WIND DATA REPORT

Brewster

February 1, 2006 – January 31, 2007

Prepared for

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August 2, 2007

Report template version 1.2

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NOTICE AND ACKNOWLEDGEMENTS

This report was prepared by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst in the course of performing work sponsored by the Renewable Energy Trust (RET), as administered by the Massachusetts Technology Collaborative (MTC). The opinions expressed in this report do not necessarily reflect those of MTC or the Commonwealth of Massachusetts, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it.

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EXECUTIVE SUMMARY

All the work presented in this Wind Data Report including installation and decommissioning of the meteorological tower and instrumentation, and the data analysis and reporting was preformed by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst.

The season covered by this report is February 1 2006 – January 31 2007. The mean recorded wind speed for this period was 5.6 m/s (12.5 mph)[1] at 49 m height and the prevailing wind direction was from the southwest. The gross data recovery percentage (the actual percentage of expected data received) was 99.9% and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was 98.9 %.

Additional information about interpreting the data presented in this report can be found in the Fact Sheet, "Interpreting Your Wind Resource Data," produced by RERL and the Massachusetts Technology Collaborative (MTC). This document is found through the RERL website:

http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_6_Wind_resource_interpretation.pdf

[1] 1m/s=2.237 mph

SECTION 1 - Station Location

As shown in Figure 1, the Brewster site is located near the intersection of Rt. 6 and Freemans Way near the parking lot of the Captain's Cove Golf Course in Brewster, MA. The coordinates for the site are: 41° 44' 08.84'' N by 70° 01' 12.69'' W. These coordinates correspond to the NAD83 datum.

Figure 1 – Brewster Site Location

SECTION 2 - Instrumentation and Equipment

The wind monitoring equipment is mounted on a 50 m (164.0 ft) NRG tower. All the monitoring equipment comes from NRG Systems, and consists of the following items:

- Symphonie Data Logger
- Electrical enclosure box
- 5 – #40 Anemometers, standard calibration (Slope - 0.765 m/s, Offset – 0.350 m/s). Two anemometers are located at 49 m (164.1 ft), two at 38 m (128.0 ft) and one at a height of 20 m (65.6 ft).
- 3 - #200P Wind direction vanes. They are located at heights of 49m (164.1 ft.), 38m (128.0 ft.) and 20m (65.6 ft) each.
- 5 – Sensor booms, 54" length
- Lightning rod and grounding cable
- Shielded sensor wire

The data from the Symphonie logger is mailed to the Renewable Energy Research Laboratory at the University of Massachusetts, Amherst on a regular basis. The logger samples wind speed and direction once every two seconds. These data are then combined into 10-minute averages and, along with the standard deviation for those 10-minute periods, are put into a binary file. These binary files are converted to ASCII text files using the NRG software BaseStation®. These text files are then imported into a database software program where they are subjected to quality assurance (QA) tests prior to using the data.

SECTION 3- Data Summary

A summary of the wind speeds and wind directions measured during the reporting period is included in Table 1. Table 1 includes the mean wind speeds measured at each measurement height, the maximum instantaneous wind speed measured at each measurement height and the prevailing wind direction measured at each measurement height. These values are provided for each month of the reporting period and for the whole reporting period.

Table 1. Wind Speed and Direction Data Summary

Date	**Mean Wind Speed**	**Max Wind Speed**	**Prevailing Wind Direction**	**Mean Wind Speed**	**Max Wind Speed**	**Prevailing Wind Direction**	**Mean Wind Speed**	**Max Wind Speed**	**Prevailing Wind Direction**
Height Units	**49 m [m/s]**	**49 m [m/s]**	**49 m [-]**	**38 m [m/s]**	**38 m [m/s]**	**38 m [-]**	**20 m [m/s]**	**20 m [m/s]**	**20 m [-]**
Feb 2006	6.4	15.5	WNW	5.7	13.9	WNW	4.3	10.5	WNW
Mar 2006	5.7	13.7	NW	5.1	12.7	NW	3.7	9.9	NW
Apr 2006	6.0	13.0	SW	5.4	11.7	SW	4.0	8.8	SW
May 2006	5.6	14.0	SW	5.1	12.6	SW	3.8	10.0	SW
June 2006	5.2	14.9	SW	4.7	13.3	SW	3.1	9.8	SW
July 2006	5.3	14.2	SW	4.8	12.6	SW	3.5	9.6	SW
Aug 2006	4.5	11.7	SW	4.0	10.9	SW	2.7	8.4	SW
Sept 2006	4.8	11.3	SW	4.2	10.5	SW	2.9	8.2	SW
Oct 2006	6.0	15.6	SW	5.3	14.3	SW	3.8	11.2	SW
Nov 2006	5.3	16.5	SW	4.7	15.1	SW	3.1	11	SW
Dec 2006	6.0	15.1	SW	5.3	13.8	SW	3.9	10.3	SW
Jan 2007	6.4	15.1	NW	5.7	13.6	NW	4.2	10.6	SW
Feb 2006-Jan 2007	**5.6**	**16.5**	**SW**	**5.0**	**15.1**	**SW**	**3.6**	**11.2**	**SW**

Wind data statistics in the table are reported when more than 90% of the data during the reporting period are valid. In cases when a larger amount of data are missing, the percent of the available data that are used to determine the data statistics is noted.

No measurement of wind speed or direction can be perfectly accurate. Wind speed measurement errors occur due to anemometer manufacturing variability, anemometer calibration errors, the response of anemometers to turbulence and vertical air flow and due to air flows caused by the anemometer mounting system. Every effort is made to reduce the sources of these errors. Nevertheless, the values reported in this report have an expected uncertainty of about ± 2% or ± 0.2 m/s, whichever is greater. Wind direction measurement errors occur due to sensor measurement uncertainty, tower effects, boom alignment measurement errors and twisting of pipe sections during the raising of a pipe tower. Efforts are also made to reduce these errors, but the reported wind directions are estimated to have an uncertainty of +/- 5 degrees.

A summary of the turbulence intensity and mean wind shear measured at each measurement height during the reporting period is included In Table 2. These values are provided for each month of the reporting period and for the whole reporting period. Turbulence Intensity is calculated by dividing the standard deviation of the wind speed by the mean wind speed and is a measure of the gustiness of a wind resource. Lower turbulence results in lower mechanical loads on a wind turbine. Turbulence intensity varies with wind speed. The average turbulence intensity presented in Table 2 is the mean turbulence intensity when the wind speed at the highest measurement height is between 9.5 and 10.5 m/s.

Shear coefficients provide a measure of the change in wind speed with height. When data at multiple heights are available, shear coefficients, α, have been determined. They can be used in the following formula to estimate the average wind speed, $U(z)$, at height z, when the average wind speed, $U(z_r)$, at height z_r is known:

$$U(z)=U(z_r)\left(\frac{z}{z_r}\right)^{\alpha}$$

The change in wind speed with height is a very complicated relationship related to atmospheric conditions, wind speed, wind direction, time of day and time of year. This formula will not always provide the correct answer at any given site. Nevertheless the calculated shear coefficient, based on measurements at two heights, can be used to characterize the degree of increase in wind speed with height at a site.

The mean wind shear coefficient that is provided here is calculated based on the mean wind speeds in Table 1, where z_{high} and z_{low} are the heights of the higher and lower mean wind speeds used in the calculation and $U(z_{low})$ and $U(z_{high})$ are the mean wind speeds at the two heights.

$$\alpha = \log\left(\frac{U(z_{high})}{U(z_{low})}\right) \Big/ \log\left(\frac{z_{high}}{z_{low}}\right)$$

Table 2. Shear and Turbulence Intensity Data Summary

Date Height Units	Turbulence Intensity at 10 m/s 49 m [-]	Turbulence Intensity at 10 m/s 40 m [-]	Turbulence Intensity at 10 m/s 25 m [-]	Mean Wind Shear Coefficient, α Between 49 m and 40 m [-]
Feb 2006	0.21	0.23	0.32	0.48
Mar 2006	0.2	0.22	0.32	0.51
Apr 2006	0.21	0.24	0.32	0.48
May 2006	0.21	0.23	0.33	0.52
June 2006	0.19	0.22	0.31	0.50
July 2006	0.18	0.21	0.34	0.56
Aug 2006	0.18	0.2	0.31	0.59
Sept 2006	0.2	0.23	0.32	0.56
Oct 2006	0.2	0.22	0.34	0.52
Nov 2006	0.21	0.23	0.32	0.56
Dec 2006	0.23	0.24	0.32	0.52
Jan 2007	0.23	0.25	0.28	0.48
Feb 2006-Jan 2007	0.20	0.23	0.32	0.52

SECTION 4- Capacity Factor

The capacity factor of a wind turbine at a given site depends on the hub height, wind speed distribution at the hub height, the wind turbine power curve and any assumptions about down time and losses due to wake effects from upwind wind turbines, etc. If the hub height wind speed is estimated from data at lower heights, then the capacity factor will also depend on the estimated wind shear and the wind speeds measured at lower heights. No simple estimate of capacity factor at a site could take all of these effects and choices into account. Nevertheless, an estimate of the capacity factor of a wind turbine at this site is provided here to help the reader understand the order of magnitude of the wind resource at this site.

The estimates assume a hub height of 80 m, a 1.8 MW wind turbine with a rotor diameter of 80 m and the mean wind speed at the highest measurement height and the mean wind shear at the site, in order to determine the mean hub height wind speed. The capacity factor (CF) is then estimated from (see G.M. Masters, Renewable and Efficient Electric Power Systems, Wiley, 2004):

$$CF = (0.087) U_{hub} - \frac{P_{rated}}{D^2}$$

where U_{hub} is the mean annual hub height wind speed in m/s, P_{rated} is the rated power of the wind turbine in kW and D is the diameter of the rotor in meters. Based on this equation, the estimated capacity factor of a wind turbine at this site would be about 0.21 or 21%.

SECTION 5- Graphs

This report contains several types of wind data graphs. Unless otherwise noted, each graph represents data from one calendar year (February 1, 2006 – January 31, 2007). The following graphs are included:

- Time Series – 10-minute average wind speeds are plotted against time in Figure 2.
- Wind Speed Distribution – A histogram plot giving the percentage of time that the wind is at a given wind speed. The wind speed distribution for Brewster, Massachusetts is shown below in Figure 3.
- Monthly Average – A plot of the monthly average wind speed over a 12-month period in shown below in Figure 4. This graph shows the trends in the wind speed over the whole period of data collection.
- Diurnal – A plot of the average wind speed for each hour of the day is presented in Figure 5. Here, the average wind speeds were approximately 6.0 m/s during the afternoon hours of a typical day.

- Turbulence Intensity – A plot of turbulence intensity as a function of wind speed. Turbulence Intensity is calculated as the standard deviation of the wind speed divided by the wind speed and is a measure of the gustiness of a wind resource. Lower turbulence results in lower mechanical loads on a wind turbine. The plot showing turbulence intensity as a function of wind speed is given below in Figure 6.

- Wind Rose – A plot, by compass direction showing the percentage of time that the wind comes from a given direction and the average wind speed in that direction. This plot is shown below in Figure 7. Here, the wind approaches from the southwest approximately 15% of the time at an average wind speed of approximately 6.0 m/s.

Data for the wind speed histograms, monthly and diurnal average plots, and wind roses are included in APPENDIX B.

<u>Wind Speed Time Series</u>

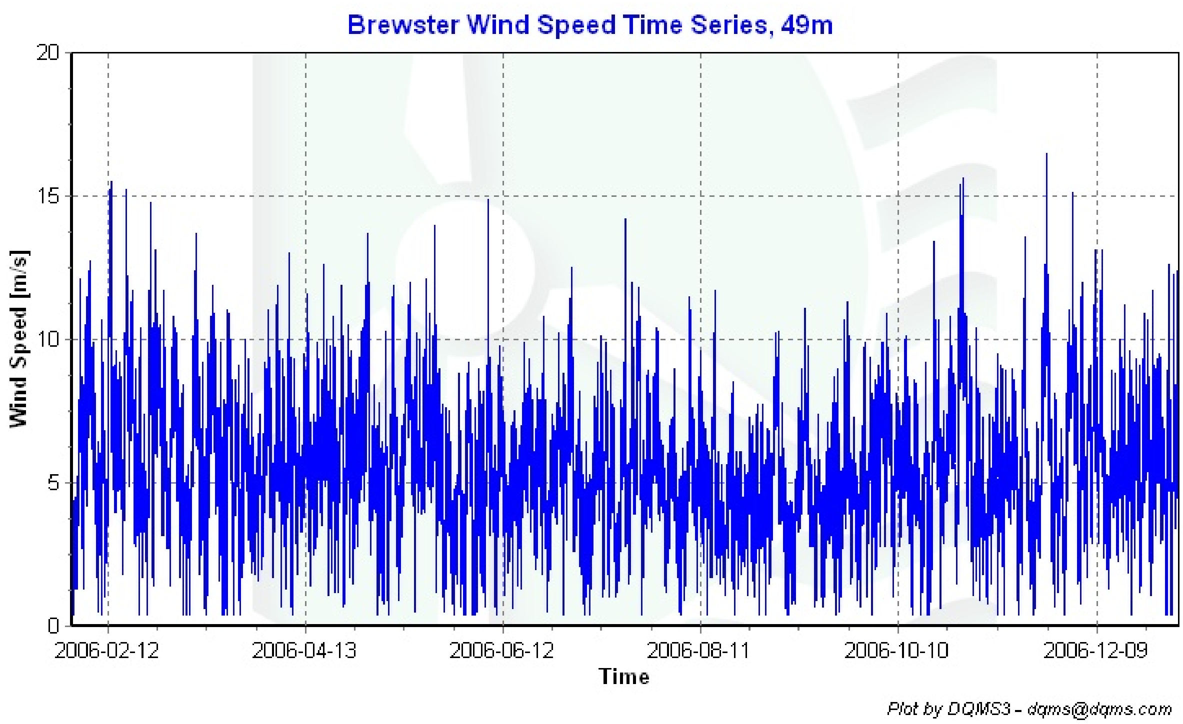

Figure 2 - Wind Speed Time Series, February 1 2006 through January 31 2007

Wind Speed Distributions

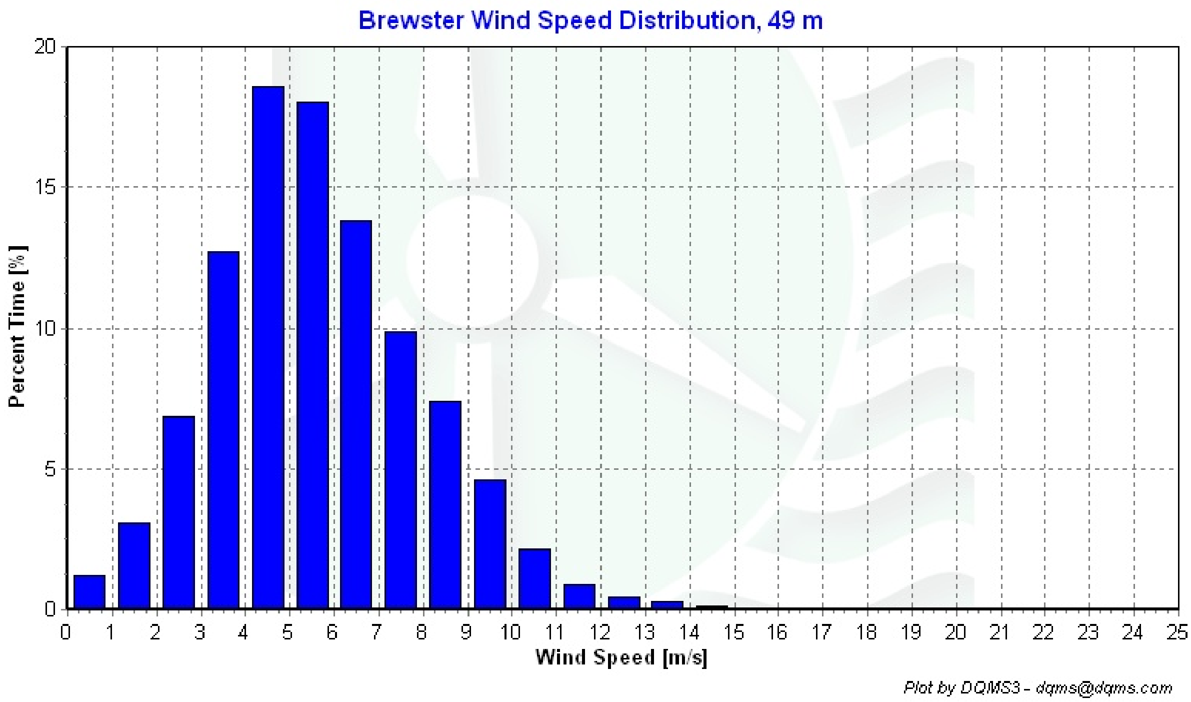

Figure 3 - Wind Speed Distribution, February 1 2006 through January 31 2007

Monthly Average Wind Speeds

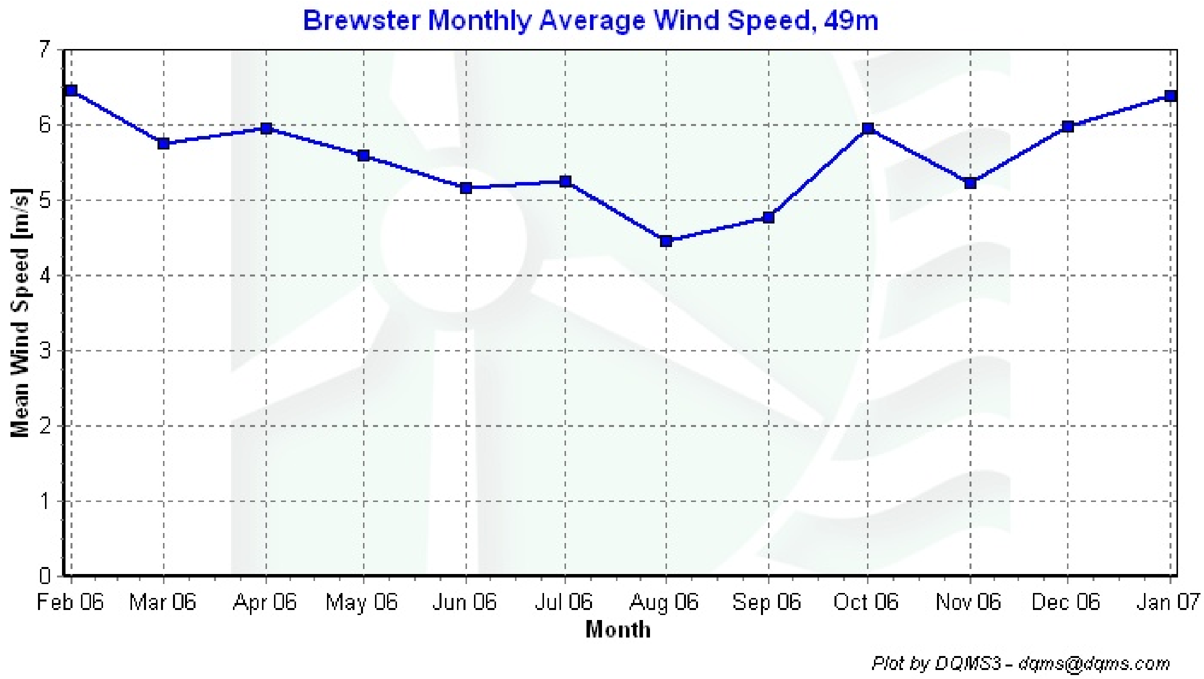

Figure 4 - Monthly Average Wind Speed, February 2006 through January 2007

Diurnal Average Wind Speeds

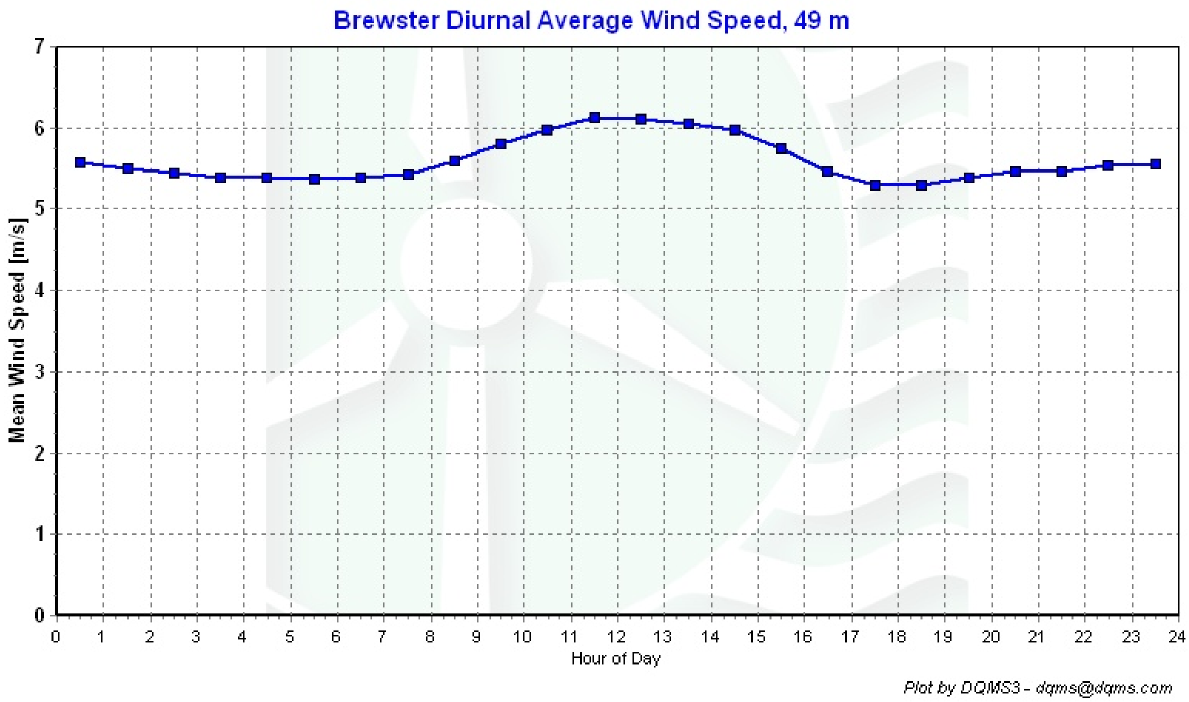

Figure 5 - Diurnal Average Wind Speed, February 1 2006 through January 31 2007

Turbulence Intensities

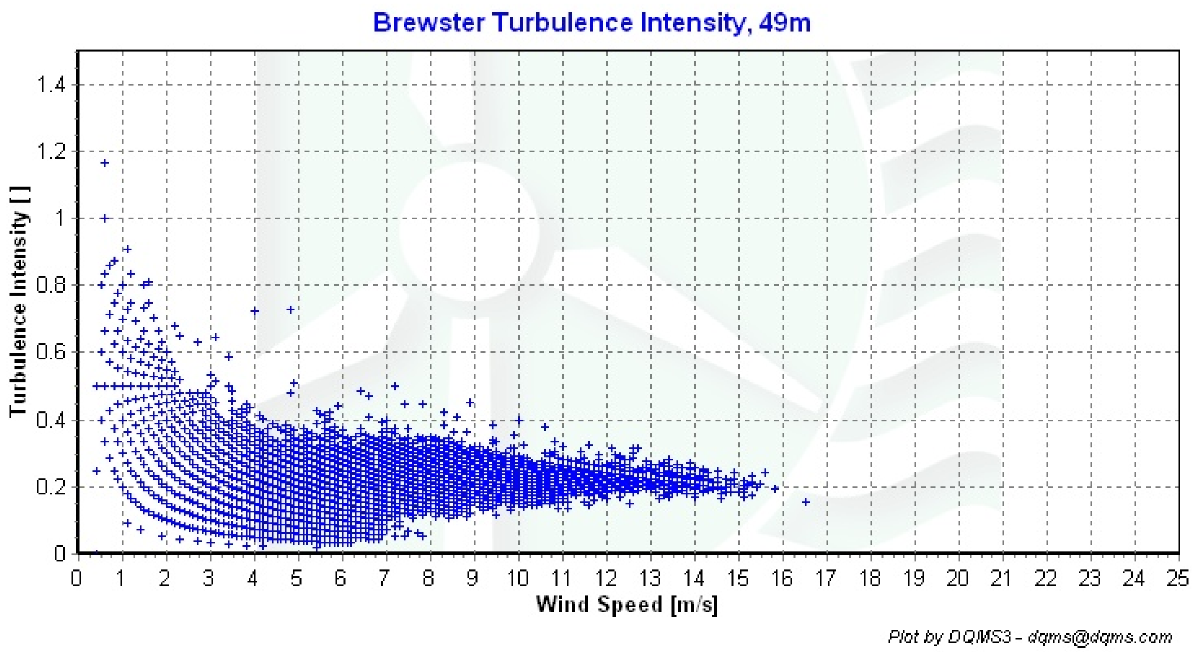

Figure 6 - Turbulence Intensity, February 1 2006 through January 31 2007

Wind Roses

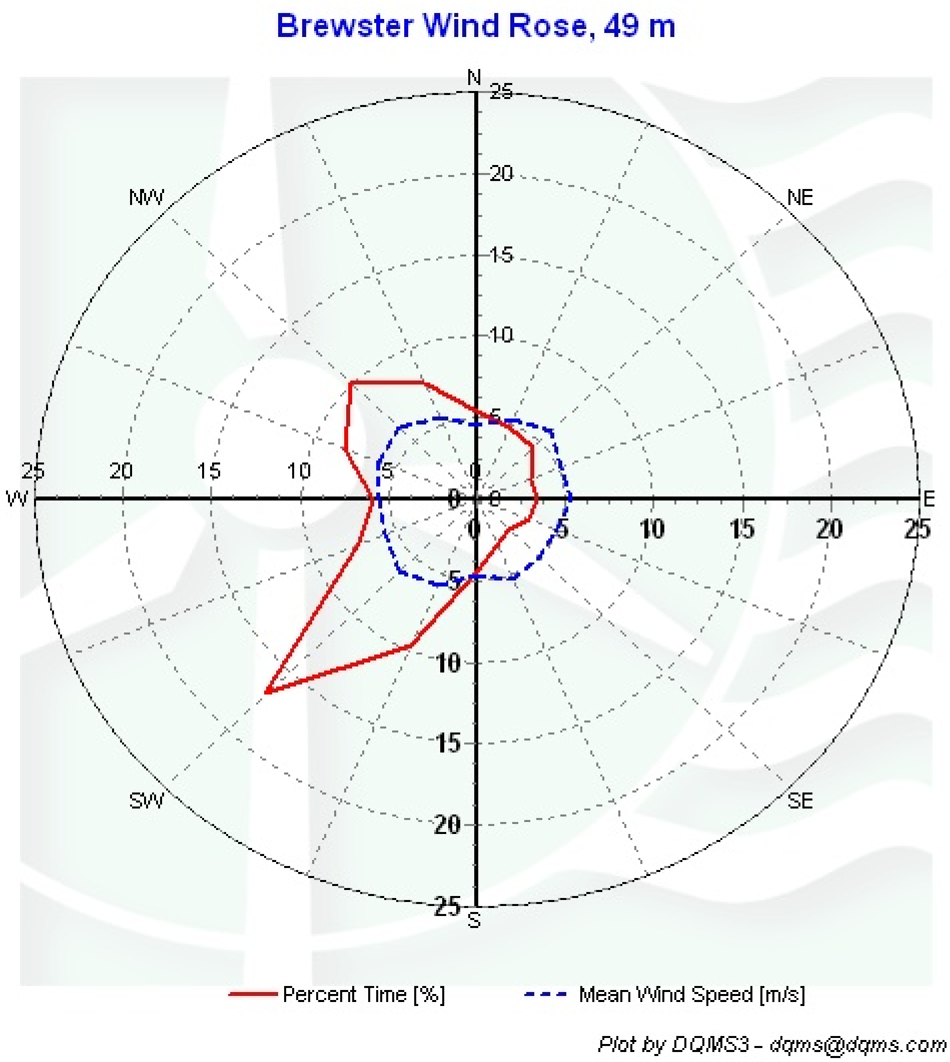

Figure 7 - Wind Rose, February 1 2006 through January 31 2007

SECTION 6 - Significant Meteorological Events

In February, March, April, May, June, July, August, September, October, November and December 2006 and January, February and March 2007 there were no major meteorological events that would have caused notable fluctuations in wind speed measurements. The average wind speeds for the general Brewster area were close to normal.

Source: http://www.erh.noaa.gov/box/MonthlyClimate2.shtml

SECTION 7 - Data Collection and Maintenance

The following maintenance/equipment problems occurred during the report period, and the following corrective actions taken:

- An event in which a tower guy wire was accidentally dragged by a truck occurred on May 3, 2006. While certain tower member sections were bent, no problems with the data were encountered.
- The secondary anemometer at 38 meters was not functioning from April 4th through October 23rd, at which point it fixed itself for unknown reasons. Throughout this time the primary anemometer at 38 meters was functioning correctly.

SECTION 8 - Data Recovery and Validation

All raw wind data are subjected to a series of tests and filters to weed out data that are faulty or corrupted. Definitions of these quality assurance (QA) controls are given below under Test Definitions and Sensor Statistics. These control filters were designed to automate the quality control process and used many of the previous hand-worked data sets made at UMass to affect a suitable emulation. The gross percentage of data recovered (ratio of the number of raw data points received to data points expected) and net percentage (ratio of raw data points which passed all QA control tests to data points expected) are shown below. [Statistics over whole period of data collection].

Gross Data Recovered [%]	99.9
Net Data Recovered [%]	98.9

Test Definitions

All raw data were subjected to a series of validation tests, as described below. The sensors tested and the parameters specific to each sensor are given in the Sensor Performance Report which is included in APPENDIX A. Data which were flagged as invalid were not included in the statistics presented in this report.

MinMax Test: All sensors are expected to report data values within a range specified by the sensor and logger manufacturers. If a value falls outside this range, it is flagged as invalid. A data value from the sensor listed in Test Field 1 (TF1) is flagged if it is less than Factor 1 (F1) or greater than Factor 2. This test has been applied to the following sensors (as applicable): wind speed, wind speed standard deviation, wind direction, temperature, and solar insolation.

$$F1 > TF1 > F2$$

MinMaxT Test: This is a MinMax test for wind direction standard deviation with different ranges applied for high and low wind speeds. A wind direction standard deviation data value (TF1) is flagged either if it is less than Factor 1, if the wind speed (TF2) is less than Factor 4 and the wind direction standard deviation is greater than Factor 2, or if the wind speed is greater than or equal to Factor 4 and the wind direction standard deviation is greater than Factor 3.

$$\begin{gathered}(TF1 < F1) \\ \text{or } (TF2 < F4 \text{ and } TF1 > F2) \\ \text{or } (TF2 \geq F4 \text{ and } TF1 > F3)\end{gathered}$$

Icing Test: An icing event occurs when ice collects on a sensor and degrades its performance. Icing events are characterized by the simultaneous measurements of near-zero standard deviation of wind direction, non-zero wind speed, and near- or below-freezing temperatures. Wind speed, wind speed standard deviation, wind direction, and wind direction standard deviation data values are flagged if the wind direction standard deviation (CF1) is less than or equal to Factor 1 (F1), the wind speed (TF1) is greater than Factor 2 (F2), and the temperature (CF2) is less than Factor 3 (F3). To exit an icing event, the wind direction standard deviation must be greater than Factor 4.

$$CF1 \leq F1 \text{ and } TF1 > F2 \text{ and } CF2 < F3$$

CompareSensors Test: Where primary and redundant sensors are used, it is possible to determine when one of the sensors is not performing properly. For anemometers, poor performance is characterized by low data values. Therefore, if one sensor of the pair reports values significantly below the other, the low values are flagged. At low wind speeds (Test Fields 1 and 2 less than or equal to Factor 3) wind speed data are flagged if the absolute difference between the two wind speeds is greater than Factor 1. At high wind speeds (Test Fields 1 or 2 greater than Factor 3) wind speed data are flagged if the absolute value of the ratio of the two wind speeds is greater is greater than Factor 2.

$$[\ TF1 \le F3 \text{ and } TF2 \le F3 \text{ and abs}(TF1 - TF2) > F1\ ]$$
$$\text{or } [\ (TF1 > F3 \text{ or } TF2 > F3) \text{ and } (\text{abs}(1 - TF1 / TF2) > F2 \text{ or abs}(1 - TF2 / TF1) > F2)\ ]$$

Sensor Statistics

A summary of the results of the data collection and filtering are given in the Sensor Performance Report which is included in APPENDIX A. The following categories of information, tabulated for each sensor, are included in that report.

Expected Data Points: the total number of sample intervals between the start and end dates (inclusive).

Actual Data Points: the total number of data points recorded between the start and end dates.

% Data Recovered: the ratio of actual and expected data points (this is the *gross data recovered percentage*).

Hours Out of Range: total number of hours for which data were flagged according to MinMax and MinMaxT tests. These tests flag data which fall outside of an expected range.

Hours of Icing: total number of hours for which data were flagged according to Icing tests. This test uses the standard deviation of wind direction, air temperature, and wind speed to determine when sensor icing has occurred.

Hours of Fault: total number of hours for which data were flagged according to CompareSensors tests. These tests compare two sensors (e.g. primary and redundant anemometers installed at the same height) and flag data points where one sensor differs significantly from the other.

% Data Good: the filter results are subtracted from the gross data recovery percentage to yield the *net data recovered percentage*.

APPENDIX A - Sensor Performance Report

Test Definitions

TstOrd	TestField1	TestField2	TestField3	CalcField1	CalcField2	TestType	Fcr1	Fcr2	Fcr3	Fcr4
1						TimeTest Insert	0	0	0	0
2	Etmp2aDEGC					MinMax	-30	60	0	0
3	Etmx2aDEGC					MinMax	-30	60	0	0
4	Etmn2aDEGC					MinMax	-30	60	0	0
5	EtmpSD2aDEGC					MinMax	-30	60	0	0
10	Anem49aMS					MinMax	0	90	0	0
11	Anem49bMS					MinMax	0	90	0	0
12	Anem38aMS					MinMax	0	90	0	0
13	Anem38bMS					MinMax	0	90	0	0
14	Anem20aMS					MinMax	0	90	0	0
15	Anem49yMS					MinMax	0	90	0	0
16	Anem38yMS					MinMax	0	90	0	0
20	AnemSD49aMS					MinMax	0	4	0	0
21	AnemSD49bMS					MinMax	0	4	0	0
22	AnemSD38aMS					MinMax	0	4	0	0
23	AnemSD38bMS					MinMax	0	4	0	0
24	AnemSD20aMS					MinMax	0	4	0	0
25	AnemSD49yMS					MinMax	0	4	0	0
26	AnemSD38yMS					MinMax	0	4	0	0
30	Vane49aDEG					MinMax	0	359.9	0	0
31	Vane38aDEG					MinMax	0	359.9	0	0
32	Vane20aDEG					MinMax	0	359.9	0	0
50	Turb49zNONE					MinMax	0	2	0	0
51	Turb38zNONE					MinMax	0	2	0	0
60	Wshr0zNONE					MinMax	-100	100	0	0
70	Pwrd49zWMS					MinMax	0	5000	0	0
71	Pwrd38zWMS					MinMax	0	5000	0	0
200	VaneSD49aDEG	Anem49yMS				MinMaxT	0	100	100	10
201	VaneSD38aDEG	Anem38yMS				MinMaxT	0	100	100	10
202	VaneSD20aDEG	Anem20aMS				MinMax	0	100	100	10
300	Anem49aMS	AnemSD49aMS	Vane49aDEG	VaneSD49aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
301	Anem49bMS	AnemSD49bMS	Vane49aDEG	VaneSD49aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
302	Anem38aMS	AnemSD38aMS	Vane38aDEG	VaneSD38aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
303	Anem38bMS	AnemSD38bMS	Vane38aDEG	VaneSD38aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
304	Anem20aMS	AnemSD20aMS	Vane20aDEG	VaneSD20aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
400	Anem49aMS	Anem49bMS				CompareSensors	1	0.25	3	0
401	Anem38aMS	Anem38bMS				CompareSensors	1	0.25	3	0
500	Amax49aMS					MinMax	0	90	0	0
501	Amax49bMS					MinMax	0	90	0	0
502	Amax38aMS					MinMax	0	90	0	0

503	Amax38bMS					MinMax	0	90	0	0
504	Amax20aMS					MinMax	0	90	0	0
510	Amin49aMS					MinMax	0	90	0	0
511	Amin49bMS					MinMax	0	90	0	0
512	Amin38aMS					MinMax	0	90	0	0
513	Amin38bMS					MinMax	0	90	0	0
514	Amin20aMS					MinMax	0	90	0	0
520	Vmax49aDEG					MinMax	0	359.9	0	0
521	Vmax38aDEG					MinMax	0	359.9	0	0
522	Vmax20aDEG					MinMax	0	359.9	0	0
530	Vmin49aDEG					MinMax	0	359.9	0	0
531	Vmin38aDEG					MinMax	0	359.9	0	0
532	Vmin20aDEG					MinMax	0	359.9	0	0

Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Anem50ams	52560	52504	99.893	0.5	107.667	31.333	98.301
AnemSD50ams	52560	52504	99.893	0.5	107.667	31.333	98.301
Anem50bms	52560	52504	99.893	0.833	108.667	0	98.643
AnemSD50bms	52560	52504	99.893	0.833	108.667	0	98.643
Anem50yMS	52560	52502	99.89	0.167	84.667	2.833	98.889
AnemSD50yMS	52560	52502	99.89	0.167	84.667	2.833	98.889
Anem38aMS	52560	52502	99.89	1.667	87.5	0	98.872
AnemSD38aMS	52560	52502	99.89	1.667	87.5	0	98.872
Anem38bMS	52560	52502	99.89	0	92.167	0	98.838
AnemSD38bMS	52560	52502	99.89	0	92.167	0	98.838
Anem38yMS	52560	52501	99.888	15	0	0	99.717
AnemSD38yMS	52560	52501	99.888	0	0	0	99.888
Anem20aMS	52560	52504	99.893	0.5	107.667	31.333	98.301
AnemSD20aMS	52560	52504	99.893	0.5	107.667	31.333	98.301
Vane50aDEG	52560	52504	99.893	0.833	108.667	0	98.643
VaneSD50aDEG	52560	52504	99.893	0.833	108.667	0	98.643
Vane38aDEG	52560	52502	99.89	0.167	84.667	2.833	98.889
VaneSD38aDEG	52560	52502	99.89	0.167	84.667	2.833	98.889
Vane20aDEG	52560	52502	99.89	1.667	87.5	0	98.872
VaneSD20aDEG	52560	52502	99.89	1.667	87.5	0	98.872
Etmp2aDEGC	52560	52502	99.89	0	92.167	0	98.838
EtmpSD2aDEGC	52560	52502	99.89	0	92.167	0	98.838
Total	**630720**	**630030**	**99.891**	**21.333**	**961.333**	**68.333**	**98.891**

APPENDIX B - Plot Data

Wind Speed Distribution Data

Wind Speed [m/s]	Percent [%]
0.5	1.19
1.5	3.07
2.5	6.82
3.5	12.7
4.5	18.59
5.5	18.05
6.5	13.79
7.5	9.87
8.5	7.39
9.5	4.59
10.5	2.16
11.5	0.9
12.5	0.44
13.5	0.29
14.5	0.12
15.5	0.04
16.5	0
17.5	0
18.5	0
19.5	0
20.5	0
21.5	0
22.5	0
23.5	0
24.5	0

Monthly Average Wind Speed Data

Date	10 min Mean [m/s]
Feb2006	6.4
Mar	5.7
Apr	6.0
May	5.6
Jun	5.2
Jul	5.3
Aug	4.5
Sep	4.8
Oct	6.0
Nov	5.3
Dec	6.0
Jan 2007	6.4

Diurnal Average Wind Speed Data

hr	Wind Speed [m/s]
0.5	5.58
1.5	5.49
2.5	5.45
3.5	5.39
4.5	5.39
5.5	5.37
6.5	5.39
7.5	5.42
8.5	5.59
9.5	5.8
10.5	5.97
11.5	6.12
12.5	6.11
13.5	6.05
14.5	5.98
15.5	5.76
16.5	5.46
17.5	5.29
18.5	5.29
19.5	5.4
20.5	5.46
21.5	5.47
22.5	5.55
23.5	5.56

Wind Rose Data

Direction	Mean Wind Speed [m/s]	Percent Time [%]
N	4.49	5.38
NNE	5.37	4.78
NE	5.92	4.52
ENE	5.18	3.3
E	5.28	3.39
ESE	4.95	3.15
SE	4.98	2.54
SSE	5.36	3.09
S	4.72	4.38
SSW	5.71	9.68
SW	6.23	16.88
WSW	5.58	7.2
W	5.56	5.85
WNW	6.03	8.1
NW	6.17	10.09
NNW	5.4	7.68