



New Mexico State University
Agricultural Science Center at Clovis
Wind Monitoring Project
Annual Performance Report

2011





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Annual Performance Report
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Prepared for:

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50 Meter Tower at New Mexico State University
Agricultural Science Center at Clovis

Wind Monitoring Project

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1 Introduction

This is a summary of results of the 2011 wind monitoring project for the Clovis Agricultural Experiment Station of New Mexico State University. As in previous years, 2011 again showed that the site is “Class IV+ wind site”, with an average annual wind speed of 8.02 m/s at 50 meters¹; a Class IV site is considered suitable for large scale wind energy development.

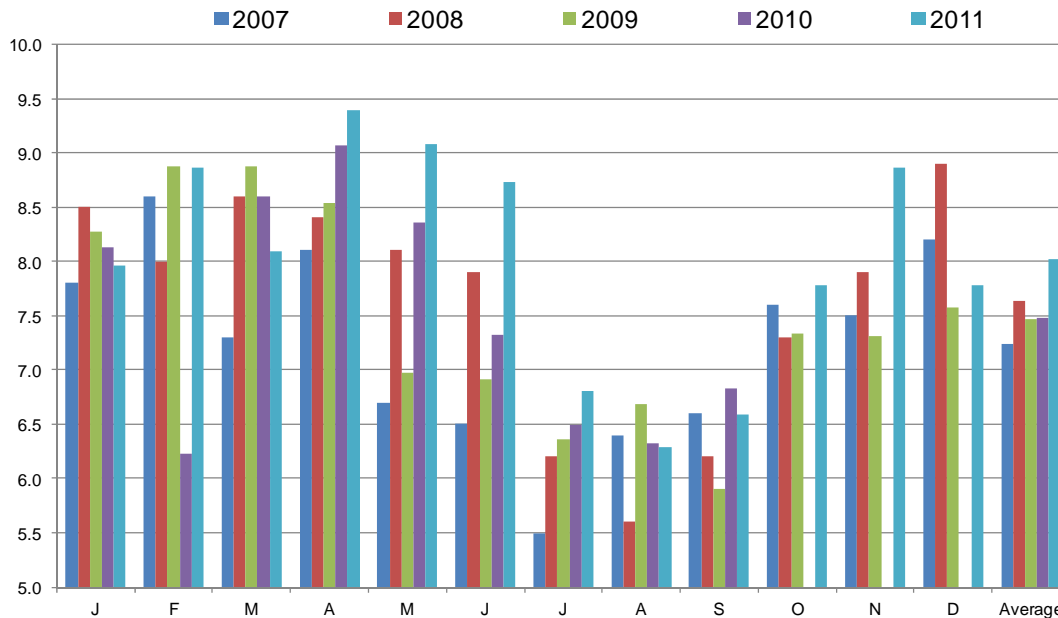
Considering that the tower has been working since November 2006 and that wind energy data for five full years is available now from the site, the results show that this has been the year with the highest wind speed so far. The following table and graph show the monthly average wind speed at 50 meters level which has been collected at the NMSU Clovis Agricultural Experimental Station.

*Average wind speeds at 50 m level for five years
at the NM the NMSU Clovis Agricultural Experimental Station (Table)*

	<i>2007</i>	<i>2008</i>	<i>2009</i>	<i>2010</i>	<i>2011</i>	<i>Monthly Average</i>
<i>January</i>	7.8	8.5	8.27	8.13	7.97	8.13
<i>February</i>	8.6	8	8.87	6.23	8.86	8.11
<i>March</i>	7.3	8.6	8.87	8.60	8.10	8.29
<i>April</i>	8.1	8.4	8.54	9.07	9.40	8.70
<i>May</i>	6.7	8.1	6.97	8.36	9.08	7.84
<i>June</i>	6.5	7.9	6.92	7.32	8.74	7.47
<i>July</i>	5.5	6.2	6.37	6.49	6.80	6.27
<i>August</i>	6.4	5.6	6.68	6.32	6.29	6.26
<i>September</i>	6.6	6.2	5.91	6.83	6.59	6.43
<i>October</i>	7.6	7.3	7.34	N/A	7.78	7.50
<i>November</i>	7.5	7.9	7.32	N/A	8.86	7.89
<i>December</i>	8.2	8.9	7.57	N/A	7.79	8.11
<i>Average</i>	<i>7.23</i>	<i>7.63</i>	<i>7.47</i>	<i>7.48</i>	<i>8.02</i>	<i>7.57</i>

¹ 1 meter = 3.28 ft.

*Average wind speeds at 50 m level for five years
at the NM the NMSU Clovis Agricultural Experimental Station (Graph)*



For 2011 the highest monthly average speed at 50 meters was for April, peaking over 9.49 m/s, and the lowest one was August with 6.26 m/s. The 2011 report incorporates again estimated energy yields for a 1.5 MW wind turbine at 65 m hub height, and the results show that the annual capacity factor was 53%. Furthermore, the long term average speed differences between day and night are also presented; the values with negative percentage indicate that the wind speed during night is less by 3% than during the day for 2011.

The prevailing wind direction for 2011, according to both wind roses at 50 m and 40 m, was the Southwest Quadrant (between 180 and 270 Degrees), with the most available wind energy (combination of prevailing direction and wind speed) coming from the West (270 Degrees).

As noted in the "2010 Yearly Performance Report", the Anemometer 2 at 50 m was not working properly since January 2010, and sometime in October 2010 the Anemometer 1 also started working improperly. Moreover, during October 2011, and probably due to a battery issue, there is not data collected at all by the data logger for the first two days of this month. Thus, data recovery rate for this year was good, but not excellent, reaching just 91.7%.

On the other hand, during January of 2011 all sensors² of the Wind meteorological tower were removed and new calibrated and serial numbered sensors were installed on the tower. These new sensors started working on January 26, 2011, data was collected and verified equipment operation, and since then data collection has been performed successfully. The sensors characteristics are summarized in the following table.

	Description	Details	Height	Model	Serial Number
1	Wind Speed 1 50m m/s	Anemometer 1 (West Side in the tower)	50 m	1900 NRG #40C Anemometer	179500151179
2	Wind Speed 2 50m m/s	Anemometer 2 (East Side in the tower)	50 m	1900 NRG #40C Anemometer	179500151163
3	Wind Speed 3 40m m/s	Anemometer 3 (West Side in the tower)	40 m	1900 NRG #40C Anemometer	179500151187
4	Wind Speed 4 30m m/s	Anemometer 4 (West Side in the tower)	30 m	1900 NRG #40C Anemometer	179500151180
5	Wind Direction 1	Wind Vane 1	50 m	NRG #200P Wind Direction Vane, 10K	N/A
6	Wind Direction 2	Wind Vane 2	40 m	NRG #200P Wind Direction Vane, 10K	N/A

² Excluding the temperature sensor.

This data summary presents the following information:

- *Monthly Average Wind Speed;*
- *Hourly Average Wind Speed;*
- *Frequency Distribution at all Levels*
- *Average Speed: Day vs. Night;*
- *Monthly Yielded Energy for a 1.5 MW Wind Turbine at 65 m Height*
- *Maximum Gust;*
- *Wind Shear;*
- *Turbulence Intensity;*
- *Data Recovery;*
- *Standard Deviation;*
- *Temperature; and*
- *Yearly Wind Direction.*

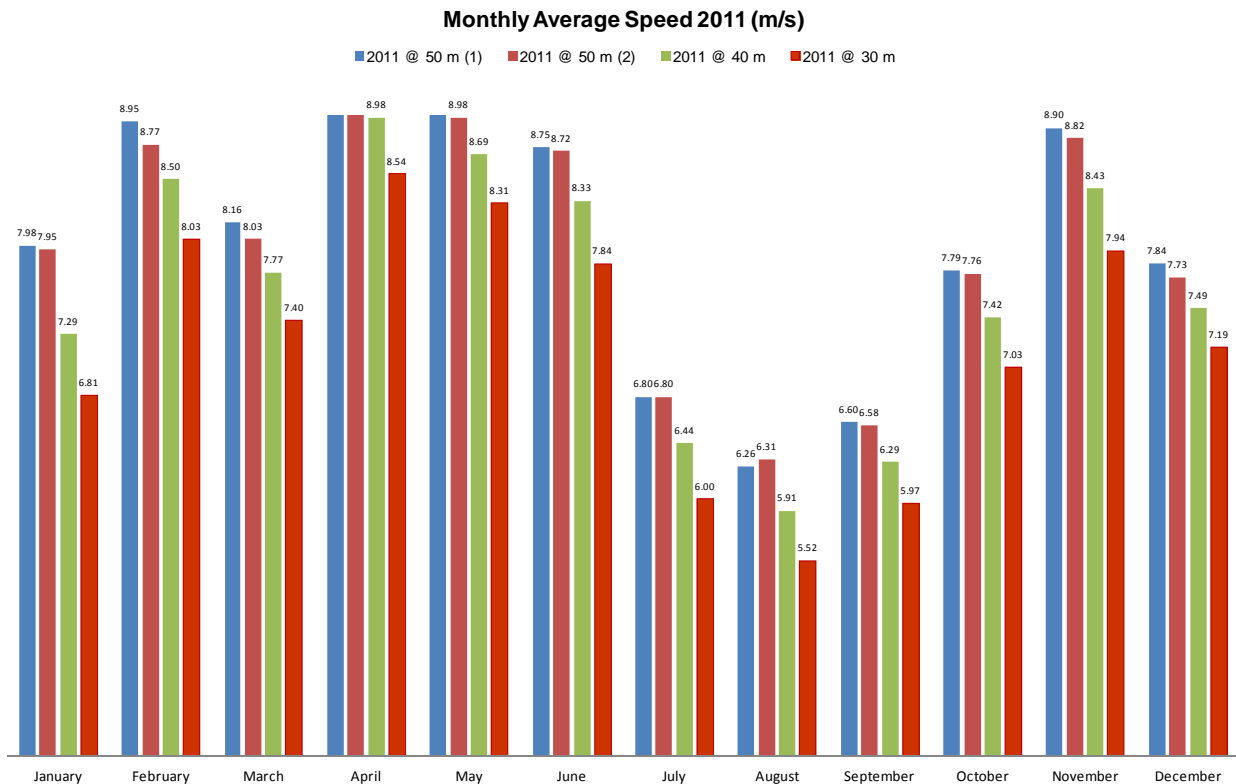
2 Monthly Average Wind Speed

The wind speed is the most important factor for the amount of energy a wind turbine can convert into electricity; the energy that wind has varies with the cube (third power) of the average wind speed. Thus, the filtered raw data results for average wind speed are provided for all three-measurement levels.

Monthly Average Wind Speed 2011 (Table)

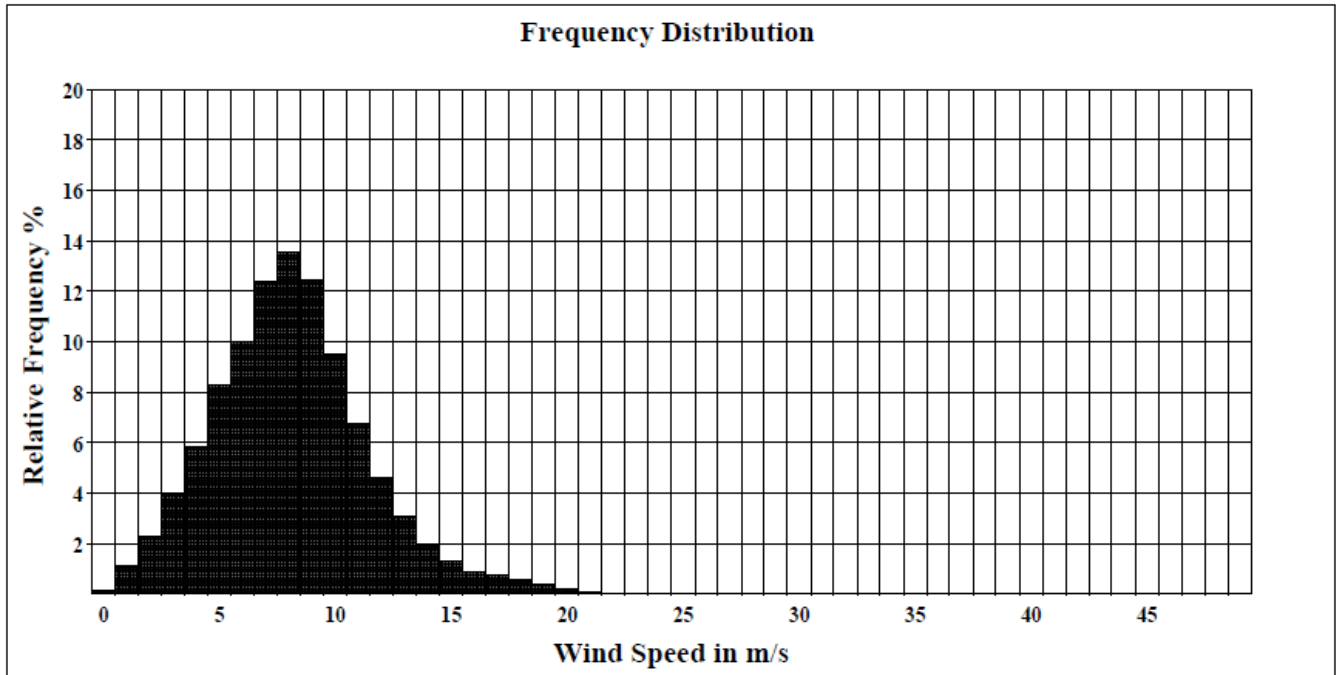
Month	50 m (1)		50 m (2)		40 m		30 m	
	m/s	mph	m/s	mph	m/s	mph	m/s	mph
January	7.98	17.85	7.95	17.78	7.29	16.31	6.81	15.23
February	8.95	20.02	8.77	19.62	8.50	19.01	8.03	17.96
March	8.16	18.25	8.03	17.96	7.77	17.38	7.40	16.55
April	9.49	21.23	9.30	20.80	8.98	20.09	8.54	19.10
May	9.17	20.51	8.98	20.09	8.69	19.44	8.31	18.59
June	8.75	19.57	8.72	19.51	8.33	18.63	7.84	17.54
July	6.8	15.21	6.80	15.21	6.44	14.41	6.00	13.42
August	6.26	14.00	6.31	14.12	5.91	13.22	5.52	12.35
September	6.6	14.76	6.58	14.72	6.29	14.07	5.97	13.35
October	7.79	17.43	7.76	17.36	7.42	16.60	7.03	15.73
November	8.9	19.91	8.82	19.73	8.43	18.86	7.94	17.76
December	7.84	17.54	7.73	17.29	7.49	16.75	7.19	16.08
Average	8.06	18.02	7.98	17.76	7.63	17.06	7.22	16.14

Monthly Average Wind Speed 2011 (Graph)

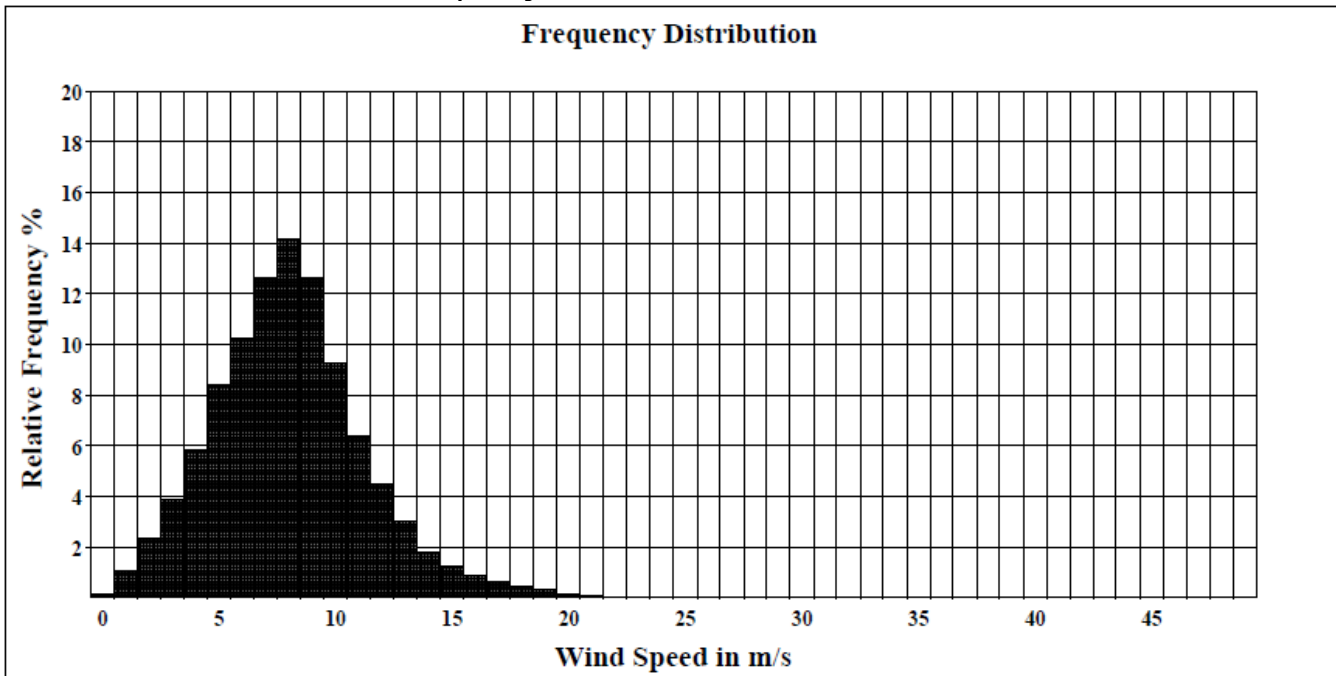


3 Frequency Distribution at all levels

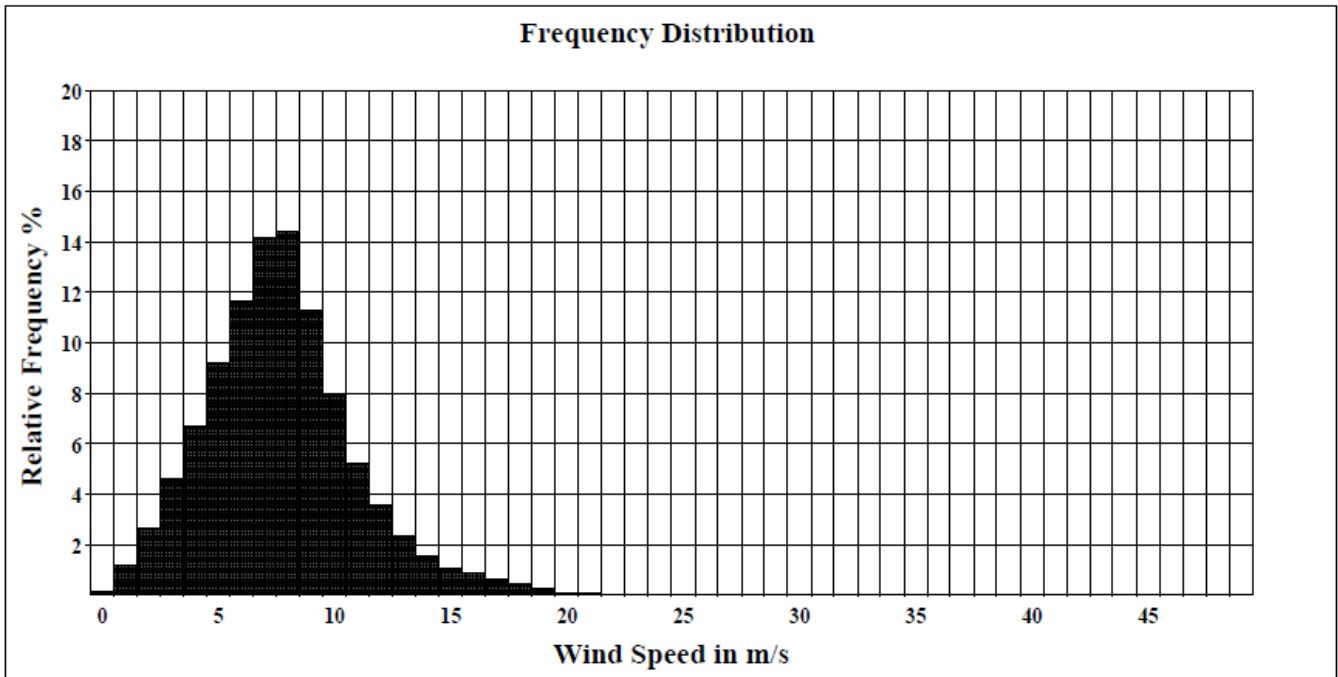
Frequency Distribution @ 50m for 2011 (1)



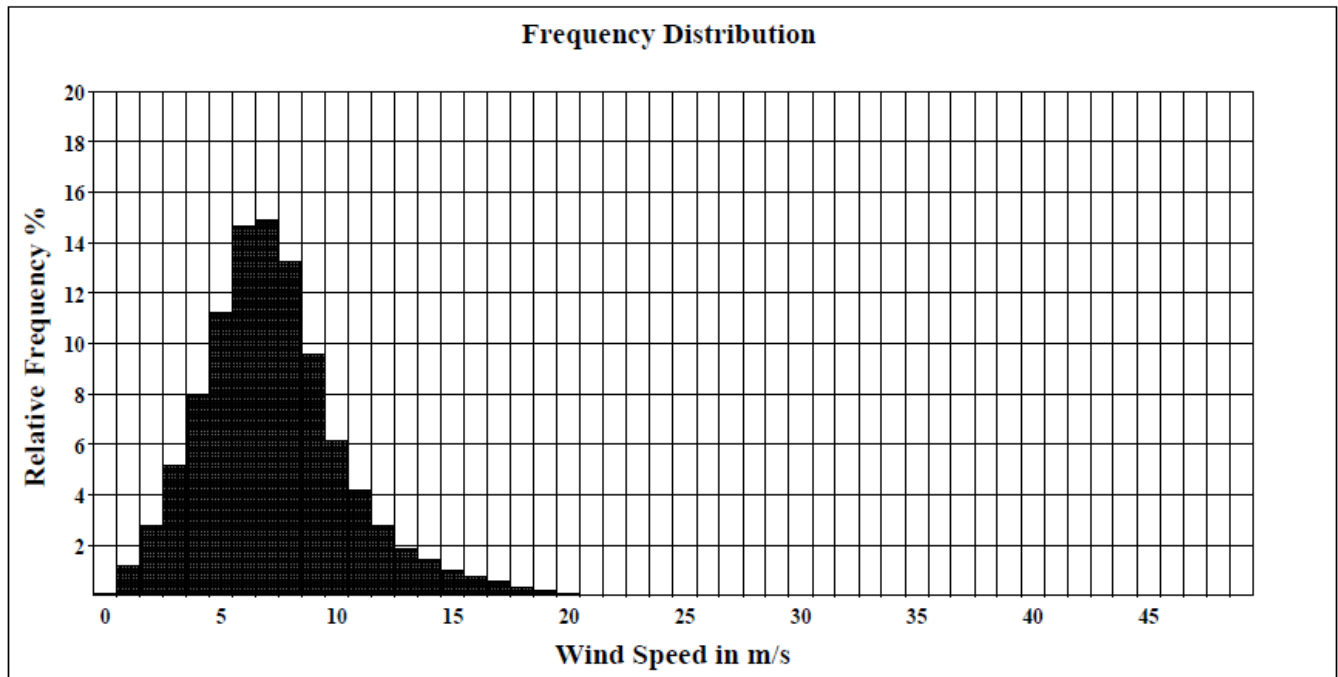
Frequency Distribution @ 50m for 2011 (2)



Frequency Distribution @ 40m for 2011



Frequency Distribution @ 30m for 2011



4 Hourly Average Wind Speed

Hourly Average Wind Speed at 50 m 2011 (m/s)

<i>Hour</i>	<i>JAN</i>	<i>FEB</i>	<i>MAR</i>	<i>APR</i>	<i>MAY</i>	<i>JUN</i>	<i>JUL</i>	<i>AUG</i>	<i>SEP</i>	<i>OCT</i>	<i>NOV*</i>	<i>DEC*</i>
00:00 - 1:00	8.75	8.85	8.20	8.85	9.40	9.25	6.60	6.50	7.45	7.65	8.95	7.45
1:00 - 2:00	9.25	8.90	7.65	8.90	9.45	9.05	6.70	6.40	7.45	7.60	8.90	7.40
2:00 - 3:00	9.95	9.10	8.00	8.45	9.25	9.05	6.55	6.55	7.45	7.50	8.85	7.55
3:00 - 4:00	11.15	8.70	8.20	8.65	9.05	8.55	6.50	6.50	7.30	7.50	9.05	7.60
4:00 - 5:00	10.45	8.80	8.30	8.75	8.55	8.25	6.20	6.40	7.15	7.50	9.00	7.50
5:00 - 6:00	10.70	9.00	8.00	8.60	8.25	7.55	5.85	6.25	6.90	7.40	9.00	7.25
6:00 - 7:00	9.80	8.85	7.80	8.35	7.90	7.55	5.60	5.15	6.20	7.30	8.70	7.20
7:00 - 8:00	7.90	8.40	7.60	9.35	8.45	8.55	6.60	5.55	6.10	7.45	8.50	7.50
8:00 - 9:00	6.20	8.30	7.85	10.20	8.50	8.55	6.40	5.55	6.40	7.85	8.55	7.10
9:00 - 10:00	5.80	9.05	7.65	9.70	8.30	8.35	5.80	5.15	5.90	8.00	8.95	7.25
10:00 - 11:00	6.40	9.25	7.50	9.50	8.20	8.25	5.60	4.90	5.60	7.95	9.50	7.45
11:00 - 12:00	6.15	9.45	7.30	10.00	8.55	8.55	5.75	5.10	5.30	8.10	9.40	8.05
12:00 - 13:00	6.25	9.30	7.85	10.20	9.25	8.75	6.10	5.20	5.40	8.10	9.55	8.35
13:00 - 14:00	6.95	9.45	8.30	10.50	9.70	9.15	6.70	5.60	6.00	7.90	9.25	8.30
14:00 - 15:00	6.50	9.15	8.30	10.55	9.80	9.15	6.90	5.65	6.35	7.65	9.35	8.40
15:00 - 16:00	7.00	9.55	8.45	10.80	10.10	9.20	7.45	6.00	6.10	7.55	9.05	8.15
16:00 - 17:00	6.45	8.90	8.40	10.45	10.20	8.95	7.60	6.70	6.05	7.20	8.50	7.45
17:00 - 18:00	5.90	8.10	7.85	9.95	10.10	9.05	7.90	7.00	6.15	7.50	8.35	8.05
18:00 - 19:00	6.25	8.00	8.00	9.05	9.45	8.70	7.85	7.35	6.85	7.70	8.50	8.25
19:00 - 20:00	5.70	8.45	8.65	9.10	9.00	8.75	8.10	7.85	7.20	8.15	8.30	8.35
20:00 - 21:00	8.10	8.75	8.80	9.10	8.95	9.40	8.40	7.45	7.20	8.60	8.65	8.10
21:00 - 22:00	8.40	8.70	8.85	9.15	9.00	8.85	8.05	7.35	7.15	8.50	8.60	7.90
22:00 - 23:00	6.50	8.60	8.70	8.80	9.30	9.00	7.30	7.30	7.40	7.80	8.70	7.55
23:00 - 24:00	6.85	8.95	8.30	8.55	9.15	9.15	6.80	7.35	7.10	7.60	8.50	7.65
<i>Average</i>	<i>7.95</i>	<i>8.85</i>	<i>8.10</i>	<i>9.40</i>	<i>9.10</i>	<i>8.75</i>	<i>6.80</i>	<i>6.30</i>	<i>6.60</i>	<i>7.80</i>	<i>8.85</i>	<i>7.75</i>

Hourly Average Wind Speed at 50 m 2011 (mph)

<i>Hour</i>	<i>JAN</i>	<i>FEB</i>	<i>MAR</i>	<i>APR</i>	<i>MAY</i>	<i>JUN</i>	<i>JUL</i>	<i>AUG</i>	<i>SEP</i>	<i>OCT</i>	<i>NOV*</i>	<i>DEC*</i>
<i>00:00 - 1:00</i>	19.57	19.80	18.34	19.80	21.03	20.69	14.76	14.54	16.67	17.11	20.02	16.67
<i>1:00 - 2:00</i>	20.69	19.91	17.11	19.91	21.14	20.24	14.99	14.32	16.67	17.00	19.91	16.55
<i>2:00 - 3:00</i>	22.26	20.36	17.90	18.90	20.69	20.24	14.65	14.65	16.67	16.78	19.80	16.89
<i>3:00 - 4:00</i>	24.94	19.46	18.34	19.35	20.24	19.13	14.54	14.54	16.33	16.78	20.24	17.00
<i>4:00 - 5:00</i>	23.38	19.69	18.57	19.57	19.13	18.45	13.87	14.32	15.99	16.78	20.13	16.78
<i>5:00 - 6:00</i>	23.94	20.13	17.90	19.24	18.45	16.89	13.09	13.98	15.43	16.55	20.13	16.22
<i>6:00 - 7:00</i>	21.92	19.80	17.45	18.68	17.67	16.89	12.53	11.52	13.87	16.33	19.46	16.11
<i>7:00 - 8:00</i>	17.67	18.79	17.00	20.92	18.90	19.13	14.76	12.41	13.65	16.67	19.01	16.78
<i>8:00 - 9:00</i>	13.87	18.57	17.56	22.82	19.01	19.13	14.32	12.41	14.32	17.56	19.13	15.88
<i>9:00 - 10:00</i>	12.97	20.24	17.11	21.70	18.57	18.68	12.97	11.52	13.20	17.90	20.02	16.22
<i>10:00 - 11:00</i>	14.32	20.69	16.78	21.25	18.34	18.45	12.53	10.96	12.53	17.78	21.25	16.67
<i>11:00 - 12:00</i>	13.76	21.14	16.33	22.37	19.13	19.13	12.86	11.41	11.86	18.12	21.03	18.01
<i>12:00 - 13:00</i>	13.98	20.80	17.56	22.82	20.69	19.57	13.65	11.63	12.08	18.12	21.36	18.68
<i>13:00 - 14:00</i>	15.55	21.14	18.57	23.49	21.70	20.47	14.99	12.53	13.42	17.67	20.69	18.57
<i>14:00 - 15:00</i>	14.54	20.47	18.57	23.60	21.92	20.47	15.43	12.64	14.20	17.11	20.92	18.79
<i>15:00 - 16:00</i>	15.66	21.36	18.90	24.16	22.59	20.58	16.67	13.42	13.65	16.89	20.24	18.23
<i>16:00 - 17:00</i>	14.43	19.91	18.79	23.38	22.82	20.02	17.00	14.99	13.53	16.11	19.01	16.67
<i>17:00 - 18:00</i>	13.20	18.12	17.56	22.26	22.59	20.24	17.67	15.66	13.76	16.78	18.68	18.01
<i>18:00 - 19:00</i>	13.98	17.90	17.90	20.24	21.14	19.46	17.56	16.44	15.32	17.22	19.01	18.45
<i>19:00 - 20:00</i>	12.75	18.90	19.35	20.36	20.13	19.57	18.12	17.56	16.11	18.23	18.57	18.68
<i>20:00 - 21:00</i>	18.12	19.57	19.69	20.36	20.02	21.03	18.79	16.67	16.11	19.24	19.35	18.12
<i>21:00 - 22:00</i>	18.79	19.46	19.80	20.47	20.13	19.80	18.01	16.44	15.99	19.01	19.24	17.67
<i>22:00 - 23:00</i>	14.54	19.24	19.46	19.69	20.80	20.13	16.33	16.33	16.55	17.45	19.46	16.89
<i>23:00 - 24:00</i>	15.32	20.02	18.57	19.13	20.47	20.47	15.21	16.44	15.88	17.00	19.01	17.11
<i>Average</i>	17.78	19.80	18.12	21.03	20.36	19.57	15.21	14.09	14.76	17.45	19.80	17.34

5 Average Speed: Day vs. Night

Average Speed: Day vs. Night 2011

		50 m (1)	50 m (2)	40 m	30 m
January	Night	1.97	1.87	7.16	6.55
	Day	1.98	1.91	7.20	6.78
	2%	-1%	-2%	-1%	-4%
February	Night	7.88	7.71	7.32	6.75
	Day	8.18	8.04	7.94	7.67
	-8%	-4%	-4%	-9%	-14%
March	Night	8.24	8.21	7.69	7.10
	Day	7.98	7.77	7.76	7.61
	0%	3%	5%	-1%	-7%
April	Night	8.47	8.35	7.76	7.12
	Day	9.76	9.52	9.49	9.30
	-21%	-15%	-14%	-22%	-31%
May	Night	9.02	8.84	8.29	7.65
	Day	9.18	8.98	8.96	8.84
	-7%	-2%	-2%	-8%	-16%
June	Night	8.36	8.38	7.72	7.00
	Day	8.43	8.35	8.24	8.02
	-5%	-1%	0%	-7%	-14%
July	Night	6.96	6.96	6.37	5.69
	Day	6.54	6.54	6.42	6.21
	1%	6%	6%	-1%	-9%
August	Night	6.80	6.86	6.23	5.61
	Day	5.61	5.66	5.49	5.35
	13%	17%	18%	12%	5%
September	Night	6.91	6.88	6.43	5.95
	Day	5.76	5.78	5.66	5.53
	13%	17%	16%	12%	7%
October	Night	7.13	7.11	6.62	6.11
	Day	7.22	7.20	7.03	6.82
	-5%	-1%	-1%	-6%	-12%
November	Night	8.38	8.33	7.77	7.13
	Day	8.74	8.62	8.43	8.14
	-8%	-4%	-3%	-9%	-14%
December	Night	7.39	7.28	6.98	6.64
	Day	7.52	7.40	7.26	6.98
	-3%	-2%	-2%	-4%	-5%
Annual Average	-3%				

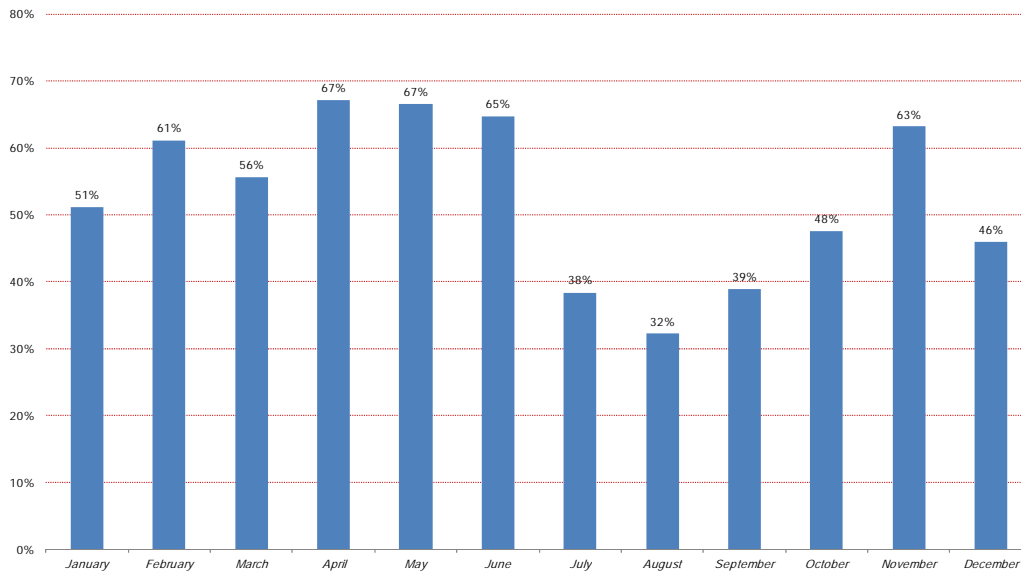
6 Energy Yield and Capacity Factor for 2011

This estimation was performed considering the approximated power curve for the GE 1.5 MW Wind Turbine @ 65 m hub height³. These results are using estimates, thus should not be considered as a feasibility analysis nor be intended as a wind farm development analysis.

Monthly Energy Yield and Capacity Factor for 2011

<i>Month</i>	<i>Capacity Factor %</i>	<i>Yield Energy MWh</i>
<i>January</i>	<i>51%</i>	<i>570.7</i>
<i>February</i>	<i>61%</i>	<i>615.8</i>
<i>March</i>	<i>56%</i>	<i>620.3</i>
<i>April</i>	<i>67%</i>	<i>724.9</i>
<i>May</i>	<i>67%</i>	<i>743.3</i>
<i>June</i>	<i>65%</i>	<i>699.1</i>
<i>July</i>	<i>38%</i>	<i>428.5</i>
<i>August</i>	<i>32%</i>	<i>360.0</i>
<i>September</i>	<i>39%</i>	<i>420.8</i>
<i>October</i>	<i>48%</i>	<i>531.3</i>
<i>November</i>	<i>63%</i>	<i>682.4</i>
<i>December</i>	<i>46%</i>	<i>513.0</i>
<i>Average/Total</i>	<i>53%</i>	<i>6,910.1</i>

Monthly Capacity Factor for 2011 (Graph)



³ The wind speed values at 65 m were calculated using the actual wind shear approximation data from 30 to 50 from this site.

7 Maximum Gust

The maximum wind speeds at the 50 meters level are an indication of the possible high wind speeds that could bring the turbines to stop; depending on their design, wind turbines have different cut-out-out wind speed, that is the highest at which a wind turbine stops producing power.

Maximum Gust at 50 m level 2011

<i>Month</i>	<i>m/s</i>	<i>mph</i>
<i>January</i>	<i>19.7</i>	<i>44.07</i>
<i>February</i>	<i>30.3</i>	<i>67.78</i>
<i>March</i>	<i>26.6</i>	<i>59.50</i>
<i>April</i>	<i>28.5</i>	<i>63.75</i>
<i>May</i>	<i>25.0</i>	<i>55.92</i>
<i>June</i>	<i>29.5</i>	<i>65.99</i>
<i>July</i>	<i>21.6</i>	<i>48.32</i>
<i>August</i>	<i>27.3</i>	<i>61.07</i>
<i>September</i>	<i>22.4</i>	<i>50.11</i>
<i>October</i>	<i>33.3</i>	<i>74.49</i>
<i>November *</i>	<i>27.3</i>	<i>61.07</i>
<i>December *</i>	<i>25.0</i>	<i>55.92</i>
<i>Average</i>	<i>26.38</i>	<i>59.00</i>

8 Wind Shear Exponent

The wind shear exponent represents the degree to which wind speed increases with height. The wind shear exponent was calculated for the 30 to 50-m height. During wind energy farm development, this parameter is used to determine an appropriate wind turbine hub height, and should be determined for each site, since its value depends on the specific characteristics of the site.

Wind Shear Exponent 2011

<i>Month</i>	<i>30 - 50 m Shear</i>
<i>January</i>	<i>0.31</i>
<i>February</i>	<i>0.21</i>
<i>March</i>	<i>0.19</i>
<i>April</i>	<i>0.21</i>
<i>May</i>	<i>0.19</i>
<i>June</i>	<i>0.21</i>
<i>July</i>	<i>0.25</i>
<i>August</i>	<i>0.25</i>
<i>September</i>	<i>0.20</i>
<i>October</i>	<i>0.00</i>
<i>November *</i>	<i>0.21</i>
<i>December *</i>	<i>0.14</i>
<i>Average</i>	<i>0.20</i>

9 Turbulence Intensity

Wind turbulence is the rapid disturbances or irregularities in the wind speed, direction, and vertical component, and it is a relative indicator of turbulence with low levels indicated by values less than or equal to 0.10, moderate levels from 0.11 to 0.25, and high levels greater than 0.25. It is an important site characteristic, because high turbulence levels may decrease power output and cause extreme loading on wind turbine components.

Turbulence Intensity Monthly Average for 2011 @ 50 m

<i>Wind Direction (°)</i>	<i>JAN</i>	<i>FEB</i>	<i>MAR</i>	<i>APR</i>	<i>MAY</i>	<i>JUN</i>	<i>JUL</i>	<i>AUG</i>	<i>SEP</i>	<i>OCT</i>	<i>NOV</i>	<i>DEC</i>	<i>Directional Average</i>
0 (N)	0.08	0.06	0.08	0.12	0.14	0.12	0.10	0.11	0.09	0.09	0.08	0.07	0.10
22.5	N/A	0.08	0.11	0.13	0.15	0.11	0.09	0.11	0.10	0.11	0.09	0.08	0.11
45	N/A	0.04	0.11	0.10	0.13	0.09	0.06	0.10	0.09	0.09	0.11	0.09	0.09
67.5	N/A	N/A	0.09	0.12	0.09	0.11	0.08	0.09	0.09	0.07	0.07	0.10	0.09
90 (E)	N/A	N/A	0.11	0.12	0.09	0.14	0.14	0.13	0.09	0.07	0.08	0.14	0.11
112.5	N/A	0.04	0.09	0.12	0.11	0.11	0.13	0.11	0.12	0.07	0.06	0.14	0.10
135	0.05	0.07	0.06	0.08	0.11	0.10	0.12	0.12	0.10	0.06	0.05	0.13	0.09
157.5	0.05	0.08	0.08	0.07	0.11	0.11	0.14	0.13	0.07	0.08	0.05	0.11	0.09
180 (S)	N/A	0.09	0.09	0.06	0.11	0.11	0.12	0.10	0.07	0.08	0.07	0.10	0.09
202.5	0.09	0.10	0.08	0.10	0.10	0.11	0.12	0.12	0.10	0.08	0.06	0.10	0.10
225	0.21	0.10	0.10	0.10	0.12	0.11	0.10	0.10	0.08	0.10	0.07	0.08	0.11
247.5	0.24	0.09	0.10	0.10	0.12	0.11	0.09	0.09	0.10	0.08	0.07	0.07	0.11
270 (W)	0.06	0.09	0.09	0.10	0.10	0.11	0.10	0.11	0.10	0.08	0.07	0.07	0.09
292.5	0.11	0.09	0.09	0.10	0.09	0.14	0.07	0.18	0.07	0.08	0.07	0.06	0.10
315	0.29	0.11	0.08	0.09	0.10	0.15	0.14	0.12	0.08	0.08	0.06	0.06	0.11
337.5	0.06	0.07	0.07	0.11	0.10	0.16	0.16	0.12	0.10	6.00	0.06	0.06	0.59
Monthly Average	0.12	0.08	0.09	0.10	0.11	0.12	0.11	0.12	0.09	0.45	0.07	0.09	0.13

Turbulence Intensity Monthly Average for 2011 @ 40 m

<i>Wind Direction (°)</i>	<i>JAN</i>	<i>FEB</i>	<i>MAR</i>	<i>APR</i>	<i>MAY</i>	<i>JUN</i>	<i>JUL</i>	<i>AUG</i>	<i>SEP</i>	<i>OCT</i>	<i>NOV</i>	<i>DEC</i>	<i>Directional Average</i>
0 (N)	0.07	0.09	0.08	0.13	0.16	0.13	0.11	0.12	0.10	0.09	0.08	0.07	0.10
22.5	0.10	0.08	0.12	0.15	0.16	0.13	0.10	0.12	0.11	0.13	0.10	0.10	0.12
45	0.08	0.07	0.11	0.11	0.13	0.09	0.07	0.11	0.09	0.09	0.11	0.08	0.10
67.5	0.07	N/A	0.10	0.12	0.10	0.11	0.08	0.10	0.10	0.07	0.08	0.10	0.09
90 (E)	0.07	N/A	0.09	0.12	0.09	0.14	0.12	0.12	0.08	0.08	0.06	0.13	0.10
112.5	0.09	0.04	0.08	0.12	0.11	0.09	0.13	0.11	0.11	0.06	0.06	0.12	0.09
135	0.07	0.08	0.07	0.09	0.12	0.11	0.12	0.12	0.11	0.07	0.06	0.15	0.10
157.5	0.07	0.10	0.10	0.08	0.12	0.13	0.14	0.14	0.09	0.10	0.07	0.13	0.11
180 (S)	0.08	0.09	0.09	0.07	0.12	0.12	0.13	0.11	0.08	0.09	0.07	0.10	0.10
202.5	0.07	0.10	0.09	0.11	0.10	0.12	0.13	0.13	0.11	0.09	0.07	0.12	0.10
225	0.08	0.11	0.11	0.11	0.12	0.11	0.11	0.11	0.08	0.10	0.07	0.08	0.10
247.5	0.09	0.12	0.11	0.10	0.12	0.11	0.09	0.10	0.11	0.08	0.07	0.07	0.10
270 (W)	0.08	0.10	0.10	0.11	0.11	0.12	0.10	0.11	0.10	0.09	0.09	0.07	0.10
292.5	0.09	0.10	0.09	0.11	0.09	0.14	0.06	0.14	0.07	0.08	0.07	0.07	0.09
315	0.08	0.11	0.08	0.10	0.10	0.16	0.17	0.14	0.09	0.06	0.06	0.07	0.10
337.5	0.07	0.08	0.08	0.11	0.10	0.17	0.17	0.13	0.10	0.07	0.07	0.07	0.10
<i>Monthly Average</i>	<i>0.08</i>	<i>0.09</i>	<i>0.09</i>	<i>0.11</i>	<i>0.12</i>	<i>0.12</i>	<i>0.11</i>	<i>0.12</i>	<i>0.10</i>	<i>0.08</i>	<i>0.07</i>	<i>0.10</i>	<i>0.10</i>

10 Temperature

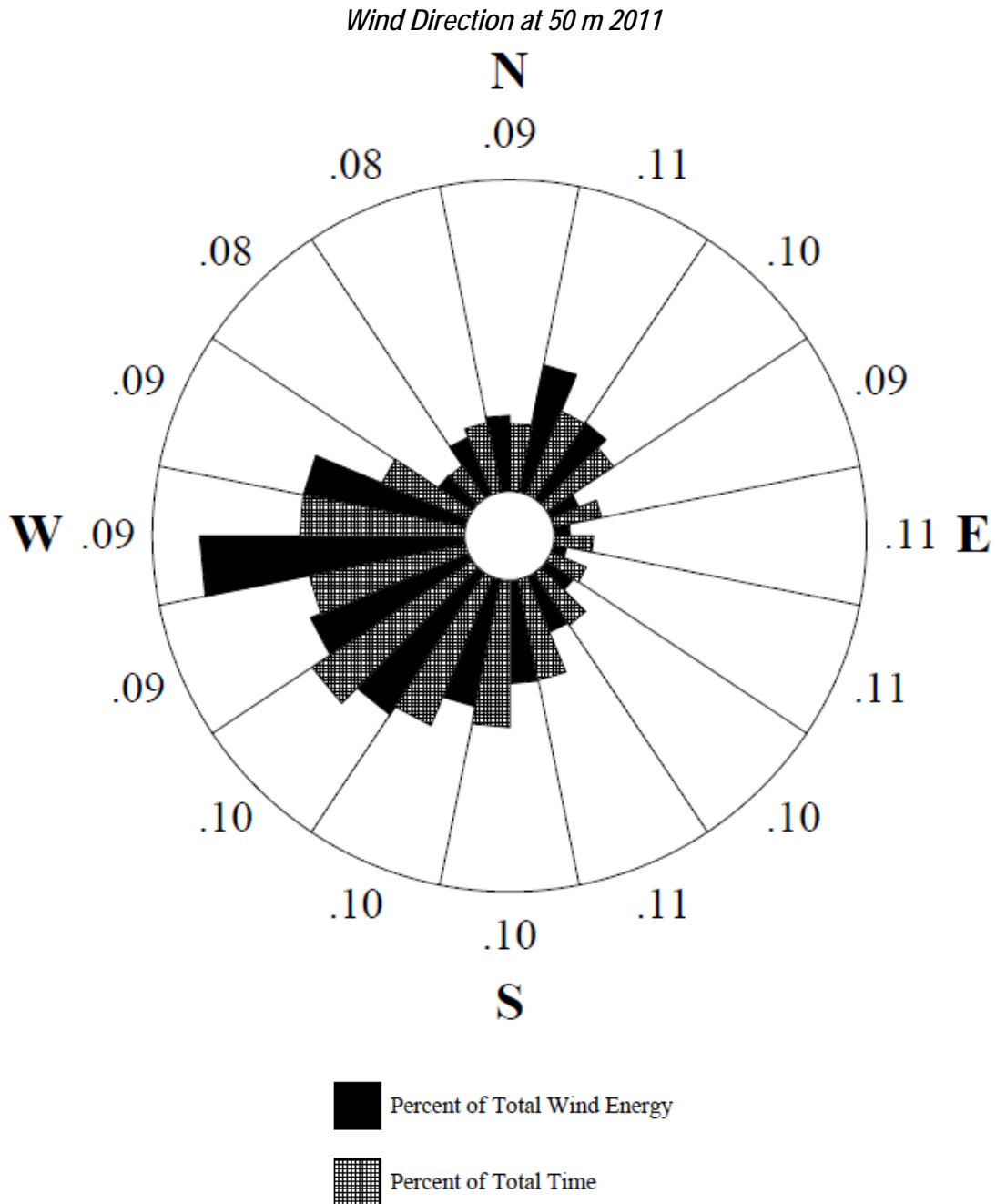
Air temperature is an important parameter of how a wind energy farm can perform and is normally measured either near ground level or near hub height. In most locations the average near ground level air temperature will be within 1°C of the average at hub height. It is also used to calculate air density, a variable required to estimate the wind power density and the power output of a wind turbine. Therefore; average, minimum and maximum temperature data is gathered and reported in the following tables.

Temperature Ranges 2011

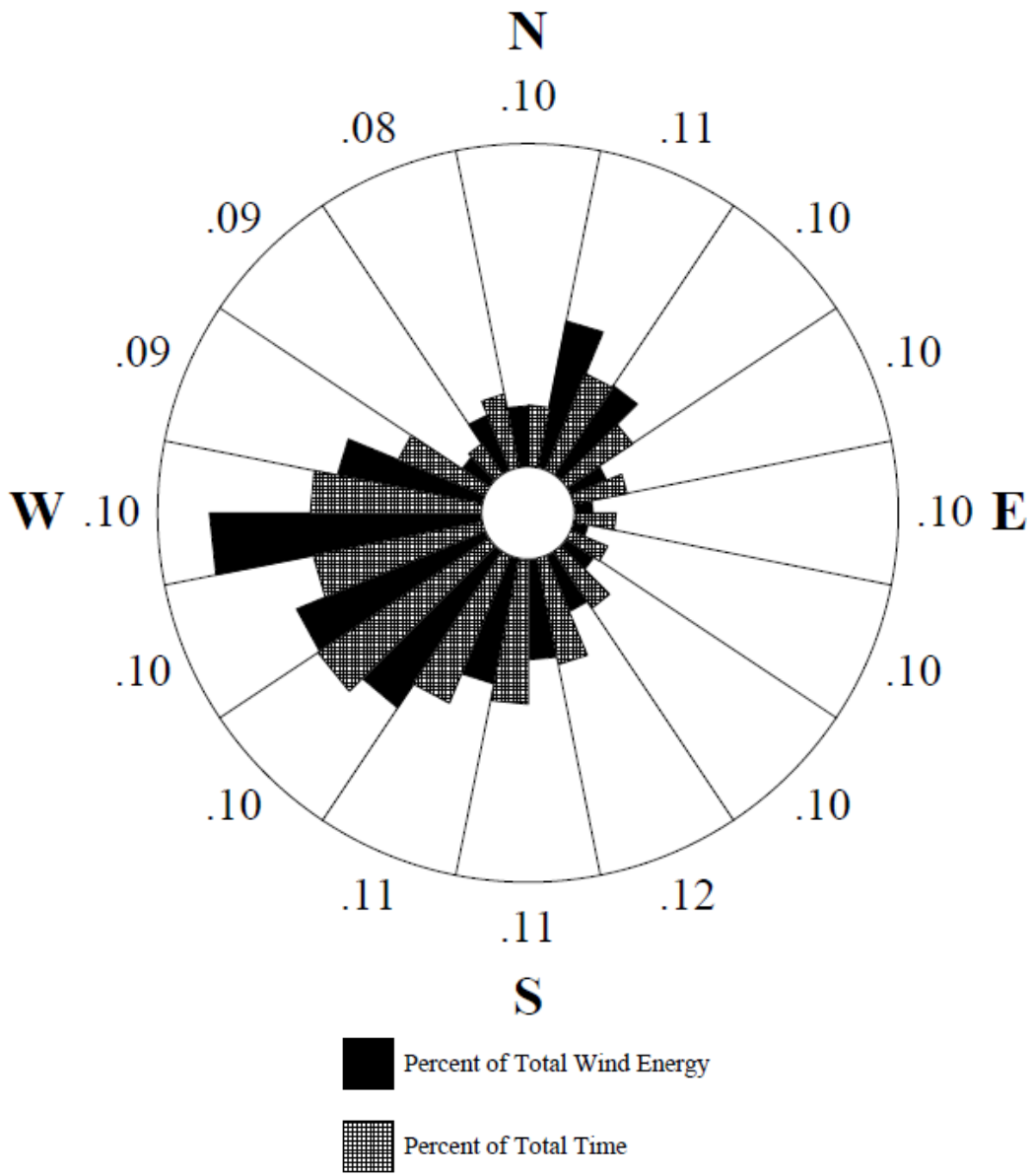
<i>Month</i>	<i>Average</i>		<i>Minimum</i>		<i>Maximum</i>	
	<i>Celsius</i>	<i>Fahrenheit</i>	<i>Celsius</i>	<i>Fahrenheit</i>	<i>Celsius</i>	<i>Fahrenheit</i>
<i>January</i>	2.8	37.0	-16.1	3.0	23.3	73.9
<i>February</i>	2.75	37.0	-23.3	-9.9	25.6	78.1
<i>March</i>	11.3	52.4	-2.9	26.8	28.9	84.0
<i>April</i>	15.9	60.7	-0.5	31.1	31.4	88.5
<i>May</i>	19.1	66.5	-1.1	30.0	37	98.6
<i>June</i>	26.8	80.2	13.1	55.6	40.6	105.1
<i>July</i>	27.8	82.2	16.8	62.2	38.8	101.8
<i>August</i>	27.5	81.5	17.7	63.9	39.7	103.5
<i>September</i>	20.7	69.4	8.9	48.0	35.9	96.6
<i>October</i>	14.4	58.0	-0.8	30.6	31.4	88.5
<i>November</i>	8.1	46.7	-6.7	19.9	25.7	78.3
<i>December</i>	0.9	33.7	-18.9	-2.0	19.6	67.3
<i>Average</i>	14.9	58.8	-1.2	29.9	32.2	88.7

11 Wind Direction

The wind direction information is important and a useful tool for siting wind turbines. It is important to know the distributions and the frequency of the varying wind directions. The different spots pie shaped wedges show what percentage of time the wind blows from that direction or the relative frequency of each one of the sixteen wind directions. The black wedges indicate the energy available at the wind blowing from that direction, and the shaded ones the percent of total time that the wind blows from such direction.



Wind Direction at 40 m 2011



12 Data Recovery

Recovery rates for wind speed data are calculated at all heights. The “Recovery Rate” represents the remaining data expressed as a percentage of total sensor hours in the period. The purpose of installing redundant sensors at the highest level is to ensure that even in the event of a sensor failure, data are still being collected.

Data Recovery Rates 2011

	Total Hours in period	Monthly Recovery Rate			Recovery Rate All Heights	Upper Level
		50 m (average both sensors)	40 m	30 m		
<i>January</i>	744	16%	87%	86%	51.6%	16.4%
<i>February</i>	672	100%	100%	100%	100.0%	100.0%
<i>March</i>	744	98%	98%	98%	98.4%	98.4%
<i>April</i>	720	100%	100%	100%	100.0%	100.0%
<i>May</i>	744	100%	100%	100%	100.0%	100.0%
<i>June</i>	720	99%	99%	99%	99.0%	99.0%
<i>July</i>	744	100%	100%	100%	100.0%	100.0%
<i>August</i>	744	100%	100%	100%	100.0%	100.0%
<i>September</i>	720	100%	100%	100%	100.0%	100.0%
<i>October</i>	744	91%	91%	91%	91.2%	91.3%
<i>November</i>	720	100%	100%	100%	100.0%	100.0%
<i>December</i>	744	96%	95%	95%	95.5%	95.6%
Average		92%	98%	98%	94.6%	91.7%

13 Standard Deviation

According to the “Wind Resource Assessment Handbook” (NREL, 1997), the standard deviation is defined as the true population standard deviation for all one or two second samples within each averaging interval. The standard deviations of wind speed and wind direction are indicators of turbulence level and atmospheric stability. It is also useful in detecting suspect or erroneous data when validating average values.

Average Internal Standard Deviation for 2011

	50 m (1)	50 m (2)	40 m	30 m
<i>January</i>	<i>0.93</i>	<i>0.91</i>	<i>0.64</i>	<i>0.64</i>
<i>February</i>	<i>0.73</i>	<i>0.76</i>	<i>0.76</i>	<i>0.78</i>
<i>March</i>	<i>0.76</i>	<i>0.77</i>	<i>0.77</i>	<i>0.78</i>
<i>April</i>	<i>0.98</i>	<i>1.01</i>	<i>1.00</i>	<i>0.99</i>
<i>May</i>	<i>0.98</i>	<i>1.01</i>	<i>1.01</i>	<i>1.00</i>
<i>June</i>	<i>0.98</i>	<i>1.00</i>	<i>1.00</i>	<i>1.01</i>
<i>July</i>	<i>0.82</i>	<i>0.82</i>	<i>0.84</i>	<i>0.84</i>
<i>August</i>	<i>0.75</i>	<i>0.75</i>	<i>0.77</i>	<i>0.77</i>
<i>September</i>	<i>0.69</i>	<i>0.69</i>	<i>0.7</i>	<i>0.71</i>
<i>October</i>	<i>0.70</i>	<i>0.71</i>	<i>0.72</i>	<i>0.73</i>
<i>November</i>	<i>0.68</i>	<i>0.71</i>	<i>0.71</i>	<i>0.72</i>
<i>December</i>	<i>0.63</i>	<i>0.65</i>	<i>0.66</i>	<i>0.68</i>
<i>Average</i>	<i>0.80</i>	<i>0.82</i>	<i>0.80</i>	<i>0.80</i>