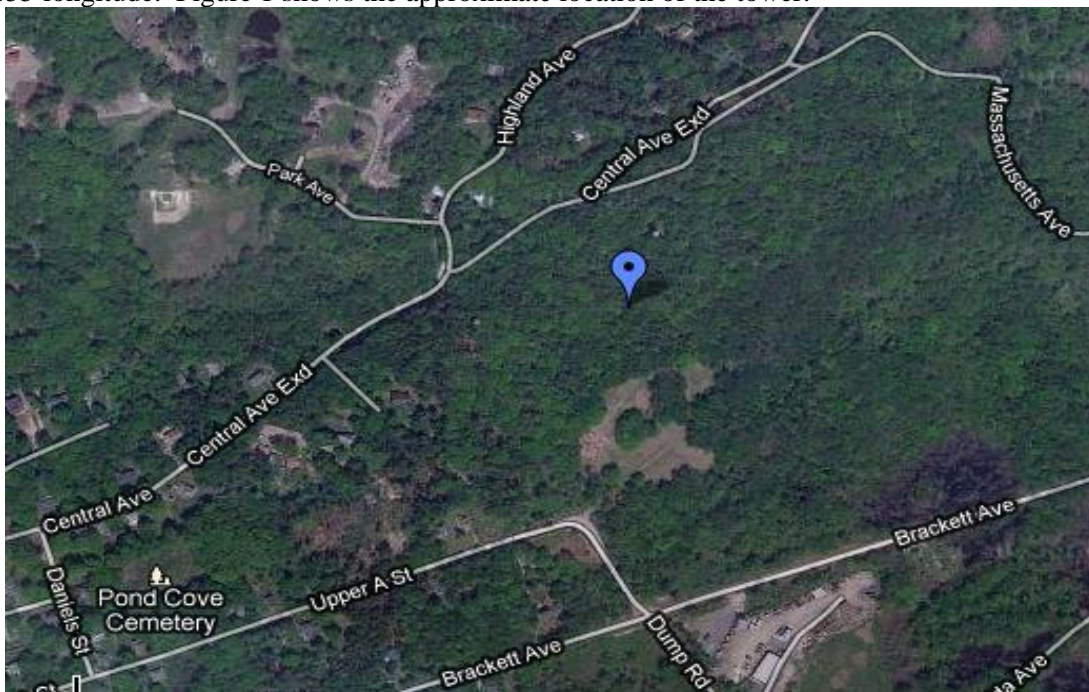


Figure 1 – Location of Tower

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

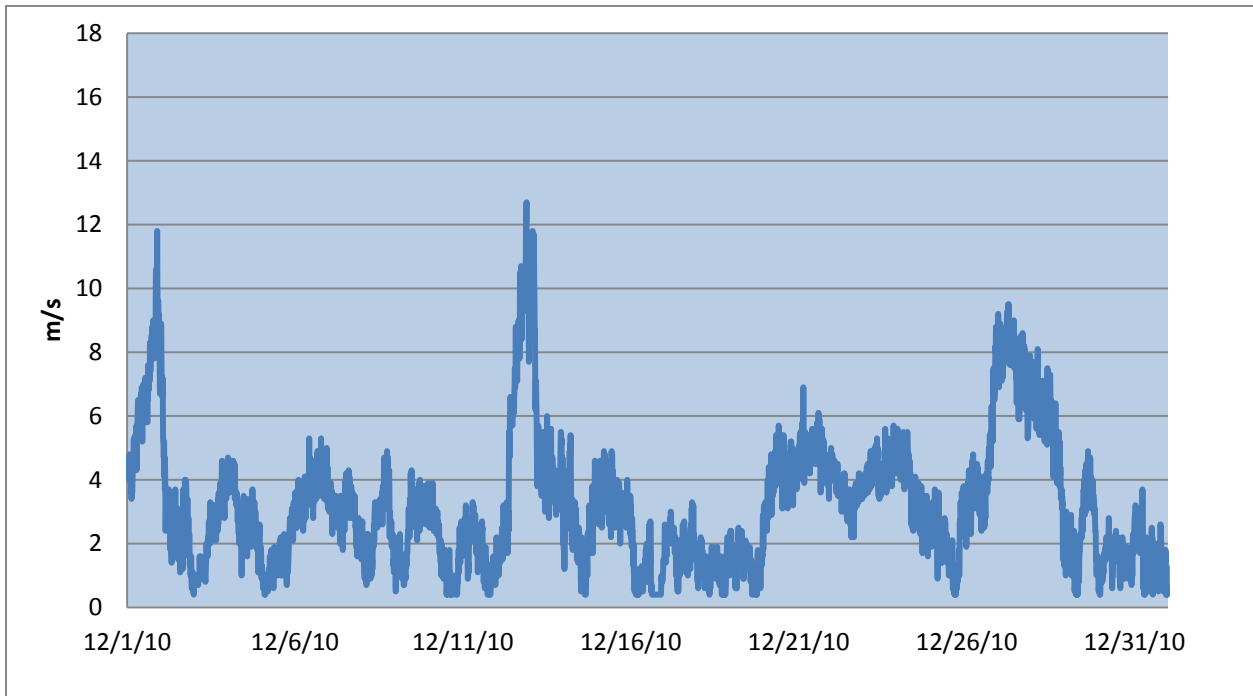
All data points from 12/01/2010 to 02/28/2011 were not recorded successfully. 164 data points were not properly recorded or transferred. This is less than 1% loss of data and does not impact the overall results.

Data Results

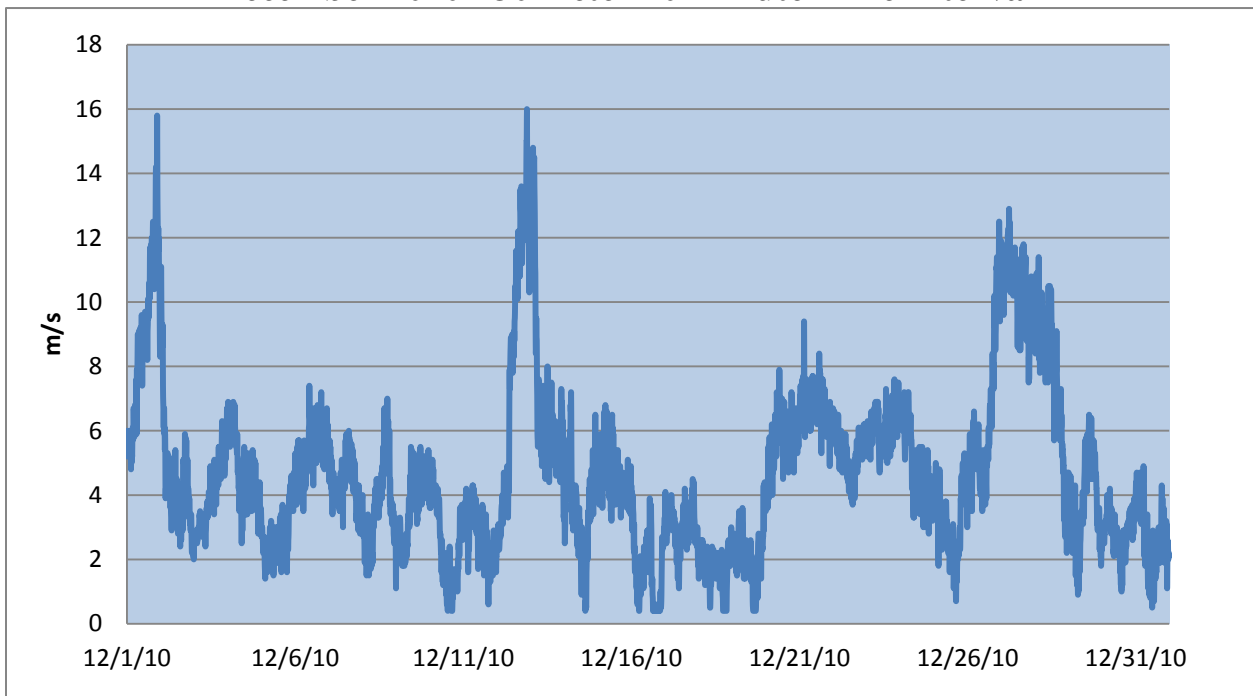
The average 30m wind speed for the entire monitoring period is 4.15 m/s. Standard commercial wind turbines have a nominal cut in speed of 4.5 to 5.3 m/s. The calculated average 30m wind speed at the site does not support the installation of a commercial scale turbine at 30m. However, new turbine designs 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:

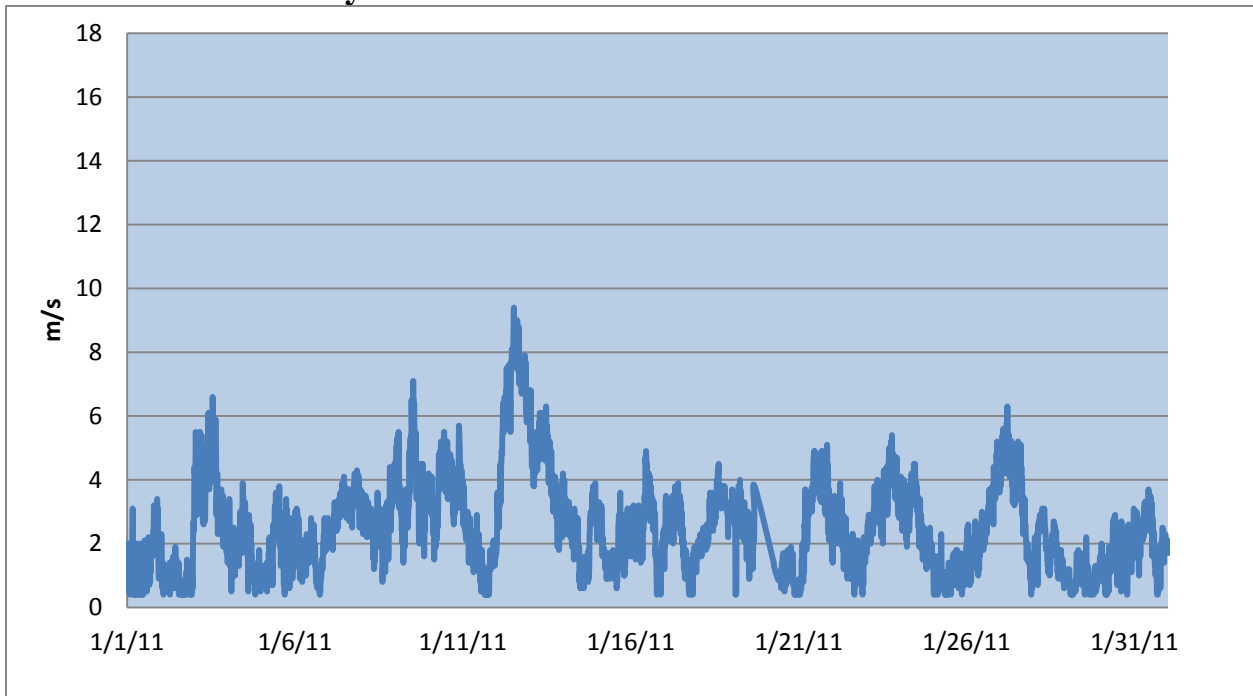
December 2010 - 20 meter 10 Minute Time Interval



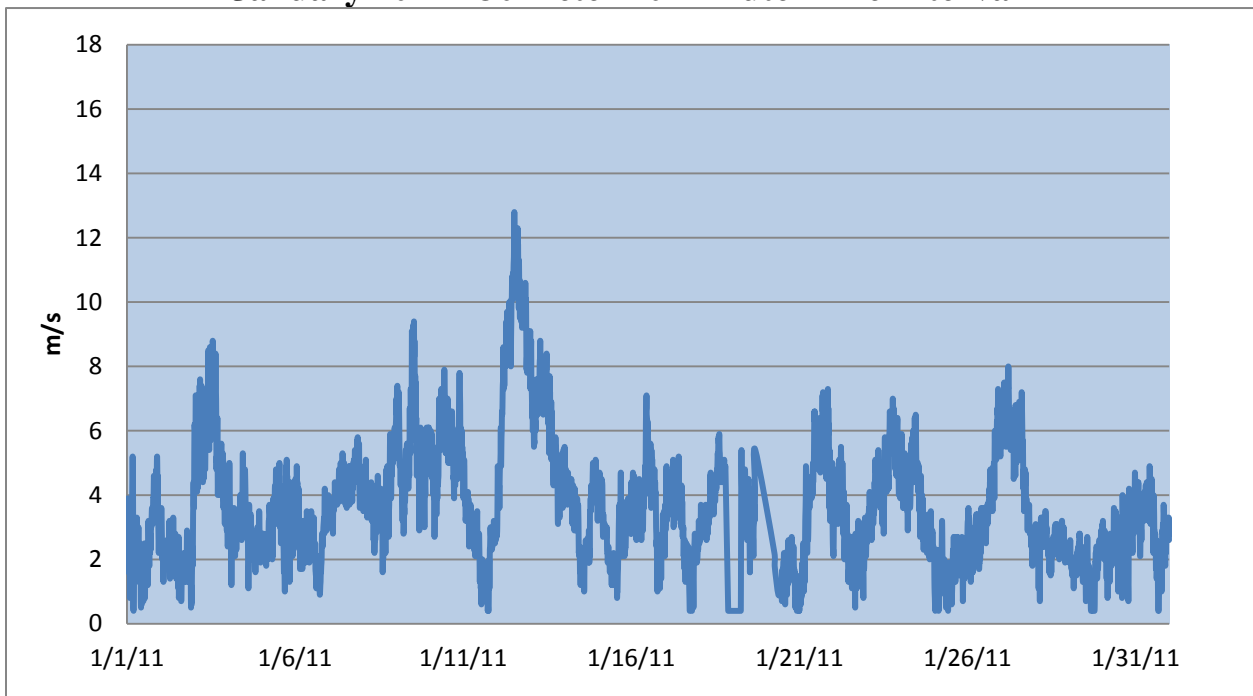
December 2010 - 30 meter 10 Minute Time Interval



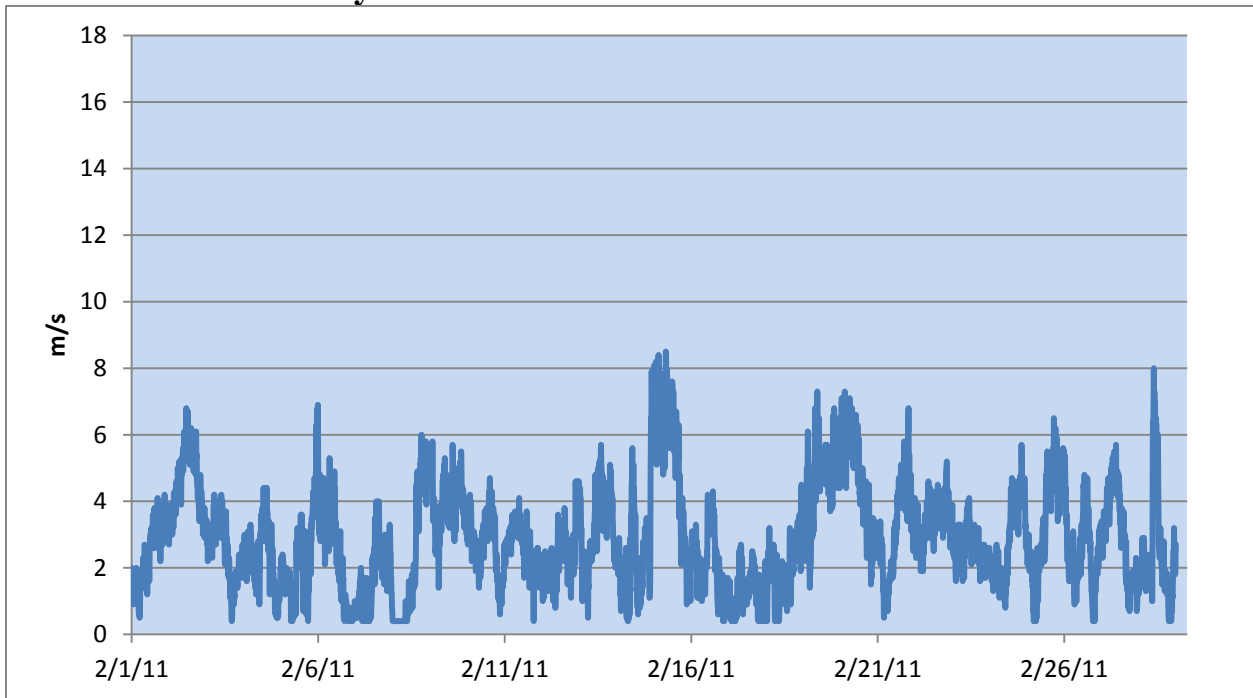
January 2011 - 20 meter 10 Minute Time Interval



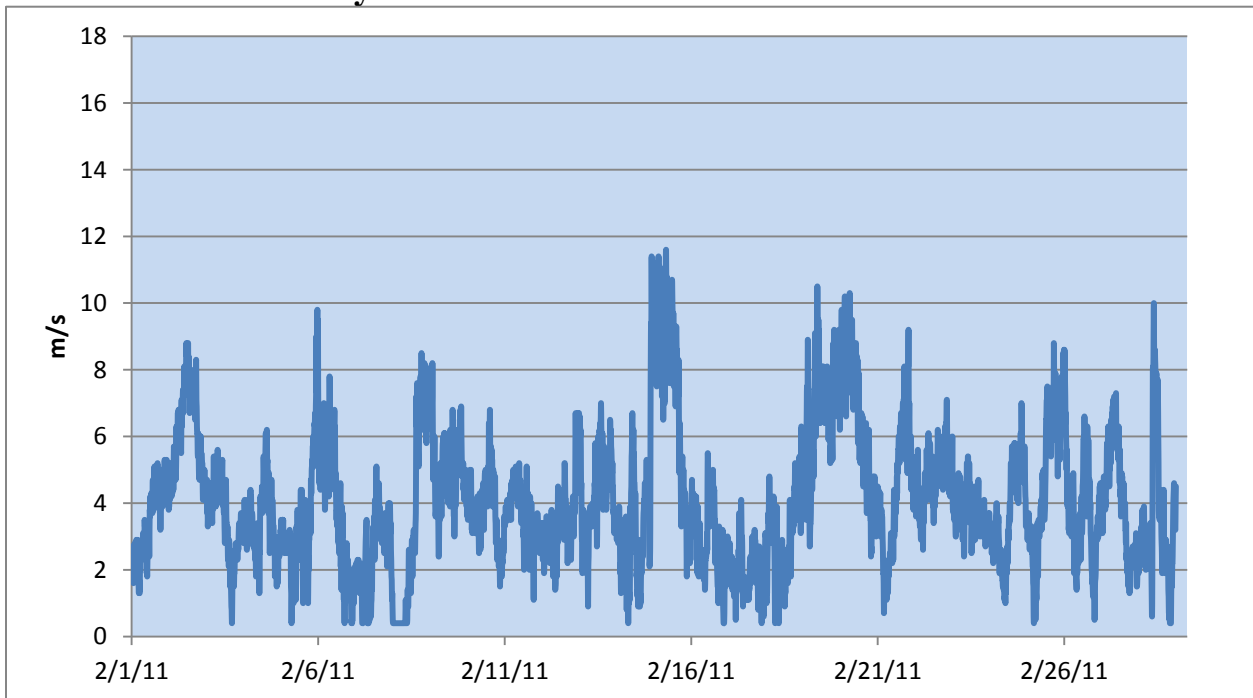
January 2011 - 30 meter 10 Minute Time Interval



February 2011 - 20 meter 10 Minute Time Interval

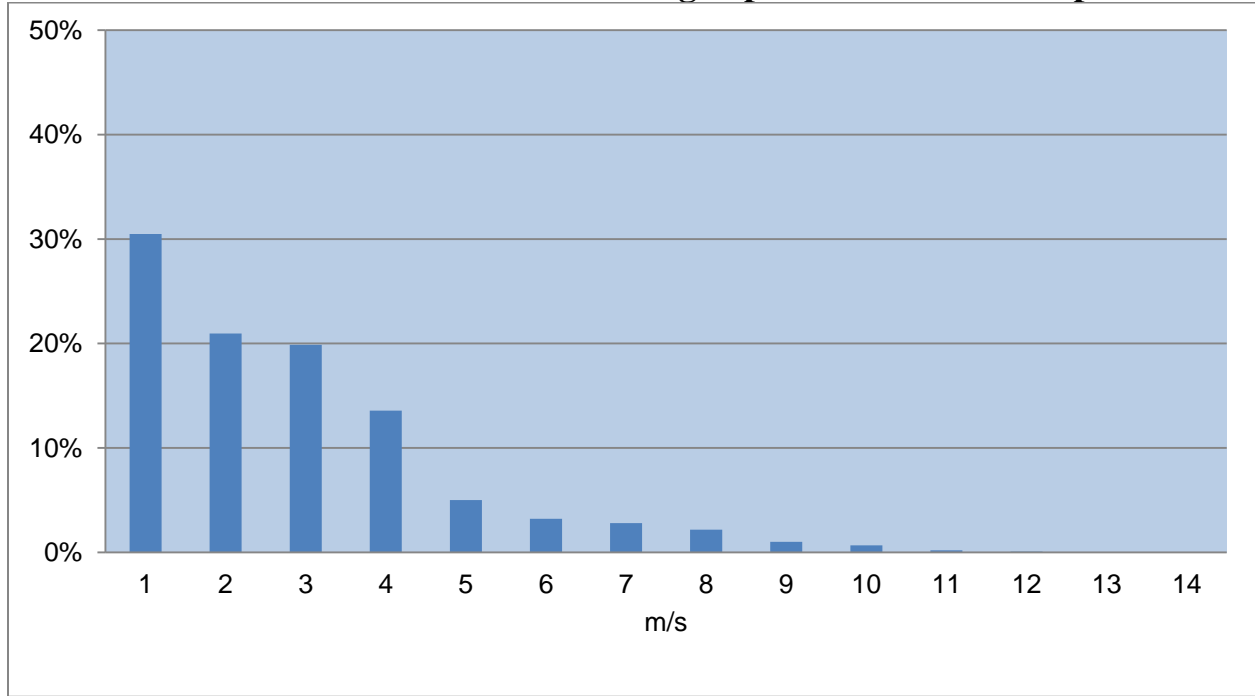


February 2011 - 30 meter 10 Minute Time Interval

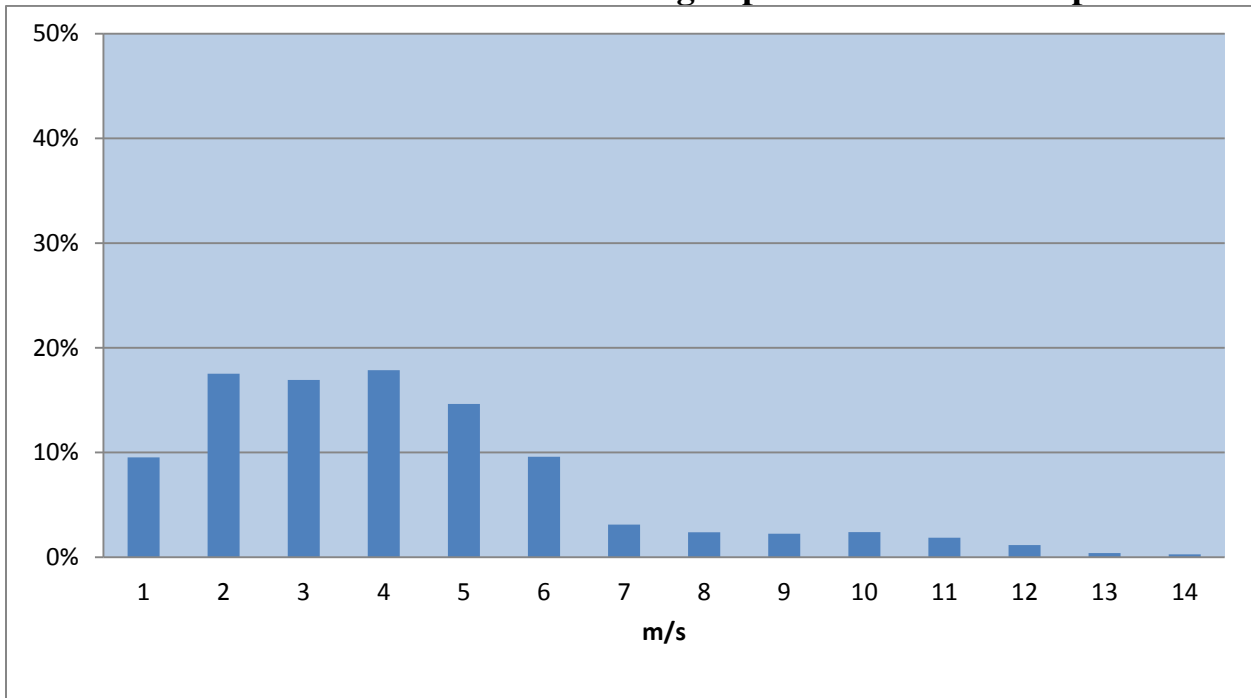


To estimate the anticipated output power for a particular site, forecasters develop equations based on probability. The analysis utilizes a Weibull Probability Density Function. To assist in the development of the probability density function, histograms depicting the percentage of time spent at a particular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

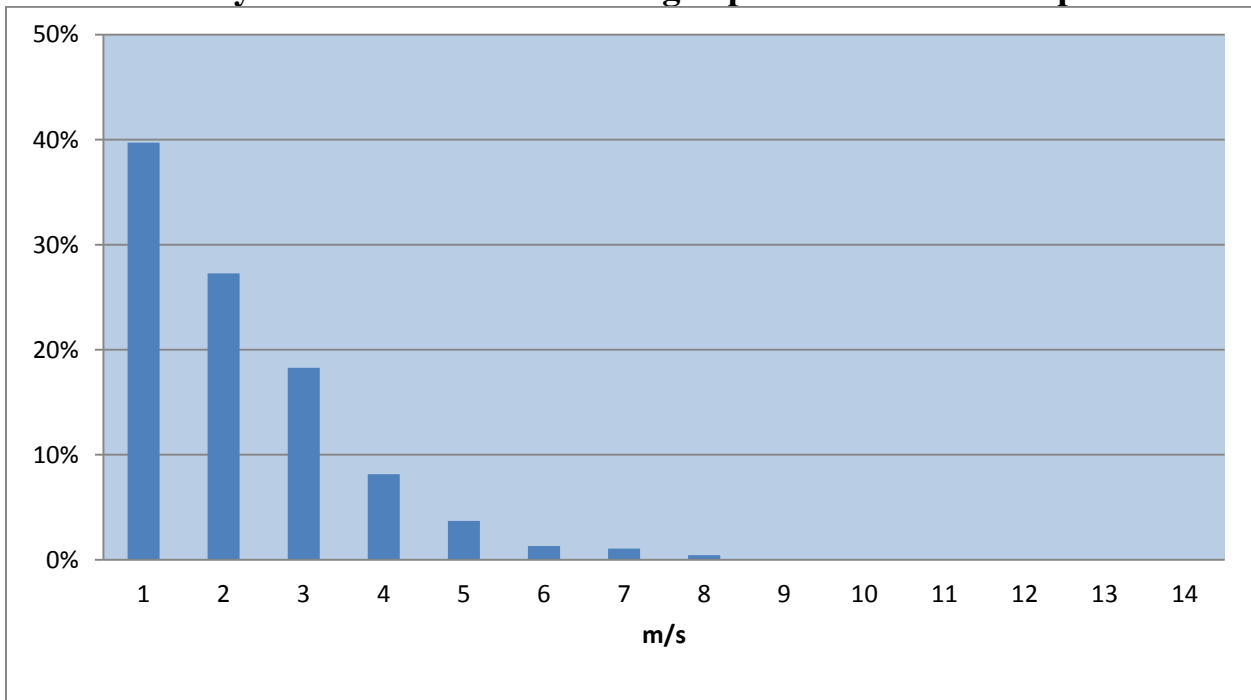
December 2010 - 20 Meter Percentage Spent at Each Wind Speed



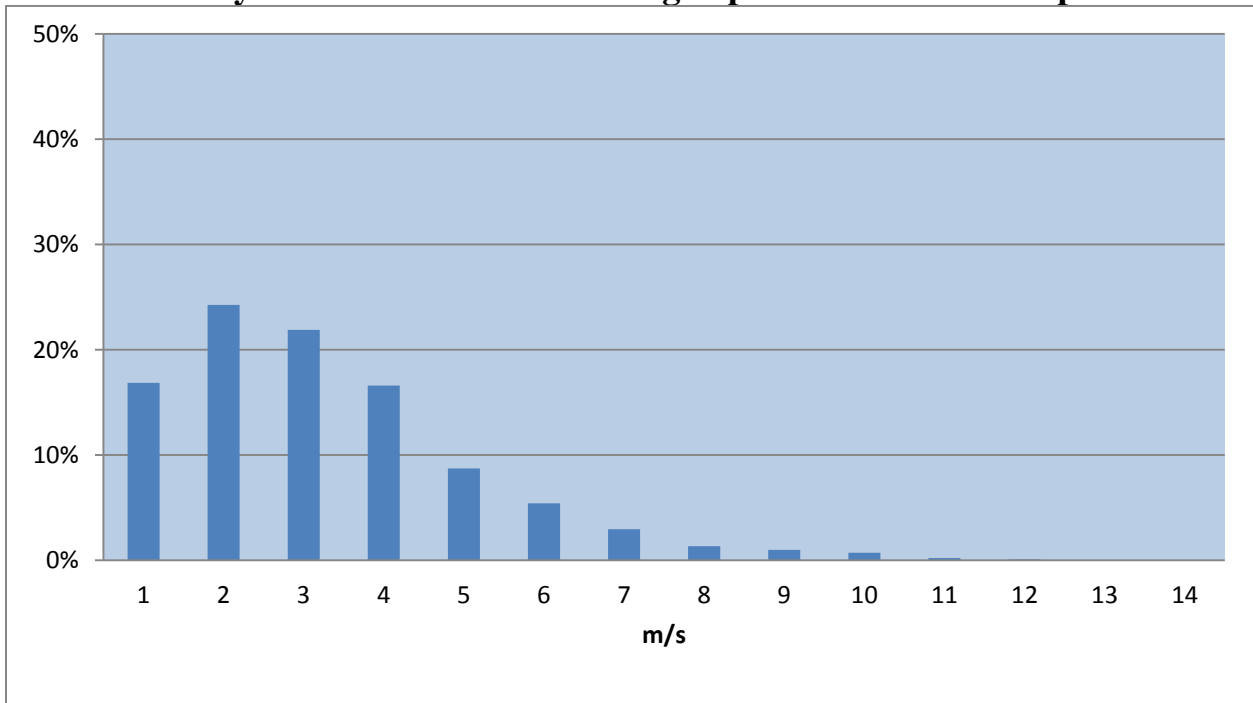
December 2010 - 30 Meter Percentage Spent at Each Wind Speed



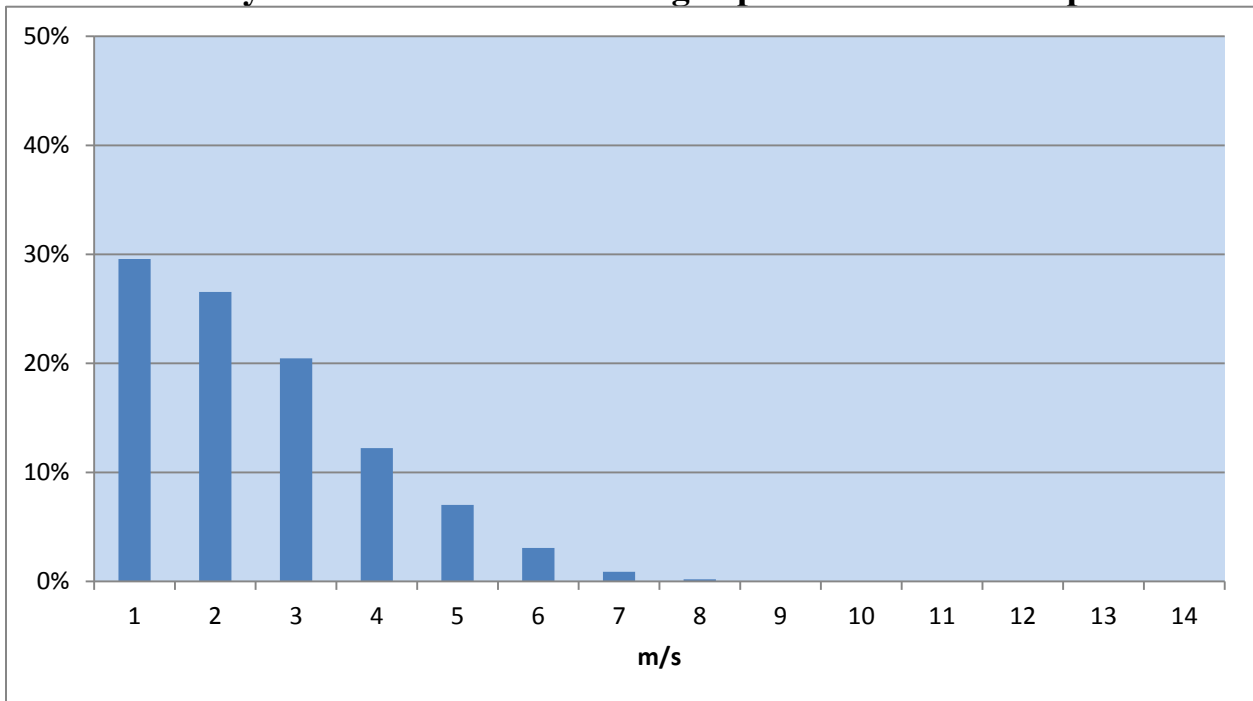
January 2011 - 20 Meter Percentage Spent at Each Wind Speed



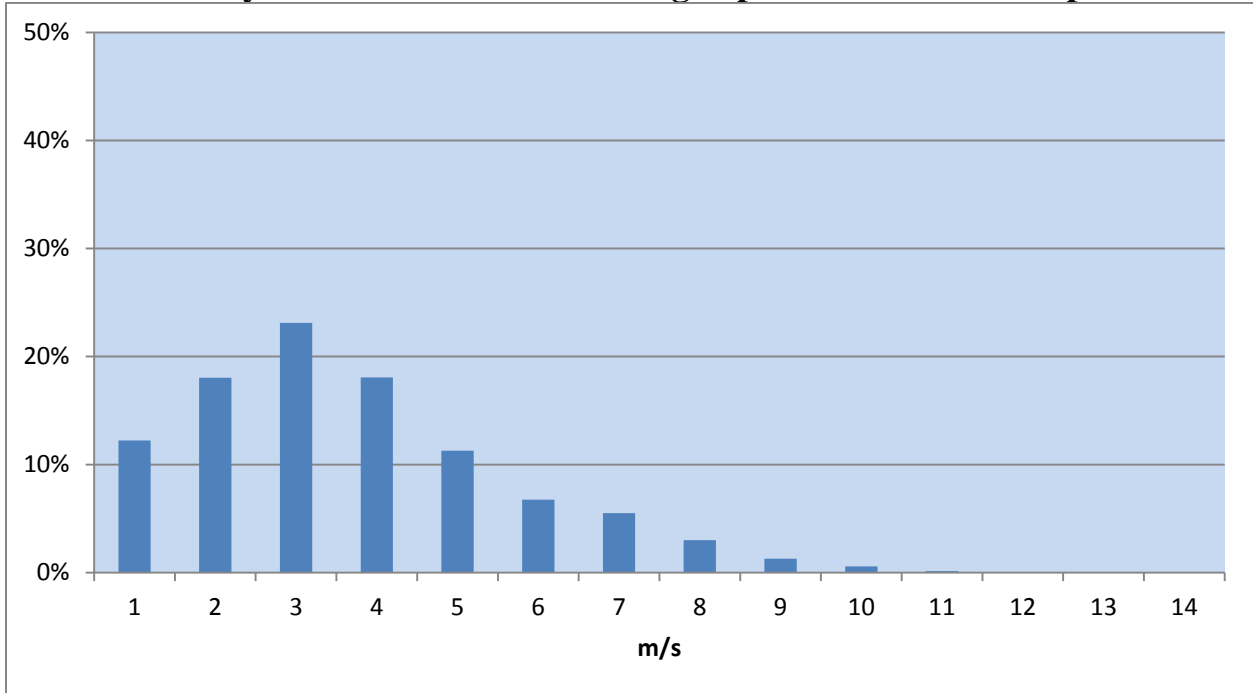
January 2011 - 30 Meter Percentage Spent at Each Wind Speed



February 2011 - 20 Meter Percentage Spent at Each Wind Speed

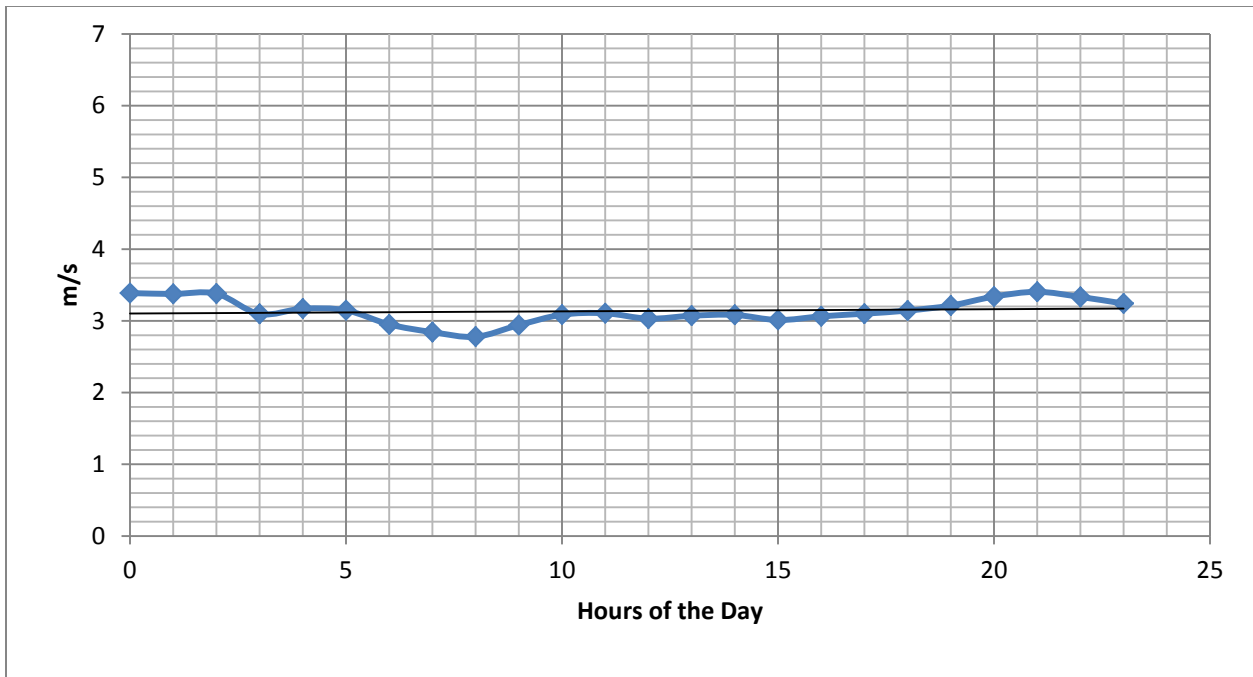


February 2011 - 30 Meter Percentage Spent at Each Wind Speed

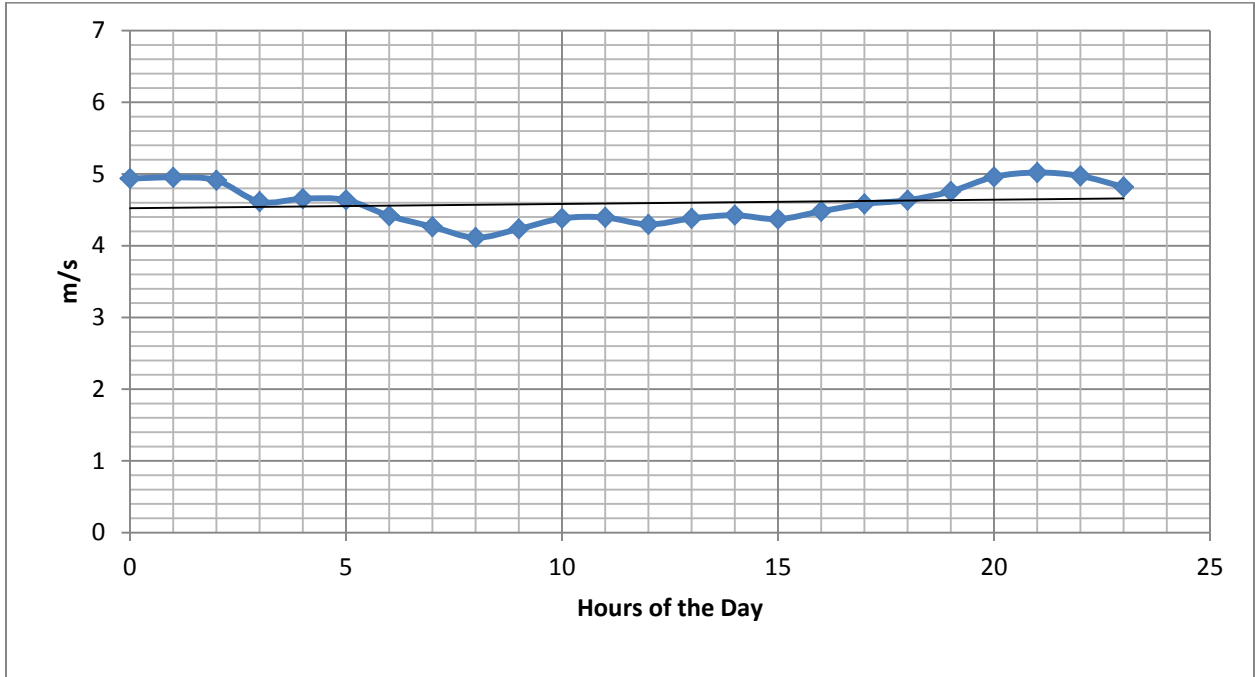


The following plots show the average wind speed each hour of the day. The data is useful to help energy forecasters match available energy from the wind with the demand on the electrical grid.

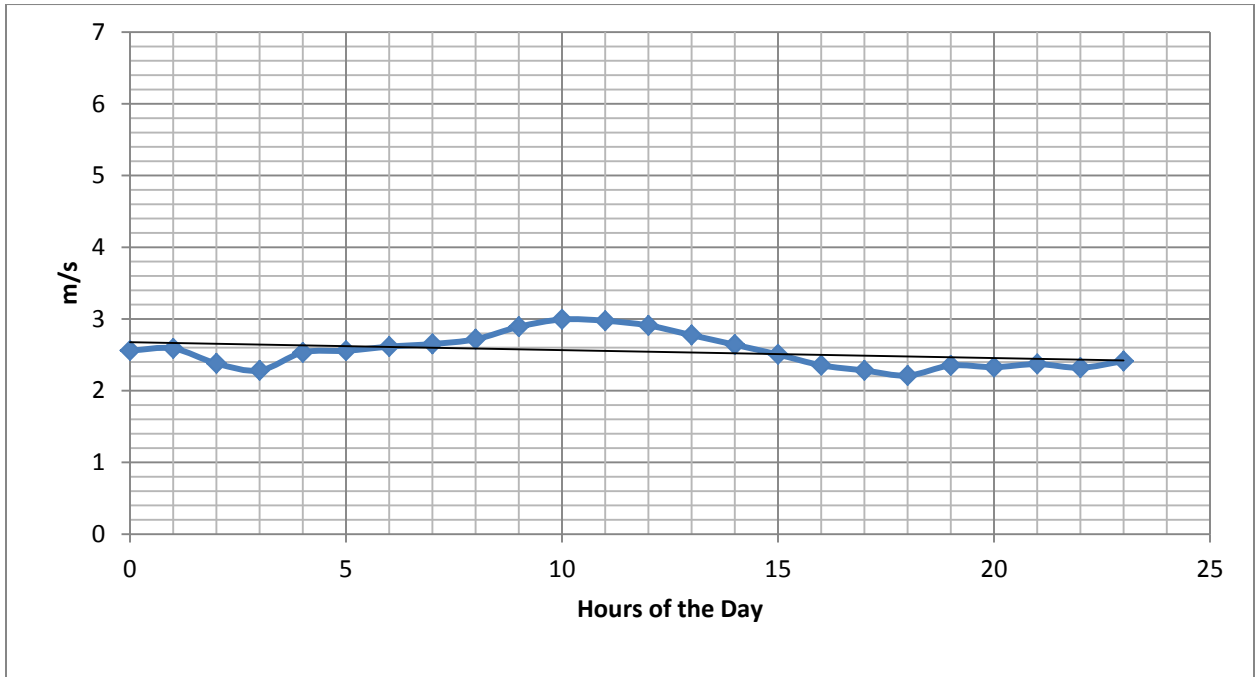
December 2010 - 20m Diurnal



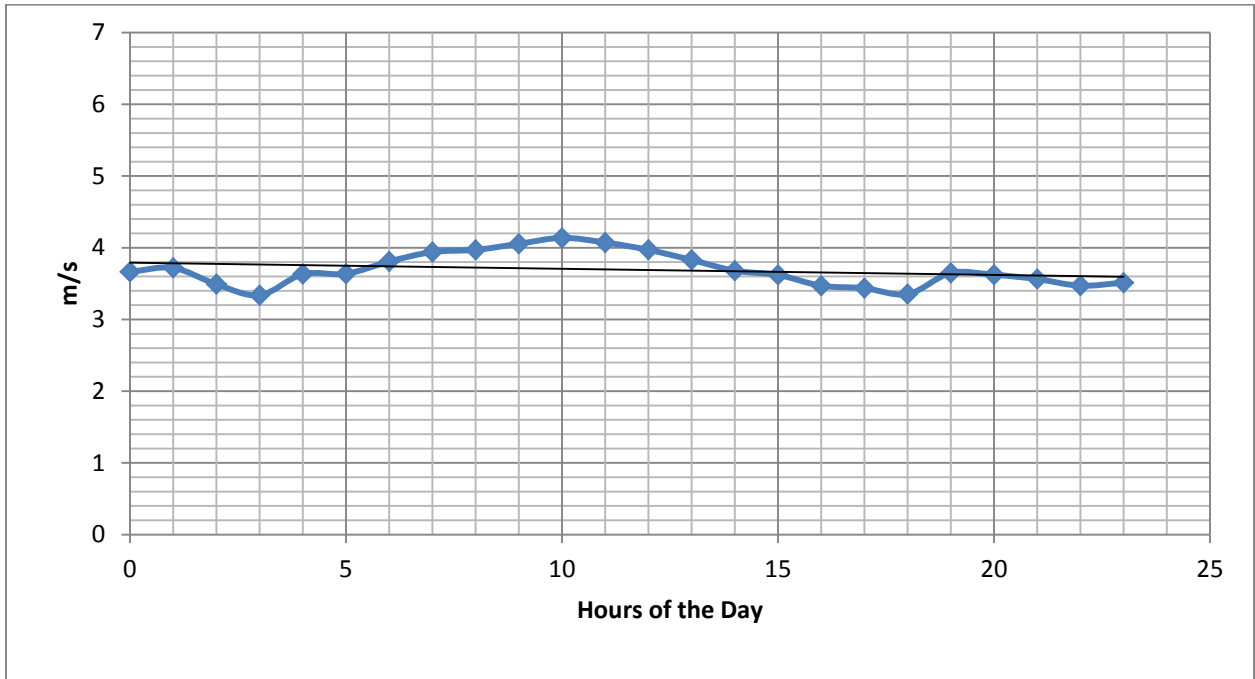
December 2010 - 30m Diurnal



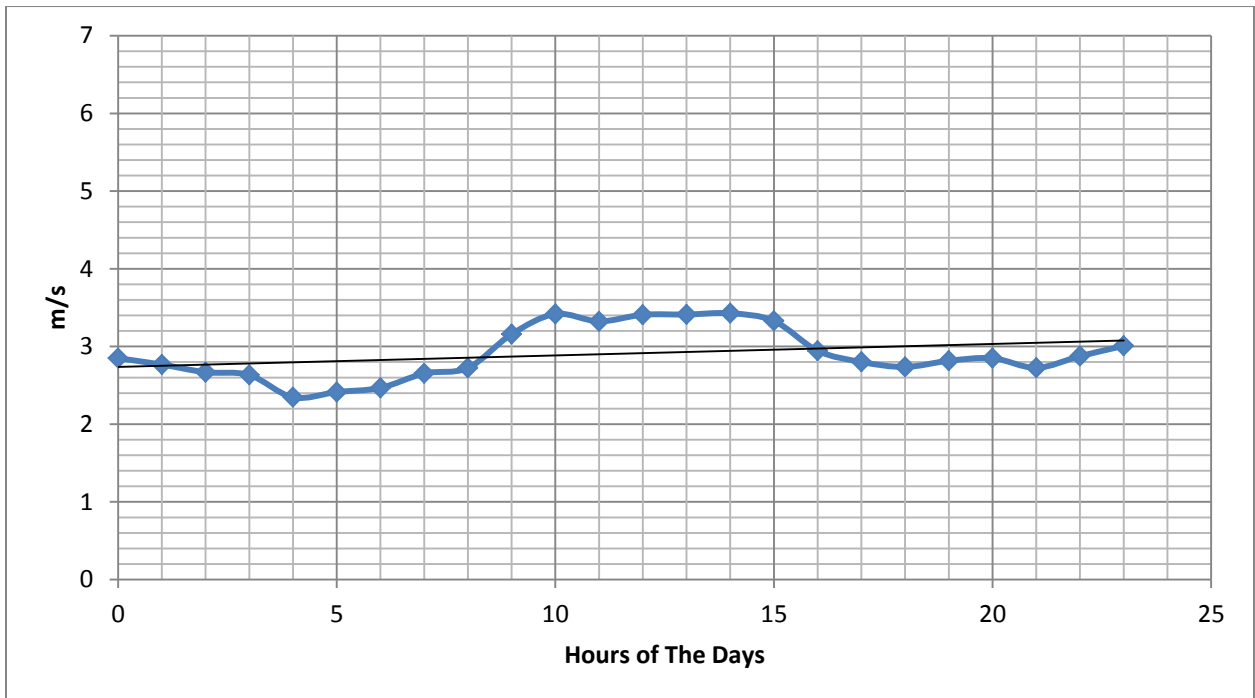
January 2011 - 20m Diurnal



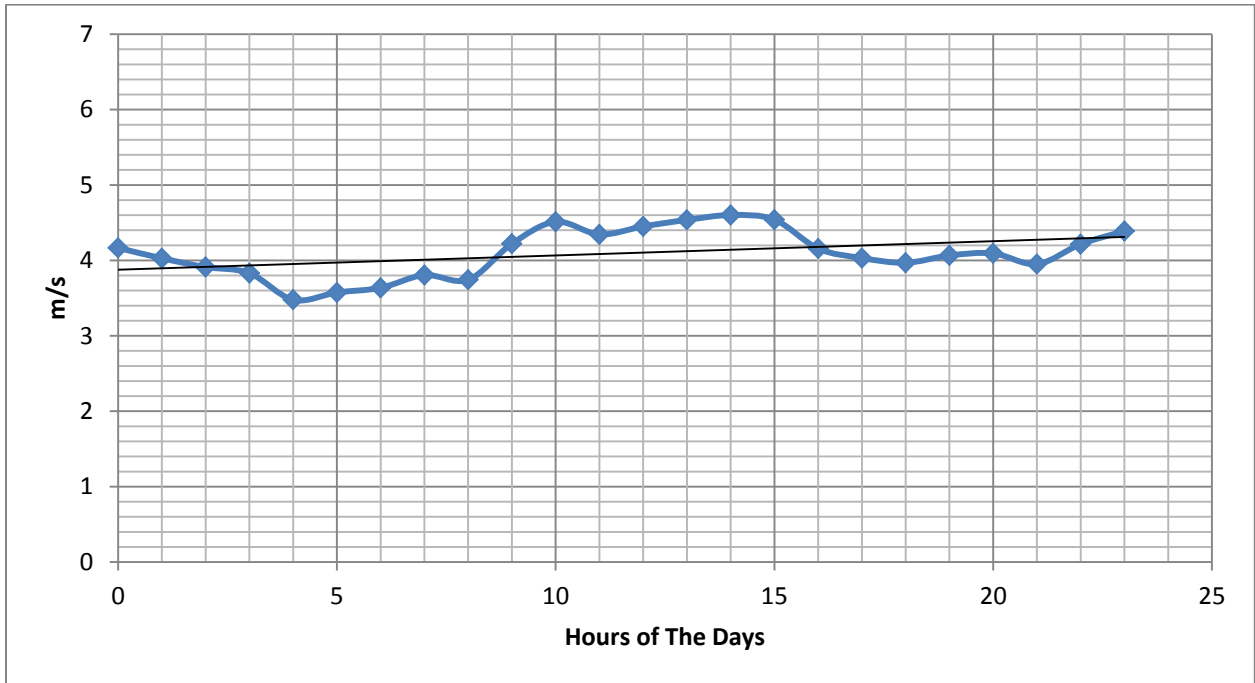
January 2011 - 30m Diurnal



February 2011 - 20m Diurnal

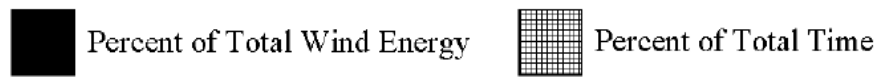


February 2011 - 30m Diurnal

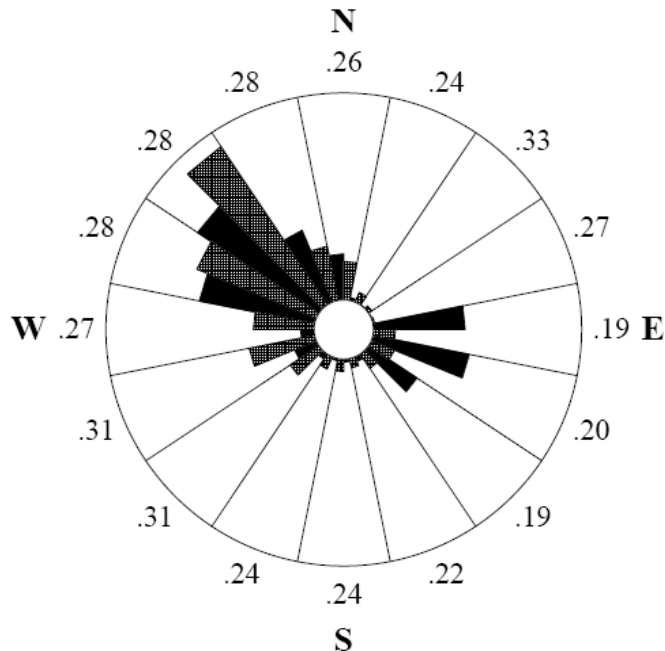


The normal direction of wind speed is useful when sitting a wind turbine. The following plots, termed wind rose, show the prevailing wind direction for each month. A legend identifying each of the plot style types is below.

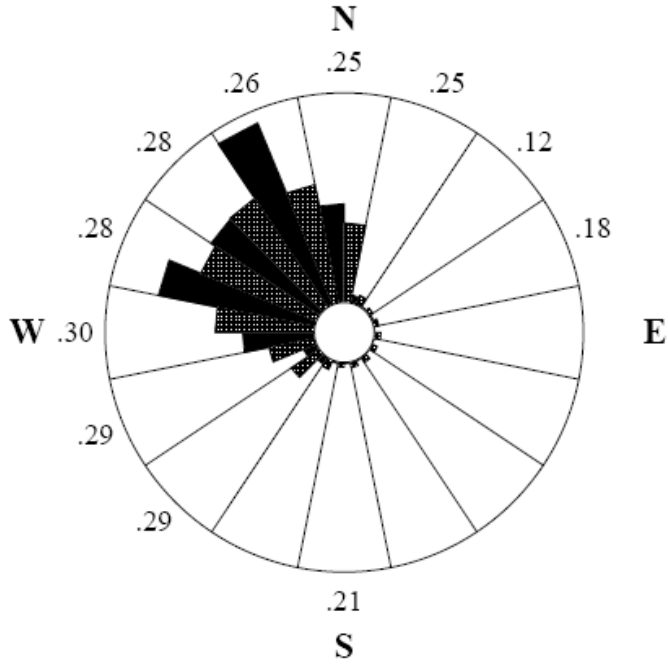
Wind Rose Legend



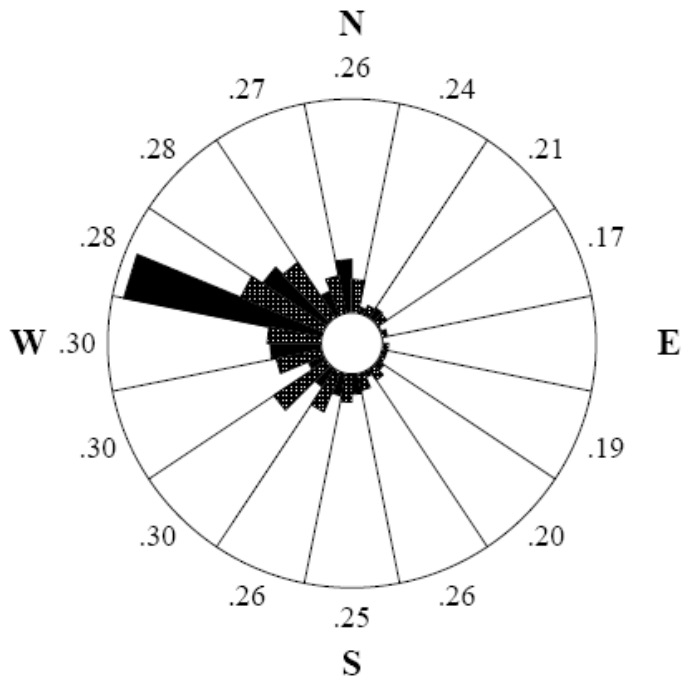
December 2010 Prevailing Wind Direction



January 2011 Prevailing Wind Direction

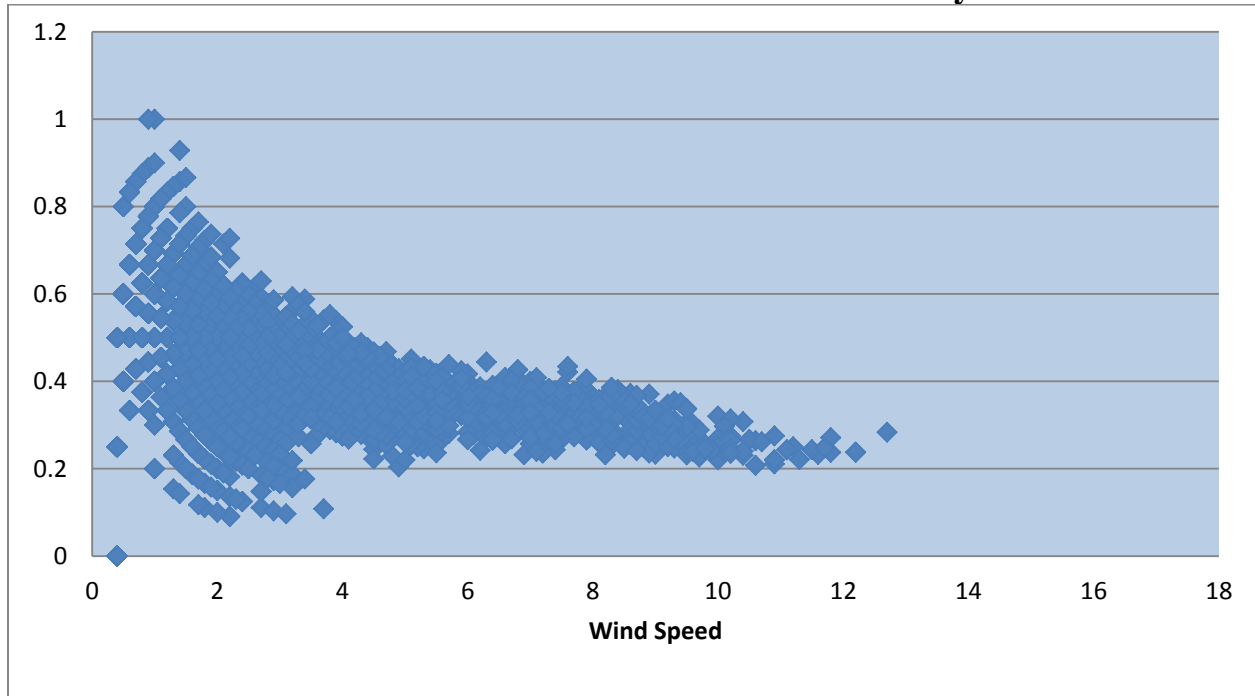


February 2011 Prevailing Wind Direction

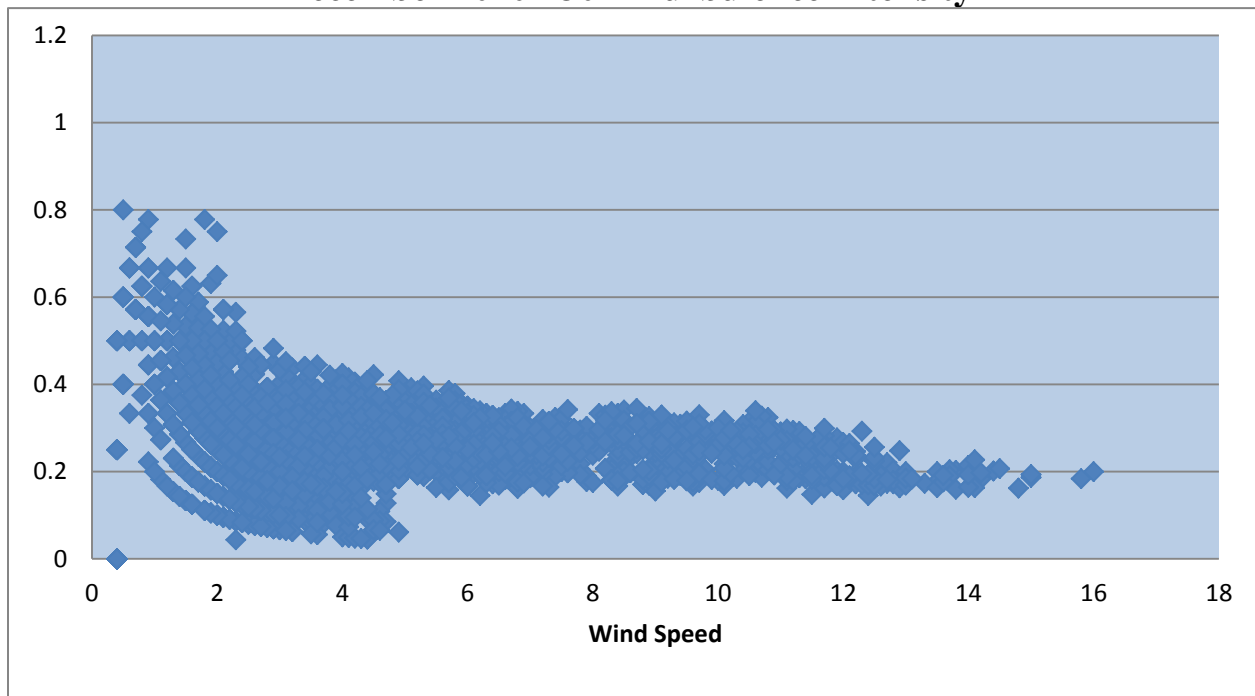


The final set of plots show the turbulence intensity. Turbulence intensity is calculated by dividing the standard deviation of the wind speed by the average wind speed and is plotted versus wind speed. It is used to determine the variation in wind speed that a turbine will see. Lower values of turbulence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

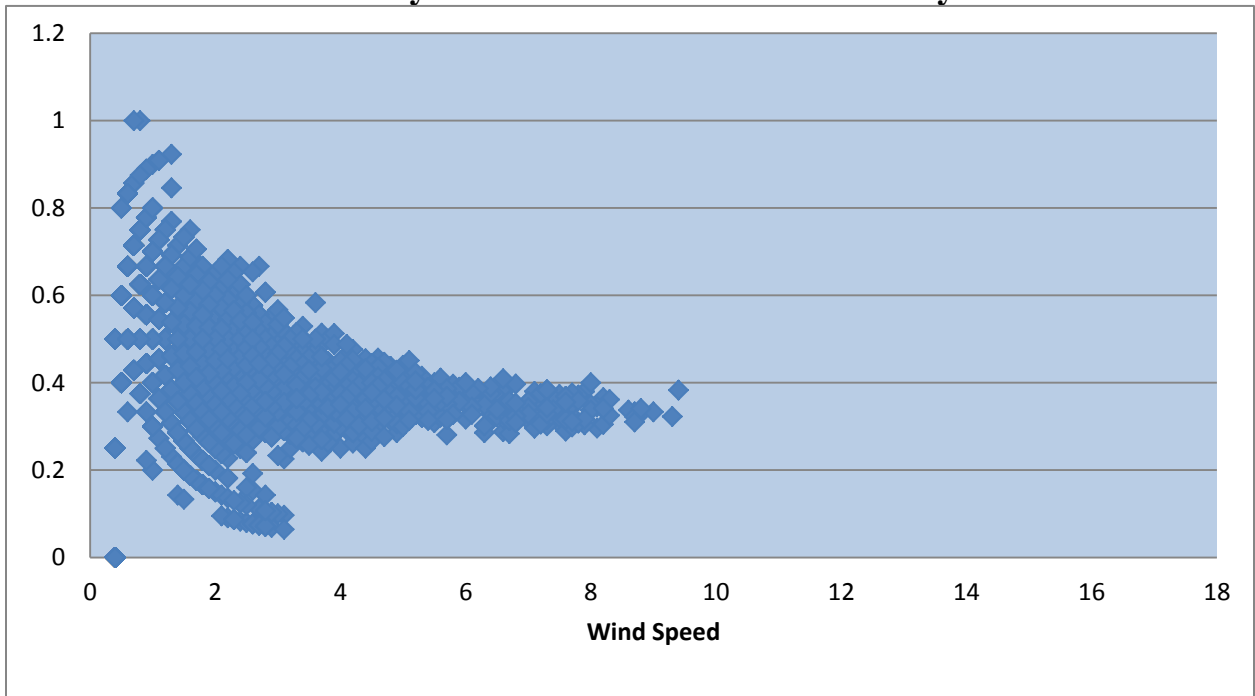
December 2010 - 20m Turbulence Intensity



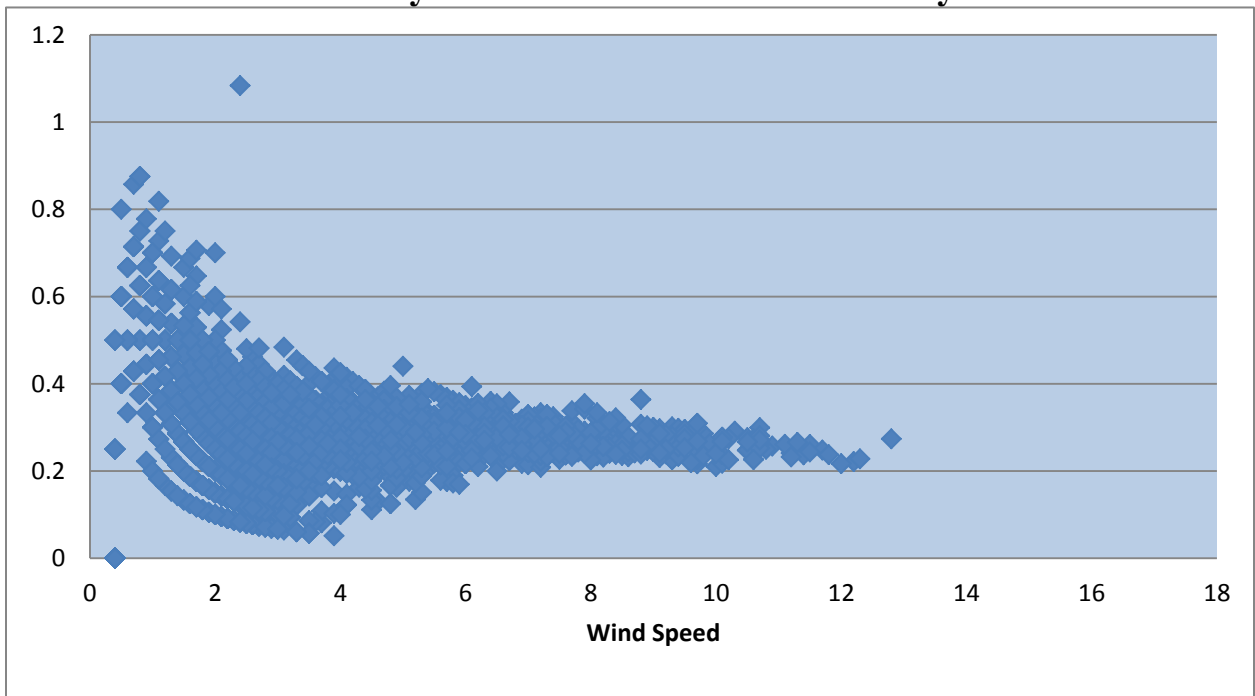
December 2010 - 30m Turbulence Intensity



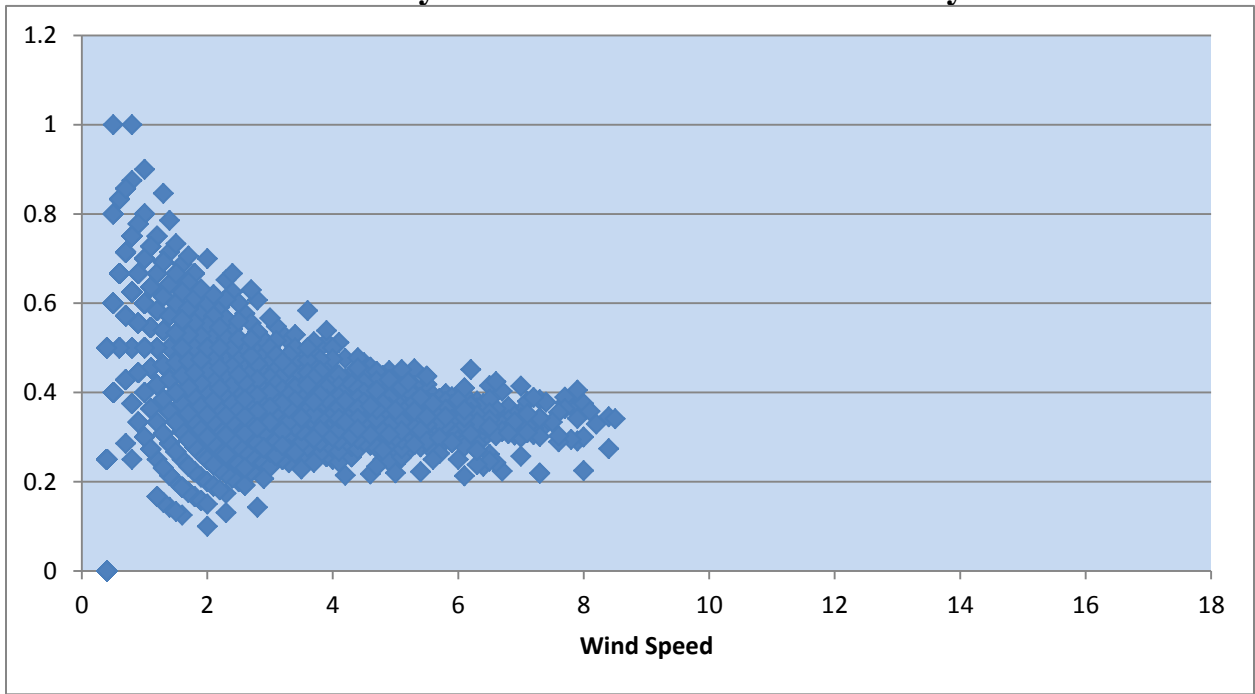
January 2011 - 20m Turbulence Intensity



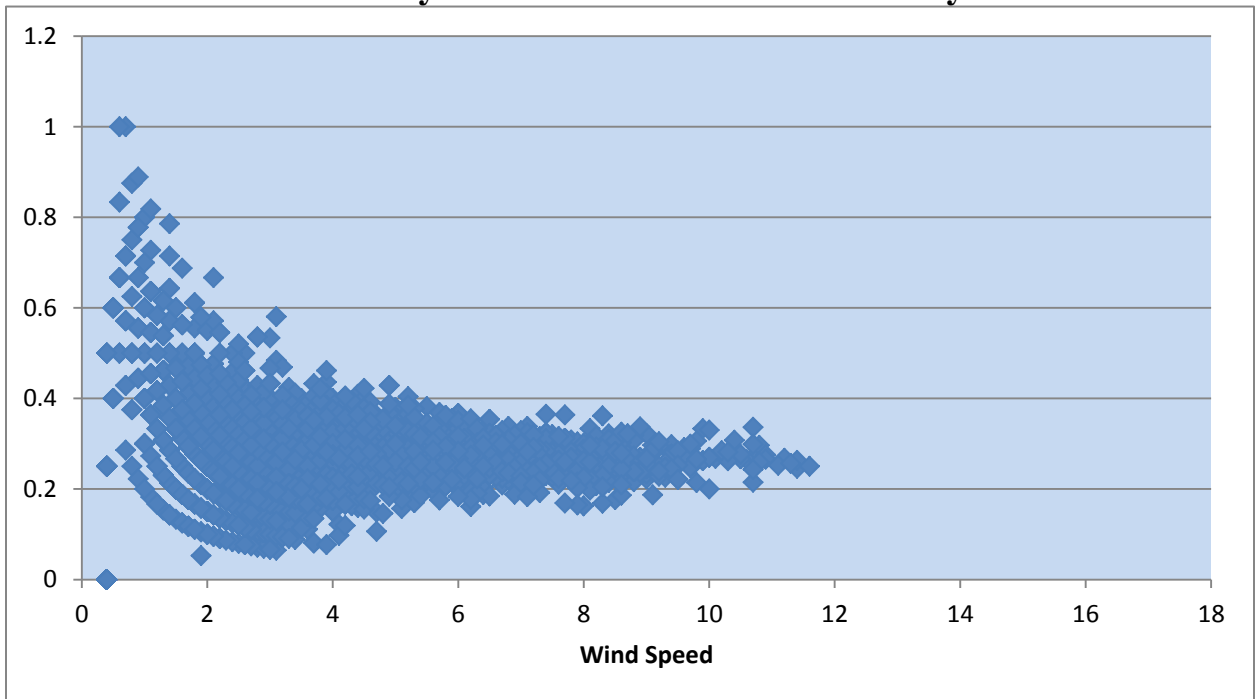
January 2011 - 30m Turbulence Intensity



February 2011 - 20m Turbulence Intensity



February 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
December, 2010	1.076
January, 2010	1.014
February, 2010	0.916

Summary of Data

The following data is a summary of the data collected August 23, 2010 to February 28, 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

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.

December 2010 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	0.5	99.93
30m Wind Speed SD	4464	4464	100	0	0	100.00
20m Wind Speed	4464	4464	100	0	0.5	99.93
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	1	99.98

January 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	19.83	97.33
30m Wind Speed SD	4464	4464	100	0	0	100.00
20m Wind Speed	4464	4464	100	0	27.17	96.35
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	47	98.95

February 2011 Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	%Data Recovered	Hours Out of Range	Hours of Icing	% Data Good
30m Wind Speed	4031	4031	100	0	0.17	99.98
30m Wind Speed SD	4031	4031	100	0	0	100.00
20m Wind Speed	4031	4031	100	0	0	100.00
20m Wind Speed SD	4031	4031	100	0	0	100.00
Wind Dir.	4031	4031	100	0	0	100.00
Temp.	4031	4031	100	0	0	100.00
Total	24186	24186	100	0	0.17	100.00

Total Data Collected From Aug 23, 2010 to Feb 28, 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
Total	163650	163650	100	0	48.17	99.84