



Wind Resource Summary for Villa Grove Site

Colorado Anemometer Loan Program

Monitoring Period: 7/28/2006 – 01/01/2008

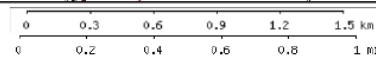
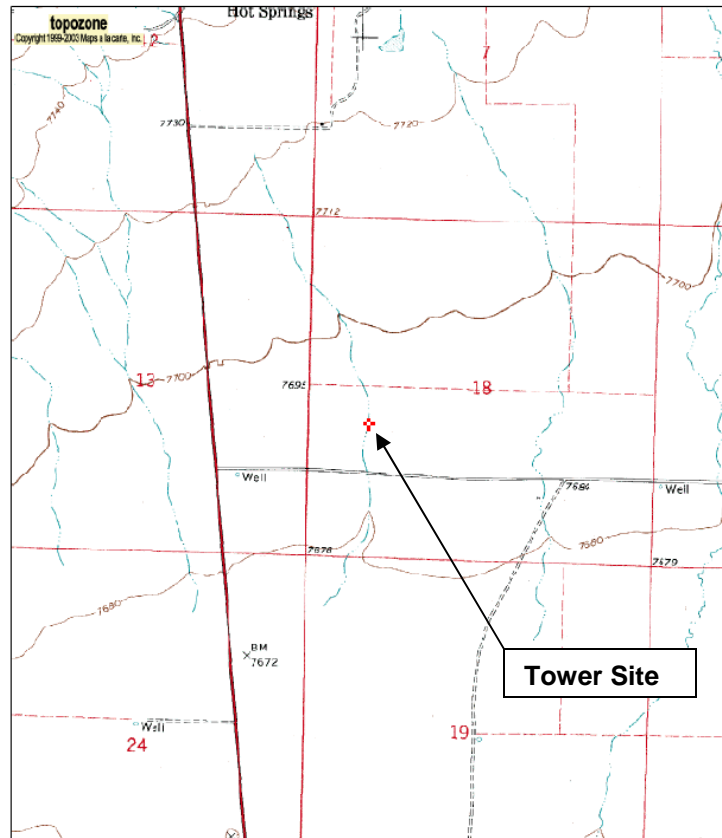
Report Date: January 14, 2008

Site Description:

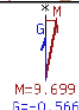
The site is located in the San Luis Valley between two mountain ranges about seven miles south of the town of Villa Grove, Colorado. The tower was placed on some pasture land about a half mile east of State Highway 17. Although the tower is on pasture land, crop circles surround the area except to the west. The exposure to the wind is good especially along the axis of the valley which runs north to south.

Table with 2 columns: Location Detail and Value. Includes Latitude, Longitude, Township, Range, Section, Elevation, Tower Type, Tower Height, Vane Offset, Direction Basis, and Mag. Declination.

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38.1500°N, 105.9167°W (NAD83/WGS84) USGS Villa Grove (CO) Quadrangle Projection is UTM Zone 13 NAD83 Datum



Wind Resource Summary

All analysis performed using Windographer 1.13

Data Properties	
Data Set Starts:	7/28/2006 8:10
Data Set Ends:	1/1/2008 11:40
Data Set Duration:	19 months
Length of Time Step:	10 minutes
Elevation (ft.):	7,700
Calm threshold (mph):	0
Wind Power Coefficients	
Power Density at 50m:	112 W/m ²
Wind Power Class:	1 (poor)
Wind Power Coefficients	
Power Law Exponent:	0.14
Surface Roughness:	0.01 m
Roughness Class:	0.78
Roughness Description:	Rough Pasture

Height above ground (m)	20
Mean wind speed (mph)	8.29
Median wind speed (mph)	7.1
Min wind speed (mph)	0.45
Max wind speed (mph)	52.8
Mean power density (W/m ²)	76
Mean energy content (kWh/m ² /yr)	668
Energy pattern factor	3.077
Weibull k	1.428
Weibull c (mph)	9.12
1-hr autocorrelation coefficient	0.699
Diurnal pattern strength	0.264
Hour of peak wind speed	18
Mean turbulence intensity	0.254
Standard deviation (mph)	5.95
Coefficient of variation (%)	71.7
Frequency of calms (%)	0
Actual observations	75,189
Missing observations	0
Data completeness (%)	100

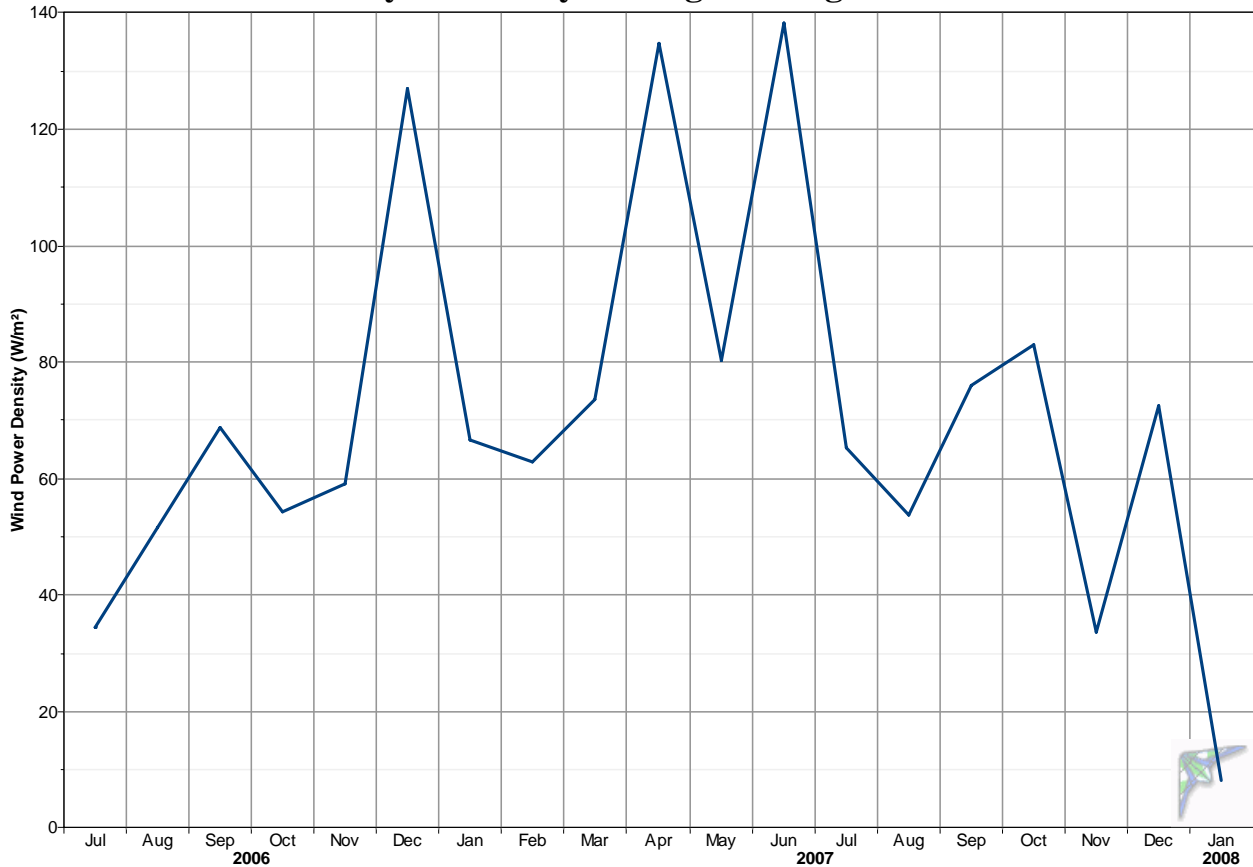
Note: Air temperature was not measured during the measuring period so air density taken to be 0.972 kg/m³ throughout the period

Annual Average Wind Resource Statistics – Speed and Direction

Hour of Day	Average Wind speed mph	Wind Power Density W/m ²	Hour of Day	Average Wind speed mph	Wind Power Density W/m ²
0.5	7.909	53.49	12.5	9.193	110.11
1.5	7.582	50.05	13.5	10.036	126.66
2.5	7.409	49.98	14.5	10.804	149.1
3.5	7.152	49.94	15.5	11.046	149.25
4.5	6.819	39.83	16.5	11.027	143.44
5.5	6.697	40.07	17.5	10.621	121.81
6.5	6.089	34.96	18.5	10.088	95.71
7.5	5.383	34.01	19.5	9.397	77.84
8.5	5.665	47.23	20.5	8.886	70.55
9.5	6.446	56.17	21.5	8.621	66.31
10.5	7.314	63.79	22.5	8.415	60.8
11.5	8.148	80.87	23.5	8.29	56.93

Direction Sector Midpoint degrees	Frequency percent	Direction Sector Midpoint degrees	Frequency percent
0	3.85	180	4.67
10	0.03	190	0.01
20	10.46	200	7.53
30	0.02	210	0.02
40	0.03	220	0.02
50	19.72	230	9.32
60	0.02	240	0.01
70	10.94	250	8.50
80	0.00	260	0.01
90	3.33	270	4.81
100	0.01	280	0.01
110	2.31	290	3.07
120	0.00	300	0.01
130	0.00	310	0.01
140	2.35	320	2.55
150	0.00	330	0.01
160	2.99	340	3.40
170	0.01	350	0.01

Wind Power Density – Monthly Average During Measurement Period



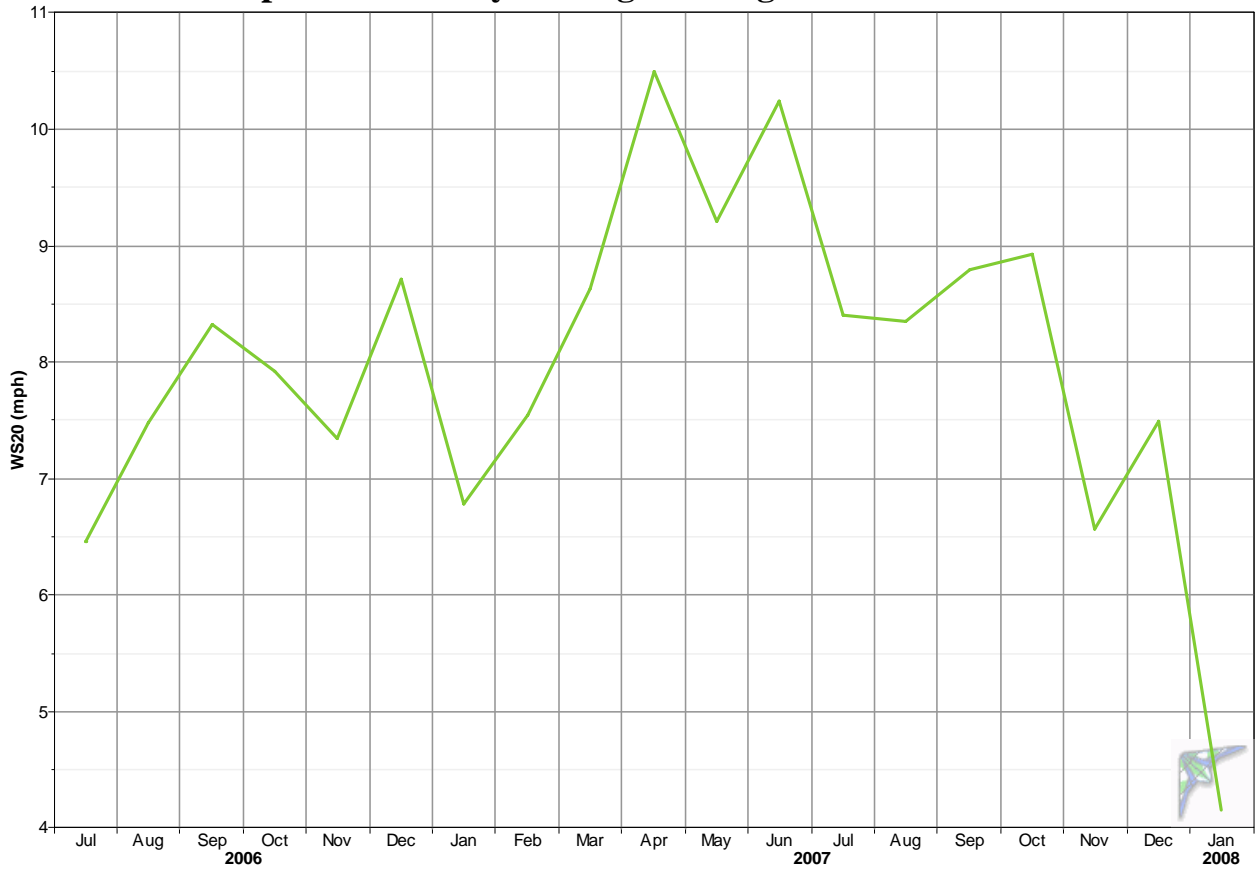
For reference, the table below provides a summary of the wind power classifications from the U.S. DOE's Colorado Wind Resource Map available at:

http://www.eere.energy.gov/windandhydro/windpoweringamerica/maps_template.asp?stateab=co

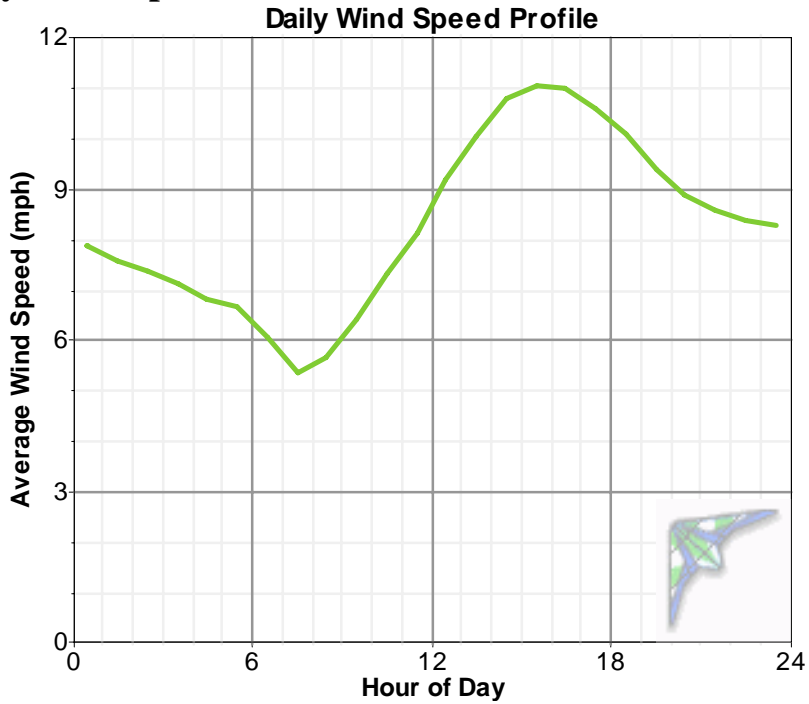
Wind Power Classification				
Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m ²	Wind Speed ^a at 50 m m/s	Wind Speed ^a at 50 m mph
1	Poor	0 - 200	0.0 - 5.9	0.0 - 13.2
2	Marginal	200 - 300	5.9 - 6.7	13.2 - 15.0
3	Fair	300 - 400	6.7 - 7.4	15.0 - 16.6
4	Good	400 - 500	7.4 - 7.9	16.6 - 17.7
5	Excellent	500 - 600	7.9 - 8.4	17.7 - 18.8
6	Outstanding	600 - 800	8.4 - 9.3	18.8 - 20.8
7	Superb	> 800	> 9.3	> 20.8

^a Wind speeds are based on a Weibull k of 2.0 at 1500 m elevation.

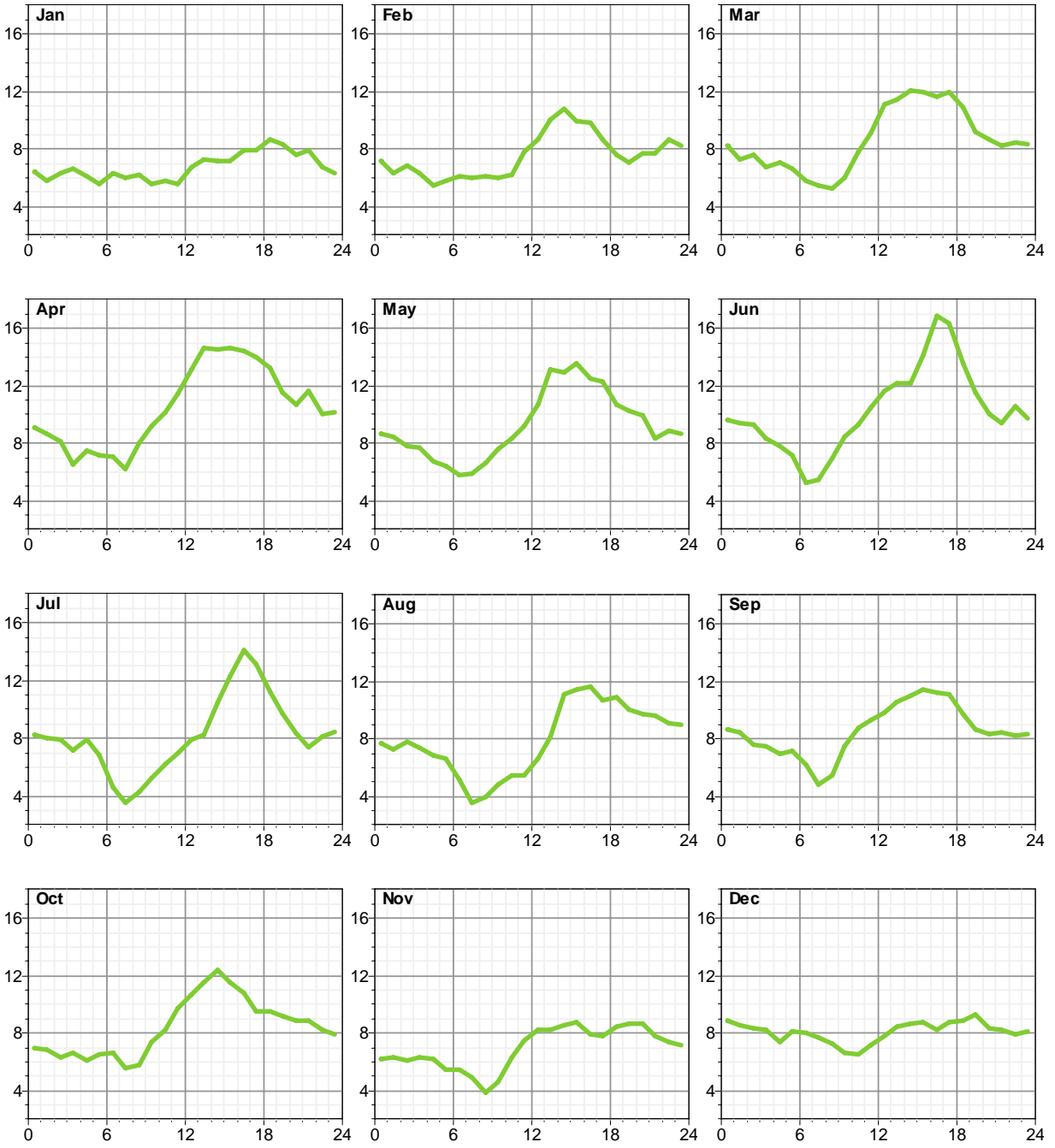
Wind Speed – Monthly Average During Measurement Period

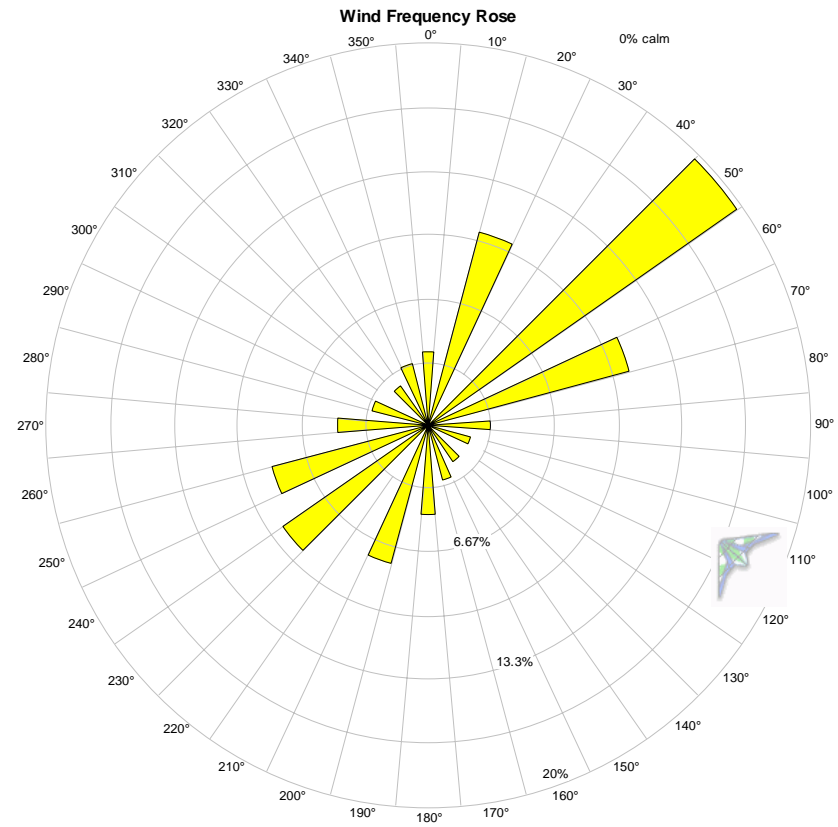
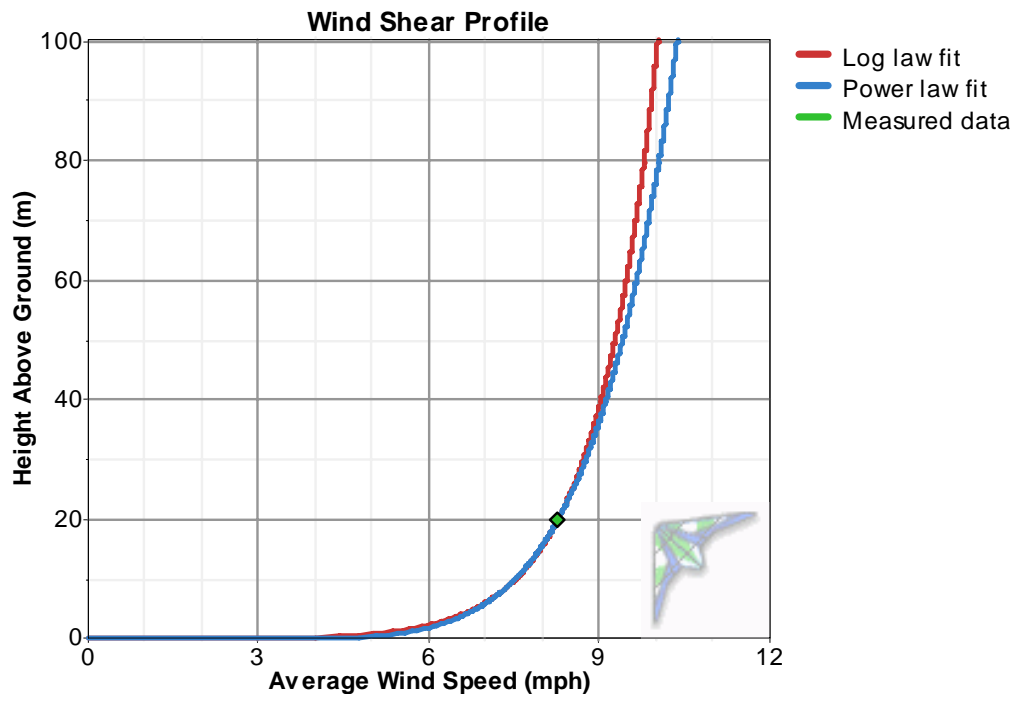


Daily Wind Speed Profile – Total For Measurement Period

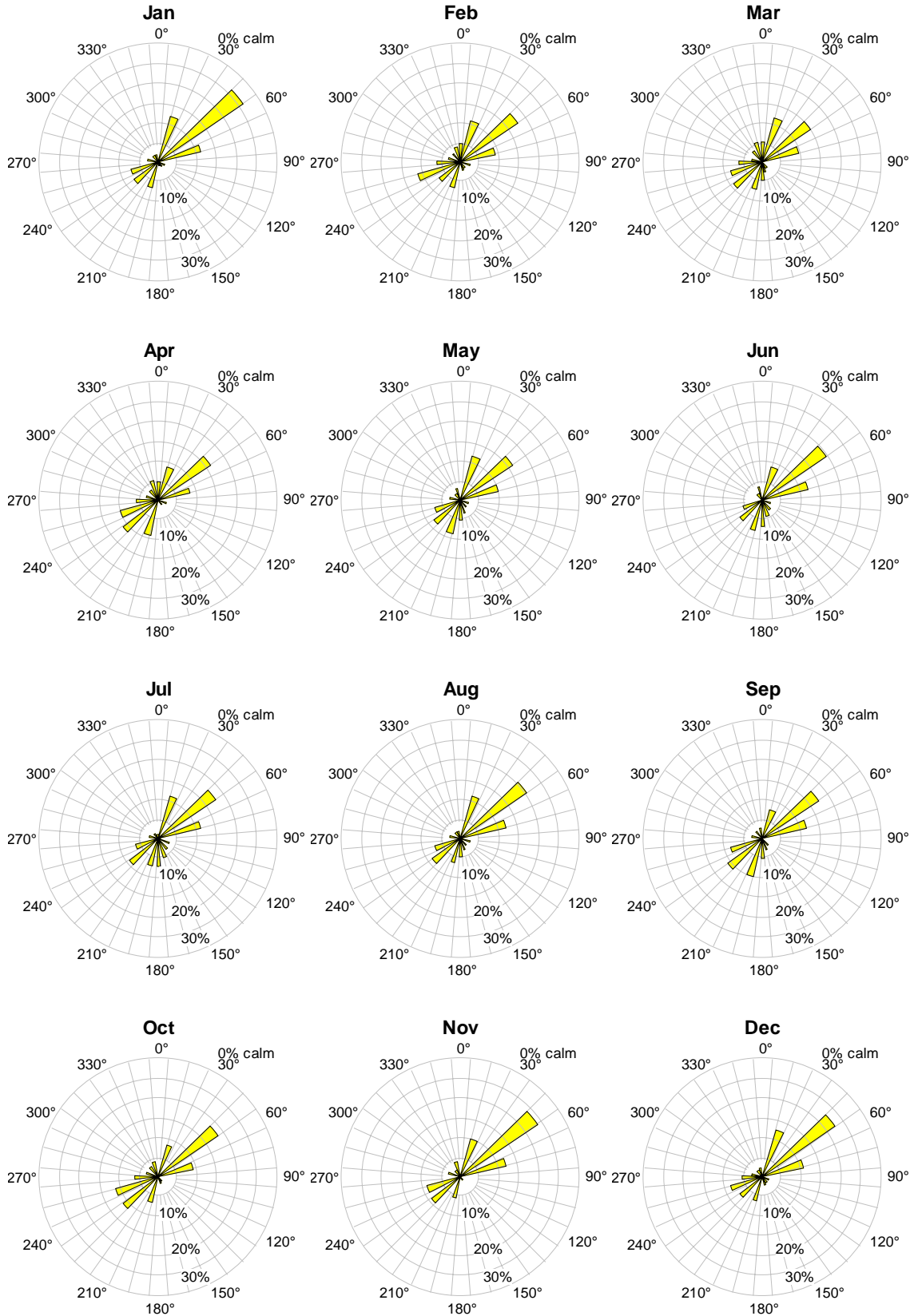


Hourly Wind Speed – By Month

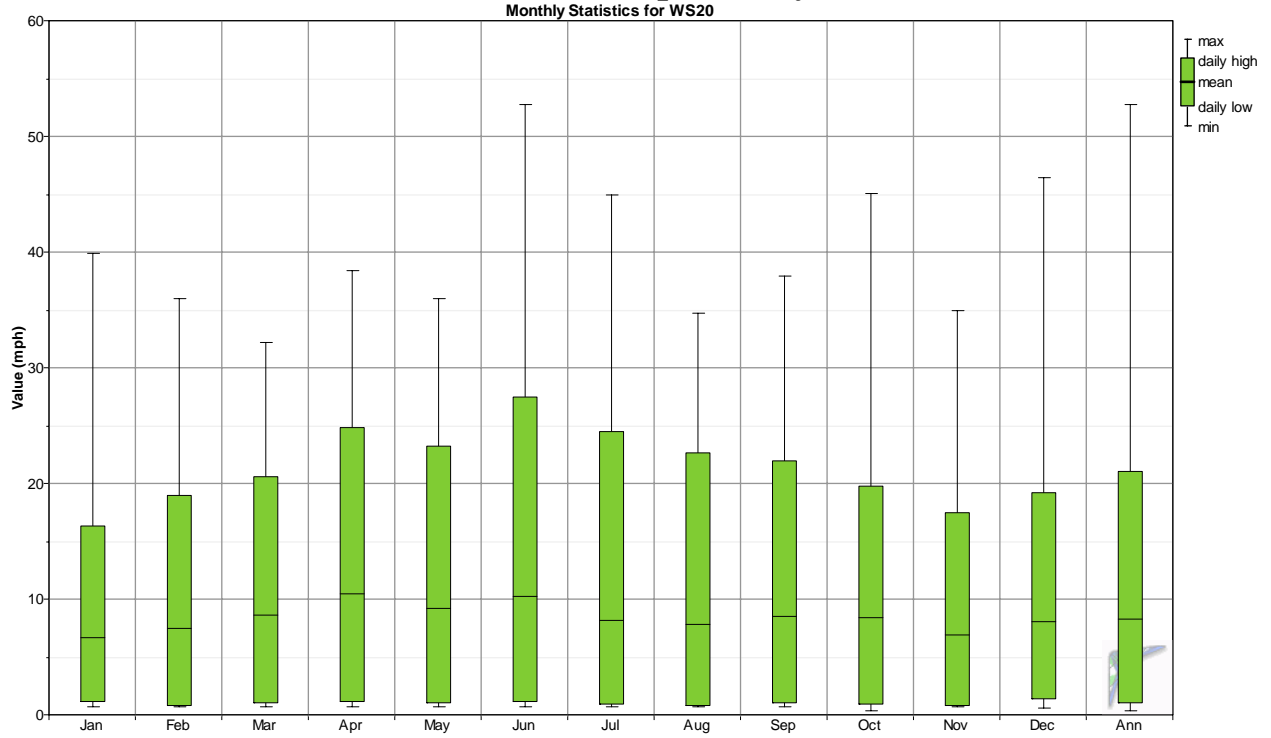




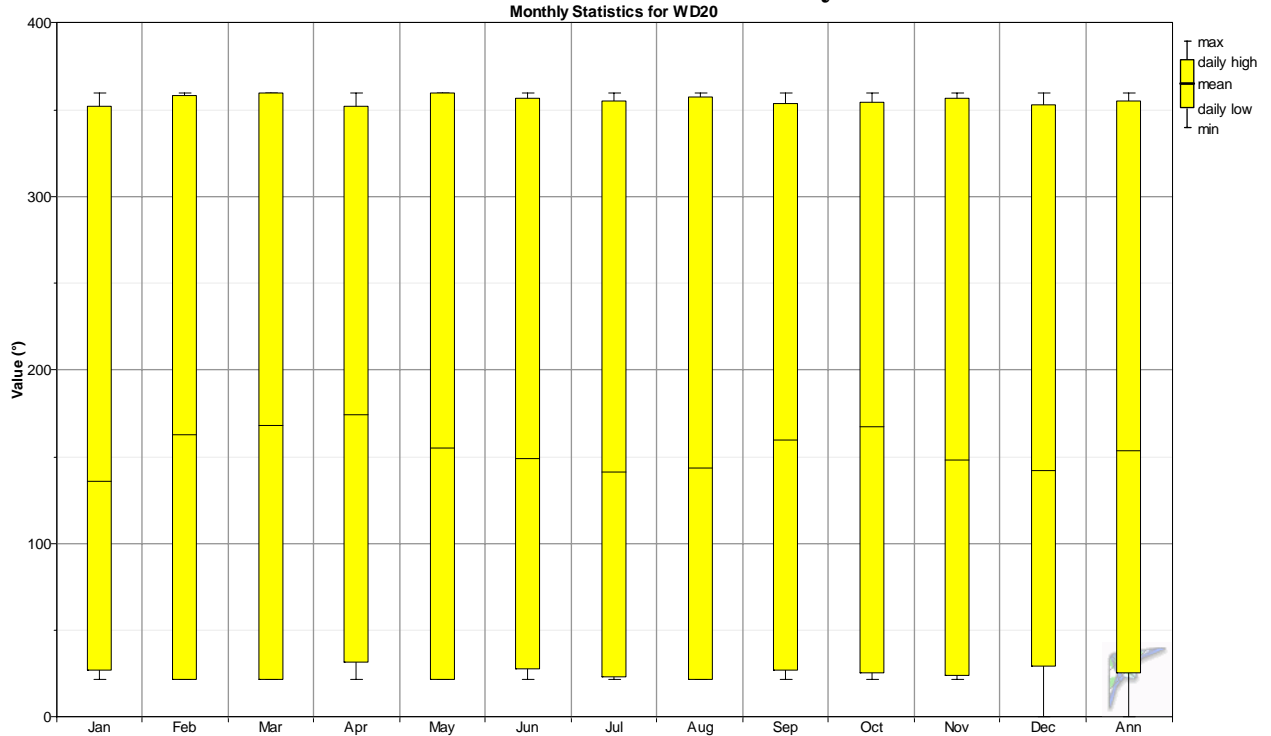
Wind Direction – By Month (All Years)



Box Plot for Wind Speed – By Month



Box Plot for Wind Direction – By Month



Estimated Wind Turbine Performance

The wind resource data from this site was compared against typical small wind turbines at 20m tower height to project the total energy production potential. The table below lists the turbines considered, the estimated turbine costs, and the expected turbine performance:

Turbine	Estimated Turbine Cost (w/o tower)	Rotor Diameter meters	Rotor Power kW	Hub Height meters	Hub Height Wind Speed mph	Time At Zero Output percent	Time At Rated Output percent	Average Net Power Output kW	Average Net Energy Output kWh/yr	Average Net Capacity Factor %
Bergey Excel-R/120V	\$16,560	6.7	7.5	20	8.29	51.6	1.4	0.59	5,130	7.8
Bergey Excel-S/60	\$20,610	6.7	10	20	8.29	31.3	0.6	0.66	5,768	6.6
Bergey XL.1	\$2,650	2.5	1	20	8.29	14.0	1.8	0.09	814	9.3
Southwest Skystream 3.7	\$8,999	3.7	1.8	20	8.29	47.2	0.0	0.17	1,487	9.4
Southwest Whisper 500	\$6,062	4.5	3	20	8.29	51.6	1.6	0.31	2,676	10.2

Note that the costs do **not** include the costs for the tower or labor for installation.



The costs shown above were obtained from publicly available costs on the Internet. For reference, the costs for these turbines were obtained from the following vendor:

*Earth Solar Group
6315 Canyon Dr.
Amarillo, TX 79110
1.800.329.3283
<http://www.earthsolar.com/>*

These turbines are not recommended or endorsed. Landowners interested in installing a turbine are encouraged to contact a wind equipment dealer or a wind developer for design assistance and equipment recommendations.

For reference a local Skystream dealer was contacted for more specific local costs and estimates. For the Skystream 3.7 turbine with a 35 foot pole and bolt kit the cost would be about \$8,200 and an additional \$700 for a 45 foot pole and \$3,200 for a 65 foot pole. The installation cost for these configurations range from \$4,000 to \$5,500 depending on tower height. Further information for the dealer is given below.

*Chris Martin, P.E.
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PO Box 5002
115 Dreamcatcher Rd.
Buena Vista, CO 81211
1.719.395.9255
www.headwatersenergy.com*