OREGON ANEMOMETER LOAN PROGRAM

Wind Resource Evaluation: Milton-Freewater

Prepared By:

Energy Resources Research laboratory

Oregon State University

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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 is 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:	Milton-Freewater
Latitude:	45-57-13
Longitude:	118-25-16
Elevation:	980 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:	August 12, 2003 @ 937 PST
Removal Date:	September 14, 2004 @ 1250 PST

Site Location: The town of Milton-Freewater is located in Northeast Oregon, approximately 10 miles south of the border with Washington in the Walla Walla Valley. The anemometer tower was located approximately five miles west of the town in an area of orchards. The location of the tower site is marked on the map included in Appendix A. Access to the site is by a paved road heading west and north from the center of town.

Site Description: The anemometer site is situated in an orchard on the south of the Walla Walla Valley. Areas to the east, north and west are mostly level and consist of similar terrain with no major trees or structures that might influence the wind flow in the area. At installation the site consisted of a mature Apple orchard. During the study period these trees were removed and young cherry trees were planted. To the south and southwest there is a ridge line that extends roughly 1000 feet above the valley bottom. This ridge is currently the site of several operating wind energy facilities.

Project Description: This site was installed after a request was made by the land owner who is interested in determining the feasibility of wind energy within the Walla Walla Valley. The entire area is planted in fruit orchards and additional sources of energy and revenue would be helpful to local growers. A preliminary evaluation prepared for the site estimated the mean annual wind to be in a range between 9.5 mph and 12.0 mph. While this is considered low, a degree of uncertainty existed in these estimates due primarily to the absence of wind observations that reflect conditions in the valley.

3.0 WIND CHARACTERISTICS

In the following sections, several characteristics of the winds at Milton-Freewater 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.

A table of site visits and the actions taken has been included in Appendix A. Data were plotted and scanned manually to identify any problems with the site. 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. These periods of icing were brief and limited to December and January.

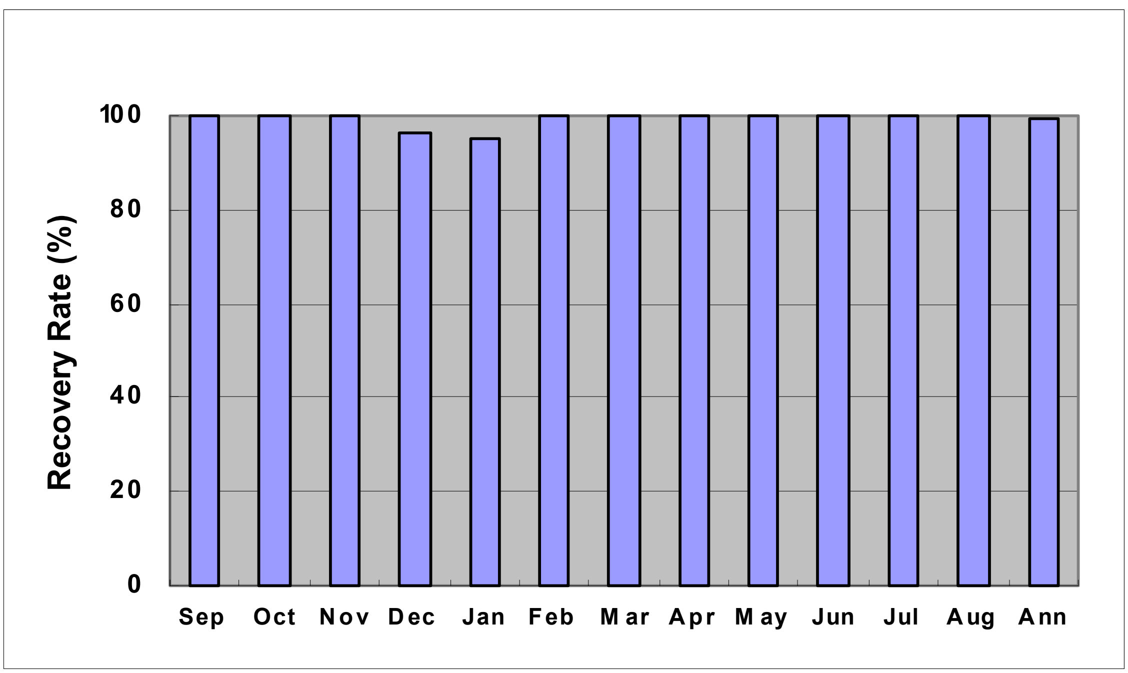


Figure 3.1: Data recovery by month for the ALP site in Milton-Freewater.

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Ann
Rec (%)	100	100	100	96.1	95.2	100	100	100	100	100	100	100	99.3

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

The annual mean wind speed at the Milton-Freewater ALP site for this reporting period was 8.05 mph. This is below the lower end of the estimated range provided in an initial evaluation of the site. In general, there is no clear seasonal pattern and all of the months have means in the same general range. The highest monthly mean was observed in March. However, in terms of wind energy, these means are somewhat low. The monthly mean values range from a low of 6.9 mph in both December and February to a high of 10.5 mph in March. The low wind speed values during the winter are somewhat surprising. This site was expected to have higher winds during the winter when winter storms pass through this region. One explanation for the low means is that the site is blocked from the mean flow from the south and southwest by the higher terrain. It is also possible that the valley or basin nature of this location produces an inversion that traps cold air close to the surface and inhibits wind flow in the lower levels. Likely it is a combination of these factors that influence the site.

In the spring and summer, much of the Gorge and surrounding areas exhibit a strengthening of the winds associated with large-scale pressure and temperature differences. This effect is not observed in this data and it is believed that the site is too sheltered in the Walla Walla Valley to show the influence of these processes.

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Ann
Mean (mph)	7.3	7.7	9.4	6.9	6.9	7.0	10.5	7.8	9.7	8.0	7.8	7.0	8.05

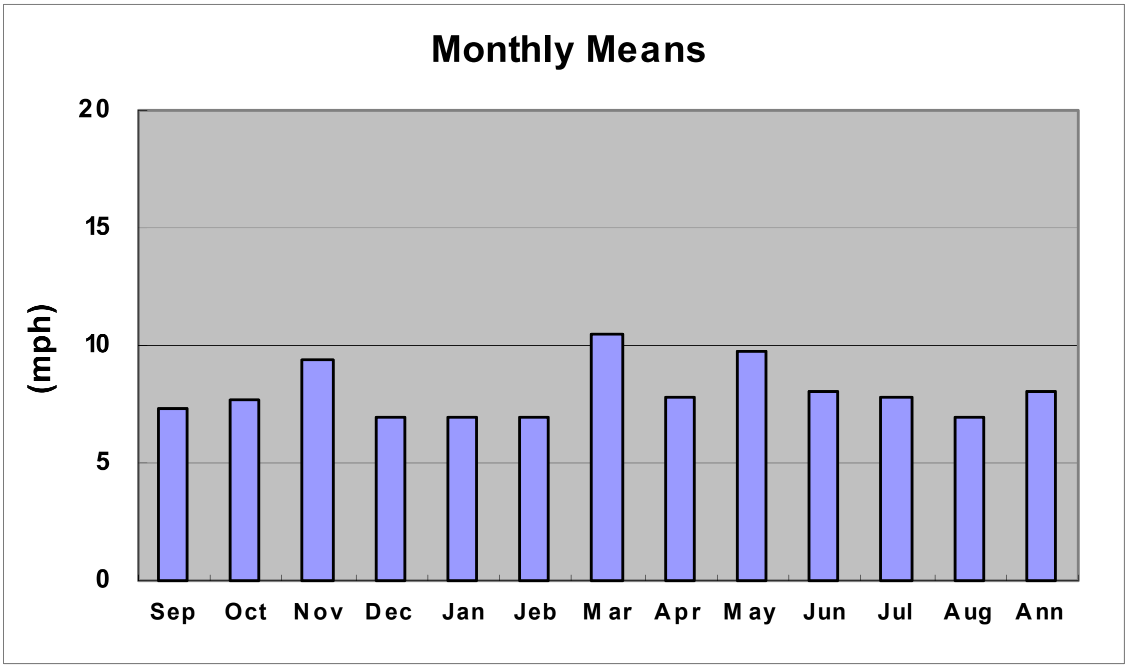


Figure 3.2: Monthly Mean Wind Speed Values for the ALP site at Milton-Freewater.

Diurnal Means: Diurnal wind patterns are 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.

In Figure 3.3, the mean diurnal patterns are shown for the individual months of March and July and for the entire period as a whole. These months are shown because they illustrate the months with the highest diurnal cycles. In March, a reasonable diurnal peak is observed during the middle of the day with the winds peaking near 12.0 mph between about 1000 and 1600 hours. The winds are at a minimum during the morning hours. For July there is only a slight diurnal peak that is observed very late in the day and peak about 2300 hours (11:00 pm). This peak, however, is only about 10.0 mph. In general, the diurnal pattern for this site is fairly weak and does not indicate the presence of any regular or persistent feature that might produce a significant wind resource.

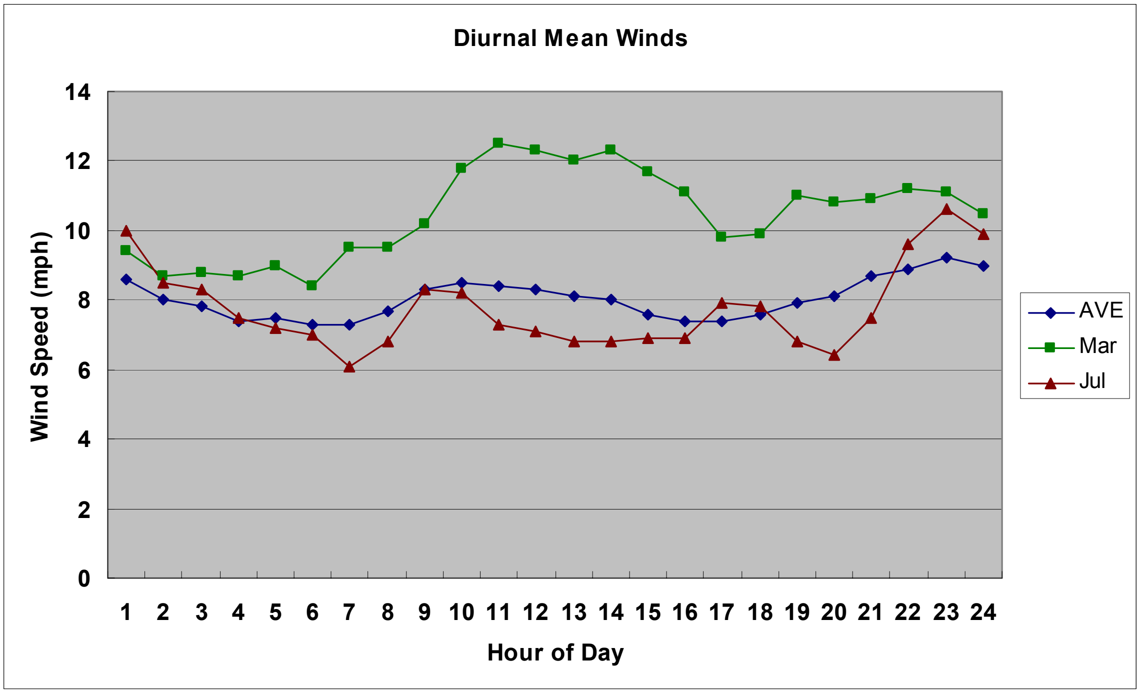


Figure 3.3: Diurnal mean wind speed values for the ALP site at Milton-Freewater.

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 this site in Milton-Freewater (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 upper end. In this case the peak is very narrow and very sharp and drops off quickly with higher wind speed category. This indicates that winds in the higher wind speed categories are infrequent and in this case, the observed winds are below 12.0 mph about 80 % of the time. In addition, the upper end is relatively low and the highest hourly wind value observed was 46 mph but less than 1.0 % of the observed values are above 30.0 mph. This is relatively low for a good wind site and suggests that there is a low frequency of winds at the upper end of the range. This is significant because it is at higher wind speeds where most of the power could potentially be produced.

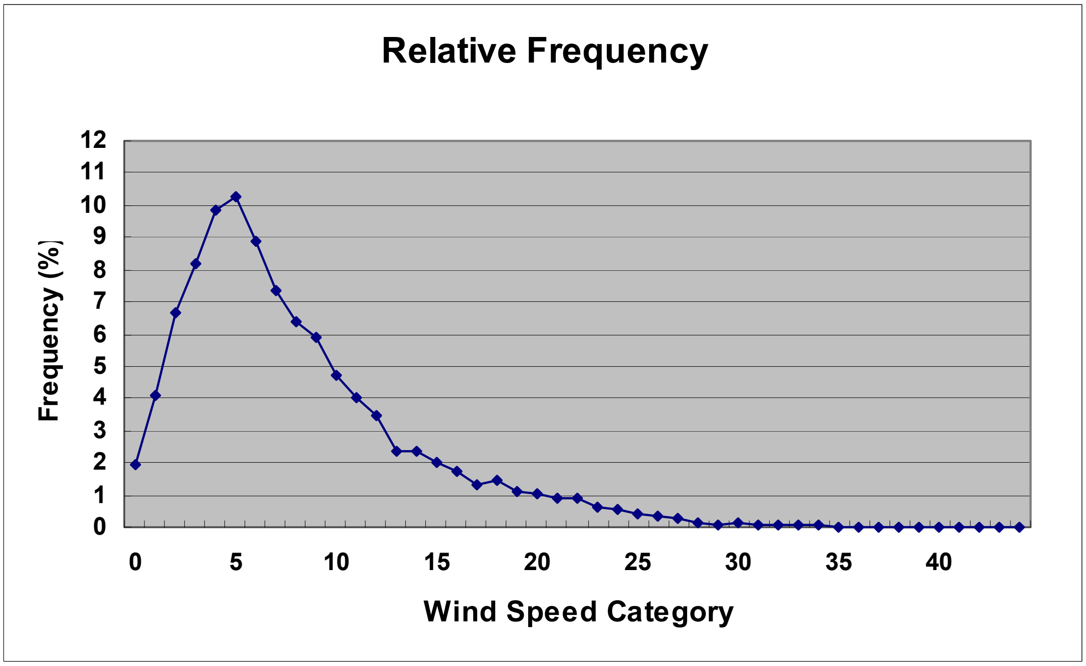


Figure 3.4: Wind speed frequency distribution for the ALP site at Milton-Freewater.

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 in Milton-Freewater (Figure 3.5), it is apparent that the winds come from several direction categories with about the same frequency. The categories from SSE through WNW account for a high percentage of the total observations and each have a frequency between about 8% and 12%. Figure 3.5 also shows that the in addition to having the highest frequencies, the winds from these directions also appear to have the higher mean speeds. The highest are the SW and WSW categories that have mean speeds of 12.8 mph and 12.1 mph. This suggests that the winds come from a direction about 20.0 % of the time in which the mean speed is over 12.0 mph.

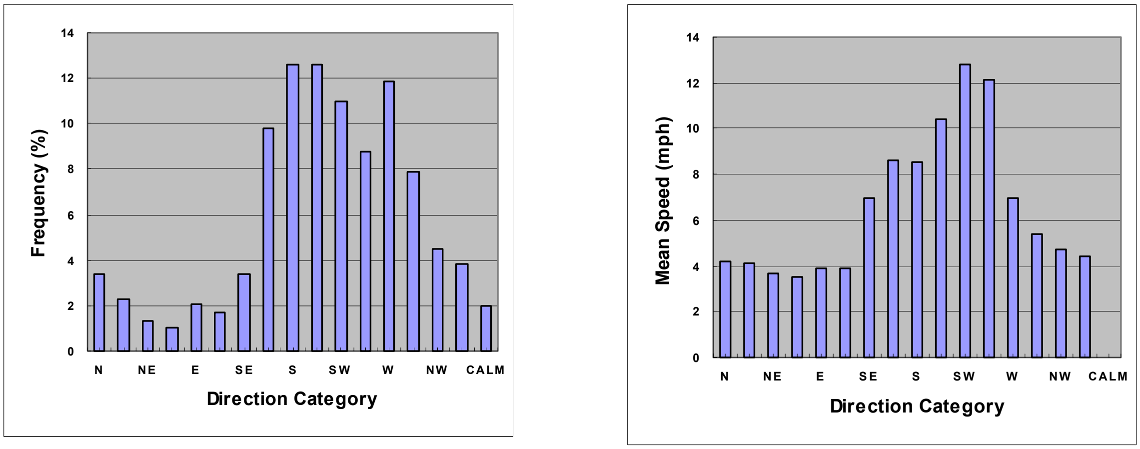


Figure 3.5: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories.

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 wind speed data 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. Shape and scale factors have been included in the event that Weibul statistics are of interest.

First, the quantities in Table 4.1 confirm what was observed in the previous section and show that the overall power characteristics at this site in Milton-Freewater are relatively low. No single month or period shows any indication that a substantial energy resource exists at this site. No month has a mean wind speed above 12.0 mph and the highest percentage of time a turbine might operate for any month was only 35.3 % (March 2004). In addition, these values show a high level of variability from month to month and clearly indicates that the site is not well suited to capture winds during the winter months. As mentioned in Section 3.0, this may be because of the higher terrain to the south and southwest or to the characteristics of the site that may be conducive to the formation of an inversion.

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 variable nature of the winds at this site. For example, the power density values for December and February were less that half those for November and March. For most sites in the Northwest, we would expect to see the peak values of this plot between the months of November to March.

Table 4.1: Observed and computed power quantities for the wind site at the ALP site in Milton-Freewater.

Month	Mean (mph)	Std. (mph)	Recovery Rate (%)	Max 1-Hr (mph)	Time in Range 12-60 mph(%)	Power Den. W/m**2	Shape Factor	Scale Factor
Sept	7.3	5.4	100.0	28.2	18.6	64	1.39	8.0
Oct	7.7	6.0	100.0	39.9	19.4	89	1.31	8.4
Nov	9.4	7.7	100.0	34.5	28.9	159	1.23	10.0
Dec	6.9	5.7	96.1	29.3	16.6	67	1.23	7.4
Jan	6.9	7.4	95.2	41.1	19.5	114	0.92	6.6
Feb	7.0	5.8	100.0	45.7	13.8	82	1.20	7.4
Mar	10.5	6.6	100.0	32.7	35.3	145	1.65	11.7
Apr	7.8	4.6	100.0	35.1	14.4	59	1.78	8.7
May	9.7	5.9	100.0	27.0	29.6	110	1.73	10.9
Jun	8.0	5.2	100.0	29.1	17.1	71	1.60	8.9
Jul	7.8	3.9	100.0	23.7	13.3	46	2.12	8.8
Aug	7.6	4.0	100.0	25.4	11.8	47	2.00	8.6
ANN	8.1	5.9	100.0	45.7	19.9	88	1.40	8.8

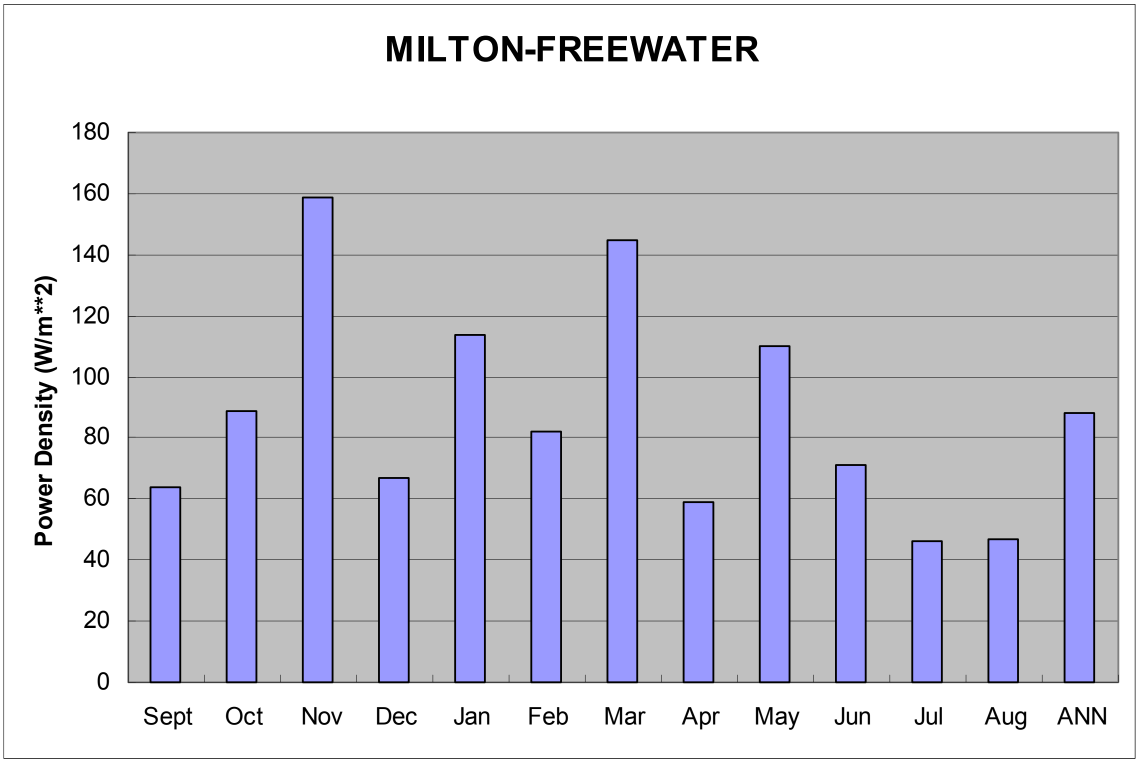


Figure 4.1: Monthly power density for the ALP site at Milton-Freewater.

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 it could produce. 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.

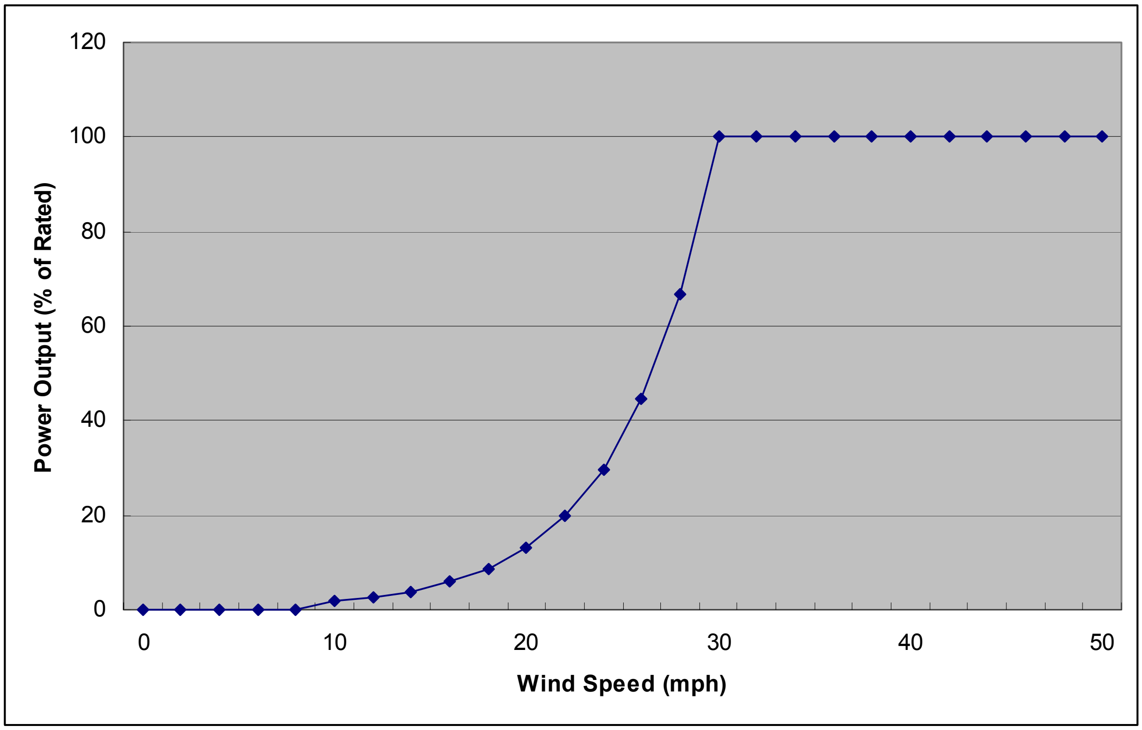


Figure 4.2: Sample power curve for a theoretical turbine

The capacity factors in Table 4.2 support the conclusions of the previous sections and indicate that there is not a significant energy resource at this site. Capacity values for each of the turbine types are relatively small and vary greatly from one month to the next. The highest capacity factors for each turbine type occur in March with the largest 0.216 (Vestas 80). This shows that, at best, a turbine would capture only about 21.6 % of its rated capacity. For the annual period as a whole, all of the values are below 0.122. For a good wind site this value would ideally be closer to 0.300 or higher.

Table 4.2: Capacity factors computed for the ALP site at Milton-Freewater 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
Sept	0.083	0.101	0.072	0.067	0.048	0.097	0.085	0.059
Oct	0.090	0.108	0.080	0.075	0.057	0.102	0.093	0.068
Nov	0.177	0.203	0.160	0.154	0.117	0.200	0.180	0.137
Dec	0.085	0.102	0.075	0.070	0.051	0.099	0.088	0.062
Jan	0.114	0.131	0.104	0.100	0.077	0.128	0.116	0.090
Feb	0.071	0.085	0.064	0.061	0.047	0.081	0.074	0.055
Mar	0.183	0.216	0.162	0.153	0.112	0.209	0.186	0.135
Apr	0.065	0.084	0.058	0.052	0.040	0.078	0.070	0.049
May	0.147	0.176	0.129	0.120	0.086	0.170	0.150	0.105
Jun	0.086	0.106	0.076	0.071	0.052	0.101	0.090	0.063
Jul	0.056	0.074	0.048	0.042	0.031	0.067	0.060	0.039
Aug	0.055	0.072	0.048	0.042	0.032	0.066	0.059	0.039
ANN	0.101	0.122	0.090	0.084	0.063	0.117	0.105	0.075

5.0 CLIMATOLOGICAL ANALYSIS

Measurements taken 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 Milton-Freewater, one long-term monitoring site was found that should provide this reference. The Bonneville Power Administration has maintained a station at a microwave site south of Kennewick Washington since 1976. In 1987, the anemometer was lowered from 105 feet to 86 feet. Data from the period after this move is used here to evaluate the climatological significance of the observation period at Milton-Freewater.

The Kennewick BPA site is well exposed and should provide a good indication of conditions in the region. While the terrain is much higher and located further to the north and west, the winds are expected to have at least some relationship to those at Milton-Freewater, especially during the winter months when conditions at Milton-Freewater were lower than expected. Wind data was obtained for the period 1987 to 2004. Information about the site and the monthly means and departures for this annual study period can be found in Table 5.1. First, the winds overall at Kennewick BPA were very close to normal for the observation period at Milton-Freewater (September 2003-August 2004). A departure of +1.6 % is extremely small for an annual period and shows that conditions in the region were close to their climatological means. Secondly, the winds during certain key months show a similar variability to those at Milton-Freewater. These include the below normal condition during December and February when the departures were -13.6 % and -31.9 % respectively. This confirms suspicions that conditions at Milton-Freewater were below what would be expected. However, the positive departure for March at Kennewick (+15.8 %) also suggests that the high wind speed observed at Milton-Freewater may also have been an anomaly.

Overall, the climatological analysis of wind data from Kennewick suggests that the observations collected at Milton-Freewater are a fair assessment of overall conditions. While a few months may have been above or below normal, conditions for the period as a whole were close to normal.

Table 5.1: Monthly mean and departures for winds at the Kennewick BPA wind site.

KENNEWICK BPA **Latitude: 46.10N** **Longitude 119.13W**		**Elevation: 2200'**	
Month	**Normal (mph) 1982-1997**	**Mean (mph) current**	**Departure (%)**
Sept	14.7	15.7	6.8
Oct	16.5	19.9	20.6
Nov	19.8	23.7	19.7
Dec	19.1	16.5	-13.6
Jan	20.4	19.3	-5.4
Feb	18.8	12.8	-31.9
Mar	19	22.0	15.8
Apr	18	15.9	-11.7
May	17.6	19.1	8.5
Jun	17.6	17.3	-1.7
Jul	15.7	15.9	1.3
Aug	15.4	17.8	15.6
ANN	17.7	18.0	1.6

6.0 SUMMARY AND DISCUSSION

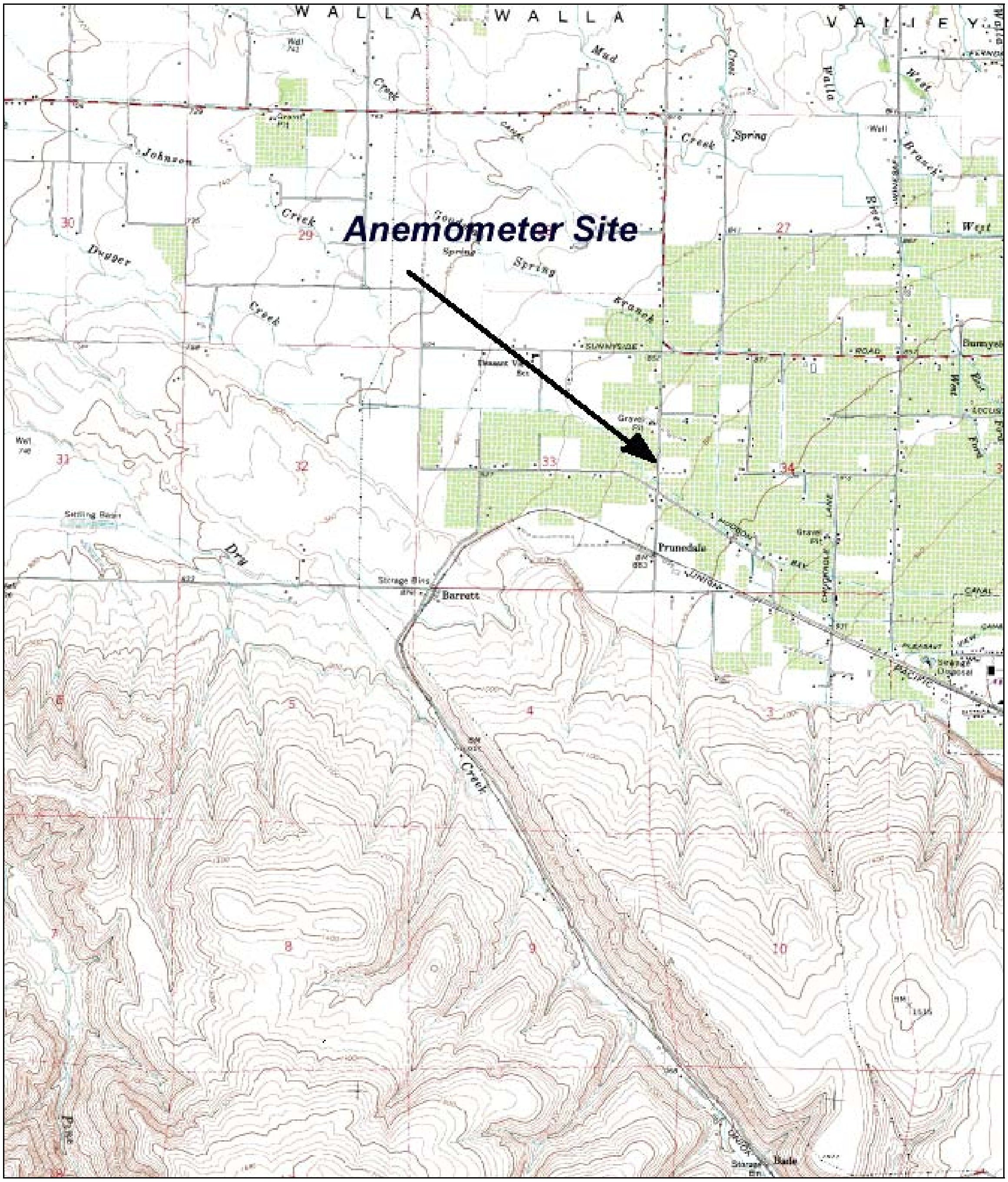
There are a number of factors that might have an influence on the interpretation of the winds observed over this annual study period at Milton-Freewater. First, measurements were taken from only one tower and it is possible that other locations in the area might provide better exposure to the prevailing winds. The location of the tower was dictated in part by the accessibility and land ownership issues and a location further up on the hills to the south or southwest might provide better exposure.

A second factor that is important to consider is that observation were collected at only one height. Flow over a valley or basin often occurs at a higher level above the ground. These types of flows are influenced by many factors including the density of the air, the exact shape of the valley or basin 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. This is particularly true in areas where a strong inversion might be present.

In summary,

1) No problems were encountered during the data collection period at this site. Several periods of icing were detected in December and January data were removed from the records for this analysis.
2) The observed annual mean wind speed was 8.05 mph.
3) The strongest winds come from the southwest and west, a direction that is not uncommon but is not the most frequently observed direction. Winds from the south and southwest, were not as strong as expected.
4) This site in the Walla Walla Valley does not appear to have a significant energy resource. An analysis of the data indicates the site is not well suited to capture winter storm winds and there is little indication of a summer resource. Overall the site does not show any periods of sustained strong winds that would be needed to produce any substantial amount of power.
5) A comparison with a nearby site where a longer history of observations are available suggests that this study period (September 2003-August 2004) was approximately 1.6% above normal and that observations over this period should provide a good indication of conditions overall.

Appendix A: Topographic Map of Milton-Freewater



Appendix B: Photographs of the Milton-Freewater tower looking southwest.

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

Date:	Changes Made Plug	 Battery	 Time	Gust (mph)	Comment
8/12/2003					Site Installed
9/12/2003	Y			45	
10/6/2003	Y			35	
11/4/2003	Y			62	
12/11/2003	Y			56	
1/17/2004	Y	Y		43	
2/13/2004	Y			68	
3/4/2004	Y			71	
4/10/2004	Y			51	
5/13/2004	Y			59	
6/4/2004	Y			44	
7/13/2004	Y	Y		44	
8/2/2004	Y			41	
9/14/2004				43	Site removed

Appendix D: Miscellaneous analysis Tables.

STATION - Milton-Freewater
WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY
DATA PERIOD OF RECORD - 9/2003 - 8/2004
NORMALIZATION PERIOD - ONE YEAR
AVERAGE WIND SPEED FOR PERIOD: 8.1 MPH
NORMALIZED AVAILABLE ENERGY: 772.1 KWH/M**2/YEAR
TOTAL HOURS OBSERVED: 8719

SPD MPH	NORMALIZED HOURS/ PERIOD	RELFREQ	CUMHRS	CUMRELFREQ	NORMALIZED AVAIL. ENERGY KWH/M**2/YEAR
0	172	1.97	8719	100.00	0.0
1	356	4.08	8547	98.03	0.0
2	583	6.69	8191	93.94	0.2
3	716	8.21	7608	87.26	1.0
4	861	9.87	6892	79.05	3.0
5	894	10.25	6031	69.17	6.0
6	773	8.87	5137	58.92	8.9
7	639	7.33	4364	50.05	11.7
8	555	6.37	3725	42.72	15.2
9	513	5.88	3170	36.36	20.0
10	410	4.70	2657	30.47	22.0
11	352	4.04	2247	25.77	25.1
12	300	3.44	1895	21.73	27.8
13	203	2.33	1595	18.29	23.9
14	206	2.36	1392	15.97	30.3
15	178	2.04	1186	13.60	32.2
16	152	1.74	1008	11.56	33.3
17	118	1.35	856	9.82	31.0
18	128	1.47	738	8.46	40.0
19	99	1.14	610	7.00	36.4
20	93	1.07	511	5.86	39.8
21	78	0.89	418	4.79	38.7
22	76	0.87	340	3.90	43.3
23	55	0.63	264	3.03	35.8
24	50	0.57	209	2.40	37.0
25	37	0.42	159	1.82	31.0
26	29	0.33	122	1.40	27.3
27	25	0.29	93	1.07	26.4
28	14	0.16	68	0.78	16.5
29	9	0.10	54	0.62	11.8
30	10	0.11	45	0.52	14.5
31	5	0.06	35	0.40	8.0
32	6	0.07	30	0.34	10.5
33	5	0.06	24	0.28	9.6
34	6	0.07	19	0.22	12.6
35	2	0.02	13	0.15	4.6
36	1	0.01	11	0.13	2.5
37	3	0.03	10	0.11	8.1
38	1	0.01	7	0.08	2.9
39	1	0.01	6	0.07	3.2
40	2	0.02	5	0.06	6.9
41	1	0.01	3	0.03	3.7
42	0	0.00	2	0.02	0.0
43	1	0.01	2	0.02	4.3
44	0	0.00	1	0.01	0.0
45	0	0.00	1	0.01	0.0
46	1	0.01	1	0.01	5.2

STATION - Milton-Freewater
MONTHLY WIND SPEEDS (MPH)
DATA PERIOD OF RECORD - 8/2003 - 9/2004

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS	AVG
2003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	7.3	7.7	9.4	6.9	3371	7.74
# OBS	0	0	0	0	0	0	0	472	720	744	720	715		
2004	6.9	7.0	10.5	7.8	9.7	8.0	7.8	7.6	9.9	0.0	0.0	0.0	6145	8.25
# OBS	700	696	744	720	744	720	744	744	325	0	0	0		
AVG	6.9	7.0	10.5	7.8	9.7	8.0	7.8	7.4	8.1	7.7	9.4	6.9	9516	8.07

STATION - Milton-Freewater
DIURNAL WIND SPEEDS (MPH)
DATA PERIOD OF RECORD - 9/2003 - 8/2004

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	7.2	7.0	6.8	6.8	6.8	6.0	6.6	7.0	7.0	7.4	7.3	7.5	6.9	7.3	6.9	6.5	6.5	6.8	7.2	7.1	6.6	6.7	6.7	6.9	6.9
FEB	6.3	5.8	5.7	6.0	6.8	6.6	6.5	6.6	7.5	8.3	8.0	7.3	7.4	7.1	7.3	7.4	7.7	7.8	7.2	7.1	7.0	6.9	6.7	5.9	7.0
MAR	9.4	8.7	8.8	8.7	9.0	8.4	9.5	9.5	10.2	11.8	12.5	12.3	12.0	12.3	11.7	11.1	9.8	9.9	11.0	10.8	10.9	11.2	11.1	10.5	10.5
APR	8.6	8.3	7.6	7.0	6.9	6.9	6.1	7.2	8.3	8.2	8.5	8.4	8.1	8.0	7.6	7.0	7.0	6.7	6.4	7.7	9.2	9.3	9.0	8.8	7.8
MAY	11.1	10.8	9.8	9.2	8.2	8.8	8.9	9.0	9.0	9.1	8.5	9.2	9.0	9.1	8.7	9.1	8.4	9.2	9.0	10.0	11.1	12.2	12.7	12.6	9.7
JUN	8.9	8.5	8.9	7.9	8.4	8.3	7.5	7.9	8.5	8.4	7.9	7.7	7.6	7.6	7.1	7.2	6.6	6.5	7.2	6.8	7.9	9.2	9.7	9.7	8.0
JUL	10.0	8.5	8.3	7.5	7.2	7.0	6.1	6.8	8.3	8.2	7.3	7.1	6.8	6.8	6.9	6.9	7.9	7.8	6.8	6.4	7.5	9.6	10.6	9.9	7.8
AUG	9.2	7.8	8.5	7.2	6.9	6.1	4.9	5.9	7.0	7.5	7.4	7.3	7.5	7.1	7.6	7.4	7.6	6.7	7.2	7.5	8.5	9.3	9.6	10.6	7.6
SEP	9.0	7.8	7.2	7.2	7.1	5.5	5.3	6.3	7.1	7.4	7.2	7.2	6.9	6.2	6.4	6.0	5.3	5.7	7.6	9.8	10.6	9.6	9.0	8.5	7.3
OCT	7.8	7.2	7.2	7.1	7.4	7.4	7.7	7.4	7.2	7.5	7.8	8.3	8.0	7.9	7.4	6.5	5.9	7.5	9.2	9.0	9.3	8.3	8.3	8.1	7.7
NOV	8.3	8.0	6.8	7.6	8.5	9.3	10.7	10.8	12.0	11.5	11.2	10.7	10.8	9.9	8.6	8.6	9.4	10.2	9.4	8.3	8.4	7.9	9.1	8.6	9.4
DEC	6.8	7.3	7.7	7.0	6.9	6.7	8.0	7.8	7.6	6.7	7.7	7.1	6.6	6.0	4.9	5.3	6.2	6.8	6.8	6.9	7.2	6.7	7.5	7.5	6.9
AVG SPD	8.6	8.0	7.8	7.4	7.5	7.3	7.3	7.7	8.3	8.5	8.4	8.3	8.1	8.0	7.6	7.4	7.4	7.6	7.9	8.1	8.7	8.9	9.2	9.0	8.1

STATION - Milton-Freewater
WIND ROSE FOR ALL DATA - 8719 OBSERVATIONS
DATA PERIOD OF RECORD - 9/2003 - 8/2004

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	3.4	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	3.4	4.2
NNE	2.3	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	2.3	4.1
NE	1.3	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	1.3	3.7
ENE	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	0.0	0.0	1.0	3.5
E	2.1	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	0.0	2.1	3.9
ESE	1.7	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	1.7	3.9
SE	2.8	0.2	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	7.0
SSE	7.2	1.5	0.4	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	8.6
S	8.6	2.3	0.9	0.4	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	12.6	8.5
SSW	6.2	2.5	2.1	1.3	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.6	10.4
SW	4.3	1.5	1.4	1.3	1.2	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	12.8
WSW	4.4	0.9	0.8	0.7	0.7	0.6	0.3	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	8.8	12.1
W	9.5	1.1	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.9	7.0
WNW	7.4	0.5	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	7.9	5.4
NW	4.3	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	4.5	4.7
NNW	3.7	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	3.8	4.4
CALM																		2.0	
TOTAL %	72.0	10.9	6.5	4.3	2.8	1.9	0.9	0.3	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	100.0	8.1

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 - milton-Freewater
ENERGY ROSE (TOTALS ARE NORMALIZED AVAILABLE ENERGY (KWH/M**2)
DATA PERIOD OF RECORD - 9/2003 - 8/2004

MON NORM.	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	OBS.	
JAN	0.1	0.0	0.0	0.0	0.1	0.0	0.3	2.2	10.4	12.0	32.8	33.1	1.5	0.6	0.0	0.0	93.3	650	744
FEB	0.1	0.0	0.0	0.0	0.0	0.1	11.8	22.0	7.5	3.6	5.9	2.1	2.2	1.2	0.2	0.0	56.6	684	672
MAR	0.1	0.1	0.0	0.1	0.0	0.0	2.2	7.8	6.7	12.6	26.3	38.2	13.8	0.8	0.3	0.1	109.1	736	744
APR	0.3	0.3	0.0	0.0	0.0	0.1	0.7	3.5	5.1	8.1	6.0	7.9	8.5	1.8	0.8	0.3	43.4	713	720
MAY	0.2	0.1	0.0	0.0	0.1	0.1	1.4	2.3	3.0	15.8	32.4	19.9	4.8	1.5	0.5	0.2	82.4	740	744
JUN	0.3	0.3	0.2	0.1	0.3	0.1	0.3	2.2	3.2	12.9	15.4	11.6	2.9	1.0	0.3	0.6	51.7	714	720
JUL	0.4	0.2	0.1	0.0	0.0	0.0	0.1	2.9	2.8	6.0	10.7	3.3	4.1	2.3	0.9	0.7	34.6	740	744
AUG	0.2	0.1	0.1	0.0	0.7	0.1	0.3	2.5	3.1	6.3	8.8	5.8	5.2	1.4	0.4	0.4	35.5	736	744
SEP	0.1	0.1	0.0	0.0	0.1	0.0	0.3	3.2	3.1	8.6	11.3	16.9	5.3	0.3	0.4	0.2	49.8	671	720
OCT	0.1	0.7	0.1	0.0	0.1	0.0	0.7	3.4	4.4	7.0	16.5	30.8	3.3	0.3	0.5	0.1	68.0	727	744
NOV	0.0	0.0	0.0	0.0	0.2	0.5	1.0	9.6	15.7	20.9	34.2	31.4	3.5	0.5	0.2	0.1	117.8	702	720
DEC	0.0	0.0	0.0	0.0	0.1	0.2	3.0	11.5	7.0	9.8	15.2	0.7	2.1	0.7	0.1	0.0	50.5	703	744
TOT	1.9	2.0	0.7	0.4	1.7	1.3	22.0	73.2	72.0	123.6	215.5	201.5	57.1	12.3	4.6	2.9	792.7	8516	8760

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.