OREGON ANEMOMETER LOAN PROGRAM

Wind Resource Evaluation: Fulton Ridge

Prepared By:
Energy Resources Research laboratory
Oregon State University

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Prepared by:

Philip L. Barbour
Stel N. Walker, Ph.D.
Energy Resources Research Laboratory
Department of Mechanical Engineering
Oregon State University
Corvallis, OR 97331

Sponsor:

Energy Trust of Oregon, Inc.
733 SW Oak Street, Suite 200
Portland Oregon,97205

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:	**Fulton Ridge**	
Latitude:	**45-35-47**	**(WGS 84)**
Longitude:	**120-55-05**	
Elevation:	**1250 ft.**	
Tower Height:	**67 feet (20m)**	
Site #	**0631**	

Types of Sensors:	NRG Maximum #40 wind speed NRG 200 series 2 wind vane
Instrumentation:	Single level mounted on top of tower
County:	Gilliam
Installation Date:	December 20, 2006
Data Available to:	April 30, 2007

Site Location: The tower was placed on top of Fulton Ridge, a wide ridge located just east of The Dalles in North-Central Oregon. The ridge starts near the Columbia River near the Dalles and sweeps to the east and then south. There is a canyon on the west side and on the east there is a steep drop down to the Deschutes River. Portions of the area are inside the Columbia River National Scenic Area. There are other hills and mountains to the west and southwest but are some distance away. There are no obstructions to the east. The immediate area is completely clear and unobstructed. The property is used for wheat production and for cattle grazing. The tower location is marked on the map included in Appendix A.

Project Description: This project was requested by the landowners who are interested in evaluating the wind resource potential of their property and in evaluating the potential for a community based wind project. The property has been in the same family for several generations.

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 the landowner 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.

For the Fulton Ridge site there was one problem with data collection that resulted in the loss of data from one of the data storage modules. For this reason the site was left in place well beyond the single annual period. This missing period spans

from March 3, 2006 to April 4, 2006. Icing events at this site were limited to a short period in January 2007. This period was identified and removed from the records. The monthly means and recovery rates for the whole period can be found in Table 1.

Table 2.1: Monthly mean and data recovery rates for the entire monitoring period.

	Site 0631	
Month	Mean (mph)	Rec. (%)
DEC	6.2	67.9
JAN	9.4	100.0
FEB	11.5	100.0
MAR	9.6	8.6
APR	12.4	88.1
MAY	13.1	100.0
JUN	15.1	100.0
JUL	17.2	100.0
AUG	15.9	100.0
SEP	13.4	100.0
OCT	11.5	100.0
NOV	9.8	100.0
DEC	8.9	100.0
JAN	9.4	98.1
FEB	7.9	100.0
MAR	11.6	100.0
APR	13.6	100.0
MEAN	11.8	86.7

3.0 WIND CHARACTERISTICS

In the following sections, several characteristics of the winds at the Fulton 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 May 1, 2006 to April 30 2007.***

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.

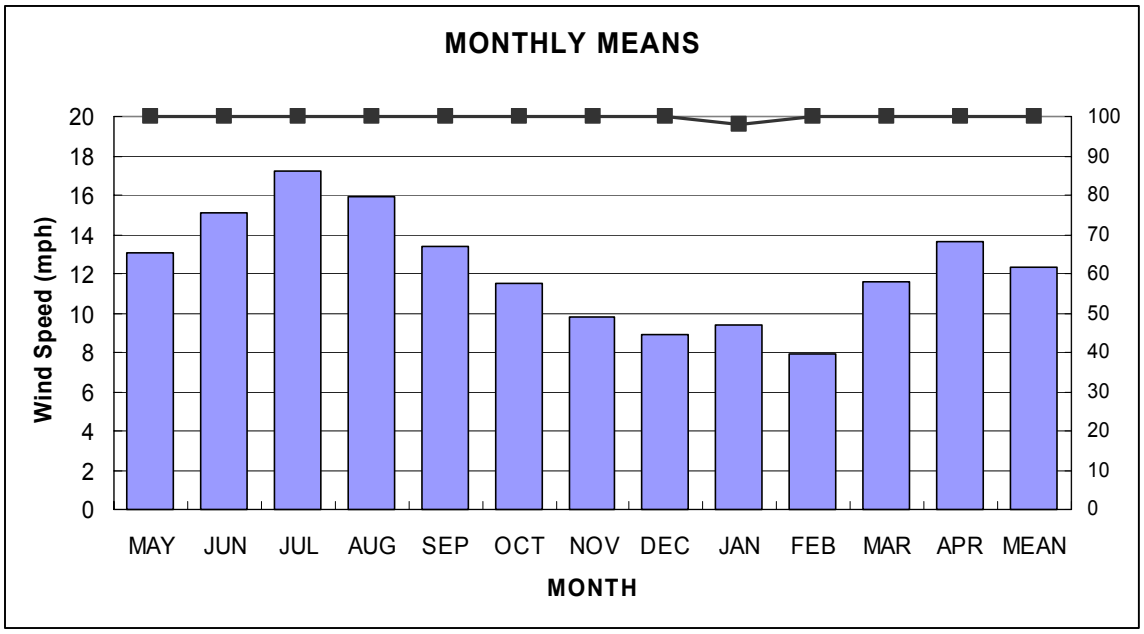

Figure 3.1: Monthly Mean Wind Speed Values for the Fulton Ridge site.

Table 3.1: Monthly mean and data recovery rates for the annual study period.

Month	Site 0631 Mean (mph)	Rec. (%)
MAY	13.1	100.0
JUN	15.1	100.0
JUL	17.2	100.0
AUG	15.9	100.0
SEP	13.4	100.0
OCT	11.5	100.0
NOV	9.8	100.0
DEC	8.9	100.0
JAN	9.4	98.1
FEB	7.9	100.0
MAR	11.6	100.0
APR	13.6	100.0
MEAN	12.3	99.8

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.

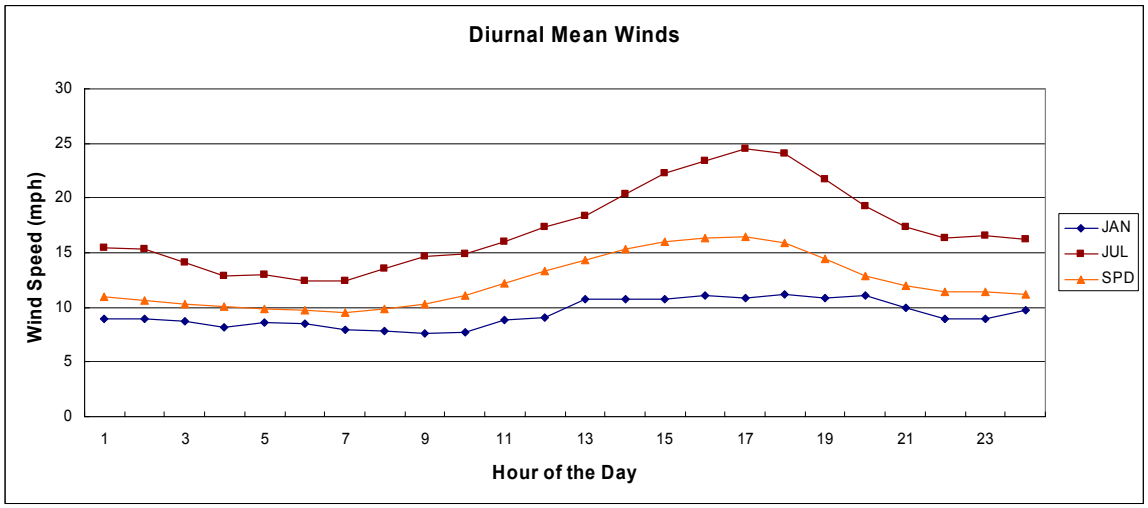

Figure 3.2: Diurnal mean wind speed values for the Fulton Ridge site.

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.

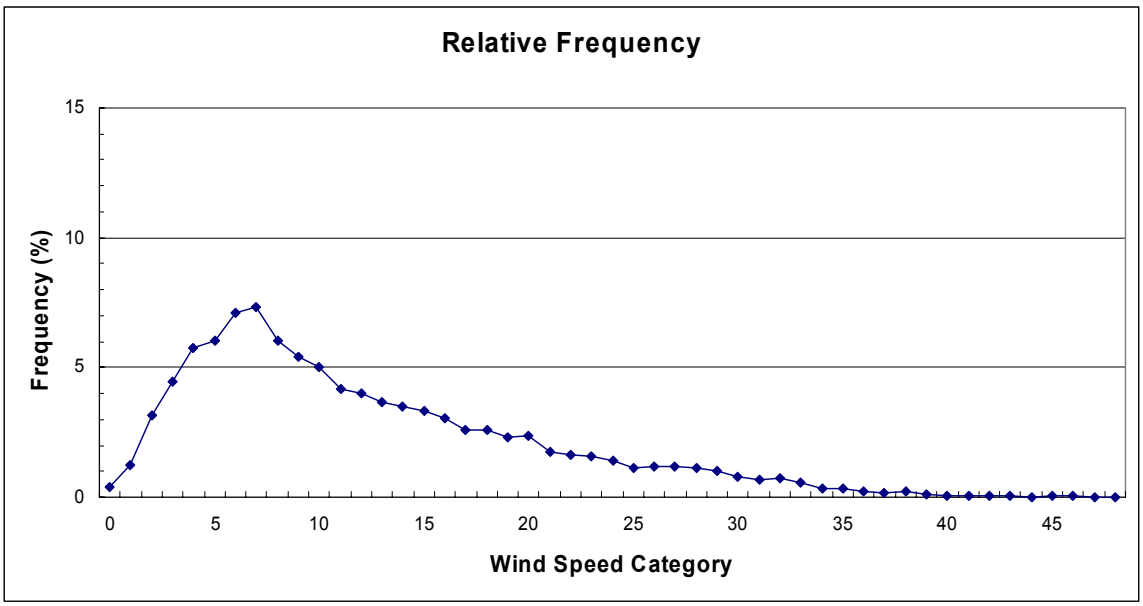

Figure 3.3: Wind speed frequency distribution for the Fulton site.

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.

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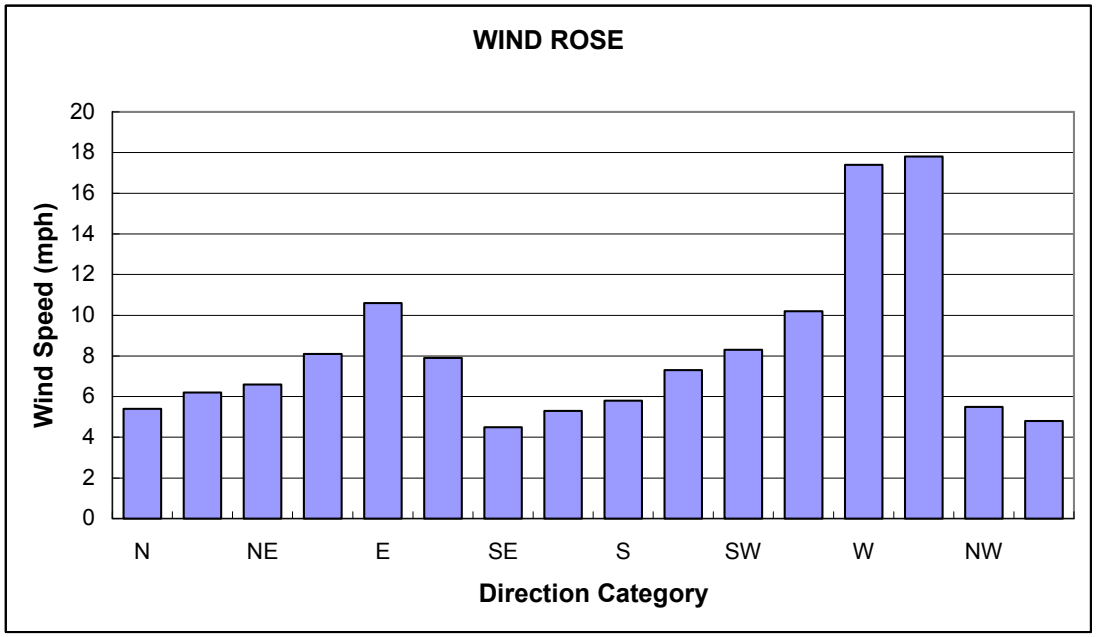


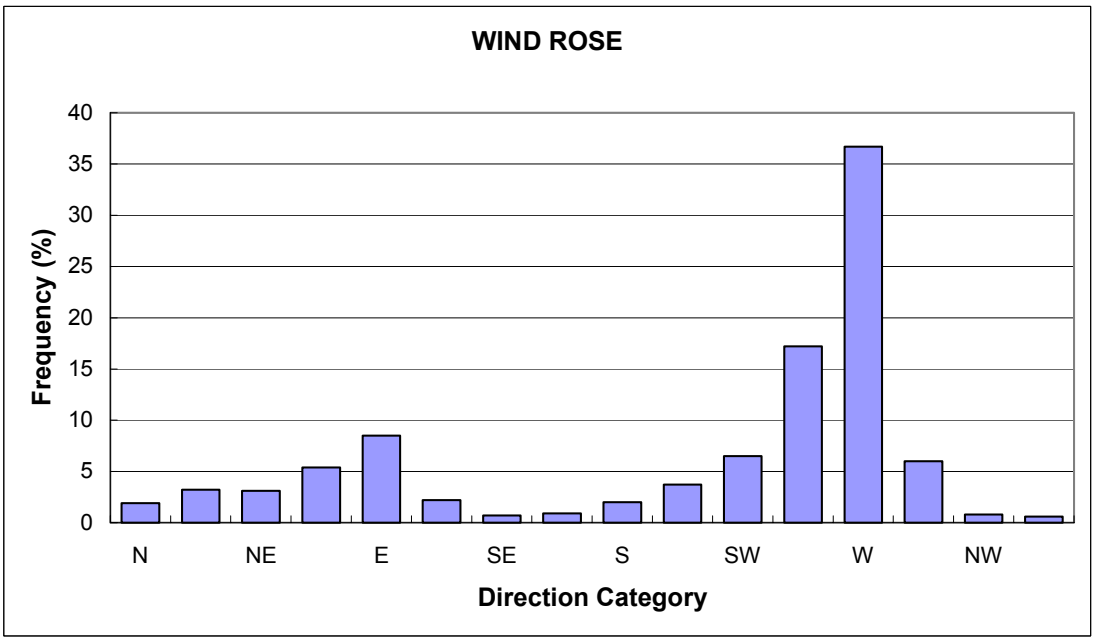


Figure 3.4: a) Average wind speed (mph) and b) frequency (%) for each of 16 wind direction categories for the annual analysis period.

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.

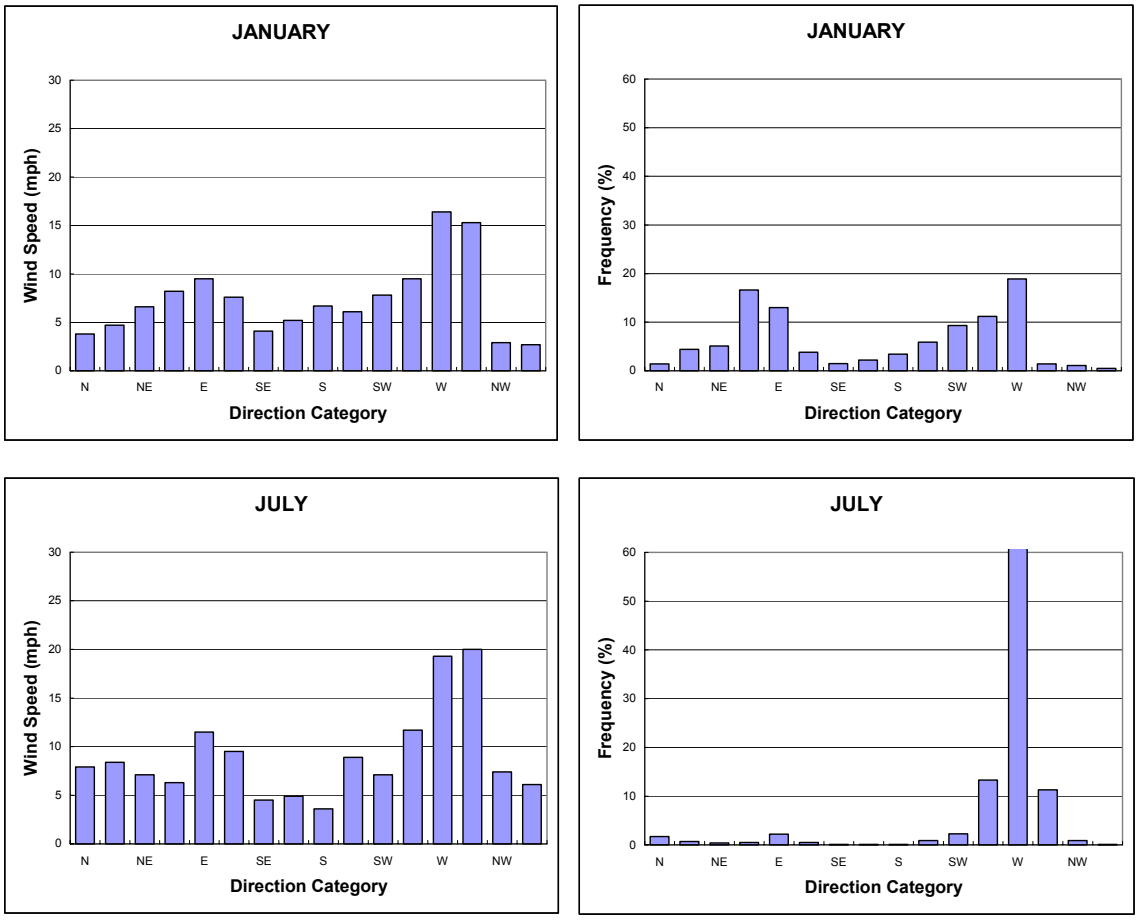


Figure 3.5: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories for a winter and summer month at the Fulton Ridge site.

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.

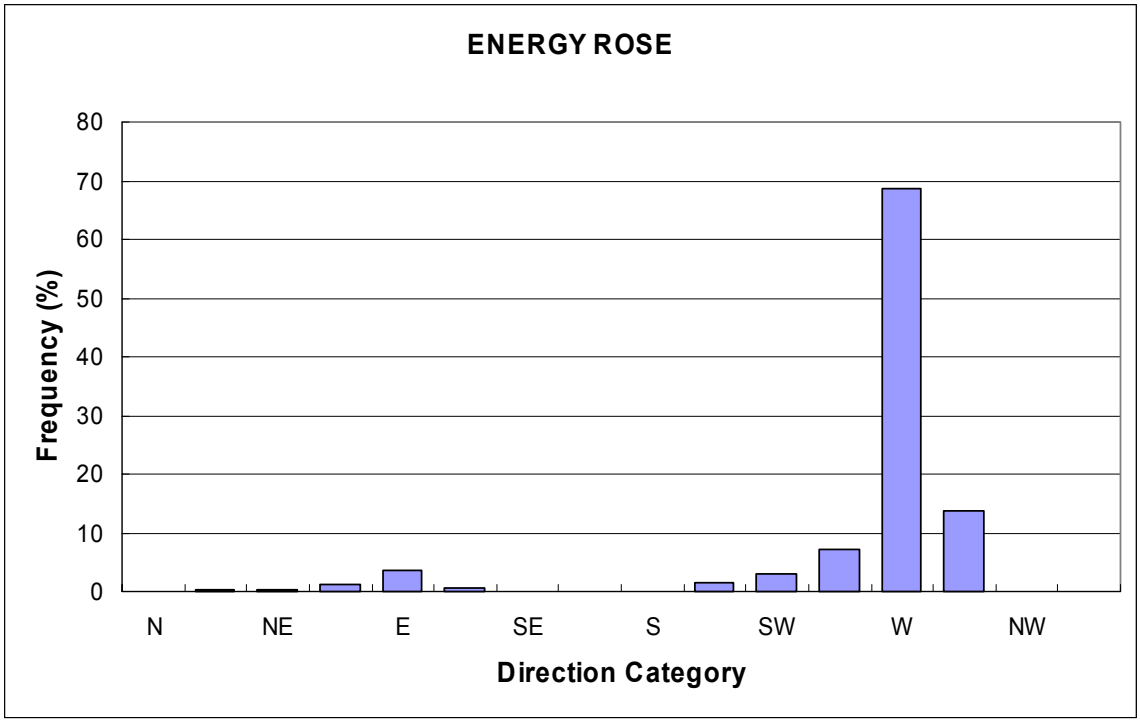


Figure 3.6: Frequency (%) of expected energy for each of 16 wind direction categories for the annual analysis period.

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 Fulton Ridge site.

Month	Mean	Std.	Recovery	Max 1-Hr	Time in Range	Power Den.
	(mph)	(mph)	Rate(%)	(mph)	(12-60 mph)	W/m^2
May	13.1	8.0	100.0	39.3	46.8	272
Jun	15.1	8.2	100.0	36.6	57.2	357
Jul	17.2	8.2	100.0	42.2	68.7	469
Aug	15.9	9.0	100.0	42.8	57.0	441
Sep	13.4	8.5	100.0	46.3	45.8	315
Oct	11.5	7.3	100.0	48.3	38.4	204
Nov	9.8	7.1	100.0	43.0	29.0	155
Dec	8.9	6.7	100.0	44.6	24.6	129
Jan	9.4	7.5	98.1	45.4	24.5	174
Feb	7.9	6.3	100.0	36.7	17.9	97
Mar	11.6	7.7	100.0	40.4	40.6	216
Apr	13.6	7.7	100.0	35.5	49.4	279
ANN	12.3	8.2	99.9	48.3	41.8	260

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 difference between the seasons. The monthly power density for February was under 100 W/m^2 while several of the summer months were above 400 W/m^2. This is largely a function of the amount of high winds observed at a site.

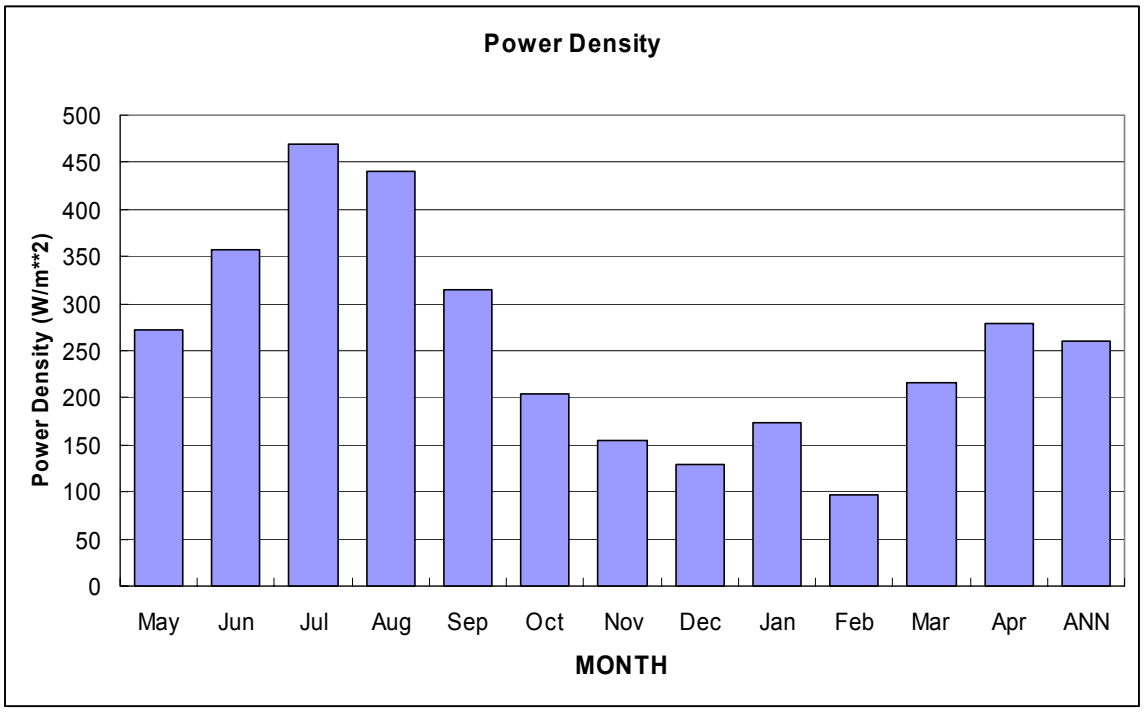


Figure 4.1: Monthly power density for the Fulton Ridge site.

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 three 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 65 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. Unfortunately, the shear coefficient is not know and must be estimated. A standard value of 0.143 is used here.

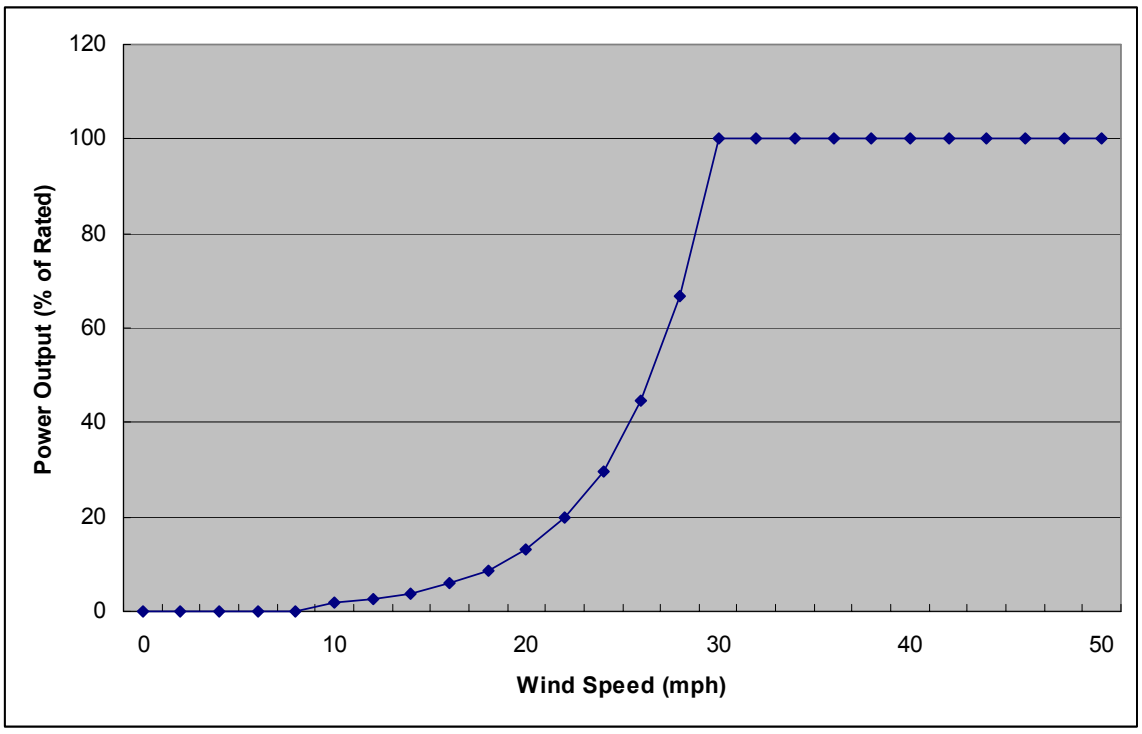


Figure 4.2: Sample power curve for a theoretical turbine

The capacity factors in Table 4.3 support the conclusions of the previous sections and indicate that several months show indications of a good wind resource and several months indicate a fairly low resource. Overall, the capacity factors are about 0.250 or 25%.

Table 4.2: Capacity factors computed for various wind turbines using the Fulton Ridge site and a shear coefficient of 0.143.

Turbine	Vestas 80	NEG Micon 72	GE Wind 70.5
Size (kW)	2000	2000	1500
Hub Ht. (ft.)	262	210	210
May	0.309	0.270	0.280
Jun	0.403	0.354	0.367
Jul	0.470	0.416	0.431
Aug	0.417	0.372	0.385
Sep	0.310	0.273	0.281
Oct	0.243	0.208	0.213
Nov	0.181	0.155	0.159
Dec	0.137	0.116	0.117
Jan	0.150	0.131	0.132
Feb	0.116	0.099	0.101
Mar	0.254	0.220	0.227
Apr	0.329	0.286	0.295
ANN	0.278	0.243	0.250

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. Fulton Ridge is reasonably close to the long-term wind monitoring site at Sevenmile Hill. This site is part of a long-term wind monitoring site operated and maintained by the BPA.

Sevenmile Hill is located just west of The Dalles at an elevation of 1880 ft. The site is located at a similar distance from the Columbia River and has similar exposure to the southwest. Sevemile Hill should provide a good indication of climatological conditions over the period of interest here. Data are available through the ERRL.

The long-term monthly means and monthly means for the current study period at Sevenmile Hills are shown in Table 5.1. Also shown are the monthly departures. Overall, the winds were close to normal (+2.3%). A few individual months had fairly high departures but nothing suggests that the study period unusual or uncharacteristic. If the departures had been larger an adjustment could be made to the Fulton Ridge data. As it is, however, the small departures are well within any level of uncertainty in the measurements and the current evaluation period appears to adequately represent the long-term conditions of the sites.

Table 5.1: Monthly mean and departures for long-term BPA wind monitoring site at Sevenmile Hill.

Sevenmile Hill **Latitude: 45.649 N** **Elevation: 1880'** **Longitude 121.272 W**			
Month	**Normal (mph) 1978-2006**	**Mean (mph) current**	**Departure (%)**
May	18.9	15.8	-16.4
Jun	20.0	19.0	-5.0
Jul	21.3	23.3	9.4
Aug	19.7	21.1	7.1
Sept	15.8	17.5	10.8
Oct	12.6	15.3	21.4
Nov	10.0	10.2	2.0
Dec	9.9	9.4	-5.1
Jan	10.2	10.1	-1.0
Feb	10.1	10.0	-1.0
Mar	13.0	14.4	10.8
Apr	15.6	16.8	7.7
ANN	14.9	15.2	2.3

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 Fulton 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 ridge is fairly long and there is likely some variation along it. The terrain is fairly open and this is not expected to be a major factor however.

A second factor that is important to consider is that observations were collected at only one height. Flow over and around ridge 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,

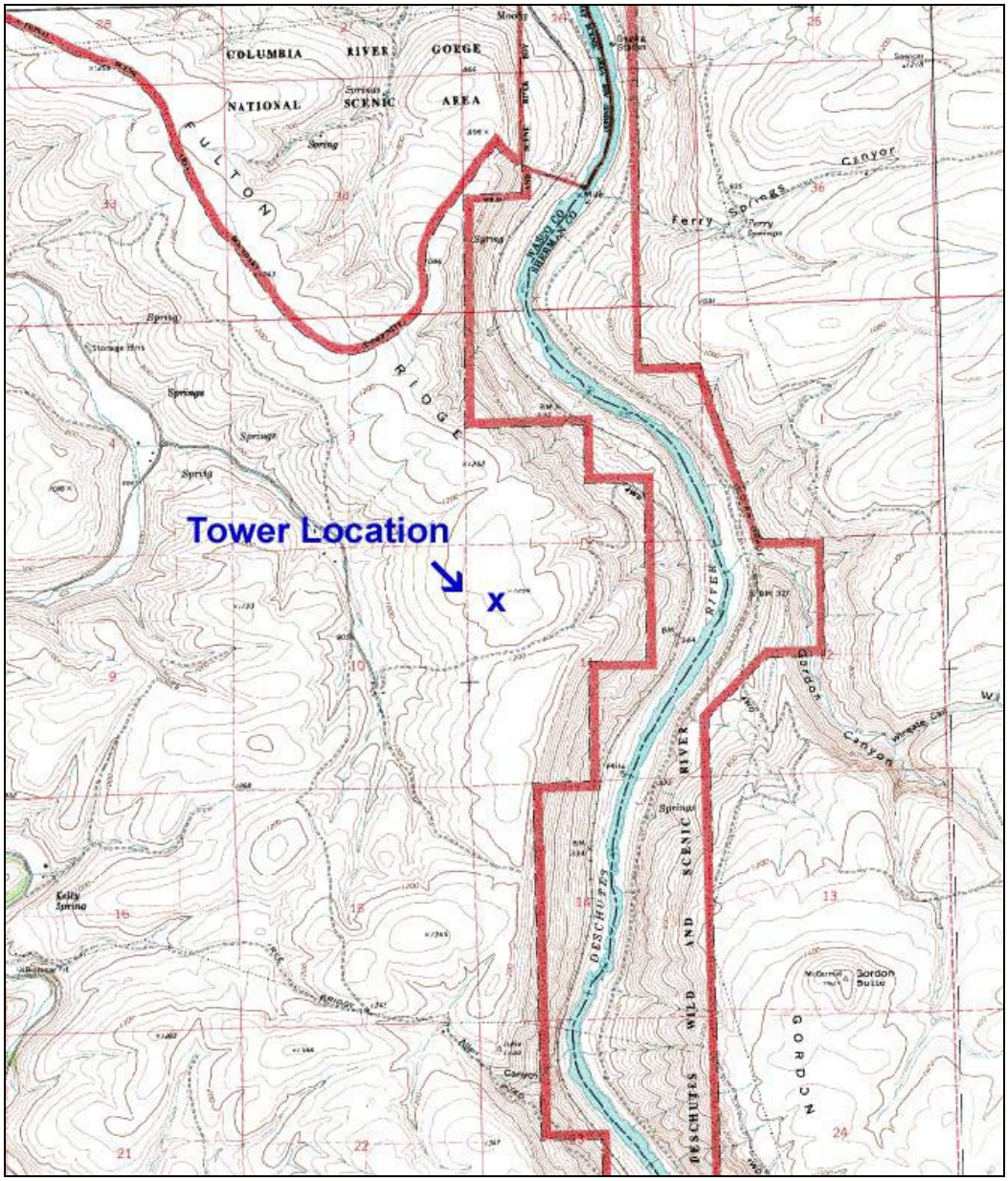
1) Data quality was good and a sufficient quantity of data was obtained to enable conditions to be characterized for a complete annual analysis period.

2) During all times of the year energy producing winds come from the west. These peak during the summer months and drop off substantially during the fall and winter.

3) Comparisons with a nearby site where a longer history of observations are available suggest that the annual study period (May 2006-April 2007) was very close to the long-term mean.

4) Gross capacity factors computed for the site using various assumptions are around 25.0% depending on the wind turbine type based on an assumed shear coefficient of 0.143.

Appendix A: Topographic map of the location of the Fulton Ridge tower site.



Appendix B: Photograph of the 20 meter tower placed on Fulton Ridge.

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

	Changes Made				
Date:	Plug	Battery	Time	Gust (mph)	Comment
12/08/2008					Site Installed
01/25/2006	Y		Y	61	
03/03/2006	Y			61	
04/04/2006	Y				Same plug installed – data lost prev.
04/28/2006	Y		Y	47	
06/07/2006	Y			74	
07/25/2006	Y			55	
08/24/2006	Y			51	
10/04/2006	Y			63	
12/10/2006	Y	Y	Y	68	
03/17/2007	Y			71	
06/19/2007				52	Site Removed – Found on ground and
					Believed to have fallen May 1, 2007

Appendix D: Miscellaneous analysis Tables.

STATION – Fulton Ridge (Site 0631)
WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY
DATA PERIOD OF RECORD - 5/2006 - 4/2007
NORMALIZATION PERIOD - ONE YEAR
AVERAGE WIND SPEED FOR PERIOD: 12.3 MPH
NORMALIZED AVAILABLE ENERGY: 2282.3 KWH/M**2/YEAR
TOTAL HOURS OBSERVED: 8746

SPD MPH	HOURS/ PERIOD	RELFREQ	CUMHRS	CUMRELFREQ	NORMALIZED AVAIL. ENERGY KWH/M**2/YEAR
0	32	0.37	8746	100.00	0.0
1	109	1.25	8714	99.63	0.0
2	274	3.13	8605	98.39	0.1
3	389	4.45	8331	95.25	0.6
4	503	5.75	7942	90.81	1.7
5	529	6.05	7439	85.06	3.5
6	619	7.08	6910	79.01	7.1
7	641	7.33	6291	71.93	11.6
8	530	6.06	5650	64.60	14.3
9	471	5.39	5120	58.54	18.1
10	441	5.04	4649	53.16	23.3
11	367	4.20	4208	48.11	25.8
12	348	3.98	3841	43.92	31.8
13	323	3.69	3493	39.94	37.5
14	305	3.49	3170	36.25	44.2
15	292	3.34	2865	32.76	52.1
16	266	3.04	2573	29.42	57.6
17	226	2.58	2307	26.38	58.7
18	227	2.60	2081	23.79	69.9
19	205	2.34	1854	21.20	74.3
20	206	2.36	1649	18.85	87.1
21	152	1.74	1443	16.50	74.4
22	144	1.65	1291	14.76	81.0
23	138	1.58	1147	13.11	88.7
24	125	1.43	1009	11.54	91.3
25	99	1.13	884	10.11	81.7
26	103	1.18	785	8.98	95.7
27	105	1.20	682	7.80	109.2
28	97	1.11	577	6.60	112.5
29	90	1.03	480	5.49	116.0
30	68	0.78	390	4.46	97.0
31	61	0.70	322	3.68	96.0
32	62	0.71	261	2.98	107.3
33	49	0.56	199	2.28	93.0
34	28	0.32	150	1.72	58.1
35	30	0.34	122	1.39	68.0
36	20	0.23	92	1.05	49.3
37	13	0.15	72	0.82	34.8
38	22	0.25	59	0.67	63.8
39	8	0.09	37	0.42	25.1
40	6	0.07	29	0.33	20.3
41	3	0.03	23	0.26	10.9
42	7	0.08	20	0.23	27.4
43	4	0.05	13	0.15	16.8
44	2	0.02	9	0.10	9.0
45	3	0.03	7	0.08	14.4
46	3	0.03	4	0.05	15.4
47	0	0.00	1	0.01	0.0
48	1	0.01	1	0.01	5.8

STATION – Fulton Ridge (Site 0631)
MONTHLY WIND SPEEDS (MPH)
DATA PERIOD OF RECORD - 12/2005 - 4/2007

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS	AVG
2005	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.2	505	6.22
# OBS	0	0	0	0	0	0	0	0	0	0	0	505		
2006	9.4	11.5	9.6	12.4	13.1	15.1	17.2	15.9	13.4	11.5	9.8	8.9	7994	12.55
# OBS	744	672	64	634	744	720	744	744	720	744	720	744		
2007	9.4	7.9	11.6	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2866	10.69
# OBS	730	672	744	720	0	0	0	0	0	0	0	0		

STATION – Fulton Ridge (Site 0631)

DIURNAL WIND SPEEDS (MPH)
DATA PERIOD OF RECORD - 5/2006 - 4/2007

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	8.9	8.9	8.7	8.2	8.6	8.5	8.0	7.8	7.6	7.7	8.8	9.1	10.7	10.8	10.8	11.1	10.9	11.2	10.9	11.1	10.0	9.0	8.9	9.7	9.4
FEB	6.9	6.8	6.3	6.8	6.5	6.6	5.8	6.0	6.4	7.3	8.1	8.3	9.0	11.3	10.9	9.8	9.3	9.8	8.9	7.9	7.7	7.6	7.7	7.6	7.9
MAR	8.8	8.7	9.0	9.3	9.4	9.1	8.6	8.2	8.6	10.1	11.9	12.9	13.8	15.1	16.7	17.6	17.3	15.9	14.1	12.7	11.5	10.7	9.9	9.3	11.6
APR	11.8	11.0	10.7	10.6	9.8	9.4	9.3	10.3	11.3	13.5	15.0	15.9	17.0	17.5	18.5	19.2	19.6	19.1	16.1	13.9	13.2	11.8	11.3	11.3	13.6
MAY	11.0	10.8	10.9	11.0	9.5	9.1	9.9	10.1	10.9	12.6	13.9	15.0	16.6	17.0	17.9	18.9	18.8	17.3	14.9	12.0	11.8	11.3	11.2	11.3	13.1
JUN	13.4	12.3	12.3	11.9	10.8	10.6	11.2	12.8	13.3	14.4	15.5	17.0	18.3	19.0	19.9	20.7	20.7	19.8	17.7	14.9	14.1	14.0	14.3	13.9	15.1
JUL	15.4	15.3	14.1	12.9	13.0	12.4	12.4	13.5	14.7	14.9	16.0	17.3	18.4	20.4	22.3	23.4	24.5	24.1	21.7	19.3	17.4	16.3	16.6	16.2	17.2
AUG	14.9	13.9	13.1	13.0	13.1	12.3	12.3	12.7	13.7	14.0	14.7	16.1	16.6	17.3	19.5	21.4	22.2	22.1	19.5	17.5	16.4	15.1	14.8	14.7	15.9
SEP	11.4	11.3	10.8	11.5	11.2	10.5	9.7	9.2	10.1	11.3	13.2	15.0	16.4	17.4	18.2	18.3	18.6	16.7	14.8	13.6	12.8	13.0	13.3	12.4	13.4
OCT	10.7	10.4	10.0	9.5	10.2	10.1	10.0	9.3	9.2	10.3	11.4	12.3	13.1	14.2	15.2	14.2	14.6	14.3	13.8	12.3	11.5	10.4	10.3	9.6	11.5
NOV	9.5	9.8	8.7	8.6	8.9	8.9	8.7	8.3	8.2	8.3	9.1	11.0	11.7	12.7	11.4	11.1	11.6	11.3	11.2	10.7	9.5	8.4	8.9	9.0	9.8
DEC	8.4	8.1	8.3	8.4	7.9	8.7	8.2	8.6	8.6	8.7	8.9	9.7	9.9	10.3	9.8	9.8	9.8	9.2	9.0	8.2	8.3	8.5	9.0	8.6	8.9
AVG SPD	11.0	10.6	10.3	10.1	9.9	9.7	9.5	9.8	10.3	11.1	12.2	13.3	14.3	15.3	16.0	16.3	16.5	15.9	14.4	12.9	12.0	11.4	11.4	11.2	12.3

STATION – Fulton Ridge (Site 0631)
WIND ROSE FOR ALL DATA - 8746 OBSERVATIONS
DATA PERIOD OF RECORD - 5/2006 - 4/2007

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	1.8	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	1.9	5.4
NNE	3.0	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	0.0	3.2	6.2
NE	2.7	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	0.0	3.1	6.6
ENE	3.7	1.0	0.5	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	5.4	8.1
E	3.8	2.1	1.3	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	0.0	8.5	10.6
ESE	1.6	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	0.0	0.0	2.2	7.9
SE	0.7	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	0.7	4.5
SSE	0.9	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	0.9	5.3
S	1.8	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	2.0	5.8
SSW	3.2	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	7.3
SW	5.1	0.6	0.3	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	8.3
WSW	9.5	3.2	2.5	1.3	0.4	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2	10.2
W	8.0	3.9	4.8	5.2	4.5	3.4	2.4	1.9	1.5	0.6	0.4	0.1	0.0	0.0	0.0	0.0	0.0	36.7	17.4
WNW	1.9	0.5	0.4	0.3	0.5	0.6	0.8	0.6	0.2	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	6.0	17.8
NW	0.8	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	0.8	5.5
NNW	0.6	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	0.6	4.8
CALM																		0.4	
TOTAL %	49.4	12.5	10.2	8.0	5.9	4.5	3.5	2.7	1.8	0.8	0.5	0.2	0.1	0.0	0.0	0.0	0.0	100.0	12.3

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 – Fulton Ridge (Site 0631)

MONTHLY POWER DENSITIES AND NORMALIZED TOTAL ENERGY WITH SPEED RANGE OF 10 TO 60 MPH
DATA PERIOD OF RECORD - 5/2006 - 4/2007
DATA RECOVERY - 100.1%

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	515.8	122477	233	497	0	17.7	31.9
FEB	336.3	65905	177	495	0	16.2	26.3
MAR	425.0	155121	365	379	0	17.9	49.1
APR	447.8	195235	436	284	0	18.3	60.6
MAY	477.4	196681	412	332	0	18.6	55.4
JUN	544.5	260525	463	257	0	19.8	64.3
JUL	582.8	345591	593	151	0	19.7	79.7
AUG	662.5	322648	487	257	0	20.6	65.5
SEP	570.9	228299	387	333	0	19.3	53.7
OCT	425.4	144634	340	404	0	17.9	45.7
NOV	387.2	108843	272	448	0	17.1	37.8
DEC	345.8	89561	259	485	0	15.8	34.8
PERIOD TOTAL	252.4	2205035	4424	4322	0	18.6	50.6