Mekoryuk, Alaska Wind Resource Report

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Photo © Doug Vaught

Summary Information

The Mekoryuk wind test site has outstanding potential for wind power development with Class 6 winds, low wind shear, and low turbulence. The wind rose indicates more variability in wind directions than observed elsewhere, but this likely is a consequence of Mekoryuk's coastal location and maritime climate influence. For a representative village-scale stall controlled turbine and pitch controlled turbine, both yield low thirty percent capacity factors at 32 meter hub heights. One wind turbine operations challenge in Mekoryuk is the occasional extreme low winter temperatures and consequent high air densities experienced.

Meteorological Tower Data Synopsis

Wind power class	Class 6 - Outstanding
Average wind speed (30 meters)	7.56 m/s
Maximum wind speed (10 min avg)	35.1 m/s
Mean wind power density (50 meters)	660 W/m^2
Mean wind power density (30 meters)	543 W/m^2
Weibull distribution parameters	k = 1.97, c = 8.48 m/s
Turbulence intensity	0.0952
Roughness class	0.80 (rough pasture)
Power law exponent	0.13 (low wind shear)
Data start date	June 11, 2005
Most recent data date	February 19, 2007

Community Profile

Location:
Mekoryuk is at the mouth of Shoal Bay on the north shore of Nunivak Island in the Bering Sea. The Island lies 30 miles off the coast. It is 149 air miles west of Bethel and 553 miles west of Anchorage. Mekoryuk is part of the Yukon Delta National Wildlife Refuge. The village area encompasses 7.4 sq. miles of land and 0.1 sq. miles of water.

History:
Nunivak Island has been inhabited for 2,000 years by the Nuniwarmiut people, or Cup'ik (Choop'ik) Eskimos. The first outside contact was in 1821 by the Russian American Company, who recorded 400 people living in 16 villages on the Island. In 1874 a summer camp called "Koot" was noted at the current site of Mekoryuk. An epidemic in 1900 decimated the population, leaving only four surviving families in the village. In the 1930s, the Evangelical Covenant Church was built by an Eskimo missionary followed by a BIA school in 1939. People moved to the village from other areas of the Island to be near the school. Reindeer were introduced for commercial purposes in 1920 by an Eskimo-Russian trader. The operation was purchased by the BIA in the 1940s and a slaughterhouse was constructed in 1945. The reindeer were crossed with caribou from Denali Park; the resulting animals are larger and harder to handle than other reindeer in the state. Thirty-four musk oxen from Greenland were transferred to the Island in 1934 in an effort to save the species from extinction. Today, the musk ox herd numbers around 500 and calves from this herd have been relocated and introduced to other areas of Alaska. The 1950s and 60s brought considerable change. An airstrip was built in 1957 and the Territorial Guard was formed. Mekoryuk had become the only permanent community on the Island. During this time, many families moved to Bethel to be near the high school, returning during late spring for fishing and sea mammal hunting. The City was incorporated in 1969 and a high school was constructed in the village in 1978.

Culture:
This Cup'ik Eskimo village maintains reindeer and musk ox herds and practices a subsistence lifestyle of fishing and hunting. The sale, importation or possession of alcohol is banned in the

village.

Economy:
Employment by the school, City, village corporation, commercial fishing, construction, and service industries prevails. The Bering Sea Reindeer Products Co. is a major employer. Trapping and Native crafts, such as knitting qiviut (musk ox underwool), provide income to many families. Fifty-five residents hold commercial fishing permits, primarily for halibut and herring roe. Coastal Villages Seafood, Inc. processes halibut and salmon in Mekoryuk. Almost all families engage in subsistence activities and most have fish camps. Salmon, reindeer, seal meat and oil are important staples.

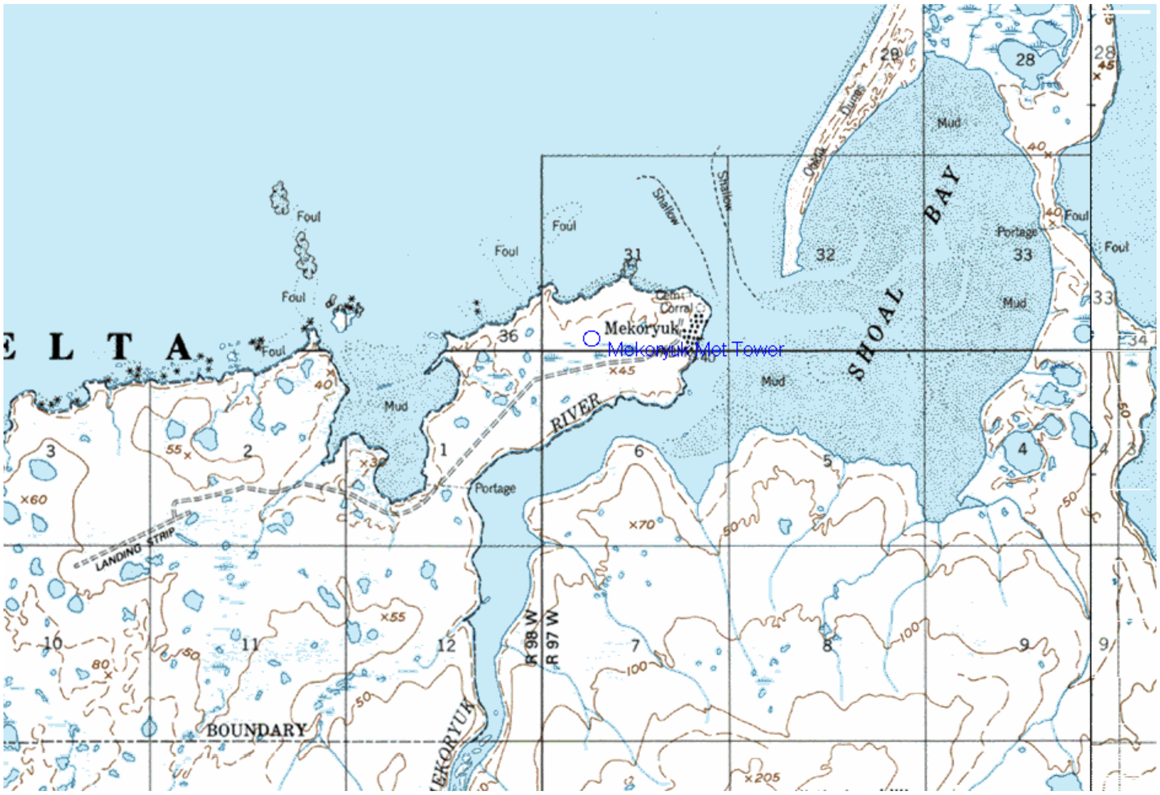
Facilities:
Water is derived from a well, is treated and stored in a tank. A new flush/haul system currently serves about 90% of homes. The school has its own well and needs a new water treatment system. The washeteria has piped disposal to a new permitted sewage lagoon.

Transportation:
Mekoryuk relies heavily on air transportation for passenger, mail and cargo service. A State-owned 3,070' long by 75' wide gravel runway allows year-round access. A breakwater protects the shoreline from Bering Sea waves. Barges deliver goods from Bethel once or twice each summer. Boats, snowmachines and ATVs are used for travel within the community.

Climate:
The Bering Sea which surrounds Nunivak Island strongly influences the climate of the island. Foggy and stormy weather are frequent. Average precipitation is 15 inches; annual snowfall is 57 inches. Summer highs average 48 to 54 degrees F; winter highs run 37 to 44 F. Extremes have been recorded from 76 to -48 F.

Meteorological Tower Site Information

Site number	0032
Site Description	Mekoryuk – AVEC community
Latitude/longitude	N 060° 23.215’; W 166° 12.112’
Site elevation	13 meters
Datalogger type	NRG Symphonie
Tower type	NRG 30-meter tall tower, 152 mm (6-in) diameter



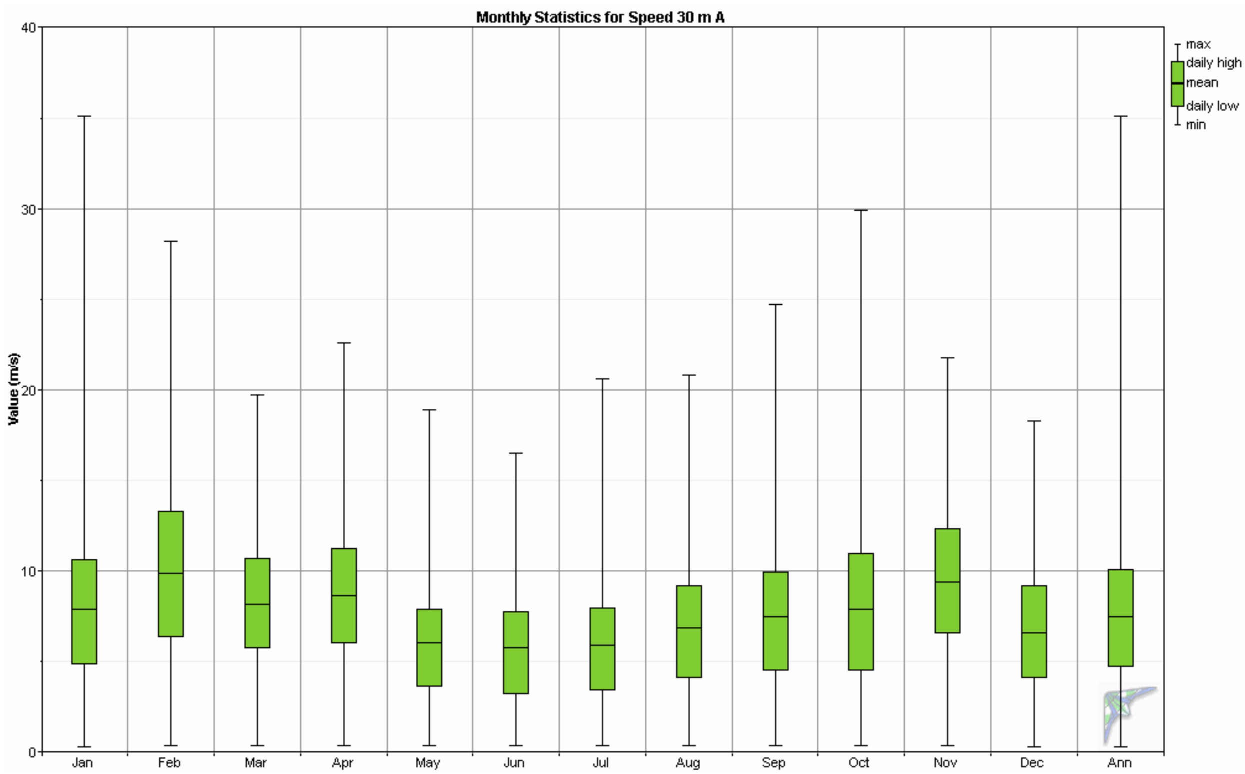
Met Tower Sensor Information

Channel	Sensor type	Height	Multiplier	Offset	Orientation
1 (30m A)	NRG #40 anemometer	30 m	0.765	0.35	north
2 (30m B)	NRG #40 anemometer	30 m	0.765	0.35	south
3 (20m)	NRG #40 anemometer	20 m	0.765	0.35	north
7	NRG #200P wind vane	27 m	0.351	245	east
9	NRG #110S Temp C	2 m	0.136	-86.383	N/A

Measured Wind Speeds

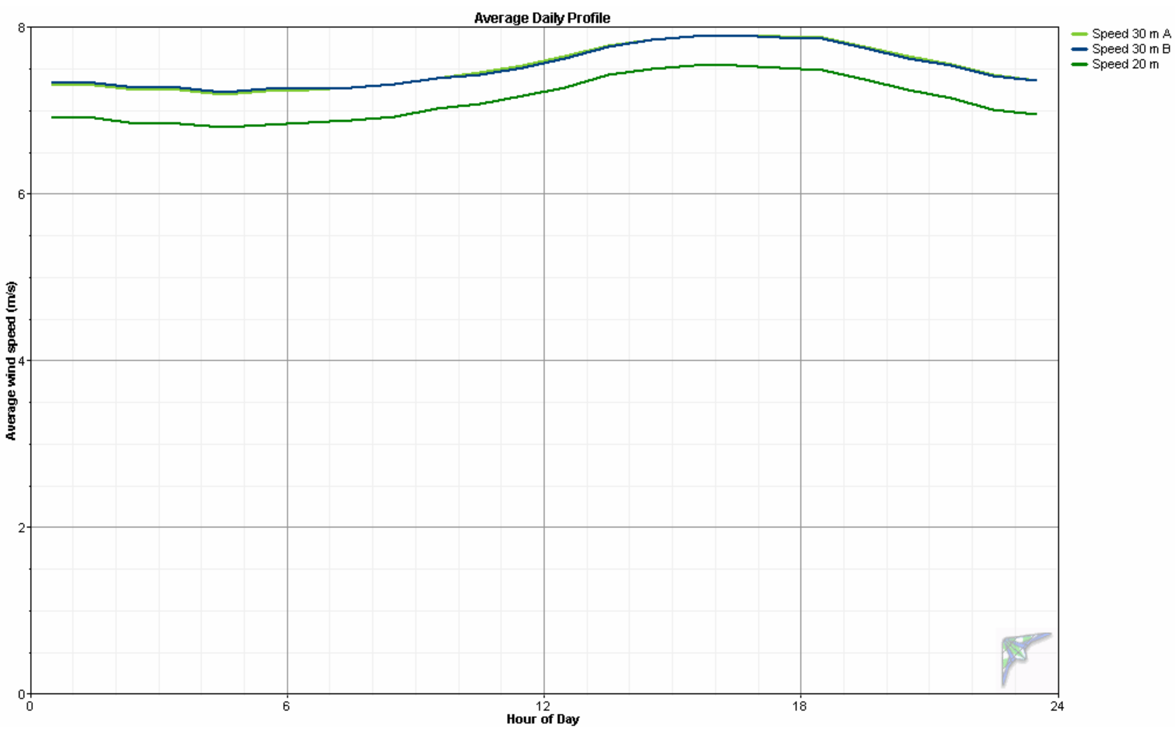
The 30-meter annual average wind speed is 7.56 m/s for channels 1 and 2 (A and B anemometers), and the 20-meter wind speed average is 7.17 m/s. Note that maximum wind data are 10 minute averages.

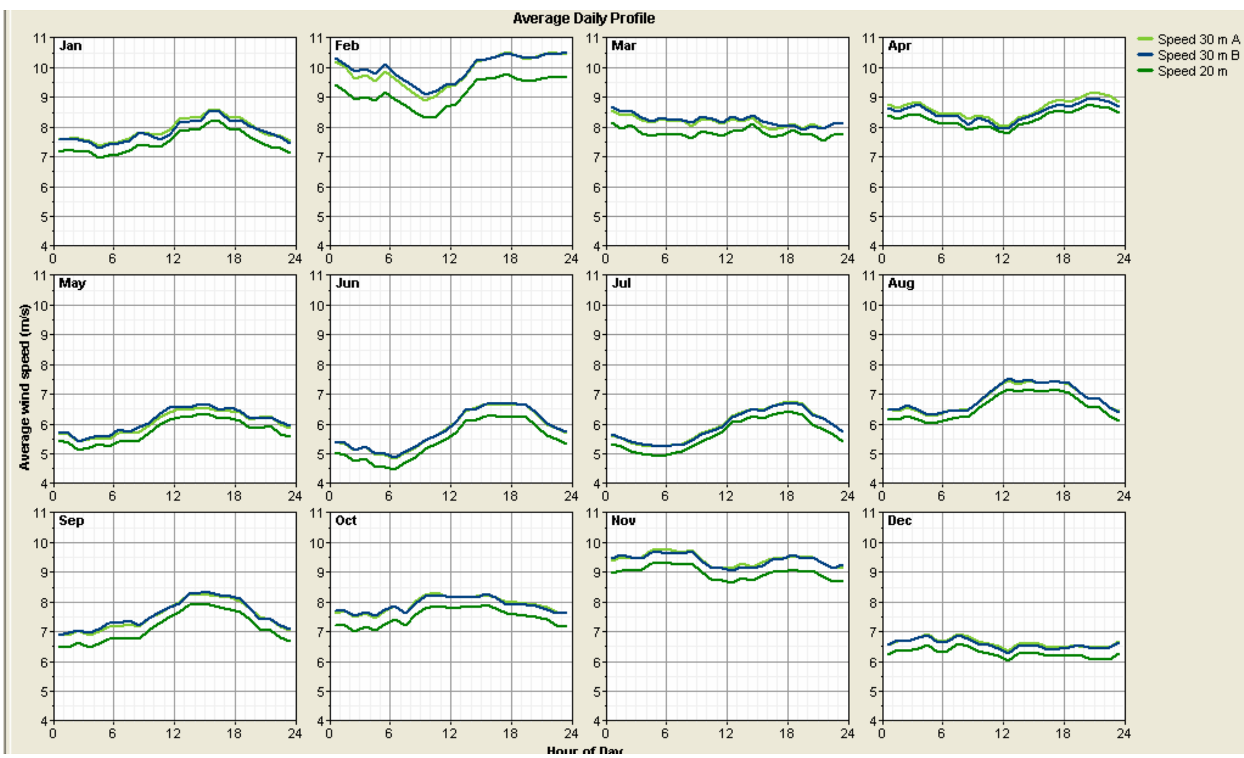
	30 m A anemometer					30 m B anem.		20 m anem.	
Month	Mean (m/s)	Max (m/s)	Std. Dev. (m/s)	Weibull k	Weibull c (m/s)	Mean (m/s)	Max (m/s)	Mean (m/s)	Max (m/s)
Jan	7.89	35.1	4.55	1.79	8.85	7.83	34.6	7.48	31.4
Feb	9.89	28.2	4.53	2.30	11.15	9.99	27.9	9.19	27.2
Mar	8.18	19.7	3.97	2.19	9.26	8.24	19.4	7.81	18.9
Apr	8.64	22.6	3.27	2.80	9.68	8.50	22.4	8.29	20.7
May	6.04	18.9	3.23	1.97	6.83	6.11	18.8	5.76	17.8
Jun	5.81	16.5	2.48	2.46	6.52	5.83	16.3	5.44	15.3
Jul	5.94	20.6	3.14	1.99	6.71	5.93	20.7	5.65	19.6
Aug	6.85	20.8	3.64	1.95	7.72	6.87	21.2	6.58	20.0
Sep	7.52	24.7	3.73	2.11	8.49	7.56	24.6	7.14	23.6
Oct	7.91	29.9	4.05	2.05	8.94	7.90	29.9	7.50	28.5
Nov	9.43	21.8	4.34	2.33	10.65	9.41	21.8	8.99	21.1
Dec	6.62	18.3	3.35	2.07	7.47	6.58	18.4	6.28	17.2
Annual	**7.56**	35.1	3.69	2.17	8.52	**7.56**	34.6	**7.17**	31.4



Daily Wind Profile

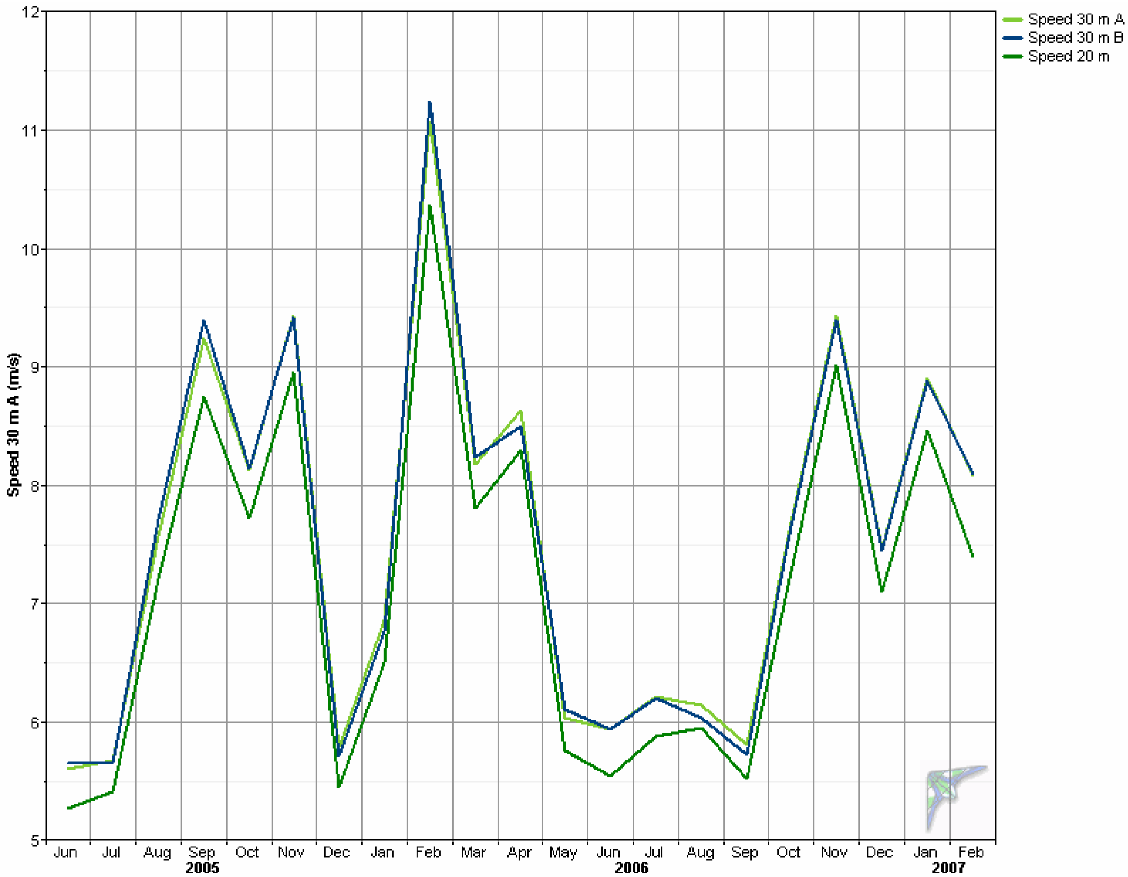
The daily wind profile indicates that the lowest wind speeds of the day occur in the morning hours of 2 to 6 a.m. and the highest wind speeds of the day occur during the afternoon and early evening hours of 2 to 7 p.m.

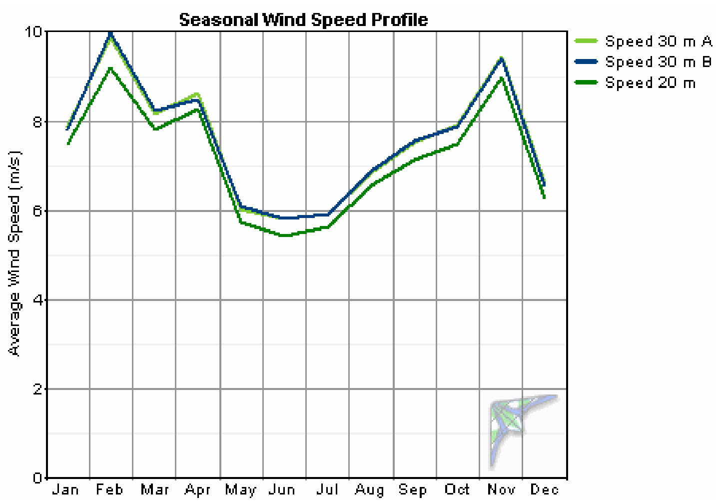




Time Series of Wind Speed Monthly Averages

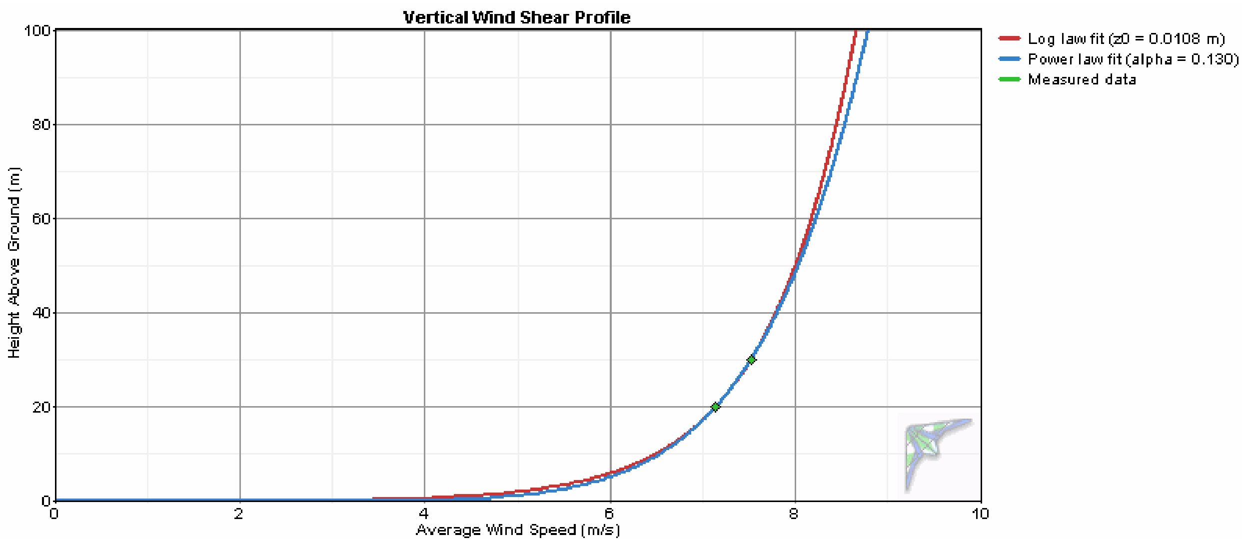
As expected, winter winds in Mekoryuk are high and summer winds comparatively low, although Mekoryuk is windy by almost any measure. The low winds of December 2005 and January 2006 were due to a persistent high pressure system that yielded cold temperatures and calm winds statewide, but was followed by a very stormy and windy February. Winter 2006/07 was less extreme in nature and perhaps more representative of typical winter weather.

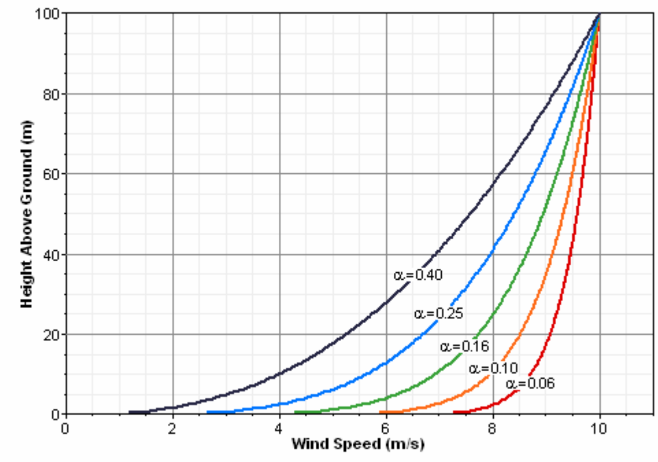


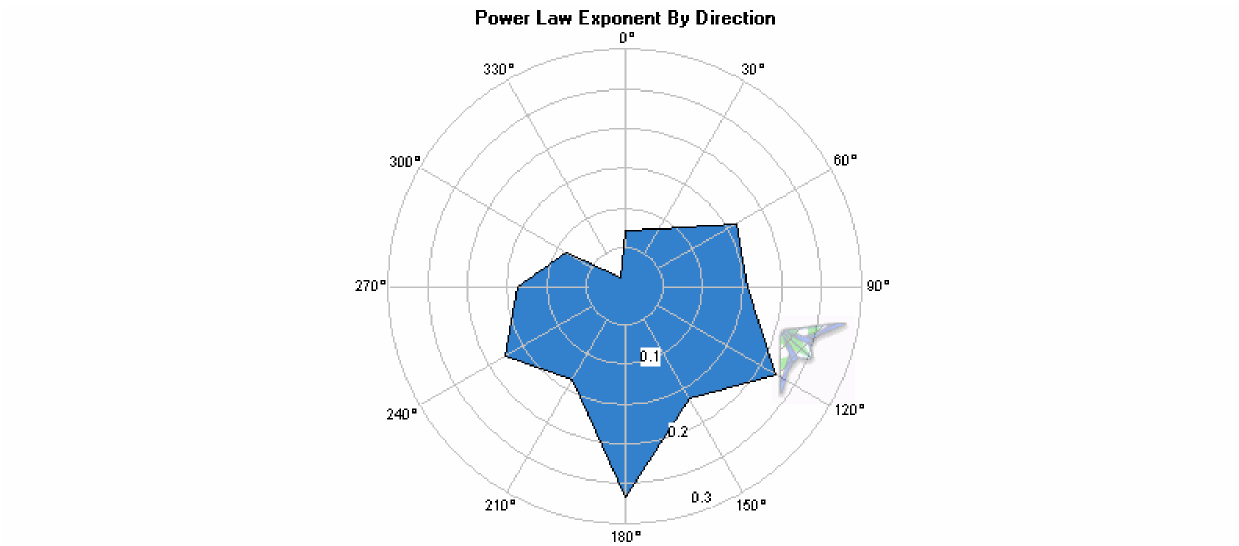


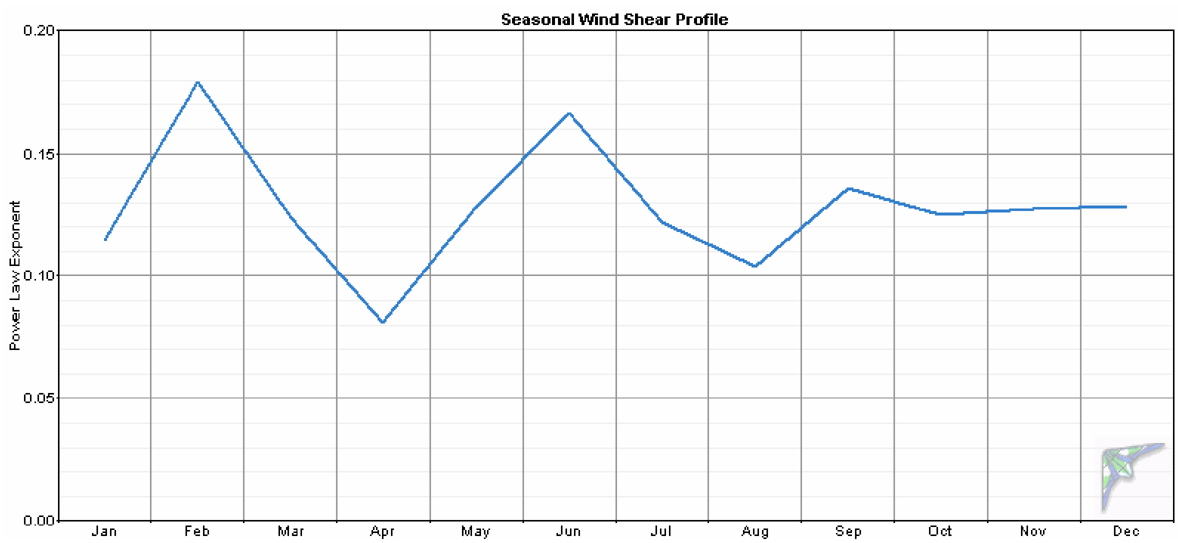
Wind Shear Profile

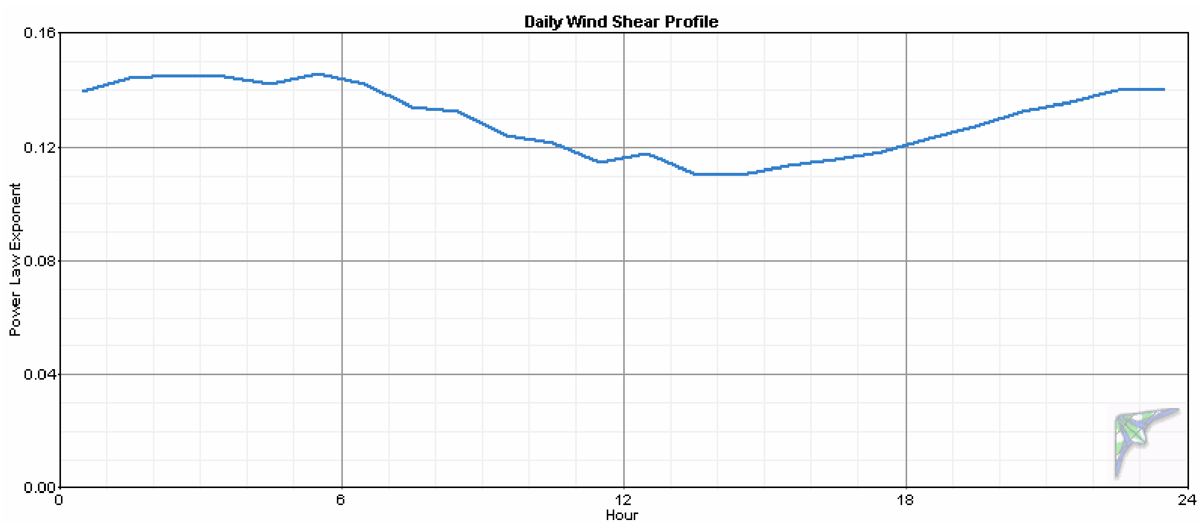
The annual average power law exponent was calculated at 0.13, with the seasonal variability shown in the lower graph, indicating low wind shear at the Mekoryuk test site. The practical application of this information is that a lower turbine height is possible as there is a relatively low marginal gain in average wind speed with height. However, a tower height/power recovery/construction cost tradeoff study is advisable.





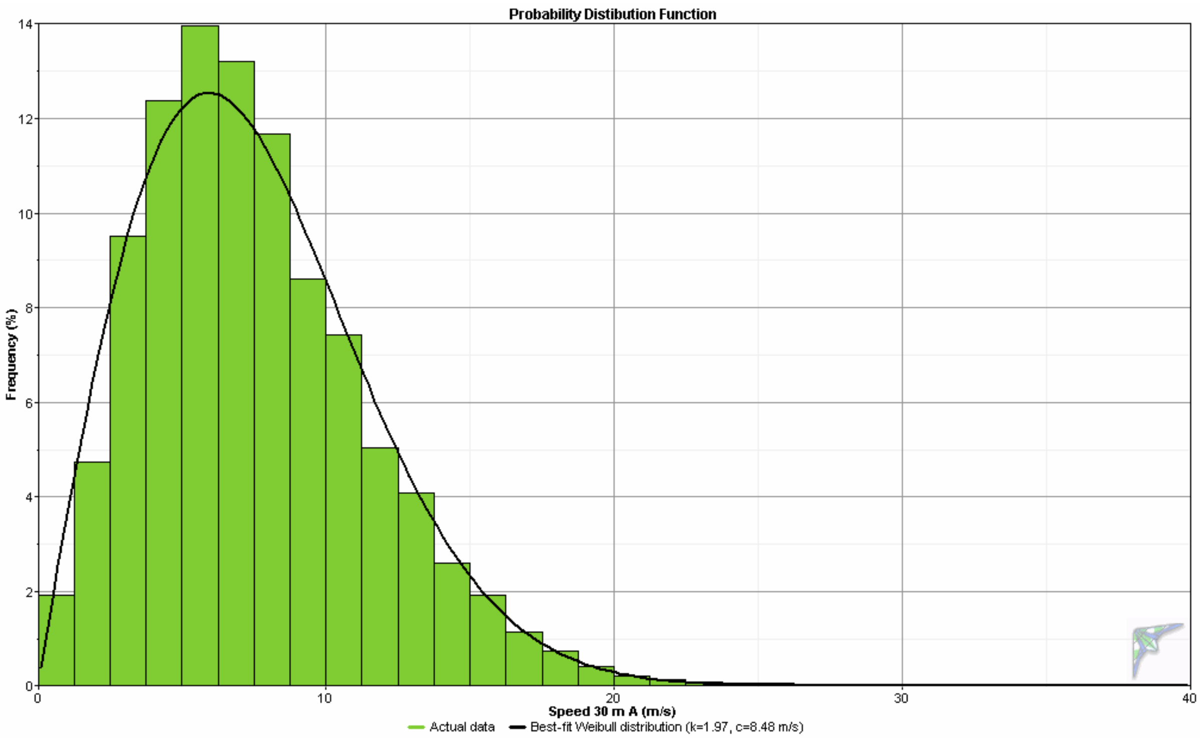

Power Law Exponent By Direction
0°
30°
60°
90°
120°
150°
180°
210°
240°
270°
300°
330°
0.1
0.2
0.3

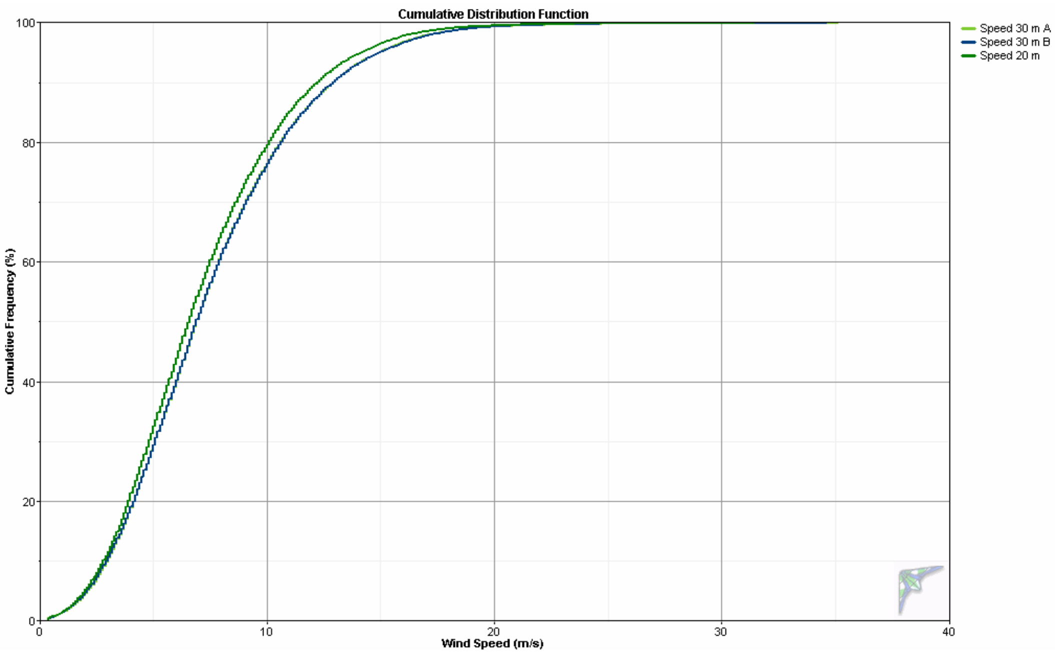

Seasonal Wind Shear Profile
Power Law Exponent
0.00
0.05
0.10
0.15
0.20
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Daily Wind Shear Profile
Power Law Exponent
0.00
0.04
0.08
0.12
0.16
0
6
12
18
24
Hour

Probability Distribution Function

The probability distribution function provides a visual indication of measured wind speeds in one meter per second "bins". Note that most wind turbines do not begin to generate power until the wind speed at hub height reaches 4 m/s, also known as the "cut-in" speed. The black line in the graph is a best fit Weibull distribution. At the 30 meter level, Weibull parameters are k = 1.97 and c = 8.48 m/s (scale factor for the Weibull distribution).

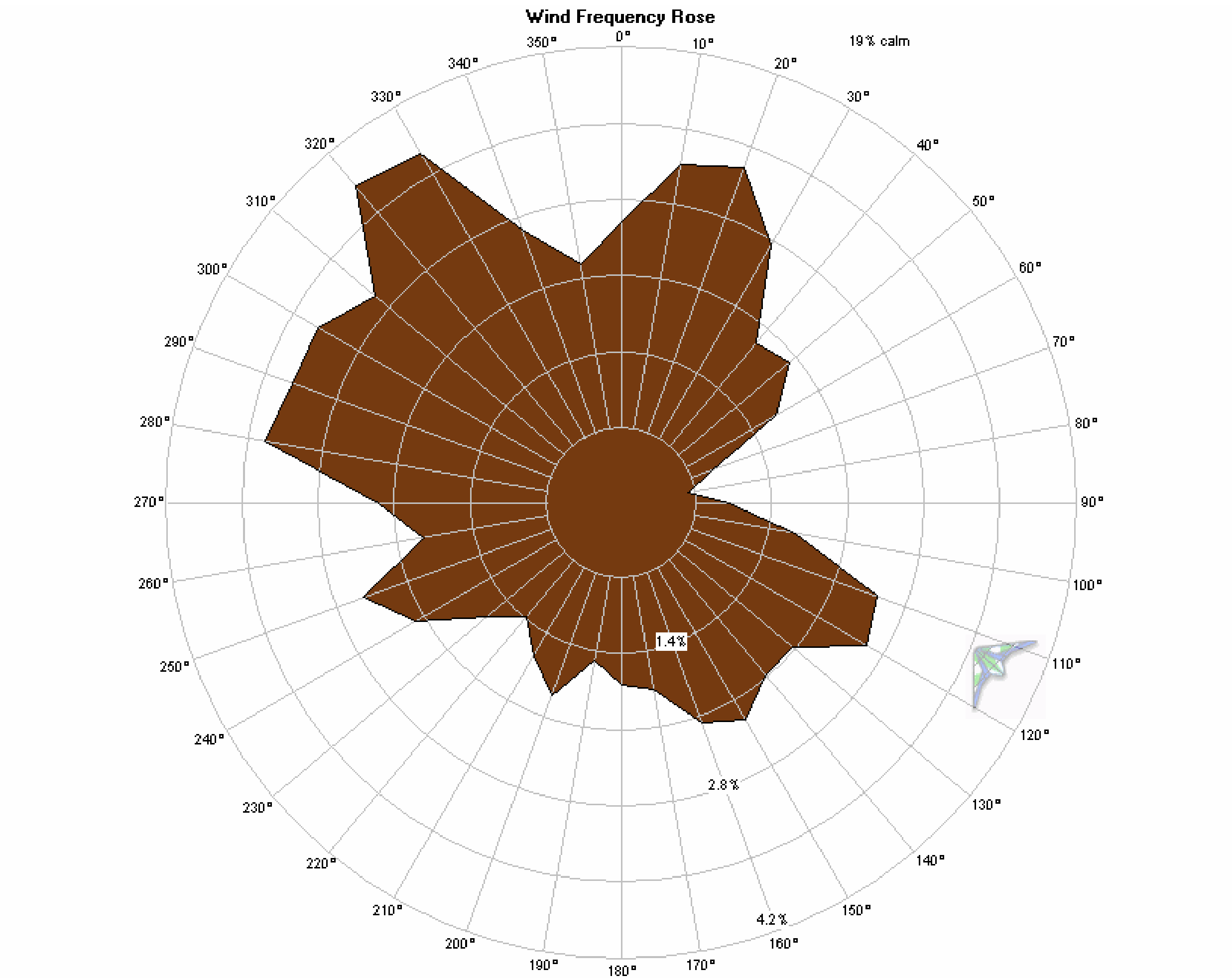




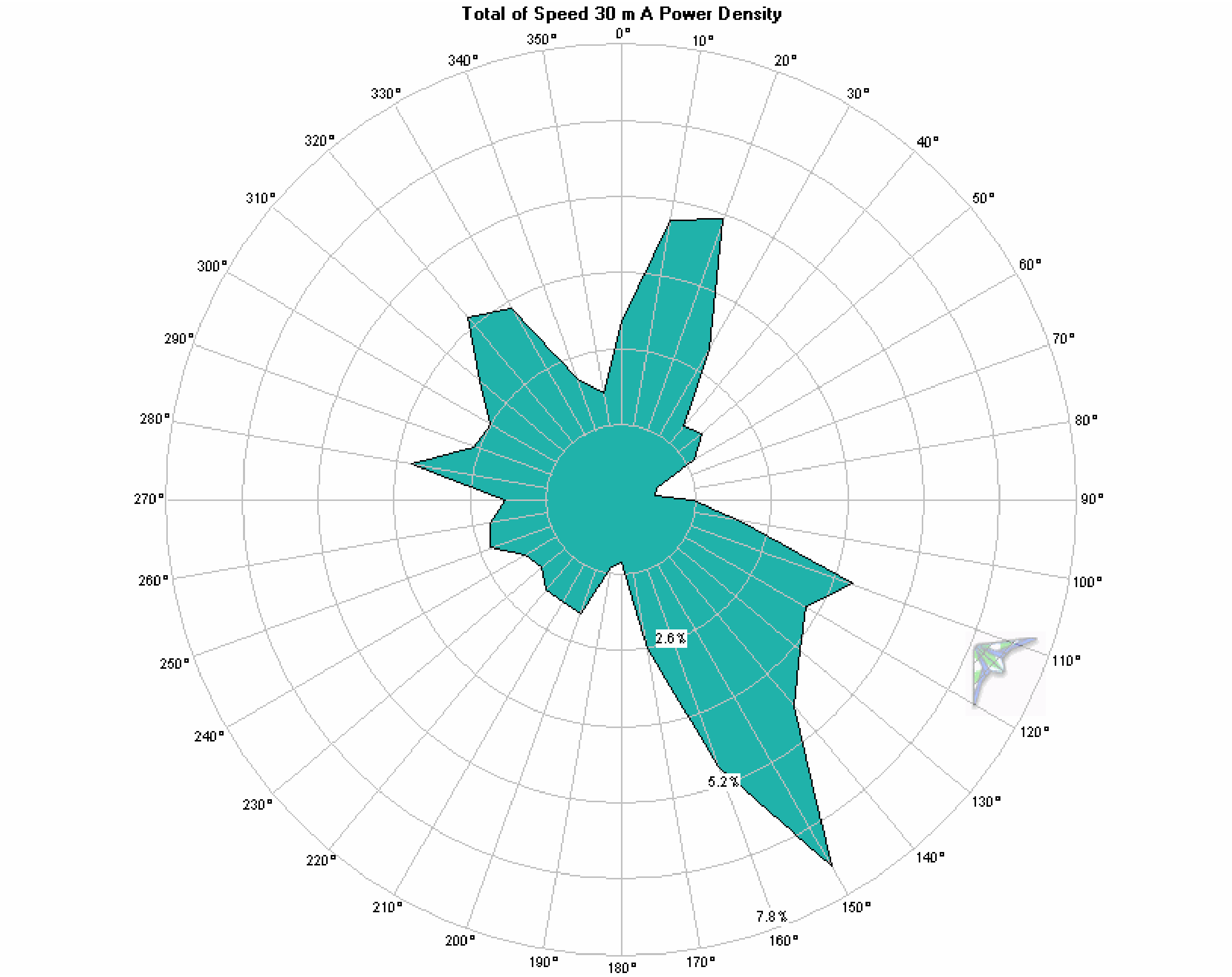
Wind Roses

Mekoryuk winds are not especially directional; the wind frequency rose indicates W, NW, NE, SE and SW components of wind. This observation is reinforced with reference to the power density rose, although with slightly more directionality. Power producing winds are chiefly NNE, SSE (most significantly), W and NW. The practical application of this information is that a site should be selected with adequate freedom from ground interference, especially on a northwest to southeast axis, and if more than one turbine is installed, the turbines should be adequately spaced apart to prevent downwind interference problems between the turbines.

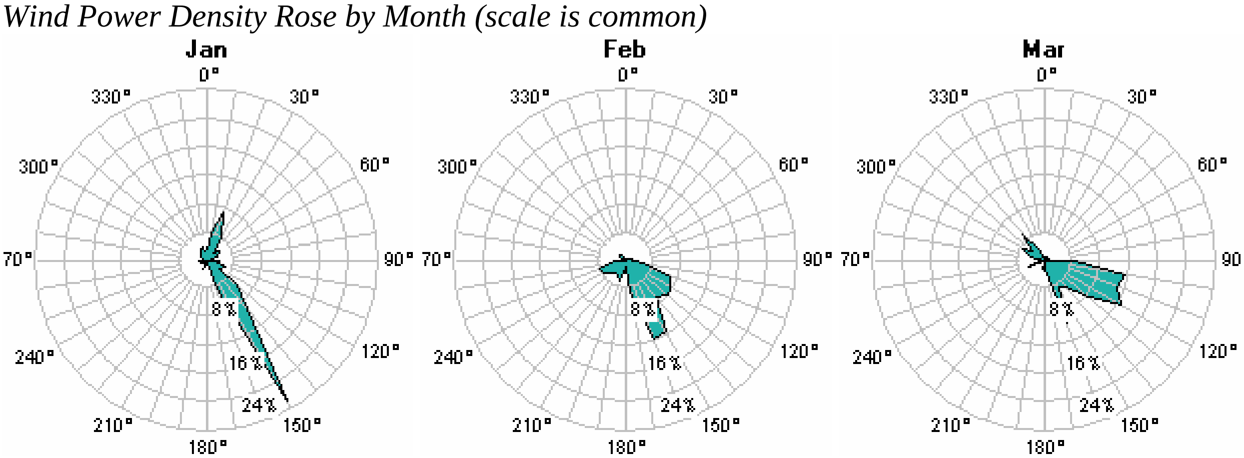
Wind frequency rose (30 meters)

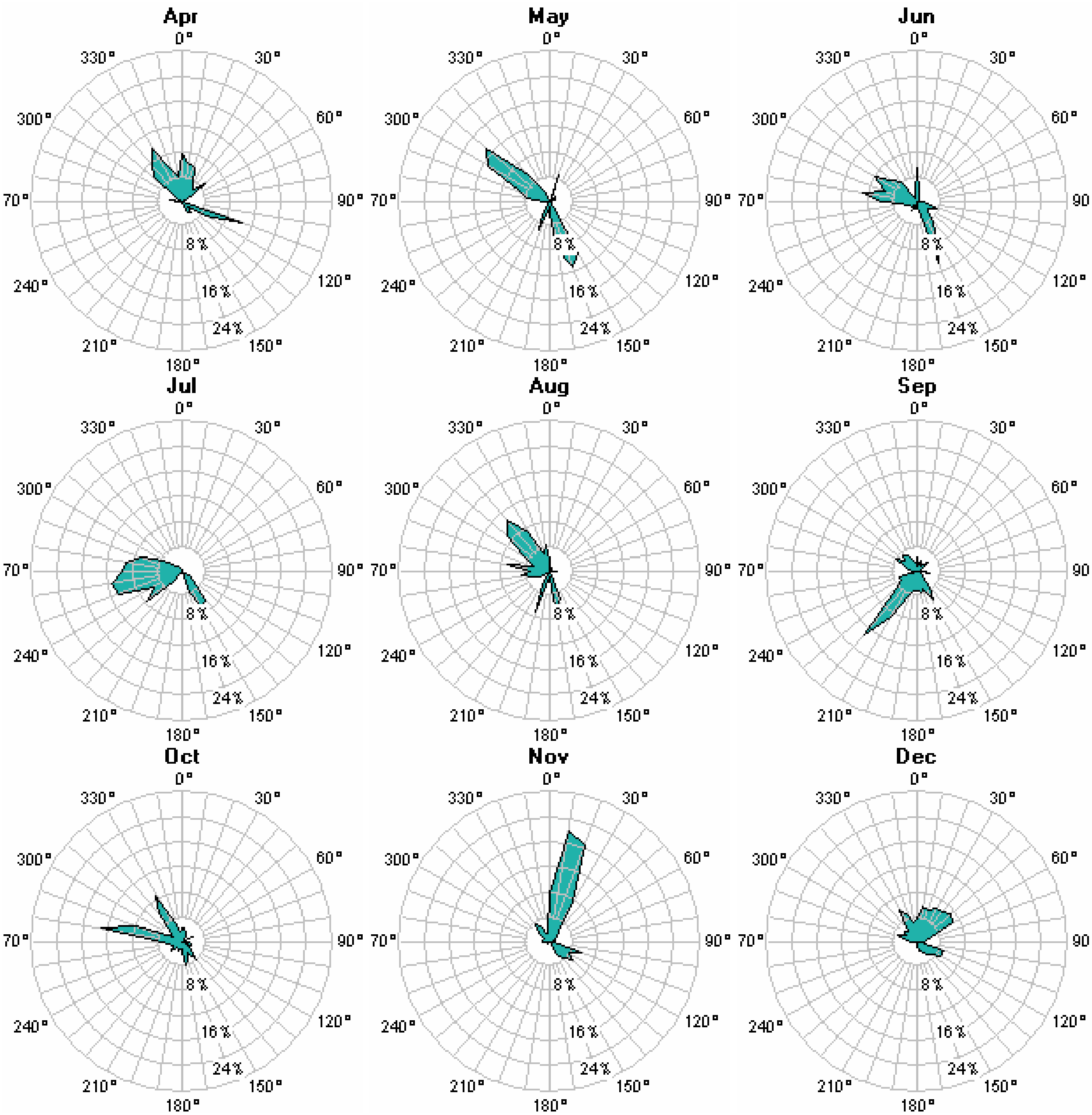


Power density rose (30 meters)



Wind Power Density Rose by Month (scale is common)

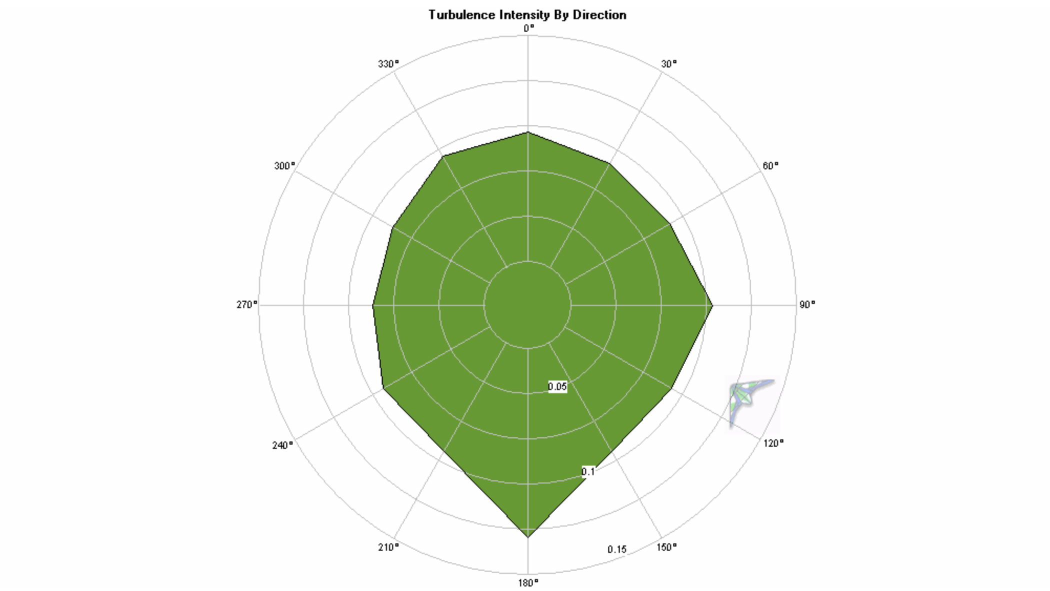



Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
0°
30°
60°
90°
120°
150°
180°
210°
240°
70°
300°
330°
8%
16%
24%

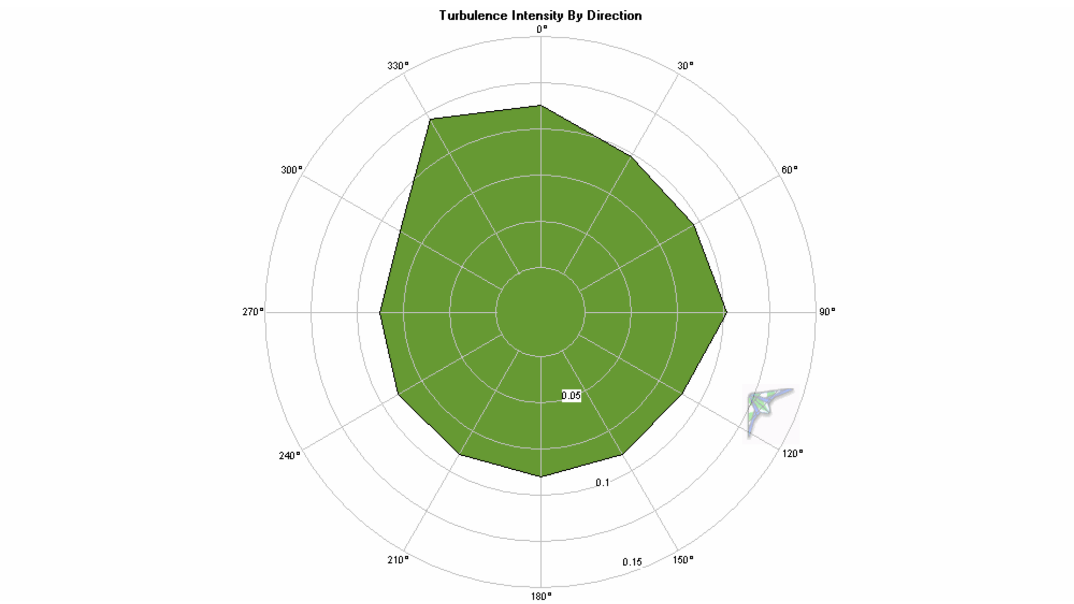
Turbulence Intensity

The Mekoryuk turbulence intensity is quite acceptable for all wind directions, with a mean turbulence intensity of 0.0952 (30 meters [A]), 0.0976 (30 meters [B]), and 0.105 (20 meters), indicating very smooth air. These turbulence intensities are calculated with a threshold wind speed of 4 m/s. The spike of relatively high turbulence to the south in channel 1 is due to placement of the 30 meter level anemometers in relation to the wind vane for varying wind directions.

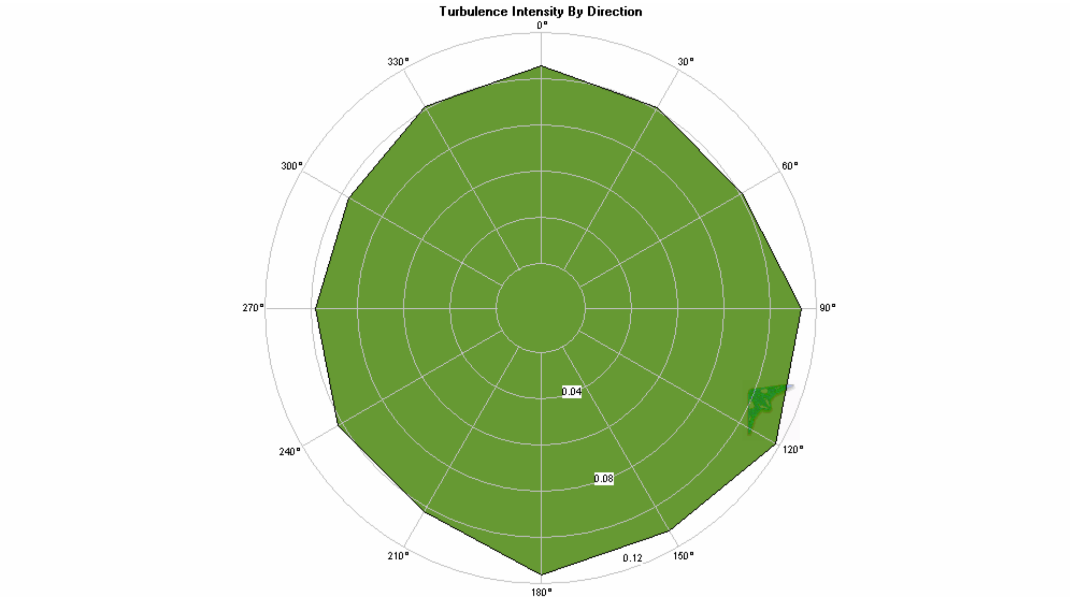
30 meter turbulence intensity (channel 1 – "A" anemometer)



30 meter turbulence intensity (channel 2 – "B" anemometer)

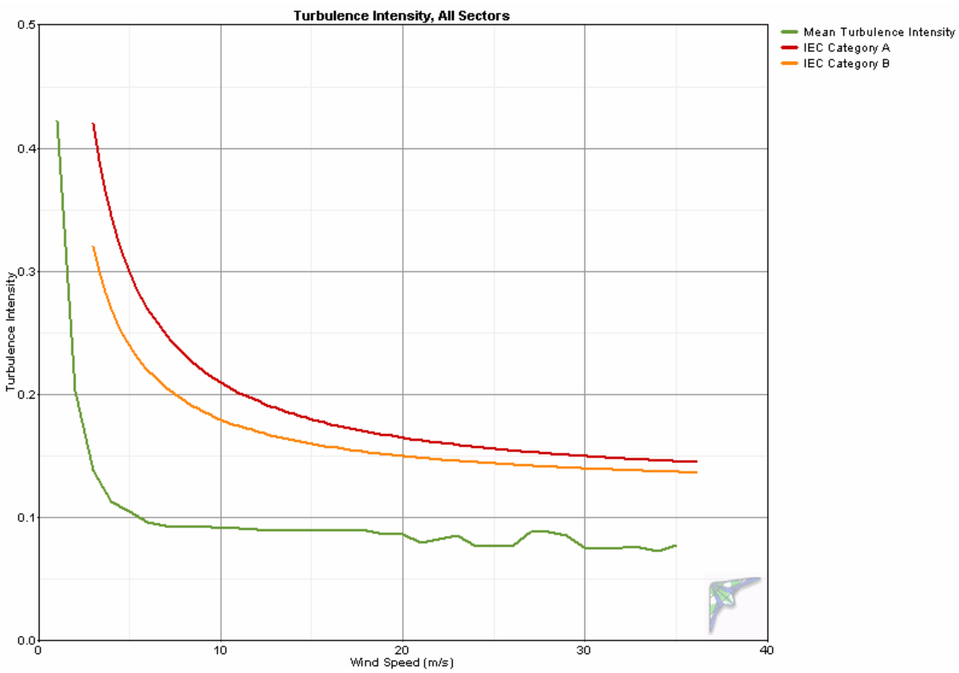


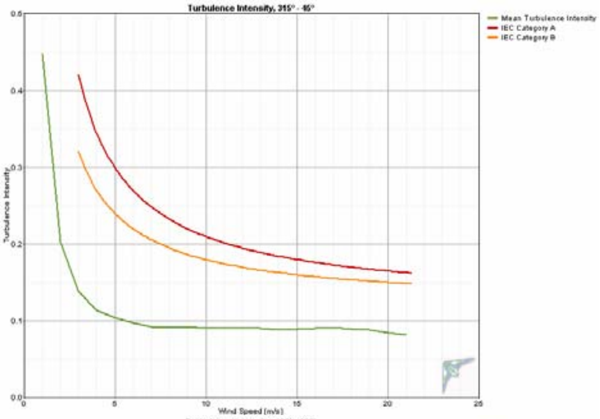
20 meter turbulence intensity

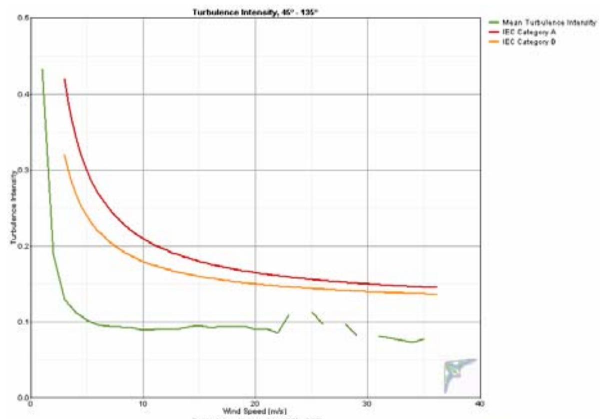


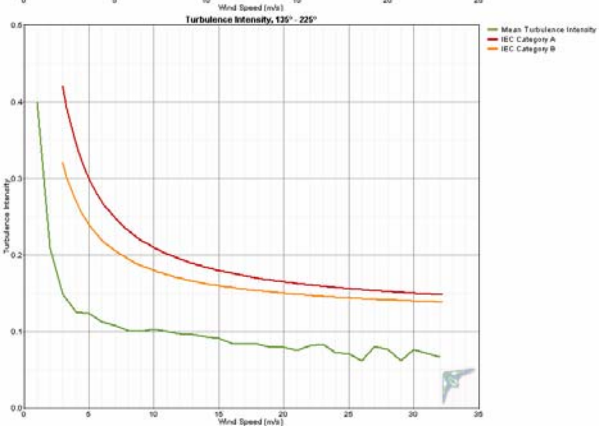
IEC Turbulence Intensity Standards

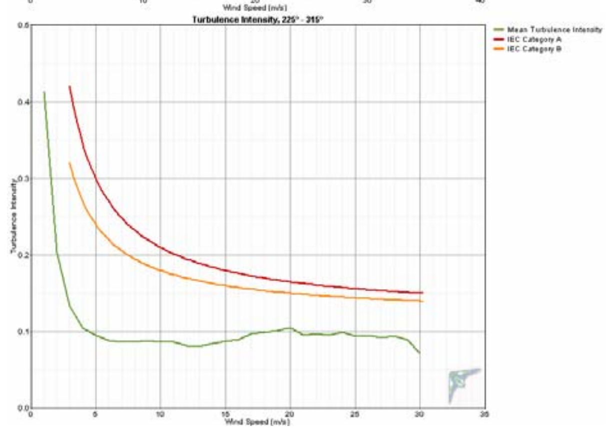
As indicated below, turbulence at the Mekoryuk project test site is well within International Energy Commission (IEC) Category A and B standards at all measured wind speeds and from all four quadrants of the wind rose.











Turbulence Table

30 meter, channel 1, A anemometer, 6/11/05 to 2/19/07

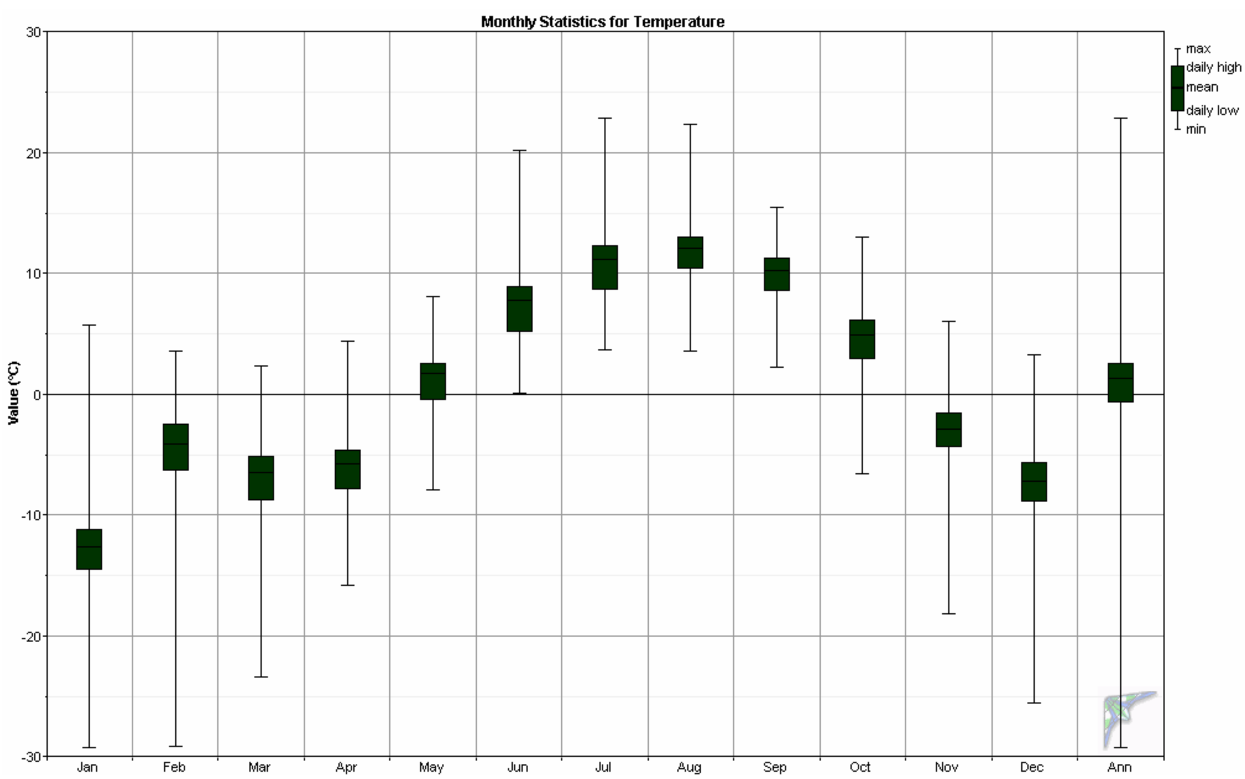
Bin Midpoint (m/s)	Bin Endpoints Lower (m/s)	Bin Endpoints Upper (m/s)	Records In Bin	Standard Deviation of Wind Speed (m/s)	Mean Turbulence Intensity	Standard Deviation of Turbulence Intensity	Characteristic Turbulence Intensity
1	0.5	1.5	538	0.403	0.413	0.239	0.652
2	1.5	2.5	1062	0.404	0.204	0.123	0.328
3	2.5	3.5	1992	0.397	0.133	0.066	0.199
4	3.5	4.5	2743	0.413	0.104	0.046	0.151
5	4.5	5.5	3146	0.470	0.095	0.039	0.134
6	5.5	6.5	3452	0.526	0.088	0.033	0.121
7	6.5	7.5	3290	0.605	0.087	0.031	0.118
8	7.5	8.5	2467	0.686	0.086	0.029	0.115
9	8.5	9.5	1867	0.789	0.088	0.030	0.118
10	9.5	10.5	1446	0.861	0.087	0.027	0.114
11	10.5	11.5	1162	0.950	0.087	0.030	0.117
12	11.5	12.5	744	0.971	0.081	0.027	0.108
13	12.5	13.5	590	1.049	0.081	0.027	0.108
14	13.5	14.5	450	1.181	0.085	0.025	0.110
15	14.5	15.5	319	1.304	0.087	0.021	0.109
16	15.5	16.5	241	1.430	0.090	0.021	0.111
17	16.5	17.5	123	1.638	0.097	0.026	0.123
18	17.5	18.5	100	1.770	0.099	0.025	0.124

19	18.5	19.5	50	1.924	0.102	0.028	0.129
20	19.5	20.5	37	2.079	0.105	0.022	0.127
21	20.5	21.5	13	1.977	0.095	0.019	0.115
22	21.5	22.5	7	2.129	0.097	0.017	0.115
23	22.5	23.5	5	2.220	0.096	0.009	0.105
24	23.5	24.5	7	2.400	0.099	0.013	0.113
25	24.5	25.5	13	2.369	0.095	0.006	0.101
26	25.5	26.5	14	2.486	0.095	0.011	0.107
27	26.5	27.5	18	2.511	0.093	0.009	0.102
28	27.5	28.5	11	2.645	0.095	0.015	0.109
29	28.5	29.5	6	2.600	0.090	0.008	0.098
30	29.5	30.5	2	2.150	0.072	0.007	0.079

Air Temperature and Density

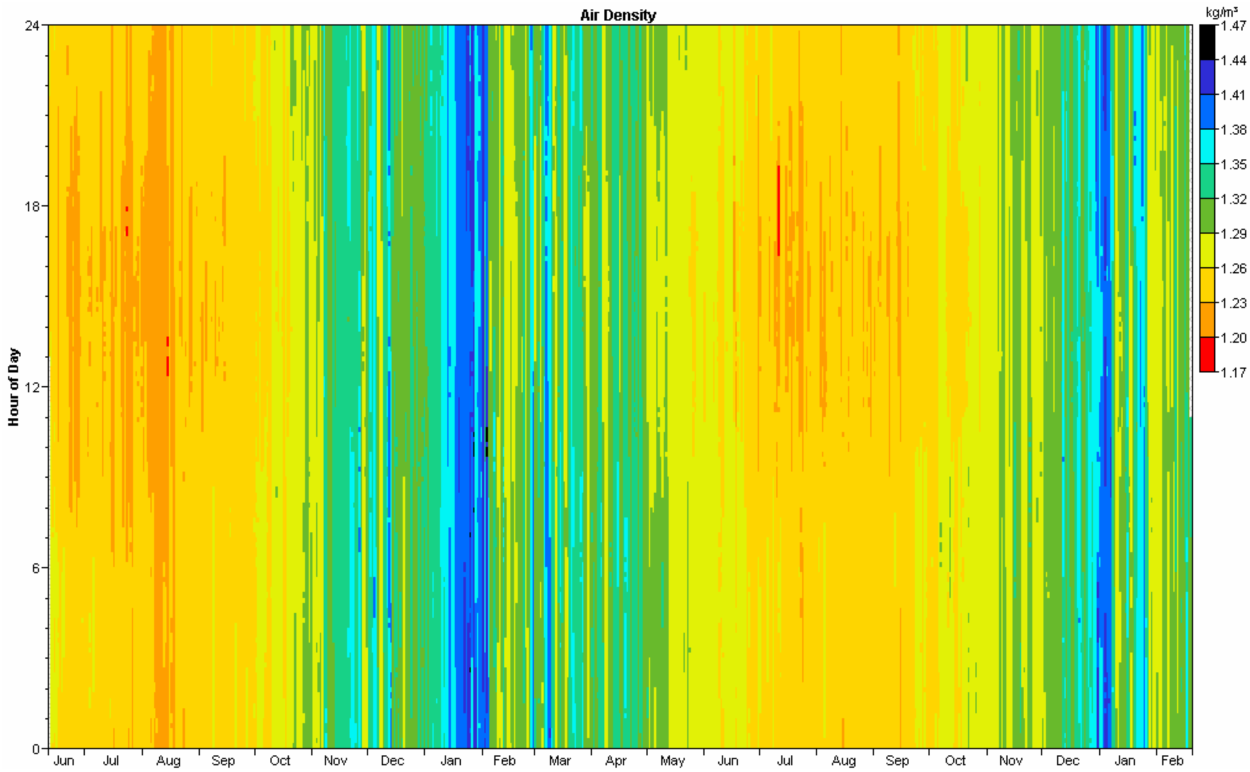
Mekoryuk measured an annual average temperature of 0.8° C. The minimum recording temperature during the measurement period was -29.2° C and the maximum temperature was 22.9° C, indicating a wide variability of ambient operating environment important to wind turbine operations. Consequent to Mekoryuk's cool temperatures, the average annual air density of 1.288 kg/m^3 is approximately four percent higher than the standard air density of 1.2235 kg/m3 (at 14.9° C temperature and 101.1 kPa pressure at an elevation of 13 meters).

	Temperature				Air Density		
Month	Mean (°C)	Min (°C)	Max (°C)	Std. Dev. (°C)	Mean (kg/m³)	Min (kg/m³)	Max (kg/m³)
Jan	-12.6	-29.2	5.7	8.13	1.354	1.264	1.444
Feb	-4.1	-29.1	3.6	6.60	1.310	1.273	1.444
Mar	-6.5	-23.4	2.4	5.85	1.322	1.279	1.411
Apr	-5.7	-15.8	4.4	3.69	1.318	1.269	1.369
May	1.8	-7.9	8.1	2.47	1.282	1.253	1.328
Jun	7.8	0.1	20.2	3.64	1.254	1.201	1.289
Jul	11.2	3.7	22.9	2.52	1.239	1.190	1.273
Aug	12.1	3.6	22.4	2.10	1.235	1.192	1.273
Sep	10.3	2.3	15.5	2.24	1.243	1.221	1.279
Oct	5.0	-6.6	13.0	2.97	1.267	1.231	1.322
Nov	-2.9	-18.2	6.1	5.19	1.304	1.262	1.382
Dec	-7.2	-25.5	3.3	5.31	1.325	1.274	1.423
Annual	**0.8**	-29.2	22.9	9.57	**1.288**	1.190	1.444



Air Density DMap

This DMap is a visual indication of the seasonal and daily variations in air density, and hence temperature. Air densities higher than standard (STP at sea level) will yield higher turbine power than predicted by turbine power curves, while density lower than standard will yield lower turbine power than predicted. Density variance from standard is accounted for in turbine predictions.



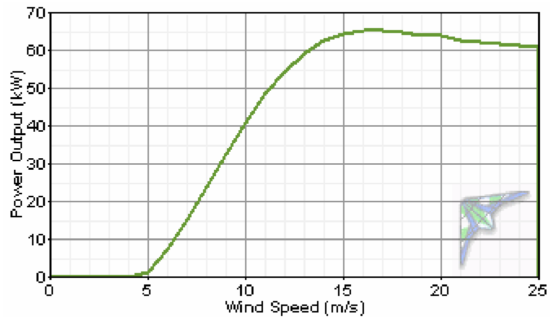
Wind Turbine Performance

The turbine performance predictions noted below are based on a 90 percent turbine availability with losses assumed as follows: 4% downtime, 2% array, 2% icing, and 2% other for a combined mathematical loss of 9.65% (loss calculations are multiplicative, not additive).

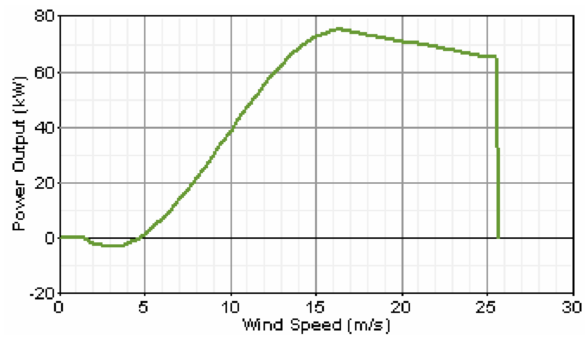
Note that these performance estimates were predicted with use of Windographer wind analysis software; power curves provided by manufacturers, are not independently verified and are assumed to be accurate. The power curves are presented for a standard air density of 1.225 kg/m^3 at sea level and 15° C. However, the predictions of power production are density compensated by multiplying the standard density power output by the ratio of the measured air density to standard air density, accounting for the site elevation.

A number of small to medium turbines are profiled in this report for comparison purposes. These turbines were selected because they have market availability and they are deemed to be within a suitable range for consideration of wind power development in a community the size of Mekoryuk.

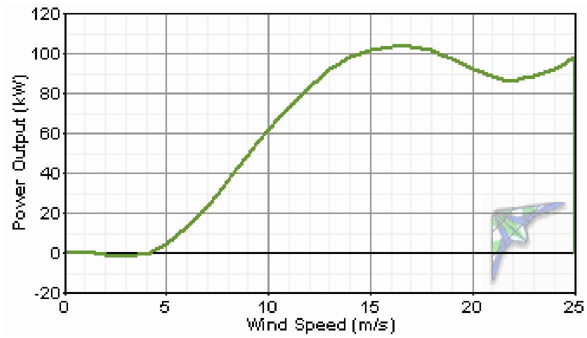
Entegrity eW-15: 65 kW rated power output, 15 meter rotor, stall-controlled (power curve provided by Entegrity Energy Systems). Available tower heights: 25 and 31 meters. Additional information is available at http://www.entegritywind.com/.



Vestas V15: 75 kW rated power output, 15 meter rotor, stall-controlled (power curve provided by Powercorp Alaska LLC). Available tower heights: 25, 31 and 34 meters. Additional information is available at http://www.pcorpalaska.com/.



Northwind 100/20: 100 kW rated power output, 20 meter rotor (19 meter rotor blades with 0.6 meter blade root extensions added), stall-controlled (power curve provided by Northern Power Systems). Available tower heights: 25 and 32 meters. Additional information is available at http://www.northernpower.com/.



eW-15

Entegrity eW-15, 31 meter hub height

Month	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Average Net Power Output (kW)	Average Net Energy Output (kWh)	Average Net Capacity Factor (%)
Jan	7.90	19	10	23	17,414	36.0
Feb	9.96	9	18	34	22,620	51.8
Mar	8.21	16	11	26	18,965	39.2
Apr	8.66	6	9	28	20,219	43.2
May	6.10	28	4	13	9,587	19.8
Jun	5.82	22	0	11	7,629	16.3
Jul	5.96	29	1	12	9,008	18.6

Aug	6.92	23	3	17	12,951	26.8
Sep	7.59	17	3	21	14,844	31.7
Oct	7.96	14	6	22	16,049	33.2
Nov	9.47	10	22	32	23,012	49.2
Dec	6.63	24	4	17	12,896	26.7
Annual	7.6	18.2	7.6	21.3	185,194	32.7

Note: 90% turbine availability

V15

Vestas V15, 31 meter hub height

Month	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Average Net Power Output (kW)	Average Net Energy Output (kWh)	Average Net Capacity Factor (%)
Jan	7.90	24	5	23	17,084	30.6
Feb	9.96	12	11	34	23,087	45.8
Mar	8.21	22	9	25	18,725	33.6
Apr	8.66	9	6	28	19,776	36.6
May	6.10	37	3	12	8,858	15.9
Jun	5.82	31	0	9	6,738	12.5
Jul	5.96	37	1	11	8,152	14.6
Aug	6.92	29	1	17	12,381	22.2
Sep	7.59	22	1	20	14,388	26.6
Oct	7.96	19	4	21	15,668	28.1
Nov	9.47	14	16	33	23,694	43.9
Dec	6.63	31	2	16	12,140	21.8
Annual	7.6	23.9	4.9	20.8	180,691	27.7

Note: 90% turbine availability

NW100/20

NPS Northwind 100/20, 32 meter hub height

Month	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Average Net Power Output (kW)	Average Net Energy Output (kWh)	Average Net Capacity Factor (%)
Jan	7.93	19	8	35	25,711	34.6
Feb	10.01	9	16	50	33,693	50.1
Mar	8.24	16	11	38	28,161	37.9
Apr	8.69	6	8	41	29,621	41.1
May	6.12	28	4	19	14,342	19.3
Jun	5.85	22	0	16	11,374	15.8
Jul	5.99	29	1	18	13,351	17.9
Aug	6.95	23	3	26	19,167	25.8
Sep	7.63	16	3	31	21,942	30.5
Oct	8.00	14	5	32	23,724	31.9
Nov	9.51	10	21	48	34,558	48.0
Dec	6.65	24	4	26	19,063	25.6
Annual	7.6	18.1	7.0	31.5	274,707	31.5

Note: 90% turbine availability

Annual Fuel Cost Avoided for Electrical Energy Generation by Diesel Genset

			Fuel Price (dollars delivered)							
Turbine	Annual Energy Output (kW-hr/yr)	Fuel Quantity Avoided (gallons)	$1.75	$2.00	$2.25	$2.50	$2.75	$3.00	$3.25	Hub Height (m)
eW-15	185,194	13,718	$24,007	$27,436	$30,866	$34,295	$37,725	$41,154	$44,584	31
V15	180,691	13,385	$23,423	$26,769	$30,115	$33,461	$36,807	$40,154	$43,500	31
NW100/20	274,707	20,349	$35,610	$40,697	$45,785	$50,872	$55,959	$61,046	$66,133	32

Note: Mekoryuk electrical energy production efficiency is 13.5 kW-hr/gal

Note: Assumes 90% turbine availability with no diversion of power to a thermal or other dump load

Temperature Conversion Chart °C to °F

°C	°F	°C	°F	°C	°F
-40	-40.0	-10	14.0	20	68.0
-39	-38.2	-9	15.8	21	69.8
-38	-36.4	-8	17.6	22	71.6
-37	-34.6	-7	19.4	23	73.4
-36	-32.8	-6	21.2	24	75.2
-35	-31.0	-5	23.0	25	77.0
-34	29.2	-4	24.8	26	78.8
-33	-27.4	-3	26.6	27	80.6
-32	-25.6	-2	28.4	28	82.4
-31	-23.8	-1	30.2	29	84.2
-30	-22.0	0	32.0	30	86.0
-29	-20.2	1	33.8	31	87.8
-28	-18.4	2	35.6	32	89.6
-27	-16.6	3	37.4	33	91.4
-26	-14.8	4	39.2	34	93.2
-25	-13.0	5	41.0	35	95.0
-24	-11.2	6	42.8	36	96.8
-23	-9.4	7	44.6	37	98.6
-22	-7.6	8	46.4	38	100.4
-21	-5.8	9	48.2	39	102.2
-20	-4.0	10	50.0	40	104.0
-19	-2.2	11	51.8	41	105.8
-18	-0.4	12	53.6	42	107.6
-17	1.4	13	55.4	43	109.4
-16	3.2	14	57.2	44	111.2
-15	5.0	15	59.0	45	113.0
-14	6.8	16	60.8	46	114.8
-13	8.6	17	62.6	47	116.6
-12	10.4	18	64.4	48	118.4
-11	12.2	19	66.2	49	120.2

Wind Speed Conversion Chart, m/s to mph

m/s	mph	m/s	mph	m/s	mph	m/s	mph	m/s	mph
0.5	1.1	10.5	23.5	20.5	45.9	30.5	68.2	40.5	90.6
1.0	2.2	11.0	24.6	21.0	47.0	31.0	69.3	41.0	91.7
1.5	3.4	11.5	25.7	21.5	48.1	31.5	70.5	41.5	92.8
2.0	4.5	12.0	26.8	22.0	49.2	32.0	71.6	42.0	93.9
2.5	5.6	12.5	28.0	22.5	50.3	32.5	72.7	42.5	95.1
3.0	6.7	13.0	29.1	23.0	51.4	33.0	73.8	43.0	96.2
3.5	7.8	13.5	30.2	23.5	52.6	33.5	74.9	43.5	97.3
4.0	8.9	14.0	31.3	24.0	53.7	34.0	76.1	44.0	98.4
4.5	10.1	14.5	32.4	24.5	54.8	34.5	77.2	44.5	99.5
5.0	11.2	15.0	33.6	25.0	55.9	35.0	78.3	45.0	100.7
5.5	12.3	15.5	34.7	25.5	57.0	35.5	79.4	45.5	101.8
6.0	13.4	16.0	35.8	26.0	58.2	36.0	80.5	46.0	102.9
6.5	14.5	16.5	36.9	26.5	59.3	36.5	81.6	46.5	104.0
7.0	15.7	17.0	38.0	27.0	60.4	37.0	82.8	47.0	105.1
7.5	16.8	17.5	39.1	27.5	61.5	37.5	83.9	47.5	106.3
8.0	17.9	18.0	40.3	28.0	62.6	38.0	85.0	48.0	107.4
8.5	19.0	18.5	41.4	28.5	63.8	38.5	86.1	48.5	108.5
9.0	20.1	19.0	42.5	29.0	64.9	39.0	87.2	49.0	109.6
9.5	21.3	19.5	43.6	29.5	66.0	39.5	88.4	49.5	110.7
10.0	22.4	20.0	44.7	30.0	67.1	40.0	89.5	50.0	111.8

Distance Conversion m to ft

m	ft	m	ft
5	16	35	115
10	33	40	131
15	49	45	148
20	66	50	164
25	82	55	180
30	98	60	197

Selected definitions (courtesy of Windographer® software by Mistaya Engineering Inc.)

Wind Power Class

The wind power class is a number indicating the average energy content of the wind resource. Wind power classes are based on the average wind power density at 50 meters above ground, according to the following table. Source: Wind Energy Resource Atlas of the United States (http://rredc.nrel.gov/wind/pubs/atlas/tables/A-8T.html)

Wind Power Class	Description	Power Density at 50m (W/m^2)
1	Poor	0-200
2	Marginal	200-300
3	Fair	300-400
4	Good	400-500
5	Excellent	500-600
6	Outstanding	600-800
7	Superb	800-2000

Windographer classifies any wind resource with an average wind power density above 2000 W/m^2 as class 8.

Probability Distribution Function

The probability distribution function f(x) gives the probability that a variable will take on the value x. It is often expressed using a frequency histogram, which gives the frequency with which the variable falls within certain ranges or bins.

Wind Turbine Power Regulation

All wind turbines employ some method of limiting power output at high wind speeds to avoid damage to mechanical or electrical subsystems. Most wind turbines employ either stall control or pitch control to regulate power output.

A stall-controlled turbine typically has blades that are fixed in place, and are designed to experience aerodynamic stall at very high wind speeds. Aerodynamic stall dramatically reduces the torque produced by the blades, and therefore the power produced by the turbine.

On a pitch-controlled turbine, a controller adjusts the angle (pitch) of the blades to best match the wind speed. At very high wind speeds the controller increasingly feathers the blades out of the wind to limit the power output.