Old Harbor, Alaska Wind Resource Update Report

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Date of Report: May 27, 2009

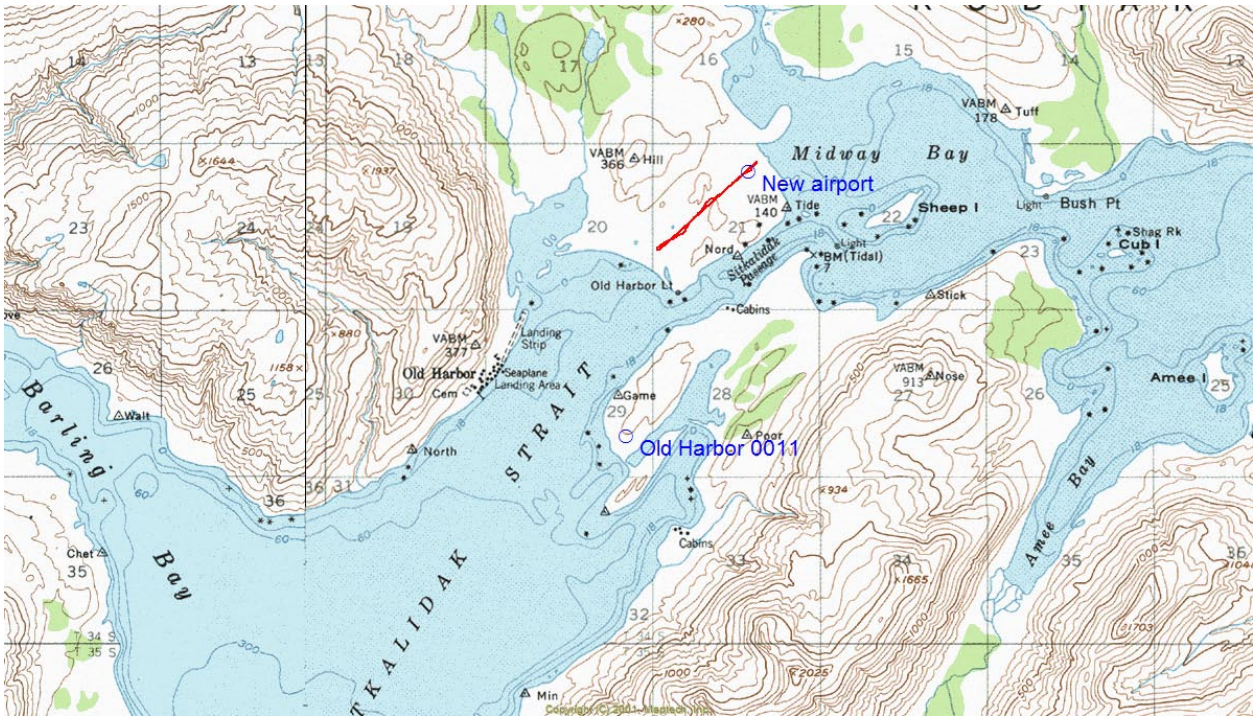
Photo: Brian Fouts

Summary Information

The Old Harbor met tower site is located on a small peninsula of Sitkalidak Island approximately one mile ESE across Sitkalidak Strait from the main part of the village of Old Harbor. This site was selected based on a desire to not interfere with the aircraft traffic pattern at the airport and yet be developable without significant road construction. With seven months of data collected, the test site had a lower wind resource than expected and the met tower was decommissioned and removed. This site on Sitkali-

dak Island was thought to have the best potential for wind power development in Old Harbor. Alternate sites that could be considered are complicated by the location of the airport on the west side of Sitkalidak Passage.

Test Site Location



Topographic Map

Meteorological Tower Data Synopsis

Data start date	October 15, 2008
Data end date	May 13, 2009 (7 months data collected)
Wind power class	Class 2 (marginal)
Wind speed average (30 meters)	4.47 m/s (to date)
Maximum two second wind gust	33.6 m/s (January 2009)
Wind power density (30 meters)	189 W/m^2
Weibull distribution parameters	k = 1.19, c = 4.73 m/s
Roughness Class	0.00 (smooth)
Power law exponent	0.037 (extremely low wind shear)
Frequency of calms (3.5 m/s threshold)	47%
Mean Turbulence Intensity	0.135 (IEC 61400-1 3rd ed. turbulence category B)

Tower Sensor Information

Channel	Sensor type	Height	Multiplier	Offset	Orientation
1	NRG #40C anemometer	30 m (A)	0.765	0.35	West
2	NRG #40C anemometer	30 m (B)	0.765	0.35	East

3	NRG #40C anemometer	20 m	0.765	0.35	West
7	NRG #200P wind vane	30 m	0.351	023	South
9	NRG #110S Temp C	2 m	0.136	-86.383	South
10	Voltmeter		0.021	0	

General Site Information

Site number	Old Harbor (datalogger site 0011)
Site Description	Sitkalidak Island, directly across harbor from the village
Latitude/longitude	N 57° 11.75', W 153° 17.90'
Site elevation	28 meters
Datalogger/modem type	NRG Symphonie/NRG Iridium satellite iPack
Tower type	NRG 30-meter tall tower, 152 mm (6 in) diameter

Data Quality Control

Data was filtered manually to remove obvious icing data. Typically, anemometer icing is identified by non-variant data readings at the sensor offset values, a standard deviation of zero, and temperature near or below freezing. The data collected in Old Harbor indicated very few icing events.

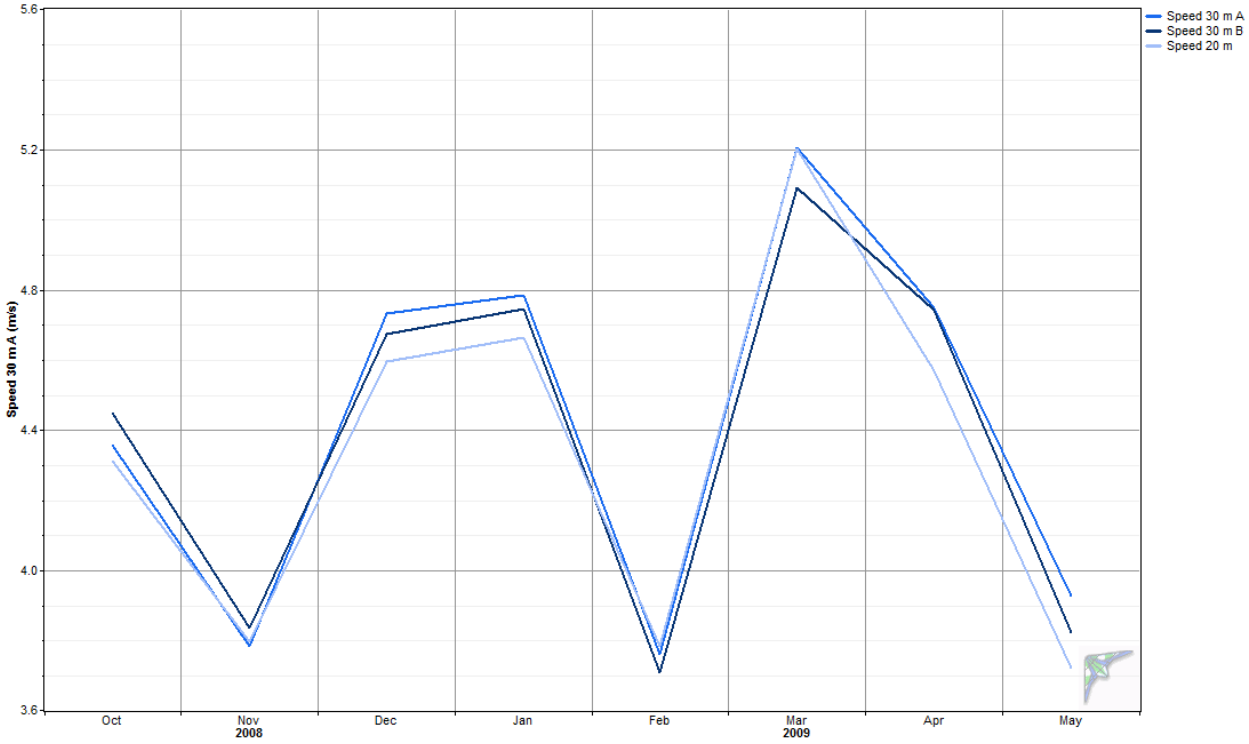
Sensor	Units	Height	Possible Records	Valid Records	Recovery Rate (%)
Speed 30 m A	m/s	30 m	30,306	30,205	99.7
Speed 30 m B	m/s	30 m	30,306	30,197	99.6
Speed 20 m	m/s	20 m	30,306	30,306	100.0
Direction 30 m	°	30 m	30,306	30,133	99.4
Temperature	°C		30,306	30,306	100.0
Voltmeter	volts		30,306	30,306	100.0

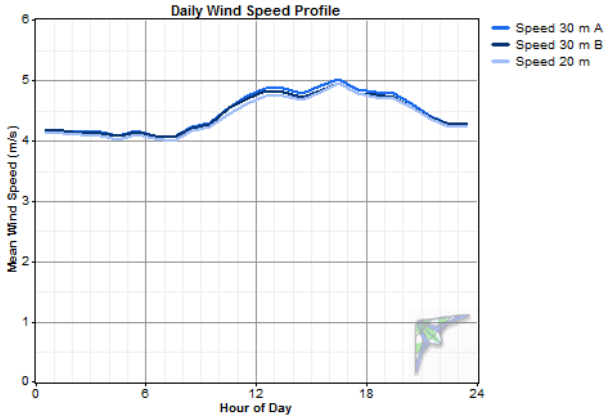
Measured Wind Speeds

Mean wind speeds measured at the site to date are quite low by usual standards of wind power development, even though the data months typically experience fairly high wind speeds on Kodiak Island.

Variable	Speed 30 m A	Speed 30 m B	Speed 20 m
Measurement height (m)	30.0	30.0	20.0
Mean wind speed (m/s)	**4.47**	**4.44**	**4.40**
MMM wind speed (m/s)	4.42	4.39	4.34
Median wind speed (m/s)	3.80	3.80	3.70
Min wind speed (m/s)	0.4	0.4	0.4
Max wind speed (m/s)	19.9	19.6	19.3
Weibull k	1.19	1.25	1.26

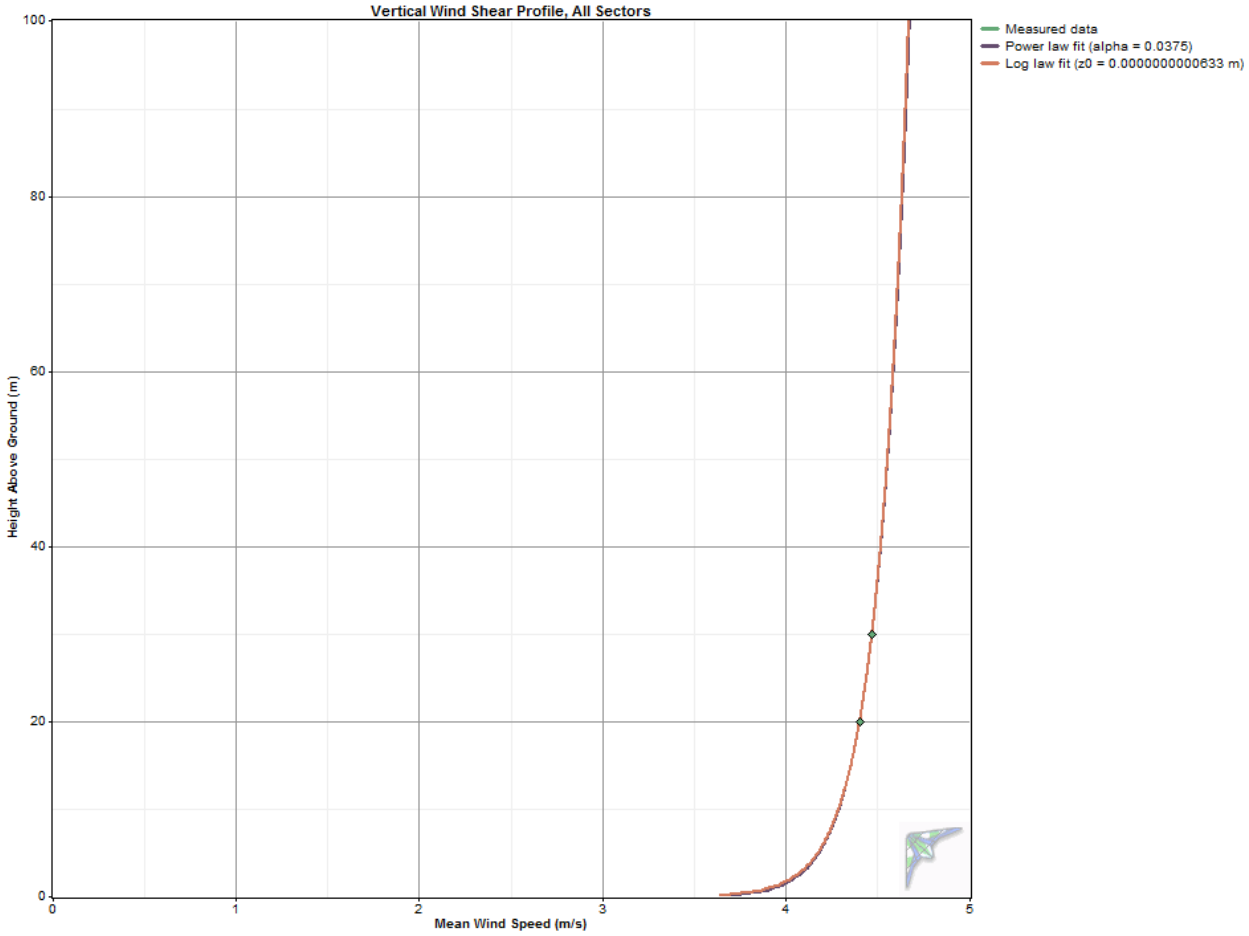
Weibull c (m/s)	4.73	4.75	4.72
Mean power density (W/m²)	189	176	171
MMM power density (W/m²)	183	171	165
Mean energy content (kWh/m²/yr)	1,656	1,539	1,498
MMM energy content (kWh/m²/yr)	1,605	1,498	1,442
Energy pattern factor	3	3	3
Frequency of calms (%)	47.5	47.0	47.9
1-hr autocorrelation coefficient	0.867	0.869	0.86
Diurnal pattern strength	0.097	0.091	0.094
Hour of peak wind speed	16	16	17





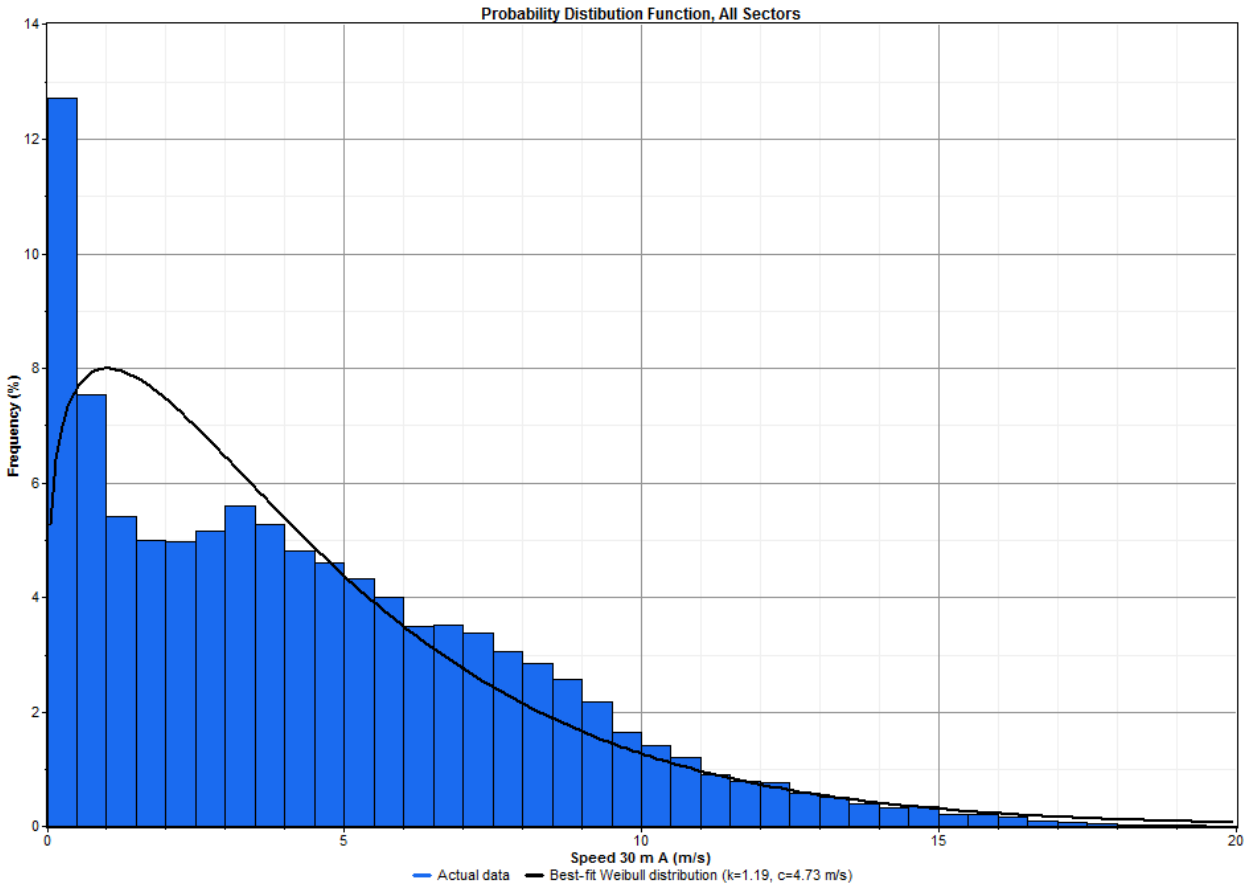
Wind Shear

The power law exponent was calculated at 0.037 for all wind directions, indicating extremely low wind shear at the Old Harbor test site. The practical application of this data is that a low turbine tower height may be possible at this location should wind power development occur.



Probability Distribution Function

The probability distribution function (PDF) provides a visual indication of measured wind speeds in one meter per second or smaller "bins". Note that most wind turbines do not begin to generate power until the wind speed at hub height reaches 3.5 m/s, known as the "cut-in" wind speed. The black line in the graph is a best fit Weibull distribution. The PDF of data collected to date indicates a wind regime dominated by calm winds.

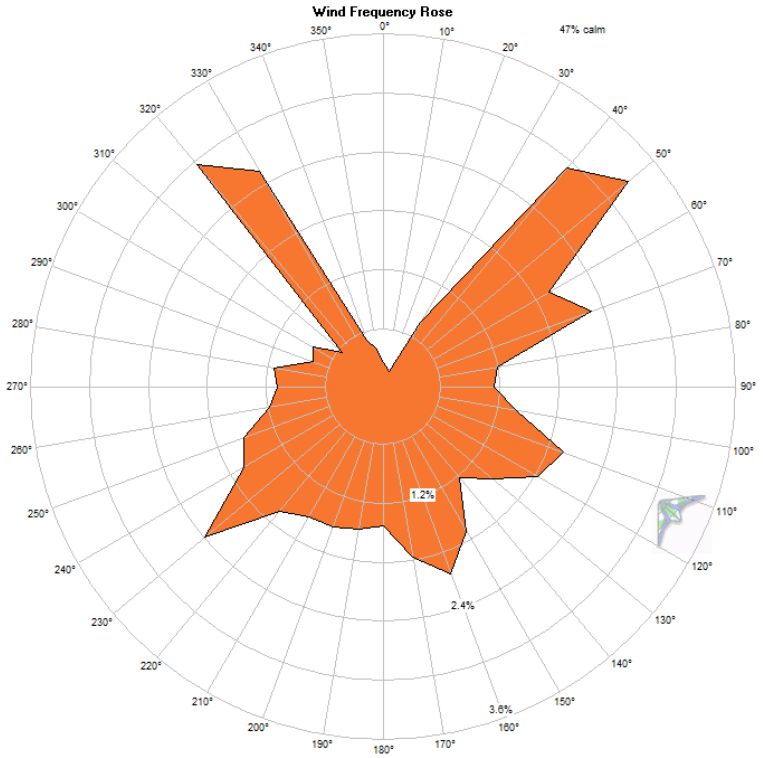


Wind Roses

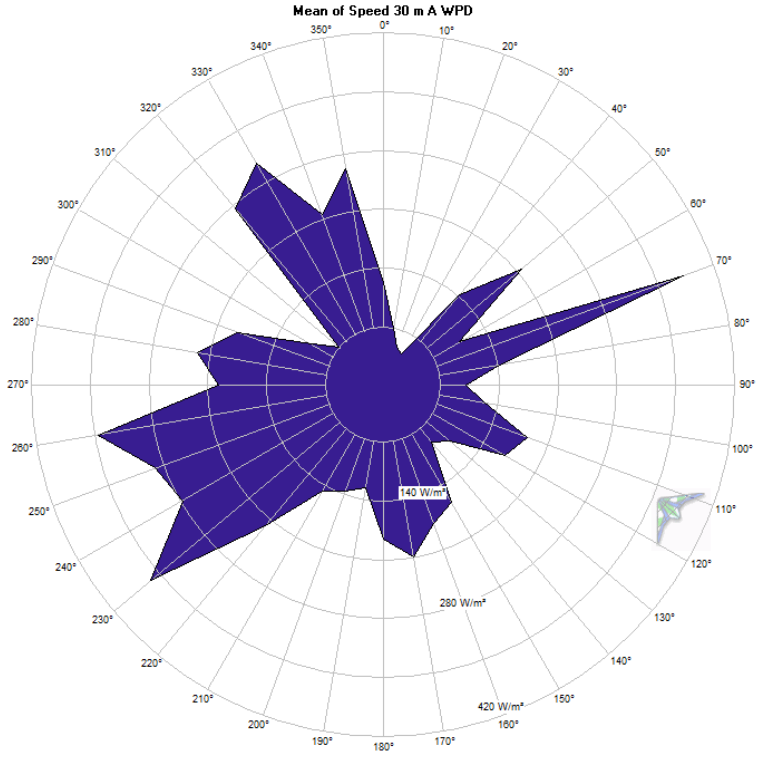
Winds at the Old Harbor met tower test site are primarily northeasterly and northwesterly with winds also frequent from east-southeast around to southwest (wind frequency rose), but the strongest winds are from northwest and southwest (mean value rose). The power density rose indicates that the power producing winds at the site are predominately northeasterly, southwesterly, and northwesterly. Interestingly, northerly winds are completely absent, indicating perhaps obstructive terrain to the north. Another site with perhaps better exposure to northerly winds may yield more productive winds.

Note that a wind threshold of 3.5 m/s was selected for the definition of calm winds. This wind speed represents the cut-in wind speed of the Northern Power NW100/21 wind turbine. By this definition, the Old Harbor met tower site experienced 47 percent calm conditions during the measurement period.

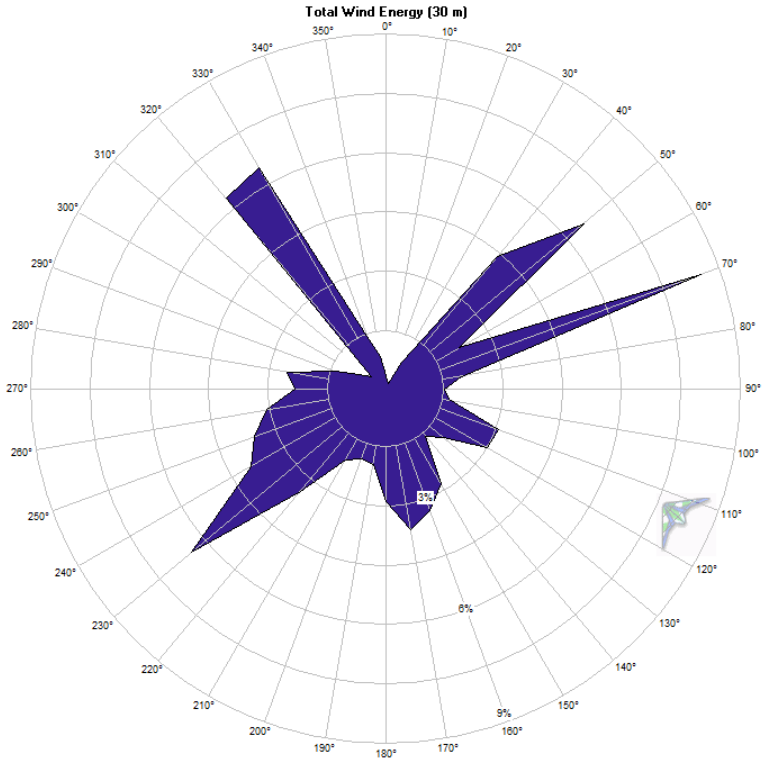
Wind Frequency Rose



Mean Value (power density) rose by direction



Total value (power density) rose



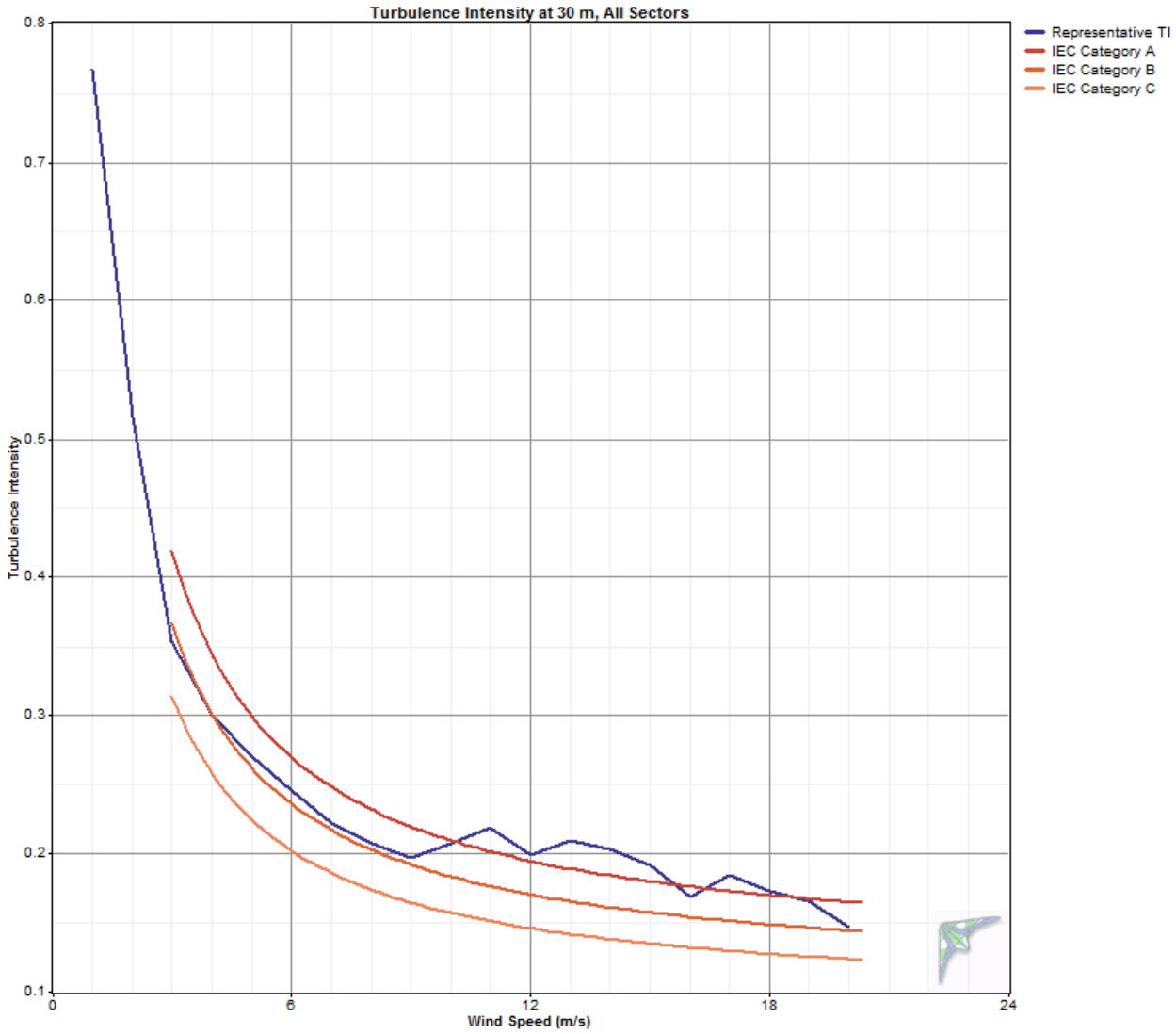
Air Temperature and Density

During the measurement period, Old Harbor had an average temperature of 2.4° C. The minimum recorded temperature during the measurement period was –11.4° C and the maximum temperature was 21.4° C.

Consequent to Old Harbor's cool temperatures, the average air density of 1.278 kg/m^3 is approximately five percent higher than the standard air density of 1.277 kg/m^3 (14.8° C and 101.0 kPa standard temperature and pressure) at 22 m elevation, indicating that Old Harbor has denser air than standard (1.222 kg/m^3) for this elevation, resulting in improved turbine performance as compared to a turbine in a similar wind regime in standard atmospheric conditions.

Turbulence

Turbulence intensity (TI) at the Old Harbor test site during the measurement period is quite high with a mean TI at 15 m/s of 0.135 and a representative TI at 15 m/s of 0.192 (30 m A sensor). The site classifies as turbulence category B by International Electrotechnical Commission (IEC) 61400-1 3rd edition (2005) criteria (note that Category B is the middle classification of turbulence for wind power development, indicating moderately high turbulence at the site).



Turbine Performance Prediction

A Northern Power Northwind 100/21 (B model) turbine was modeled in the wind regime measured to date to assess expected turbine performance. At a 37 m hub height, availability of 95 percent and with 7.0 months of data extrapolated to a year, a NW100 turbine would generate 150,900 kWh/yr at a capacity factor of 17.2 percent.

Month	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (kW)	Mean Net Energy Output (kWh/yr)	Net Capacity Factor (%)
Jan	4.8	26.8	1.3	19	14,286	19.2
Feb	3.8	40.3	1.2	14	9,078	13.5
Mar	5.2	22.6	2.8	22	16,553	22.2
Apr	4.7	26.1	0.6	19	13,634	18.9
May	3.9	34.8	0.1	13	9,292	12.5
Jun	n/a	n/a	n/a	n/a	n/a	n/a
Jul	n/a	n/a	n/a	n/a	n/a	n/a
Aug	n/a	n/a	n/a	n/a	n/a	n/a
Sep	n/a	n/a	n/a	n/a	n/a	n/a
Oct	4.4	33.7	0.5	18	13,214	17.8
Nov	3.8	35.3	1.4	12	8,510	11.8
Dec	4.7	29.3	3.3	19	13,972	18.8
Overall	4.4	30.5	1.6	17	150,909	17.2