PRELIMINARY ASSESSMENT OF THE ENERGY PRODUCTION OF THE PROPOSED KIBBY MOUNTAIN WIND FARM

Client	**TransCanada Energy**
Contact	Nick Di Domenico
Document No	38055/OR/01
Issue	C
Status	FINAL
Classification	Client's Discretion
Date	19 December 2006

Author:

Richard S J Abrams

Checked by:

Marc P LeBlanc

Approved by:

Adam Schwarz

DISCLAIMER

Acceptance of this document by the client is on the basis that Garrad Hassan Canada Inc. is not in any way to be held responsible for the application or use made of the findings of the results from the analysis and that such responsibility remains with the client.

GH has not conducted wind measurements itself and cannot, therefore, be responsible for the accuracy of the data supplied to it.

Key To Document Classification

Strictly Confidential	:	Recipients only
Private and Confidential	:	For disclosure to individuals directly concerned within the recipient's organisation
Commercial in Confidence	:	Not to be disclosed outside the recipient's organisation
GH only	:	Not to be disclosed to non GH staff
Client's Discretion	:	Distribution at the discretion of the client subject to contractual agreement
Published	:	Available to the general public

Revision History

Issue	Issue date	Summary
A	6 Dec 06	Original Issue
B	8 Dec 06	Re-issue for LURC application
C	19 Dec 06	Re-issue with seasonal and diurnal energy production predictions

Circulation:	Copy No:
Client	1 & 2
GH Ottawa	3
GH Bristol	4

Copy No:____

CONTENTS

1 INTRODUCTION

TransCanada Energy (TCE) is developing the proposed Kibby Mountain Wind Farm in Maine. TCE has instructed Garrad Hassan Canada Inc. (GH) to carry out an independent preliminary assessment of the wind climate and expected energy production of the proposed wind farm. The results of the work are reported here.

GH has also undertaken previously due diligence work on the Kibby Mountain site when TransCanada were initially considering the development of the site. This work involved:

- Document review the preliminary wind and energy production estimates produced by Richard Simon.
- Specification of a wind monitoring program for the Kibby Mountain area.
- Identifying issues for developing and operating a wind farm project in the area.

The results of this work can be found in [1.1].

A description of the long-term wind climate at a potential wind farm is best determined using wind data recorded at the site. TCE has supplied to GH between 6 and 8 months of data recorded at three on-site masts.

When only a short period of site data are available, it is usual to combine the site measurements with long-term measurements from a local meteorological station. On behalf of TCE, GH has obtained data from the Sherbrook and Lenoxville Environment Canada (EC) and Berlin, Bangor, Grenville and Millinocket National Weather Service (NWS) Automated Surface Observing System (ASOS) meteorological stations.

The proposed layout and turbine model currently under consideration have been supplied by TCE. These have been analysed here, in conjunction with the results of the wind analysis, to predict the long-term energy output of the proposed wind farm.

It is important to note that energy assessment require a minimum 12 to 24 months of wind data collected at the site. Consequently, the work presented here is preliminary and a final study will be conducted when a minimum 12 months of site data has been collected.

2 DESCRIPTION OF THE SITE AND MONITORING EQUIPMENT

2.1 The site

The site is located approximately 35 km northeast of the town of Stratton in western Maine near the Maine-Québec border, as shown in Figure 2.1. Also shown in this figure are the Sherbrook Airport, Lennoxville, Berlin, Bangor, Grenville and Millinocket meteorological stations which have been considered as sources of long-term wind data in the assessment of the site wind regime.

The proposed Kibby Mountain site area lies on two main ridges between 750 m and 1200 m above sea level. The four ridge areas generally run in a north-south direction. The terrain slopes associated with these features are mostly between 10 and 30 degrees with a few slopes reaching 45 degrees. The general terrain at the site can be described as highly complex.

The ground cover consists of a mixture of deciduous and coniferous trees, mainly birch and balsam fir, with a few significant areas cleared through logging. It is assumed that the tree heights range from approximately 15 m for elevations above 850 m, and up to 30 m in valleys.

A more detailed map showing the site layout is presented in Figure 2.2, which also shows the location of the anemometry masts.

The surface roughness length of the site and surrounding area was assessed using a public available canopy map [2.1]. Following the Davenport classification [2.2], the following general figures are considered appropriate:

Wooded areas of high density	0.5 m
Wooded areas of low density	0.3 m
Cleared site areas	0.03 m

2.2 General meteorological mechanism

It is expected that the main general mechanism that produces significant winds at the Kibby Mountain site is the formation of a prominent depression track across the area. It is quite common, especially in the winter, to find most of western and upper Maine, the St-Laurent seaway, the Gaspé peninsula, and the maritime provinces at the tail end of a well developed depression or storm track moving across the North American continent [2.3]. The fronts of weather systems, which are sources of strong winds, have a tendency to orient themselves along the track. The formation of the track is in turn strongly influence by the position and strength of the jet stream above.

Given the significant elevation of the ridges when compared to Québec plains to the west, the Kibby Mountain site is well exposed to the westerly winds produced by this track formation. The perpendicular north-south ridges also promote an acceleration of the wind speeds as the wind move across the site.

2.3 Monitoring equipment

Site measurements have been recorded at three 60 m masts, referred to in this report as Masts A1, B1 and BII-1. Details of the measurements recorded at site and the grid co-ordinates of each mast are presented in Table 2.1.

The masts are 60 m aluminium four-sided lattice towers manufactured by Énergie SBB International.

The wind data have been recorded using NRG systems throughout with one heated IceFree3 anemometer and five Maximum 40 anemometers, one heated IceFree3 wind vane and one 200 P wind vane, and a 110S temperature sensor.

NRG Symphonie data loggers have been utilised at all masts, programmed to record the mean, standard deviation, maximum and minimum values of wind speed, wind direction and temperature over a ten-minute averaging period.

The instruments mounted on Masts A1, B1 and BII-1 include a heated anemometer at 62 m, two anemometers and a heated wind vane at 60 m, an anemometer and wind vane at 50 m, and a single anemometer at 40 m.

An investigation of the calibration of 472 NRG Maximum 40 anemometers has been reported in [2.4], the results of which include a proposed consensus transfer function for this model of anemometer. This transfer function was applied to the output signal from the anemometers by the data logger, as follows:

Recorded wind speed [m/s] = 0.765 x Data frequency [Hz] + 0.35 m/s

However all of the NRG Maximum 40 anemometers on the site have been individually calibrated by Otech Engineering. Copies of the calibration certificates are included in Appendix I. These individual calibrations have been applied retrospectively by GH to all the data recorded at the individual anemometers. A summary of the transfer functions applied to the output signal from the anemometers is presented in Table 2.2.

In the case of the heated anemometers on Masts A1 and BII-1, the applied transfer function was equal to the manufacturer’s recommended calibration for when the heating system is applied only. In the case of the heated anemometer on Mast B1 the applied transfer function was equal to the consensus calibration reported in [2.4]. Since the status of the heating system affects the consistency of the measurement period data and relative high response time for this type of sensor, the heated anemometers were not used directly in this analysis, other than for identifying periods and assessing the frequency of, icing events.

Maintenance records for the site measurements have been provided. The standard of documentation is good and certainly sufficient to ensure full traceability of the instrumentation.

All anemometers are mounted on booms approximately 8.5 mast diameters long. The cups of the anemometers are approximately 12 boom diameters above the boom. These mounting arrangements are broadly consistent with the recommendations of the IEA [2.5].

It is noted that a visit to the site has been conducted by GH staff during the initial due diligence process in November 2004. However, no recent inspection to assess the terrain, tree heights and surface roughness, the position of the monitoring equipment and the mounting arrangements has been undertaken for this preliminary report and all of the details provided here regarding the site are based solely upon information provided by TCE. GH will undertake a site visit to inspect the site prior to the final report.

3 SELECTION OF A REFERENCE METEOROLOGICAL STATION

In the assessment of the wind regime at a potential turbine location it is generally necessary to correlate data recorded near the turbine location with data recorded from a nearby long-term reference meteorological station. Wind data near a turbine location are often only recorded for a short period and such correlation is required to ensure that the estimates of the wind speeds at the site are representative of the long-term. When selecting an appropriate meteorological station for this purpose it is important that it should have good exposure and that data are consistent over the measurement period being considered.

GH has investigated potential sources of consistent, long-term reference data in the surrounding area. The Sherbrook Airport and Lennoxville EC and the Berlin, Bangor, Grenville and Millinocket ASOS meteorological stations have been identified as potential reference sources. At this time, GH has not visited any of the meteorological stations.

Time series data comprising mean wind speed and direction from each station were obtained directly from EC and the NWS by GH. The location of each station is illustrated in Figure 2.1.

Investigation of the monthly wind speed trends has resulted in finding severe inconsistencies in the Sherbrooke Airport, Lennoxville and Greenville station data sets. Consequently GH considers these three stations unsuitable for a direct source of long-term data for the site.

Monthly correlations were undertaken between the mean wind speeds recorded at each remaining station and Mast A1. The quality of the correlations is considered to be reasonable for the Berlin and Millinocket station with coefficient of determination, R^2, values of 0.84 and 0.90, respectively. However, the correlation quality for the Bangor station is considered to be unsuitable with an R^2 of 0.55. Consequently, the Bangor station has not been considered further as a source of long-term data for the site.

Unfortunately, the exposure or consistency of the Berlin and Millinocket data sets cannot be confirmed at this time due to the availability of NWS staff for comment. GH is concerned with the significant downward trend shown in Figure 3.1 since 2000 and in particular for the 2006 season. While this may a be real physical trend, confirmation of the consistency and exposure of the stations, as well as additional on site data, are required before considering these two stations further as a direct sources of long-term reference data. It is expected that this shortcoming will be addressed in the final report.

Until NWS staff can be contacted and the Berlin and Millinocket stations inspected for exposure and consistency, the analysis of the long-term wind regime at the Kibby Mountain site has relied on the approximately eight month period of data recorded at Masts A1, B1 and BII-1 from March to November 2006. It is noted that NWS staff will be contacted and stations inspected for the final report. Given that a less than one year period has been collected at the site, a pragmatic approach based on all six stations has been used to extend the measurement period to a long-term annual estimate for the purpose of this preliminary study. This is discussed further in Section 6.1.

4 WIND DATA

The data sets which have been used in the analysis described in the following sections are summarised in Table 2.1.

4.1 Wind data recorded at the site

A check across all instruments of the data from Masts A1, B1 and BI-1 revealed 2969, 3698 and 1886 hours respectively where wind speed data were missing or suspect. These data were excluded from the analysis

Approximately three days of possible icing events for the 8-month measurement period were identified by observation of the wind data recorded at the site. Given that no winter data have been collected, it is expected that the number days of possible icing events will be considerably greater over the full year period. These observations and the expected winter climate at the site have been employed in estimating the expected downtime due to icing as presented in Section 6.5.

The duration, basic statistics and data coverage for Masts A1, B1 and BII-1 data are summarised in Tables 4.1 to 4.3.

5 DESCRIPTION OF THE PROPOSED WIND FARM

5.1 The wind turbine

The turbine which is proposed for the Kibby Mountain Wind Farm, is the Vestas V90 3.0 MW. The basic parameters of the turbine are presented in Table 5.1.

The power curve used in this analysis has been obtained by GH on behalf of TCE and is presented in Table 5.2. This power curve is for an air density of 1.15 kg/m³, and a turbulence intensity of 10 %.

The supplied power curve is based on calculations and exhibits a peak power coefficient, Cp, of 0.45. This is considered to be reasonable for a modern wind turbine.

Using historical pressure and temperature records from nearby meteorological stations and standard lapse rate assumptions, GH has estimated the long-term mean air density at the site to be 1.154 kg/m³ at an average hub elevation of 953 m above sea level.

The supplied power curve used in this analysis has been adjusted to the predicted site air density, in accordance with the recommendations of [5.1]. This has been undertaken on an individual turbine basis.

5.2 Wind farm layout

TCE have supplied the layout for the wind farm [5.2]. A map of the site showing the wind turbine locations is presented in Figure 2.2.

For this preliminary study, 48 turbine locations have considered in the energy yield estimates. It is noted that four of these locations are currently being considered as spares and that the final report will be limited to 44 turbine layout for a total project rated capacity of 132 MW.

It is noted that inter-turbine spacing of 2.8 rotor diameters is proposed. In some cases the turbines have a spacing of 3 rotor diameters in prevailing wind directions, and the increased turbulence levels resulting from these spacings may increase fatigue loads. It is also noted that turbines are proposed in the immediate vicinity of trees.

6 RESULTS OF THE ANALYSIS

The energy production assessment of the proposed wind turbine involved several steps, which are summarised below:

- In order to improve coverage of the 60 m measurements, data recorded at Masts A1, B1 and BII-1 at 50 m were correlated to data recorded at Masts A1, B1 and BII-1 at 60 m respectively. These correlations were used to synthesise missing wind speed and direction measurements at the Masts A1, B1 and BII-1 at 60 m.

- In order to extend the available wind data period at Masts B1 and BII-1, data recorded and synthesised at Mast A1 at 60 m were correlated to data recorded and synthesised at Masts B1 and BII-1 at 60 m. These correlations were used to synthesise wind speed and direction measurements at Masts B1 and BII-1 at 60 m.

- The wind speed and direction frequency distribution at Masts A1, B1 and BII-1 at 60 m height were derived for the period from April to November 2006.

- As a pragmatic approach, an annual adjustment to the 8-month site measurement period based on monthly mean wind speeds was derived from the meteorological stations considered.

- Based on the wind shear derived from the wind speed measurements, the long-term wind speed and direction distribution derived from Masts A1, B1 and BII-1 were extrapolated to hub height.

- Wind flow modelling was carried out to determine the hub height wind speed variations over the proposed turbine location relative to the site masts.

- The energy production of the proposed wind turbine was calculated taking account of topographic effects, availability, electrical transmission efficiency, air density effects and other potential losses.

A more complete description of the methods employed is included in Appendix II.

6.1 Long-term mean wind speed regime at Mast A1 at 60 m

As detailed in Section 4, wind measurements from Mast A1 over a period of approximately eight months were available for the analysis. Data recorded at Mast A1 at 50 m were correlated to data recorded at 60 m on a ten-minute basis. This correlation was used to synthesise missing wind speed and direction measurements at 60 m.

Given that this measurement period is unlikely to be representative of the annual wind regime and the lack of a suitable source of long-term reference data, a pragmatic approach of comparing the relative annual windiness of the measurement period on a monthly basis to the reference stations considered has been used as an overall seasonal adjustment to the measured data. The average annual adjustment has been estimated to be an increase of 8.4% as presented in Table 6.1.

It is noted that this pragmatic approach is subject to high degree of uncertainty given the poor correlation of several of the meteorological stations and their unconfirmed consistency. However, GH considers that this approach will yield a more representative annual figure than using the site data alone.

By applying the pragmatic annual adjustment to the measured data set, the predicted long-term annual mean wind speed at Mast A1 at 60 m was found to be 8.4 m/s. The corresponding long-term joint wind speed and direction frequency distribution is presented in Table 6.2 and in the form of a wind rose in Figure 6.1. It is observed that the wind rose has a predominance of winds from the west and northwest.

6.2 Long-term mean wind speed regime at Masts B1 and BII-1 at 60 m

As detailed in Section 4, wind measurements from Masts B1 and BII-1 over a period of approximately 6 months were available for the analysis. Data recorded at both masts at 50 m were correlated to data recorded at 60 m respectively on a ten-minute basis. These correlations were used to synthesise a few periods of missing wind speed and direction data at 60 m.

In order to extend the wind measurement period at these two masts, data recorded and synthesised at Mast A1 at 60 m were correlated to data recorded and synthesised at Masts B1 and BII-1 at 60 m respectively on a ten-minute basis.

The following checks on the correlations were undertaken. Wind data from Masts B1 and BII-1 at 60 m were factored by the directional speed up ratios determined in the correlation to the Mast A1 at 60 m. If the correlation is reliable then the mean wind speed of the synthesised wind data would be similar to the actual data for exactly the same period. This was the case and therefore additional data from Masts B1 and BII-1 at 60 m were synthesised over the period of March to November 2006 where data were not available.

By the same method described in Section 6.1, a pragmatic seasonal adjustment to the data has been applied. The predicted long-term annual mean wind speeds at Masts B1 and BII-1 at 60 m were found to be 9.6 m/s and 8.5 m/s respectively. The corresponding long-term joint wind speed and direction frequency distributions are presented in Tables 6.3 and 6.4 and in the form of wind roses in Figures 6.2 and 6.3. It is observed that the wind roses have a predominance of winds from the west and northwest.

6.3 Estimation of the hub height wind regimes

The boundary layer power law exponent was estimated at each of the masts from the available measurements. The power law relates the ratio of measured wind speeds, U_1/U_2, to the ratio of measurement heights minus effective tree height, $(z_1\text{-}d)/(z_2\text{-}d)$, using the wind shear exponent, α, as follows:

$$\frac{U_1}{U_2} = \left(\frac{z_1 - d}{z_2 - d}\right)^{\alpha} \quad [6.1]$$

The average measured wind shear exponents calculated for Masts A1, B1 and BII-1 were 0.08, 0.08, and 0.12, respectively. These values have been used to extrapolate to the hub height long-term mean wind speed at each site mast.

It is important to note that there is a high level of uncertainty associated with the assumption that the shear exponents derived from the period of data available from a site mast are representative of long-term expectations. This is of particular concern with the current measurement campaign, where less than a year of data is available.

It is assumed for this assessment that the average measured wind shear exponents are representative of the hub height wind regime at the site masts. Applying this shear exponent to extrapolate the predicted long-term mean wind speeds to the proposed turbine hub height leads to hub height wind speeds of 8.7 m/s, 9.9 m/s and 8.8 m/s at Masts A1, B1 and BII-1 at 80 m respectively.

The predicted long-term mean wind speed and direction frequency distribution at each site mast was then factored to the long-term hub height mean wind speed estimated above.

6.4 Site wind speed variations

The variation in wind speed between the mast and turbine locations has been predicted using the WAsP computational flow model as described in Appendix II.

Given the distance between site masts and the complexity of the terrain, the wind flow model has been initiated from the long-term mean wind speed and direction frequency distributions derived for Masts A1, B1 and BII-1 at 80 m as follows:

- Turbines A1 to A20 initiated from Mast A1.
- Turbines B1 to B6 and B17 to B28 initiated from Mast B1.
- Turbines B7 to B16 initiated from Mast BII-1.

The wind farm is located within complex terrain which includes areas of steep slopes and forestry. The presence of steep slopes can cause localised separation of the flow. In regions of separated flow it is known that the accuracy of wind flow modelling is poor due to the formation of a separation bubble which reduces the effective slope, as described by Cook [6.1].

For turbine locations with slopes significantly in excess of 17 degrees in the prevailing wind directions, to a greater extent than at the initiation anemometry mast location, there is a tendency for the WAsP model to overpredict the wind speed and consequently energy production of such turbines. Conversely, if the initiation anemometry mast is located in an area more heavily influenced by slopes in excess of 17 degrees than the turbine locations, there is a tendency for the WAsP model to underpredict the wind speed at such turbines.

A review of the wind farm was therefore undertaken to establish whether such conditions were present. Areas of steep slopes are marked as red areas in Figure 6.4 and it can be seen that there are steep slopes along the majority of the ridge lines.

From this investigation it is considered that the conditions for possible over or under prediction of wind speeds by WAsP, as detailed above, are present at this site. To account for this, the following pragmatic steps have been taken:

- A reduction of 5 % has been applied to hub height wind speed at Turbine A20.

- A reduction of 2 % has been applied to hub height wind speeds at Turbines A19 and B7.

- A reduction of 1 to 5% has been applied to hub height wind speeds at Turbines B21 to B28.

- An increase of 2 % has been applied to hub height wind speed at Turbine A17.

- An increase of 5 % has been applied to hub height wind speeds at Turbines A1 to A14 and B12 to B15.

As detailed in Section 2.1, there are proposed turbine locations within areas of forestry at the site. The wind flow modelling therefore needs careful consideration. Where there are obstacles to the wind flow, such as trees or buildings in the vicinity of a wind turbine, it is necessary to include the effect of the obstacles in the wind flow modelling [6.2]. The following methodology has therefore been applied:

- The trees are at a height of 15 m on average and the flow displacement height has been assumed to be equal to the tree height.

- For the site mast and proposed turbine location, an effective reduction of between 1 m and 14 m in the measurement or hub height has been estimated to account for the influence of trees as an obstacle to the wind flow. The selection of these heights is based on the displacement height of the trees, the proximity of the mast or turbine to the trees and the frequency of occurrence of the relevant wind directions.

For the purpose of this assessment, it has been assumed that current forest cover found on site will be representative of that for the project life of the proposed wind farm.

6.5 Projected energy production

The energy production of the wind farm is detailed in the table below and definitions of the various loss factors are included in Appendix II.

Rated Power	**144.0**	**MW**
Ideal output	507.1	GWh/annum
Topographic effect	89.0%	GH calculated
Wake effect	95.2%	GH calculated
Electrical efficiency	97.0%	GH assumption
Availability	97.0%	GH assumption
Icing and blade degradation, low temperature shutdown and access disruption	95.0%	GH assumption
High wind hysteresis	98.7%	GH estimate
Substation maintenance	99.8%	Typical value
Utility downtime	100.0%	Not considered by GH
Power curve adjustment	100.0%	Not considered by GH
Wind sector management	100.0%	Not considered by GH
Net output	**378.3**	**GWh/annum**

The value for topographic loss has been calculated using the methods described in Appendix II. It is understood that there are no other operational wind farms in the vicinity of the development.

The table above includes potential sources of energy loss that have been estimated, assumed or not considered. It is recommended that the client consider each of these losses and the possible effect they may have on the wind farm.

6.6 Seasonal and diurnal variation

The expected average seasonal and diurnal variation in energy production has been approximately estimated from the available site measurements at Masts A1, B1 and BII-1.

Based on the predicted long-term hub height wind speed and direction frequency distributions at Masts A1, B1 and BII-1, a power performance matrix was developed for the Kibby Mountain Wind Farm. A time series of air density was developed from the combination of temperature and pressure records from Masts A1, B1 and BII-1 and the Berlin and Millinocket meteorological stations. By applying the 7 months of concurrent density, wind speed and direction data recorded at the site to the performance matrix a simulated time series of power production data was produced.

Based on the above methodology, the expected seasonal and diurnal variation in energy production is presented in Table 6.5 in the form of a 12 x 24 matrix. It is noted that the uncertainty associated with the prediction of any given month or hour of day is significantly greater than that associated with the prediction of the annual energy production. It is also noted that the results presented are inclusive of topographical and array losses only.

REFERENCES

1.1 "Preliminary Review And Development Assistance For A Proposed Wind Farm Site In Kibby Mountain, Maine", GH report 4755/AP/01 Issue B, December 20, 2004.

2.1 USGS website, http://seamless.usgs.gov

2.2 "Wind speed profiles over terrain with roughness changes", Engineering Sciences Data , Item No. 84011, April 1993.

2.3 Barry R G and Chorley R J, "Atmosphere, weather and climate", 1998.

2.4 Lockhart T J and Bailey B H, "The Maximum Type 40 Anemometer Calibration Project", Proceedings of the AWEA Conference, California 1998.

2.5 Recommended Practices for Wind Turbine Testing and Evaluation, "11. Wind speed measurement and use of cup anemometry", IEA, Edition 1, 1999.

5.1 "Wind turbine generator systems – Part 12: Wind turbine power performance testing", BS EN 61400-12: BSI, 1998.

6.1 Cook N J "The Designer's" guide to wind loading of building structures", Part 1, Butterworths, 1985.

6.2 I Troen and E L Petersen, "European Wind Atlas", Risø National Laboratory, Denmark, 1989.

LIST OF TABLES

LIST OF FIGURES

Location	Description of measurements	Period
Mast A1 (380543, 5026893)	Ten minute mean, maximum, minimum and standard deviation of wind speed at heights of 62 m, 60 m, 50 m and 40 m. Ten minute mean, maximum, minimum and standard deviation at 60 m and 50 m.	March 2006 – November 2006
Mast B1 (376519, 5023316)	Ten minute mean, maximum, minimum and standard deviation of wind speed at heights of 62 m, 60 m, 50 m and 40 m. Ten minute mean, maximum, minimum and standard deviation at 60 m and 50 m.	April 2006 – November 2006
Mast BII-1 (375925, 5020796)	Ten minute mean, maximum, minimum and standard deviation of wind speed at heights of 62 m, 60 m, 50 m and 40 m. Ten minute mean, maximum, minimum and standard deviation at 60 m and 50 m.	March 2006 – October 2006

Note: Co-ordinate system is UTM Zone 19T NAD83

Table 2.1 Summary of measurements made at the Kibby Mountain site masts.

Instrument type	Height [m]	Boom orientation [°N]	Serial number	Logger slope [m/s/Hz]	Logger offset [m/s]	Calibrated slope [m/s/Hz]	Calibrated slope [m/s]	Applied slope [m/s/Hz]	Applied slope [m/s]
NRG IceFree3	62	-	14728-3	0.572	1	-	-	Not used	Not used
NRG Max #40	60	270	26320	0.765	0.35	0.7623	0.3805	0.9965	0.0317
NRG Max #40	60	90	26321	0.765	0.35	0.7645	0.372	0.9993	0.0222
NRG Max #40	50	270	26322	0.765	0.35	0.767	0.3883	1.0026	0.0374
NRG Max #40	50	90	26323	0.765	0.35	0.7671	0.37	1.0027	0.0190
NRG Max #40	40	270	26324	0.765	0.35	0.7647	0.3599	0.9996	0.0100
NRG IceFree3	60	180	30647-3	-	-	-	-	-	-
NRG 200P	50	180	-	-	-	-	-	-	-

Table 2.2 Summary of the transfer functions for the sensors at Mast A1

Instrument type	Height [m]	Boom orientation [°N]	Serial number	Logger slope [m/s/Hz]	Logger offset [m/s]	Calibrated slope [m/s/Hz]	Calibrated slope [m/s]	Applied slope [m/s/Hz]	Applied slope [m/s]
NRG IceFree3	62	-	-	0.765	0.35	-	-	Not used	Not used
NRG Max #40	60	265	26331	0.765	0.35	0.7637	0.3662	0.9983	0.0168
NRG Max #40	60	350	26332	0.765	0.35	0.7692	0.3458	1.0055	-0.0061
NRG Max #40	50	265	26333	0.765	0.35	0.7697	0.3505	1.0061	-0.0017
NRG Max #40	50	350	26334	0.765	0.35	0.768	0.3539	1.0039	0.0025
NRG Max #4	40	265	26335	0.765	0.35	0.7651	0.3827	1.0001	0.0327
NRG IceFree3	60	170	30646-3	-	-	-	-	-	-
NRG 200P	50	170	-	-	-	-	-	-	-

Table 2.3 Summary of the transfer functions for the sensors at Mast B1

Instrument type	Height [m]	Boom orientation [°N]	Serial number	Logger slope [m/s/Hz]	Logger offset [m/s]	Calibrated slope [m/s/Hz]	Calibrated slope [m/s]	Applied slope [m/s/Hz]	Applied slope [m/s]
NRG IceFree3	62	-	14727-3	0.572	1	-	-	Not used	Not used
NRG Max #40	60	265	26325	0.765	0.35	0.7645	0.3763	0.9993	0.0265
NRG Max #40	60	90	26326	0.765	0.35	0.7652	0.3384	1.0003	-0.0117
NRG Max #40	50	265	26327	0.765	0.35	0.7665	0.3631	1.0020	0.0124
NRG Max #40	50	90	26328	0.765	0.35	0.7648	0.3833	0.9997	0.0334
NRG Max #40	40	265	26329	0.765	0.35	0.7669	0.3949	1.0025	0.0440
NRG IceFree3	60	175	30648-3	-	-	-	-	-	-
NRG 200P	50	175	-	-	-	-	-	-	-

Table 2.4 Summary of the transfer functions for the sensors at Mast BII-1

Month	Mean wind speed [m/s]	Wind speed data coverage [%]	Wind direction data coverage [%]
Mar-06	9.4	76	75
Apr-06	9.1	97	98
May-06	7.6	98	99
Jun-06	7.2	100	100
Jul-06	6.9	100	100
Aug-06	7.0	95	92
Sep-06	7.1	100	100
Oct-06	8.5	84	77
Nov-06	8.4	17	17

Table 4.1 Measurements made at Mast A1 at a height of 60 m.

Month	Mean wind speed [m/s]	Wind speed data coverage [%]	Wind direction data coverage [%]
Apr-06	9.5	66	62
May-06	8.7	98	95
Jun-06	8.1	98	96
Jul-06	7.8	83	99
Aug-06	-	0	94
Sep-06	8.6	95	98
Oct-06	9.8	82	74
Nov-06	9.7	17	17

Table 4.2 Measurements made at Mast B1 at a height of 60 m.

Month	Mean wind speed [m/s]	Wind speed data coverage [%]	Wind direction data coverage [%]
Mar-06	8.0	14	15
Apr-06	8.6	99	92
May-06	7.8	96	97
Jun-06	6.6	97	99
Jul-06	7.7	35	100
Aug-06	-	0	96
Sep-06	7.4	95	99
Oct-06	7.3	62	64

Table 4.3 Measurements made at Mast BII-1 at a height of 60 m.

Turbine type	Vestas V90	
Diameter	90	m
Hub height	80	m
Rotor speed	9 - 19	rpm
No. of blades	3	
Nominal rated power	3000	kW

Table 5.1 Main parameters of the Vestas V90 wind turbine.

Wind speed [m/s at hub height]	**Electrical power [kW]**
3	0
4	70
5	176
6	329
7	543
8	829
9	1191
10	1602
11	2010
12	2392
13	2717
14	2915
15	2984
16	2998
17	3000
18	3000
19	3000
20	3000
21	3000
22	3000
23	3000
24	3000
25	3000

Performance for air density 1.15 kg/m^3 and 10% turbulence intensity

Table 5.2 Performance data for the Vestas V90 wind turbine.

	Bangor	Berlin	Greenville	Millinocket	Sherbrooke	Lennoxville
January	7.6	4.6	8.4	6.7	3.0	3.1
February	8.3	4.7	8.2	6.6	3.1	3.0
March	8.9	5.2	8.1	6.9	3.3	3.3
April	9.2	5.3	8.0	6.9	3.2	3.3
May	8.0	4.9	6.7	5.9	2.8	3.1
June	7.4	3.9	5.5	5.1	2.4	2.6
July	6.8	3.4	4.6	4.5	2.2	2.5
August	6.5	2.8	4.7	4.2	2.1	2.2
September	6.9	3.3	5.7	4.7	2.2	2.4
October	7.9	4.1	7.3	5.8	2.8	2.9
November	7.8	4.6	8.2	6.3	3.0	3.1
December	7.6	4.1	8.1	6.7	3.0	3.1
Annual Avg	**7.7**	**4.3**	**7.0**	**5.8**	**2.8**	**2.9**
Apr-Oct Avg	**7.5**	**4.0**	**6.1**	**5.3**	**2.5**	**2.7**
Annual factor	+2.8%	+7.3%	+14.7%	+10.5%	+9.0%	+6.0%
Average factor	**+8.4%**					

Table 6.1 Annual windiness adjustment

Site: **Mast A1 at 60 m** **Period: March 2006 – November 2006**

Wind Speed (m/s)	Wind Direction (degrees)												No Direction	Total (%)
	0	30	60	90	120	150	180	210	240	270	300	330		
0	0.02	0.01	0.02	0.01	0.04	0.06	0.02	0.01	0.02	0.02	0.02	0.04	0.02	0.33
1	0.08	0.07	0.07	0.06	0.13	0.19	0.16	0.19	0.08	0.14	0.11	0.07	0.06	1.40
2	0.13	0.14	0.12	0.07	0.17	0.43	0.46	0.30	0.28	0.31	0.22	0.12	0.14	2.90
3	0.18	0.20	0.30	0.23	0.25	0.52	0.55	0.51	0.45	0.58	0.48	0.24	0.15	4.65
4	0.35	0.26	0.46	0.36	0.38	0.59	0.63	0.53	0.61	0.83	0.84	0.45	0.10	6.39
5	0.45	0.29	0.36	0.39	0.51	0.55	0.73	0.79	0.70	1.11	1.46	0.81	0.09	8.24
6	0.49	0.28	0.29	0.38	0.57	0.54	0.75	0.90	0.81	1.37	2.12	1.28	0.12	9.89
7	0.64	0.25	0.29	0.40	0.67	0.62	0.65	0.79	0.77	1.46	2.70	1.68	0.09	11.01
8	0.84	0.20	0.27	0.42	0.79	0.58	0.54	0.58	0.55	1.37	3.16	1.78	0.04	11.13
9	0.84	0.16	0.25	0.42	0.76	0.44	0.48	0.36	0.35	1.20	3.30	1.58	0.03	10.18
10	0.60	0.13	0.21	0.40	0.64	0.36	0.41	0.28	0.26	1.02	2.97	1.34	0.03	8.64
11	0.32	0.12	0.15	0.28	0.59	0.24	0.39	0.20	0.19	0.77	2.27	1.06	0.05	6.64
12	0.23	0.10	0.15	0.18	0.44	0.23	0.26	0.14	0.15	0.50	1.79	0.76	0.04	4.97
13	0.18	0.08	0.20	0.08	0.48	0.23	0.14	0.06	0.07	0.35	1.39	0.52	0.06	3.84
14	0.20	0.04	0.14	0.05	0.43	0.11	0.05	0.01	0.04	0.18	1.01	0.39	0.03	2.68
15	0.16	0.02	0.03	0.03	0.24	0.13	0.01	0.01	0.05	0.19	0.78	0.31	0.02	1.97
16	0.13	+	+	0.01	0.15	0.05	+	+	0.03	0.15	0.54	0.20	0.01	1.27
17	0.09			0.01	0.05	0.01			0.03	0.13	0.39	0.14	0.01	0.86
18	0.05			0.01	0.03				0.01	0.09	0.30	0.12	+	0.60
19	0.03			+	0.03				0.01	0.06	0.24	0.09	+	0.47
20	0.03			+	0.02				0.01	0.04	0.20	0.06	0.01	0.37
21	0.01			+	0.02				0.01	0.04	0.19	0.06	0.02	0.35
22	+				0.02				0.01	0.05	0.18	0.07	0.02	0.35
23					0.01					0.05	0.13	0.05	0.01	0.26
24					0.01					0.04	0.09	0.02	0.01	0.18
25										0.03	0.07	+	0.02	0.12
26										0.04	0.05	0.01	0.01	0.10
27										0.03	0.04	0.02	+	0.09
28										0.01	0.02	0.02	+	0.06
29										0.02	0.01	0.03	+	0.07
30										0.01	+	0.01		0.02
31										+		+		+
32														
33														
34														
35														
36														
37														
38														
39 - 44														
45 and over														
Total (%)	6.04	2.34	3.34	3.78	7.44	5.87	6.22	5.66	5.49	12.19	27.08	13.34	1.21	100
Av.Speed (m/s)	8.58	6.68	7.17	7.51	8.99	6.85	6.52	6.17	6.62	8.38	9.85	9.26	7.66	8.40

NB: + indicates non-zero percentage <0.005%, blank indicates zero percentage

Table 6.2 Predicted wind speed and direction frequency distribution at Mast A1 at 60 m

Site: Mast B1 at 60 m **Period: March 2006 – November 2006**

Wind Speed (m/s)	Wind Direction (degrees)												No Direction	Total (%)
	0	30	60	90	120	150	180	210	240	270	300	330		
0	0.02	0.02	0.01	0.04	0.01	0.04	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.27
1	0.08	0.08	0.07	0.03	0.07	0.13	0.14	0.11	0.12	0.14	0.10	0.10	0.04	1.22
2	0.10	0.12	0.16	0.11	0.15	0.23	0.23	0.24	0.25	0.25	0.18	0.13	0.08	2.22
3	0.15	0.21	0.20	0.18	0.12	0.29	0.33	0.31	0.40	0.45	0.35	0.20	0.14	3.34
4	0.25	0.27	0.36	0.25	0.17	0.36	0.37	0.43	0.55	0.65	0.52	0.31	0.12	4.60
5	0.44	0.30	0.41	0.26	0.21	0.44	0.42	0.43	0.62	0.94	0.87	0.64	0.08	6.04
6	0.58	0.33	0.35	0.27	0.26	0.48	0.49	0.47	0.65	1.26	1.19	1.06	0.08	7.47
7	0.69	0.32	0.29	0.33	0.39	0.52	0.59	0.63	0.71	1.51	1.42	1.38	0.09	8.85
8	0.78	0.31	0.24	0.37	0.51	0.56	0.66	0.72	0.75	1.59	1.82	1.52	0.07	9.90
9	0.73	0.33	0.20	0.37	0.50	0.55	0.65	0.65	0.68	1.58	2.29	1.47	0.06	10.06
10	0.47	0.17	0.18	0.42	0.43	0.48	0.59	0.64	0.62	1.70	2.32	1.25	0.08	9.34
11	0.28	0.09	0.13	0.47	0.40	0.45	0.53	0.53	0.49	1.58	2.10	1.06	0.07	8.18
12	0.20	0.09	0.18	0.32	0.45	0.40	0.42	0.40	0.36	1.33	1.64	0.83	0.07	6.67
13	0.16	0.08	0.14	0.29	0.46	0.37	0.33	0.32	0.23	1.03	1.22	0.53	0.04	5.21
14	0.15	0.08	0.18	0.17	0.40	0.33	0.19	0.19	0.18	0.86	0.95	0.33	0.01	4.01
15	0.13	0.05	0.12	0.09	0.32	0.26	0.15	0.11	0.13	0.62	0.86	0.23	+	3.09
16	0.11	0.04	0.09	0.04	0.25	0.17	0.11	0.05	0.10	0.46	0.78	0.13	+	2.35
17	0.09	0.04	0.07	0.02	0.19	0.15	0.07	0.02	0.07	0.33	0.58	0.10	+	1.73
18	0.07	0.02	0.03	0.01	0.14	0.12	0.04	0.01	0.05	0.25	0.46	0.06	+	1.26
19	0.06	0.02	+	0.01	0.07	0.07	0.01	+	0.05	0.23	0.36	0.05	+	0.93
20	0.04	0.01	0.01	0.01	0.02	0.04	+		0.03	0.19	0.26	0.04	+	0.65
21	0.02	+	0.01	0.01	0.01	0.01			0.01	0.15	0.23	0.03	+	0.48
22	0.01	+	+	+	0.02				0.01	0.14	0.21	0.04		0.45
23	0.01	+	+		0.03		+		0.01	0.14	0.21	0.03	+	0.42
24	+				0.01		+		0.01	0.11	0.23	0.02	0.01	0.40
25					0.01				+	0.06	0.16	0.01		0.24
26					+					0.05	0.12			0.17
27					+					0.05	0.08			0.13
28										0.04	0.04			0.09
29										0.04	0.05	+		0.10
30										0.02	0.06	+		0.08
31										0.01	0.03	+		0.04
32										0.01	0.01			0.02
33										0.01	+			0.01
34										0.01	+			0.01
35										+				+
36														
37														
38														
39 - 44														
45 and over														
Total (%)	5.60	3.00	3.41	4.06	5.58	6.47	6.35	6.29	7.09	17.80	21.72	11.59	1.04	100
Av.Speed (m/s)	8.66	7.50	7.98	8.77	10.57	9.11	8.40	8.11	8.12	10.41	11.31	9.15	6.79	9.58

NB: + indicates non-zero percentage <0.005%, blank indicates zero percentage

Table 6.3 Predicted wind speed and direction frequency distribution at Mast B1 at 60 m

Site: Mast BII-1 at 60 m **Period: March 2006 – November 2006**

Wind Speed (m/s)	Wind Direction (degrees)												No Direction	Total (%)
	0	30	60	90	120	150	180	210	240	270	300	330		
0	0.05	0.02	0.03	0.04	0.05	0.05	0.03	0.02	0.02	0.07	0.05	0.07	0.02	0.52
1	0.08	0.05	0.05	0.08	0.15	0.30	0.16	0.11	0.12	0.11	0.19	0.16	0.04	1.60
2	0.11	0.10	0.11	0.16	0.43	0.62	0.43	0.27	0.23	0.31	0.36	0.24	0.13	3.49
3	0.22	0.17	0.18	0.31	0.49	0.76	0.69	0.50	0.31	0.52	0.88	0.41	0.14	5.58
4	0.33	0.19	0.26	0.44	0.54	0.91	0.69	0.67	0.46	0.60	1.34	0.67	0.11	7.20
5	0.49	0.18	0.27	0.55	0.63	0.92	0.48	0.66	0.64	0.75	1.96	1.10	0.08	8.71
6	0.59	0.19	0.23	0.49	0.73	0.84	0.23	0.50	0.65	0.87	2.42	1.65	0.11	9.49
7	0.56	0.21	0.18	0.37	0.85	0.77	0.09	0.30	0.51	0.81	2.70	2.09	0.11	9.54
8	0.47	0.20	0.16	0.37	0.97	0.71	0.05	0.11	0.36	0.63	3.13	2.26	0.07	9.48
9	0.36	0.14	0.12	0.33	0.98	0.55	0.04	0.03	0.22	0.45	3.55	2.24	0.04	9.05
10	0.23	0.09	0.09	0.30	0.82	0.42	0.02	0.01	0.10	0.26	3.49	1.93	0.04	7.79
11	0.17	0.06	0.08	0.28	0.74	0.43	+		0.06	0.24	3.10	1.44	0.08	6.68
12	0.12	0.04	0.03	0.26	0.68	0.33		+	0.03	0.12	2.40	0.91	0.08	5.00
13	0.07	0.01	0.04	0.25	0.49	0.27		+	0.01	0.08	1.71	0.61	0.05	3.60
14	0.04	0.01	0.04	0.19	0.54	0.20			+	0.07	1.31	0.38	0.04	2.81
15	0.02	+	0.02	0.12	0.46	0.13			+	0.07	1.11	0.28	0.03	2.24
16	0.01	+	0.01	0.07	0.38	0.07			+	0.04	0.96	0.20	0.01	1.75
17	0.01			0.04	0.23	0.04			+	0.03	0.74	0.14	0.01	1.22
18	+			0.01	0.10	0.01			+	0.03	0.55	0.11	+	0.83
19					0.07	+				0.03	0.44	0.08	+	0.62
20					0.04					0.03	0.33	0.04	+	0.44
21					0.04					0.01	0.30	0.04	0.01	0.39
22					0.03					0.01	0.26	0.04	0.02	0.37
23					0.03						0.23	0.05	0.02	0.32
24					0.02					0.01	0.17	0.06	0.01	0.28
25					0.03					+	0.16	0.05	0.01	0.27
26					0.02					+	0.14	0.03	0.02	0.21
27					0.01						0.11	0.04	0.01	0.17
28					+						0.07	0.05	+	0.12
29											0.06	0.04	+	0.10
30											0.05	0.03		0.08
31											0.02	0.01		0.03
32											0.01			0.01
33											+			+
34														
35														
36														
37														
38														
39 - 44														
45 and over														
Total (%)	3.93	1.66	1.91	4.63	10.52	8.32	2.93	3.17	3.73	6.16	34.31	17.44	1.29	100
Av.Speed (m/s)	6.88	6.21	6.20	7.75	9.29	6.77	3.88	4.55	5.68	6.78	10.36	9.02	8.21	8.51

NB: + indicates non-zero percentage <0.005%, blank indicates zero percentage

Table 6.4 Predicted wind speed and direction frequency distribution at Mast BII-1 at 60 m.

	Energy production [%]											
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
0000	n/a	n/a	n/a	0.49	0.41	0.31	0.34	0.30	0.32	0.49	n/a	n/a
0100	n/a	n/a	n/a	0.46	0.43	0.31	0.34	0.33	0.31	0.48	n/a	n/a
0200	n/a	n/a	n/a	0.42	0.46	0.30	0.35	0.31	0.29	0.47	n/a	n/a
0300	n/a	n/a	n/a	0.46	0.44	0.30	0.33	0.29	0.30	0.41	n/a	n/a
0400	n/a	n/a	n/a	0.43	0.43	0.32	0.28	0.29	0.31	0.42	n/a	n/a
0500	n/a	n/a	n/a	0.38	0.42	0.33	0.25	0.29	0.33	0.45	n/a	n/a
0600	n/a	n/a	n/a	0.36	0.38	0.30	0.22	0.27	0.31	0.45	n/a	n/a
0700	n/a	n/a	n/a	0.35	0.33	0.26	0.20	0.22	0.26	0.36	n/a	n/a
0800	n/a	n/a	n/a	0.39	0.35	0.26	0.18	0.23	0.25	0.32	n/a	n/a
0900	n/a	n/a	n/a	0.37	0.32	0.27	0.20	0.26	0.25	0.31	n/a	n/a
1000	n/a	n/a	n/a	0.36	0.29	0.28	0.22	0.31	0.24	0.33	n/a	n/a
1100	n/a	n/a	n/a	0.39	0.29	0.28	0.26	0.28	0.26	0.34	n/a	n/a
1200	n/a	n/a	n/a	0.42	0.31	0.31	0.27	0.29	0.28	0.36	n/a	n/a
1300	n/a	n/a	n/a	0.41	0.32	0.30	0.26	0.32	0.28	0.39	n/a	n/a
1400	n/a	n/a	n/a	0.45	0.33	0.31	0.26	0.30	0.29	0.43	n/a	n/a
1500	n/a	n/a	n/a	0.46	0.35	0.32	0.25	0.28	0.31	0.45	n/a	n/a
1600	n/a	n/a	n/a	0.43	0.36	0.34	0.24	0.28	0.29	0.44	n/a	n/a
1700	n/a	n/a	n/a	0.46	0.35	0.28	0.26	0.31	0.32	0.51	n/a	n/a
1800	n/a	n/a	n/a	0.52	0.36	0.28	0.26	0.33	0.33	0.48	n/a	n/a
1900	n/a	n/a	n/a	0.52	0.38	0.26	0.27	0.36	0.35	0.48	n/a	n/a
2000	n/a	n/a	n/a	0.53	0.39	0.29	0.29	0.35	0.38	0.47	n/a	n/a
2100	n/a	n/a	n/a	0.47	0.39	0.28	0.31	0.31	0.39	0.46	n/a	n/a
2200	n/a	n/a	n/a	0.48	0.37	0.30	0.31	0.31	0.35	0.51	n/a	n/a
2300	n/a	n/a	n/a	0.47	0.41	0.33	0.32	0.26	0.32	0.51	n/a	n/a

Note: The table will be completed once a minimum of 12 months of data has been collected on site

Table 6.5 Predicted seasonal and diurnal variation in energy production.

Figure 2.1 Location of the Kibby Mountain site and the EC and NWS meteorological stations.

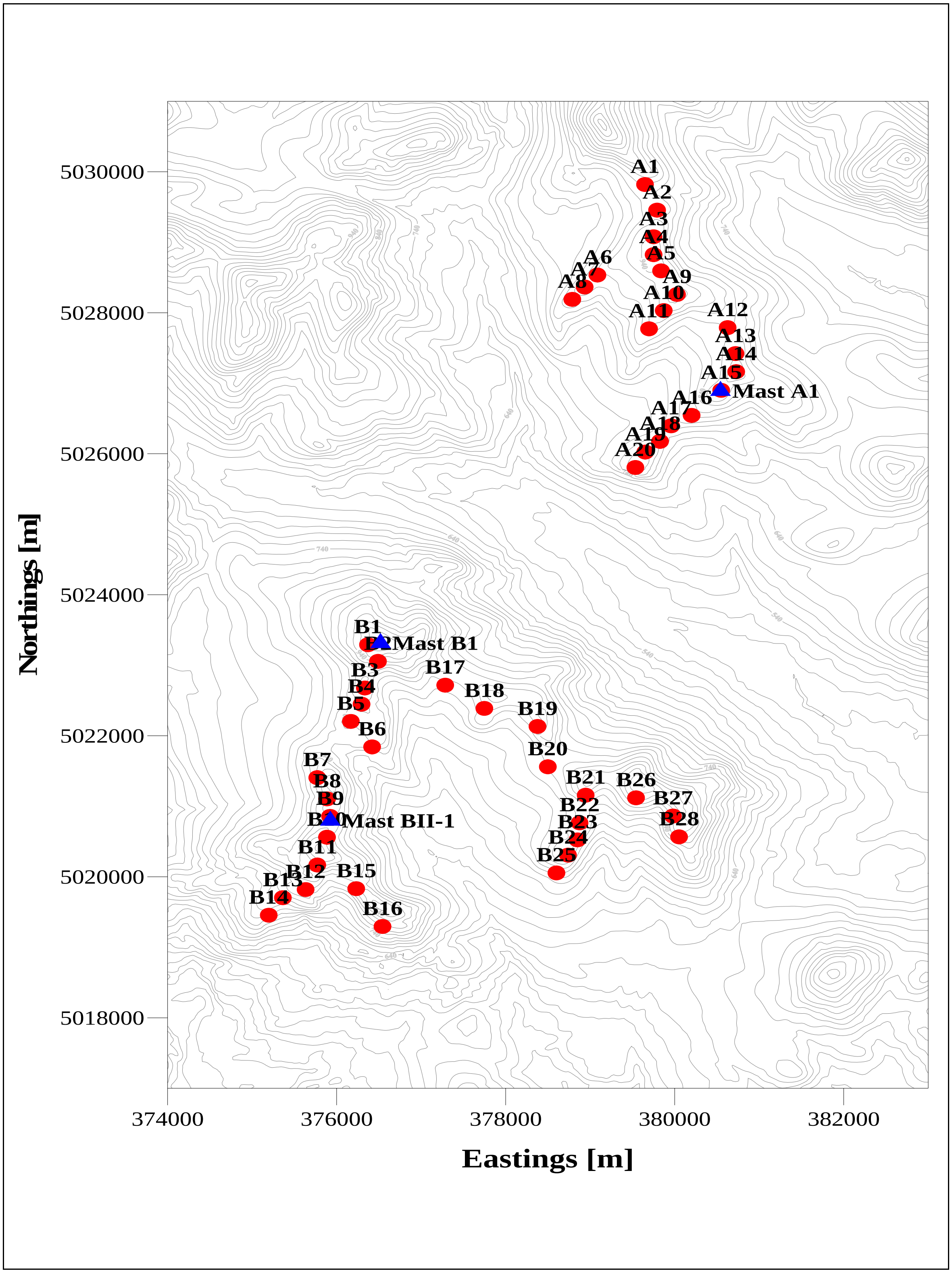


Figure 2.2 Proposed turbine layout and site masts locations.

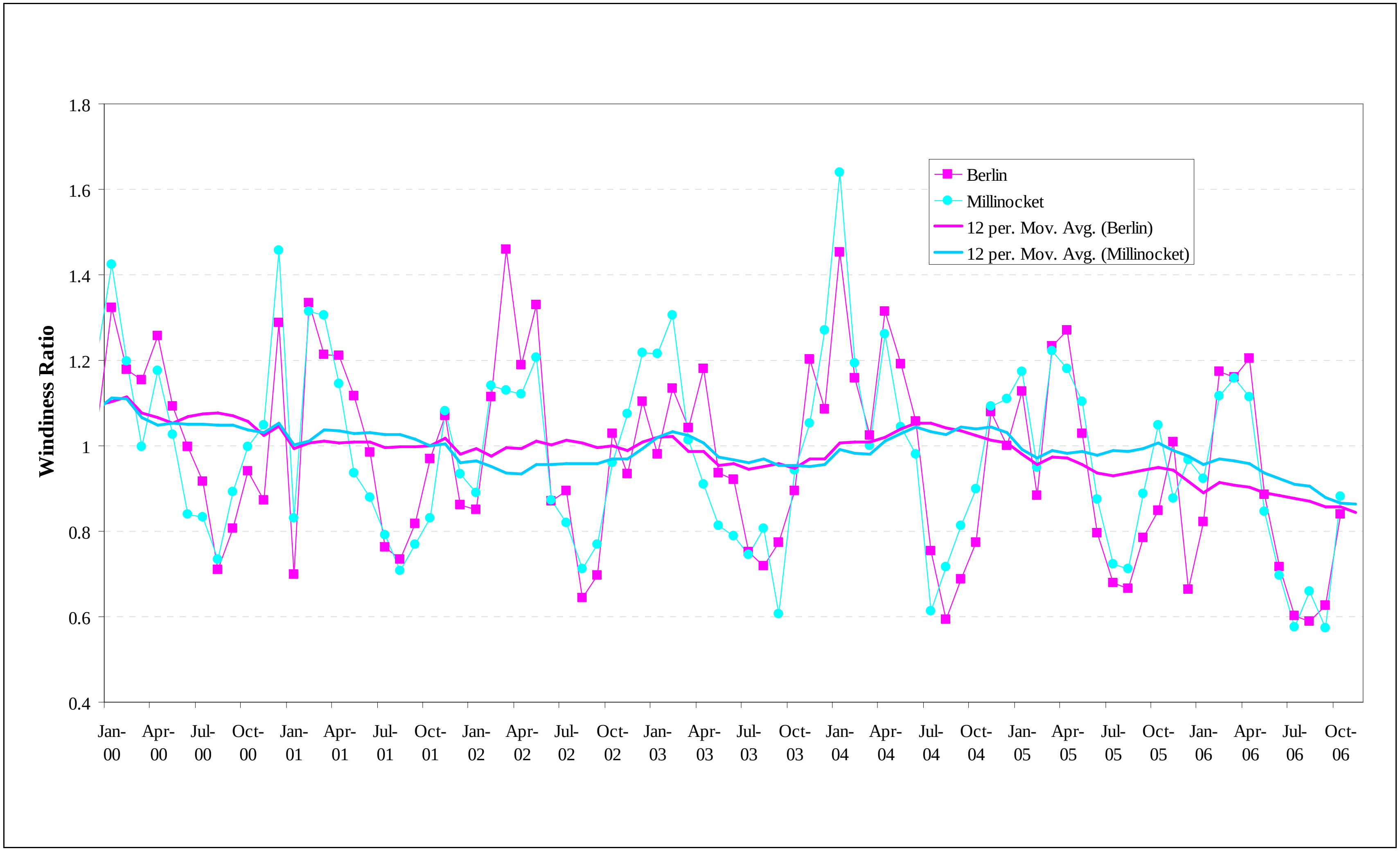


Figure 3.1 Windiness of monthly mean wind speeds at the Berlin and Millinocket meteorological stations.

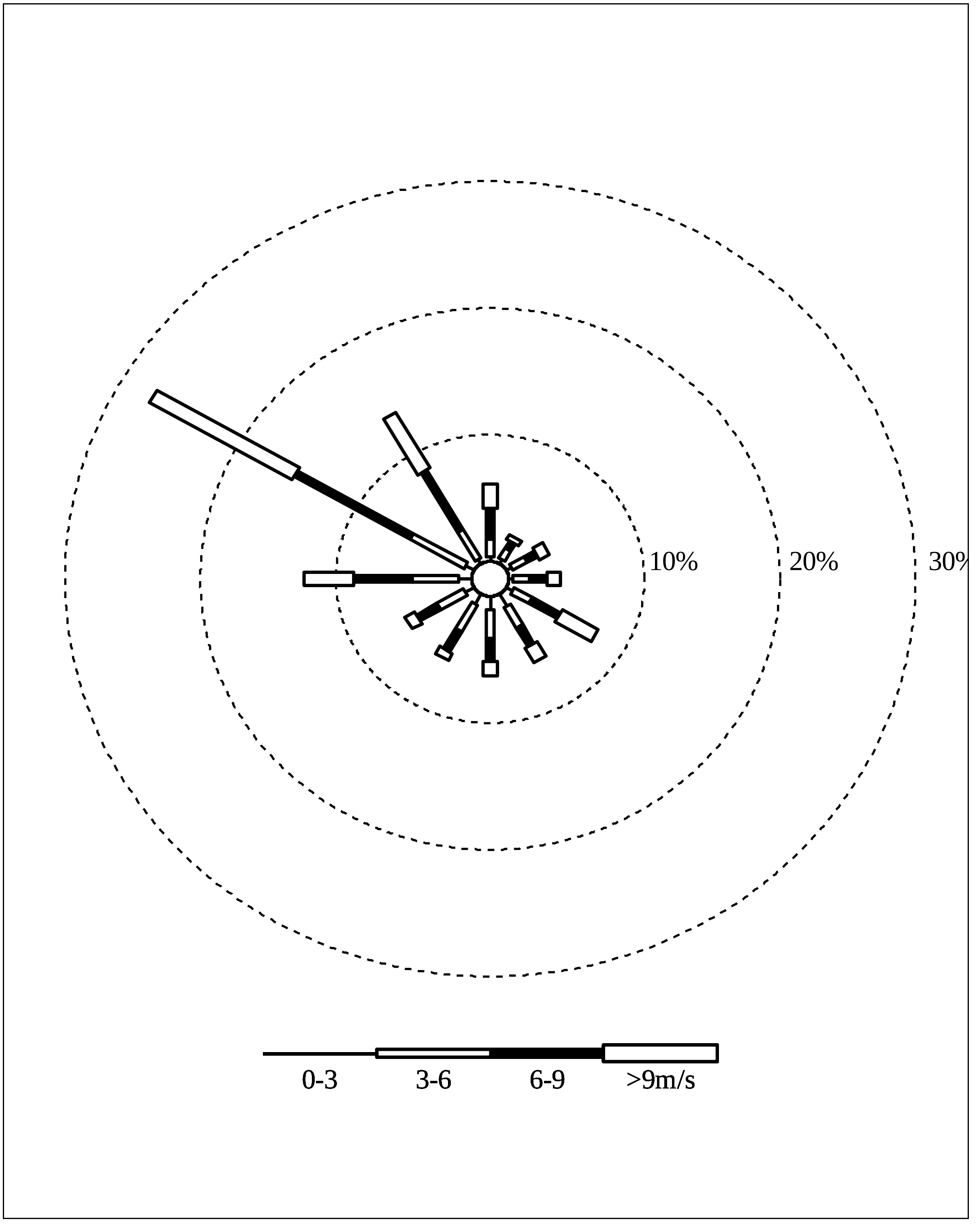


Figure 6.1 Predicted long-term annual wind rose for Mast A1 at 60 m.

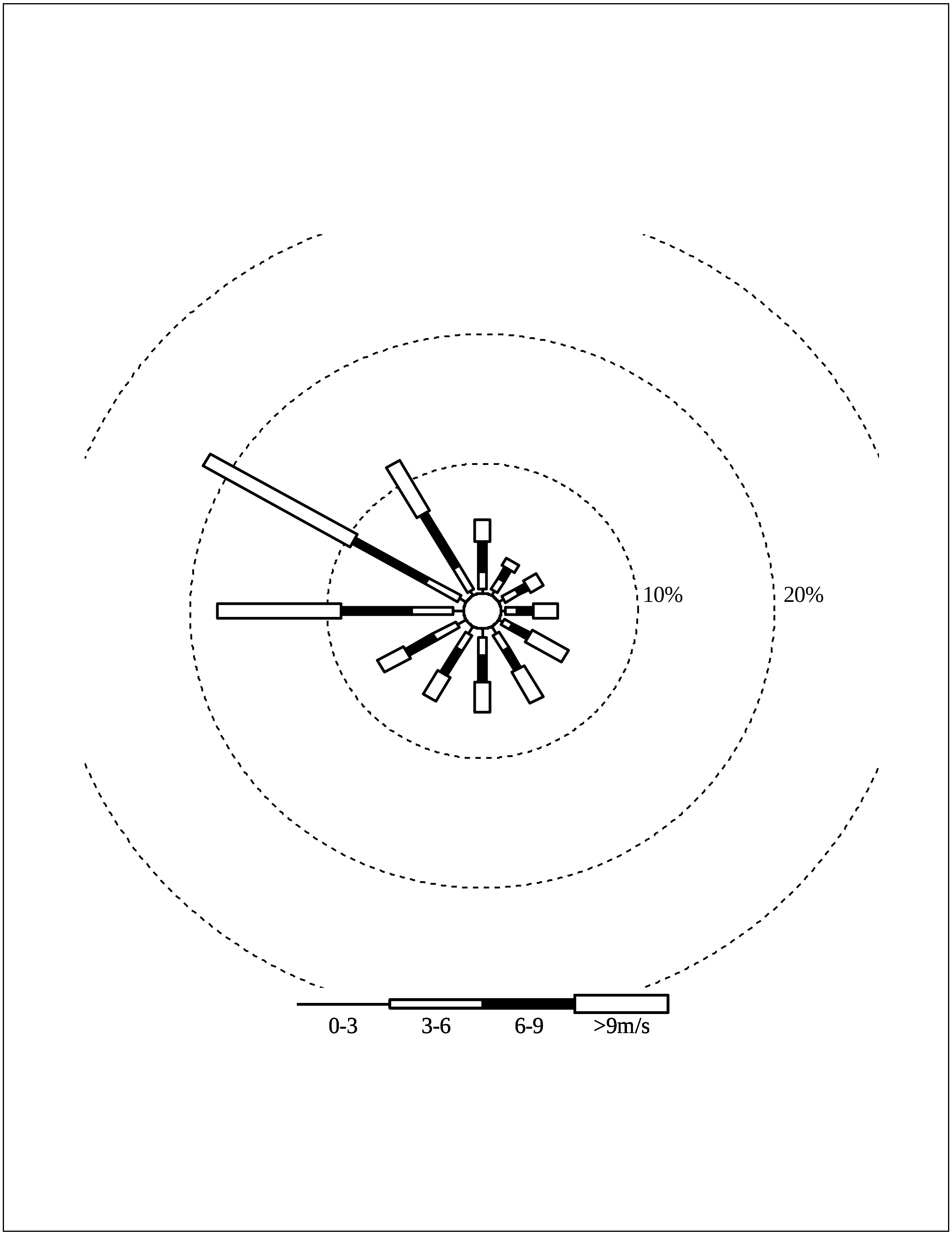


Figure 6.2 Predicted long-term annual wind rose for Mast B1 at 60 m.

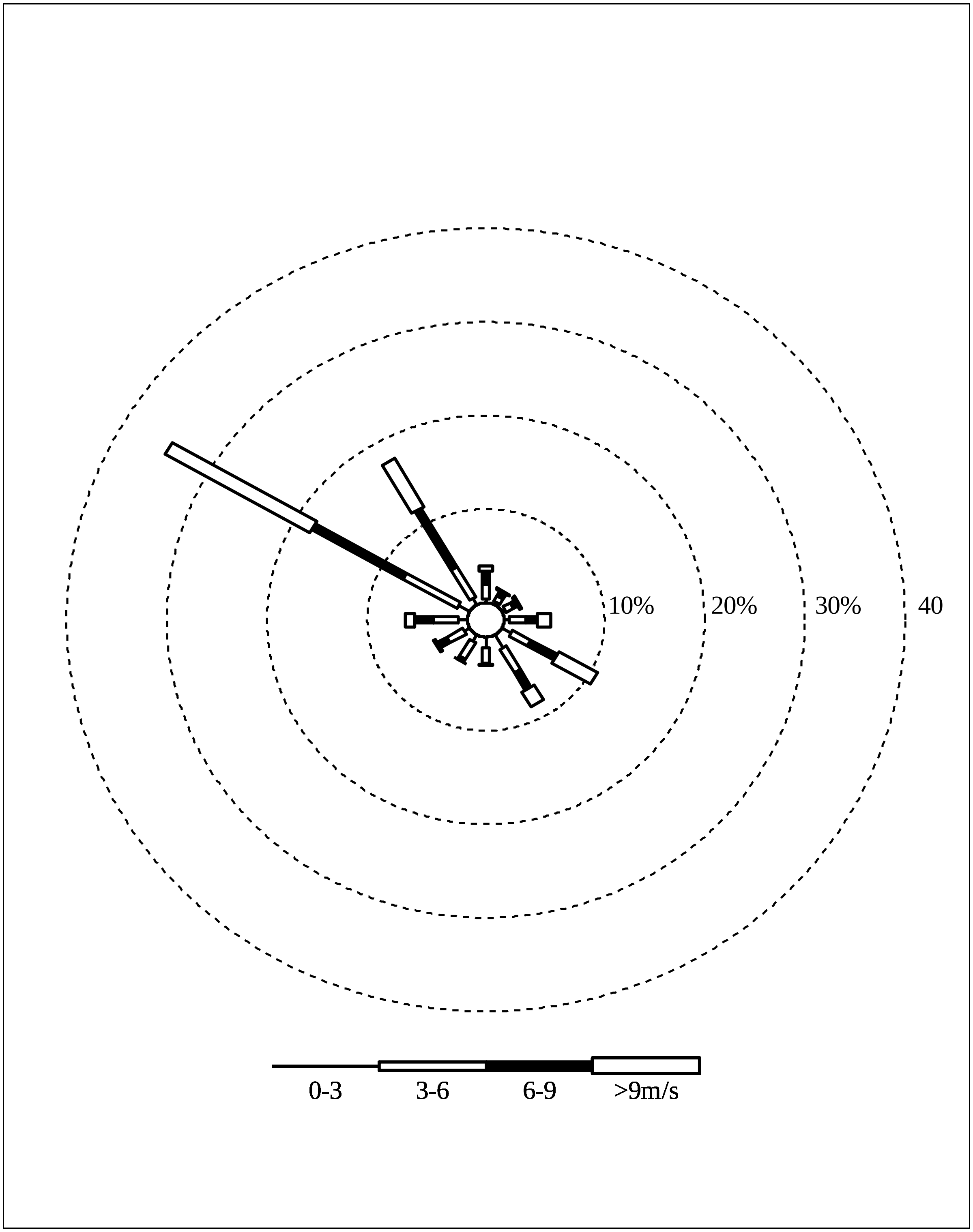


Figure 6.3 Predicted long-term annual wind rose for Mast BII-1 at 60 m.

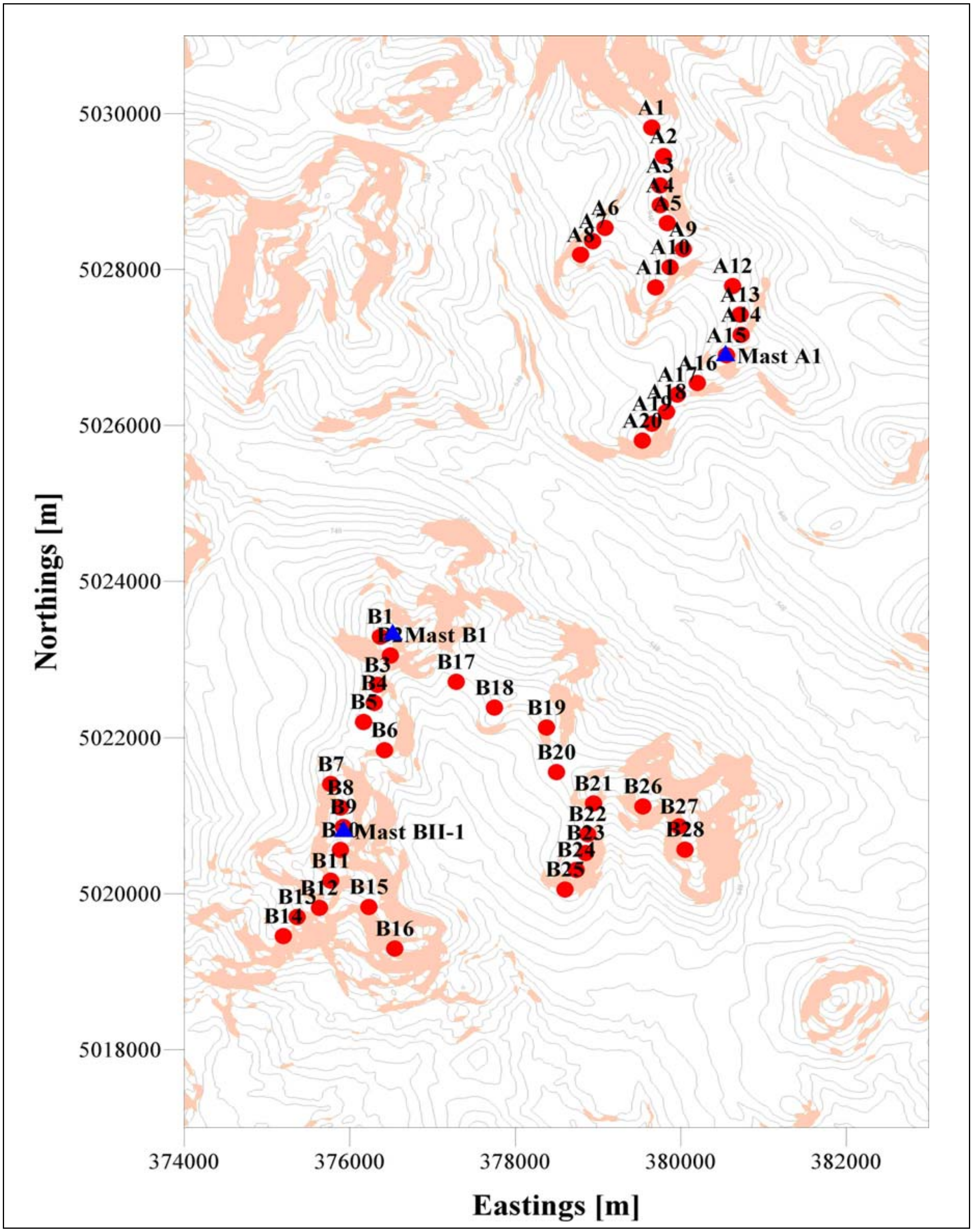


Figure 6.4 Areas of steep terrain

APPENDIX I

Anemometer calibration certificates

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26321
Test Date: 12/16/05 2:30 PM

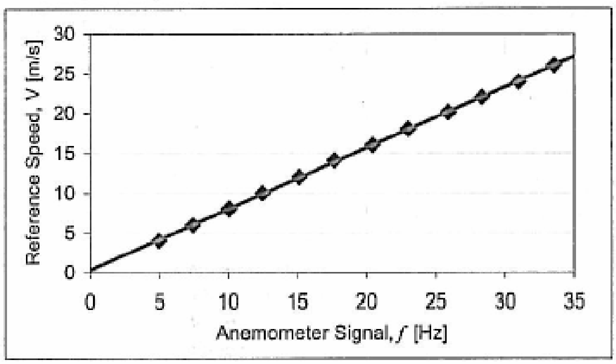
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

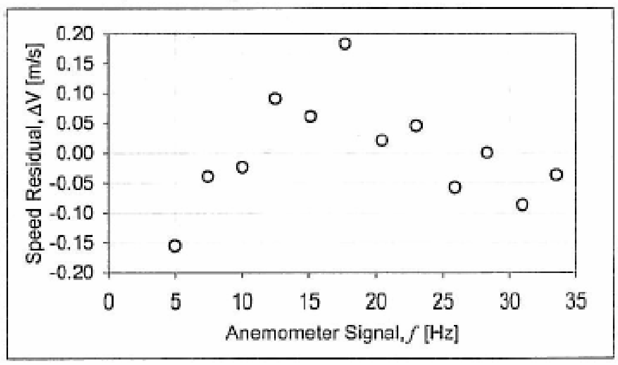
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.004
Mean Ambient Pressure = 101174 Pa
Mean Ambient Temperature = 14.6 deg C
Mean Relative Humidity = 49.7% RH
Mean Density = 1.2214 kg/cubic meter

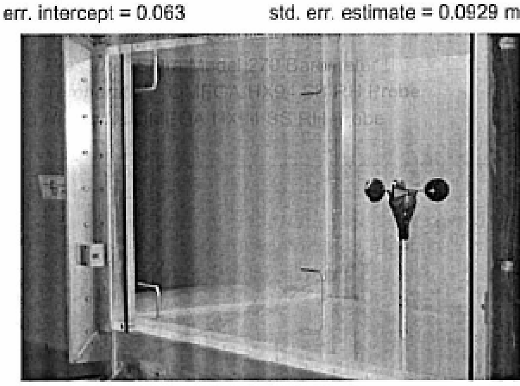




Calibration Transfer Function:

V [m/s] = 0.7645 f [Hz] + 0.372

std. err slope = 0.003   r = 0.9999
std. err. intercept = 0.063   std. err. estimate = 0.0929 m/s



Manufacturer's Certification

Slope+k value = 0.7655 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.08%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.017	4.970	-0.155	2.180%
6.015	7.433	-0.039	2.167%
8.030	10.047	-0.024	2.168%
10.018	12.498	0.091	2.166%
12.006	15.137	0.061	2.165%
14.078	17.688	0.183	2.168%
16.036	20.461	0.021	2.167%
18.023	23.028	0.045	2.165%
20.118	25.903	-0.058	2.166%
22.027	28.325	0.000	2.165%
23.982	30.995	-0.087	2.164%
25.999	33.568	-0.037	2.165%

*** references available upon request*   40_sn26321_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.

630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26322
Test Date: 12/16/05 2:40 PM

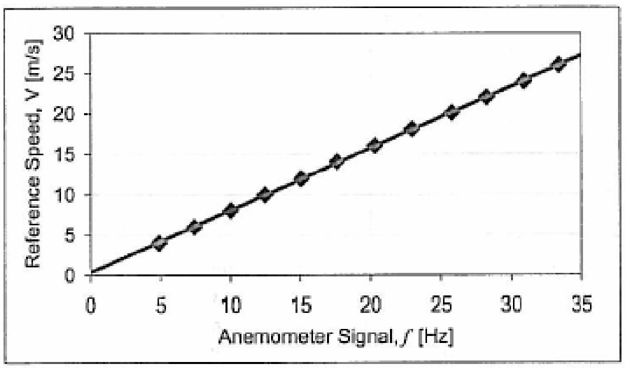
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

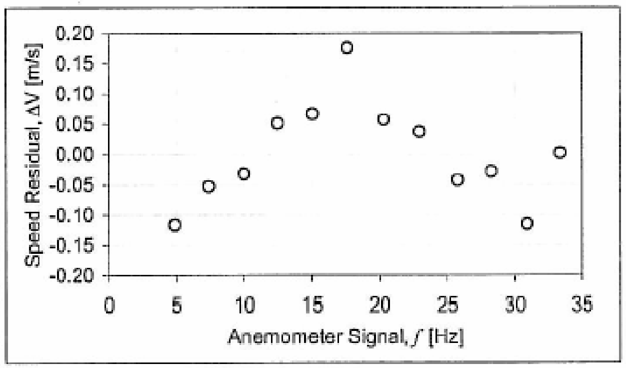
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: $\Delta p_c = 49.78\ V + 0.025$
Velocity Correction Coefficient: 1.0038
Mean Ambient Pressure = 101163 Pa
Mean Ambient Temperature = 14.7 deg C
Mean Relative Humidity = 49.8% RH
Mean Density = 1.2211 kg/cubic meter

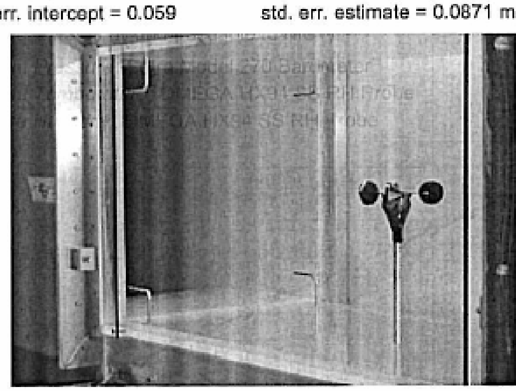




Calibration Transfer Function:

$$V\ [m/s] = 0.767\ f\ [Hz] + 0.3883$$

std. err slope = 0.0028
std. err. intercept = 0.059
r = 0.9999
std. err. estimate = 0.0871 m/s



Manufacturer's Certification

Slope+k value = 0.7687 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.49%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.015	4.880	-0.116	1.949%
6.016	7.406	-0.053	1.942%
8.034	10.009	-0.032	1.934%
10.014	12.482	0.051	1.936%
12.008	15.063	0.066	1.936%
14.070	17.607	0.176	1.934%
16.033	20.322	0.057	1.935%
18.025	22.945	0.037	1.934%
20.109	25.766	-0.043	1.935%
22.032	28.255	-0.029	1.933%
23.985	30.914	-0.116	1.933%
26.003	33.392	0.001	1.933%

*** references available upon request*

40_sn26322_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26323
Test Date: 12/16/05 2:50 PM

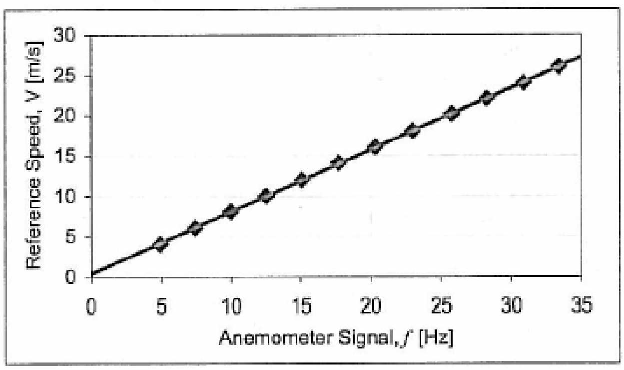
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

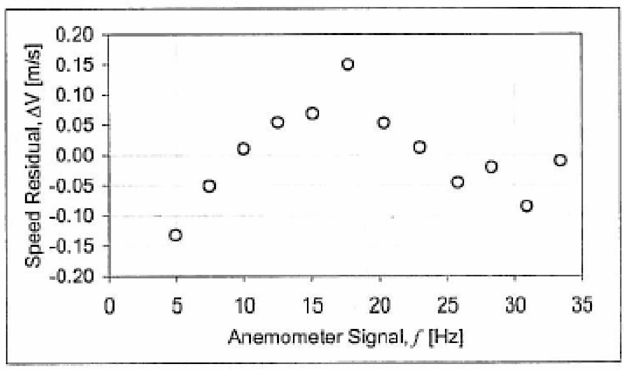
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0035
Mean Ambient Pressure = 101165 Pa
Mean Ambient Temperature = 14.7 deg C
Mean Relative Humidity = 49.8% RH
Mean Density = 1.2209 kg/cubic meter

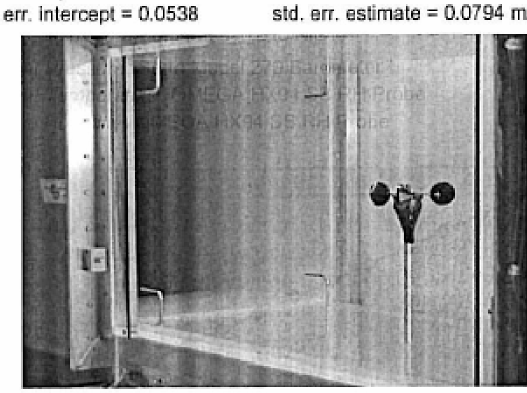




Calibration Transfer Function:

V [m/s] = 0.7671 f [Hz] + 0.37

std. err slope = 0.0025   r = 0.9999
std. err. intercept = 0.0538   std. err. estimate = 0.0794 m/s



Manufacturer's Certification

Slope+k value = 0.768 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.4%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.016	4.926	-0.133	2.130%
6.018	7.429	-0.051	2.119%
8.033	9.976	0.010	2.118%
10.019	12.508	0.054	2.117%
12.007	15.080	0.068	2.117%
14.090	17.690	0.150	2.116%
16.027	20.342	0.053	2.115%
18.013	22.984	0.012	2.120%
20.099	25.778	-0.046	2.115%
22.039	28.274	-0.021	2.114%
23.988	30.899	-0.085	2.115%
26.002	33.427	-0.010	2.116%

*** references available upon request*

40_sn26323_2005-12-16_cal.pdf

APPENDIX J: CALIBRATION SHEETS FOR ANEMOMETERS

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7724

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

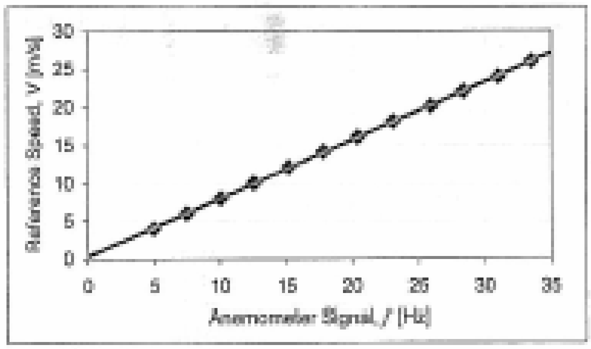
This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

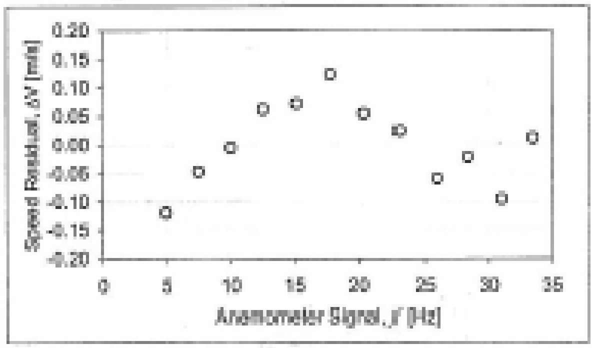
Model No: NRG #40
Serial No: 26324
Test Date: 12/16/05 3:00 PM

IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.
Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1
Test Conditions
Diff Pressure Transducer Calibration: Δp_s = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0034
Mean Ambient Pressure = 101160 Pa
Mean Ambient Temperature = 15 deg C
Mean Relative Humidity = 49.3% RH
Mean Density = 1.2195 kg/cubic meter





Calibration Transfer Function:

V [m/s] = 0.7647 f [Hz] + 0.3599

std. err slope = 0.0024 | r = 1
std. err. intercept = 0.0512 | std. err. estimate = 0.0755 m/s

Manufacturer's Certification

Slope*k value = 0.7651 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope*k' value = 0.03%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.012	4.931	-0.118	2.496%
6.019	7.462	-0.047	2.492%
8.021	10.026	-0.005	2.492%
10.021	12.553	0.062	2.489%
12.018	15.151	0.072	2.488%
14.030	17.706	0.123	2.486%
16.023	20.412	0.054	2.488%
18.023	23.067	0.024	2.489%
20.124	25.923	-0.059	2.489%
22.024	28.359	-0.022	2.486%
23.981	31.015	-0.095	2.487%
25.993	33.505	0.011	2.486%

*** references available upon request*

40_sn26324_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26320
Test Date: 12/16/05 2:19 PM

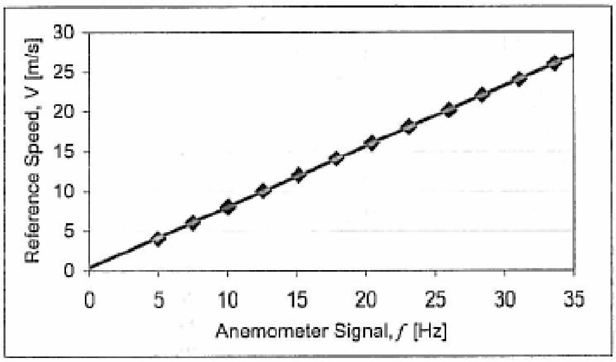
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

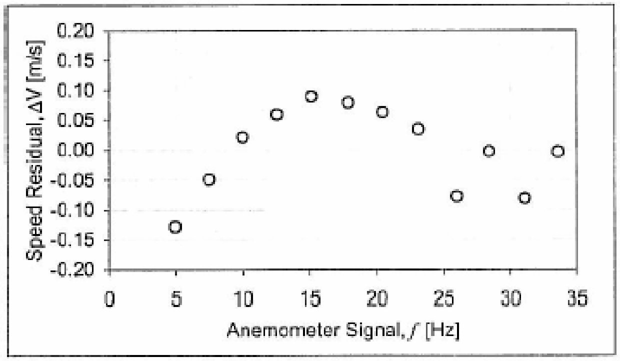
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0035
Mean Ambient Pressure = 101183 Pa
Mean Ambient Temperature = 14.5 deg C
Mean Relative Humidity = 49.7% RH
Mean Density = 1.2218 kg/cubic meter

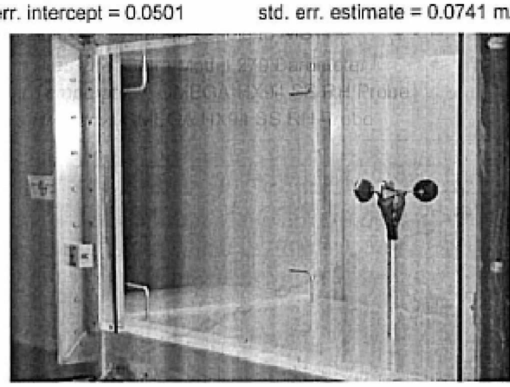




Calibration Transfer Function:

$$V\ [m/s] = 0.7623\ f\ [Hz] + 0.3805$$

std. err slope = 0.0024 r = 1
std. err. intercept = 0.0501 std. err. estimate = 0.0741 m/s



Manufacturer's Certification

Slope+k value = 0.7635 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = -0.18%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.018	4.941	-0.129	1.975%
6.018	7.460	-0.049	1.965%
8.029	10.006	0.021	1.962%
10.018	12.566	0.059	1.964%
12.006	15.135	0.089	1.964%
14.079	17.867	0.079	1.965%
16.032	20.452	0.062	1.962%
18.023	23.100	0.034	1.963%
20.112	25.988	-0.078	1.963%
22.025	28.400	-0.003	1.963%
23.990	31.080	-0.081	1.963%
26.000	33.615	-0.004	1.966%

*** references available upon request*

40_sn26320_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26334
Test Date: 12/17/05 12:33 PM

IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

Wind Tunnel Test Facility

Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment

Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)

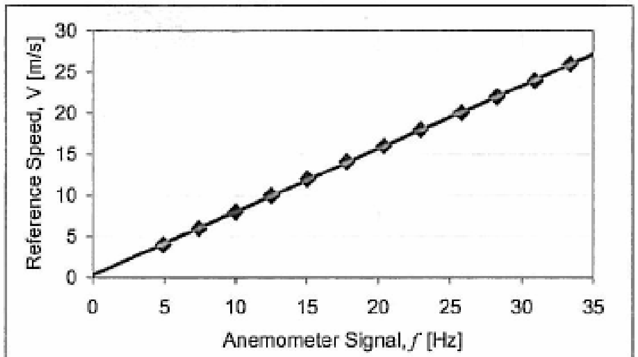
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

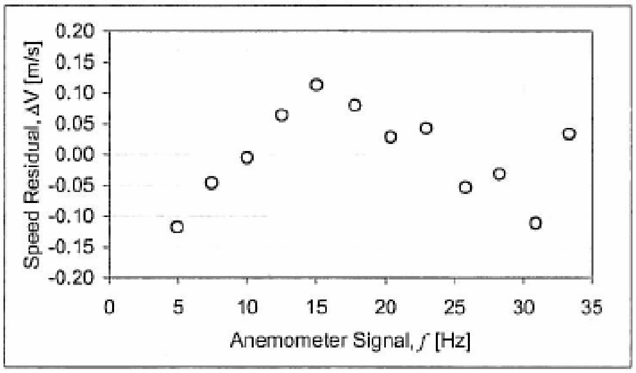
Data Acquisition

Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions

Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0034
Mean Ambient Pressure = 101344 Pa
Mean Ambient Temperature = 14.1 deg C
Mean Relative Humidity = 48.5% RH
Mean Density = 1.226 kg/cubic meter

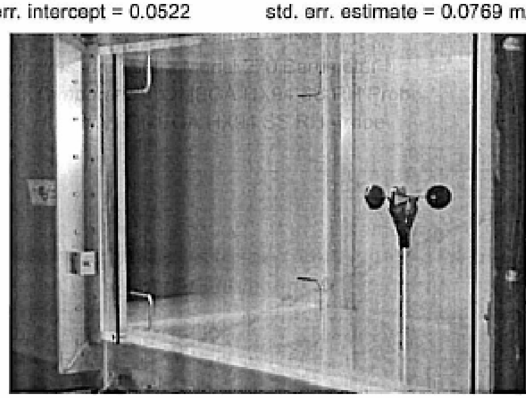




Calibration Transfer Function:

V [m/s] = 0.768 f [Hz] + 0.3539

std. err slope = 0.0025　　r = 0.9999
std. err. intercept = 0.0522　　std. err. estimate = 0.0769 m/s



Manufacturer's Certification

Slope+k value = 0.7681 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.42%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.022	4.930	-0.118	2.194%
6.017	7.434	-0.046	2.190%
8.026	9.997	-0.005	2.187%
10.023	12.507	0.064	2.186%
12.009	15.030	0.113	2.185%
14.087	17.778	0.080	2.184%
16.034	20.381	0.029	2.185%
18.012	22.938	0.043	2.186%
20.108	25.792	-0.053	2.184%
22.030	28.267	-0.031	2.184%
23.982	30.911	-0.111	2.185%
26.004	33.356	0.034	2.184%

*** references available upon request*

40_sn26334_2005-12-17_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26333
Test Date: 12/17/05 12:22 PM

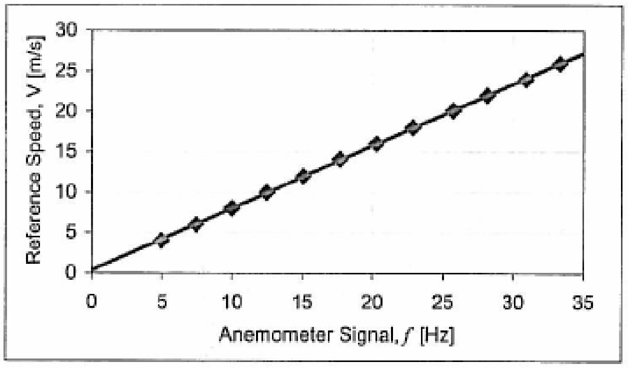
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

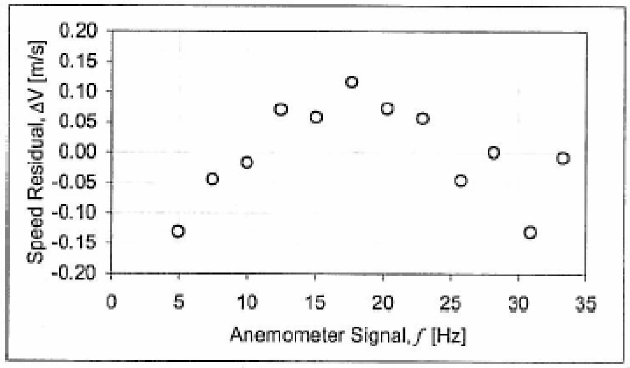
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0036
Mean Ambient Pressure = 101374 Pa
Mean Ambient Temperature = 13.9 deg C
Mean Relative Humidity = 48.5% RH
Mean Density = 1.227 kg/cubic meter

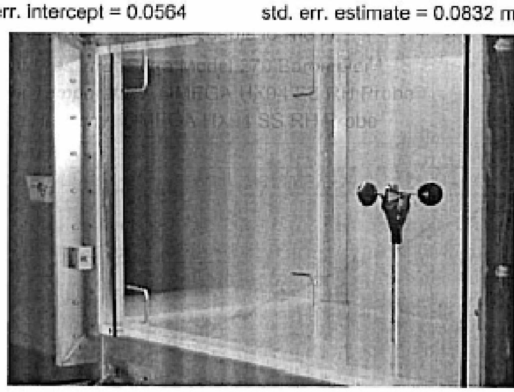




Calibration Transfer Function:

$$V\ [m/s] = 0.7697\ f\ [Hz] + 0.3505$$

std. err slope = 0.0027 r = 0.9999
std. err. intercept = 0.0564 std. err. estimate = 0.0832 m/s



Manufacturer's Certification

Slope+k value = 0.7697 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.63%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.019	4.937	-0.131	2.246%
6.017	7.420	-0.044	2.242%
8.030	10.000	-0.017	2.238%
10.025	12.478	0.071	2.232%
12.013	15.077	0.059	2.234%
14.080	17.687	0.117	2.233%
16.034	20.283	0.073	2.236%
18.022	22.887	0.057	2.234%
20.115	25.738	-0.046	2.232%
22.021	28.155	0.001	2.233%
23.992	30.886	-0.131	2.232%
25.990	33.323	-0.008	2.233%

** *references available upon request*

40_sn26333_2005-12-17_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26332
Test Date: 12/17/05 12:10 PM

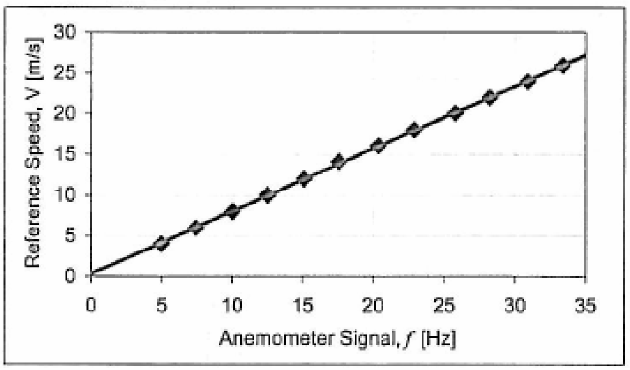
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

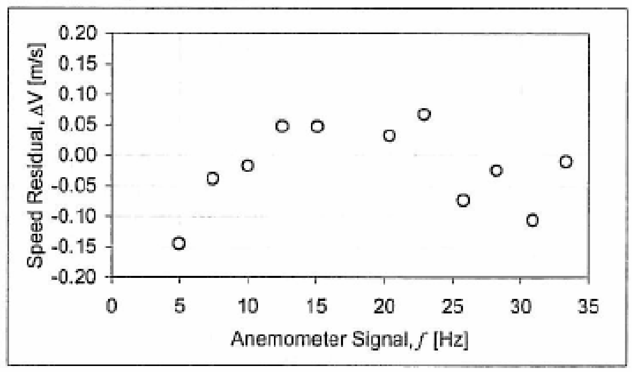
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0038
Mean Ambient Pressure = 101414 Pa
Mean Ambient Temperature = 13.7 deg C
Mean Relative Humidity = 48.6% RH
Mean Density = 1.2283 kg/cubic meter

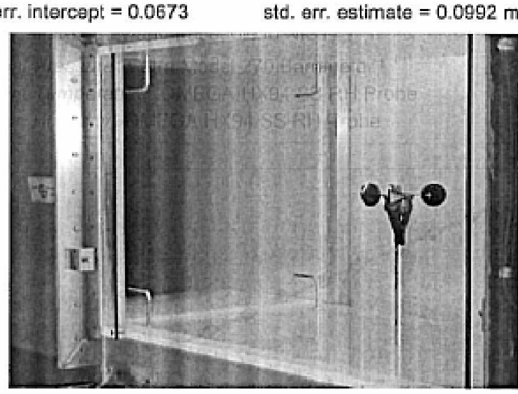




Calibration Transfer Function:

V [m/s] = 0.7692 f [Hz] + 0.3458

std. err slope = 0.0032 r = 0.9999
std. err. intercept = 0.0673 std. err. estimate = 0.0992 m/s



Manufacturer's Certification

Slope+k value = 0.769 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.54%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.014	4.957	-0.145	2.076%
6.016	7.422	-0.039	2.068%
8.028	10.010	-0.017	2.067%
10.020	12.515	0.047	2.066%
12.011	15.104	0.047	2.066%
14.072	17.559	0.220	2.070%
16.041	20.362	0.032	2.065%
18.022	22.892	0.067	2.065%
20.111	25.791	-0.073	2.067%
22.016	28.205	-0.025	2.065%
24.002	30.891	-0.106	2.066%
25.994	33.357	-0.010	2.066%

*** references available upon request*

40_sn26332_2005-12-17_cal.pdf

APPENDIX J: CALIBRATION SHEETS FOR ANEMOMETERS

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26331
Test Date: 12/17/05 12:01 PM

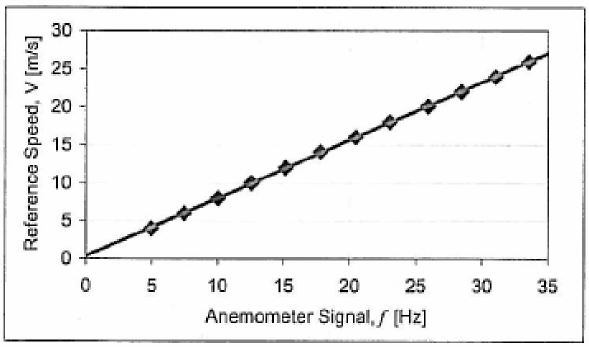
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

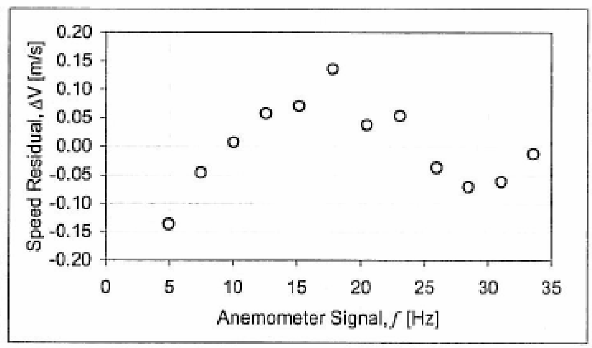
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: $\Delta p_c = 49.78\ V + 0.025$
Velocity Correction Coefficient: 1.0044
Mean Ambient Pressure = 101418 Pa
Mean Ambient Temperature = 13.6 deg C
Mean Relative Humidity = 48.5% RH
Mean Density = 1.2289 kg/cubic meter

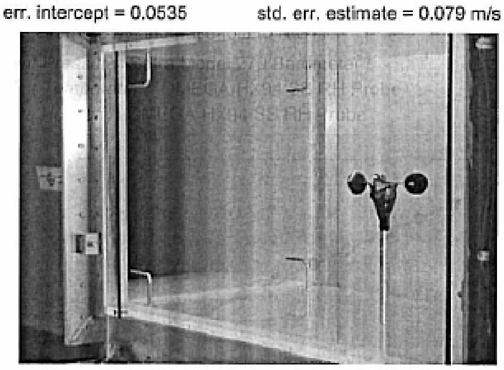




Calibration Transfer Function:

$$V\ [m/s] = 0.7637\ f\ [Hz] + 0.3662$$

std. err slope = 0.0025 r = 0.9999
std. err. intercept = 0.0535 std. err. estimate = 0.079 m/s



Manufacturer's Certification

Slope+k value = 0.7644 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = -0.06%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.013	4.953	-0.137	2.383%
6.013	7.453	-0.046	2.384%
8.023	10.015	0.007	2.377%
10.023	12.568	0.058	2.376%
12.013	15.157	0.071	2.379%
14.081	17.779	0.136	2.376%
16.033	20.464	0.038	2.376%
18.022	23.047	0.054	2.376%
20.128	25.923	-0.037	2.376%
22.015	28.439	-0.070	2.376%
24.002	31.028	-0.062	2.374%
25.982	33.557	-0.013	2.376%

*** references available upon request*

40_sn26331_2005-12-17_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

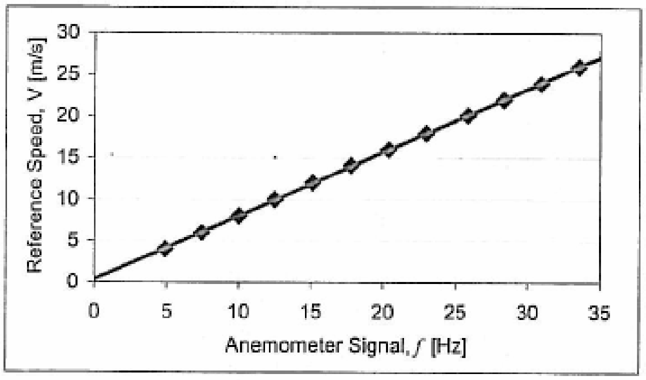
This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

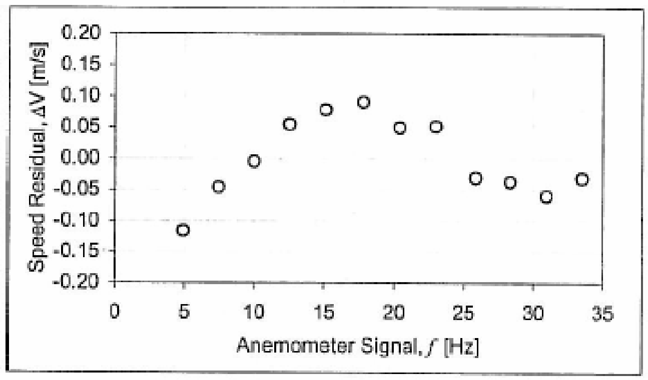
Model No: NRG #40
Serial No: 26335
Test Date: 12/17/05 12:48 PM

IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.
Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1
Test Conditions
Diff Pressure Transducer Calibration: $\Delta p_c = 49.78\ V + 0.025$
Velocity Correction Coefficient: 1.0029
Mean Ambient Pressure = 101316 Pa
Mean Ambient Temperature = 14.4 deg C
Mean Relative Humidity = 48.2% RH
Mean Density = 1.2241 kg/cubic meter

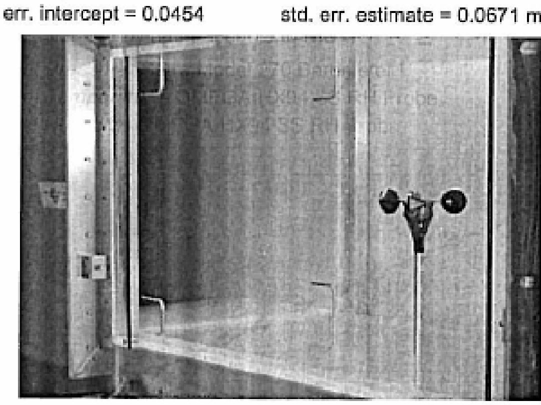




Calibration Transfer Function:

$$V\ [m/s] = 0.7651\ f\ [Hz] + 0.3827$$

std. err slope = 0.0021 | r = 1
std. err. intercept = 0.0454 | std. err. estimate = 0.0671 m/s



Manufacturer's Certification

Slope+k value = 0.7665 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.21%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.024	4.911	-0.116	2.392%
6.013	7.419	-0.046	2.373%
8.030	10.002	-0.005	2.369%
10.013	12.516	0.055	2.368%
12.022	15.111	0.078	2.369%
14.081	17.786	0.091	2.367%
16.023	20.377	0.050	2.369%
18.015	22.978	0.052	2.367%
20.137	25.860	-0.031	2.367%
22.022	28.331	-0.037	2.366%
23.981	30.921	-0.059	2.367%
25.995	33.517	-0.031	2.366%

*** references available upon request*

40_sn26335_2005-12-17_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26329
Test Date: 12/16/05 5:05 PM

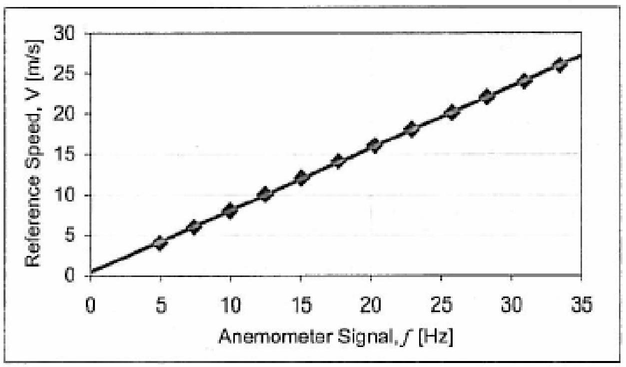
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

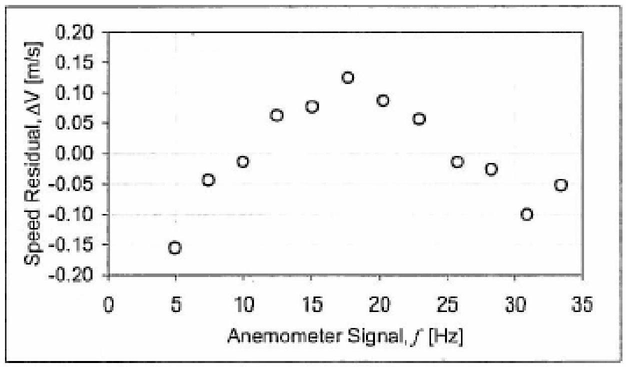
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: $\Delta p_c = 49.78\ V + 0.025$
Velocity Correction Coefficient: 1.0026
Mean Ambient Pressure = 101147 Pa
Mean Ambient Temperature = 15.5 deg C
Mean Relative Humidity = 48.9% RH
Mean Density = 1.2171 kg/cubic meter

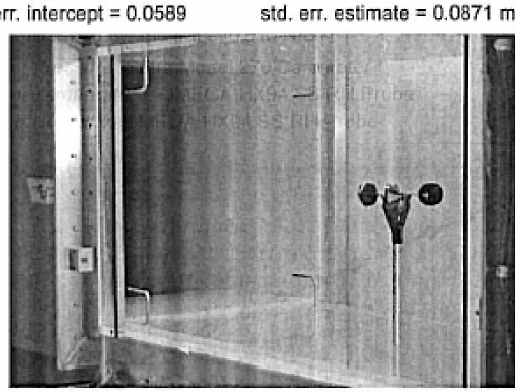




Calibration Transfer Function:

$$V\ [m/s] = 0.7669\ f\ [Hz] + 0.3949$$

std. err slope = 0.0028 | r = 0.9999
std. err. intercept = 0.0589 | std. err. estimate = 0.0871 m/s



Manufacturer's Certification
Slope+k value = 0.7688 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.51%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.023	4.934	-0.156	2.330%
6.015	7.385	-0.044	2.303%
8.017	9.957	-0.014	2.300%
10.008	12.455	0.062	2.300%
12.025	15.065	0.077	2.298%
14.081	17.684	0.125	2.299%
16.028	20.272	0.087	2.299%
18.020	22.909	0.056	2.300%
20.129	25.752	-0.015	2.298%
22.019	28.232	-0.026	2.298%
23.997	30.907	-0.100	2.297%
25.987	33.440	-0.052	2.297%

*** references available upon request*

40_sn26329_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26328
Test Date: 12/16/05 4:56 PM

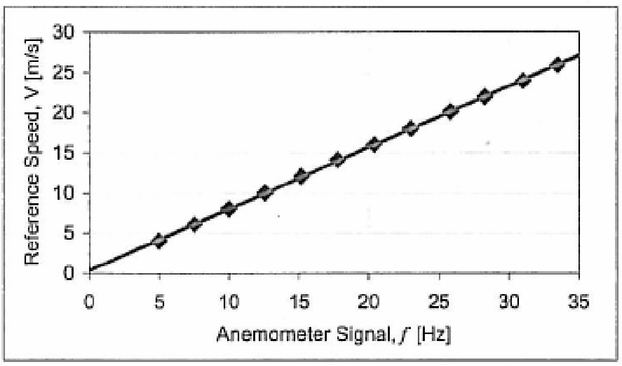
IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

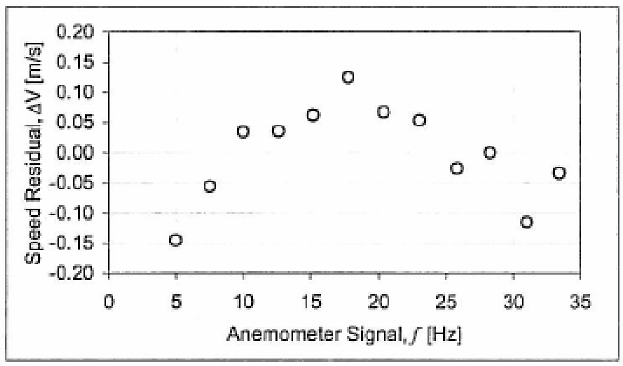
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 0.9984
Mean Ambient Pressure = 101150 Pa
Mean Ambient Temperature = 15.4 deg C
Mean Relative Humidity = 49% RH
Mean Density = 1.2174 kg/cubic meter

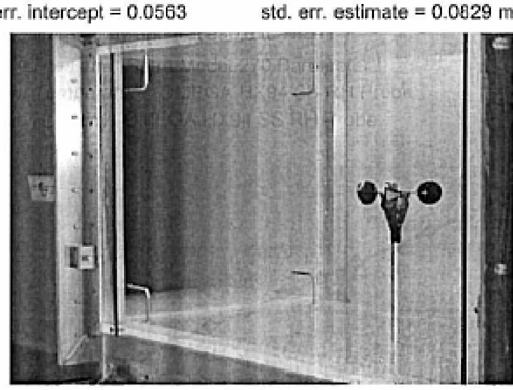




Calibration Transfer Function:

V [m/s] = 0.7648 f [Hz] + 0.3833

std. err slope = 0.0027   r = 0.9999
std. err. intercept = 0.0563   std. err. estimate = 0.0829 m/s



Manufacturer's Certification

Slope+k value = 0.7663 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.18%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.033	4.962	-0.145	5.145%
6.065	7.502	-0.056	4.776%
8.061	9.994	0.034	4.775%
10.056	12.601	0.035	4.776%
12.056	15.180	0.062	4.776%
14.100	17.770	0.125	4.775%
16.033	20.375	0.067	4.775%
18.039	23.013	0.053	4.775%
20.119	25.838	-0.026	4.775%
22.005	28.269	0.000	4.775%
23.977	30.999	-0.116	4.776%
25.938	33.455	-0.034	4.776%

*** references available upon request*

40_sn26328_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

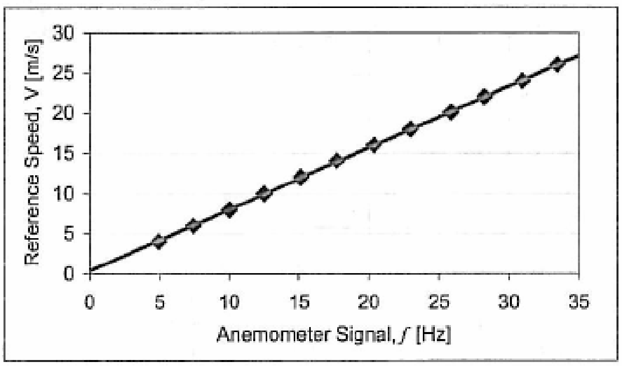
Model No: NRG #40 — *IUT Range: 4 - 26 m/s*
Serial No: 26327 — *IUT Output: 0 - 10V (TTL Signal)*
Test Date: 12/16/05 4:46 PM — *IUT Power Supply: 14 VDC*

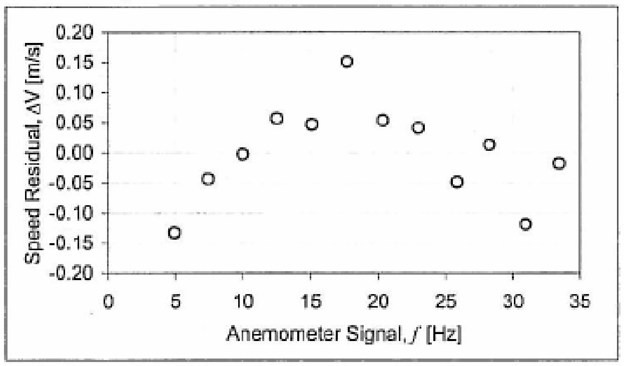
Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0031
Mean Ambient Pressure = 101150 Pa
Mean Ambient Temperature = 15.4 deg C
Mean Relative Humidity = 49.1% RH
Mean Density = 1.2178 kg/cubic meter

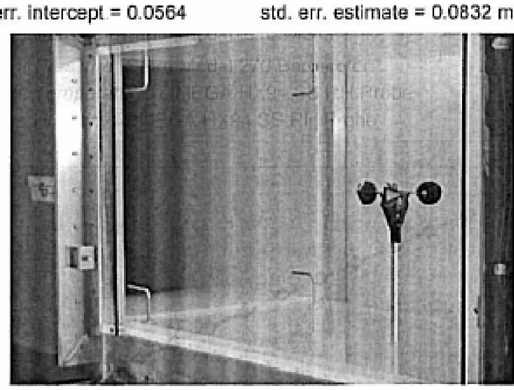




Calibration Transfer Function:

V [m/s] = 0.7665 f [Hz] + 0.3631

std. err slope = 0.0027 — r = 0.9999
std. err. intercept = 0.0564 — std. err. estimate = 0.0832 m/s



Manufacturer's Certification

Slope+k value = 0.7671 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.29%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.016	4.939	-0.133	2.261%
6.012	7.426	-0.043	2.250%
8.027	10.001	-0.003	2.249%
10.016	12.519	0.057	2.255%
12.006	15.128	0.047	2.247%
14.086	17.706	0.151	2.253%
16.024	20.360	0.054	2.248%
18.014	22.972	0.041	2.248%
20.133	25.853	-0.048	2.249%
22.030	28.248	0.013	2.249%
23.983	30.969	-0.119	2.248%
25.995	33.462	-0.018	2.248%

*** references available upon request*

40_sn26327_2005-12-16_cal.pdf

OTECH ENGINEERING, Inc.

630 Peña Drive, Suite 200
Davis, CA 95616-7726

Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

Model No: NRG #40
Serial No: 26326
Test Date: 12/16/05 4:37 PM

IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

Wind Tunnel Test Facility

Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.

Measuring Equipment

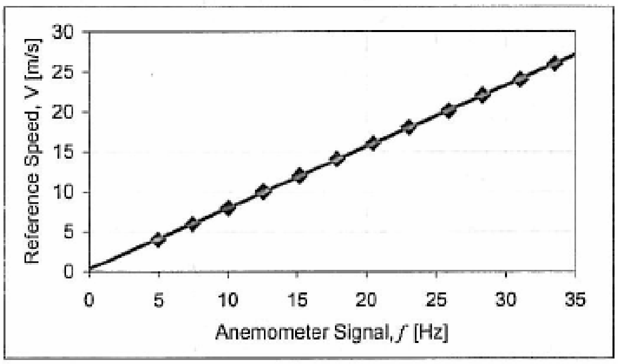
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

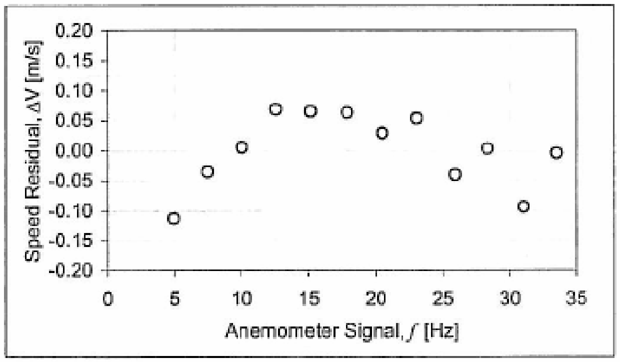
Data Acquisition

Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1

Test Conditions

Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.004
Mean Ambient Pressure = 101152 Pa
Mean Ambient Temperature = 15.2 deg C
Mean Relative Humidity = 49.5% RH
Mean Density = 1.2185 kg/cubic meter

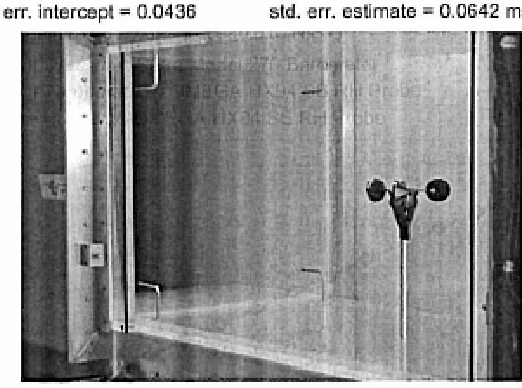




Calibration Transfer Function:

V [m/s] = 0.7652 f [Hz] + 0.3384

std. err slope = 0.0021   r = 1
std. err. intercept = 0.0436   std. err. estimate = 0.0642 m/s



Manufacturer's Certification

Slope+k value = 0.7647 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = -0.03%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.014	4.951	-0.113	2.028%
6.017	7.468	-0.036	2.022%
8.024	10.037	0.005	2.019%
10.024	12.569	0.069	2.018%
12.011	15.170	0.065	2.018%
14.066	17.857	0.063	2.019%
16.038	20.481	0.028	2.021%
18.020	23.037	0.054	2.019%
20.117	25.902	-0.040	2.020%
22.022	28.334	0.003	2.017%
24.000	31.046	-0.094	2.019%
25.992	33.533	-0.005	2.017%

*** references available upon request*

40_sn26326_2005-12-16_cal.pdf

APPENDIX J: CALIBRATION SHEETS FOR ANEMOMETERS

OTECH ENGINEERING, Inc.
630 Peña Drive, Suite 200
Davis, CA 95616-7726
Phone/Fax: (530) 757-2264
Email: johnobermeier@davis.com

ANEMOMETER CALIBRATION REPORT

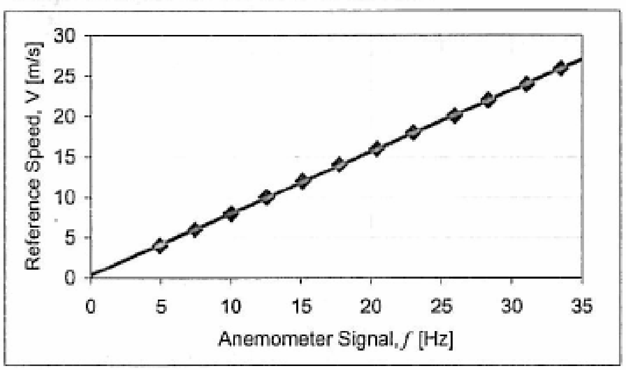
This document reports that a wind tunnel calibration was performed for the cup anemometer listed below and that this anemometer performs within ±1% of the manufacturing control specifications. Prior to calibration, the anemometer was also subjected to a minimum five minute 'run-in' to account for any bearing temperature variability due to mechanical friction.

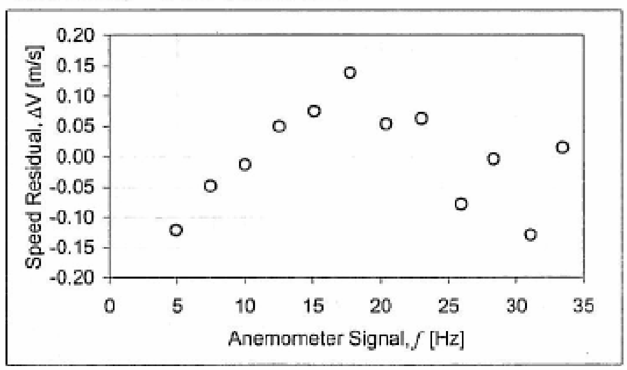
Model No: NRG #40
Serial No: 26325
Test Date: 12/16/05 4:27 PM

IUT Range: 4 - 26 m/s
IUT Output: 0 - 10V (TTL Signal)
IUT Power Supply: 14 VDC

Wind Tunnel Test Facility
Type: Eiffel (open circuit, suction)
Test Section Size: 0.61 m x 0.61 m
Manufacturer: Engineering Laboratory Design, Inc.
Measuring Equipment
Reference Speed: United Sensor Type PA Pitot-Static Tube with MKS Barotron Type 220D Differential Pressure Transducer (calibrated by and traceable to NIST)
Ambient Pressure: Setra Model 270 Barometer
Ambient Temperature: OMEGA HX94 SS RH Probe
Relative Humidity: OMEGA HX94 SS RH Probe

Data Acquisition
Hardware: National Instruments PCI-MIO-16E-4 A/D Board with SC-2345
Software: National Instruments LabVIEW 7.1
Test Conditions
Diff Pressure Transducer Calibration: Δp_c = 49.78 V + 0.025
Velocity Correction Coefficient: 1.0036
Mean Ambient Pressure = 101163 Pa
Mean Ambient Temperature = 15 deg C
Mean Relative Humidity = 49.8% RH
Mean Density = 1.2195 kg/cubic meter

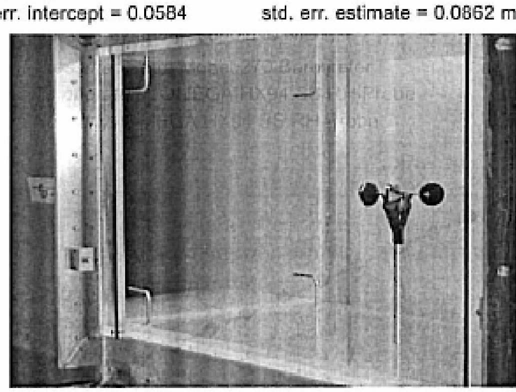




Calibration Transfer Function:

V [m/s] = 0.7645 f [Hz] + 0.3763

std. err slope = 0.0028   r = 0.9999
std. err. intercept = 0.0584   std. err. estimate = 0.0862 m/s



Manufacturer's Certification

Slope+k value = 0.7656 m/s per Hz
Fixed intercept, k = 0.35 m/s
% deviation from consensus 'slope+k' value = 0.1%

Reference Speed [m/s]	Anemometer Output [Hz]	Residual [m/s]	Speed Uncertainty
4.021	4.926	-0.121	2.063%
6.012	7.435	-0.048	2.062%
8.021	10.017	-0.013	2.059%
10.020	12.550	0.050	2.053%
12.011	15.120	0.075	2.054%
14.079	17.743	0.138	2.056%
16.029	20.404	0.054	2.056%
18.025	23.003	0.063	2.053%
20.118	25.925	-0.078	2.056%
22.021	28.318	-0.004	2.053%
23.998	31.068	-0.129	2.055%
25.991	33.485	0.015	2.053%

*** references available upon request*

40_sn26325_2005-12-16_cal.pdf

APPENDIX II

Data analysis procedure

1. Correlation of wind speed and direction.
2. Site wind speed variations.
3. Projected energy production
4. References

1 Correlation of wind speed and direction

The method used to determine the long-term mean wind speed for a "target" site from a "reference" site is based on the Measure-Correlate-Predict approach, which is outlined below.

The first stage in the approach is to measure, over a period of about one year, concurrent wind data from both the "target" site and the nearby "reference" site for which well established long-term wind records are available. The short-term measured wind data are then used to establish the correlation between the winds at the two locations. Finally, the correlation is used to adjust the long-term historical data recorded at the "reference" site to calculate the long-term mean wind speed at the site.

The concurrent data are correlated by comparing wind speeds at the two locations for each of twelve 30 degree direction sectors, based on the wind direction recorded at the "reference" site. This correlation involves two steps:

- Wind directions recorded at the two locations are compared to determine whether there are any local features influencing the directional results. Only those records with speeds in excess of 5 m/s at both locations are used.

- Wind speed ratios are determined for each of the direction sectors using a principal component analysis with the solution forced through the origin. This method is equivalent to a linear least-squared regression forced through the origin minimising the orthogonal offset.

In order to minimise the influence of localised winds on the wind speed ratio, the data are screened to reject records where the speed recorded at the "reference" site falls below 3 m/s or a slightly different level at the "target" site. The average wind speed ratio is used to adjust the 3 m/s wind speed level for the "reference" site to obtain the higher level for the "target" site, to ensure unbiased exclusion of data. The wind speed at which this level is set is a balance between excluding low winds from the analysis and still having sufficient data for the analysis. The level used excludes only winds below the cut-in wind speed of a wind turbine which do not contribute to the energy production.

The result of the analysis described above is a table of wind speed ratios, each corresponding to one of twelve direction sectors. These ratios are used to factor the wind data measured at the "reference" site over the historical reference period, to obtain the long-term mean wind speed at the "target" site.

2 Site wind speed variations

To calculate the variation of mean wind speed over the site, the computer wind flow model, WAsP is used. Details of the model and its validation are given by Troen and Petersen [1].

The inputs to the model are a digitised map of the topography and surface roughness length of the terrain for the site and surrounding area. A digitised map of an area surrounding the site of 20 km x 20 km was derived from 1:50,000 scale maps supplied by GH. Although this domain size is much larger than the area of the site itself, such an area is necessary since the flow at any point is dictated by the terrain several kilometres upwind.

Wind flow is affected by the roughness of the ground. The surface roughness length of the site and surrounding area has been estimated, as detailed in the main text.

The wind flow calculations were carried out for 30 degree steps in wind direction corresponding to the measured wind rose and results were produced as speed-up factors relative to the mast location for a grid encompassing the site area.

To determine the long-term mean wind speed at any location, the speed-up factor for each wind direction was weighted with the measured probability previously derived for the mast location. All directions were then summed to obtain the long-term mean wind speed at the required location.

3 Projected energy production

The components of the derivation of the wind farm net energy output prediction are listed and described below:

Ideal energy output

The ideal energy production is the theoretical output of the wind farm with the hub height wind speeds at the appropriate mast location applied for all associated turbines. Any density adjustment required due to a difference between the air density at hub height at the reference mast location and that assumed for the turbine power curve is applied as discussed in the main body of the report and included in the ideal energy output.

Topographic and wake effect calculations

The first step in modelling flow through an array of wind turbines is the calculation of the flow in the wake of a single machine. Immediately downstream of the rotor, there is a momentum deficit with respect to free stream conditions, which is equal to the thrust force on the machine. As the flow proceeds downstream, there is a spreading of the wake and recovery to free stream conditions. Turbulent momentum transfer is important in this process.

The model used here, WindFarmer, has been developed by GH and validated using measurements on both full-scale machines and on wind-tunnel models [2, 3, 4].

The model is employed in a scheme which, taking each wind speed and direction in turn calculates the power production of the wind farm. The important parameters used in this process are:

- array layout
- upstream mean wind speed
- ambient turbulence
- wind turbine thrust characteristic
- wind turbine power characteristic
- rotor speed
- topographical speed-up factors from site wind flow calculations

Topographical effects are accounted for in the model using the speed-up factors calculated by the wind flow model described above. Any air density adjustments required due to differences between the hub height air density at the turbine locations and that at the reference mast location is applied as discussed in the main body of the report and included in the topographic effect. The array model is used to calculate the wind speed in the turbine wakes, assuming the terrain is flat, and the wind speed is adjusted by the speed-up factor when the wake reaches a downstream turbine.

Electrical transmission efficiency

A figure of 97 % has been assumed for the electrical efficiency of the wind farm based on GH's experience of typical wind farm electrical distribution system designs. A formal calculation of the electrical loss should be undertaken when the electrical system has been defined.

Turbine availability

A figure of 97 % has been assumed for turbine availability based on data from modern operational wind farms. However, availability may be a matter of warranty between the owner and the turbine supplier and the assumed figure should be reviewed when the terms of that warranty are clear.

Icing and blade degradation, low temperature shutdown and access disruption

The turbine production may be affected by the build up of insects, dirt or ice on the blades. This build up will change the characteristics of the blade and therefore affect the performance of the blades and the turbine output. An adjustment has been included to allow for lost production due to blade fouling.

The turbines specified shut down for periods when the ambient temperature is below -30°C. The frequency of occurrence of this phenomenon has been estimated using temperature data recorded at the considered EC and NWS meteorological stations. Where periods of unavailability coincide with access disruption, additional losses may occur.

A figure of 95 % has been assumed to be an appropriate starting assumption for the combination of the above losses.

High wind hysteresis

This is caused by the turbine cut in and cut out control criteria for high wind speeds. The magnitude of this loss is influenced by three factors.

1. The turbine will cut out when the maximum mean wind speed is exceeded and it will not cut in again until this mean wind speed is below a mean wind speed level lower than the cut out mean wind speed.
2. The turbine will cut out if the instantaneous gust wind speed exceeds a maximum level and the turbine will not cut in until the wind speed drops to a lower value.
3. The accuracy of the calibration of the instruments that are determining the wind characteristics at the turbine.

These three effects will cause the turbine to possibly lose production for some proportion of high mean wind speed occurrences. The magnitude of this lost production has been estimated by GH by repeating the analysis using a power curve with the cut out wind speed reduced by 2.5 m/s.

Substation maintenance

Net wind farm production may be reduced due to the electrical output not being transferred to the grid network while the substation is shutdown for maintenance. A typical figure of 99.8% is assumed in this analysis to represent one day per year of planned maintenance. This is included as scheduled maintenance can not generally be accurately planned to occur on a day with low wind speeds.

Utility downtime

Net wind farm production will be reduced if the grid is not available for the wind farm to output electricity to it. This type of loss must be considered on a site specific basis. It has not been considered in this analysis.

Power curve adjustment

Adjustment to the energy prediction to account for variations in the actual turbine performance in comparison to the supplied power curve. This may be a matter of warranty between the owner and the turbine supplier and the estimated figure should be reviewed when the terms of that warranty are clear and a detailed assessment of this issue has been conducted.

Wind sector management

If wind turbine spacing is close the site conditions may exceed the wind conditions within the wind turbine certification criteria. In these circumstances it may be necessary to shut down some turbines which are closely spaced when the wind direction is parallel to the line of turbines. This issue has not been considered in this analysis.

4 References

1. I Troen and E L Petersen, “European Wind Atlas”, Risø National Laboratory, Denmark, 1989.

2. U Hassan, A G Glendinning and C A Morgan, “A Wind Tunnel Investigation of the wake structure and machine loads within small wind turbine farms”, Proc of the 12th BWEA Wind Energy Conference, IMechE, 1990.

3. J Højstrup, “Turbulence measurements in a windfarm”, Proc. EWEA Wind Energy Conference, Madrid, 1990.

4. J G Warren et al. "Performance of wind farms in complex terrain", Proc. Of the 17th BWEA Wind Energy Conference, 1995.