

OREGON ANEMOMETER LOAN PROGRAM

Wind Resource Evaluation: Middle Mountain 50m Tower Site



Prepared By:
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1.0 *SITE DESCRIPTION*

Site Name: Middle Mountain 50m
Latitude: 45-35-12 (WGS 84)
Longitude: 121-35-50
Elevation: 2628 ft.
County: Hood River
Tower Height: 50 meter
Site # 5418

Types of Sensors: NRG Maximum #40 wind speed
NRG 200 series2 wind vane
Instrumentation: 48.75m (161 ft.) – Wind Speed (2)
41m (135 ft.) – Wind Speed (2)
30m (99 ft.) – Wind Speed
20m (67 ft.) – Wind Speed
46.6m (153 ft.) – Wind Direction
38m (125 ft.) – Wind Direction

Types of Data: 10 min. average wind speed (mph)
10 min. mean wind direction (deg)
10 min temperature (Deg F)
Standard Deviation, maximum and minimum over 10 min.
period also available for each data type.

Installation Date: June 07, 2008
Data Available to: August 8, 2009

Site Location: **Site Location:** The site is located on the top of a fairly isolated mountain approximately 10 miles south of the City of Hood River in North-Central Oregon. The current 50 meter tower was placed on approximately the same location where a 20 meter tower was located for just over two years. This portion of the ridge faces west and southwest. Mount Hood is visible to the south, southwest and other ridges are visible to the west. There is a valley visible between these ridges located slightly south of west. The mountain is forested although much of it has been logged in recent years. The site can be accessed by traveling south on Hwy 35 for about 10 miles and turning west on to Gilhouley Rd. The tower locations are marked on the map included in Appendix A.

Project Description: The property is owned and managed by Hood River County and is under consideration for a community scale wind project.

2.0 WIND DATA PROCESSING

NRG equipment was used at this site including #40 anemometers and a Symphony data logger. Data chips were swapped out on roughly a monthly basis by a nearby land owner and sent to the ERRL. Raw NRG Symphony files were read and downloaded from the data cards. NRG Symphony software was used to read these files and produce 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. In this process each level/site combination is assigned a two digit site code. These codes are listed in Table 1.

Table 1: Site codes and information for the Middle Mountain 50m site.

Site ID	Site Name	Latitude dd-mm-ss	Longitude dd-mm-ss	Elev. (ft)	Sensor Ht (ft)	Period of Record
T1	Middle Mtn 50m	45-35-12	121-35-50	2628	160	June 2008- August 9, 2009
T2	Middle Mtn 50m	45-35-12	121-35-50	2628	135	June 2008- August 9, 2009
T3	Middle Mtn 50m	45-35-12	121-35-50	2628	98	June 2008- August 9, 2009
T4	Middle Mtn 50m	45-35-12	121-35-50	2628	66	June 2008- August 9, 2009

In addition to the filter available for use with the NRG Symphony software, data files were also scanned manually to identify any additional periods in which ice was might be present and to identify any additional problems. Several significant and sustained icing periods were detected primarily during the months of December 2008, January 2009 and February and 2009.

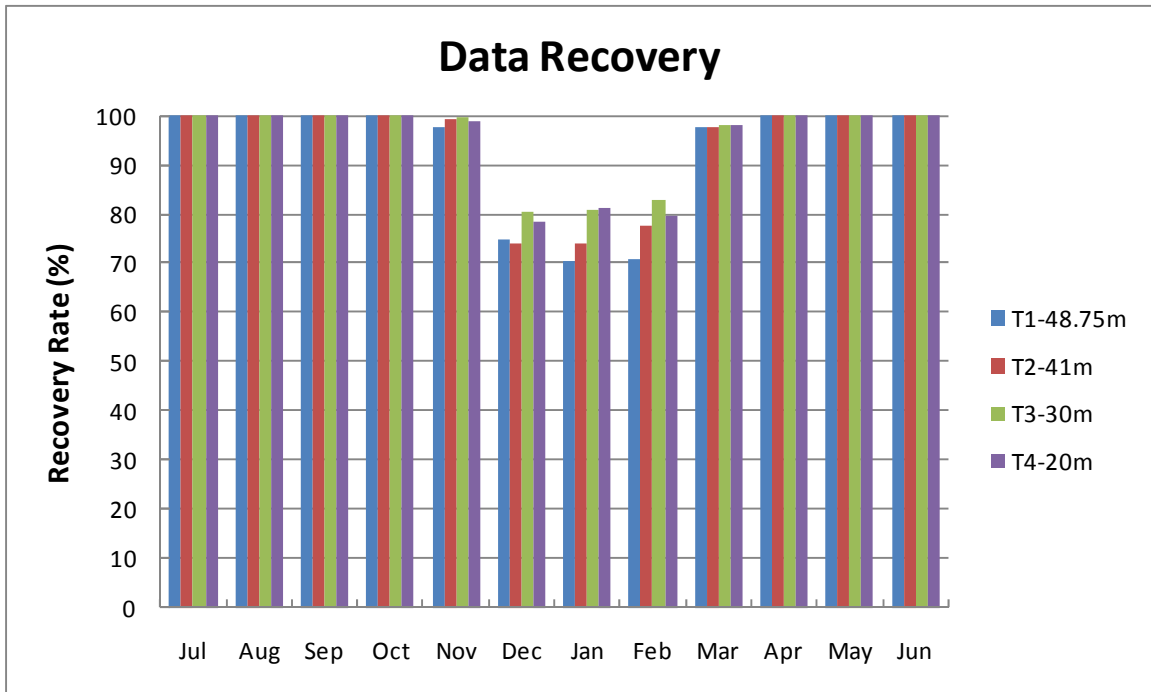


Figure 1: Data recovery for the 4 levels of the Middle Mountain 50m site.

3.0 WIND CHARACTERISTICS

In the following sections, several characteristics of the winds at the Middle Mtn. 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. Plots of various quantities are included in this section and more complete tables can be found in Appendix B.

This analysis is also confined to a single annual period. This is done so that the results are not biased by the addition of data from only a single season or a portion of a year. *The period analyzed here is for July 1, 2008 to June 30 2009.*

Monthly Means:

Table 2: Monthly Mean Wind Speed Values and data recovery rates for the annual study period.

Month	T1 (48.75m)		T2(41m)		T3 (30m)		T4 (20m)	
	(mph)	Rec. (%)	(mph)	Rec. (%)	(mph)	Rec. (%)	(mph)	Rec. (%)
Jul	15.6	100.00	15.1	100.00	15.0	100.00	14.3	100.00
Aug	13.8	100.00	13.5	100.00	12.9	100.00	12.3	100.00
Sep	11.6	100.00	11.1	100.00	10.5	100.00	9.9	100.00
Oct	10.7	100.00	10.5	100.00	9.9	100.00	9.3	100.00
Nov	11.5	97.78	11.2	99.31	10.6	99.44	10.1	99.03
Dec	16.1	74.87	15.7	73.92	14.7	80.24	14.0	78.36
Jan	17.2	70.30	16.1	74.19	14.8	80.78	14.6	81.32
Feb	8.9	70.69	8.5	77.44	7.7	82.90	7.3	79.45
Mar	15.5	97.45	15.3	97.58	14.7	98.12	14.1	97.85
Apr	13.9	100.00	13.8	100.00	13.2	100.00	12.8	100.00
May	13.6	100.00	13.5	100.00	12.9	100.00	12.4	100.00
Jun	16.4	100.00	16.0	100.00	15.6	100.00	15.2	100.00
ANN	13.7	92.63	13.4	93.56	12.8	95.14	12.2	94.69

Diurnal Means:

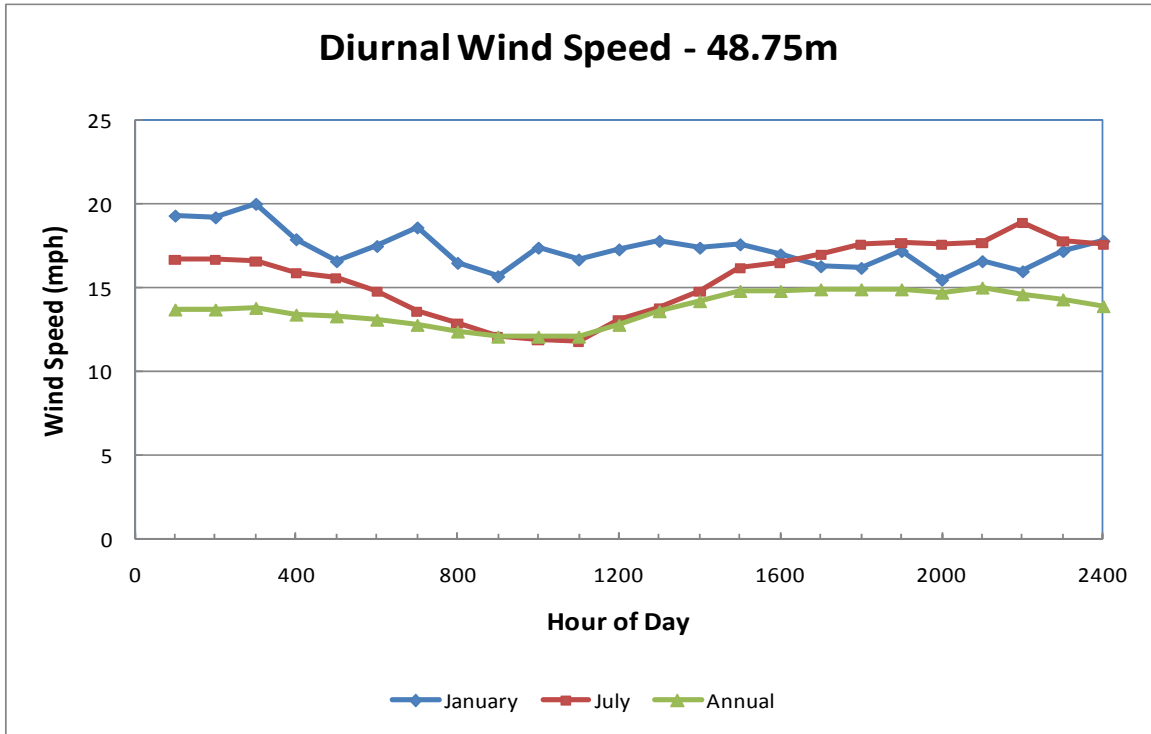


Figure 2: Diurnal mean wind speed values for the 50 m level of the Middle Mtn. 50 meter Site.

Frequency Distribution:

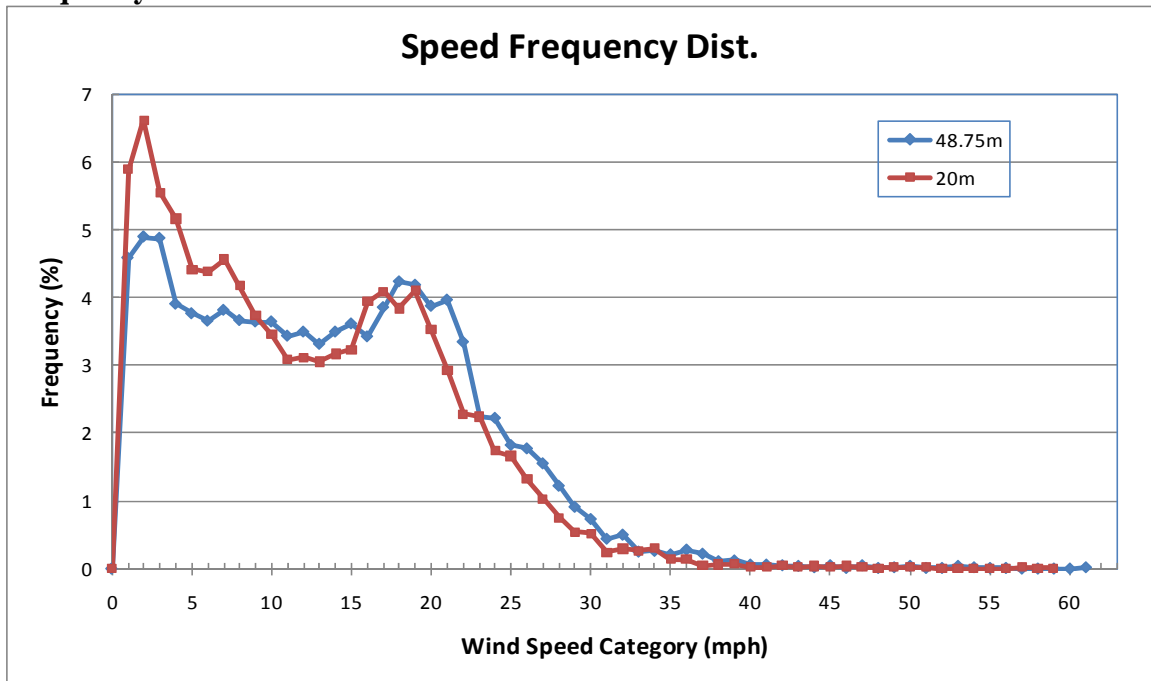


Figure 3: Wind speed frequency distribution for the 50m and 31.5 m levels of the Middle Mtn. 50 meter Site.

Wind Rose:

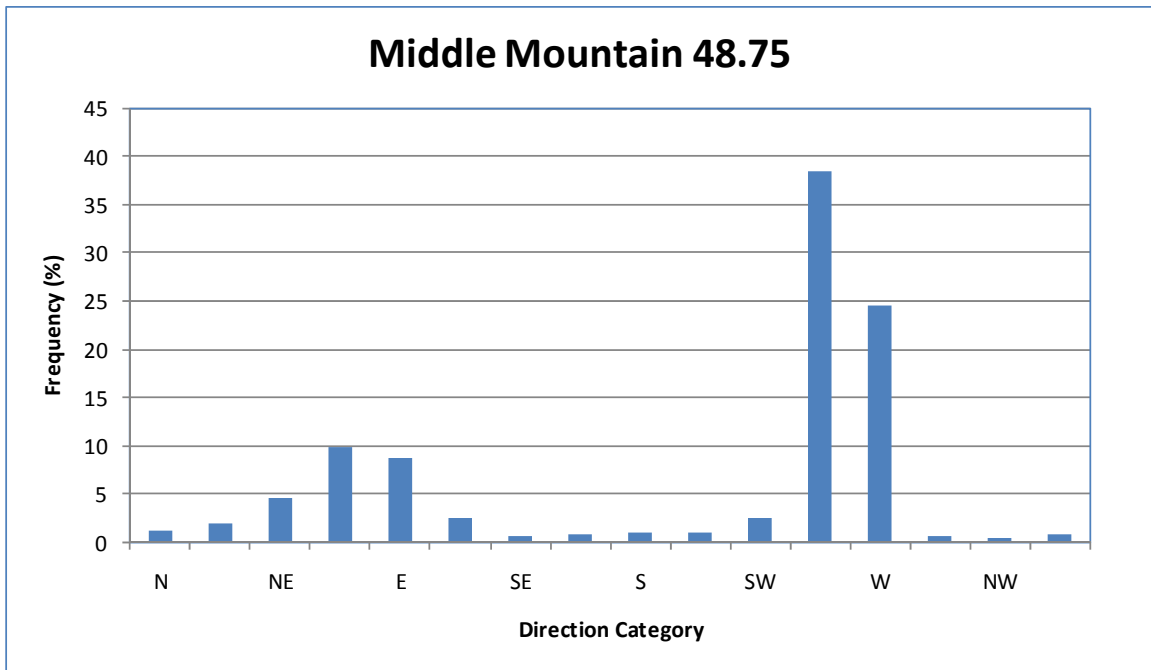
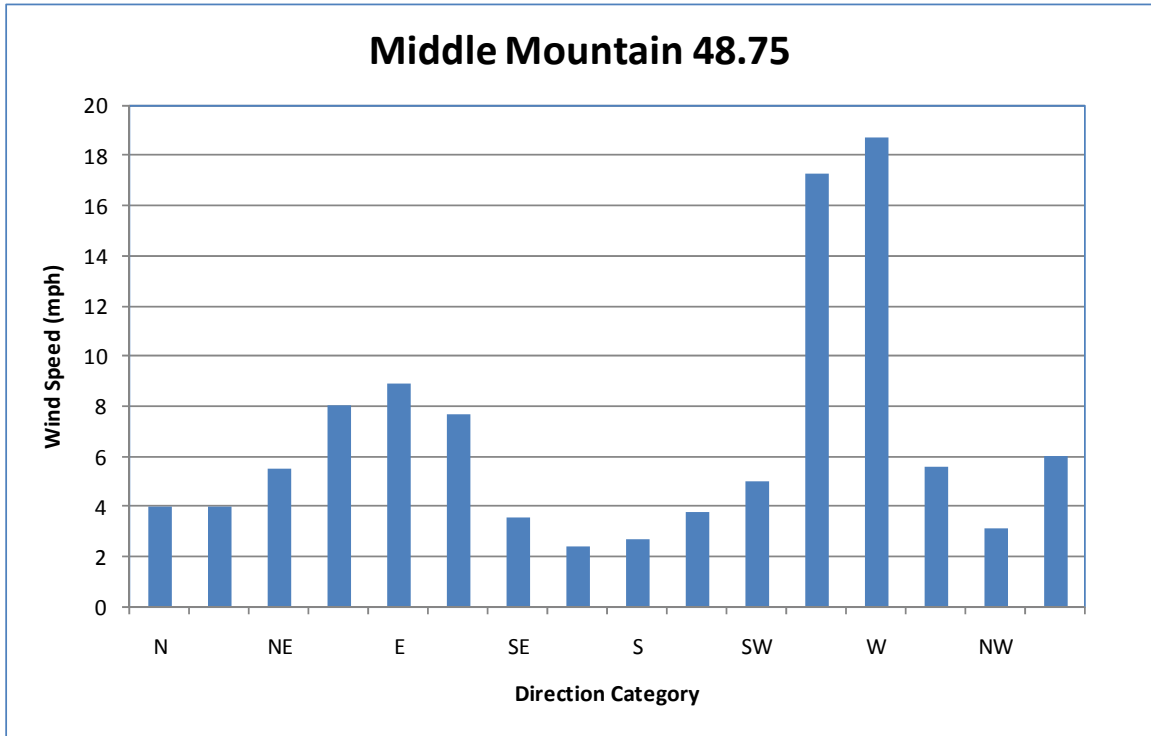


Figure 4a-b: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories from the 50m level of the Middle Mtn. 50 meter Site.

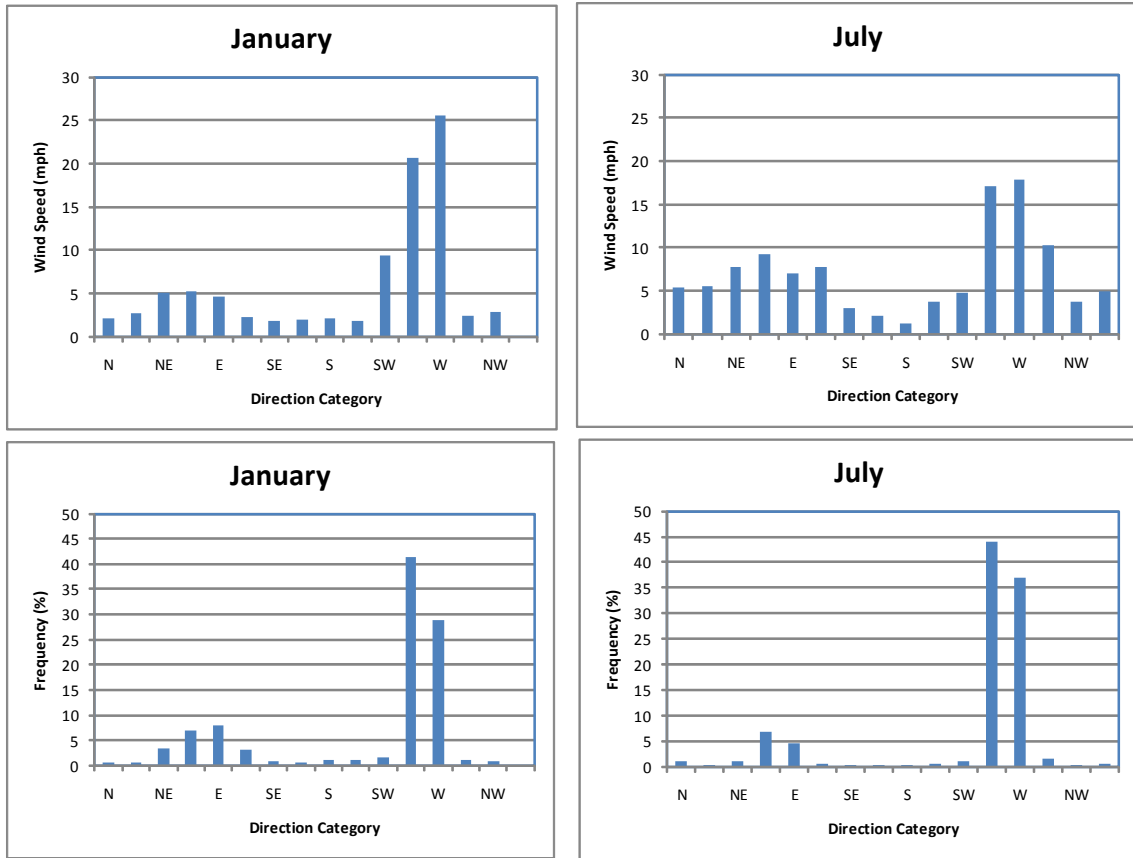


Figure 5a-d: Frequency (%) and average wind speed (mph) for each of 16 wind direction categories for the months of January and July from the 50m level of the Middle Mtn. 50 meter Site.

4.0 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 difficulty with this is usually finding appropriate long-term sites to base this on. For the current site, the nearest sites with good quality long-term records are two sites within the BPA long-term wind monitoring network. These sites include Sevenmile Hill and Goodnoe Hills. These long-term normals are taken using data from 1980 to 2009.

The wind speed departures show that the winds at both sites were very close to normal for the period as a whole. There were, however, several individual months in which the winds varied significantly from normal. Unfortunately, there is no clear pattern or agreement between these two sites, knowledge of the meteorological conditions in the area would suggest that Sevenmile Hill would best indicate conditions during the spring and summer and Goodnoe Hills would likely be best for the winter months.

Table 3: Monthly mean and departures for winds at two BPA long-term wind sites. Current period is July 2008 to June 2009.

SEVENMILE HILL - BPA				GOODNOE HILLS - BPA			
	Current	Mean	Depart.		Current	Mean	Depart.
Month	(mph)	(mph)	(%)	Month	(mph)	(mph)	(%)
JUL	22.4	21.3	5.2	JUL	16.8	16.6	1.2
AUG	18.5	19.6	-5.6	AUG	9.9	15.5	-36.1
SEP	14.3	15.9	-10.1	SEP	16.0	13.9	15.1
OCT	13.6	12.7	7.1	OCT	15.1	13.2	14.4
NOV	10	9.8	2.0	NOV	15.3	13.1	16.8
DEC	10.9	9.6	13.5	DEC	16.9	11.9	42.0
JAN	14.1	10.5	34.3	JAN	16.3	13.1	24.4
FEB	7.6	10.1	-24.8	FEB	15.5	12.6	23.0
MAR	15.4	13.2	16.7	MAR	11.3	14.3	-21.0
APR	16.7	15.6	7.1	APR	12.0	16.0	-25.0
MAY	15.7	18.8	-16.5	MAY	12.6	16.6	-24.1
JUN	21.9	20.2	8.4	JUN	13.9	17.2	-19.2
ANN	15.1	15.0	0.6	ANN	14.3	14.6	-2.1

In addition to these long-term sites there is a small weather station located to the west of Fir Mountain near another Anemometer Loan Program site on Middle Mountain. This station is part of the RAWS network (Remote automated Weather Stations) managed by the Forest Service and BLM. The station has continuous data but the site is not well suited to accurately evaluate wind variability. The sensor is located near the ground and is surrounded by a number of tall trees. Nevertheless, it is worth examining here.

Middle Mtn. RAWS			
	Current	Mean	Depart.
Month	(mph)	(mph)	(%)
JUL	8.9	7.7	16.2
AUG	8.2	7.8	5.3
SEP	7.2	8.9	-18.5
OCT	6.6	8.4	-22.1
NOV	7.1	7.6	-6.1
DEC	8.2	7.5	9.2
JAN	8.1	7.7	5.9
FEB	5.6	8.6	-34.3
MAR	9.0	9.1	-1.3
APR	8.6	9.2	-6.1
MAY	8.2	9.5	-13.0
JUN	9.1	8.6	6.3
ANN	7.9	8.3	-4.8

The Middle Mountain RAWS site shows the winds were slightly below normal for this period overall and that several months had winds well below normal (September, October, February). Overall, these three sites suggest the winds were likely close to normal for this annual analysis period.

5.0 *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 monthly mean and recovery rate of the hourly values, the maximum one hour average, the available power, the frequency that the wind was observed within a wind speed range (12 mph to 60 mph) and the shear coefficient (alpha). These quantities are shown in Table 5 and reveal a number of things about the potential for generating energy at the site.

Table 5: Observed and computed power quantities for the Middle Mtn. 50 meter Site. Values shown are for the 48.75m (160 ft.) and 30m (98 ft.) levels. The last three columns are for the 48.75m level.

Month	160 ft.		98 ft.		Shear Factor	Max 1-Hr (mph)	Time in Range (12-60) mph (%)	Available Energy kWh/m**2
	Mean (mph)	Recovery Rate (%)	Mean (mph)	Recovery Rate (%)				
Jul	15.4	100.00	13.0	100.00	0.087	34.4	66.50	231
Aug	13.6	100.00	11.4	100.00	0.125	34.5	55.10	188
Sep	12.9	100.00	10.8	100.00	0.202	31.8	42.60	124
Oct	11.4	100.00	9.4	100.00	0.171	37.9	44.00	120
Nov	12.3	99.70	10.2	99.30	0.165	53.3	44.20	217
Dec	14.9	79.40	12.9	74.70	0.182	41.9	61.40	345
Jan	17.1	68.10	13.0	80.00	0.182	63.5	58.10	573
Feb	10.6	76.50	8.6	79.20	0.182	39.8	27.40	111
Mar	16.7	96.50	14.1	98.10	0.108	48.1	64.60	293
Apr	15.1	100.00	13.0	100.00	0.105	33	58.80	185
May	14.3	100.00	12.3	100.00	0.105	41.3	51.30	208
Jun	17.8	100.00	15.4	100.00	0.095	33.3	71.50	242
ANN	14.3	93.40	12.0	94.30	0.153	63.5	54.30	2734

One significant feature of this table is the high shear factors observed at the site for many of the months. The values for September through February range from 0.165 to 0.182. This indicates a strong increase in wind speed with height. This is likely a result of the fact the site is located on the edge of a sharp ridge and the flow up and over might be missing the lower levels of the tower in some cases. This appears to be accentuated during the cold season.

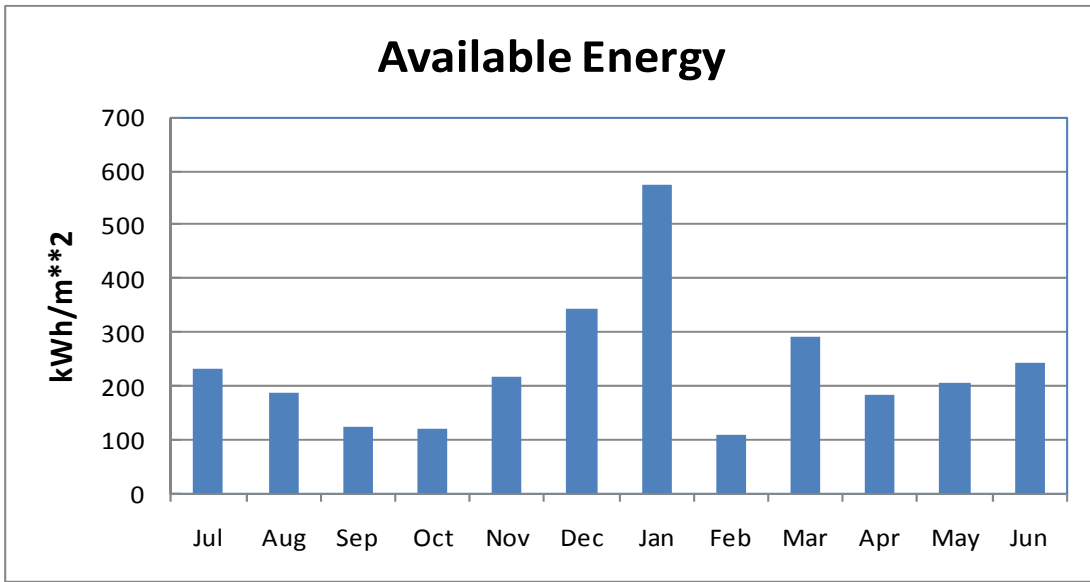


Figure 6: Monthly available power for 50m level of the Middle Mtn. 50 m site.

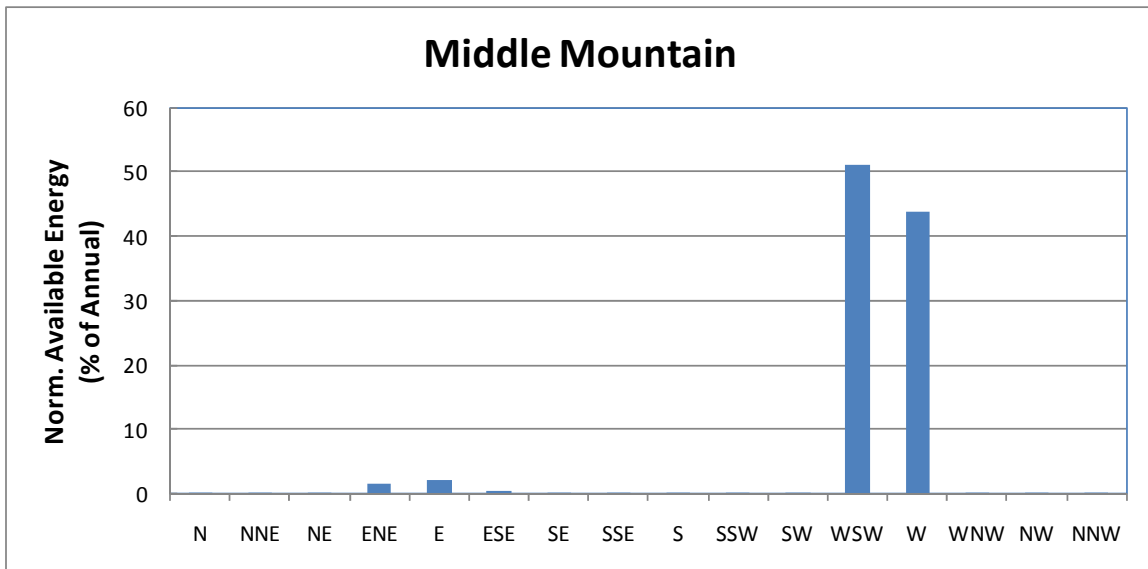


Figure 7: Annual Energy Rose for the 50m level at the Fir Mtn. 50m site.

An analysis program was run to evaluate the energy that could be produced by five separate wind turbine types. This analysis program adjusts the site Weibul distribution using the shear coefficient (alpha) calculated from the hourly values (from 103 ft. to 164 ft.). Density variations are approximated using the site elevation and a standard atmosphere. Five wind turbine types are shown for reference. Gross capacity factors for each month for the five wind turbines are shown in Tables 6 and 7. Net capacity factor estimates would account for array losses, availability losses, electric line and transmission losses, yaw, turbulence, control, blade soiling, icing and high wind cycling. While these losses would be dependent upon the design of the wind farm, a general

estimate is that these losses could be in the range of eleven to fifteen percent. Table 6 includes the estimates using data and shear values from the 30m and 48.75m levels while Table 7 includes values using the 20 m and 48.75 m levels. There some differences between the two but they are generally very similar.

Table 6: Gross monthly and annual capacity factors for five wind turbine types using observed shear factors.

	Lower Level (98')		Upper Level (160')		Vestas 80	GE 70.5	Nordex 80	Nordex 90	Souzlou 88
	Mean (mph)	%	Mean (mph)	%	2000 kW	1500 kW	2500 kW	2300 kW	2000 kW
Jul	15.0	100.00	15.4	100.00	0.319	0.319	0.268	0.349	0.364
Aug	12.9	100.00	13.6	100.00	0.268	0.263	0.225	0.293	0.307
Sep	10.5	100.00	12.9	100.00	0.204	0.190	0.170	0.224	0.237
Oct	9.9	100.00	11.4	100.00	0.185	0.174	0.153	0.203	0.216
Nov	10.6	99.44	12.3	99.70	0.216	0.208	0.187	0.235	0.242
Dec	14.7	80.24	14.9	79.40	0.375	0.368	0.340	0.404	0.416
Jan	14.8	80.78	17.1	68.10	0.422	0.428	0.387	0.451	0.460
Feb	7.7	82.90	10.6	76.50	0.137	0.130	0.119	0.149	0.156
Mar	14.7	98.12	16.7	96.50	0.340	0.339	0.296	0.370	0.382
Apr	13.2	100.00	15.1	100.00	0.269	0.265	0.225	0.295	0.309
May	12.9	100.00	14.3	100.00	0.263	0.261	0.225	0.286	0.296
Jun	15.6	100.00	17.8	100.00	0.352	0.351	0.295	0.386	0.403
ANN	12.8	95.14	14.3	93.40	0.284	0.276	0.244	0.309	0.322

To obtain these capacity factors the winds at the top level are extrapolated upwards to the turbine hub height using the computed shear value. However, these shear values are large and may not be representative of conditions above the tower height. Using high values can produce unrealistically high capacity factors.

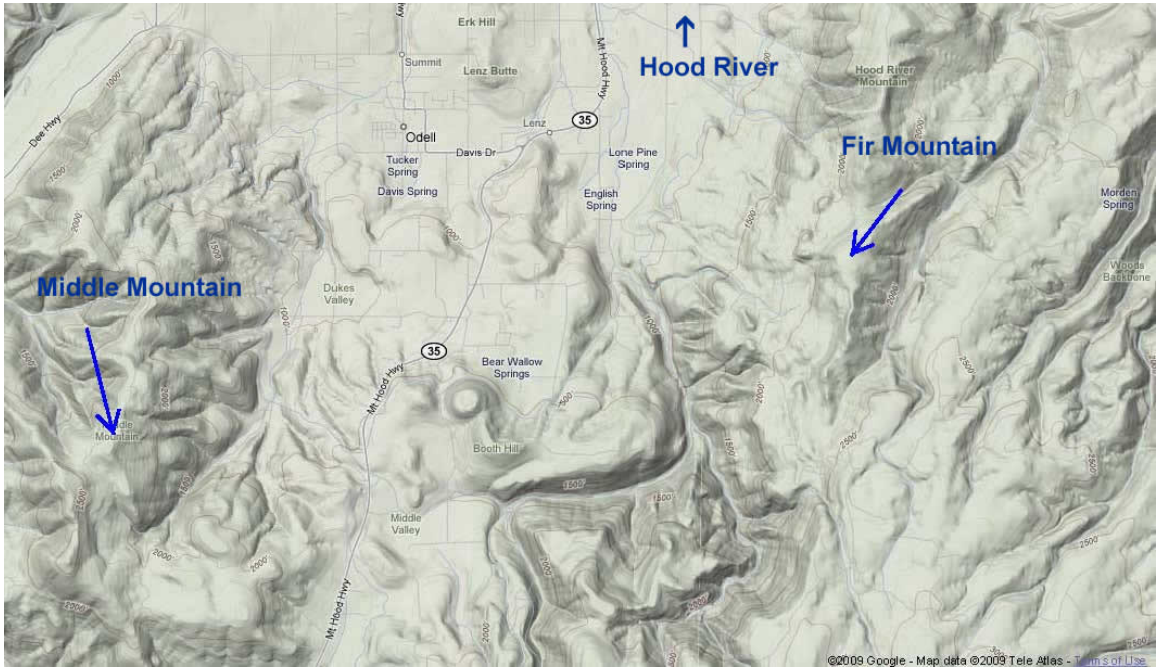
Table 6: Gross monthly and annual capacity factors for five wind turbine types using observed shear factors between the 20m and 48.75m levels.

	Lower Level (66')		Upper Level (160')		Vestas 80	GE 70.5	Nordex 80	Nordex 90	Souzlou 88
	Mean (mph)	%	Mean (mph)	%	2000 kW	1500 kW	2500 kW	2300 kW	2000 kW
Jul	14.3	100.00	15.4	100.00	0.323	0.321	0.271	0.354	0.369
Aug	12.3	100.00	13.6	100.00	0.269	0.264	0.226	0.294	0.309
Sep	9.9	100.00	12.9	100.00	0.198	0.187	0.165	0.218	0.229
Oct	9.3	100.00	11.4	100.00	0.183	0.172	0.151	0.201	0.213
Nov	10.1	99.03	12.3	99.70	0.213	0.206	0.184	0.231	0.240
Dec	14.0	78.36	14.9	79.40	0.367	0.363	0.332	0.396	0.407
Jan	14.6	81.32	17.1	68.10	0.418	0.424	0.383	0.448	0.454
Feb	7.3	79.45	10.6	76.50	0.143	0.133	0.124	0.155	0.164
Mar	14.1	97.85	16.7	96.50	0.341	0.340	0.297	0.370	0.382
Apr	12.8	100.00	15.1	100.00	0.268	0.264	0.224	0.293	0.307
May	12.4	100.00	14.3	100.00	0.262	0.260	0.224	0.285	0.295
Jun	15.2	100.00	17.8	100.00	0.348	0.348	0.291	0.381	0.397
ANN	12.2	94.69	14.3	93.40	0.278	0.273	0.239	0.303	0.315

Summary,

- 1) No problems were detected in the data for this site that might hinder an interpretation of the collected data. Icing was detected during the winter months and removed from the records prior to performing the analyses presented here. This icing was significant during December, January and February.
- 2) The measured shear coefficient between the 30 meter and 48.5 meter levels was 0.153 on an annual basis. This is slightly high and is likely associated with higher shear during winter months. It is expected that this is likely a result of the towers proximity to the edge of the ridge and the flow around the mountain.
- 3) Winds, especially energy producing winds came almost exclusively from the West and West-Southwest directions.
- 4) Computed gross capacity factors for four sample wind turbine types were found in a range between 24% and about 32%. Estimates of the net capacity factors would be somewhat lower. This wide range reflects the uncertainty associated with the high observed shear and the different turbines considered.
- 5) A comparison with wind data from a nearby long-term wind monitoring site indicated that the wind observed over the analysis period (July 2008 to June 2009) were very close to long-term mean although several individual months varied significantly.

Appendix A: Topographic map of the general area in which the Fir Mtn. 50m site is located.



Appendix B: Photograph looking west, southwest from the tower that was on Middle Mountain prior to the current tower.



Appendix C: Miscellaneous analysis Tables.

STATION - Middle Mtn. 50m (T1 - 48.75 m)					
WIND SPEED FREQUENCY DISTRIBUTION WITH NORMALIZED AVAILABLE ENERGY					
DATA PERIOD OF RECORD - 7/2008 - 6/2009					
NORMALIZATION PERIOD - ONE YEAR					
AVERAGE WIND SPEED FOR PERIOD: 13.7 MPH					
NORMALIZED AVAILABLE ENERGY: 2737.7 KWH/M**2/YEAR					
TOTAL HOURS OBSERVED: 8137					
SPD	HOURS/				NORMALIZED
MPH	PERIOD	RELFREQ	CUMHRS	CUMRELFREQ	AVAIL. ENERGY
					KWH/M**2/YEAR
0	0	0.00	8137	100.00	0.0
1	373	4.58	8137	100.00	0.0
2	398	4.89	7764	95.42	0.2
3	396	4.87	7366	90.52	0.6
4	317	3.90	6970	85.66	1.1
5	306	3.76	6653	81.76	2.1
6	297	3.65	6347	78.00	3.5
7	310	3.81	6050	74.35	5.8
8	298	3.66	5740	70.54	8.3
9	296	3.64	5442	66.88	11.8
10	296	3.64	5146	63.24	16.1
11	279	3.43	4850	59.60	20.2
12	284	3.49	4571	56.18	26.7
13	269	3.31	4287	52.69	32.2
14	284	3.49	4018	49.38	42.5
15	294	3.61	3734	45.89	54.1
16	278	3.42	3440	42.28	62.1
17	313	3.85	3162	38.86	83.8
18	344	4.23	2849	35.01	109.3
19	340	4.18	2505	30.79	127.1
20	315	3.87	2165	26.61	137.4
21	322	3.96	1850	22.74	162.5
22	272	3.34	1528	18.78	157.9
23	183	2.25	1256	15.44	121.4
24	181	2.22	1073	13.19	136.4
25	148	1.82	892	10.96	126.0
26	144	1.77	744	9.14	137.9
27	126	1.55	600	7.37	135.2
28	99	1.22	474	5.83	118.5
29	74	0.91	375	4.61	98.4
30	59	0.73	301	3.70	86.8
31	36	0.44	242	2.97	58.5
32	41	0.50	206	2.53	73.2
33	20	0.25	165	2.03	39.2
34	21	0.26	145	1.78	45.0
35	17	0.21	124	1.52	39.7
36	23	0.28	107	1.31	58.5
37	18	0.22	84	1.03	49.7
38	9	0.11	66	0.81	26.9
39	10	0.12	57	0.70	32.3
40	5	0.06	47	0.58	17.4
41	5	0.06	42	0.52	18.8
42	4	0.05	37	0.45	16.2
43	3	0.04	33	0.41	13.0
44	2	0.02	30	0.37	9.3
45	4	0.05	28	0.34	19.9
46	1	0.01	24	0.29	5.3
47	4	0.05	23	0.28	22.6
48	1	0.01	19	0.23	6.0
49	2	0.02	18	0.22	12.8
50	3	0.04	16	0.20	20.4
51	1	0.01	13	0.16	7.2
52	1	0.01	12	0.15	7.7
53	3	0.04	11	0.14	24.3
54	2	0.02	8	0.10	17.2
55	1	0.01	6	0.07	9.1
56	1	0.01	5	0.06	9.6

STATION - Middle Mtn. 50m (T1 - 48.74m)

MONTHLY WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 7/2008 - 6/2009

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS
2008	0.0	0.0	0.0	0.0	0.0	0.0	15.6	13.8	11.6	10.7	11.5	16.1	4213
# OBS	0	0	0	0	0	0	744	744	720	744	704	557	
2009	17.2	8.9	15.5	13.9	13.6	16.4	0.0	0.0	0.0	0.0	0.0	0.0	3924
# OBS	523	492	725	720	744	720	0	0	0	0	0	0	

_STATION - Middle Mtn. 50m (T2 - 41m)

STATION - t2

MONTHLY WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 7/2008 - 6/2009

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS
2008	0.0	0.0	0.0	0.0	0.0	0.0	15.1	13.5	11.1	10.5	11.2	15.7	4217
# OBS	0	0	0	0	0	0	744	744	720	744	715	550	
2009	16.1	8.5	15.3	13.8	13.5	16.0	0.0	0.0	0.0	0.0	0.0	0.0	4001
# OBS	552	539	726	720	744	720	0	0	0	0	0	0	

STATION - Middle Mtn. 50m (T3 - 30m)

STATION - t3

MONTHLY WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 7/2008 - 6/2009

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS
2008	0.0	0.0	0.0	0.0	0.0	0.0	15.0	12.9	10.5	9.9	10.6	14.7	4265
# OBS	0	0	0	0	0	0	744	744	720	744	716	597	
2009	14.8	7.7	14.7	13.2	12.9	15.6	0.0	0.0	0.0	0.0	0.0	0.0	4092
# OBS	601	577	730	720	744	720	0	0	0	0	0	0	

STATION - Middle Mtn. 50m (T4 - 20m)

MONTHLY WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 7/2008 - 6/2009

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	# OBS
2008	0.0	0.0	0.0	0.0	0.0	0.0	14.3	12.3	9.9	9.3	10.1	14.0	4248
# OBS	0	0	0	0	0	0	744	744	720	744	713	583	
2009	14.6	7.3	14.1	12.8	12.4	15.2	0.0	0.0	0.0	0.0	0.0	0.0	4070
# OBS	605	553	728	720	744	720	0	0	0	0	0	0	

STATION - Middle Mtn. 50m (T1 - 48.75m)

DIURNAL WIND SPEEDS (MPH)

DATA PERIOD OF RECORD - 7/2008 - 6/2009

	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	19.3	19.2	20.0	17.9	16.6	17.5	18.6	16.5	15.7	17.4	16.7	17.3	17.8	17.4	17.6	17.0	16.3	16.2	17.2	15.5	16.6	16.0	17.2	17.8	17.2	17.2
JAN	7.9	7.4	7.9	8.7	9.0	8.3	9.0	9.5	8.4	8.3	8.0	8.3	8.9	8.7	9.2	9.0	9.4	9.8	10.3	9.6	10.5	9.0	9.4	8.7	8.9	8.9
FEB	15.5	15.3	15.7	14.7	13.7	13.3	13.9	13.6	14.1	13.5	14.5	15.2	16.0	17.4	17.2	17.4	16.8	16.4	16.5	16.1	16.1	16.4	16.6	15.9	15.5	15.5
MAR	14.3	14.5	14.2	13.9	13.9	13.7	12.5	11.8	11.1	12.0	12.6	13.6	14.2	15.1	15.1	15.4	14.9	14.7	14.3	15.4	15.3	15.5	14.7	13.9	13.9	13.9
APR	15.0	15.1	14.1	12.7	13.2	13.1	11.8	10.7	10.5	10.5	11.2	12.3	12.8	14.4	14.5	14.8	14.8	14.5	14.5	15.3	16.0	15.6	14.4	14.8	13.6	13.6
MAY	17.0	17.3	17.5	16.7	17.0	16.5	15.7	14.3	13.7	13.4	13.2	13.8	14.6	14.8	16.3	17.0	17.7	18.2	17.1	17.7	19.1	18.4	18.5	17.5	16.4	16.4
JUN	16.7	16.7	16.6	15.9	15.6	14.8	13.6	12.9	12.1	11.9	11.8	13.1	13.8	14.8	16.2	16.5	17.0	17.6	17.7	17.6	17.7	18.9	17.8	17.6	15.6	15.6
JUL	12.5	13.3	13.2	13.1	13.5	13.5	13.1	12.4	12.0	12.6	12.4	13.2	15.1	14.8	15.4	15.5	16.3	14.8	14.7	14.7	14.7	14.4	13.7	13.2	12.5	13.8
AUG	11.6	10.5	9.8	9.7	10.3	10.4	10.3	9.4	9.5	10.1	10.6	11.5	12.1	13.1	13.6	13.2	12.9	12.7	13.6	13.9	13.7	13.0	12.2	11.4	11.6	11.6
SEP	11.1	10.7	10.8	10.4	10.8	10.6	10.7	11.3	11.3	10.3	9.7	10.1	10.7	11.1	11.3	11.0	10.2	10.6	11.2	10.9	10.8	10.4	10.4	11.1	10.7	10.7
OCT	9.7	10.9	11.7	11.6	11.0	11.5	11.4	11.8	10.9	11.2	10.1	10.7	11.1	12.1	12.3	12.7	13.6	14.3	13.3	12.0	11.2	11.3	10.1	9.8	11.5	11.5
NOV	13.5	13.5	15.0	15.0	15.2	14.8	14.9	15.3	15.5	16.2	15.5	16.1	16.6	18.2	18.6	17.8	17.9	18.5	17.3	17.9	17.0	15.4	15.2	14.8	16.1	16.1
DEC																										
AVG	13.7	13.7	13.8	13.4	13.3	13.1	12.8	12.4	12.1	12.1	12.1	12.8	13.6	14.2	14.8	14.8	14.9	14.9	14.9	14.7	15.0	14.6	14.3	13.9	13.7	13.7

STATION - Middle Mtn. 50m (T1 - 48.75m)

WIND ROSE FOR ALL DATA - 8137 OBSERVATIONS
 DATA PERIOD OF RECORD - 7/2008 - 6/2009

SPEED CATEGORIES (MPH)

DIR	0		10		13		16		19		22		25		28		31		34		37		40		43		46		49		52		55		TOTAL %	MEAN SPEED (MPH)
	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO	TO			
N	1.1	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	0.0	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	1.2	4.0	
NNE	1.9	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	0.0	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	4.0	
NE	4.1	0.4	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	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	5.5		
ENE	7.1	1.4	0.9	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	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	9.9	8.0		
E	4.9	1.7	1.2	0.7	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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	8.9		
ESE	1.5	0.4	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	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	2.5	7.7		
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	0.0	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	3.6			
SSE	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	0.0	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	2.4			
S	1.1	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	0.0	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	2.7			
SSW	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	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	3.8			
SW	2.4	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	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	5.0			
WSW	7.1	3.8	4.9	6.5	6.5	4.0	2.9	1.5	0.6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	38.5	17.3			
W	3.4	2.1	3.0	4.0	4.9	2.8	1.9	1.0	0.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	24.5	18.7			
WNW	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	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	5.6			
NW	0.4	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	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	3.1			
NNW	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	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	0.8	6.0			
CALM																																	0.0			
TOTAL %	38.7	10.3	10.4	11.7	11.9	6.9	4.9	2.4	1.0	0.8	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	100.0	13.7			

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 - Middle Mtn. 50m (T1 - 48.75m)
 ENERGY ROSE (TOTALS ARE NORMALIZED AVAILABLE ENERGY (KWH/M**2))
 DATA PERIOD OF RECORD - 7/2008 - 6/2009

MON	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTAL	OBS.
JAN	0.0	0.0	0.5	1.2	0.8	0.1	0.0	0.0	0.0	0.0	2.5	221.4	345.1	0.0	0.0	0.0	571.6	523
FEB	0.0	0.1	1.2	5.5	12.8	0.3	0.0	0.0	0.1	0.1	0.3	68.0	22.8	0.0	0.0	0.0	111.1	492
MAR	0.0	0.0	0.5	4.5	7.2	0.6	0.0	0.0	0.0	0.1	0.3	181.2	99.7	0.5	0.0	0.0	294.5	725
APR	0.1	0.1	0.3	3.5	5.4	1.2	0.1	0.0	0.0	0.0	0.4	98.4	75.6	0.0	0.0	0.0	185.1	720
MAY	0.0	0.1	0.6	2.9	5.3	0.8	0.0	0.0	0.1	0.0	0.3	129.7	68.6	0.2	0.0	0.0	208.7	744
JUN	0.1	0.1	0.3	2.6	1.2	0.1	0.0	0.0	0.0	0.9	0.6	136.7	100.0	0.0	0.1	0.0	242.6	720
JUL	0.1	0.0	0.3	2.9	1.0	0.2	0.0	0.0	0.0	0.0	0.1	123.4	102.9	1.0	0.0	0.0	232.0	744
AUG	0.0	0.2	0.3	3.1	1.9	0.3	0.3	0.0	0.1	0.0	0.1	82.0	99.7	0.1	0.0	0.0	188.0	744
SEP	0.0	0.2	0.7	6.2	6.8	3.7	0.0	0.0	0.0	0.0	0.0	60.7	45.3	0.0	0.0	0.0	123.6	720
OCT	0.1	0.2	0.7	4.1	5.4	2.6	0.0	0.0	0.0	0.0	0.3	67.5	40.1	0.1	0.0	0.0	121.2	743
NOV	0.0	0.1	1.5	4.7	7.5	0.9	0.0	0.0	0.0	0.0	0.4	92.8	109.3	0.0	0.0	0.0	217.4	704
DEC	0.4	0.1	0.2	6.5	4.6	3.4	0.0	0.0	0.0	0.1	0.1	190.5	138.6	0.0	0.0	1.7	346.1	557
TOT	0.9	1.1	7.1	47.6	59.8	14.2	0.5	0.1	0.3	1.3	5.6	1452.2	1247.6	1.9	0.1	1.8	2842.1	8136

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.