

WIWASOLVET

TOTAL PRIMARY ENERGY SOLUTIONS. SP

Wind Energy Report

Prospecting Met Mast: Cape Breton, NS

Site: 46.054, -60.329

Date: December 8th, 2016



Summary Wind Statistics

The tables outlined on this page comprise the comprehensive statistics and information for the specified site. All data are based on the time period from 1986 to 2015. Please note that for some sites a total of 60 years of hourly statistics are available for the specified site upon request.

Wind Speeds

Mean Wind Speed (Long term)	7.36 m/s
Mean Wind Speed (W90 Reduction)	7.01 m/s
Median Wind Speed	6.67 m/s

Maximum hourly averaged wind speed
in the data series requested 40.41 m/s

An explanation of the terms and values in the above table is as follows:

Mean wind speed is the estimated long term average wind speed based on the chosen time period. As the sample size increases (i.e. time period), the precision of our estimate increases within in similar long term climate patterns.

Mean Wind Speed (W90 Reduction) is a conservative estimate of the 90th percentile of the mean wind speed for the site. The difference from the Mean Wind Speed (Long Term) calculates a revised mean wind speed with a 90% confidence of being surpassed. The W90 statistics are the 90th percentile of the errors assuming a normal distribution of the wind speeds.

It is important to note that the W90 data are not comparable with figures derived from the variability in hourly mean wind speeds. These should be considered separately.

Wind Speed P50:P90:P99 Exceedance Probability

Figure 1 illustrates the probability (%) that the wind speed exceeds 5 m/s, 10 m/s and 15 m/s in a given month. The variability above and below these thresholds assist with understanding the natural fluctuations of the wind resource over the year. These monthly variations are derived from the wind frequency analysis.

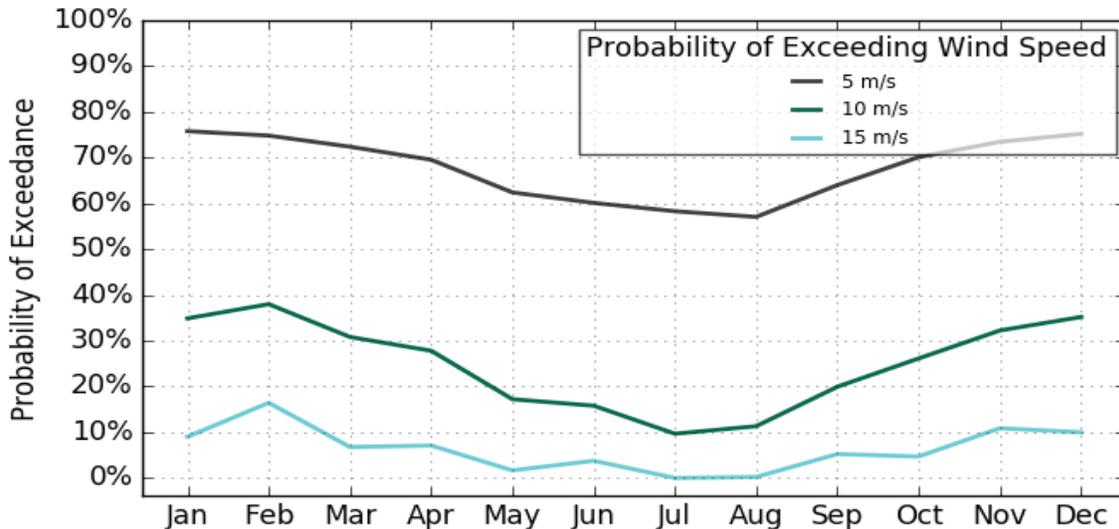


Figure 1: P50-P90 Probability of Exceedance of Wind Speed Classes

Daily Variation in Average Hourly Wind Speeds

Based on the data from 1986 to 2015, Figure 2 displays the average wind speed (m/s) for each hour of the day at the chosen site.

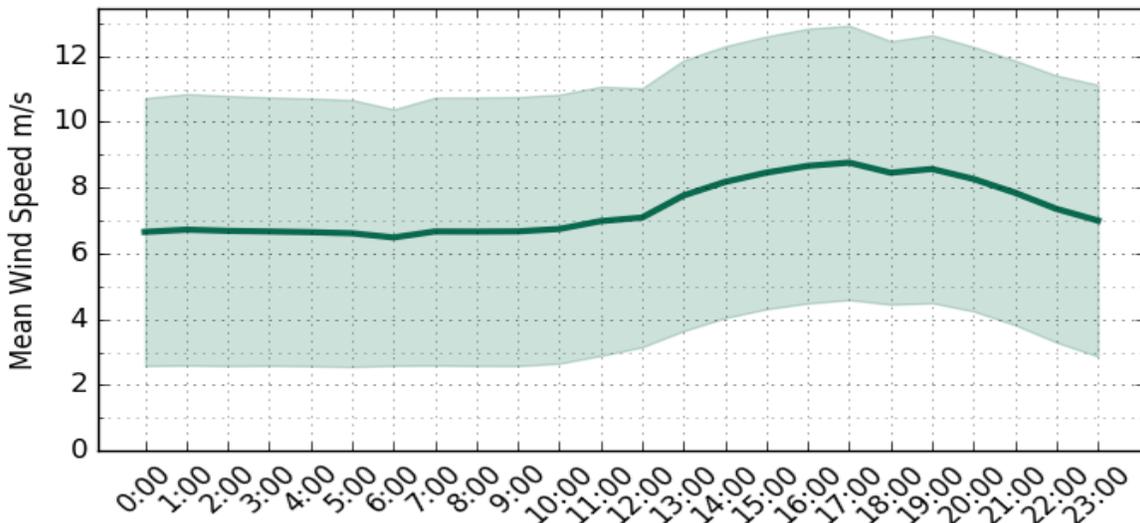
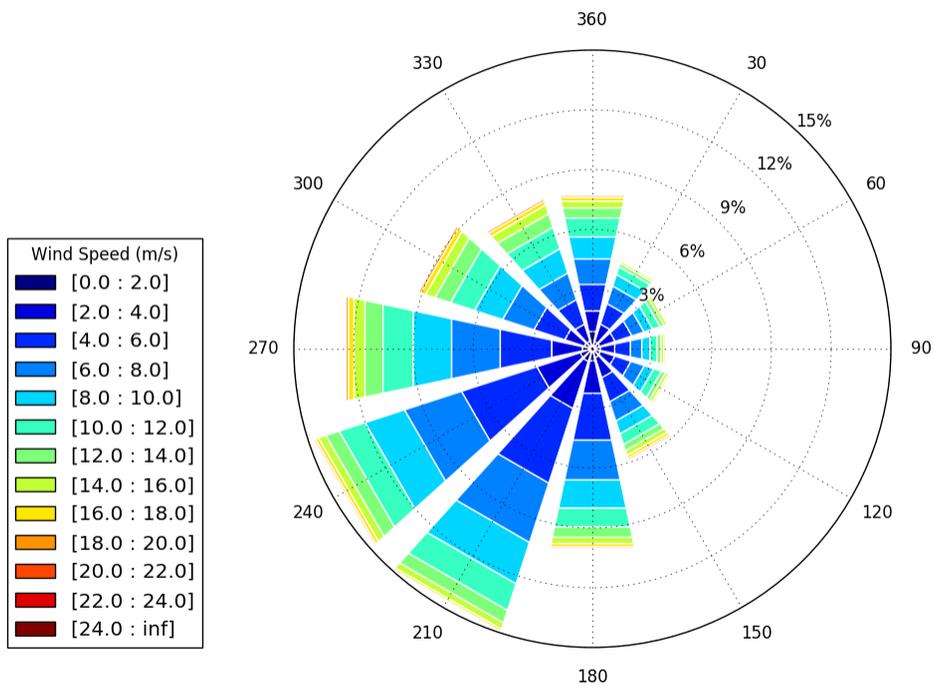


Figure 2: Daily Variation in Average Hourly Wind Speeds

Whole-year and Monthly Wind Roses

A wind rose shows the long term frequency of winds blowing from particular directions over a specified period. The full-year wind speed and direction distribution for the site is represented by the wind rose shown in Figure 3. For a monthly breakdown, refer to the Figure 4 in the following section of this report.

The wind speeds are represented by the colours (refer to the legend). The percentage of the time wind is blowing from each direction is represented by the length of the radial shells.



Monthly Wind Roses

As noted, Figure 4 displays the wind roses on a month by month basis. The structure is the same, however, the long term monthly roses give a clearer indication of the expected wind frequencies during different times of the year.

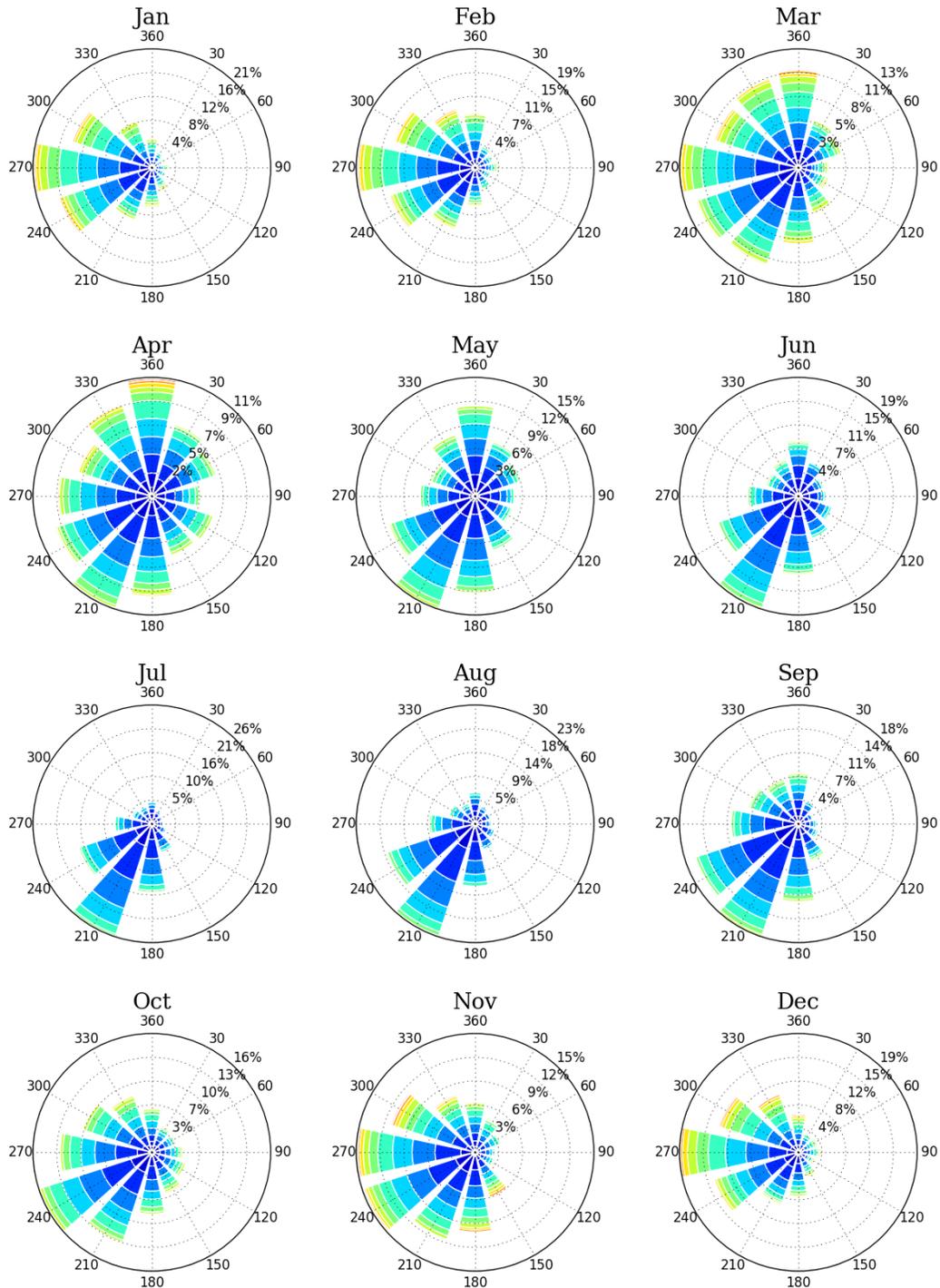


Figure 4: Long term monthly windroses

Wind Frequency Distribution

Table 1 shows the wind frequency analysis for the complete time period, using 30° direction sectors and 1 m/s wind speed bins. The wind frequency analysis for 1986 onwards can also be provided as a CSV file showing the data for each month of the year.

	360	330	300	270	240	210	180	150	120	90	60	30	Total
	-0	-30	-60	-90	-120	-150	-180	-210	-240	-270	-300	-330	
0-1m/s	0.59	0.09	0.096	0.11	0.11	0.11	0.13	0.13	0.11	0.11	0.11	0.1	1.80
1-2m/s	0.28	0.27	0.28	0.3	0.32	0.41	0.51	0.54	0.43	0.35	0.29	0.28	4.25
2-3m/s	0.43	0.38	0.35	0.33	0.38	0.61	0.87	0.97	0.78	0.54	0.42	0.42	6.49
3-4m/s	0.57	0.49	0.4	0.41	0.47	0.68	1.2	1.6	1.1	0.74	0.51	0.53	8.68
4-5m/s	0.68	0.53	0.45	0.44	0.52	0.88	1.6	2.3	1.6	1.0	0.66	0.65	11.4
5-6m/s	0.58	0.42	0.36	0.38	0.47	0.76	1.5	2.0	1.5	1.1	0.7	0.64	10.5
6-7m/s	0.66	0.43	0.33	0.36	0.47	0.73	1.5	1.8	1.5	1.2	0.76	0.68	10.4
7-8m/s	0.5	0.32	0.24	0.28	0.36	0.55	1.1	1.4	1.2	1.0	0.67	0.64	8.32
8-9m/s	0.45	0.28	0.22	0.24	0.3	0.49	1.0	1.2	1.0	0.93	0.67	0.63	7.48
9-10m/s	0.41	0.23	0.19	0.21	0.27	0.4	0.88	1.0	0.87	0.85	0.66	0.59	6.60
10-11m/s	0.41	0.2	0.21	0.21	0.24	0.37	0.77	0.84	0.77	0.83	0.63	0.58	6.07
11-12m/s	0.29	0.16	0.17	0.17	0.23	0.27	0.52	0.59	0.55	0.68	0.54	0.45	4.60
12-13m/s	0.22	0.11	0.12	0.12	0.15	0.2	0.4	0.43	0.41	0.56	0.45	0.37	3.54
13-14m/s	0.12	0.068	0.076	0.1	0.11	0.15	0.27	0.27	0.3	0.4	0.3	0.24	2.41
14-15m/s	0.13	0.074	0.09	0.09	0.11	0.15	0.21	0.23	0.25	0.34	0.27	0.22	2.17
15-16m/s	0.093	0.051	0.05	0.076	0.084	0.1	0.15	0.13	0.16	0.26	0.19	0.19	1.52
16-17m/s	0.062	0.038	0.04	0.057	0.072	0.069	0.091	0.077	0.12	0.16	0.12	0.12	1.02
17-18m/s	0.065	0.028	0.04	0.046	0.064	0.059	0.07	0.047	0.088	0.13	0.096	0.1	0.834
18-19m/s	0.034	0.021	0.023	0.033	0.041	0.038	0.042	0.029	0.063	0.074	0.061	0.061	0.520
19-20m/s	0.033	0.019	0.018	0.026	0.042	0.041	0.033	0.031	0.042	0.068	0.052	0.064	0.468
20-21m/s	0.018	0.016	0.0098	0.017	0.03	0.022	0.018	0.018	0.03	0.034	0.03	0.033	0.275
21-22m/s	0.016	0.012	0.01	0.01	0.022	0.014	0.017	0.011	0.028	0.026	0.022	0.018	0.206
22-23m/s	0.0059	0.0087	0.0063	0.011	0.012	0.0067	0.0067	0.0071	0.013	0.015	0.019	0.012	0.123
23-24m/s	0.0071	0.0043	0.0028	0.0031	0.011	0.0059	0.0035	0.0047	0.0075	0.0087	0.013	0.012	0.0834
≥ 24m/s	0.018	0.0059	0.0047	0.017	0.022	0.0083	0.0067	0.0094	0.0051	0.017	0.016	0.013	0.142
Total	6.68	4.26	3.79	4.07	4.89	7.14	12.9	15.7	13.0	11.4	8.27	7.62	100%

Table 1: Wind Frequency Distribution based on wind speed classes and broken into sectors.

Wind Speed Distributions and Weibull Statistics

It is important to represent the irregularity in wind frequency distribution. Therefore, Weibull curves have been used to best represent the asymmetric relationship between wind and time. Figure 5 shows this analysis for wind speed, regardless of the wind direction.

The frequency with which each wind speed category (x-axis) occurs is represented by the blue bars on the graph. The optimum Weibull curve, built using the shape and scale parameters, is superimposed over the bars (i.e. fitted to the data).

Shape parameter (α) - determines the shape of the curve

Scale parameter (λ) - magnitude of peak frequency wind speed class

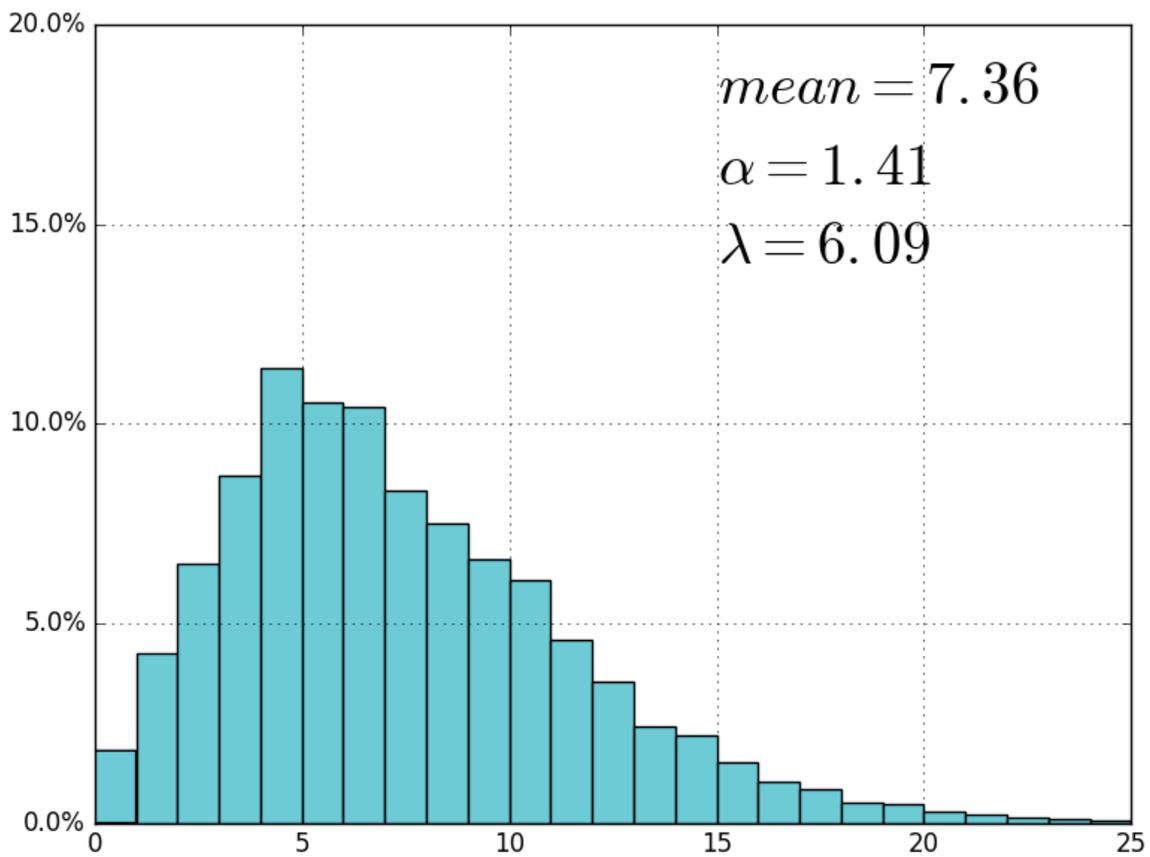


Figure 5: Annual 360°, wind speed distribution overlaid with an evenly fitted Weibull distribution

30° sector, annual wind frequency analysis

Displayed in Figure 6, the wind frequency analysis is broken down by direction (30° sectors). These directional wind speed distributions are superimposed with uniformly fitted Weibull distributions. This is helpful in determining optimal placement and spacing of turbines on larger wind farms.

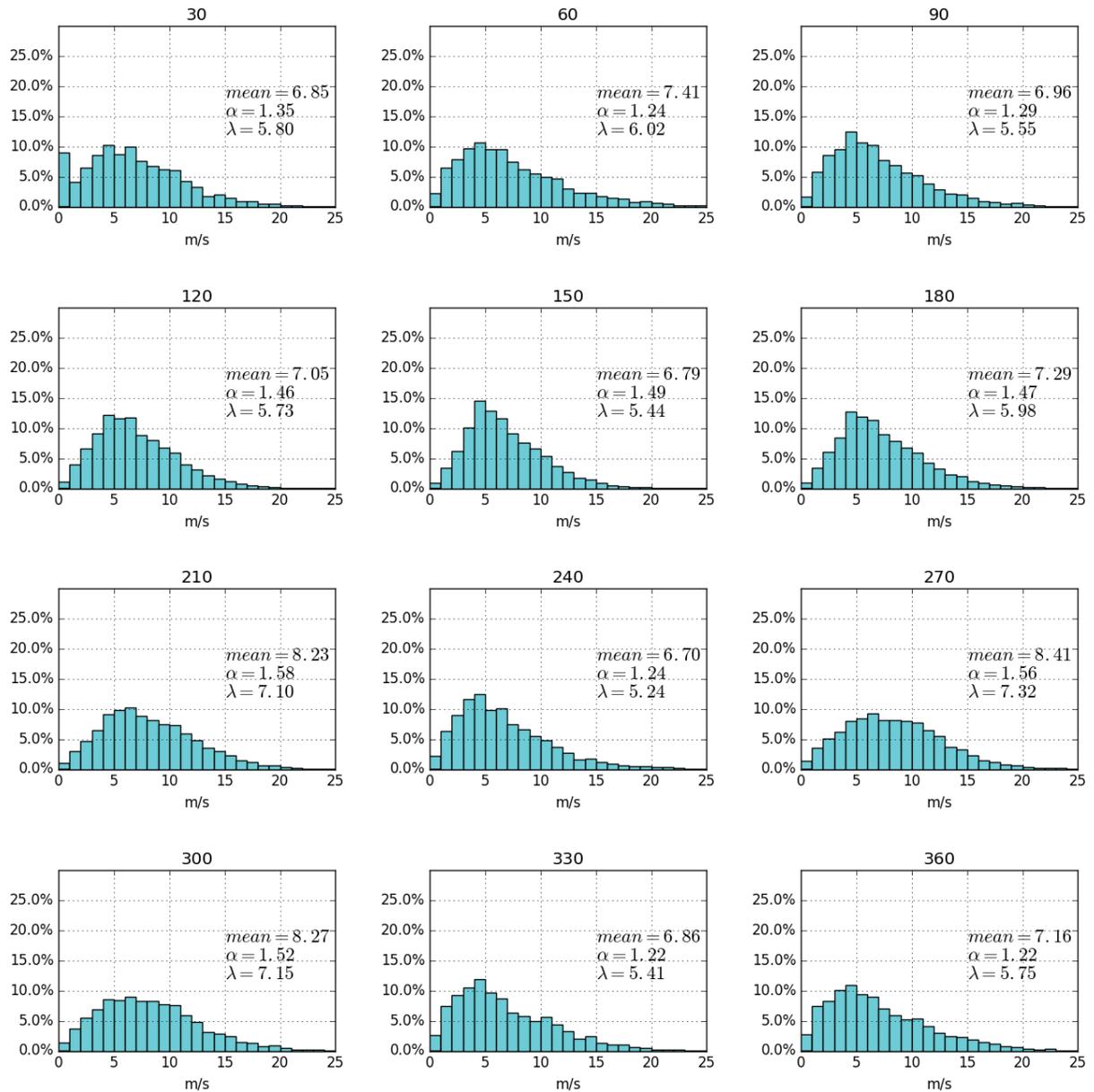


Figure 6: Whole-year, directional wind speed distributions overlaid with Weibull distributions

Monthly wind frequency analysis

Displayed in Figure 7, the wind frequency analysis is broken down by months. These monthly wind speed distributions are superimposed with uniformly fitted Weibull distributions. This is a great way to determine how much energy may be produced each month.

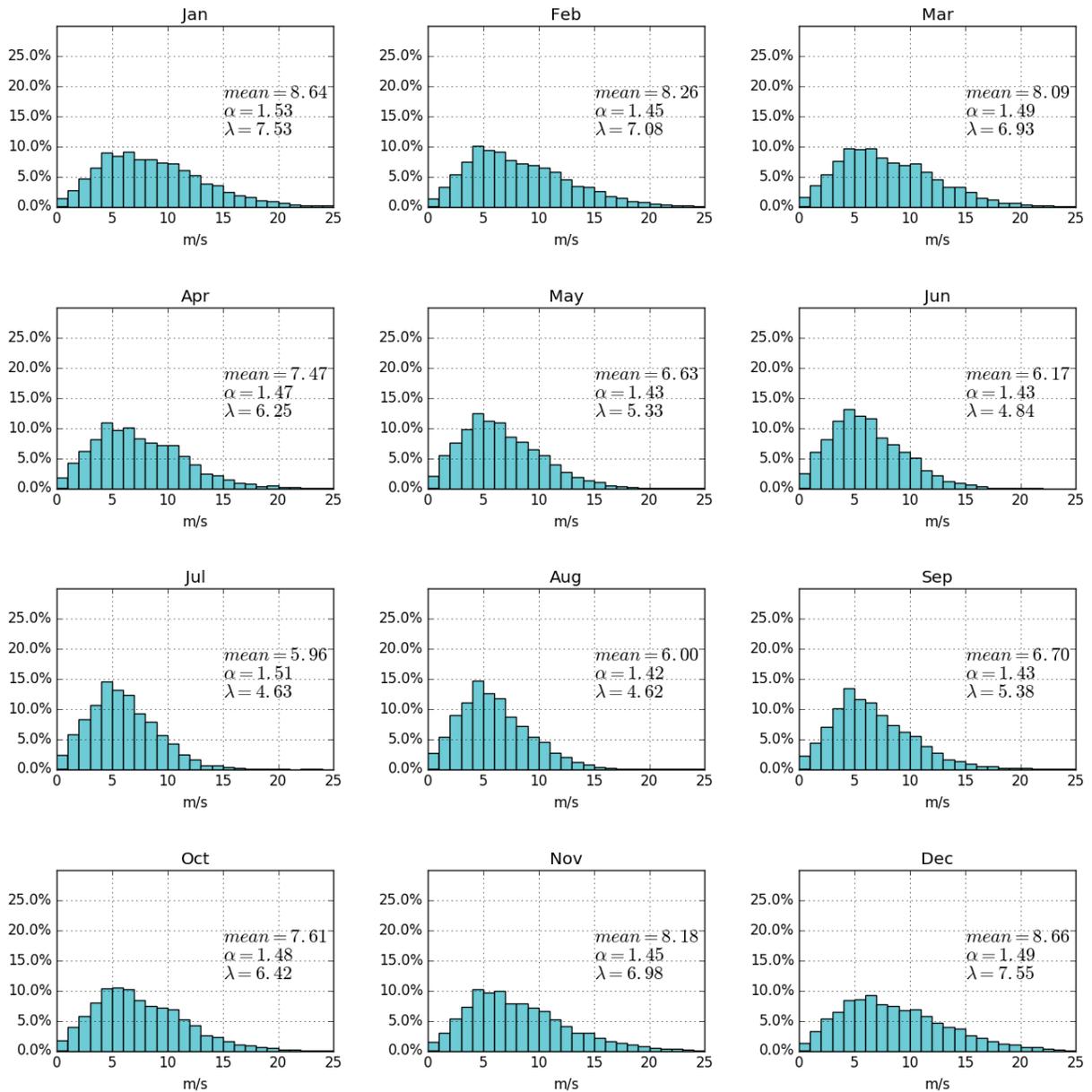


Figure 7: Monthly wind speed distributions overlaid with evenly fitted Weibull distributions

Long Term Climate Variability

Figure 8 below demonstrates the year-to-year variability for the chosen site. This will assist in understanding the mean wind speed from a long-term climatological variability perspective. The plot displays the annual mean wind speeds over 30 years as horizontal marks. The blue box encompasses 50% of the years, with a black horizontal line marking the median. Blue Whiskers indicate the 5th and 95th Percentiles of the dataset. All values are presented relative to the 30-year mean wind speed for the region.

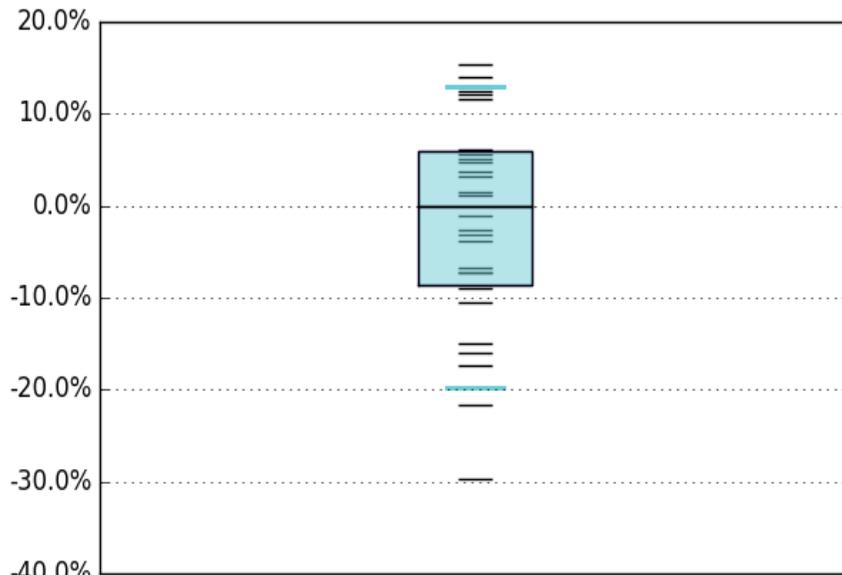


Figure 8: Percentage of Variance from Mean Wind Speed with ticks for each Year

Note: While the information within the graph is an important indicator of the scale of climate variability for the site, it must not be misinterpreted as a forecast of future variability at the site.

Monthly and Annual Mean Wind Speed Statistics

Figure 9 illustrates the monthly mean wind speed with the Standard Deviation to show variation around the mean. Standard error is the standard deviation divided by square root of the sample size (1 to 60 years) away on either side of the mean (assuming normal distribution). Table 2 gives the mean wind speeds (monthly and annual), as well as the standard deviations. These values were derived from hourly data. A physical Met Mast typically collects data for 1-2 years before on site characteristics are known with high certainty, with this in mind, a more complete data set demonstrates decadal climate variations and scales to fit the regional data points.

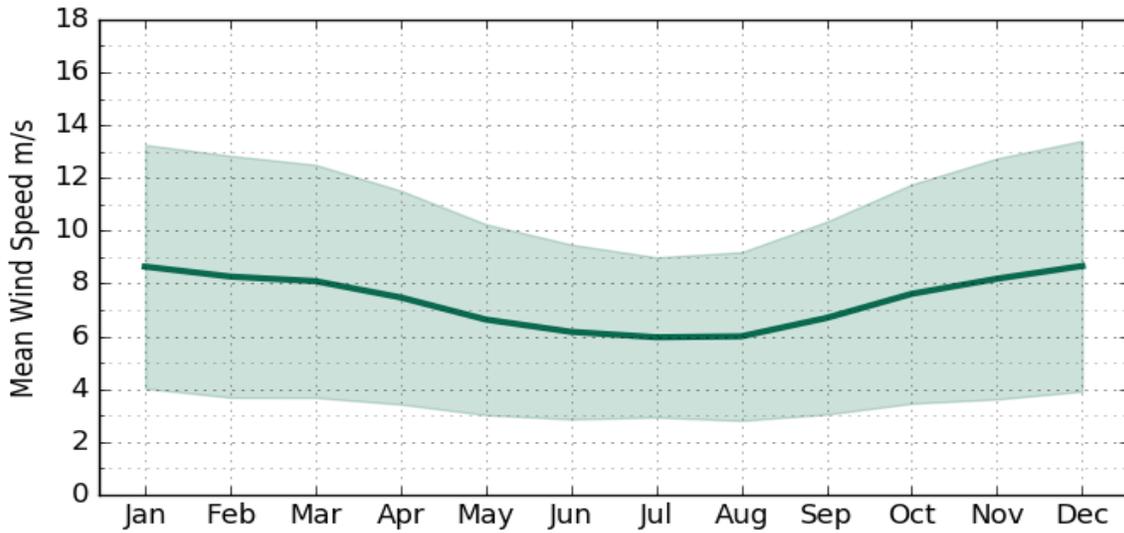


Figure 9: Monthly mean wind speed with 16th and 84th percentiles

Month	Mean Wind Speed(m/s)	Standard Deviation(m/s)	Standard Error (m/s)
Jan	8.64	4.62	0.86
Feb	8.26	4.58	0.85
Mar	8.09	4.41	0.82
Apr	7.47	4.05	0.75
May	6.63	3.61	0.67
Jun	6.17	3.31	0.61
Jul	5.96	3.03	0.56
Aug	6.0	3.19	0.59
Sep	6.7	3.65	0.68
Oct	7.61	4.15	0.77
Nov	8.18	4.56	0.85
Dec	8.66	4.75	0.88
Annual	7.4	4.0	0.74

Table 2: Monthly and annual mean wind speeds and hourly standard deviations

Annual Energy Production – Turbine Comparison

The site will be expected to produce an Annual Energy Production (AEP):

FD-21-50, 60 kW turbine	
Annual Energy Production	275.9 MWh/annually
Annual Revenue at \$0.15 CAN/kWh	\$41,397
Hub Height	36 meter
Manufacturer	GHREPOWER

E-3120 (3 Phase) 50 kW turbine	
Annual Energy Production	249.7 MWh/annually
Annual Revenue at \$0.15 CAN/kWh	\$37,458
Hub Height	36 meter
Manufacturer	Endurance Wind Power

FD21-100/12 100 kW turbine	
Annual Energy Production	384.2 MWh/annually
Annual Revenue at \$0.15 CAN/kWh	\$57,636
Hub Height	36 meter
Manufacturer	GHREPOWER

Owner

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