Wind Resource Assessment for Middle Mountain in Hood River County, OR

Summary

This brief report summarizes wind data collected at a 50m meteorological tower located at a proposed windfarm site, about 10 miles south of Hood River, OR. Long-term wind speed and energy estimates have been made for GE 1.5 MW 77m turbines and Siemens 2.3 MW 93m turbines. The estimated mean wind speed at the met tower, at 80m is 15.5 mph (6.9 mps). The estimated net capacity factor is 29.6% for the Siemens 2.3 MW turbines, at 80m hub-height. The estimated net CF for the GE turbines is 30.1%. These are equivalent estimates to the new windfarms being developed near Arlington, OR.

Analysis

The Hood River County site is located on Middle Mountain, a north-south trending ridgeline. The elevation ranges from ~2,300 to 2,642 feet and the site is located south of the Columbia River in the area just east of the Cascades ridgelines. Although it is east of the deepest part of the Columbia Gorge, it is still referred to as the Gorge, and numerous wind studies have been made in this area over the last 25 years, by BPA and Oregon State University (OSU), and others.

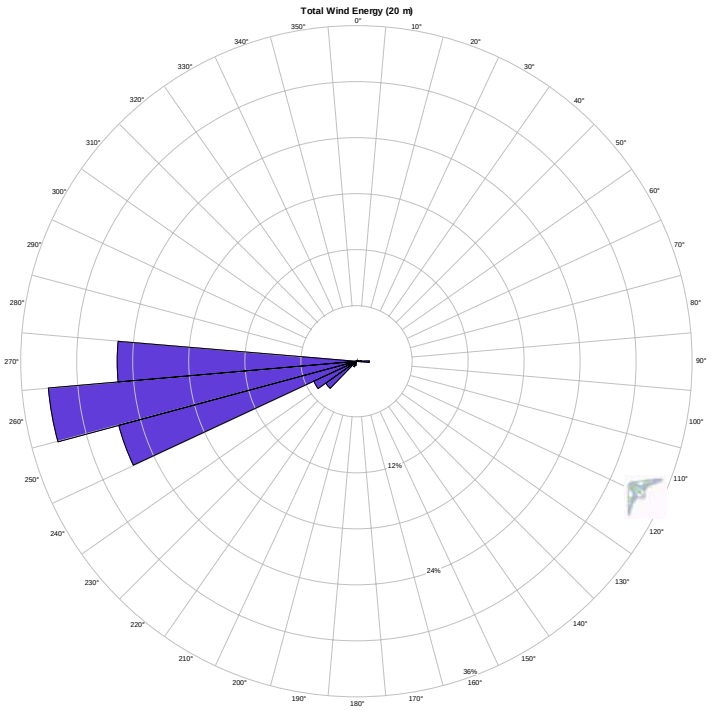
In April 2006, a 20m meteorological (met) tower was installed at the proposed site. A topo map is attached which shows the location of the met tower. In June 2008 the 20m tower was replaced with a multi-level 50m tower at almost the exact same location. The analyses are based on 2.5 years of data, from June 2006 through October 2008, which were provided by OSU. To make long term speed and energy estimates, wind data from the on-site met tower have been correlated to the OSU reference tower known as Seven Mile Hill. Seven Mile Hill is about 20 miles east of the Hood River County site, just west of The Dalles. The Seven Mile Hill site has over 10 years of data since the last sensor change took place in the mid 1990s. Only data collected after this sensor change, were included in the estimates.

Table one is a monthly diurnal wind speed summary for the 2.5-year period at the 20m level at the Hood River County Middle Mountain tower. The table is a 12 by 24 matrix of monthly and diurnal (time-of-day) mean speeds. The table shows that the monthly mean speeds (bottom row) are highest in the late spring and summer and lowest in October. The annual mean speed at 20m is shown at the bottom of the table and is 13.1 mph. The bottom of the table shows the monthly and total data recovery, which was 96%. Figure 1 is a bar chart which graphically depicts the monthly mean speeds listed on the bottom of Table 1. The graph shows that the monthly wind speeds are fairly constant year-round.

Table 1 listed the diurnal mean speeds at 20m. Figure 2 is a plot which shows the diurnal mean wind speeds for January, July and the full year. The graph shows that there is a diurnal peak in the evening hours, with lowest winds at 9 am to 10 am in July. In January there is also a diurnal peak in the afternoon and evening hours, but the magnitude of the diurnal cycle is much smaller than in the summer. This is because the summer winds are thermally driven, and the winter winds are more storm driven.

Figure 3 is a wind energy rose from the site. The windrose shows that the prevailing winds blow from 260 degrees, the west and west-southwesterly directions. 91% of the annual energy budget comes from these two sectors. The highest wind speeds are from the west direction. A turbine row would be oriented normal to the prevailing directions, and the windrose shows that practically none of the energy budget comes from wind directions that would be parallel to the north-south turbine row.

Figure 3: Middle Mountain 20m level Wind Energy Rose



Methodology and Estimates

The methodology used in making the long-term speed and energy estimates includes the following steps. (1) Quality check the wind data for icing, failed sensors, etc., by inter-level and inter-site correlations, (2) calculate the vertical shear exponents at the 50m met tower (change in wind speed with height), (3) correlate the met tower's data to the reference site at Seven Mile Hill, and estimate annual mean speeds at the Hood River County met tower (4) using the vertical shear exponent, adjust the 50m mean speed

estimate to 80m, (5) and generate a wind speed distribution and calculate gross and net energy output, (6) estimate terrain impacts for a turbine row, relative to the met tower location. The results of these steps are the long-term mean speed estimates and energy output estimates for the GE and Siemens turbines at the Project site.

The wind data were collected and supplied by the Wind Lab at Oregon State University. The data had already been QA'd by their personnel. OSU has operated a Wind Lab in the Mechanical Engineering Department for about three decades I have screened and quality checked the data by several techniques including visual scans and inter-level correlations. Almost all data received by OSU appear to be valid. There were some periods of apparent light icing that were invalid, that I deleted from my analysis. The data collected use the U.S. Industry standard Maximum type 40 cup anemometer and NRG data logger. The NREL recommended slope and offset (transfer functions) have been used for all wind data collected.

Vertical wind shear. The 50m tower has wind speed sensors at 20m, 30m, 41m and 49 meters. In the layer between 49m and 20m the exponent was 0.125. The vertical shear is the change of wind speed with respect to height above ground, and is expressed as an exponent, known as alpha. I have used the measured shear value between 20m and 49m, to extrapolate to the proposed hub-height; 80 meters.

Correlation to reference, wind speed estimates. Wind data from the 50m tower, have been correlated to Seven Mile Hill. The correlation coefficient (r) was 0.68 for the entire period, using hourly mean speeds. On a seasonal basis the correlation coefficient was 0.62 in the winter months and 0.77 in the summer months. The predicted long term mean speed at 20m was 13.0 based on the Seven Mile Hill site. This is nearly identical to the measured mean speed of 13.1 mph shown in Table 1, in other words the measurement period was a normal period.

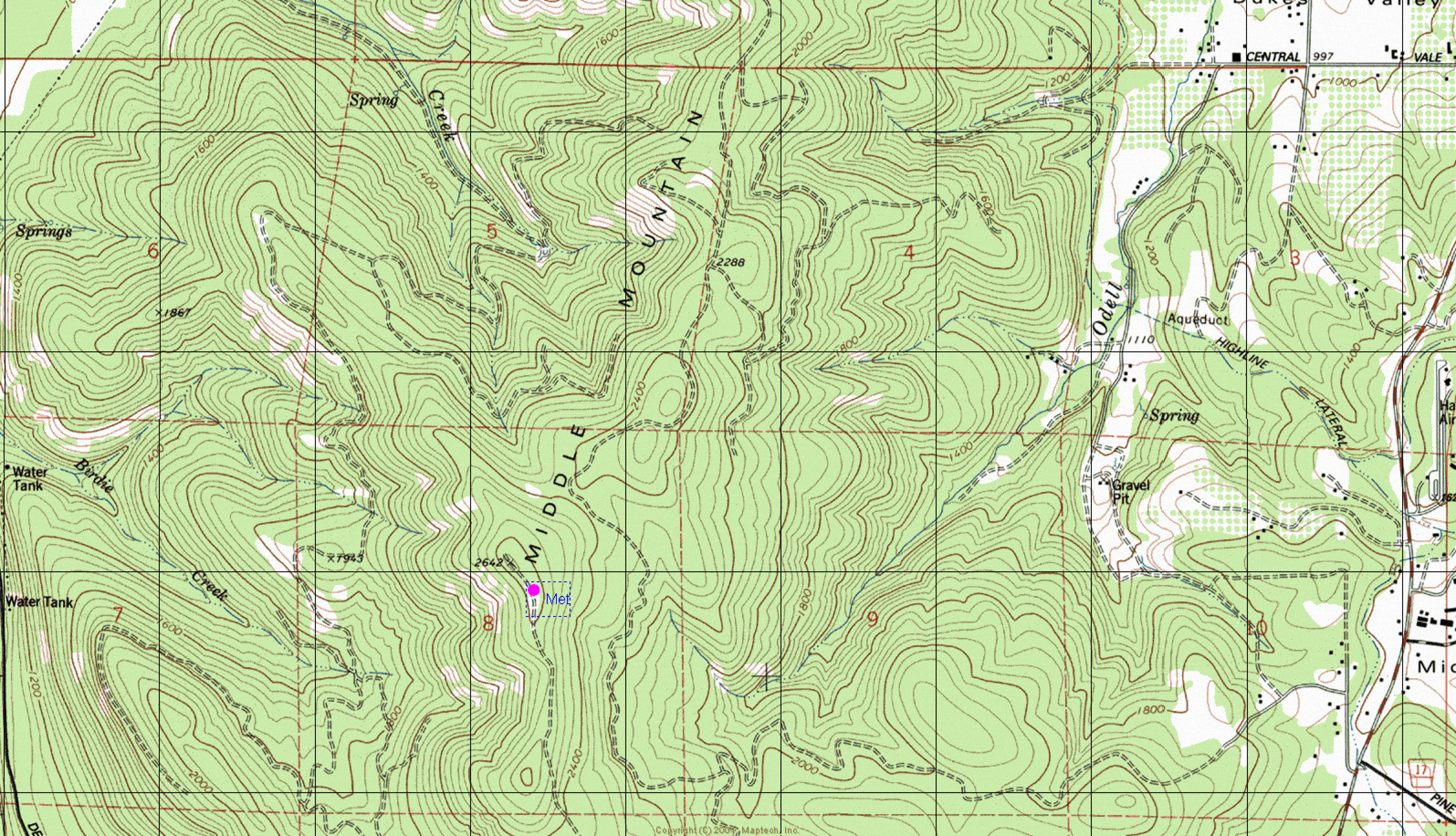
Using the shear exponent of 0.125, the 80m estimate is 15.5 mph (6.9 mps) at the met tower site. The topo map shows that the met tower is sited at 2628 feet near the highest point on Middle Mountain. The turbines would run north-south and the elevation drops about 150 feet to the south of the met tower and about 250 feet to the north of the met tower. Based on siting experience, I estimate that the energy content at 6 to 10 turbine sites will average 90% of the met tower location. This 90% figure is a preliminary estimate and could be pessimistic, but two additional met towers need to be installed on this ridge to validate this preliminary estimate.

Energy Calculation The wind speed distribution for calculating theoretical energy is based on the dataset from the on-site met tower, scaled to the estimated long term speed; 6.9 mps. The air density at the site is estimated at 1.13 kg/m3. The power curves were provided by the manufacturers. The distributions are attached as tables 2a-b and show that the gross energy output estimate at the met tower location is 7,486.9 MWh for the Siemens and 4,967.5 MWh for the GE 77m.

The array losses are estimated to be 0% for a proposed N-S row of turbines based on the windrose discussed above. Icing losses are estimated to be 2.0%. The other loss assumptions are 2% for electrical, 5% for availability and 3% for miscellaneous losses such as turbulence, power curve/blade soiling. In the first year of operations, availability losses may be higher than 5%, perhaps as high as 10%. The combined loss factor (by multiplication) is 0.885. Thus the net energy output for a single Siemens turbine at the met tower would be 6,625.9 MWh which is equivalent to a net capacity factor (NCF) of 32.9%. For a single GE turbine the net output estimate is 4,396.2 MWh, or an NCF of 33.5%.

For a group of wind turbines the estimated output is 90% of the met tower location. Therefore the NCF for a group of 6 to 10 Siemens turbines is 29.6%. For a group of GE turbines the net capacity factor estimate is 30.1%. These estimated NCFs are comparable to projects being constructed in the eastern Columbia Gorge near Arlington, OR, and are therefore considered viable.

Ron Nierenberg
December 4, 2008



Spring
Creek
Springs
MIDDLE MOUNTAIN
2288
2642
Met
CENTRAL
997
VALE
Odell
1110
Aqueduct
HIGHLINE
LATERAL
Spring
Gravel Pit
Water Tank
Birdie
Creek
Water Tank
x1867
x1943
5
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Table 1 Monthly Diurnal Mean Wind Speeds

Columbia River gorge, OR
Hood River Middle Mtn 20m level (MPH)

Apr 12, 2006 - Oct 25, 2008

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
01	11.5	14.0	12.5	12.8	14.5	14.8	16.0	13.6	11.7	11.4	13.1	12.8	**13.3**
02	11.5	13.1	12.3	13.0	14.0	14.8	15.7	13.3	11.2	11.4	13.1	12.5	**13.1**
03	11.2	13.0	12.5	12.7	13.9	14.1	15.5	13.1	10.7	11.3	13.3	12.3	**12.9**
04	11.0	13.3	12.2	12.5	13.6	13.5	14.9	12.9	10.6	11.2	13.3	12.9	**12.7**
05	10.9	12.6	11.9	12.4	13.1	13.3	14.1	12.6	10.4	11.5	12.8	12.9	**12.4**
06	11.4	11.6	12.1	12.0	12.6	13.3	13.4	12.0	10.4	11.0	12.7	12.3	**12.1**
07	11.4	11.2	11.9	11.2	12.2	12.3	12.2	11.5	10.3	11.1	12.5	11.5	**11.6**
08	11.5	11.0	12.0	11.0	12.1	11.7	11.1	10.6	9.9	11.2	12.5	11.4	**11.3**
09	11.2	11.1	11.8	11.6	12.5	11.6	10.1	10.6	9.8	10.9	11.7	11.5	**11.1**
10	10.9	11.7	11.8	12.0	13.3	11.8	10.1	11.0	10.3	10.2	11.3	11.4	**11.3**
11	11.3	12.0	12.5	13.1	14.1	12.4	10.9	11.5	11.1	10.0	11.2	11.7	**11.8**
12	11.6	12.4	13.8	14.2	14.3	13.2	11.8	12.7	12.0	10.3	11.6	11.4	**12.5**
13	12.9	13.4	14.8	14.9	15.3	14.1	12.9	13.7	12.7	11.0	12.3	11.6	**13.4**
14	13.5	14.5	16.2	15.4	15.5	15.2	14.1	14.1	13.4	11.4	12.4	11.4	**14.0**
15	13.8	15.3	16.6	15.7	15.7	15.7	15.2	14.7	13.9	12.1	12.3	11.6	**14.5**
16	13.4	15.3	15.9	15.0	15.8	16.1	15.9	15.4	14.0	11.9	12.5	12.5	**14.6**
17	12.8	15.0	15.5	14.9	15.1	16.6	16.3	16.1	13.8	11.7	11.9	13.5	**14.6**
18	13.0	14.9	14.8	14.2	14.3	15.9	16.9	15.1	14.1	12.1	11.5	13.5	**14.3**
19	13.3	14.7	14.3	13.7	14.5	15.9	17.3	15.0	14.1	12.2	11.3	14.4	**14.4**
20	13.1	14.4	14.0	14.0	14.7	16.4	17.9	15.4	14.0	11.7	11.5	14.3	**14.4**
21	12.9	14.0	13.9	13.5	14.7	15.9	17.6	15.5	13.3	11.3	10.9	13.0	**14.1**
22	12.9	13.7	13.6	13.3	14.7	15.9	17.8	15.2	13.1	10.8	10.9	13.0	**13.9**
23	12.5	13.1	12.8	13.5	14.6	15.7	17.1	14.4	12.9	11.1	11.6	13.0	**13.7**
24	11.6	13.2	12.8	13.5	14.6	15.4	16.6	13.8	12.1	11.3	12.4	13.0	**13.5**
Mean	**12.1**	**13.3**	**13.4**	**13.3**	**14.1**	**14.4**	**14.6**	**13.5**	**12.1**	**11.3**	**12.1**	**12.5**	**13.1**

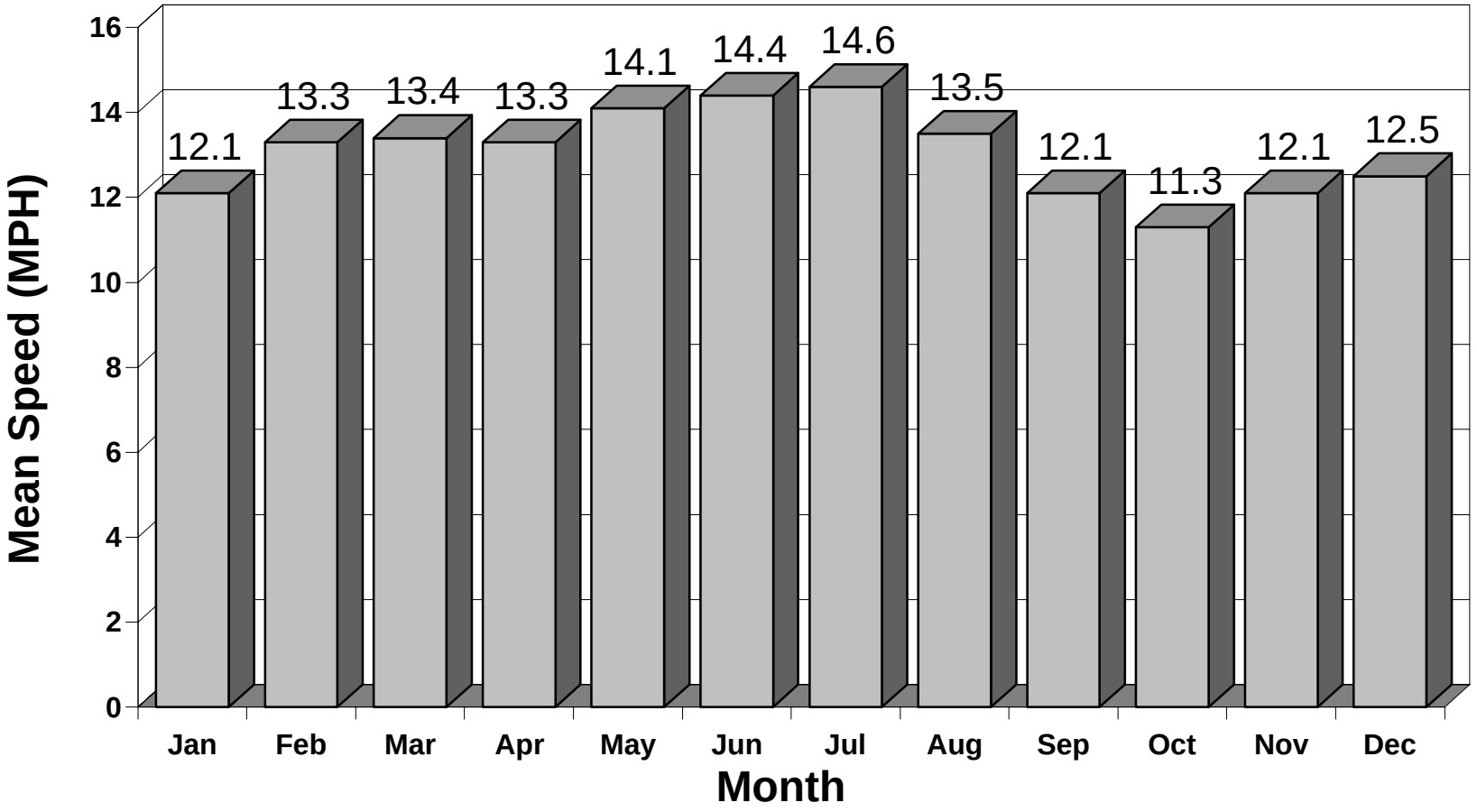
Valid Hrs	1388	1254	1463	1887	2167	1976	2232	2232	2160	2080	1367	1118
Missing Hrs	100	114	25	9	65	184	0	0	0	8	73	370

21,324 hours of valid data, 948 hours missing, 95.7% data recovery

Mean of monthly means: 13.1

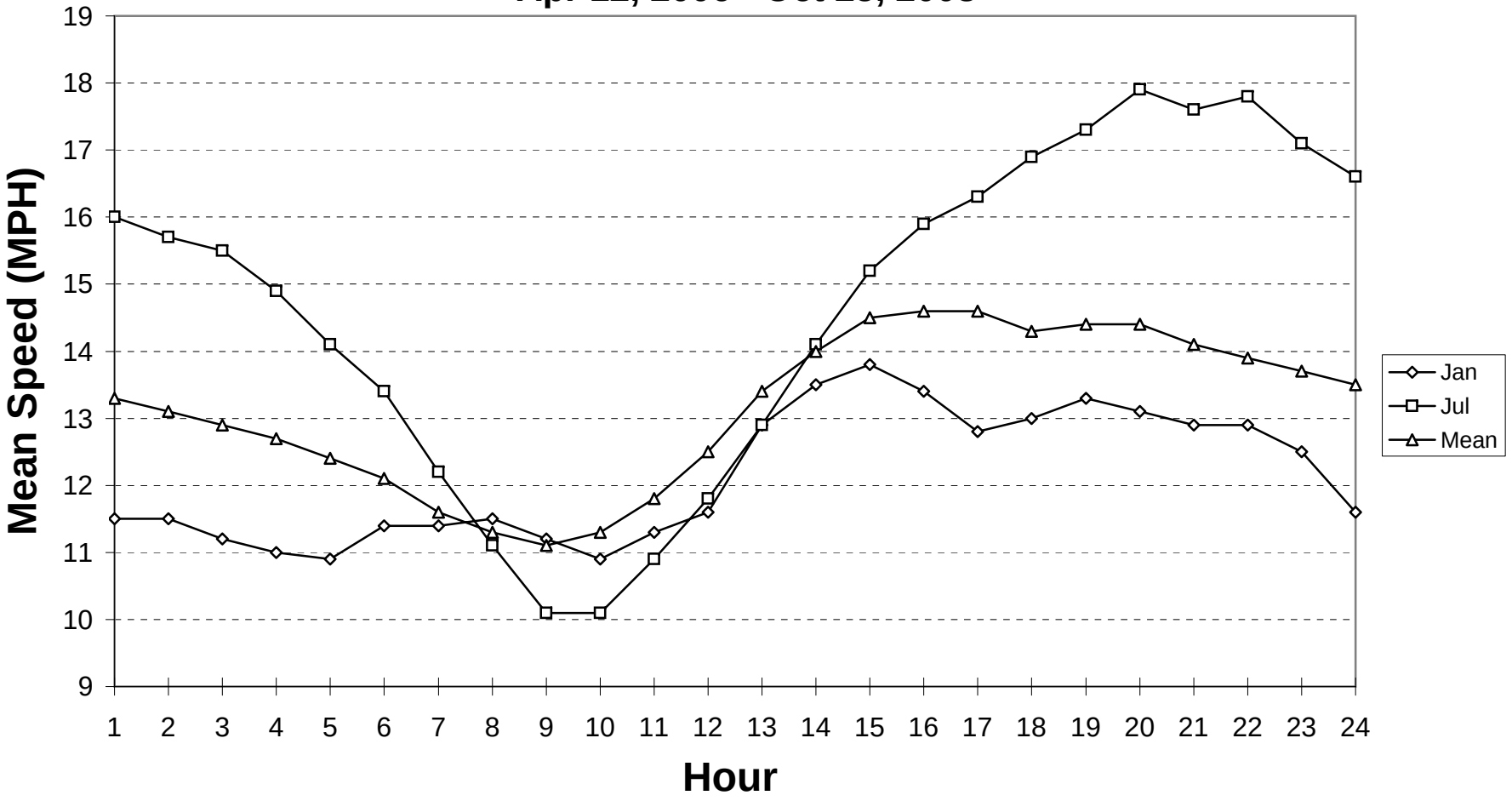
RON NIERENBERG
Consulting Meteorologist

Figure 1 Monthly Mean Wind Speeds
Columbia River gorge, OR
Hood River Middle Mtn 20m level (MPH)
Apr 12, 2006 - Oct 25, 2008



RON NIERENBERG
Consulting Meteorologist

Figure 2: Diurnal Mean Wind Speeds
Columbia River gorge, OR
Hood River Middle Mtn 20m level (MPH)
Apr 12, 2006 - Oct 25, 2008



RON NIERENBERG
Consulting Meteorologist

Table 2a

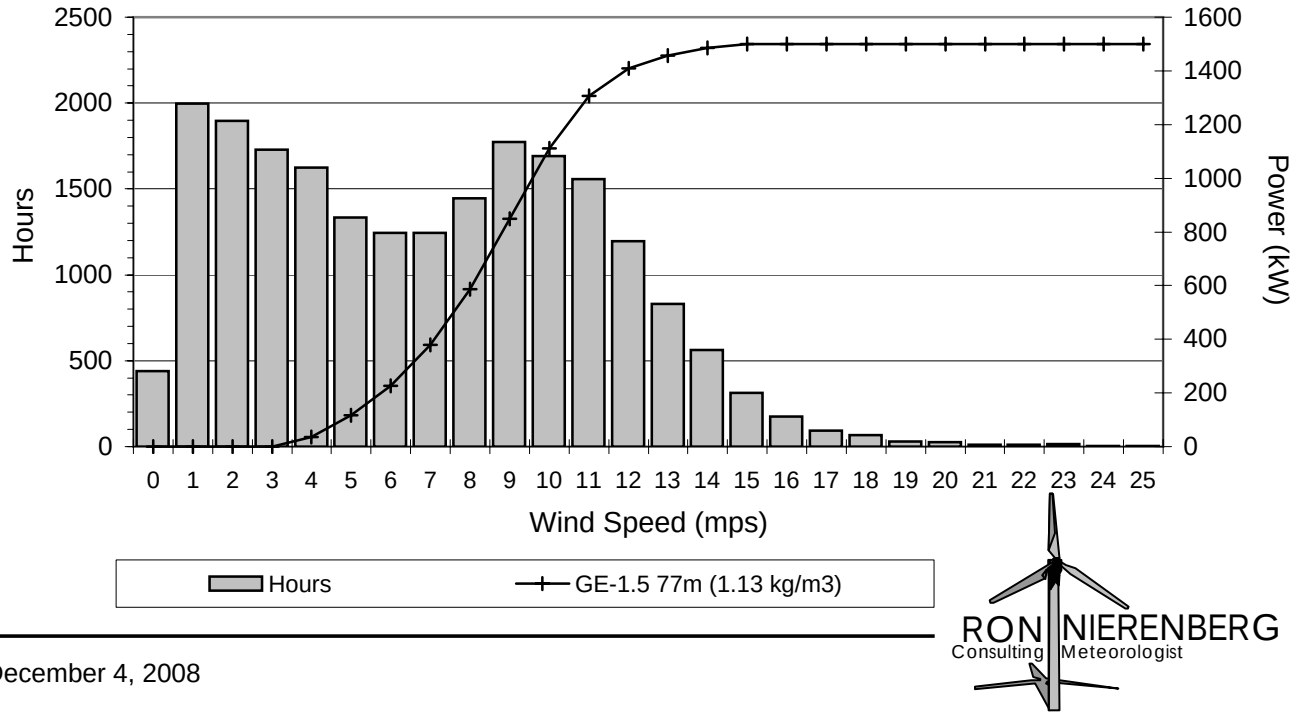
Linear Adjusted Wind Speed Distribution
Columbia River gorge, OR
Middle Mtn 80m Apr 12, 2006 - Oct 25, 2008

GE-1.5 77m (1.13 kg/m3)

Speed (mps)	Hours	Power kW	Energy kWh
0	440	0	0
1	1998	0	0
2	1897	0	0
3	1729	0	0
4	1625	37	59,524
5	1332	118	156,923
6	1244	228	283,259
7	1246	380	473,679
8	1446	587	848,903
9	1775	849	1,507,721
10	1691	1,112	1,880,003
11	1556	1,307	2,033,381
12	1195	1,410	1,684,663
13	829	1,456	1,207,265
14	564	1,486	837,842
15	312	1,500	468,000
16	176	1,500	264,000
17	93	1,500	139,500
18	67	1,500	100,500
19	31	1,500	46,500
20	26	1,500	39,000
21	10	1,500	15,000
22	10	1,500	15,000
23	15	1,500	22,500
24	4	1,500	6,000
25	2	1,500	3,000
26	6	0	0
27+	5	0	0
Totals:	21324	hrs	12,092,160 kWh

Adjusted (1.178) mean wind speed = 6.9 mps

21,324 hours of data, normalized to one year = 4,967,518 kWh



RON NIERENBERG
Consulting Meteorologist

December 4, 2008

Table 2b

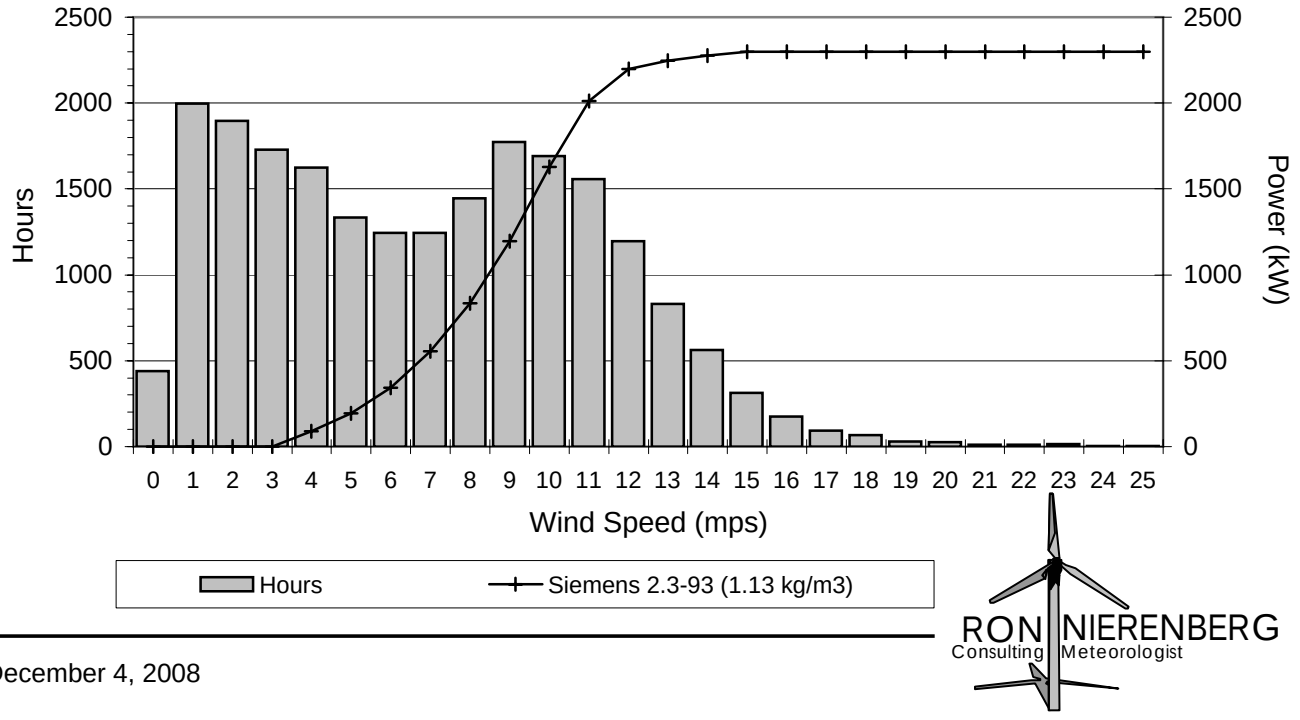
Linear Adjusted Wind Speed Distribution
Columbia River gorge, OR
Middle Mtn 80m Apr 12, 2006 - Oct 25, 2008

Siemens 2.3-93 (1.13 kg/m3)

Speed (mps)	Hours	Power kW	Energy kWh	
0	440	0	0	
1	1998	0	0	
2	1897	0	0	
3	1729	0	0	
4	1625	90	146,510	
5	1332	192	255,851	
6	1244	343	426,692	
7	1246	555	691,131	
8	1446	834	1,205,935	
9	1775	1,198	2,125,669	
10	1691	1,629	2,754,233	
11	1556	2,012	3,130,579	
12	1195	2,198	2,626,777	
13	829	2,246	1,862,067	
14	564	2,276	1,283,670	
15	312	2,300	717,600	
16	176	2,300	404,800	
17	93	2,300	213,900	
18	67	2,300	154,100	
19	31	2,300	71,300	
20	26	2,300	59,800	
21	10	2,300	23,000	
22	10	2,300	23,000	
23	15	2,300	34,500	
24	4	2,300	9,200	
25	2	2,300	4,600	
26	6	0	0	
27+	5	0	0	
Totals:	21324	hrs	18,224,910	kWh

Adjusted (1.178) mean wind speed = 6.9 mps

21,324 hours of data, normalized to one year = 7,486,881 kWh



RON NIERENBERG
Consulting Meteorologist

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