OREGON ANEMOMETER LOAN PROGRAM

Wind Resource Evaluation: Blue Mountain Foothills

Prepared By:
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1.0 INTRODUCTION

The Oregon anemometer loan program was established in the fall of 2002 in order to assist landowners in the state evaluate the wind energy potential of their property. The program is funded by a grant from the Energy Trust of Oregon and is administered by the Energy Resources Research Laboratory at Oregon State University. The program involves several steps, beginning with a preliminary evaluation of the site. If estimates of the site show promise then a monitoring system is installed for a fixed duration (typically on year). The site is monitored regularly and the data processed and checked at regular intervals. Upon completion of the first year, the collected wind data are summarized and a report is prepared evaluating the wind data and the wind resource of the location.

This report represents the final portion of the project and is designed to give the landowner the information necessary to make an informed choice about the role wind energy might play in their property. The report is separated in to sections with section 2.0 devoted to a description of the site, its location and the type of terrain found there. Section 3.0 includes a summary of the wind data collected during the study period including data quality checks and a characterization of the measured winds. In section 4.0 the wind data is analyzed to determine the amount of power production that might be expected from the site and to examine characteristics that might influence these estimates. This is followed in section 5.0 in which wind data from a nearby site is summarized and used to place the current study period in climatological context. A discussion and summary is then presented in section 6.0

2.0 SITE DESCRIPTION

Site Name:	Beebe Property – Blue Mountain Foothills
Latitude:	45-55-00
Longitude:	118-14-35
Elevation:	2680 ft.
County:	Umatilla
Sensor Height:	67 ft.
Types of Sensors:	NRG Maximum #40 wind speed
	NRG 200 series2 wind vane
Types of Data:	10 min. average wind speed (mph)
	10 min. std. dev. wind speed (mph)
	10 min. wind direction (16 categories)
Installation Date:	September 14, 2004 @ 1000 PST
Removal Date:	October 10, 2005 @ 1700 PST

Site Location: The Beebe Property is located east of the town of Milton Freewater on the western slope of the Blue Mountains. Access to the site made by turning off of Highway 11 near the silo on the southern edge of Milton-Freewater and heading east along the Walla Walla River to Power line Rd. Next turn east on Government Mountain Road and proceed up the hill for several miles. The tower was located at the location marked on the map included in Appendix A.

Site Description: The Blue Mountains are a major mountain range in Northeastern Oregon with peaks approaching 6000 ft. The Range is oriented in a general North-South direction and borders the Columbia Basin on its eastern edge. The foothills are on the western slope of the mountains and look out across the Basin. Several wind projects are visible in the distance across the valley in which the town of Milton-Freewater sits. The area surrounding this tower site consists of a series of ridges and valleys that slope down to the west. The tower was positioned on a relatively level spot with good exposure. Most of the surrounding area has been used to grow wheat crops in the past. Most of the vegetation is low grasses with groves of trees in the valleys.

Project Description: The owner of the site is interested in evaluating the site for possible installation of a small wind project or small wind system that can be used to help in powering a small hunting lodge.

3.0 WIND CHARACTERISTICS

In the following sections, several characteristics of the winds at the foothills site are examined and discussed. The goals are to evaluate the characteristics that can help explain the physical processes at work at the site and to highlight the properties that are important to assessing the wind energy potential. These evaluations are done using hourly averaged means that have been constructed using the 10 minute means recorded at the site. This is done so that existing analysis programs can be used and is not expected to have any appreciable influence on the interpretation of data.

Data Recovery: The amount of data recovered during an observation period is important to characterize and should be examined to determine the confidence of other characteristics.

During the annual period at this site, there were no problems detected that might influence the collected wind data. A table of site visits and the actions taken has been included in Appendix B. Data were plotted and scanned manually to identify any problems with the site. For the most part, data collection from the site was complete and there were no periods of missing data. However, data for several periods were removed from the records because the effects of icing were detected. This was only done for periods with a clear presence of icing and it is possible that other periods with a more limited influence occurred. Icing is identified as prolonged periods with a wind speed of 0.0 mph and a constant direction. For this site icing was confined to the months between November and January and was most significant in January when nearly 20 % of the values were removed.

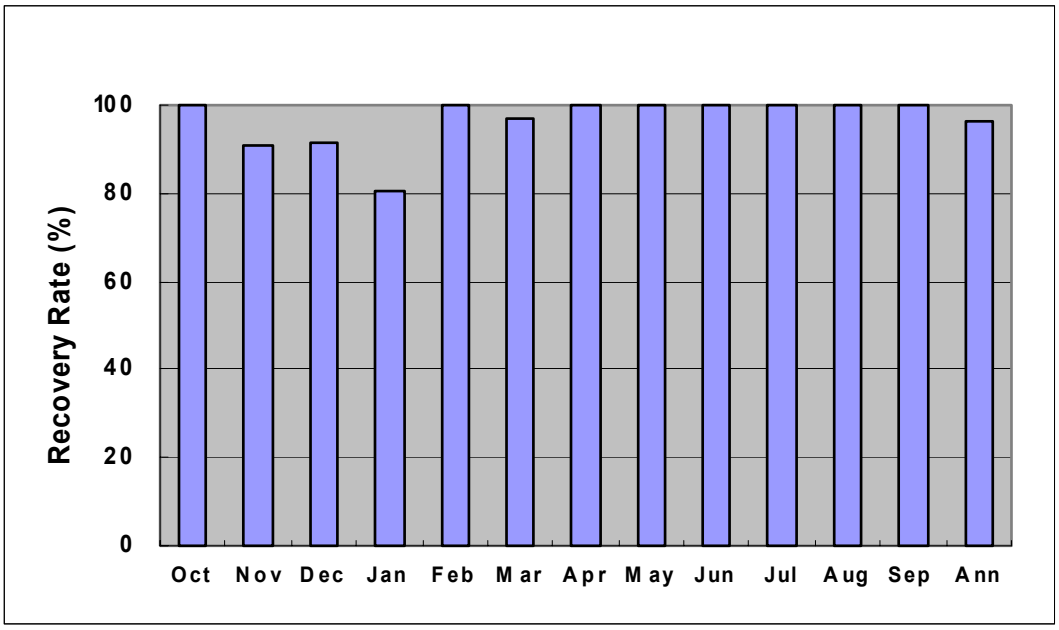


Figure 3.1: Data recovery by month for the Blue Mountain Foothills Site.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
Rec (%)	100.0	91.0	91.5	80.8	100.0	96.8	100.0	100.0	100.0	100.0	100.0	100.0	96.6

Monthly Means: Monthly means are often constructed and used to determine the overall strength of the winds during different periods of the year.

The monthly mean wind speeds show that the Blue Mountain Foothill site has stronger winds during the winter months and weaker winds during the spring and summer. The monthly means ranged from a low of 8.7 mph in September to a high of 15.7 mph in March. The extremely low value in February is likely uncharacteristic as the region was experiencing well below normal storm activity. The lower winds during the summer months are an interesting feature of this data. The site sits across a valley from a major wind power producing region that has strong winds during the summer. The winds are generated by temperature differences between western Oregon and Washington and the Columbia Basin as acts as an outflow for the wind coming through the Columbia River Gorge. One of the major uncertainties of this site was whether these winds extended across the valley. Apparently they do not.

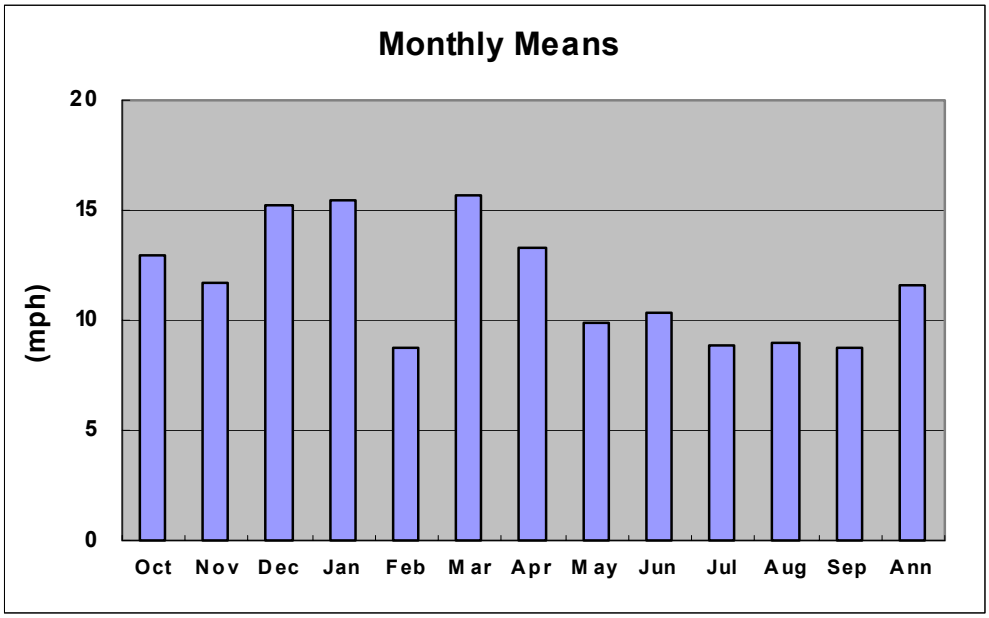


Figure 3.2: Monthly Mean Wind Speed Values for the Blue Mountain Foothill site.

Month	Oct	Nov	Dec	Jan	Jeb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
Mean (mph)	12.9	11.7	15.2	15.5	8.7	15.7	13.3	9.9	10.3	8.9	9.0	8.7	11.6

Diurnal Means: The diurnal pattern of winds is an important characteristic for many wind sites and helps illuminate the mechanisms responsible for the winds. In general, a diurnal pattern is associated with a site at which strong thermal influences play a role. These are normally accentuated during the summer months when the daily heating cycle is at its greatest. Diurnal variations can also provide an indication of dependable and predictable winds at a site.

For the Blue Mountain Foothills site there is no clear diurnal pattern present for the annual period as a whole or for individual months during either the summer or winter (see Fig. 3.3). There is a slight peak in the wind speed during the afternoon in June but the magnitude is very small and the winds drop back off just after midnight. This confirms the speculation of the previous section that suggested that the thermally driven wind common to many areas of North-Central Oregon during the summer are not observed at this site. Some degree of variation is observed during the winter months but it is not significant and may be a result in changes in stability over different times of the day.

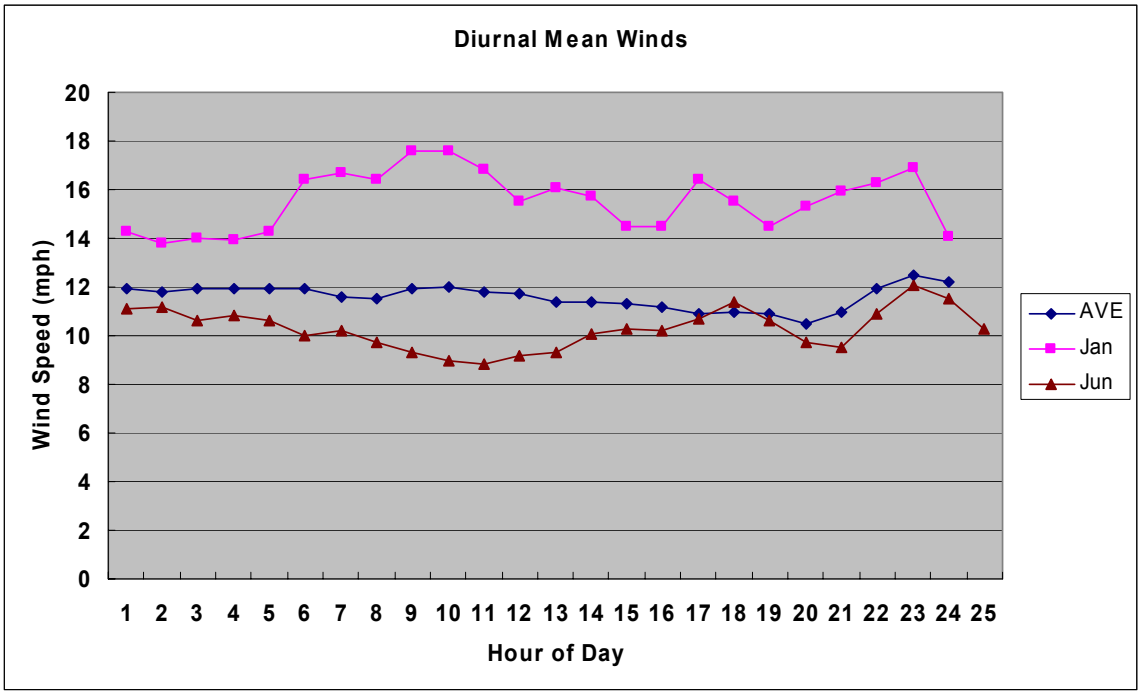


Figure 3.3: Diurnal mean wind speed values for Blue Mountain Foothills.

Frequency Distribution: How the wind speed at a site is distributed over various wind speed categories is an important indication of the wind resource potential of a site. An ideal site would have winds that blow at a high rate for long periods. This is not normally the case, however, and wind records from a site show a skewed distribution with a higher frequency of winds at lower speeds.

For the Blue Mountain Foothills site (Figure 3.4) we see that the distribution is fairly typical with a low frequency of winds at the lowest range, a peak centered around 6.0 mph and a trailing tail at the upper end. In this case the peak is relatively broad and shows that it is most common to have winds in the range of 2-12 mph. This peak would likely be smoother with additional data. What this figure shows is that for this site the winds are in an energy producing range (above 12.0 mph) about 40 % of the time and above the general rated speed of most turbines (about 30.0 mph) roughly 5 % of the time. In addition, the upper end of the curve trails up above 60.0 mph indicating that this site does experience occasional high wind periods. The highest hourly value from this site was 68 mph.

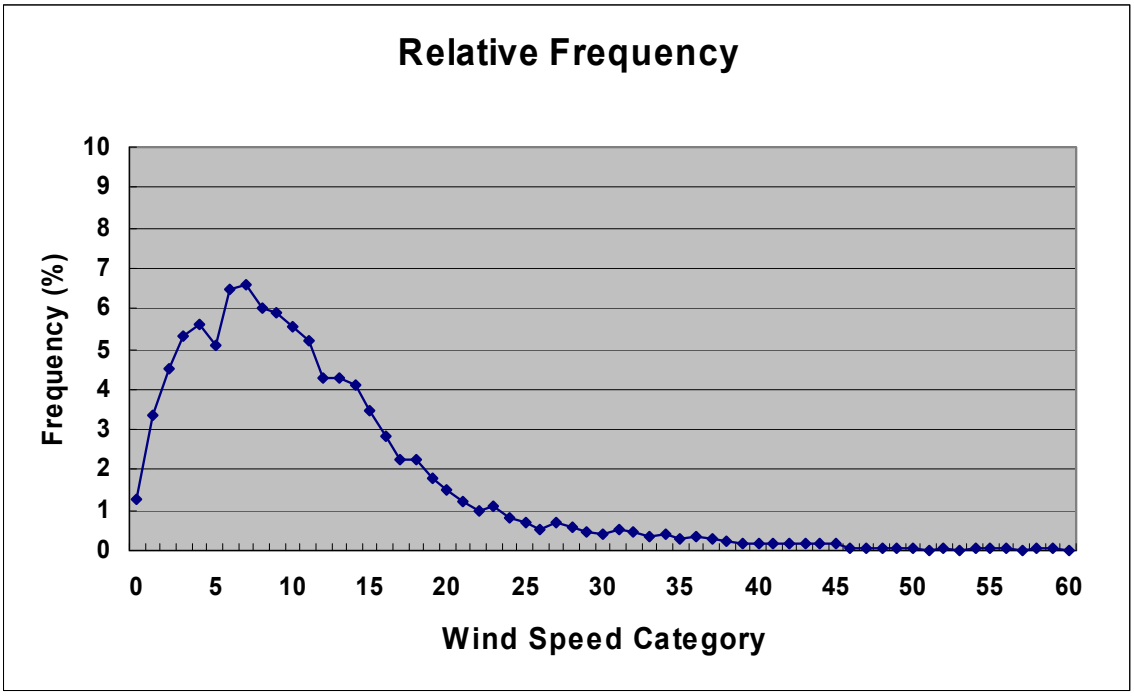


Figure 3.4: Wind speed frequency distribution for Blue Mountain Foothills.

Wind Rose: How the wind varies with direction is also important to understanding the physical processes that contribute to the local winds at a site and eventually in designing a wind facility. A wind rose is often used to display this information and show the frequency with which the wind occurs in different direction categories. A similar plot can be used to show the strength of the wind from each of the direction categories.

For this site (Figure 3.5) it is apparent that the predominant wind direction is from the south. The four wind categories from SSE to SW account for about 60 % of the observed winds. Most other categories have relatively small frequencies except North which has a

frequency of 8.6 %. It is also clear from Figure 3.5 that the winds on average are much stronger for the southerly wind categories. The highest mean is for the SE category (2*). This is the direction from which the highest individual winds were observed including several values above 60.0 mph. The lack of winds from the other wind categories and the low mean speed values for these categories suggest that the primary source of winds at this site are storm systems that sweep through this region.

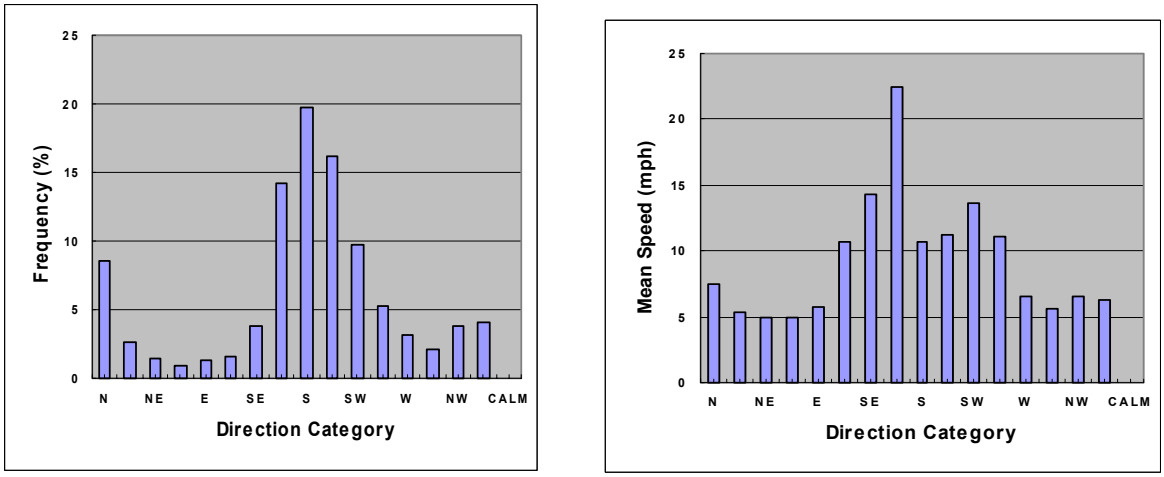


Figure 3.5: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories.

Discussion:

The plots and tables in this section are designed to help characterize the wind at this site and lead into an evaluation of the wind resource potential of the site. When put together, the Monthly means, diurnal means, frequency distribution and wind rose indicate that the winds at this site are generated primarily by winter storms. This will mean that as a resource, energy will be available only over a portion of the year and will depend on the strength, frequency and duration of storm systems. These factors can vary substantially from year to year.

4.0 SITE POWER CHARACTERISTICS

In order to evaluate the wind power potential at this site a number of quantities were computed using the collected wind data. As with the wind characteristics, hourly wind data was used to complete this work. The power density calculation requires air density. This is estimated assuming a standard atmosphere and the site elevation. The computed quantities include the mean and standard deviation of the hourly values, the recovery rate, the maximum one hour average, the wind power density and the frequency that the wind was observed within a wind speed range (12 mph to 60 mph). These quantities are shown in Table 4.1 and reveal a number of things about the potential for generating energy the site.

The quantities in Table 4.1 show the seasonal nature of the winds over the monitoring period at this site. Other than February, the months between October and April show high values of nearly all of these quantities with some impressive values. For several months, hourly averaged winds above 60.0 mph were observed, the winds were in an operating range above 50 % of the time and the power densities were above 500 W/m**2. Other months, especially July through August, had low values of all these quantities. This further illustrates the seasonal nature of the winds at this site and the absence of any wind resource during the summer months.

To examine the overall amount of energy contained in the wind, the power density is very useful. It represents the amount of energy that would be available to a unit area each hour. The monthly mean values are shown in Figure 4.1 and highlight the seasonal characteristics of this site. The power density values are generally above 300 W/m**2 for October through April (excluding February) but quite low for June through September.

Table 4.1: Computed power quantities for the Blue Mountain Foothills site.

Month	Mean (mph)	Std. (mph)	Recovery Rate (%)	Max 1-Hr (mph)	Time in Range 12-16 mph(%)	Power Den. W/m**2	Shape Factor	Scale Factor
Oct	12.9	9.8	100.0	59.9	44.6	362	1.35	14.1
Nov	11.7	10.0	91.0	47.5	36.8	330	1.18	12.3
Dec	15.2	11.7	91.5	60.4	53.9	584	1.33	16.5
Jan	15.5	13.4	80.8	67.5	49.9	757	1.18	16.4
Feb	8.7	7.8	100.0	39.7	27.8	147	1.14	9.1
Mar	15.7	10.9	96.8	55.3	54.0	558	1.48	17.3
Apr	13.3	10.5	100.0	55.7	42.9	444	1.29	14.4
May	9.9	6.3	100.0	38.9	31.2	124	1.64	11.1
Jun	10.3	4.9	100.0	26.5	37.2	94	2.24	11.6
Jul	8.9	4.7	100.0	33.8	21.9	70	2.00	10.1
Aug	9.0	4.5	100.0	23.1	26.1	65	2.13	10.1
Sep	8.7	5.1	100.0	29.6	21.3	75	1.80	9.8
ANN	11.6	9.1	96.6	67.5	37.0	292	1.30	12.5

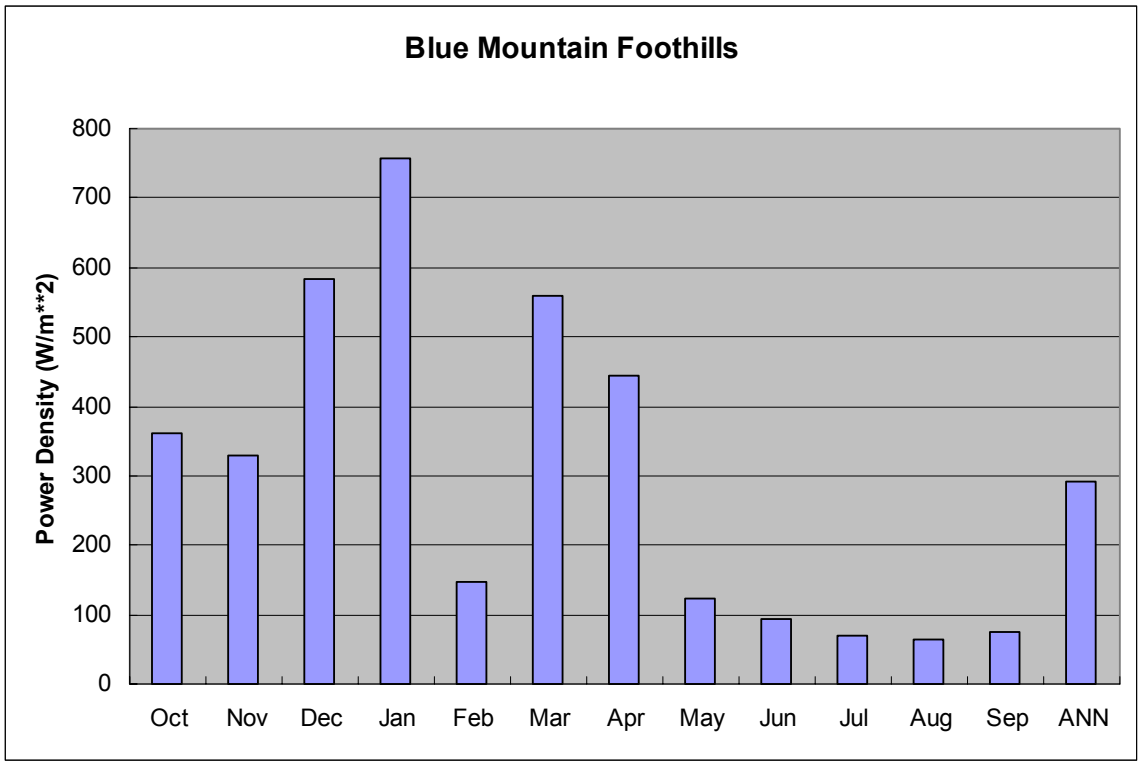


Figure 4.1: Monthly power density for the Blue Mountain Foothills site.

In addition to evaluating these basic power characteristics it is possible to estimate how specific wind turbines might interact with the winds at a particular site. Using the collected wind data and the characteristics of a particular wind turbine it is possible to estimate the amount of power that could be produced. This is done by comparing the wind data with a power curve for a specific wind turbine. A power curve is simply the curve that shows the relationship between the wind speed and the amount of power a turbine can produce. An example is provided in Figure 4.2. There are several portions of the curve that are important. At low wind speeds, below the cut-in speed, no energy is produced. Any turbine has a lower threshold below which it won't operate. This is in part because there is little energy available at these levels. In the middle is a ramp up zone where even a small increase in wind speed results in a larger increase in power. At some point, depending on the type of turbine, the amount of power hits its rated capacity as the blades are pitched to spill energy and protect the turbine. At the upper end, energy production will stop if the winds reach a cut-out speed. This is the speed at which a turbine is shut down.

In Table 4.2, energy capacity factors are shown for eight different types of turbines. The capacity factor is the ratio of the amount of energy produce to the amount of energy that could be produced if a turbine ran at its rated capacity all the time. The rated capacity is effectively a theoretical maximum and capacity factors generally range from 0.0 to 0.40. It's difficult to compare these because of the different turbine characteristics but they are given to provide a range of values that might be expected from this site. In computing

these values, it is necessary to adjust the observed data which is measured at 67 feet to the hub height of the particular turbine. In this case this is done using a standard assumption that the wind follows a typical power law profile with a coefficient of 0.143.

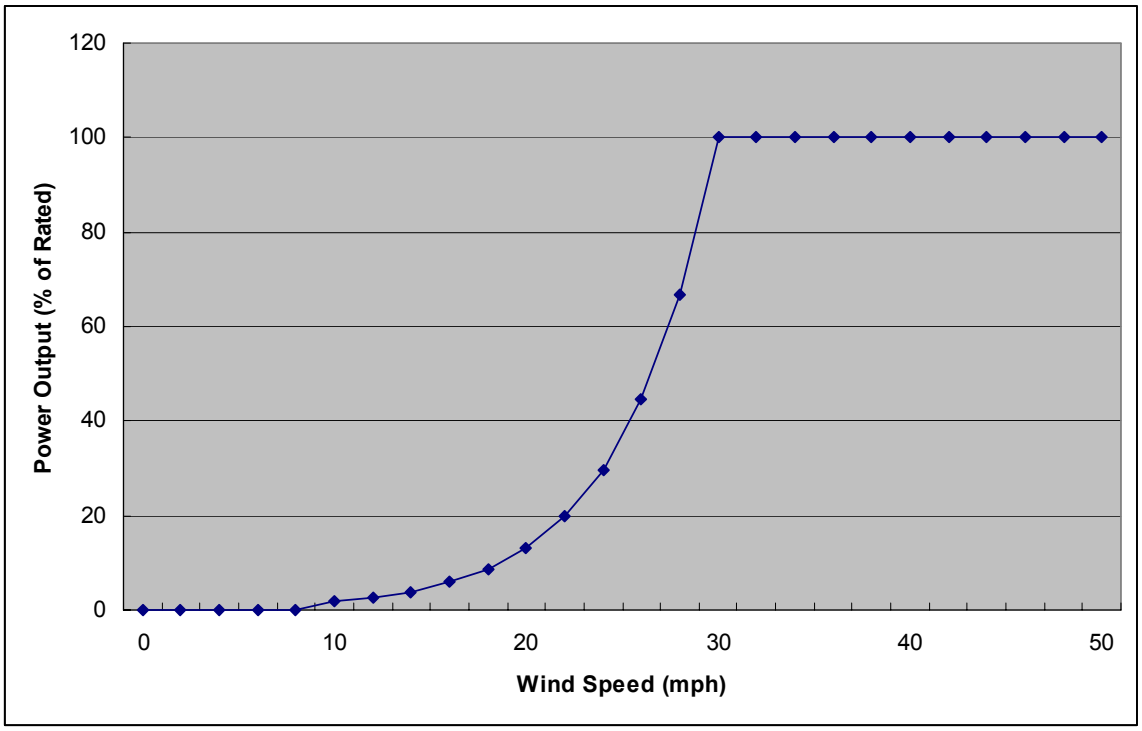


Figure 4.2: Sample power curve for a theoretical turbine

The capacity factors in Table 4.2 support the conclusions of the previous section and indicate that there appears to be a fairly good potential for wind generation during the winter at this site but little potential during the summer. Capacity values for each of the turbines generally range from below 0.1 to values near or above 0.3. The annual values vary some from turbine to turbine but are generally around 0.2. For a good wind site we would expect to see capacity factors above 0.3 annually and above this for at least several months of the year.

Table 4.2: Capacity factors computed for the Blue Mountain Foothills site using observed wind data and characteristics of eight different wind turbines.

Turbine	Vesta 47	Vestas 80	Vestas 66	Vestas 7.5	BWC EXCEL	GE Wind 70.5	Vestas 29	Mitsubishi
Size (kW)	660	2000	1650	55	10	1500	225	250
Hub Ht. (ft.)	131	262	197	59	79	210	103	100
Oct	0.252	0.283	0.229	0.225	0.181	0.279	0.258	0.206
Nov	0.218	0.246	0.202	0.196	0.162	0.242	0.223	0.182
Dec	0.325	0.353	0.300	0.308	0.255	0.352	0.333	0.282
Jan	0.331	0.356	0.307	0.321	0.267	0.356	0.341	0.292
Feb	0.139	0.161	0.126	0.123	0.097	0.157	0.143	0.112
Mar	0.319	0.353	0.298	0.301	0.257	0.351	0.332	0.278
Apr	0.230	0.257	0.207	0.214	0.177	0.251	0.241	0.190
May	0.133	0.159	0.118	0.111	0.084	0.151	0.137	0.101
Jun	0.131	0.161	0.112	0.102	0.073	0.150	0.134	0.092
Jul	0.087	0.110	0.076	0.068	0.050	0.102	0.092	0.063
Aug	0.085	0.109	0.073	0.065	0.047	0.099	0.090	0.060
Sep	0.088	0.109	0.077	0.070	0.053	0.102	0.093	0.065
ANN	0.192	0.219	0.175	0.173	0.139	0.213	0.199	0.158

5.0 CLIMATOLOGICAL ANALYSIS

Measurements take over a single one-year period can provide a good estimation of the winds and wind energy potential of a site. However, this is a fairly limited period and is only meaningful if we can place the period into a larger climatological context. For the Blue Mountain Foothills site, the long-term wind monitoring site at Kennewick, Washington should useful. The Kennewick site is operated and maintained by the Bonneville Power Administration and has been in place since 1976 and in its current configuration since 1987.

Kennewick was selected primarily because of it's proximity to the site and because of the long period of record. There are some significant differences however, including the elevation and the anemometer height and the seasonal wind characteristics. Kennewick is closer to the Columbia Gorge outflow region and is known to have fairly strong winds during summer periods. Although these factors will influence the observed winds at the sites the site may still be of use in establishing the climatological significance of the monitoring period at the Blue Mountain Foothills.

Information about the site and the monthly means and departures for this annual study period can be found in Table 5.1. First, as expected, the winds overall are similar to the Foothills site during the winter but much higher during the summer. In spite of the relative differences, the departures indicate that for the period overall, the winds were very close to normal. An annual departure of 4 % is relatively small. However, there were some significant monthly departures and it is interesting to note that the months between November and February all had substantial negative departures. While this was expected for February it is somewhat surprising for the other months and suggests that the winter winds may be somewhat stronger that indicated by the observed values during this study period. It would be nice to make a similar comparison for the summer months but it is not clear that the relationship between these two sites is adequate to justify any characterization.

Table 5.1: Monthly mean and departures for winds at Kennewick, BPA.

Kennewick BPA Latitude: 46-06-15 N Longitude: 119-07-43 W		Elevation: 2200' Sensor Ht: 86'	
Month	**Normal (mph) 1987-2006**	**Mean (mph) current**	**Departure (%)**
Oct	16.9	18.3	8.3
Nov	19.9	16.1	-19.1
Dec	18.7	17.5	-6.4
Jan	20.1	16.6	-17.4
Feb	18.2	15.0	-17.6
Mar	19.3	21.0	8.8
Apr	17.9	17.5	-2.2
May	17.7	17.7	0.0
Jun	17.7	20.2	14.1
Jul	15.6	14.0	-10.3
Aug	15.4	13.7	-11.0
Sep	15.0	16.3	8.7
ANN	17.7	17.0	-4.0

6.0 SUMMARY AND DISCUSSION

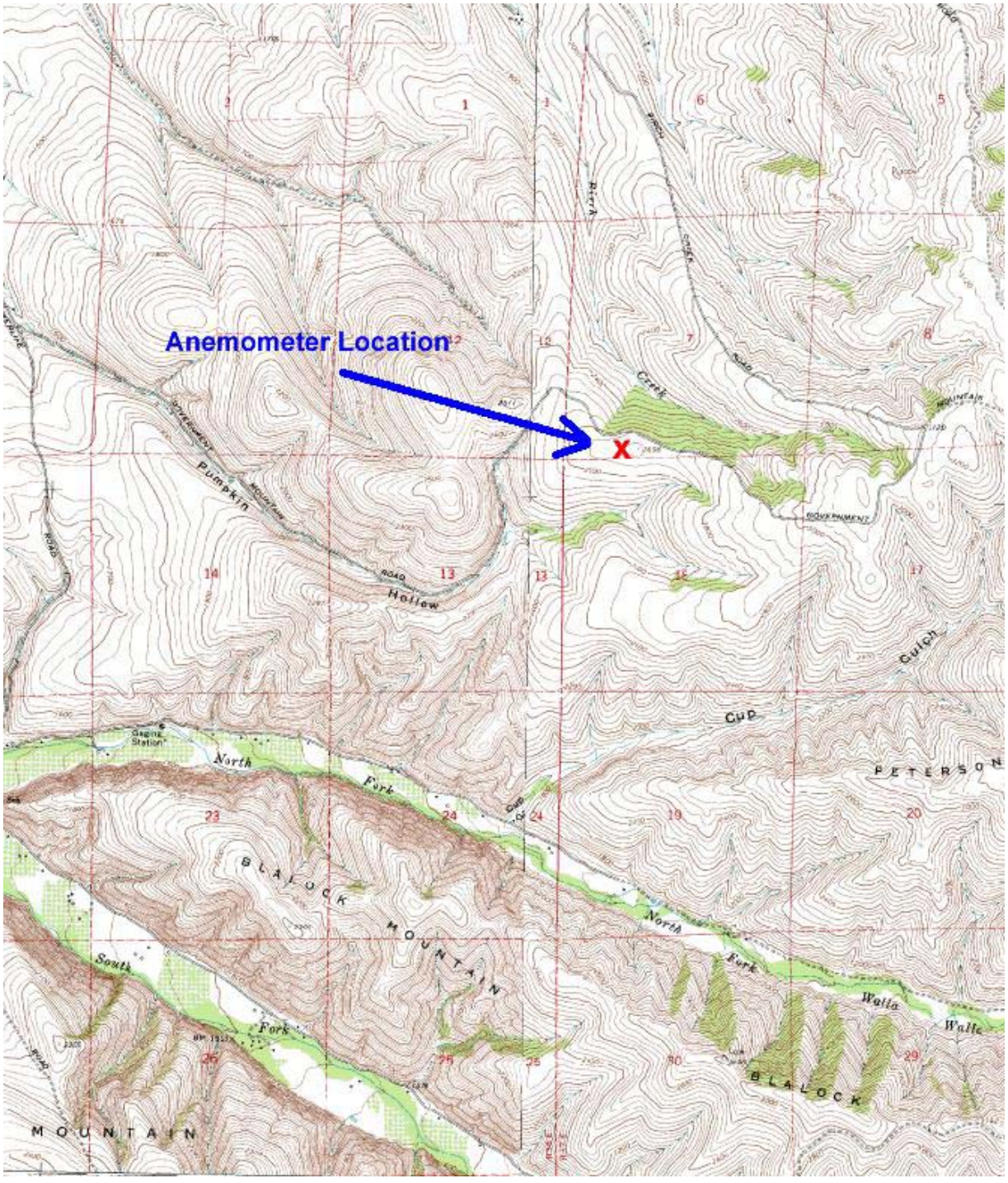
There are a number of factors that might have an influence on the interpretation of the winds observed over this annual study period at the Blue Mountain Foothills site. First, measurements were taken from only one tower and it is possible that other locations in the general area might provide better exposure to the prevailing winds. Although care was taken to locate a location with good exposure to all directions, some blocking of the winds from the east and south-east is possible. While this is not expected to be a significant factor it is possible that another site would have different wind characteristics.

A second factor that is important to consider is that observations were collected at only one height. Flow along a mountain range, especially one with canyons and ridges extending down, can be very complex and difficult to estimate. These types of flows are influenced by many factors including the density of the air, the exact shape of the mountain and the upper air wind characteristics. Observations taken at a different height above ground would most likely show some differences that might be important to a determination of economic feasibility.

In summary,

1) No problems were encountered during the annual data collection period. Several periods of prolonged icing were detected and removed from the records. The observed annual mean wind speed was 11.6 mph.
2) The Blue Mountain Foothills site appears to have a good winter wind resource with periods of extremely strong winds.
3) No significant summer wind resource was observed.
4) A comparison with a nearby site where a longer history of observations is available suggests that wind during this study period (October 2004-September 2005) were very close to normal but that the winter winds may have actually been below normal. This was insufficient, however, to indicate if the low winds during the summer were typical or not.

Appendix A: Topographic Map of the Blue Mountain Foothills site.



Appendix B: Site Visit Records and wind gust during period prior to visit.

	Changes Made				
Date:	Plug	Battery	Time	Gust (mph)	Comment
9/14/2004					Site Installed
10/3/2004	Y			47	
11/6/2004	Y			87	
12/11/2004	Y			80	
1/22/2005	Y			92	
2/11/2005	Y	Y		57	
3/16/2005	Y			59	
4/15/2005	Y			78	
5/9/2005	Y			62	
6/15/2005	Y			57	
7/13/2005	Y			64	
8/7/2005	Y	Y		46	
9/23/2005	Y			44	
10/10/2005				47	Site Removed

Appendix C: Miscellaneous analysis Tables.

STATION – BLUE MOUNTAIN FOOTHILLS
WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY
DATA PERIOD OF RECORD - 10/2004 - 9/2005
NORMALIZATION PERIOD - ONE YEAR
AVERAGE WIND SPEED FOR PERIOD: 11.6 MPH
NORMALIZED AVAILABLE ENERGY: 2548.0 KWH/M2/YEAR**
TOTAL HOURS OBSERVED: 8465

SPD MPH	HOURS/ PERIOD	RELFREQ	CUMHRS	CUMRELFREQ	AVAIL. ENERGY KWH/M**2/YEAR
0	107	1.26	8465	100.00	0.0
1	282	3.33	8358	98.74	0.0
2	380	4.49	8076	95.40	0.2
3	448	5.29	7696	90.92	0.6
4	476	5.62	7248	85.62	1.6
5	429	5.07	6772	80.00	2.8
6	546	6.45	6343	74.93	6.2
7	556	6.57	5797	68.48	10.0
8	509	6.01	5241	61.91	13.6
9	500	5.91	4732	55.90	19.1
10	470	5.55	4232	49.99	24.6
11	441	5.21	3762	44.44	30.7
12	360	4.25	3321	39.23	32.5
13	362	4.28	2961	34.98	41.6
14	348	4.11	2599	30.70	50.0
15	295	3.48	2251	26.59	52.1
16	241	2.85	1956	23.11	51.6
17	191	2.26	1715	20.26	49.1
18	189	2.23	1524	18.00	57.7
19	154	1.82	1335	15.77	55.3
20	129	1.52	1181	13.95	54.0
21	104	1.23	1052	12.43	50.4
22	82	0.97	948	11.20	45.7
23	92	1.09	866	10.23	58.6
24	70	0.83	774	9.14	50.6
25	58	0.69	704	8.32	47.4
26	45	0.53	646	7.63	41.4
27	61	0.72	601	7.10	62.8
28	47	0.56	540	6.38	54.0
29	37	0.44	493	5.82	47.2
30	34	0.40	456	5.39	48.0
31	46	0.54	422	4.99	71.7
32	40	0.47	376	4.44	68.6
33	29	0.34	336	3.97	54.5
34	32	0.38	307	3.63	65.8
35	23	0.27	275	3.25	51.6
36	28	0.33	252	2.98	68.3
37	26	0.31	224	2.65	68.9
38	18	0.21	198	2.34	51.7
39	16	0.19	180	2.13	49.6
40	17	0.20	164	1.94	56.9
41	15	0.18	147	1.74	54.1
42	14	0.17	132	1.56	54.3
43	17	0.20	118	1.39	70.7
44	14	0.17	101	1.19	62.4
45	17	0.20	87	1.03	81.0
46	7	0.08	70	0.83	35.0
47	7	0.08	63	0.74	38.0
48	7	0.08	56	0.66	40.5
49	3	0.04	49	0.58	18.5

STATION – BLUE MOUNTAIN FOOTHILLS (Cont'd)

WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY
DATA PERIOD OF RECORD - 10/2004 - 9/2005
NORMALIZATION PERIOD - ONE YEAR
AVERAGE WIND SPEED FOR PERIOD: 11.6 MPH
NORMALIZED AVAILABLE ENERGY: 2548.0 KWH/M2/YEAR**
TOTAL HOURS OBSERVED: 8465

SPD MPH	HOURS/ PERIOD	RELFREQ	CUMHRS	CUMRELFREQ	AVAIL. ENERGY KWH/M**2/YEAR
50	6	0.07	46	0.54	39.2
51	2	0.02	40	0.47	13.9
52	5	0.06	38	0.45	36.8
53	2	0.02	33	0.39	15.6
54	6	0.07	31	0.37	49.4
55	5	0.06	25	0.30	43.5
56	3	0.04	20	0.24	27.6
57	2	0.02	17	0.20	19.4
58	4	0.05	15	0.18	40.8
59	3	0.04	11	0.13	32.2
60	2	0.02	8	0.09	22.6
61	0	0.00	6	0.07	0.0
62	1	0.01	6	0.07	12.5
63	1	0.01	5	0.06	13.1
64	1	0.01	4	0.05	13.7
65	1	0.01	3	0.04	14.4
66	1	0.01	2	0.02	15.0
67	0	0.00	1	0.01	0.0
68	1	0.01	1	0.01	16.4

STATION – BLUE MOUNTAIN FOOTHILLS
MONTHLY WIND SPEEDS (MPH)
DATA PERIOD OF RECORD - 9/2004 - 10/2005

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS
2004	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2	12.9	11.7	15.2	2479
#OBS	0	0	0	0	0	0	0	0	399	744	655	681	
2005	15.5	8.7	15.7	3.3	9.9	10.3	8.9	9.0	8.7	11.1	0.0	0.0	6617
#OBS	601	672	720	720	744	720	744	744	720	232	0	0	

STATION – BLUE MOUNTAIN FOOTHILLS
DIURNAL WIND SPEEDS (MPH)
DATA PERIOD OF RECORD - 10/2004 - 9/2005

MON	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	AVG SPD
JAN	14.3	13.8	14.0	13.9	14.3	16.4	16.7	16.4	17.6	17.6	16.8	15.5	16.1	15.7	14.5	14.5	16.4	15.5	14.5	15.3	15.9	16.3	16.9	14.1	15.5
FEB	7.9	8.8	9.3	9.1	9.0	10.0	8.7	8.3	8.8	8.5	8.9	9.2	8.6	8.8	8.4	7.8	6.6	7.5	8.4	9.0	9.3	9.6	9.8	8.9	8.7
MAR	14.8	14.8	15.0	14.6	14.5	13.9	15.0	15.1	16.0	17.1	17.0	17.1	17.1	17.7	16.7	15.2	14.7	14.1	16.2	16.6	16.3	15.7	15.3	15.7	15.7
APR	15.7	14.6	14.2	14.3	15.1	15.1	15.1	14.2	14.8	14.2	13.6	12.9	11.4	12.8	12.0	12.2	11.2	11.4	11.3	11.1	11.4	13.0	13.6	13.6	13.3
MAY	11.7	11.4	10.2	9.9	9.9	9.0	8.9	8.8	9.2	9.6	9.2	9.7	9.5	9.8	10.6	10.6	9.4	8.6	8.1	8.3	9.2	11.3	12.6	12.0	9.9
JUN	11.1	11.2	10.6	10.8	10.6	10.0	10.2	9.7	9.3	9.0	8.8	9.2	9.3	10.1	10.3	10.2	10.7	11.4	10.6	9.7	9.5	10.9	12.1	11.5	10.3
JUL	9.8	9.3	8.8	8.9	8.6	9.0	8.0	8.2	8.8	9.2	9.0	9.3	9.0	9.1	10.1	10.3	10.1	10.5	8.9	7.6	6.9	7.5	7.6	9.5	8.9
AUG	8.6	8.2	8.7	9.0	9.2	9.1	7.3	7.7	8.2	9.3	10.0	10.4	10.3	10.5	10.4	10.3	10.1	10.1	9.0	5.9	6.0	7.4	10.0	9.5	9.0
SEP	8.5	9.2	9.4	9.7	9.4	9.3	9.9	8.7	9.4	10.4	10.4	10.1	9.8	9.3	9.4	8.9	7.9	7.2	5.6	5.0	6.3	8.0	9.1	8.3	8.7
OCT	12.0	12.4	13.4	13.7	13.2	12.9	13.0	13.6	13.4	13.9	14.2	14.0	13.6	12.9	11.9	12.0	11.2	11.4	12.0	12.3	13.0	13.3	13.4	13.0	12.9
NOV	11.6	11.7	13.0	13.1	13.3	13.1	12.8	13.2	12.8	11.4	10.9	11.1	10.4	10.0	9.4	8.9	8.9	10.6	11.6	10.9	13.2	14.0	13.4	12.1	11.7
DEC	16.9	16.3	16.8	16.8	16.3	15.9	15.3	15.7	15.4	15.0	13.3	12.5	12.7	11.3	11.8	13.7	14.3	14.6	15.5	15.9	16.9	16.9	18.3	18.7	15.2
AVG SPD	11.9	11.8	11.9	11.9	11.9	11.9	11.6	11.5	11.9	12.0	11.8	11.7	11.4	11.4	11.3	11.2	10.9	11.0	10.9	10.5	11.0	11.9	12.5	12.2	11.6

STATION - BLUE MOUNTAIN FOOTHILLS
WIND ROSE FOR ALL DATA - 8465 OBSERVATIONS
DATA PERIOD OF RECORD - 10/2004 - 9/2005

SPEED CATEGORIES(MPH)

DIR	0 TO 10	10 TO 13	13 TO 16	16 TO 19	19 TO 22	22 TO 25	25 TO 28	28 TO 31	31 TO 34	34 TO 37	37 TO 40	40 TO 43	43 TO 46	46 TO 49	49 TO 52	52 TO 55	>= 55	TOTAL %	MEAN SPEED (MPH)
N	6.4	1.2	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	7.5
NNE	2.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	5.3
NE	1.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4.9
ENE	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	5.0
E	1.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	5.8
ESE	0.8	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	10.7
SE	1.3	0.3	0.6	0.5	0.5	0.2	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	14.3
SSE	3.1	1.4	1.2	0.9	0.8	1.0	1.0	0.8	1.0	0.6	0.6	0.5	0.5	0.2	0.1	0.2	0.3	14.2	22.5
S	9.6	4.0	3.4	1.4	0.6	0.4	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.8	10.7
SSW	7.1	3.0	2.9	1.8	0.7	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.2	11.2
SW	3.5	1.6	1.2	1.2	0.9	0.6	0.2	0.2	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	9.8	13.7
WSW	2.7	0.9	0.6	0.3	0.3	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	11.1
W	2.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	6.5
WNW	1.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	5.6
NW	3.3	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	6.5
NNW	3.6	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1	6.3
CALM																		1.3	
TOTAL %	52.8	14.2	11.5	6.7	4.1	2.8	1.8	1.3	1.4	0.9	0.7	0.5	0.5	0.2	0.1	0.2	0.3	100.0	11.6

NOTE: MEAN SPEED OF THE TOTAL IN A WIND ROSE MAY DIFFER FROM THE SPEED FREQUENCY DISTRIBUTION FOR A GIVEN PERIOD DUE TO DATA SELECTION. SPEED FREQUENCY DISTRIBUTIONS REQUIRE ONLY A WIND SPEED OBSERVATION BE PRESENT. WIND ROSES, ON THE OTHER HAND, REQUIRE BOTH SPEED AND DIRECTION BE PRESENT FOR EACH OBSERVATION.

STATION – BLUE MOUNTAIN FOOTHILLS
ENERGY ROSE (TOTALS ARE NORMALIZED AVAILABLE ENERGY (KWH/M2)**
DATA PERIOD OF RECORD - 10/2004 - 9/2005

MON	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	OBS.
JAN	0.1	0.3	0.0	0.0	0.0	0.4	14.9	451.7	29.9	21.1	54.8	1.8	0.1	0.0	0.0	0.2	575.3	585
FEB	1.0	0.2	0.0	0.1	0.1	0.3	5.2	52.8	13.1	7.4	22.8	1.2	0.1	0.0	0.0	0.2	104.7	629
MAR	3.9	0.4	0.3	0.0	0.3	3.1	15.6	263.6	28.5	19.3	55.4	25.6	2.1	0.0	0.2	0.9	418.9	701
APR	1.2	2.5	0.3	0.3	0.5	5.1	15.3	247.7	16.5	11.1	13.7	7.5	1.1	0.2	0.5	0.2	323.6	698
MAY	3.3	1.1	0.2	0.2	1.4	4.3	4.3	35.2	13.4	19.4	8.4	2.8	0.3	0.2	0.1	0.5	95.2	699
JUN	2.1	1.6	0.2	0.1	0.3	0.1	3.3	4.2	9.5	21.9	15.1	7.8	0.6	0.3	0.4	0.6	68.1	700
JUL	2.3	0.2	0.2	0.1	0.1	3.1	1.9	3.0	8.4	9.4	10.4	4.8	1.3	1.6	3.9	2.3	53.0	727
AUG	3.7	0.3	0.6	0.1	0.2	0.8	0.2	1.0	8.7	13.8	7.6	5.5	1.6	0.5	2.1	2.3	48.9	711
SEP	2.0	0.1	0.1	0.0	0.1	0.1	1.7	9.4	12.7	7.3	13.1	4.7	0.7	0.6	1.1	1.2	54.8	698
OCT	0.4	0.1	0.1	0.1	0.1	1.9	14.8	179.4	16.6	26.4	23.0	11.6	1.0	0.0	0.1	0.2	275.7	723
NOV	0.2	0.2	0.1	0.3	0.1	0.6	7.3	180.8	13.2	19.3	16.4	4.7	0.2	0.0	0.0	0.1	243.5	636
DEC	0.2	0.1	0.0	0.0	0.2	1.2	23.9	337.4	44.0	18.0	13.3	1.3	0.1	0.1	0.0	0.1	439.9	671
TOT	20.5	7.1	2.0	1.2	3.3	21.1	108.4	1766.1	214.3	194.4	253.9	79.5	9.1	3.5	8.5	8.7	2701.8	8178

NOTE: AVAILABLE ENERGY IN AN ENERGY ROSE MAY DIFFER FROM THE SPEED FREQUENCY DISTRIBUTION FOR A GIVEN PERIOD DUE TO DATA SELECTION. SPEED FREQUENCY DISTRIBUTIONS REQUIRE ONLY A WIND SPEED OBSERVATION BE PRESENT. ENERGY ROSES, ON THE OTHER HAND, REQUIRE BOTH SPEED AND DIRECTION BE PRESENT FOR EACH OBSERVATION.

STATION – BLUE MOUNTAIN FOOTHILLS
MONTHLY POWER DENSITIES AND NORMALIZED TOTAL ENERGY WITH SPEED RANGE OF 10 TO 60 MPH
DATA PERIOD OF RECORD - 10/2004 - 9/2005
DATA RECOVERY - 96.9%

MONTH	MEAN POWER (W/M**2)	NORMALIZED TOTAL ENERGY (KWH/M**2)	NO. DATA PTS. WITHIN RANGE	NO. DATA PTS. BELOW 10	NO. DATA PTS. ABOVE 60	MEAN SPD(MPH) WITHIN RANGE	PERCENT TIME WITHIN RANGE
JAN	1108.1	456799	333	262	6	23.6	55.4
FEB	463.2	104617	204	468	0	18.6	30.4
MAR	856.5	408897	462	258	0	21.1	64.2
APR	838.2	323055	373	347	0	20.1	51.8
MAY	267.7	85120	318	426	0	15.4	42.7
JUN	167.8	63276	365	355	0	14.2	50.7
JUL	157.6	43962	279	465	0	13.6	37.5
AUG	135.1	40261	298	446	0	13.4	40.1
SEP	179.3	46272	258	462	0	13.9	35.8
OCT	664.6	263201	396	348	0	19.6	53.2
NOV	713.0	239709	296	359	0	20.0	45.2
DEC	941.6	416625	405	275	1	22.1	59.5
PERIOD TOTAL	272.2	2378032	3987	4471	7	18.3	47.1