Supplemental Wind Analysis of Morrow Co. 50m Site
Oregon Anemometer Loan Program

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This analysis has been prepared in order to supplement the analysis of data collected from a 50 meter tower installed on property located NE of Lexington in Morrow County. The purpose of this additional analysis is to summarize data from the 20m tower that was located at the site for over two years. The focus is to make a general comparison between the winds at the two tower locations. As in the analysis of the 50m data, hourly values have been constructed and are used here. This summary is also limited to two complete annual periods (May 2005 to April 2007). This is done to avoid biasing for partial seasons.

This site is located just a few mile North-East of the town of Lexington in Morrow County. The property consists of land sloping upwards to the south of Baseline road. The towers are located near the highest portion of the property along the southern edge where the land drops back downward. The 20m Tower is locate several hundred feet higher up than the 50m tower. The 20m tower was installed as part of the Oregon State Anemometer Loan Program sponsored by the Energy Trust of Oregon.

SITE DESCRIPTION

Site Name:	**Morrow County 20m**	
Latitude:	**45-30.268**	**(WGS-84)**
Longitude:	**119-33.399**	
Elevation:	**1982 ft.**	
Tower Height:	**67 feet**	
Site #	**0625**	

Types of Sensors:	NRG Maximum #40 wind speed NRG 200 series2 wind vane
Instrumentation:	Single level on top of tower
County:	Morrow
Installation Date:	April 5, 2005
Data Removed:	September 25, 2007

Site Problems:

When the site was removed in September 2007 several problems were noticed. First, the ground cable had come loose. As a result, direction values appeared to be drifting and would not accurately reflect the winds at the site. Further comparisons with the 50m tower suggested that the direction sensor had begun to wear out some time previous. This wear was estimated to have become noticeable around the beginning of 2007. As a result, direction data after December 2006 were removed from the records and have not been used in the analyses presented here.

Monthly Mean Winds:

The monthly mean wind speed values from the two sites are shown in Table 1. The two sites have fairly similar means for the overlap period. The 20m site generally falls somewhere between the values from the 30m and 40m levels reflecting the slightly higher elevation of the site.

Table 1: Monthly means from two Morrow County Sites

	Site 0625		W1 50m (164')		W2 40m (131')		W3 30m (99')	
Month	Mean (mph)	Rec. (%)	Mean (mph)	Rec. (%)	Mean (mph)	Rec. (%)	Mean (mph)	Rec. (%)
MAY-05	13.4	100.0						
JUN	16.7	100.0						
JUL	14.2	100.0						
AUG	14.2	100.0						
SEP	13.2	100.0						
OCT	10.9	100.0						
NOV	14.2	78.5						
DEC	13.1	75.3						
JAN-06	19.8	100.0						
FEB	14.7	100.0						
MAR	14.6	100.0						
APR	13.1	100.0						
MAY	13.3	100.0	13.9	100.0	13.7	100.0	13.2	100.0
JUN	12.8	100.0	13.5	100.0	13.3	100.0	12.8	100.0
JUL	13.9	100.0	14.9	100.0	14.6	100.0	14.1	100.0
AUG	13.5	100.0	14.2	100.0	14.0	100.0	13.6	100.0
SEP	12.4	100.0	13.1	100.0	12.9	100.0	12.5	100.0
OCT	12.0	100.0	12.8	100.0	12.6	100.0	12.2	100.0
NOV	16.9	100.0	18.7	99.9	18.2	100.0	17.2	99.9
DEC	11.0	82.5	11.8	84.0	11.7	83.5	10.8	86.3
JAN-07	13.4	78.9	14.0	81.3	13.9	80.9	13.3	80.2
FEB	14.7	89.3	15.6	90.3	15.5	90.5	14.6	91.4
MAR	12.8	100.0	13.3	100.0	13.2	100.0	12.8	100.0
APR	14.3	100.0	14.4	100.0	14.6	100.0	14.0	100.0
ANN	13.9	96.0	14.2	96.3	14.0	96.2	13.4	96.5

Wind Direction:

To examine the observed wind direction at each site two separate plots have been constructed. These can be combined in to a wind rose but are left separate here to help illustrate the differences between the two sites more clearly. This information is show in Figures 2 and 3. Figure 2 shows the frequency that the wind blows from different

Figure 1: Frequency with which the wind is from different direction categories.

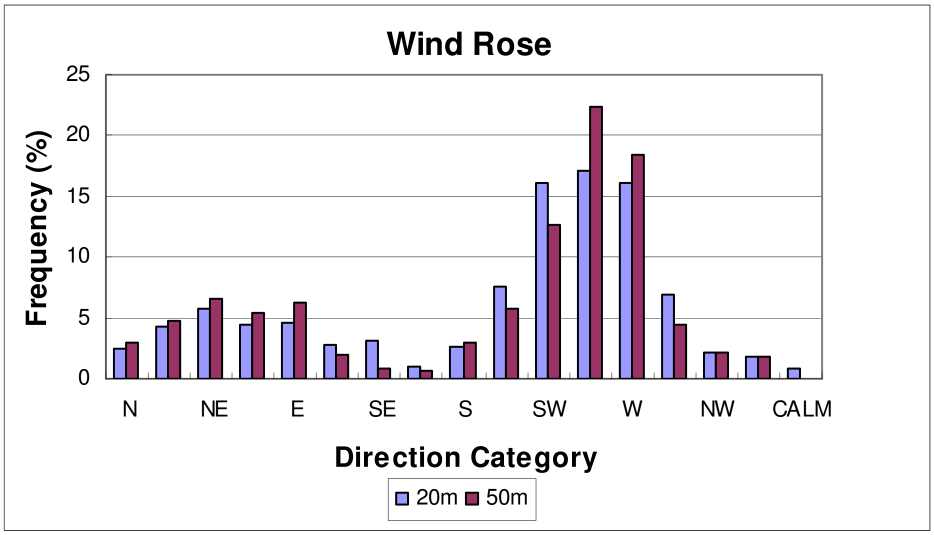
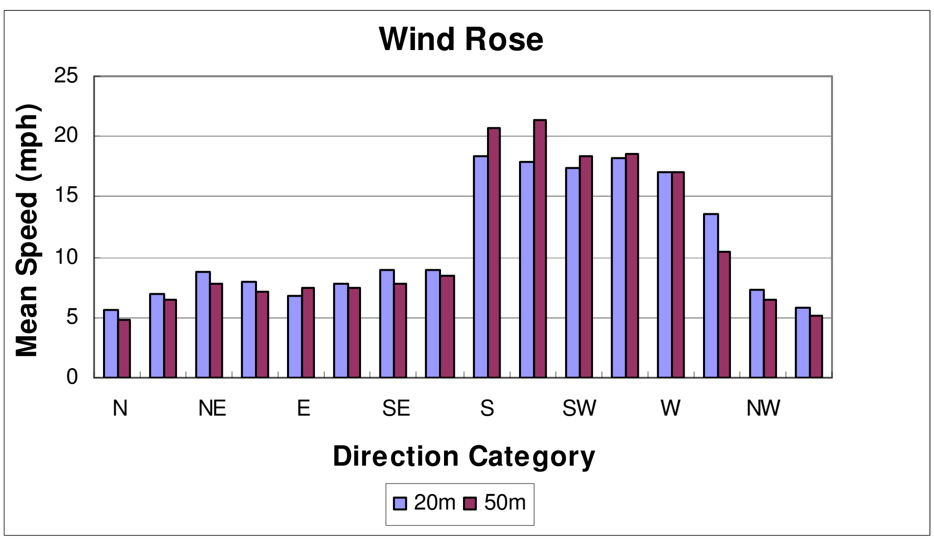


Figure 2: Wind speed associated with different wind direction categories.



direction categories and Figure 3 shows the wind speed associated with each of these categories. For the most part the two sites have similar characteristics and show an expected consistency. Data from the 50m level shows a somewhat narrower focus of the wind direction. This is likely due to the height of the sensor above ground and the greater possibility of surface influences at the 20m sensor level. This may also be partially due to the nature of the data. The 20m site was equipped with a system that records values in 16 direction categories rather than a continuous direction value like the 50m system. In general, however, the two sites are very similar.

Frequency Distribution:

The frequency distribution of each site is shown in Figure 4 below and illustrates some differences between the sites. First, the 50m site shows higher frequencies in the lower (below 7 mph) and upper (above 23 mph) ranges and lower frequencies in the mid-ranges.

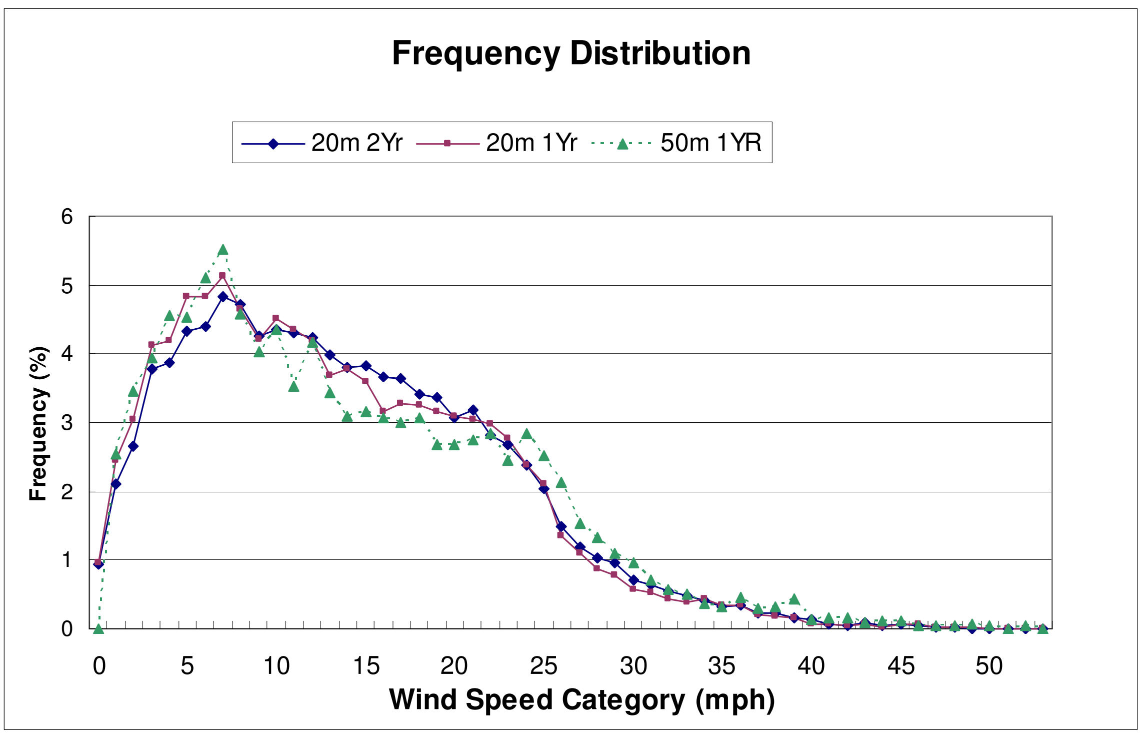


Figure 3: Wind speed frequency distribution for the Morrow County sites.

Diurnal Wind Speed:

The mean diurnal wind speed values can be found in Figure 5. These indicate that the two sites are consistent and show only a slight annual mean diurnal variation.

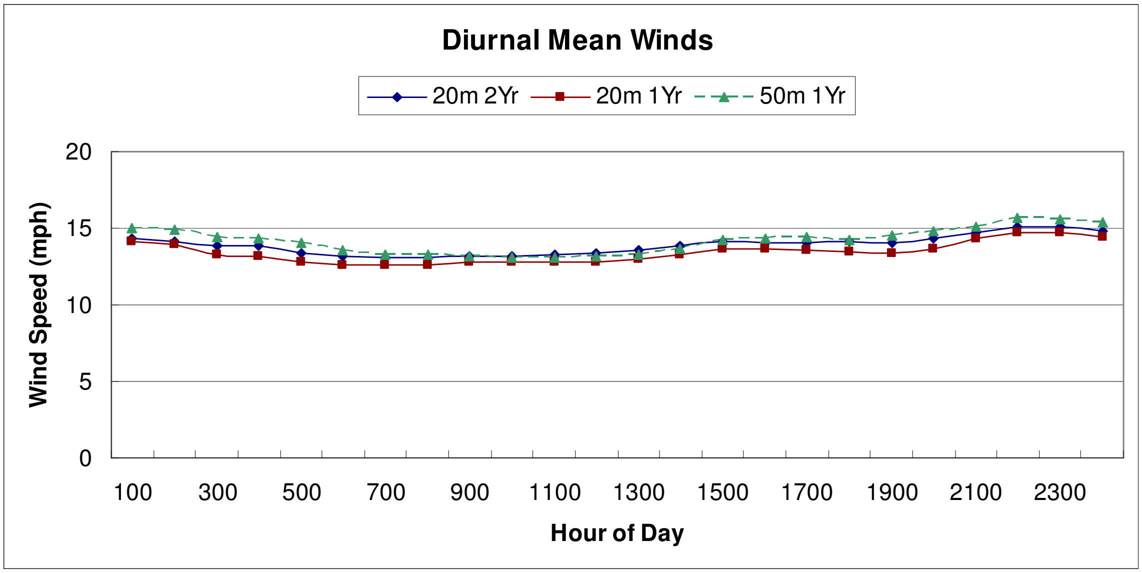


Figure 4: Mean diurnal winds speed at the Morrow County sites:

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 are used. 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 Tables 2 and reveal a number of things about the potential for generating energy the site. Values for the 50m site can be found in the main report. The power density calculation requires air density. This is estimated assuming a standard atmosphere and the site elevation

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. In general it is clear that the wind potential in the summer is fairly consistent and that during the winter will depend on the particular period. Some winter periods will have more storm activity than others and this location appears to have a higher resource during these periods.

Table 2: Wind and power quantities from the Morrow County 20m 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
May	13.4	7.15	100.0	35.1	53.8	240	178
Jun	16.7	7.36	100.0	40.0	70.8	383	275
Jul	14.2	7.08	100.0	42.6	58.9	266	198
Aug	14.2	7.43	100.0	33.6	57.0	273	203
Sep	13.2	6.99	100.0	38.0	54.0	230	166
Oct	10.9	6.13	100.0	28.9	44.0	133	99
Nov	14.2	9.99	78.5	44.8	52.0	392	282
Dec	13.1	8.55	75.3	37.2	48.6	280	208
Jan	19.8	10.76	100.0	49.8	75.1	762	567
Feb	14.7	11.01	100.0	45.9	46.7	495	333
Mar	14.6	8.21	100.0	46.7	58.3	336	250
Apr	13.1	7.61	100.0	48.3	51.2	247	177
ANN	14.4	8.54	96.1	49.8	56.2	335	2938
May	13.3	7.20	100.0	32.8	49.5	239	178
Jun	12.8	6.48	100.0	29.0	50.3	196	141
Jul	13.9	6.74	100.0	37.0	56.9	242	180
Aug	13.5	7.48	100.0	36.5	51.3	253	188
Sep	12.4	7.75	100.0	39.4	43.9	232	167
Oct	12.0	8.30	100.0	45.3	45.0	239	178
Nov	16.9	10.37	100.0	52.5	64.0	552	397
Dec	11.0	10.80	82.5	48.7	33.9	353	262
Jan	13.4	10.71	78.9	50.7	44.0	413	308
Feb	14.7	9.22	89.3	43.4	59.5	378	254
Mar	12.8	7.66	100.0	35.0	51.7	232	173
Apr	14.3	7.17	100.0	44.8	56.0	273	197
ANN	13.4	8.47	95.9	52.5	50.7	296	2593
2-Year	13.9	8.52	96.0	52.5	53.4	316	5531

To confirm this conclusion, 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. The two sites are treated slightly different because of their data characteristics. Power estimates from the 20m tower are constructed using the mean shear factor computed from the 50m tower over the one year analysis period (alpha =

0.110). Estimates for the 50m site use the shear factors for the individual months. In Table 3, energy capacity factors are shown for two 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.

Table 3: Capacity factors for two turbine types and wind at the two Morrow County sites.

	20 Meter Site		50 Meter Site	
Turbine	AER 1500-70	GE Wind 70.5	AER 1500-70	GE Wind 70.5
Size (kW)	1500	1500	1500	1500
Hub Ht. (ft.)	213	210	213	210
May	0.302	0.293		
Jun	0.457	0.442		
Jul	0.327	0.320		
Aug	0.354	0.342		
Sep	0.284	0.278		
Oct	0.192	0.189		
Nov	0.369	0.358		
Dec	0.325	0.315		
Jan	0.585	0.570		
Feb	0.355	0.346		
Mar	0.336	0.328		
Apr	0.290	0.282		
ANN	0.348	0.339		
May	0.301	0.291	0.270	0.262
Jun	0.279	0.271	0.252	0.246
Jul	0.322	0.303	0.307	0.299
Aug	0.324	0.312	0.296	0.286
Sep	0.267	0.260	0.247	0.242
Oct	0.268	0.266	0.253	0.247
Nov	0.468	0.454	0.472	0.459
Dec	0.241	0.236	0.234	0.228
Jan	0.323	0.314	0.302	0.295
Feb	0.371	0.361	0.360	0.349
Mar	0.303	0.293	0.263	0.256
Apr	0.340	0.329	0.279	0.271
ANN	0.317	0.308	0.295	0.287
ANN-2YR	0.333	0.323		

These quantities show a relative consistency between the two sites. The higher capacity factors at the 20m site are partly a function of the assumptions used (mean alpha factor) and partly a function of the higher elevation. The uncertainty in the estimates for the 20m site is likely much greater considering these assumptions.

Conclusions:

There are some limitations to this analysis that should be acknowledged. The most important of these is the use of data adjusted to turbine hub height (from 20 meters). The standard adjustment method used here should account for much of the differences but there may be some characteristics of each site that are not fully accounted for in this process.

In general, it is apparent that there is a slight difference in the wind characteristics between these two sites. While they are not separated by a great distance, the local terrain and elevations are different and these are reflected in the wind characteristics. The 20 meter tower was located at the highest point and may not represent the entire site While the 50m tower is located lower along the slope and may provide a better representation of the property as a whole. It is probable that the winds are slightly weaker down the hill. How much weaker is difficult to say without collecting additional data.