



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

2009





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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 document presents a summary of results of the 2009 wind monitoring results for the Clovis Agricultural Experiment Station of New Mexico State University. The tower was installed in November 2006 with continuous monitoring since. As in previous years, 2009 again showed that the site is “Class IV+ wind site”, with an average annual wind speed of 7.5 m/s at 50 meters; a Class IV site is considered suitable for large scale wind energy development.

The 2009 report also now incorporates estimated energy yields for a 1.5 MW wind turbine at 65 m hub height, as well as the potential windfarm capacity factor; which for 2009 was approximately 47%. 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 than during the day for 2009. As in past years, the prevailing wind direction for 2009, according to the wind roses at 40 m and 50 m, was the Southwest Quadrant (between 180 and 270 Degrees).

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.

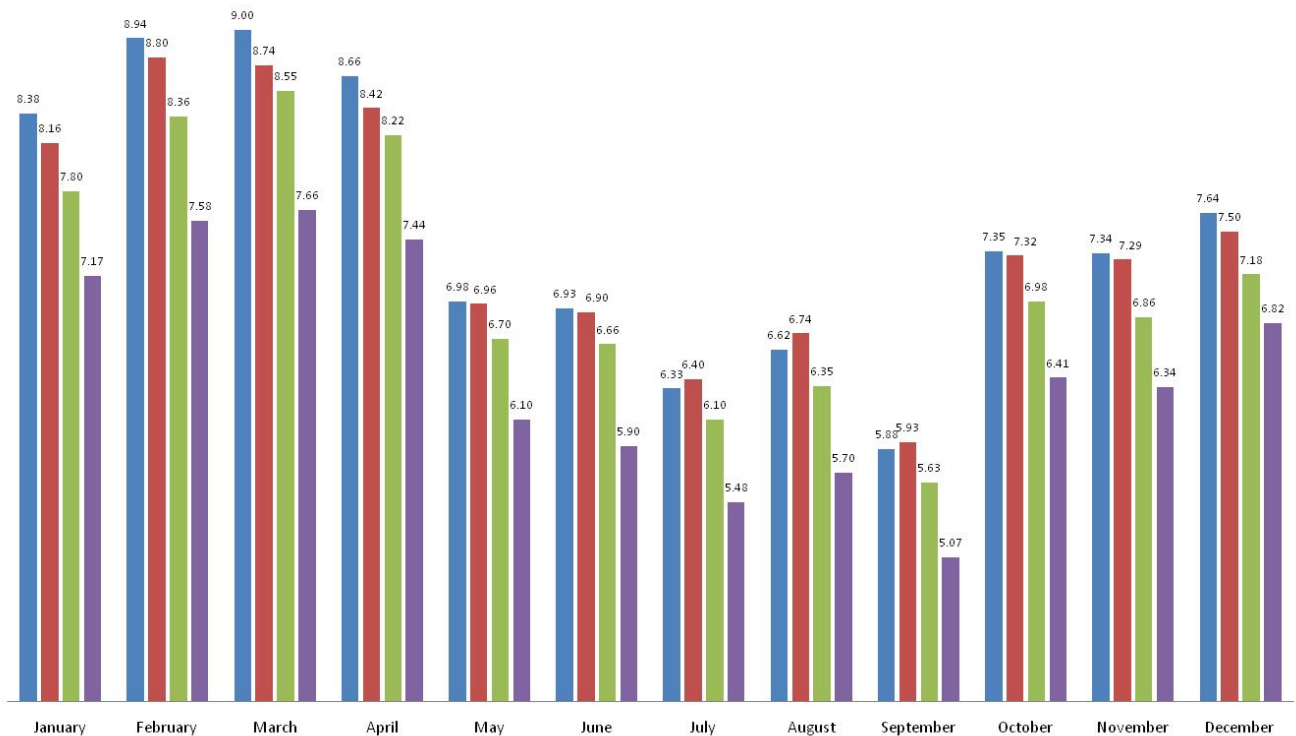
Monthly Average Wind Speed 2009 (Table)

Month	50 m (1)		50 m (2)		40 m		30 m	
	m/s	mph	m/s	mph	m/s	mph	m/s	mph
January	8.38	18.75	8.16	18.25	7.80	17.45	7.17	16.04
February	8.94	20.00	8.80	19.69	8.36	18.70	7.58	16.96
March	9.00	20.13	8.74	19.55	8.55	19.13	7.66	17.13
April	8.66	19.37	8.42	18.84	8.22	18.39	7.44	16.64
May	6.98	15.61	6.96	15.57	6.70	14.99	6.10	13.65
June	6.93	15.50	6.90	15.43	6.66	14.90	5.90	13.20
July	6.33	14.16	6.40	14.32	6.10	13.65	5.48	12.26
August	6.62	14.81	6.74	15.08	6.35	14.20	5.70	12.75
September	5.88	13.15	5.93	13.27	5.63	12.59	5.07	11.34
October	7.35	16.44	7.32	16.37	6.98	15.61	6.41	14.34
November	7.34	16.42	7.29	16.31	6.86	15.35	6.34	14.18
December	7.64	17.09	7.50	16.78	7.18	16.06	6.82	15.26
Average	7.50	16.79	7.43	16.62	7.12	15.92	6.47	14.48

Monthly Average Wind Speed 2009 (Graph)

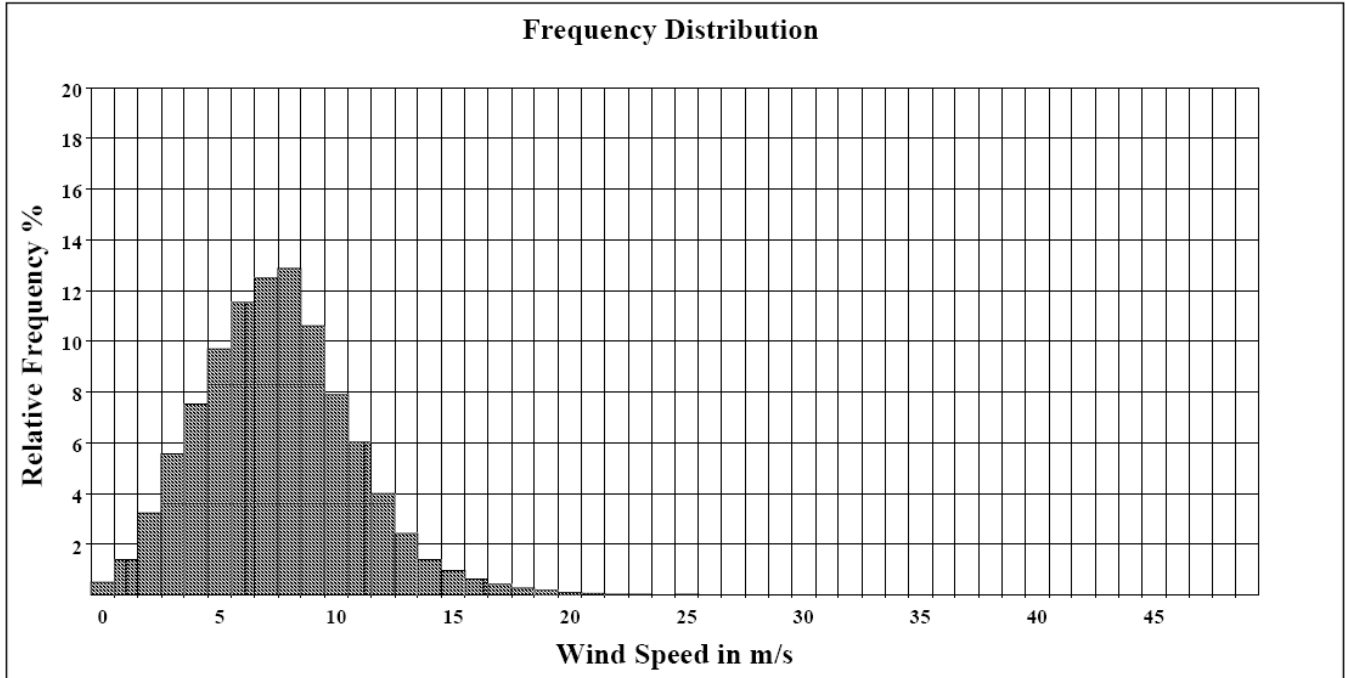
Monthly Average Speed 2009 (m/s)

■ 2009 (1) @ 50 m ■ 2009 (2) @ 50 m ■ 2009 @ 40 m ■ 2009 @ 30 m

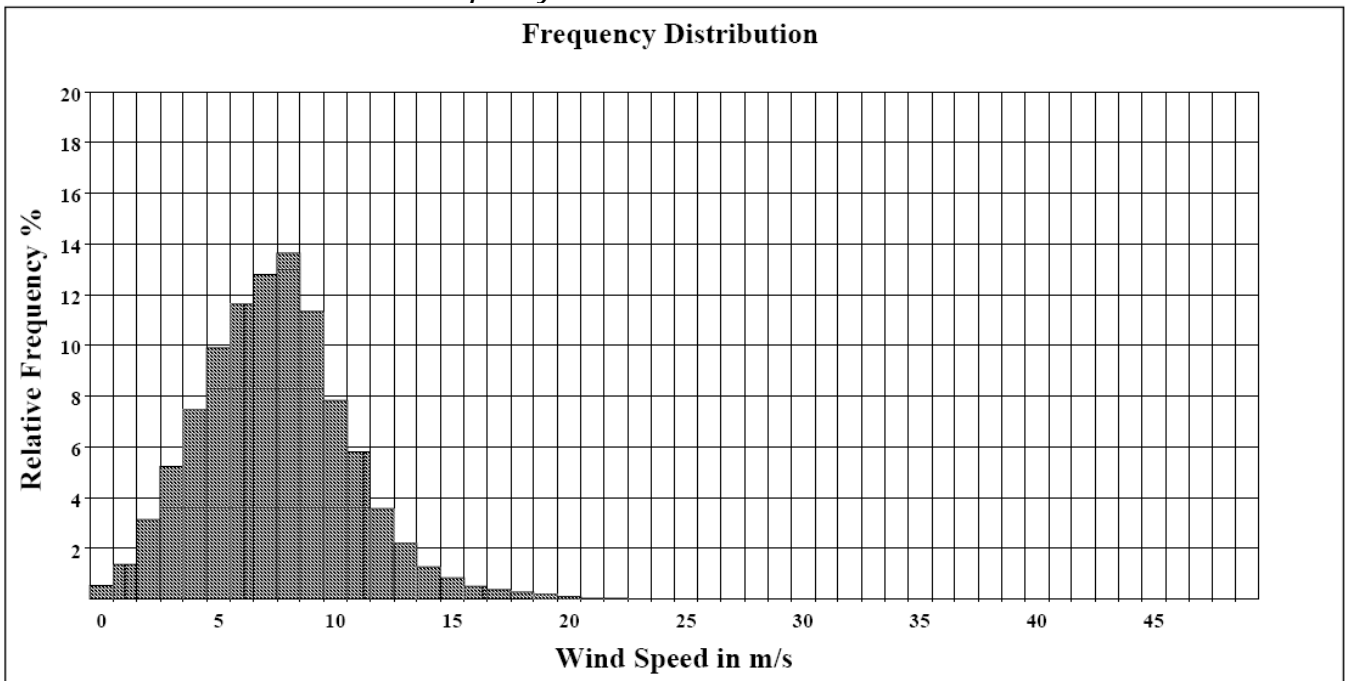


3 Frequency Distribution at all levels

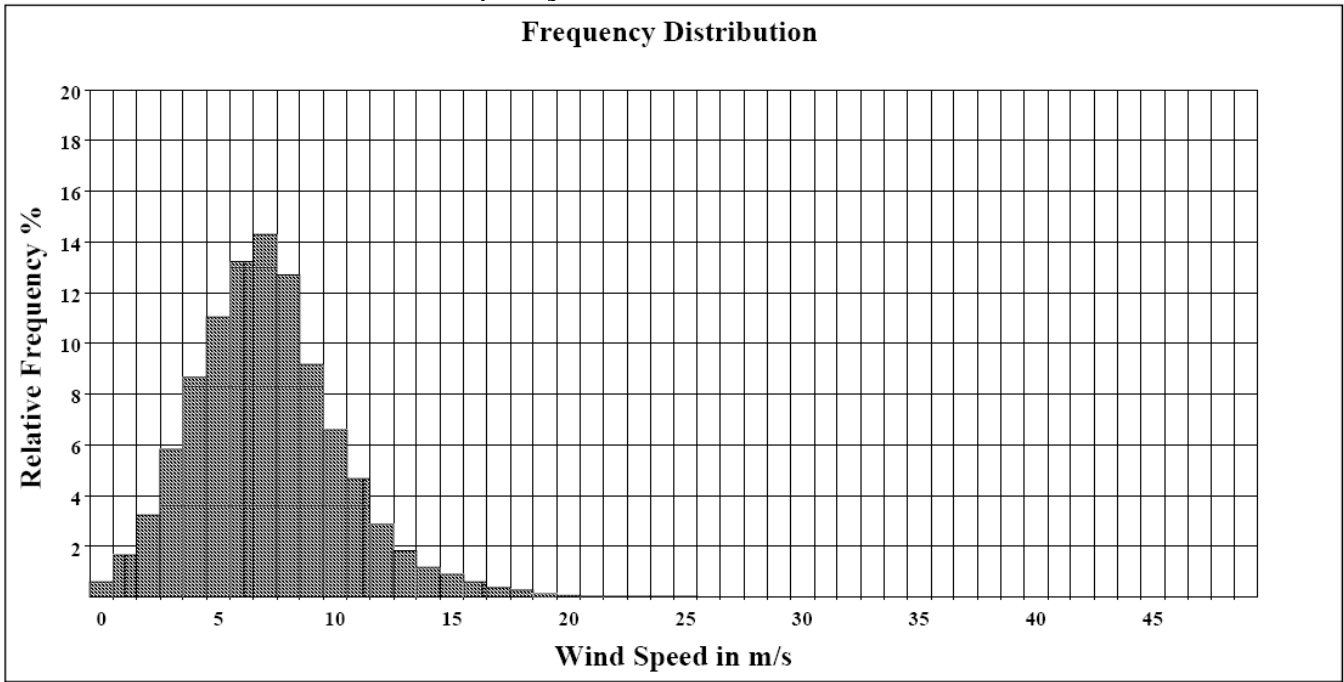
Frequency Distribution @ 50m for 2009



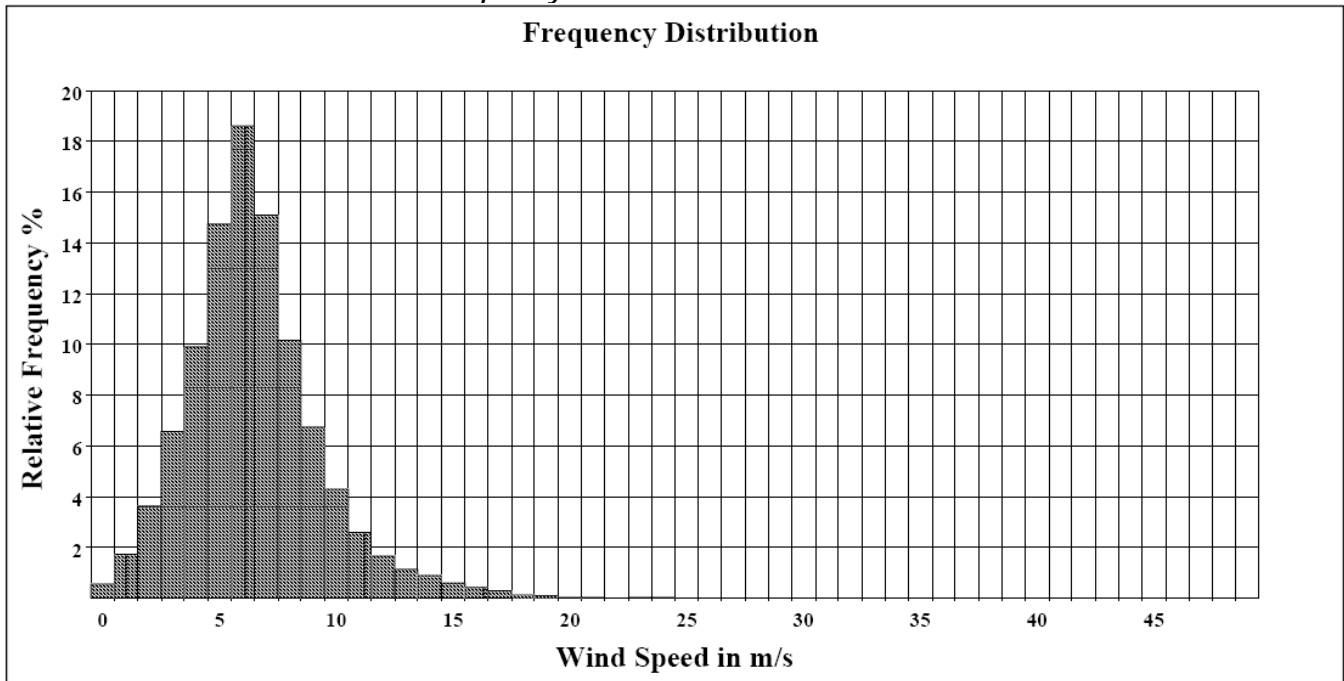
Frequency Distribution 2 @ 50m for 2009



Frequency Distribution @ 40m for 2009



Frequency Distribution @ 30m for 2009



4 Hourly Average Wind Speed

Hourly Average Wind Speed 2009 (m/s)

Hour	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
00:00 - 1:00	8.75	9.70	8.85	9.15	7.15	6.50	6.55	7.25	6.15	7.10	7.90	8.20
1:00 - 2:00	8.95	9.35	8.95	8.50	7.00	6.65	6.10	7.25	5.85	6.90	7.60	8.05
2:00 - 3:00	9.70	9.15	8.90	8.80	7.00	6.45	6.20	6.95	5.65	7.00	7.25	7.95
3:00 - 4:00	9.10	9.35	8.60	8.90	6.70	6.20	6.05	6.10	5.55	7.00	7.50	8.00
4:00 - 5:00	9.60	9.05	8.80	8.60	6.45	6.45	5.95	6.05	5.50	6.75	7.65	7.95
5:00 - 6:00	9.50	8.95	8.85	8.25	6.15	5.65	5.95	6.30	5.50	6.95	7.55	7.75
6:00 - 7:00	9.25	8.65	8.15	7.75	6.50	5.40	5.90	5.95	5.30	6.55	7.65	7.95
7:00 - 8:00	8.30	8.25	7.70	8.20	6.95	6.30	6.10	6.25	5.30	6.35	7.45	7.30
8:00 - 9:00	7.30	8.25	8.30	8.90	6.55	6.60	6.20	6.75	5.70	6.75	6.95	6.75
9:00 - 10:00	6.85	8.60	9.00	9.05	6.10	6.55	5.95	6.45	5.65	7.30	7.15	6.95
10:00 - 11:00	7.25	9.00	9.15	8.65	5.90	6.50	5.55	6.10	5.75	7.60	7.10	7.05
11:00 - 12:00	7.15	8.60	9.65	8.20	5.90	6.40	5.45	5.85	5.35	7.75	7.20	7.20
12:00 - 13:00	7.25	8.65	9.70	8.40	6.00	6.90	5.45	5.85	5.25	7.80	7.10	7.60
13:00 - 14:00	7.10	8.60	9.45	8.25	6.20	7.40	6.05	6.00	5.50	7.80	6.95	7.45
14:00 - 15:00	7.30	8.75	9.55	8.60	6.35	7.35	6.00	6.45	5.35	7.75	6.85	7.10
15:00 - 16:00	6.75	8.85	9.10	8.60	6.80	7.85	6.15	6.80	5.85	7.70	6.80	6.70
16:00 - 17:00	7.10	8.25	8.60	8.50	7.45	8.35	6.85	7.00	6.55	7.60	6.90	6.55
17:00 - 18:00	7.60	8.15	8.20	8.50	8.30	8.40	7.45	7.50	6.35	7.80	7.40	7.15
18:00 - 19:00	7.70	8.65	8.20	8.10	8.40	8.00	7.55	7.25	6.75	7.95	7.45	7.60
19:00 - 20:00	8.45	8.55	8.55	8.50	7.90	7.50	7.25	6.95	6.80	8.00	7.30	7.90
20:00 - 21:00	9.10	9.40	9.15	8.40	7.90	7.55	6.95	7.35	6.75	7.75	7.15	7.85
21:00 - 22:00	9.40	9.40	9.15	8.65	7.95	7.00	6.85	7.45	6.35	7.55	7.25	7.95
22:00 - 23:00	9.40	9.15	9.10	8.70	8.05	7.15	7.05	6.95	6.35	7.30	7.65	8.15
23:00 - 24:00	8.60	9.55	8.90	8.80	7.65	6.75	7.15	7.10	6.55	7.15	7.90	8.50
Average	8.30	8.85	8.85	8.55	7.00	6.90	6.35	6.65	5.90	7.35	7.30	7.55

Hourly Average Wind Speed 2009 (mph)

Hour	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
00:00 - 1:00	19.57	21.70	19.80	20.47	15.99	14.54	14.65	16.22	13.76	15.88	17.67	18.34
1:00 - 2:00	20.02	20.92	20.02	19.01	15.66	14.88	13.65	16.22	13.09	15.43	17.00	18.01
2:00 - 3:00	21.70	20.47	19.91	19.69	15.66	14.43	13.87	15.55	12.64	15.66	16.22	17.78
3:00 - 4:00	20.36	20.92	19.24	19.91	14.99	13.87	13.53	13.65	12.41	15.66	16.78	17.90
4:00 - 5:00	21.47	20.24	19.69	19.24	14.43	14.43	13.31	13.53	12.30	15.10	17.11	17.78
5:00 - 6:00	21.25	20.02	19.80	18.45	13.76	12.64	13.31	14.09	12.30	15.55	16.89	17.34
6:00 - 7:00	20.69	19.35	18.23	17.34	14.54	12.08	13.20	13.31	11.86	14.65	17.11	17.78
7:00 - 8:00	18.57	18.45	17.22	18.34	15.55	14.09	13.65	13.98	11.86	14.20	16.67	16.33
8:00 - 9:00	16.33	18.45	18.57	19.91	14.65	14.76	13.87	15.10	12.75	15.10	15.55	15.10
9:00 - 10:00	15.32	19.24	20.13	20.24	13.65	14.65	13.31	14.43	12.64	16.33	15.99	15.55
10:00 - 11:00	16.22	20.13	20.47	19.35	13.20	14.54	12.41	13.65	12.86	17.00	15.88	15.77
11:00 - 12:00	15.99	19.24	21.59	18.34	13.20	14.32	12.19	13.09	11.97	17.34	16.11	16.11
12:00 - 13:00	16.22	19.35	21.70	18.79	13.42	15.43	12.19	13.09	11.74	17.45	15.88	17.00
13:00 - 14:00	15.88	19.24	21.14	18.45	13.87	16.55	13.53	13.42	12.30	17.45	15.55	16.67
14:00 - 15:00	16.33	19.57	21.36	19.24	14.20	16.44	13.42	14.43	11.97	17.34	15.32	15.88
15:00 - 16:00	15.10	19.80	20.36	19.24	15.21	17.56	13.76	15.21	13.09	17.22	15.21	14.99
16:00 - 17:00	15.88	18.45	19.24	19.01	16.67	18.68	15.32	15.66	14.65	17.00	15.43	14.65
17:00 - 18:00	17.00	18.23	18.34	19.01	18.57	18.79	16.67	16.78	14.20	17.45	16.55	15.99
18:00 - 19:00	17.22	19.35	18.34	18.12	18.79	17.90	16.89	16.22	15.10	17.78	16.67	17.00
19:00 - 20:00	18.90	19.13	19.13	19.01	17.67	16.78	16.22	15.55	15.21	17.90	16.33	17.67
20:00 - 21:00	20.36	21.03	20.47	18.79	17.67	16.89	15.55	16.44	15.10	17.34	15.99	17.56
21:00 - 22:00	21.03	21.03	20.47	19.35	17.78	15.66	15.32	16.67	14.20	16.89	16.22	17.78
22:00 - 23:00	21.03	20.47	20.36	19.46	18.01	15.99	15.77	15.55	14.20	16.33	17.11	18.23
23:00 - 24:00	19.24	21.36	19.91	19.69	17.11	15.10	15.99	15.88	14.65	15.99	17.67	19.01
Average	18.57	19.80	19.80	19.13	15.66	15.43	14.20	14.88	13.20	16.44	16.33	16.89

5 Average Speed: Day vs. Night

Average Speed: Day vs. Night 2009

		50 m (1)	50 m (2)	40 m	30 m
January	Night	4.54	4.55	4.27	3.93
	Day	4.08	4.07	4.04	3.81
	0.07	0.10	0.11	0.05	0.03
February	Night	10.42	10.40	9.66	8.71
	Day	10.90	10.91	10.73	10.16
	-0.09	-0.05	-0.05	-0.11	-0.17
March	Night	8.68	8.76	8.37	5.27
	Day	9.20	9.29	9.26	6.10
	-0.10	-0.06	-0.06	-0.11	-0.16
April	Night	9.75	9.62	9.17	8.23
	Day	11.15	11.01	11.13	10.53
	-0.20	-0.14	-0.14	-0.21	-0.28
May	Night	8.65	8.62	8.21	7.44
	Day	9.20	9.16	9.20	8.64
	-0.10	-0.06	-0.06	-0.12	-0.16
June	Night	7.79	7.79	7.36	6.46
	Day	9.52	9.52	9.54	8.83
	-0.28	-0.22	-0.22	-0.30	-0.37
July	Night	7.89	7.94	7.49	6.67
	Day	8.44	8.48	8.42	7.89
	-0.11	-0.07	-0.07	-0.12	-0.18
August	Night	8.03	8.13	7.56	6.72
	Day	8.79	8.88	8.76	8.25
	-0.14	-0.09	-0.09	-0.16	-0.23
September	Night	6.86	6.90	6.47	5.83
	Day	7.51	7.57	7.49	7.06
	-0.14	-0.09	-0.10	-0.16	-0.21
October	Night	8.49	8.51	8.02	7.35
	Day	9.54	9.57	9.45	9.04
	-0.16	-0.12	-0.12	-0.18	-0.23
November	Night	8.10	8.09	7.49	6.88
	Day	8.57	8.57	8.41	8.01
	-0.10	-0.06	-0.06	-0.12	-0.16
December	Night	9.19	9.10	8.61	8.19
	Day	8.88	8.90	8.75	8.53
	0.00	0.03	0.02	-0.02	-0.04
Annual Average	-0.11				

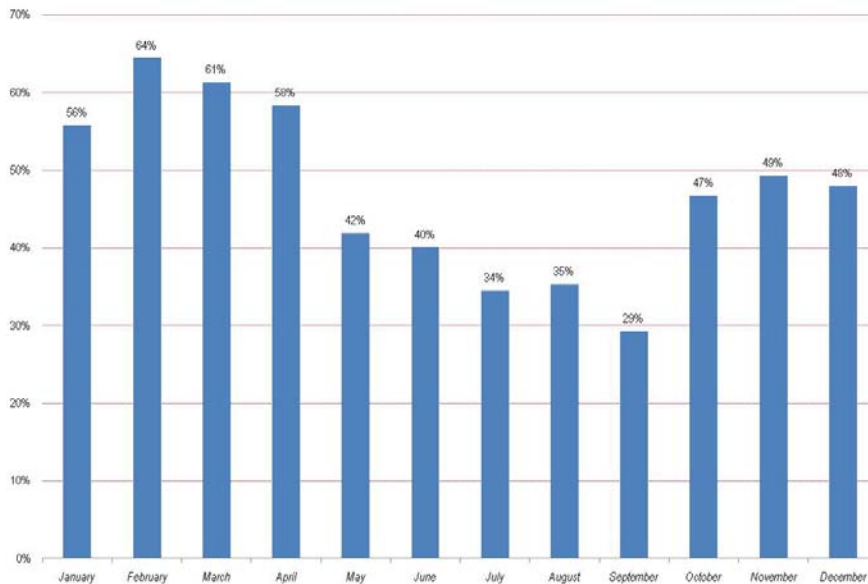
6 Energy Yield and Capacity Factor for 2009

This estimation was performed considering the approximated power curve for the GE 1.5 MW Wind Turbine @ 65 m hub height¹. These results are only 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 2009

Month	Capacity Factor %	Yield Energy MWh
January	56%	266.8 ²
February	64%	649.5
March	61%	684.3
April	58%	629.4
May	42%	467.4
June	40%	433.0
July	34%	384.8
August	35%	394.6
September	29%	316.0
October	47%	521.7
November	49%	532.8
December	48%	535.6
Average/Total	47%	5,816.5

Monthly Capacity Factor for 2009 (Graph)



¹ The wind speed values at 65 m were calculated using the actual wind shear approximation data from 30 to 50 from this site.

² The Energy yielded for January appears low because it was only considered the recovered data for this month, which was around 42%.

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 2009

<i>Month</i>	<i>m/s</i>	<i>mph</i>
<i>January</i>	<i>16.40</i>	<i>36.69</i>
<i>February</i>	<i>21.80</i>	<i>48.77</i>
<i>March</i>	<i>20.60</i>	<i>46.08</i>
<i>April</i>	<i>24.60</i>	<i>55.03</i>
<i>May</i>	<i>16.60</i>	<i>37.13</i>
<i>June</i>	<i>17.00</i>	<i>38.03</i>
<i>July</i>	<i>15.20</i>	<i>34.00</i>
<i>August</i>	<i>18.50</i>	<i>41.38</i>
<i>September</i>	<i>18.00</i>	<i>40.26</i>
<i>October</i>	<i>16.30</i>	<i>36.46</i>
<i>November</i>	<i>16.80</i>	<i>37.58</i>
<i>December</i>	<i>24.30</i>	<i>54.36</i>
<i>Average</i>	<i>18.84</i>	<i>42.15</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 2009

<i>Month</i>	<i>30 - 50 m Shear</i>
<i>January</i>	<i>0.31</i>
<i>February</i>	<i>0.32</i>
<i>March</i>	<i>0.32</i>
<i>April</i>	<i>0.30</i>
<i>May</i>	<i>0.26</i>
<i>June</i>	<i>0.31</i>
<i>July</i>	<i>0.28</i>
<i>August</i>	<i>0.29</i>
<i>September</i>	<i>0.29</i>
<i>October</i>	<i>0.27</i>
<i>November</i>	<i>0.29</i>
<i>December</i>	<i>0.22</i>
<i>Average</i>	<i>0.29</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 2009 @ 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>
<i>0 (N)</i>	0.06	0.10	0.10	0.11	0.13	0.10	0.13	0.11	0.13	0.11	0.08	0.10	0.11
<i>22.5</i>	0.09	0.09	0.09	0.09	0.11	0.15	0.11	0.13	0.11	0.10	0.08	0.09	0.10
<i>45</i>	0.00	0.08	0.11	0.09	0.10	0.11	0.11	0.12	0.11	0.11	0.07	0.07	0.09
<i>67.5</i>	0.09	0.09	0.07	0.09	0.12	0.10	0.14	0.11	0.11	0.08	0.07	0.07	0.10
<i>90 (E)</i>	0.09	0.07	0.09	0.10	0.12	0.11	0.14	0.11	0.10	0.09	0.10	0.09	0.10
<i>112.5</i>	0.04	0.08	0.10	0.09	0.12	0.11	0.12	0.10	0.08	0.09	0.05	0.08	0.09
<i>135</i>	0.06	0.08	0.09	0.11	0.09	0.11	0.11	0.10	0.08	0.09	0.06	0.06	0.09
<i>157.5</i>	0.08	0.08	0.09	0.10	0.11	0.12	0.12	0.12	0.10	0.09	0.08	0.07	0.10
<i>180 (S)</i>	0.06	0.07	0.08	0.10	0.11	0.13	0.12	0.11	0.09	0.09	0.08	0.07	0.09
<i>202.5</i>	0.06	0.07	0.06	0.11	0.10	0.11	0.11	0.12	0.09	0.09	0.07	0.07	0.09
<i>225</i>	0.06	0.06	0.10	0.09	0.12	0.10	0.10	0.10	0.10	0.09	0.06	0.06	0.09
<i>247.5</i>	0.07	0.06	0.10	0.10	0.12	0.13	0.11	0.09	0.09	0.09	0.06	0.06	0.09
<i>270 (W)</i>	0.07	0.05	0.07	0.11	0.15	0.14	0.11	0.12	0.08	0.08	0.07	0.07	0.09
<i>292.5</i>	0.07	0.09	0.07	0.16	0.17	0.11	0.09	0.15	0.10	0.09	0.07	0.08	0.10
<i>315</i>	0.09	0.13	0.12	0.16	0.20	0.13	0.11	0.12	0.10	0.10	0.08	0.08	0.12
<i>337.5</i>	0.09	0.13	1.00	0.15	0.19	0.16	0.14	0.09	0.11	0.10	0.09	0.11	0.20
<i>Monthly Average</i>	0.07	0.08	0.15	0.11	0.13	0.12	0.12	0.11	0.10	0.09	0.07	0.08	0.10

Turbulence Intensity Monthly Average for 2009 @ 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)	0.09	0.12	0.11	0.15	0.14	0.14	0.14	0.13	0.14	0.13	0.11	0.11	0.13
22.5	0.10	0.10	0.11	0.11	0.11	0.13	0.12	0.14	0.11	0.11	0.09	0.10	0.11
45	0.09	0.09	0.09	0.09	0.12	0.13	0.13	0.13	0.12	0.11	0.07	0.06	0.10
67.5	0.09	0.12	0.12	0.09	0.12	0.12	0.12	0.11	0.12	0.09	0.07	0.06	0.10
90 (E)	0.11	0.09	0.10	0.11	0.12	0.11	0.13	0.11	0.10	0.11	0.08	0.10	0.11
112.5	0.10	0.09	0.09	0.11	0.11	0.12	0.13	0.10	0.10	0.10	0.11	0.08	0.10
135	0.04	0.09	0.10	0.10	0.12	0.12	0.13	0.11	0.09	0.10	0.09	0.08	0.10
157.5	0.06	0.09	0.11	0.10	0.11	0.14	0.11	0.12	0.10	0.10	0.08	0.08	0.10
180 (S)	0.09	0.08	0.10	0.11	0.10	0.13	0.11	0.11	0.10	0.10	0.07	0.07	0.10
202.5	0.07	0.08	0.09	0.12	0.12	0.12	0.12	0.12	0.10	0.09	0.07	0.08	0.10
225	0.06	0.08	0.10	0.10	0.13	0.13	0.11	0.11	0.09	0.09	0.07	0.07	0.10
247.5	0.07	0.07	0.09	0.10	0.15	0.11	0.10	0.08	0.10	0.09	0.07	0.08	0.09
270 (W)	0.08	0.09	0.08	0.10	0.09	0.08	0.12	0.12	0.07	0.09	0.07	0.08	0.09
292.5	0.07	0.07	0.08	0.11	0.16	0.09	0.13	0.11	0.11	0.11	0.07	0.08	0.10
315	0.09	0.06	0.09	0.14	0.24	0.22	0.13	0.10	0.13	0.11	0.10	0.09	0.13
337.5	0.09	0.14	0.12	0.13	0.18	0.15	0.16	0.11	0.13	0.13	0.09	0.09	0.13
Monthly Average	0.08	0.09	0.10	0.11	0.13	0.13	0.12	0.11	0.11	0.10	0.08	0.08	0.10

10 Temperature

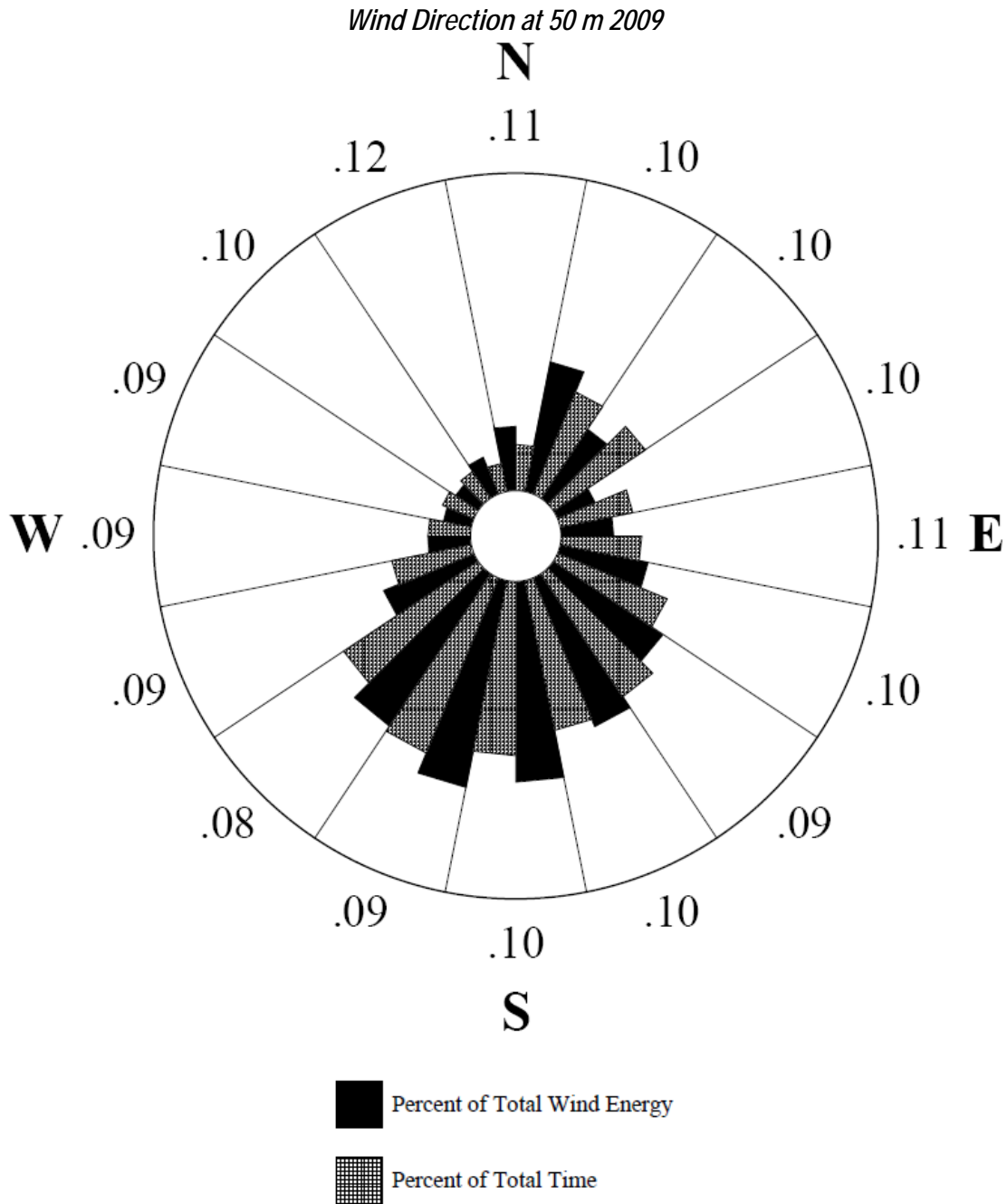
Air temperature is an important parameter of how a wind energy farm can perform and is normally measured either near ground level or near hub height. In most locations the average near ground level air temperature will be within 1°C of the average at hub height. It is also used to calculate air density, 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 2009

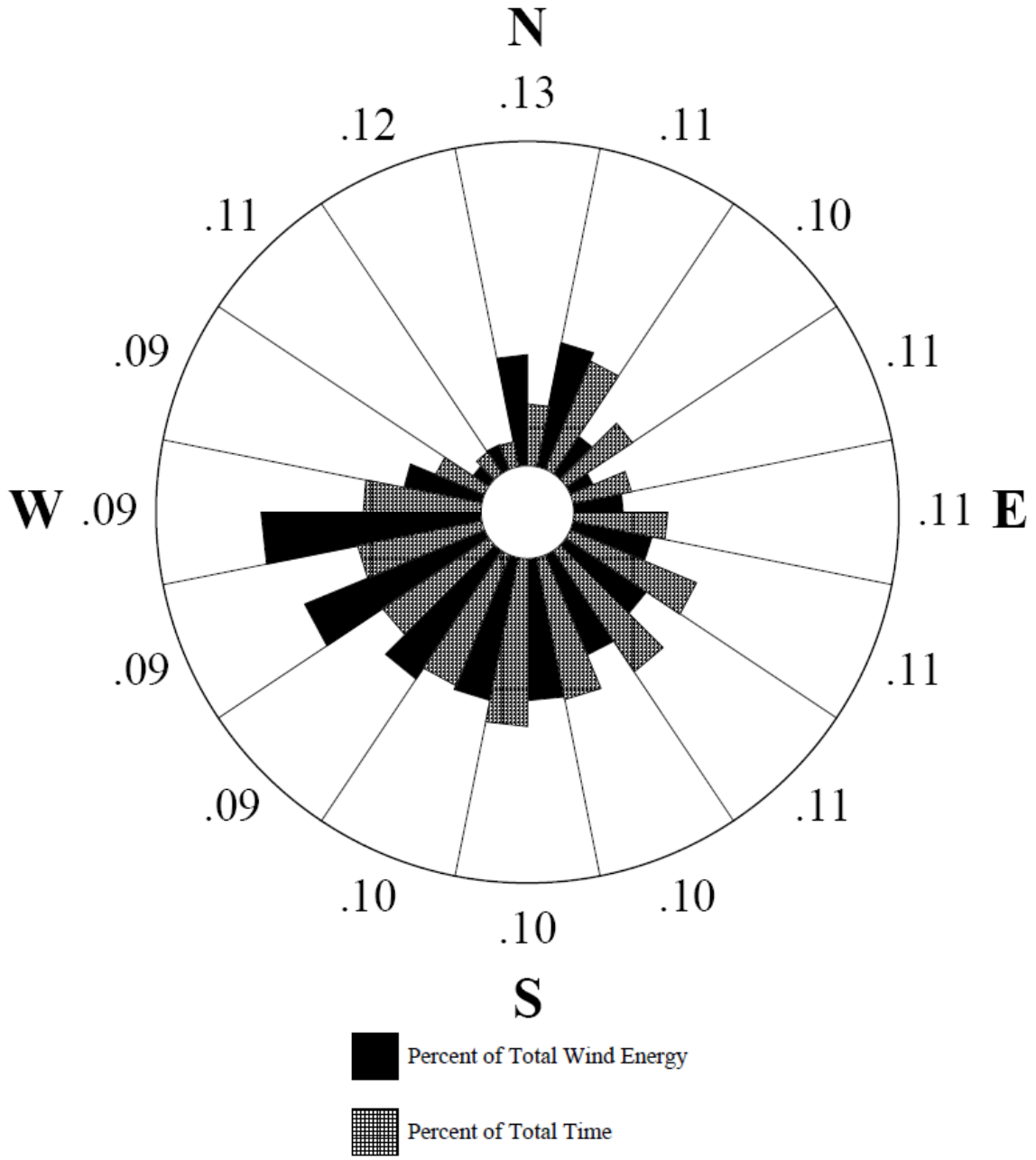
<i>Month</i>	<i>Average</i>		<i>Minimum</i>		<i>Maximum</i>	
	<i>Celsius</i>	<i>Fahrenheit</i>	<i>Celsius</i>	<i>Fahrenheit</i>	<i>Celsius</i>	<i>Fahrenheit</i>
<i>January</i>	3.43	38.2	-11.6	11.1	24.7	76.5
<i>February</i>	7.56	45.6	-7.4	18.7	25.8	78.4
<i>March</i>	10.37	50.7	-7.9	17.8	28.2	82.8
<i>April</i>	13.47	56.2	-5.5	22.1	31.9	89.4
<i>May</i>	18.53	65.4	5.5	41.9	34.6	94.3
<i>June</i>	23.93	75.1	11.4	52.5	36.6	97.9
<i>July</i>	25.09	77.2	13	55.4	39.4	102.9
<i>August</i>	24.47	76.0	13.8	56.8	37.1	98.8
<i>September</i>	19.06	66.3	2.9	37.2	33.7	92.7
<i>October</i>	12.02	53.6	-4	24.8	30.5	86.9
<i>November</i>	8.87	48.0	-6.6	20.1	26.5	79.7
<i>December</i>	0.51	32.9	-13.4	7.9	17.5	63.5
<i>Average</i>	13.9	57.1	-0.8	30.5	31.1	87.0

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 2009



12 Data Recovery

Recovery rates for wind speed data are calculated at all heights. The “Hours Lost” column indicates the number of hourly data points that were missing or removed during the data validation process for each monitoring height. 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 2009

	Total Hours in period	Hours Lost			Recovery Rate All Heights	Upper Level
		50 m	40 m	30 m		
<i>January</i>	744	433.2	425.3	431.8	42.3%	42.2%
<i>February</i>	672	0.0	0.0	0.0	100.0%	100.0%
<i>March</i>	744	0.0	0.0	0.0	100.0%	100.0%
<i>April</i>	720	0.0	0.0	0.0	100.0%	100.0%
<i>May</i>	744	0.0	0.0	0.0	100.0%	100.0%
<i>June</i>	720	0.0	0.0	0.0	100.0%	100.0%
<i>July</i>	744	0.0	0.0	0.0	100.0%	100.0%
<i>August</i>	744	0.0	0.0	0.0	100.0%	100.0%
<i>September</i>	720	0.0	0.0	0.0	100.0%	100.0%
<i>October</i>	744	0.0	0.0	0.0	100.0%	100.0%
<i>November</i>	720	0.0	0.0	0.0	100.0%	100.0%
<i>December</i>	744	0.0	0.0	0.0	100.0%	100.0%
Average	730.0	36.1	35.4	36.0	95.2%	95.2%

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 the turbulence level and atmospheric stability, and is also useful in detecting suspect or erroneous data when validating average values

Average Internal Standard Deviation for 2009

	50 m (1)	50 m (2)	40 m	30 m
<i>January</i>	<i>0.66</i>	<i>0.71</i>	<i>0.70</i>	<i>0.70</i>
<i>February</i>	<i>0.72</i>	<i>0.76</i>	<i>0.76</i>	<i>0.75</i>
<i>March</i>	<i>0.78</i>	<i>0.84</i>	<i>0.82</i>	<i>0.81</i>
<i>April</i>	<i>0.88</i>	<i>0.91</i>	<i>0.93</i>	<i>0.90</i>
<i>May</i>	<i>0.81</i>	<i>0.80</i>	<i>0.84</i>	<i>0.78</i>
<i>June</i>	<i>0.85</i>	<i>0.85</i>	<i>0.87</i>	<i>0.81</i>
<i>July</i>	<i>0.77</i>	<i>0.76</i>	<i>0.78</i>	<i>0.73</i>
<i>August</i>	<i>0.75</i>	<i>0.74</i>	<i>0.76</i>	<i>0.72</i>
<i>September</i>	<i>0.65</i>	<i>0.65</i>	<i>0.67</i>	<i>0.67</i>
<i>October</i>	<i>0.72</i>	<i>0.73</i>	<i>0.75</i>	<i>0.74</i>
<i>November</i>	<i>0.55</i>	<i>0.65</i>	<i>0.57</i>	<i>0.57</i>
<i>December</i>	<i>0.60</i>	<i>0.63</i>	<i>0.64</i>	<i>0.65</i>
<i>Average</i>	<i>0.73</i>	<i>0.75</i>	<i>0.76</i>	<i>0.74</i>