

OREGON ANEMOMETER LOAN PROGRAM

Wind Resource Evaluation: Wickiup Ridge



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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 one 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: Wickiup Ridge
Latitude: 46-05-42 (WGS 84)
Longitude: 123-35-24.5
Elevation: 2420 ft.
Tower Height: 67 feet (20 meters)
Site # 0640

Types of Sensors: NRG Maximum #40 wind speed
NRG 200 series 2 wind vane
Instrumentation: Single level mounted on the top of a 20 m tilt up NRG tower.
County: Clatsop
Installation Date: April 06, 2007
Data Available to: August 13, 2008

Site Location: Wickiup Ridge is located east-southeast of the city of Astoria on the Northern Oregon coast. The ridge is located approximately 15 miles south of the Columbia River near an area called Knappa. The Ridge is oriented generally North-South with a narrow road on the spine and steep slopes on both sides. The northern end of the ridge hooks towards the east some.

Project Description: This project is part of a larger project to evaluate and quantify the energy resources available on property that encompasses the watershed for the City of Astoria. Access to the site is through the City's watershed and requires permission.

Data Collection and Processing: NRG equipment was used at this site including #40 anemometers and a Wind Explorer data logger. Data plugs were swapped out on roughly a monthly basis by officials from the OSU Extension Service and sent to the ERRL. Raw NRG files were read and downloaded from the data cards and used to generate monthly files of ten minute averages. These files were then converted to hourly averages and converted to an internal ERRL format to accommodate data checking and to perform analysis using existing programs. Data were plotted and scanned manually to detect problems and to flag periods of suspected icing.

The site was installed in early April 2007. The site ran well until May 25th when the cables on the tower were chewed through, most likely, by resident Elk. The cables were repaired and fortified and data collection began again on June 20th, 2007. In order to evaluate the site using a complete, continuous annual period, data collection continued past the proposed annual collection period.

No other problems with the site have been identified that might affect the interpretation of the collected wind data.

3.0 WIND CHARACTERISTICS

In the following sections, several characteristics of the winds at the Wickiup Ridge 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 characteristics 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. These evaluations are confined to a single annual period so that the results are not biased by the addition of data from only a particular season or a portion of a year. *The period analyzed here is for July 1, 2007 to June 30 2008.*

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

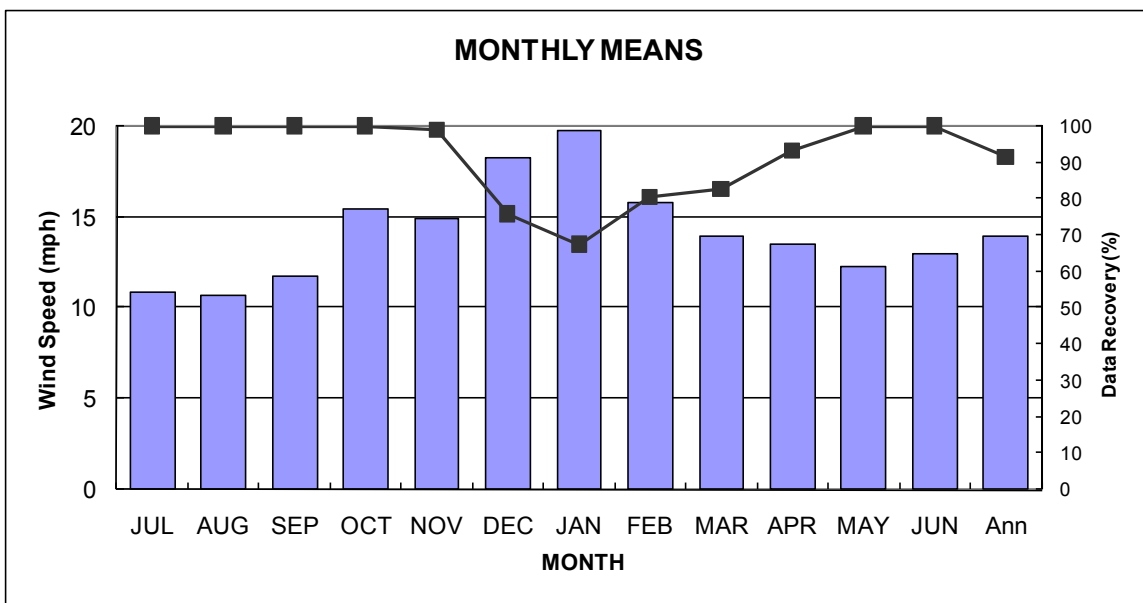


Figure 3.1: Monthly Mean Wind Speed Values for the Wickiup Ridge site.

Table 3.1: Monthly mean and data recovery rates at 67 ft. (20m) for the annual study period.

Month	Site 0640	
	Mean (mph)	Rec. (%)
JUL	10.9	100.00
AUG	10.7	100.00
SEP	11.8	100.00
OCT	15.5	100.00
NOV	14.9	99.03
DEC	18.3	75.81
JAN	19.8	67.47
FEB	15.8	80.60
MAR	14.0	82.80
APR	13.5	93.19
MAY	12.3	100.00
JUN	13.0	100.00
ANN	13.9	91.56

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.

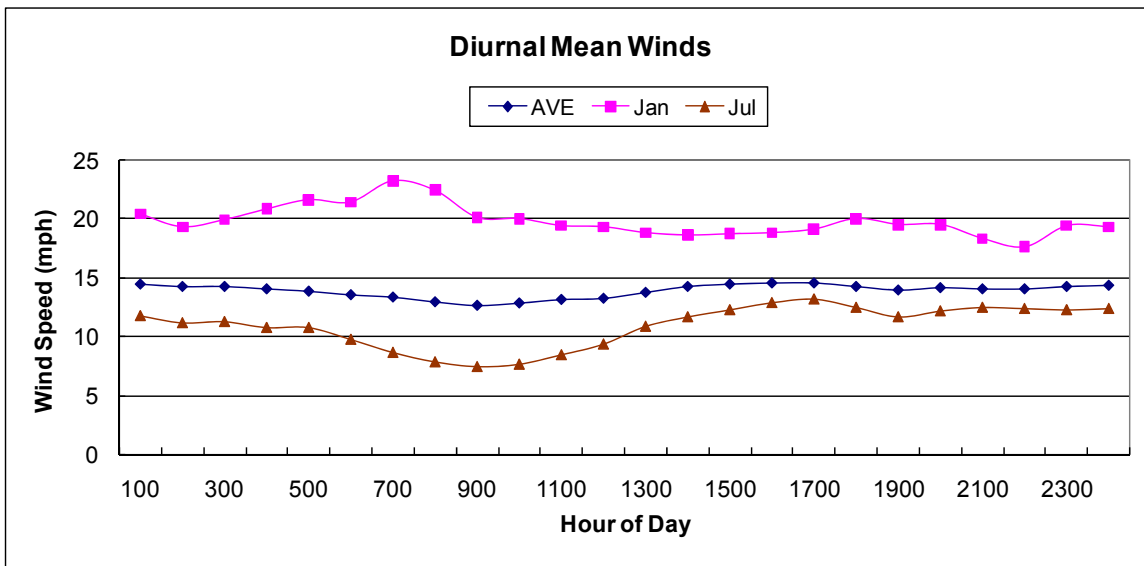


Figure 3.2: Diurnal mean wind speed values for the Wickiup Ridge site.

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.

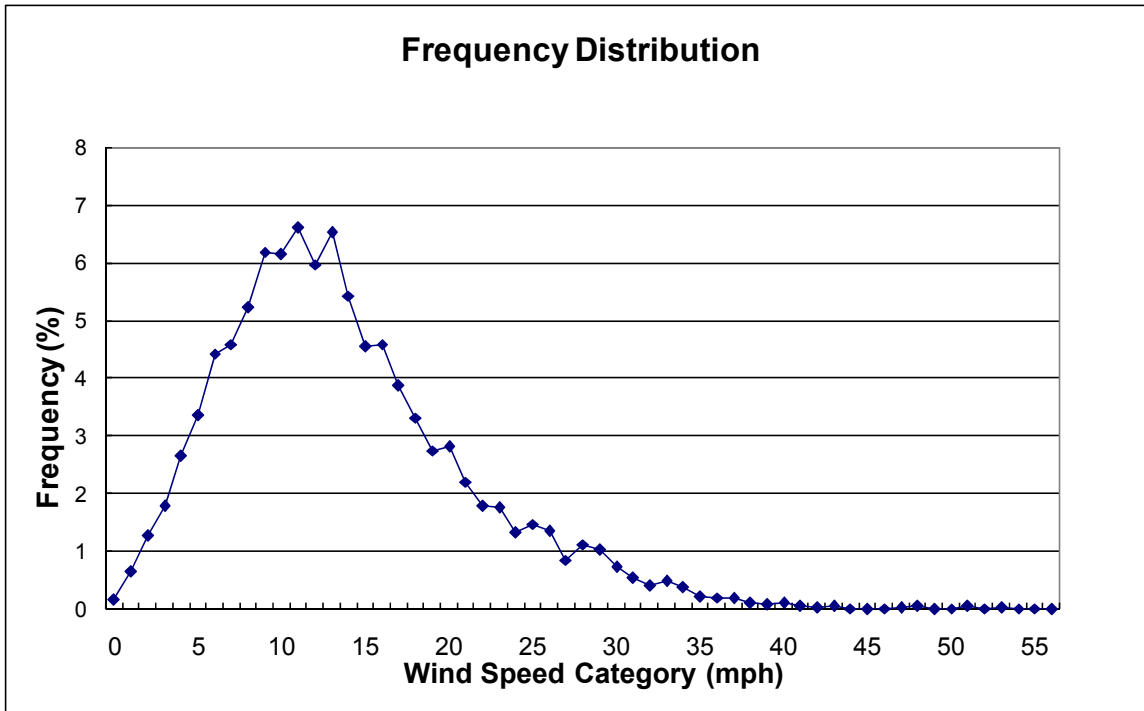


Figure 3.3: Wind speed frequency distribution for the Wickiup Ridge site.

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. The winds at this site had been expected to come from the west during the summer months. The wind rose shows not sign of this. It is possible that the instrumentation was installed without the proper orientation.

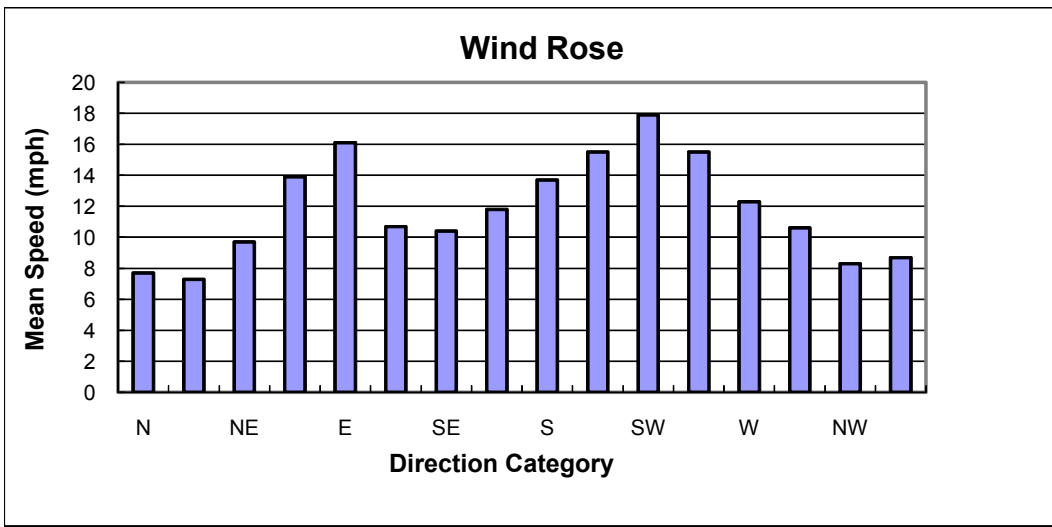
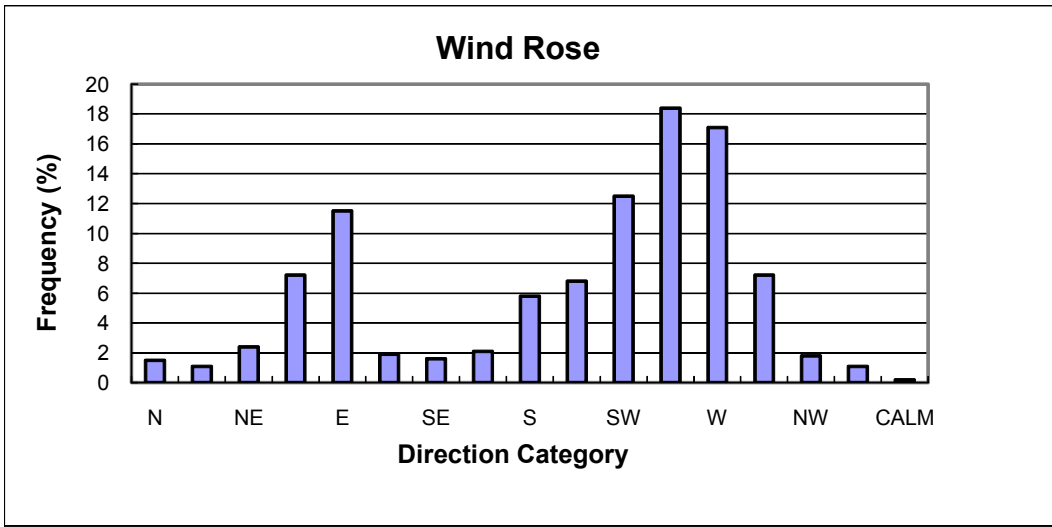


Figure 3.4: Frequency a) and average wind speed (b) for each of 16 wind direction categories for the annual analysis period.

In order understand better the winds at the site during different times of year; similar plots have been constructed using data from the individual months for the winter and summer. These can be seen in figures 3.5a-d and show any differences between the two periods.

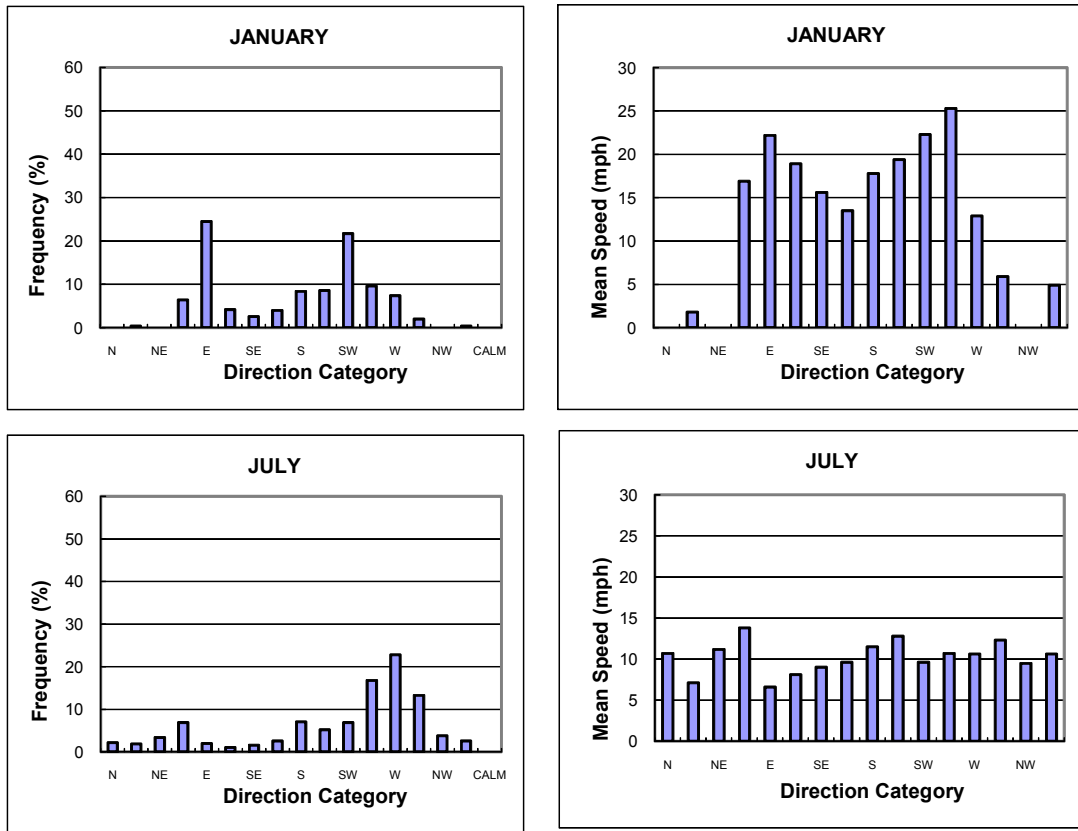


Figure 3.5: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories for a winter and summer month at the Wickiup Ridge site.

Energy Rose: In the same way a wind rose shows the strength and frequency of the wind for different direction categories, an energy rose can show the relative energy that can be expected for these same direction categories. In this case the percentage of total normalized available energy is shown for each direction category.

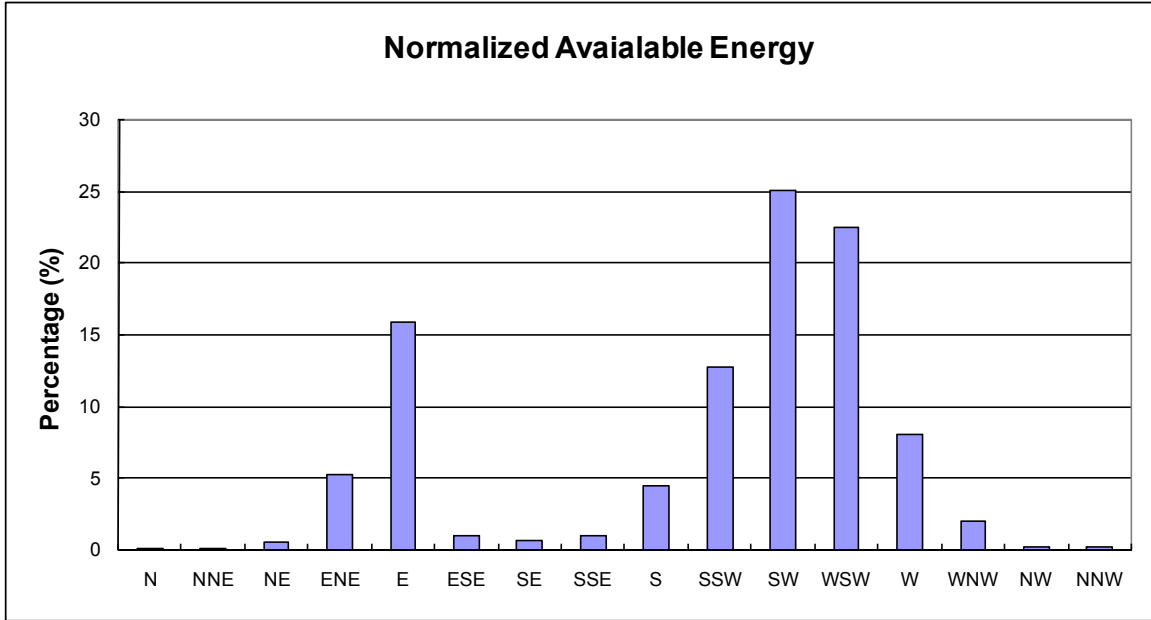


Figure 3.6: Percentage (%) of expected normalized energy for each of 16 wind direction categories for the annual analysis period.

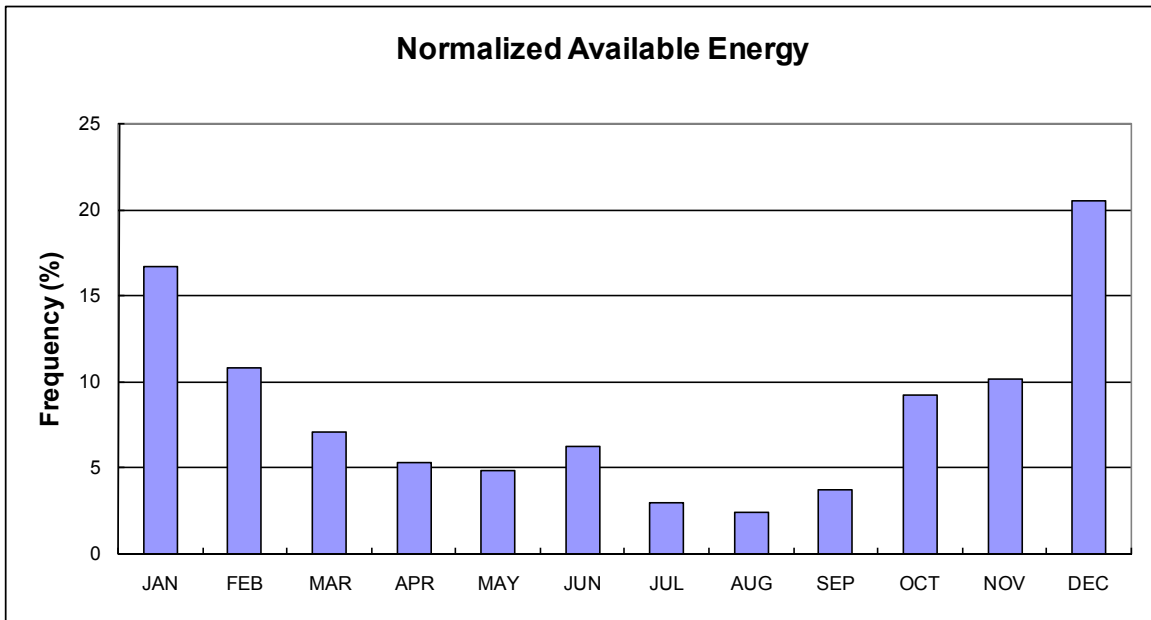


Figure 3.7: Frequency (%) of expected normalized energy for each month of the annual analysis period.

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 at the site.

Table 4.1: Observed and computed power quantities at the Wickiup Ridge site.

Month	Mean	Std.	Recovery	Max 1-Hr	Time in Range (12-60)	Power Den.	Avail Power
	(mph)	(mph)	Rate (%)	(mph)	mph (%)	W/m ²	kWh/m ²
Jul	10.9	4.70	100.0	30.6	40.9	107	79
Aug	10.7	3.90	100.0	20.7	39.9	87	65
Sep	11.8	5.30	100.0	30.9	48.6	138	100
Oct	15.5	7.40	100.0	46.2	64.4	332	247
Nov	14.9	8.80	99.0	54.3	52.6	376	271
Dec	18.3	11.30	75.8	55.2	64.7	738	549
Jan	19.8	8.30	67.5	40.6	79.1	604	449
Feb	15.8	9.10	80.6	56.2	58.5	434	292
Mar	14.0	7.00	82.8	43.3	58.1	255	190
Apr	13.5	5.90	93.2	29.4	56.9	188	142
May	12.3	6.20	100.0	33.6	48.3	174	130
Jun	13.0	7.10	100.0	39.8	47.4	232	167
ANN	13.9	7.60	91.8	56.2	53.9	287	2514

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 nature of the winds at this site. The lowest values are found in the summer and indicate the summer-time coastal winds aren't a significant factor at this site.

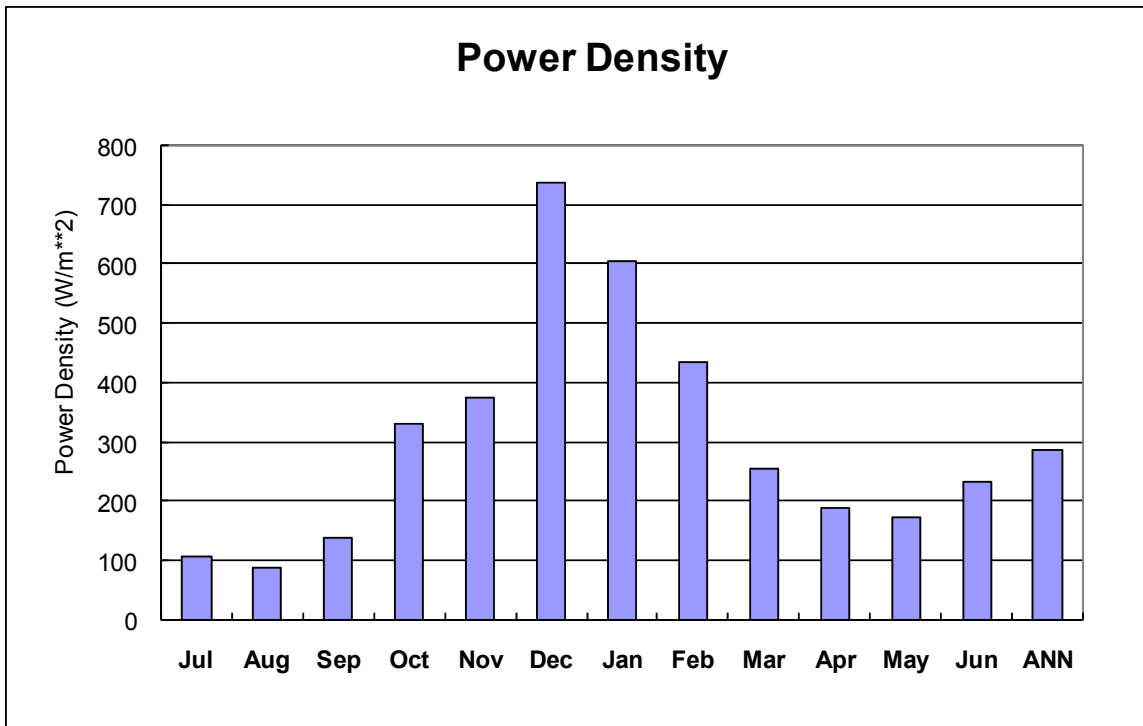


Figure 4.1: Monthly power density for the Wickiup Ridge site.

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 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 that is generated reaches the rated limit of the generator (rated capacity). The blades are then pitched to spill energy and protect the generator. 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 to protect the structural integrity of the turbine.

In Table 4.2, energy capacity factors are shown for four 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 967 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. To do this a shear coefficient must be used. Two values are used here (0.0 and 0.1) to obtain a range over which we would likely observe.

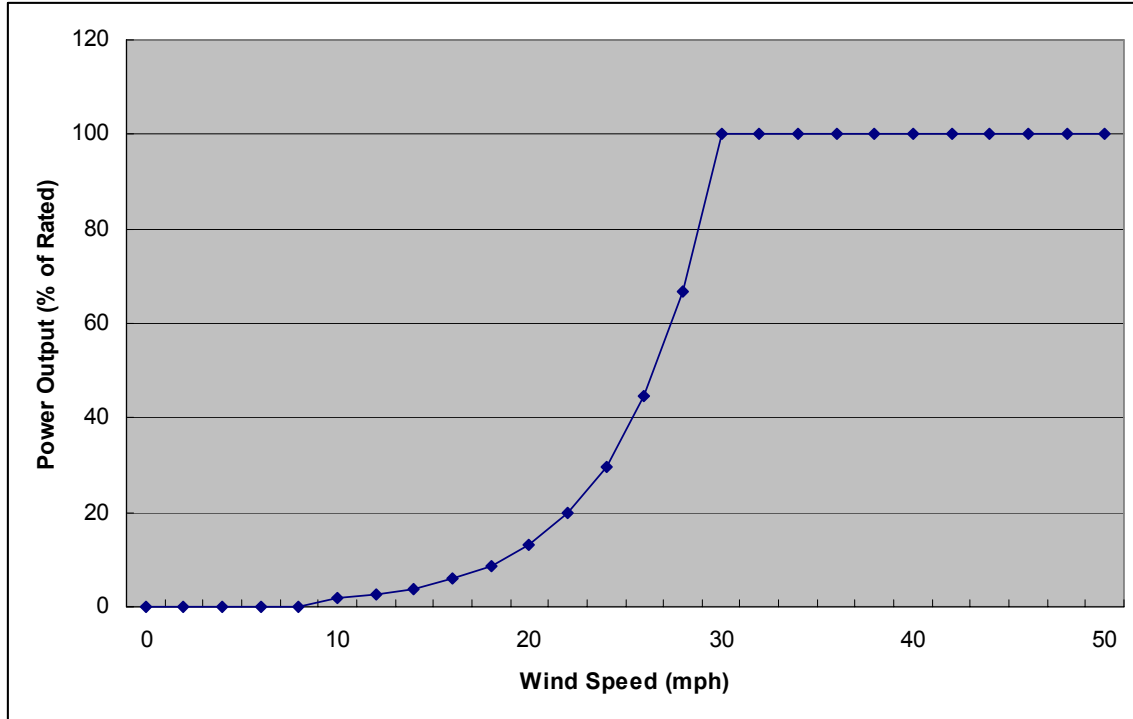


Figure 4.2: Sample power curve for a theoretical turbine

The capacity factors in Table 4.3 support the conclusions of the previous sections and illustrate the seasonal resource available at this site. The capacity factors range from a low of 0.128 (12.8%) to a high of 0.429 (42.9%). The annual values range from 0.250 to 0.310 depending on the turbine type and suggest a low but reasonable resource exists.

Table 4.2: Capacity factors computed for various wind turbines using the Wickiup Ridge site and a shear coefficient of 0.0.

Turbine	Vestas 47	Mit 250	GE Wind 70.5	Suzlon 88
Size (kW)	660	2000	1500	2000
Hub Ht. (ft.)	131	262	210	289
Jul	0.106	0.086	0.099	0.108
Aug	0.088	0.071	0.080	0.088
Sep	0.139	0.113	0.128	0.142
Oct	0.287	0.238	0.282	0.302
Nov	0.272	0.238	0.272	0.288
Dec	0.385	0.344	0.390	0.406
Jan	0.463	0.429	0.470	0.493
Feb	0.298	0.263	0.299	0.315
Mar	0.234	0.193	0.226	0.245
Apr	0.211	0.166	0.201	0.220
May	0.173	0.139	0.166	0.180
Jun	0.186	0.163	0.182	0.194
ANN	0.226	0.192	0.221	0.237

Table 4.3: Capacity factors computed for various wind turbines using the Wickiup Ridge site and a shear coefficient of 0.10.

Turbine	Vestas 47	Mit 250	GE Wind 70.5	Suzlon 88
Size (kW)	660	250	1500	2000
Hub Ht. (ft.)	131	100	210	289
Jul	0.132	0.098	0.142	0.172
Aug	0.113	0.082	0.120	0.150
Sep	0.170	0.128	0.182	0.220
Oct	0.328	0.261	0.356	0.398
Nov	0.304	0.258	0.329	0.361
Dec	0.416	0.364	0.439	0.467
Jan	0.507	0.441	0.550	0.592
Feb	0.330	0.282	0.356	0.387
Mar	0.272	0.213	0.295	0.337
Apr	0.251	0.285	0.275	0.319
May	0.205	0.155	0.223	0.259
Jun	0.215	0.179	0.234	0.266
ANN	0.259	0.210	0.280	0.315

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. The nearest long-term NWS site which should provide the necessary climatological information is at the Astoria Airport.

The Astoria NWS station is one of the oldest in the State of Oregon with observation dating back to 1899. The site is located only a few miles from the Pier 3 along the western edge of Young's Bay. The area is level and open and although the site has different terrain characteristics than Wickiup Ridge, the site should be sufficient to evaluate the climatological characteristics of the region. Data were obtained from the NCDC archives in two formats to verify the outcome. One was the monthly "Local Climatological Data" bulletins that are issued monthly and the seconds were daily averages obtained for the period between 1985 and 2008. Results from both sources were consistent.

The long-term monthly means and monthly means for the current study period for each of these sites are shown in Table 5.1. Also shown are the monthly departures. Overall, wind conditions for the analysis period appeared to be below normal by 14.0 %. For this period, all of the months had negative departures. This suggests that the winds during the analysis period may be underestimating the long-term conditions at Wickiup Ridge. However, the difference in terrain and exposure between the Astoria airport and the site at Wickiup Ridge is significant and it is not clear how well conditions are represented by the airport data.

Table 5.1: Monthly means for the current observation period, long-term normals and departures for the NWS station in Astoria.

Astoria NWS			
Latitude: 46:09 N Elevation: 10'			
Longitude 123:53 W			
Month	Normal (mph) 1984-2006	Mean (mph) current	Departure (%)
Jul	8.5	7.4	-12.9
Aug	7.8	6.2	-20.5
Sept	7.0	6.2	-11.4
Oct	7.1	6.6	-7.0
Nov	8.3	6.1	-26.5
Dec	8.7	8.7	0.0
Jan	8.9	7.9	-11.2
Feb	8.5	6.6	-22.4
Mar	8.3	6.9	-16.9
Apr	8.1	6.8	-16.0
May	8.0	6.7	-16.3
Jun	8.2	7.7	-6.1
ANN	8.1	7.0	-14.0

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 Wickiup Ridge site. First, measurements were taken from only one location and it is possible that other locations in the immediate area might provide better exposure to the prevailing winds. The northern end of the Ridge is somewhat higher and could have higher winds and be better exposed to during easterly wind conditions.

A second factor that is important to consider is that observations were collected at only one height. Flow over and around hill tops can be very complex and difficult to estimate. These types of flows are influenced by many factors including the density of the air and the exact shape and orientation of the local terrain. Observations taken at a different height above ground would most likely show some differences that might be important to a determination of economic feasibility. A better understanding of the wind shear (variation of wind with height) would also improve the confidence of the power estimates presented here.

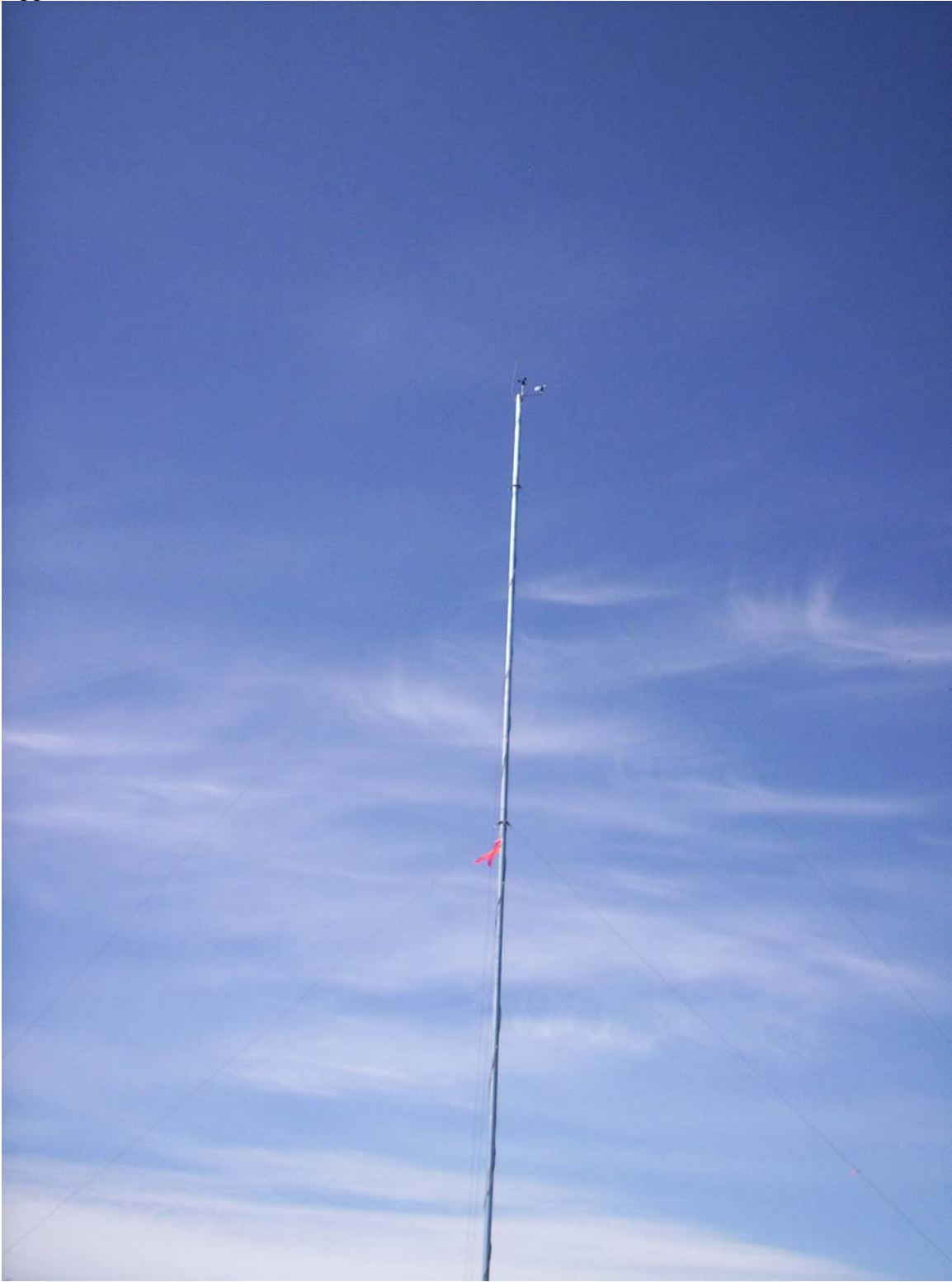
In summary,

- 1) Data quality was good and a sufficient quantity of data was obtained to enable conditions to be characterized for a complete annual analysis period. There were several periods of extensive icing observed in the data which could have an impact on the computed quantities.
- 2) The strongest and most consistent winds come from the W to WNW. This appears to be the case for all time of the year.
- 3) Comparisons with a nearby site where a longer history of observations are available suggest that during the annual study period (July 2007 to June 2008) the winds were possibly 14% below normal although the reference site used (Astoria Airport) is not in similar terrain.
- 4) Gross annual capacity factors computed for the site using various assumptions range between 20% and 31.5% depending on the assumption made (alpha value) and the type of wind turbine considered.

Appendix A: Topographic map of the location of the Wickiup Ridge site site.



Appendix B:



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

Changes Made					
Date:	Plug	Battery	Time	Gust (mph)	Comment
04/06/2007					Site Installed
05/02/2007	Y	Y		57	
06/20/2007	Y			45	Cables Repaired
08/02/2007	Y			50	
09/13/2007	Y			45	
11/01/2007	Y			80	
12/20/2007	Y			108	
03/10/2008	Y		Y	91	
04/16/2008	Y	Y		62	
06/11/2008	Y			57	
08/13/2008	Y			42	Data Collection Continuing

Appendix D: Miscellaneous analysis Tables.

STATION - Wickiup Ridge (Site 0640)
 WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY
 DATA PERIOD OF RECORD - 7/2007 - 6/2008
 NORMALIZATION PERIOD - ONE YEAR
 AVERAGE WIND SPEED FOR PERIOD: 13.9 MPH
 NORMALIZED AVAILABLE ENERGY: 2517.4 KWH/M**2/YEAR
 TOTAL HOURS OBSERVED: 8043

SPD MPH	HOURS/ PERIOD	REL FREQ	CUMHRS	CUMREL FREQ	NORMALIZED AVAIL. ENERGY KWH/M**2/YEAR
0	14	0.17	8043	100.00	0.0
1	53	0.66	8029	99.83	0.0
2	102	1.27	7976	99.17	0.0
3	145	1.80	7874	97.90	0.2
4	214	2.66	7729	96.10	0.8
5	270	3.36	7515	93.44	1.9
6	356	4.43	7245	90.08	4.3
7	369	4.59	6889	85.65	7.0
8	420	5.22	6520	81.06	11.9
9	498	6.19	6100	75.84	20.1
10	494	6.14	5602	69.65	27.4
11	531	6.60	5108	63.51	39.2
12	480	5.97	4577	56.91	46.0
13	525	6.53	4097	50.94	64.0
14	437	5.43	3572	44.41	66.5
15	367	4.56	3135	38.98	68.7
16	369	4.59	2768	34.42	83.8
17	311	3.87	2399	29.83	84.7
18	267	3.32	2088	25.96	86.3
19	221	2.75	1821	22.64	84.1
20	227	2.82	1600	19.89	100.7
21	178	2.21	1373	17.07	91.4
22	145	1.80	1195	14.86	85.6
23	142	1.77	1050	13.05	95.8
24	108	1.34	908	11.29	82.8
25	119	1.48	800	9.95	103.1
26	109	1.36	681	8.47	106.2
27	69	0.86	572	7.11	75.3
28	91	1.13	503	6.25	110.8
29	84	1.04	412	5.12	113.6
30	59	0.73	328	4.08	88.3
31	44	0.55	269	3.34	72.7
32	34	0.42	225	2.80	61.8
33	40	0.50	191	2.37	79.7
34	31	0.39	151	1.88	67.6
35	18	0.22	120	1.49	42.8
36	17	0.21	102	1.27	44.0
37	16	0.20	85	1.06	44.9
38	9	0.11	69	0.86	27.4
39	7	0.09	60	0.75	23.0
40	9	0.11	53	0.66	31.9
41	5	0.06	44	0.55	19.1
42	3	0.04	39	0.48	12.3
43	5	0.06	36	0.45	22.0
44	2	0.02	31	0.39	9.4
45	0	0.00	29	0.36	0.0
46	2	0.02	29	0.36	10.8
47	3	0.04	27	0.34	17.3
48	6	0.07	24	0.30	36.8
49	1	0.01	18	0.22	6.5
50	2	0.02	17	0.21	13.9
51	5	0.06	15	0.19	36.8
52	2	0.02	10	0.12	15.6
53	3	0.04	8	0.10	24.8

STATION - Wickiup Ridge (Site 0640)

MONTHLY WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 4/2007 - 8/2008

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS	AVG
2007	0.0	0.0	0.0	13.6	12.3	11.9	10.9	10.7	11.8	15.5	14.9	18.3	5654	13.32
# OBS	0	0	0	590	579	256	744	744	720	744	713	564		
2008	19.8	15.8	14.0	13.5	12.3	13.0	11.2	9.5	0.0	0.0	0.0	0.0	4856	13.63
# OBS	502	561	616	671	744	720	744	298	0	0	0	0		

STATION - Wickiup Ridge (Site 0640)

DIURNAL WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 7/2007 - 6/2008

	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
MON	10.4	19.3	19.9	20.8	21.6	21.4	23.2	22.4	20.1	20.0	19.4	19.3	18.8	18.6	18.7	18.8	19.1	20.0	19.5	19.5	18.3	17.6	19.4	19.3	19.8
JAN	17.5	17.3	16.5	15.7	15.4	14.8	15.4	15.5	14.6	15.1	15.2	14.8	15.0	15.6	14.5	14.7	15.1	15.9	15.9	16.7	16.4	16.4	16.6	17.9	15.8
FEB	14.1	14.2	14.1	14.0	13.8	14.0	13.9	13.7	13.9	14.4	15.3	15.3	15.7	15.5	15.4	14.9	13.5	13.7	13.4	12.9	13.3	12.5	12.7	13.3	14.0
MAR	13.4	13.1	13.4	14.3	13.5	12.5	12.1	12.2	13.1	12.9	13.2	12.9	13.2	14.2	14.8	14.9	14.9	14.8	13.7	13.7	13.0	12.6	13.5	13.3	13.5
APR	12.3	12.3	12.3	12.0	11.7	11.3	10.9	10.8	10.9	11.1	11.0	11.4	12.3	13.3	13.6	13.9	13.2	12.7	13.0	13.5	13.4	13.6	12.9	12.6	12.3
MAY	13.3	13.3	13.3	12.8	12.7	11.6	11.4	11.3	10.7	10.6	11.1	11.6	12.4	13.4	14.5	14.4	14.6	14.8	14.0	13.1	13.4	13.6	14.0	14.6	13.8
JUN	11.8	11.2	11.3	10.8	10.8	9.8	8.7	7.9	7.5	7.7	8.5	9.4	10.9	11.7	12.3	12.9	13.2	12.5	11.7	12.2	12.5	12.4	12.3	12.4	10.9
JUL	11.4	11.7	11.3	11.0	10.3	10.0	9.2	8.6	8.0	7.9	8.4	9.2	10.3	11.4	12.1	12.3	12.4	11.6	11.4	12.2	12.2	11.9	11.5	11.4	10.7
AUG	12.5	11.9	11.8	11.6	11.5	11.4	11.2	11.3	10.8	10.4	10.5	10.6	11.0	12.1	12.7	12.3	12.1	12.4	12.3	12.4	11.9	12.8	13.3	12.9	11.8
SEP	15.0	15.1	15.8	16.2	16.4	16.3	16.0	16.1	15.7	15.7	15.8	15.7	15.8	16.3	15.8	14.9	15.4	15.6	15.6	14.6	14.6	14.6	14.6	14.2	15.5
OCT	16.7	17.1	16.8	16.2	16.1	15.8	15.6	14.8	15.2	15.2	15.3	13.8	13.1	12.4	12.6	13.7	14.5	13.8	13.4	14.0	14.5	14.9	15.5	15.8	14.9
NOV	19.2	18.8	19.1	18.1	17.8	18.2	18.0	17.2	16.3	16.9	17.8	18.8	18.9	18.9	19.4	19.8	19.3	17.7	17.4	18.2	18.5	18.3	17.7	18.9	18.3
DEC																									
AVG	14.5	14.3	14.3	14.1	13.9	13.6	13.4	13.0	12.7	12.9	13.2	13.3	13.8	14.3	14.5	14.6	14.6	14.3	14.0	14.2	14.1	14.1	14.3	14.4	13.9

STATION - Wickiup Ridge (Site 0640)

WIND ROSE FOR ALL DATA - 8043 OBSERVATIONS
 DATA PERIOD OF RECORD - 7/2007 - 6/2008

DIR	SPEED CATEGORIES (MPH)																TOTAL %	MEAN SPEED (MPH)	
	0	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52			>=
TO	1.1	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	1.5	7.7
TO	10	13	16	19	22	25	28	31	34	37	40	43	46	49	52	55	55	5.8	13.7
N	0.8	0.3	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	1.1	7.3
NNE	1.3	0.6	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	2.4	9.7
NE	2.1	1.3	1.4	1.0	0.7	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.2	13.9
ENE	3.1	1.7	1.7	1.0	0.9	0.8	1.1	0.7	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	11.5	16.1
E	1.0	0.3	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	0.0	0.0	1.9	10.7
ESE	0.8	0.3	0.2	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	1.6	10.4
SE	0.9	0.5	0.2	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	2.1	11.8
SSE	1.7	1.1	1.2	0.7	0.6	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.8	13.7
S	2.0	1.0	1.1	1.0	0.6	0.3	0.2	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	6.8	15.5
SSW	2.9	1.4	1.5	1.4	1.3	1.2	1.1	0.7	0.4	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	12.5	17.9
SW	4.6	3.5	3.3	2.0	1.5	1.0	0.7	0.8	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	18.4	15.5
WSW	6.1	4.3	2.7	2.3	1.1	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.1	12.3
W	3.3	1.9	1.2	0.7	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	7.2	10.6
WNW	1.3	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	0.0	0.0	1.8	8.3
NW	0.7	0.2	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	1.1	8.7
NNW																			
CALM																			
0.2																			
TOTAL	33.6	18.9	15.5	10.9	7.2	4.5	3.6	2.7	1.2	0.7	1.2	0.2	0.1	0.1	0.1	0.1	0.0	100.0	13.9
%																			

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 - Wickiup Ridge (Site 0640)

ENERGY ROSE (TOTALS ARE NORMALIZED AVAILABLE ENERGY (KWH/M**2)
 DATA PERIOD OF RECORD - 7/2007 - 6/2008

MON	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	OBS.	NORM.
JAN	0.0	0.0	0.0	15.5	135.7	15.3	5.1	5.8	23.8	36.4	128.6	73.0	9.4	0.2	0.0	0.0	448.8	502	744
FEB	0.1	0.1	0.7	13.2	48.8	1.9	0.2	0.3	5.0	11.7	81.6	117.9	11.1	0.1	0.0	0.0	292.8	559	672
MAR	0.0	0.0	0.0	4.7	22.4	1.1	0.8	1.2	11.0	24.9	63.6	36.4	24.7	0.1	0.0	0.0	190.8	616	744
APR	0.2	0.0	1.1	7.3	28.0	0.6	0.6	0.6	4.4	6.5	32.5	32.3	18.0	10.7	0.2	0.1	143.1	668	720
MAY	0.5	0.3	0.9	12.6	20.0	0.6	0.1	0.7	2.1	1.0	14.0	39.5	36.5	1.4	0.2	0.2	130.6	740	744
JUN	0.1	0.0	2.8	6.2	2.5	0.5	0.2	0.6	3.0	4.6	28.3	85.7	27.8	3.6	1.1	0.6	167.6	718	720
JUL	0.9	0.6	3.0	11.4	0.4	0.4	0.6	1.2	8.0	8.6	4.9	10.2	13.9	12.0	1.8	2.0	79.8	739	744
AUG	0.8	0.9	1.8	3.8	0.7	0.1	0.0	0.4	2.8	1.7	6.9	13.9	18.4	8.7	2.6	2.0	65.4	737	744
SEP	0.5	0.7	1.7	20.7	10.1	0.3	0.4	4.1	4.7	2.8	7.6	14.0	19.3	12.5	0.2	0.2	99.6	717	720
OCT	0.2	0.1	1.8	14.0	45.1	1.6	2.9	4.0	15.6	20.6	81.5	50.2	6.7	3.6	0.1	0.1	248.2	743	744
NOV	0.0	0.2	0.8	16.2	92.9	0.9	1.7	2.5	22.5	23.2	50.7	40.1	20.9	1.0	0.1	0.0	273.7	707	720
DEC	0.1	0.2	0.3	16.4	22.4	3.2	4.2	5.9	16.3	202.2	176.5	94.0	9.8	1.9	0.2	0.1	553.8	559	744
TOT.	3.5	3.1	15.0	142.1	428.9	26.3	16.8	27.1	119.2	344.2	676.7	607.2	216.6	55.7	6.6	5.4	2694.3	8005	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.