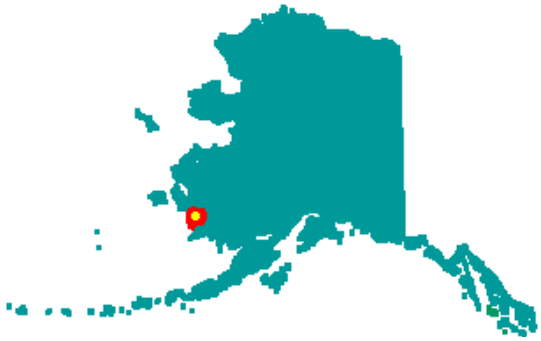
Quinhagak, Alaska Wind Resource Report

Report prepared by: Douglas Vaught, P.E., V3 Energy, LLC, Eagle River, AK
Date of report: August 17, 2007

Photo: Doug Vaught



Summary Information

Meteorological Tower Data Synopsis

Wind power class (measured to date)	Class 4 – Good
Average wind speed (30 meters)	6.31 m/s
Maximum wind gust (2 seconds)	43.6 m/s (1/30/07)
Mean wind power density (50 meters)	436 W/m^2
Mean wind power density (30 meters)	340 W/m^2
Mean energy content (30 meters)	2,978 kWh/m^2/yr
Roughness Class	2.35 (few trees)
Power law exponent	0.197 (moderate wind shear)
Turbulence intensity	0.0915 (low)
Frequency of calms (4 m/s threshold)	27 percent
Data start date	October 23, 2005
Most recent data date	May 24, 2007

Community Profile

Location:
Quinhagak is on the Kanektok River on the east shore of Kuskokwim Bay, less than a mile from the Bering Sea coast. It lies 71 miles southwest of Bethel at approximately 59.748890° North Latitude and 161.915830° West Longitude. (Sec. 17, T005S, R074W, Seward Meridian.) Quinhagak is located in the Bethel Recording District. The area encompasses 4.7 sq. miles of land and 0.6 sq. miles of water.

History:
The Yup'ik name is Kuinerraq, meaning "new river channel." Quinhagak is a long-established village whose origin has been dated to 1,000 A.D. It was the first village on the lower Kuskokwim to have sustained contact with whites. Gavril Sarichev reported the village on a map in 1826. After the purchase of Alaska in 1867, the Alaska Commercial Co. sent annual supply ships to Quinhagak with goods for Kuskokwim River trading posts. Supplies were lightered to shore from the ship, and stored in a building on Warehouse Creek. A Moravian Mission was built in 1893. There were many non-Natives in the village at that time; most waiting for boats to go upriver. In 1904 a mission store opened, followed by a post office in 1905 and a school in 1909. Between 1906 and 1909, over 2,000 reindeer were brought in to the Quinhagak area. They were managed for a time by the Native-owned Kuskokwim Reindeer Company, but the herd had scattered by the 1950s. In 1915 the Kuskokwim River was charted, so goods were barged directly upriver to Bethel. In 1928, the first electric plant opened; the first mail plane arrived in 1934. The City was incorporated in 1975.

Culture:
The community is primarily Yup'ik Eskimos who fish commercially and are active in subsistence food gathering. The sale, importation or possession of alcohol is banned in the village.

Economy:
Most of the employment is with the school, government services or commercial fishing. Trapping, basket weaving, skin sewing and ivory carving also provide income. Subsistence remains an important part of the livelihood; seal and salmon are staples of the diet. Eighty-three residents hold commercial fishing permits for salmon net and herring roe fisheries. Coastal Villages Seafood LLC processes halibut and salmon in Quinhagak.

Facilities:

All services are provided by the Native Village of Kwinhagak, under agreement with the City. Water is derived from a well near the Kanektok River. The water treatment plant, storage tank, and waterline were relocated in 1997 as part of a new flush/haul system for the community. Forty homes are now served by the new system, with water delivery and tank haul. An old BIA building has been renovated as a new washeteria and health clinic. The school and washeteria are connected directly to the water plant. Eighty-nine households still haul water and use honeybuckets, and funds are being appropriated to expand the flush/haul system. Major improvements continue.

Transportation:

Quinhagak relies heavily on air transportation for passenger mail and cargo service. A State-owned 2,600' long by 60' wide gravel airstrip is available. A longer runway is nearly complete, which will enable direct flights to Anchorage. Float planes land on the Kanektok River. A harbor and dock were recently completed. Barges deliver heavy goods at least twice a year. Boats, ATVs, snow machines, and some vehicles are used for local transportation. Winter trails are marked to Eek and Goodnews Bay.

Climate:

Quinhagak is located in a marine climate. Precipitation averages 22 inches, with 43 inches of snowfall annually. Summer temperatures average 41 to 57 degrees F, winter temperatures average 6 to 24 F. Extremes have been measured from 82 to -34 F.

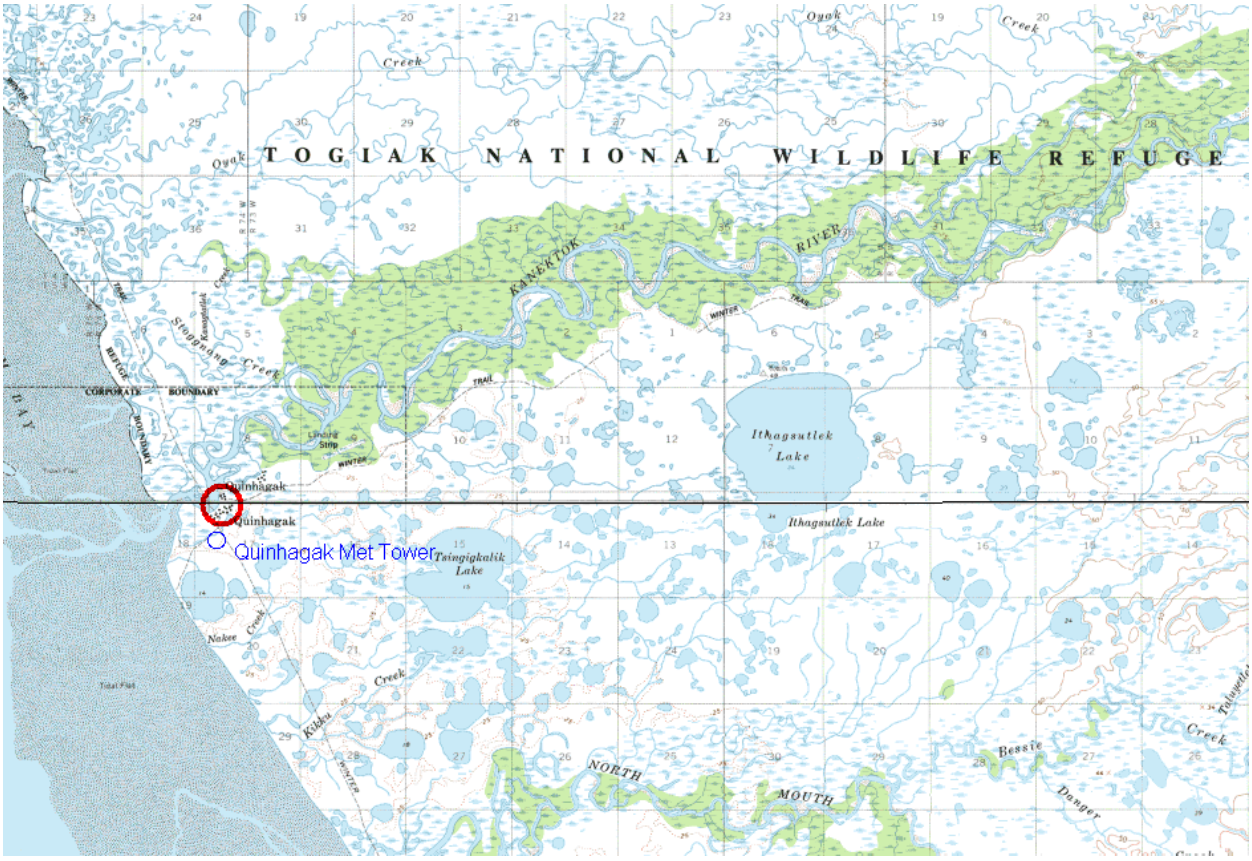
(Above information from State of Alaska Department of Commerce, Community, and Economic Development website, http://www.dced.state.ak.us/)

Met Tower Sensor Information

Channel	Sensor type	Height	Multiplier	Offset	Orientation
1	NRG #40 anemometer	30 m (A)	0.765	0.35	NE
2	NRG #40 anemometer	30 m (B)	0.765	0.35	SW
3	NRG #40 anemometer	20 m	0.765	0.35	SW
7	NRG #200P wind vane	25 m	0.351	220	NE
9	NRG #110S Temp C	2 m	0.136	-86.383	N/A

Site Information

Site number	0022
Site Description	Adjacent to proposed new powerplant, near tank farm
Latitude/longitude	N 059° 44.646’; W 161° 55.030’
Site elevation	3 meters
Datalogger type	NRG Symphonie
Tower type	NRG 30-meter tall tower, 152 mm (6-in) diameter


TOGIAK NATIONAL WILDLIFE REFUGE
Oyak Creek
KANEKTOK RIVER
Stoggnang Creek
CORPORATE BOUNDARY
Quinhagak
Quinhagak Met Tower
Ithagsutlek Lake
Tsingigkalik Lake
Nakee Creek
Kiska Creek
NORTH MOUTH
Bessie Creek
Danger Creek
TRAIL
WINTER

Data Quality Control Summary

Data was filtered to remove presumed icing events that yield false zero wind speed data. Data that met the following criteria were filtered: wind speed < 1 m/s, wind speed standard deviation = 0, and temperature < 3 °C. Other obvious icing data was removed even if it did not meet the above criteria. An offset failure in the temperature sensor occurred on July 7, 2006 resulting logged temperature data reading approximately 30° C lower than normal. An offset correction of +32.8° was added to all subsequent temperature data. It is not known if this offset correction is completely accurate for the ten months it covers, but a near accurate temperature record of the site was deemed more desirable than deleting most of the temperature record.

Data Quality Control Summary Table

		30 m A anem.		30 m B anem.		20 m anem.	
		Records	Recovery Rate	Records	Recovery Rate	Records	Recovery Rate
2005	Oct	1,235	90.5	1,235	90.5	1,235	90.5
2005	Nov	3,428	79.4	3,851	89.1	3,851	89.1
2005	Dec	4,148	92.9	3,986	89.3	4,464	100
2006	Jan	4,464	100	4,464	100	4,464	100
2006	Feb	4,032	100	4,032	100	4,032	100
2006	Mar	4,464	100	4,464	100	4,464	100
2006	Apr	4,320	100	4,320	100	4,320	100
2006	May	4,464	100	4,464	100	4,464	100
2006	Jun	4,320	100	4,320	100	4,320	100
2006	Jul	4,464	100	4,464	100	4,464	100
2006	Aug	4,464	100	4,464	100	4,464	100
2006	Sep	4,320	100	4,320	100	4,320	100
2006	Oct	4,464	100	4,464	100	4,464	100
2006	Nov	4,320	100	4,320	100	4,320	100
2006	Dec	4,464	100	4,464	100	4,464	100
2007	Jan	4,464	100	4,464	100	4,464	100
2007	Feb	4,032	100	4,032	100	4,032	100
2007	Mar	4,464	100	4,464	100	4,464	100
2007	Apr	4,201	97.2	4,320	100	4,204	97.3
2007	May	3,366	100	3,366	100	3,366	100
All data		81,898	98.3	82,278	98.7	82,640	99.1

		25 m vane		Temperature	
		Records	Recovery Rate	Records	Recovery Rate
2005	Oct	1,235	90.5	1,235	100
2005	Nov	3,397	78.6	4,320	100
2005	Dec	3,204	71.8	4,464	100
2006	Jan	4,193	93.9	4,464	100

2006	Feb	3,703	91.8	4,032	100
2006	Mar	4,464	100	4,464	100
2006	Apr	3,929	90.9	4,320	100
2006	May	4,464	100	4,464	100
2006	Jun	4,320	100	4,320	100
2006	Jul	4,464	100	4,464	100
2006	Aug	4,464	100	4,464	100
2006	Sep	4,320	100	4,320	100
2006	Oct	4,464	100	4,464	100
2006	Nov	4,320	100	4,320	100
2006	Dec	4,464	100	4,464	100
2007	Jan	4,239	95	4,464	100
2007	Feb	4,032	100	4,032	100
2007	Mar	4,464	100	4,464	100
2007	Apr	4,320	100	4,320	100
2007	May	3,366	100	3,366	100
All data		79,826	95.8	83,225	100

Note: shaded temperature data notes months where +32.8° offset correction was inserted for sensor offset error

Measured Wind Speeds

The Channel 1 (30-meter [A]) anemometer wind speed average for the reporting period is 6.31 m/s. The Channel 2 (30-meter [B]) anemometer wind speed average is 6.30 m/s and the Channel 3 (20-meter) anemometer wind speed average for the reporting period is 5.80 m/s.

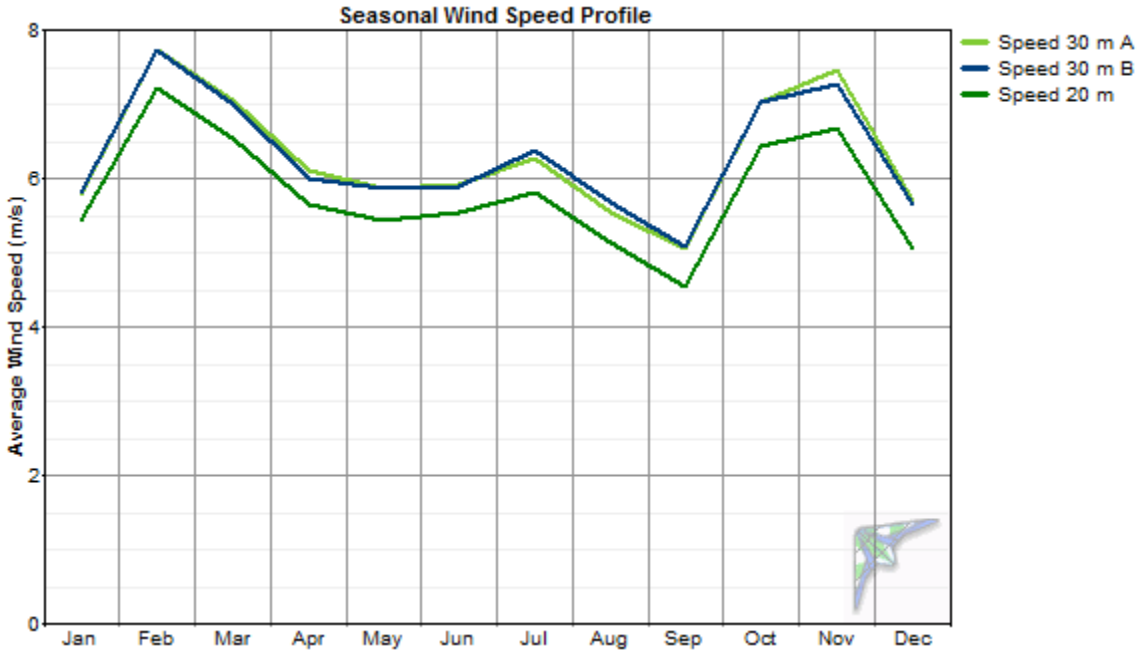
Typically, the highest wind speeds occur during the winter months of October through March with the lowest winds during the summer months of May through September. The unusually low winds measured in January 2006 were due to a persistent high pressure system over Alaska that month that yielded calm winds and extremely cold weather Statewide. January 2006 was then followed by an extremely windy February 2006. As one can see, the winds during winter 2005/06 were quite different from winter 2006/07.

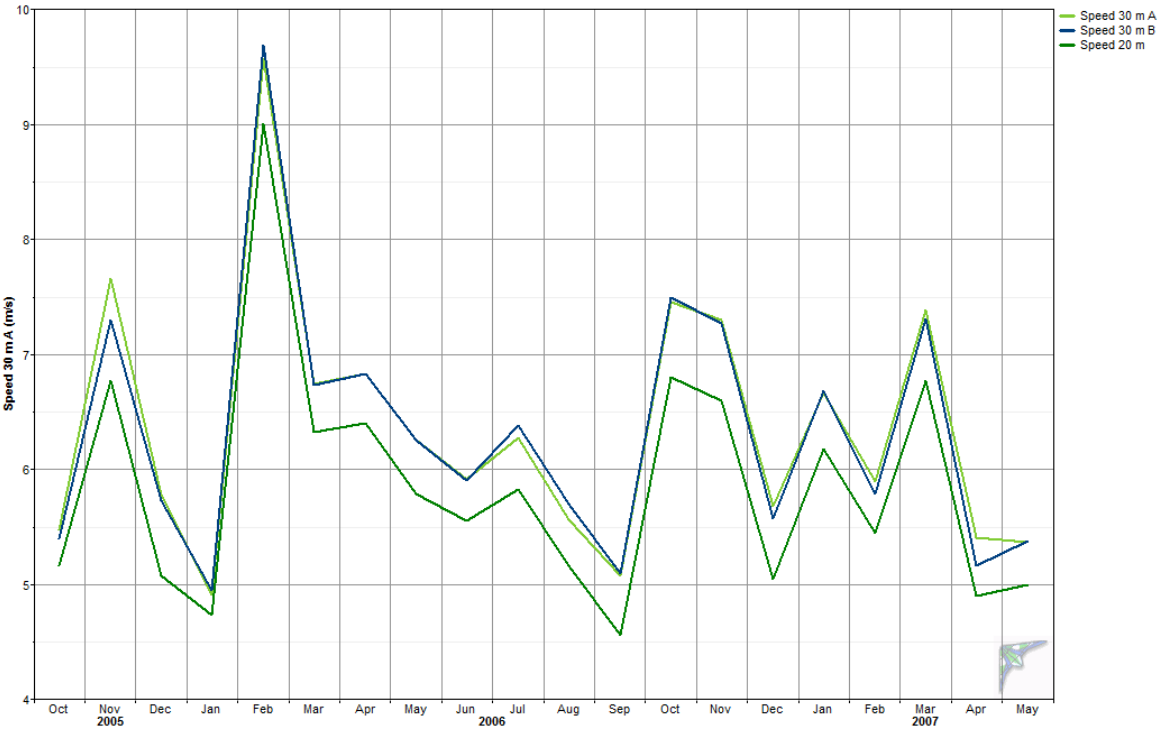
The daily wind speed profile indicates that the lowest winds of the day occur in the morning at about 3 a.m. to 9 a.m. and the highest winds of the day occur in the afternoon and early evening hours of about 1 p.m. to 8 p.m. This correlates reasonably well with the times of day where load demand is highest.

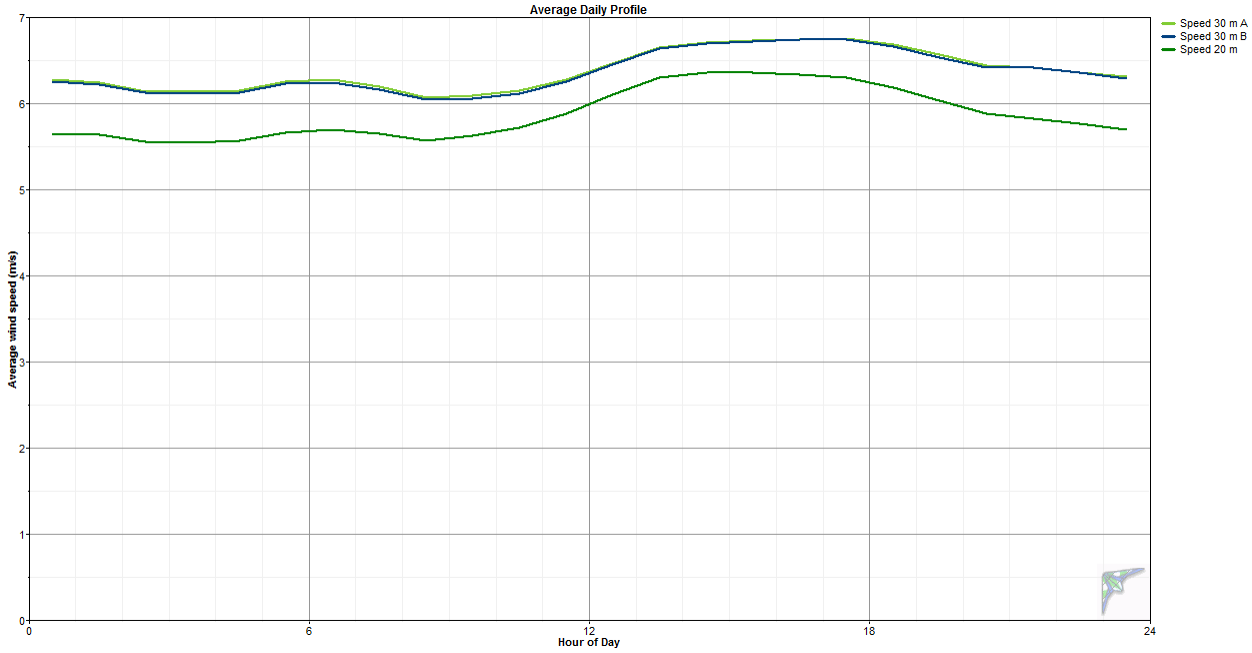
Anemometer Data Summary

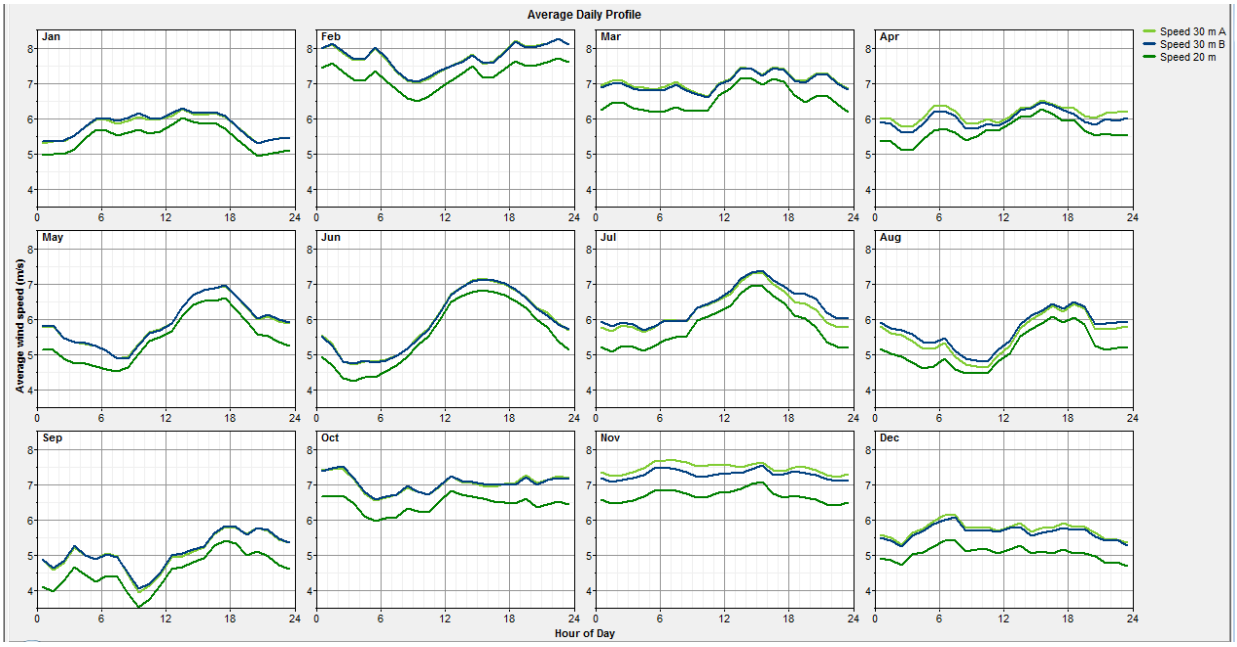
	30 m A anemometer					30 m B anem.		20 m anemometer	
Month	Mean (m/s)	Max (m/s)	SD (m/s)	Weibull k	Weibull c (m/s)	Mean (m/s)	Max (m/s)	Mean (m/s)	Max (m/s)
Jan	5.79	43.6	4.33	1.38	6.34	5.82	43.9	5.46	41.6
Feb	7.74	33.2	4.65	1.74	8.71	7.75	33.6	7.23	32.1
Mar	7.07	29.4	3.59	2.05	7.96	7.03	29.8	6.55	29.1
Apr	6.13	22.6	2.96	2.19	6.93	6.00	22.9	5.66	22.6
May	5.88	20.2	2.68	2.32	6.63	5.88	19.9	5.45	19.9
Jun	5.92	19.5	2.79	2.25	6.69	5.90	19.5	5.56	19.5
Jul	6.28	20.6	2.81	2.36	7.08	6.39	21.8	5.83	20.2
Aug	5.56	16.4	2.85	2.05	6.28	5.70	16.8	5.16	16.4
Sep	5.08	24.4	2.98	1.80	5.72	5.10	24.8	4.56	24.0
Oct	7.03	26.3	3.74	1.95	7.92	7.04	26.0	6.45	25.2
Nov	7.47	27.5	3.59	2.18	8.42	7.29	27.9	6.69	26.8
Dec	5.73	21.8	2.72	2.20	6.45	5.65	22.1	5.06	21.4
Annual	6.31	43.6	3.31	2.04	7.09	6.30	43.9	5.80	41.6

Note: Max speed data are 2 second gust readings


Seasonal Wind Speed Profile
Average Wind Speed (m/s)
0
2
4
6
8
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Speed 30 m A
Speed 30 m B
Speed 20 m


Speed 30 m A (m/s)
4
5
6
7
8
9
10
Oct
Nov
2005
Dec
Jan
Feb
Mar
Apr
May
Jun
2006
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
2007
Apr
May
Speed 30 m A
Speed 30 m B
Speed 20 m

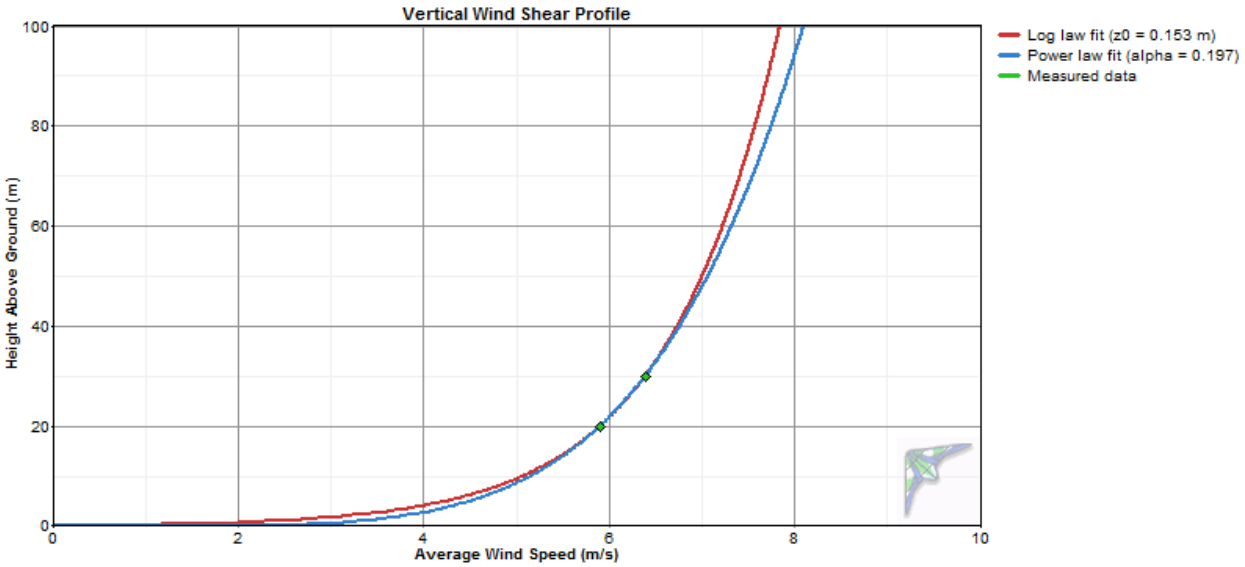

Average Daily Profile
Speed 30 m A
Speed 30 m B
Speed 20 m
Average wind speed (m/s)
Hour of Day

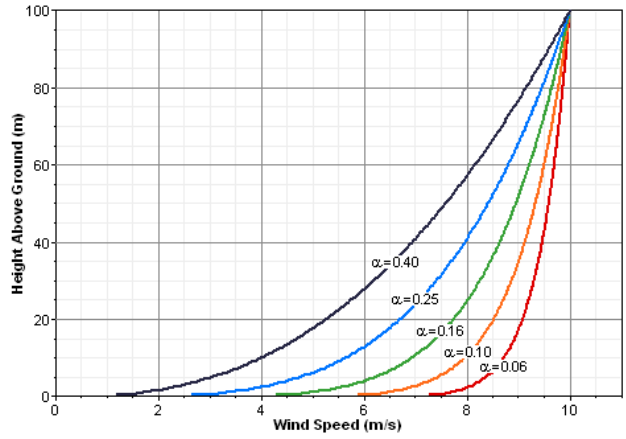

Average Daily Profile
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Speed 30 m A
Speed 30 m B
Speed 20 m
Average wind speed (m/s)
Hour of Day

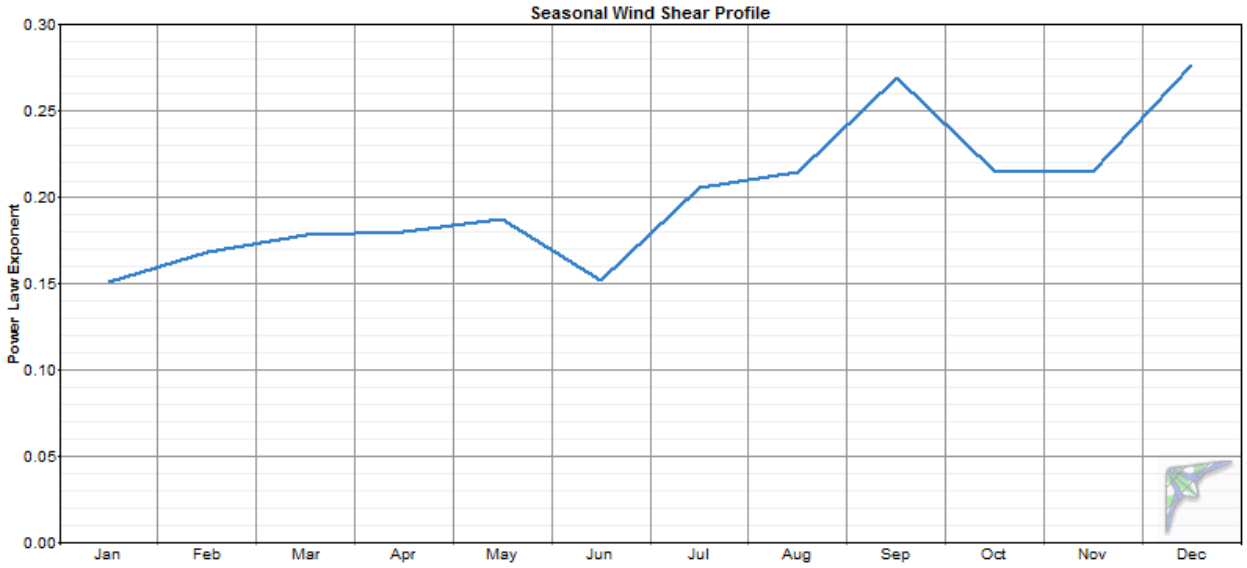
Wind Shear

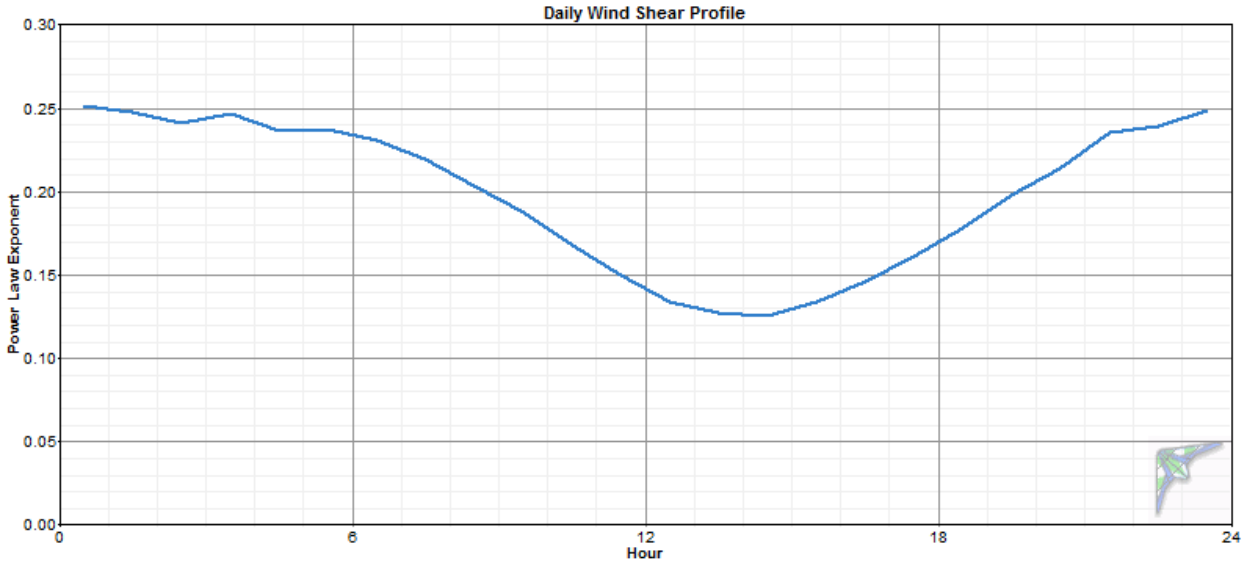
The power law exponent was calculated at 0.197, indicating moderate wind shear at the Quinhagak met tower test site. The shear data is shown in greater detail in the accompanying seasonal, daily and directional plots of the power law exponent, or wind shear.

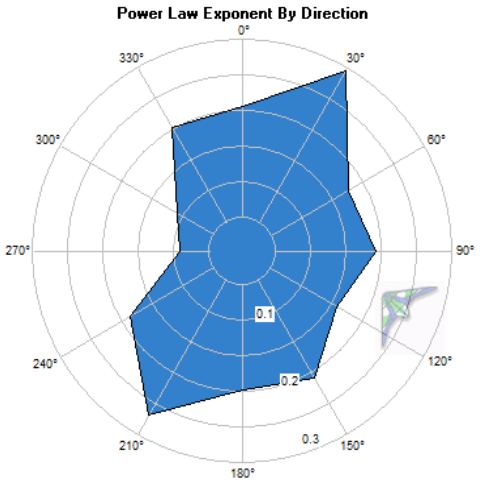
The practical application of this data is that one can expect appreciably higher power production with increased turbine tower height. A tower height/power production cost tradeoff study is recommended. Note that some of the observed shear may be due to the presence of tanks and other structures north of the met tower test site and would not be indicative of general wind shear conditions in the Quinhagak area.





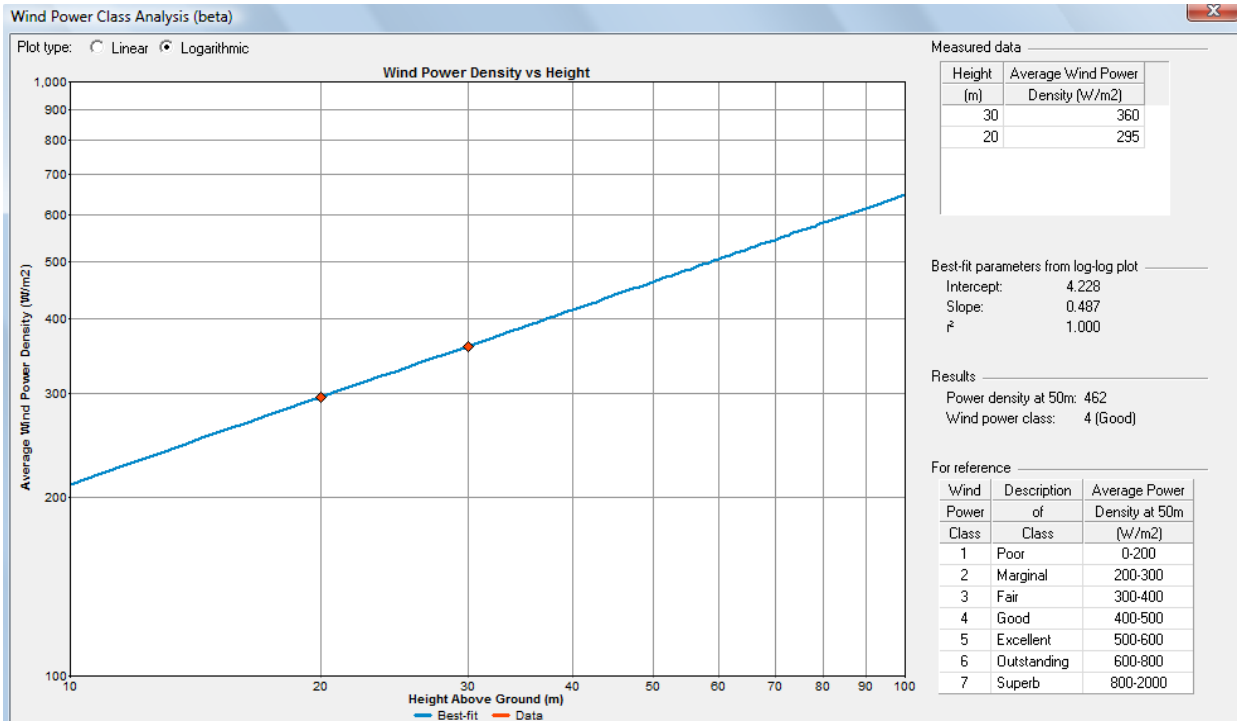

Seasonal Wind Shear Profile
Power Law Exponent
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Daily Wind Shear Profile
Power Law Exponent
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
6
12
18
24
Hour


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

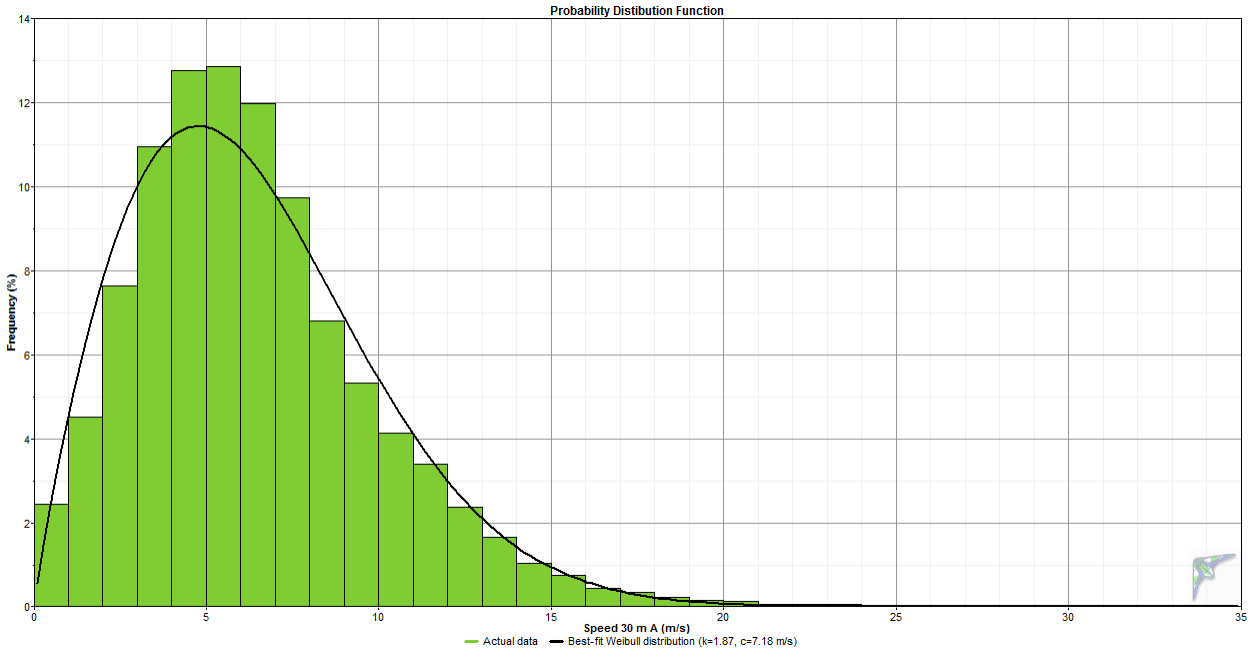
Wind power class

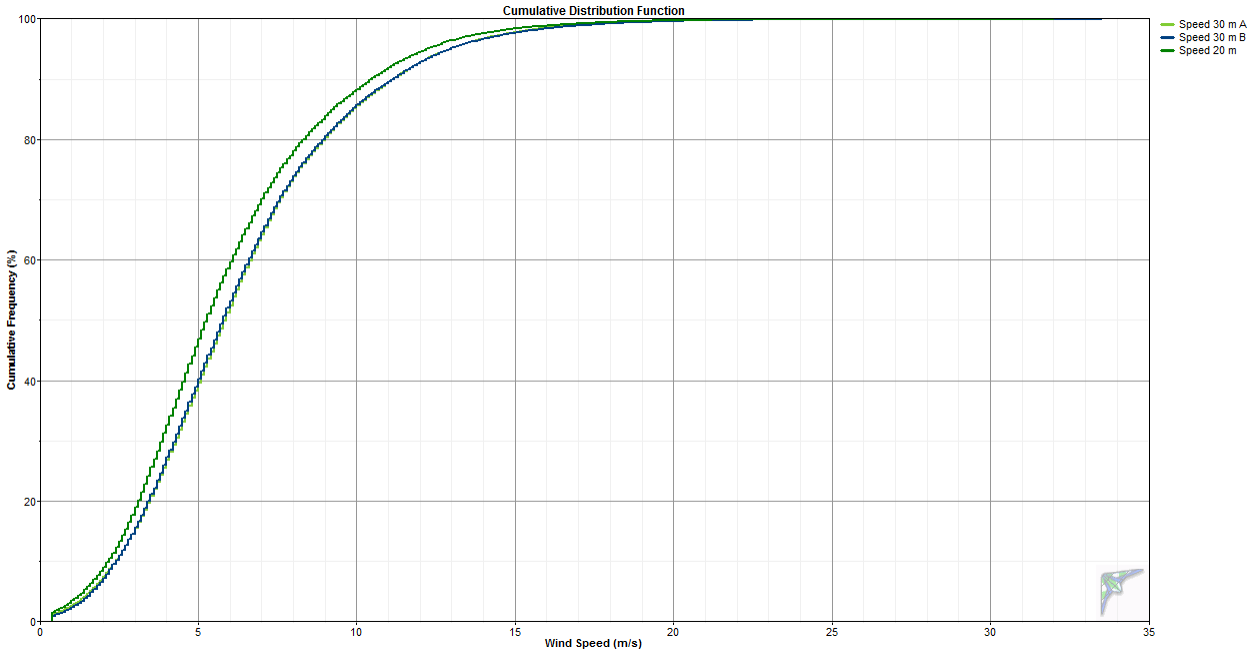
Another view of wind shear is wind power density by height above ground level. As can be seen in the figure below, power density and hence potential turbine power production increases substantially with turbine hub height. Note that the measured power densities in the figure below differ from those reported in the data summary table on page 2 of this report. The figure below uses all data (October 2005 through May 2007) while in the summary table this data is coverted to annual averages.



Probability Distribution Function

The graphed 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 reached 4 m/s; using this criteria, 27% of Quinhagak's winds are calm (less than 4 m/s). The black line in the graph is a best fit Weibull approximation of the wind speed distribution. At the 30 meter level, the Weibull parameters are k = 1.87 (indicates a relatively narrow distribution of wind speeds) and c = 7.18 m/s (scale factor for the Weibull distribution).



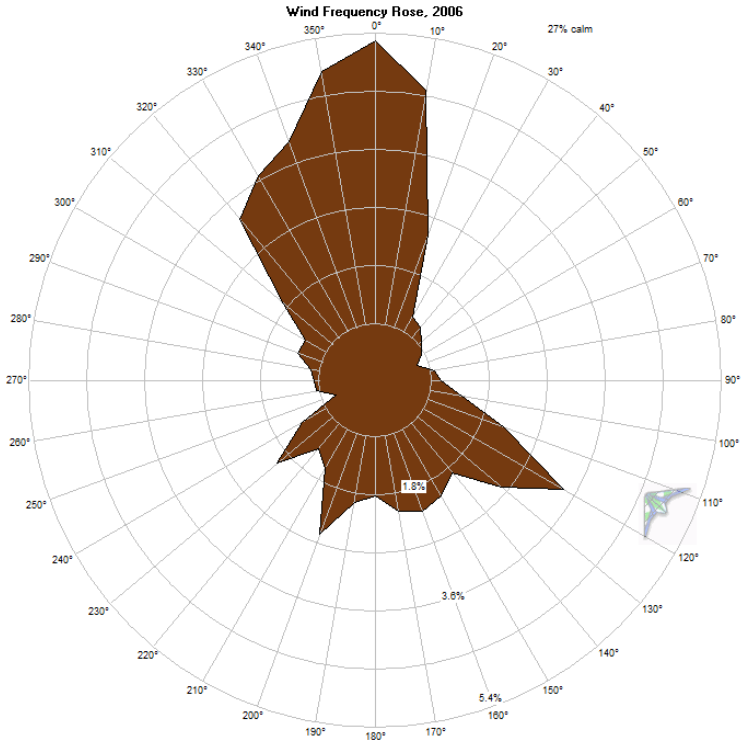


Wind Roses

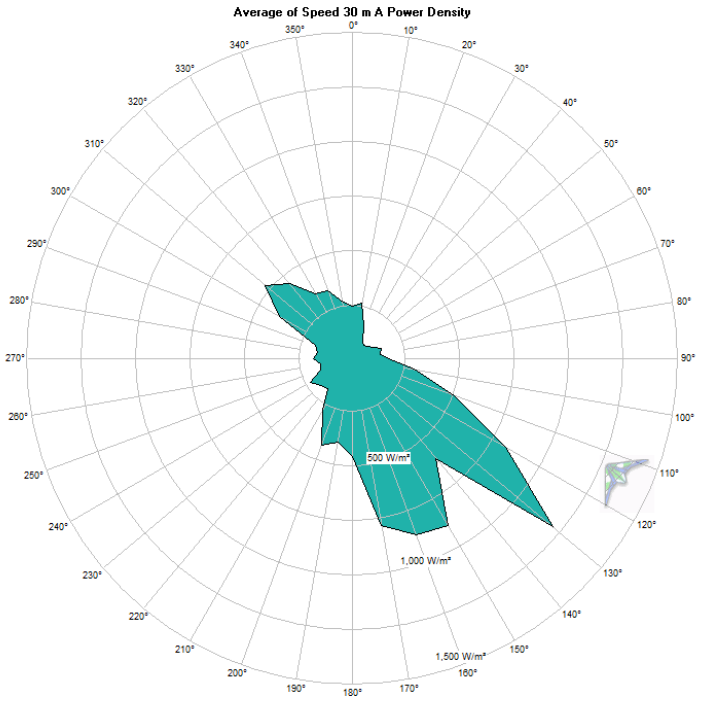
Quinhagak winds are directional in frequency (percent of time) from the north and to a lesser extent from the southwest, south and southeast (wind frequency rose). Interestingly though, the power of the winds (mean value by direction) indicate that the southeast winds, when they occur, are much stronger than the northerly winds. Combining the frequency rose and the mean value rose yields the third wind rose – the total value (power density) rose. This wind rose indicates frequency of power density by direction and is most important of the three for siting of turbines.

To minimize wake turbulence, wind turbines should be located with due consideration of clear zones from nearby obstructions and especially other turbines. If one were to consider just the frequency rose, turbines might be placed on more of an east-west alignment. But with consideration of the total value (power density) rose, turbines should be located on a northeast to southwest alignment with plenty of clearance from obstructions located to the northwest and southeast of the turbines.

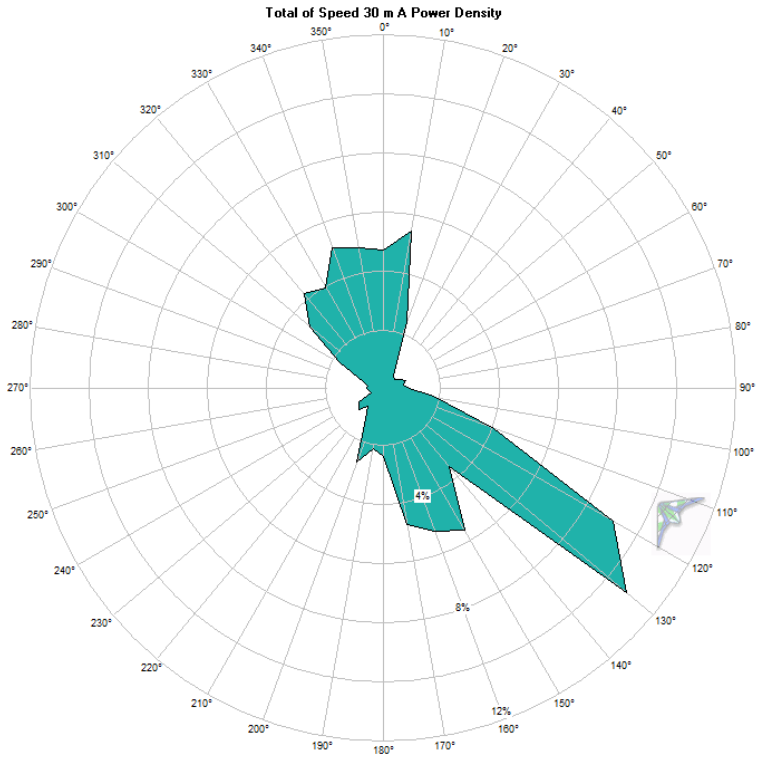
Wind frequency rose (25 meters)



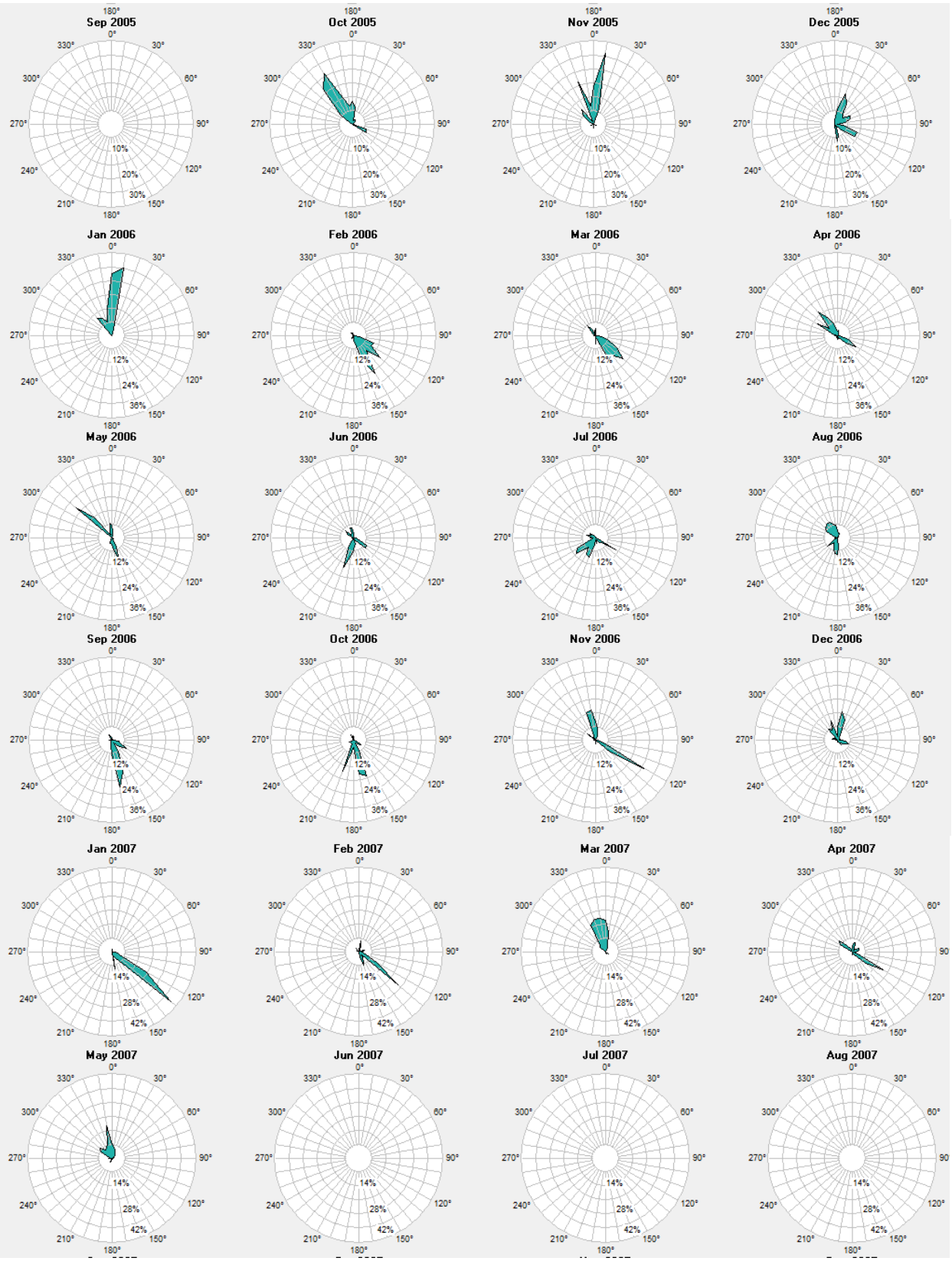
Mean Value (power density) by direction (25 meters)



Total value (power density) rose (25 meters)

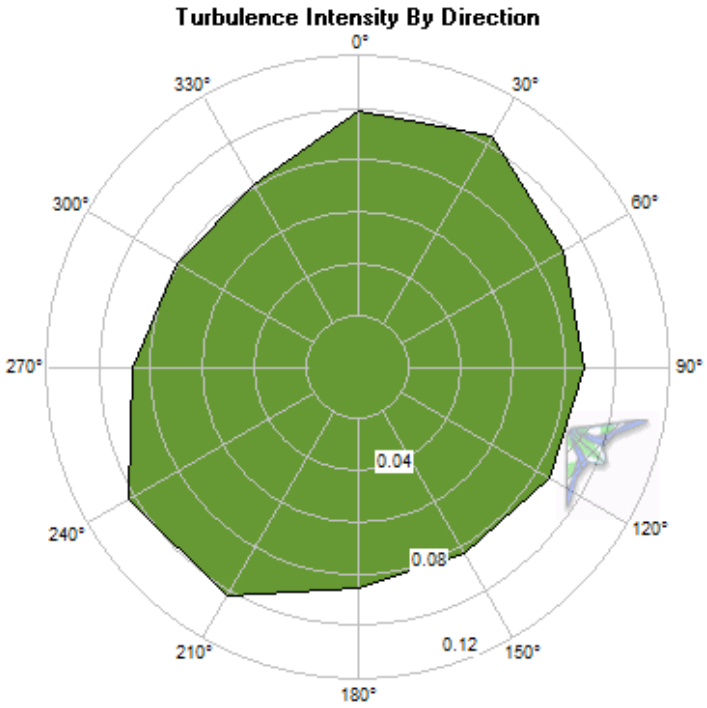


Monthly wind power density roses; scale is common



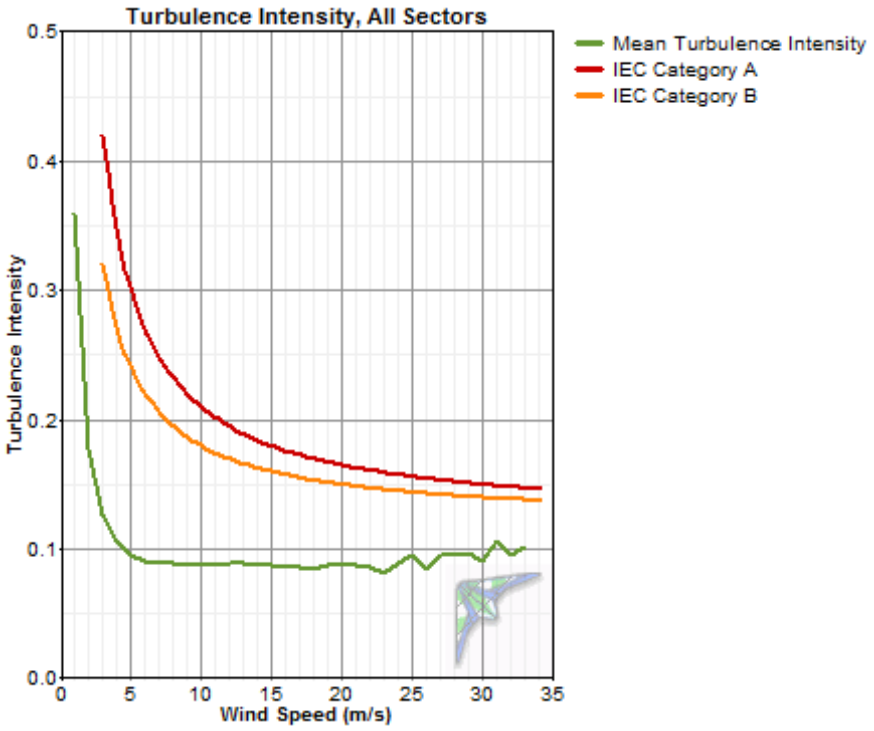
Turbulence Intensity

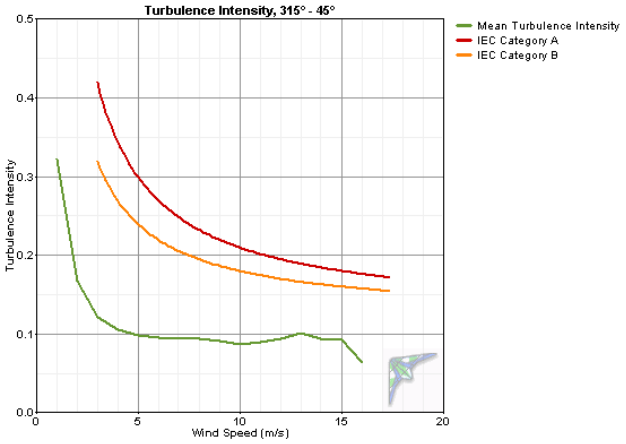
The turbulence intensity is acceptable for the north-northeast and southeast wind directions, with mean turbulence intensity of 0.0915, indicating relatively smooth air for wind turbine operations. This turbulence intensity is calculated with a threshold wind speed of 4 m/s (only wind speeds exceeding 4 m/s are considered). The relatively high turbulence intensity to the northeast and southwest are of little consequence as essentially no power producing winds are from these directions.

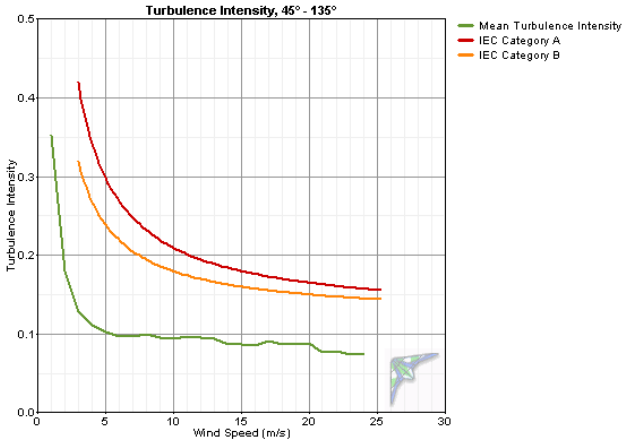


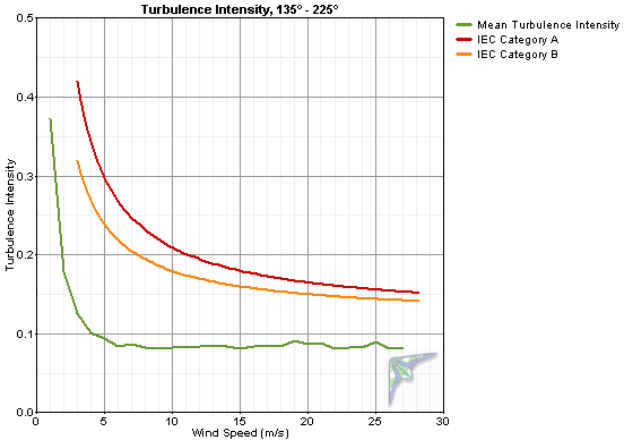
International Electrotechnical Commission standards

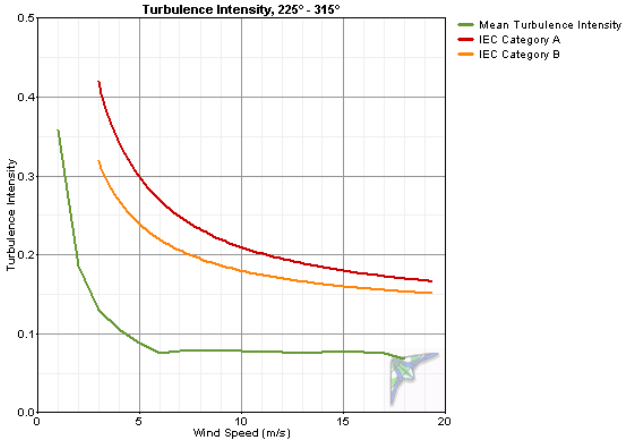
As shown below, turbulence at the Quinhagak project test site is well within International Electrotechnical Commission (IEC) Category A and B standards by an all sectors view and also when considered by 90 degree direction sectors.


Turbulence Intensity, All Sectors
Mean Turbulence Intensity
IEC Category A
IEC Category B
Turbulence Intensity
Wind Speed (m/s)


Turbulence Intensity, 315° - 45°
Mean Turbulence Intensity
IEC Category A
IEC Category B
Turbulence Intensity
Wind Speed (m/s)


Turbulence Intensity, 45° - 135°
Mean Turbulence Intensity
IEC Category A
IEC Category B
Turbulence Intensity
Wind Speed (m/s)


Turbulence Intensity, 135° - 225°
Mean Turbulence Intensity
IEC Category A
IEC Category B
Turbulence Intensity
Wind Speed (m/s)


Turbulence Intensity, 225° - 315°
Mean Turbulence Intensity
IEC Category A
IEC Category B
Turbulence Intensity
Wind Speed (m/s)

Turbulence Table

Turbulence Intensity Table, 30 m A anemometer, 25 m vane, 10/22/05 to 5/24/07

Bin	Bin Endpoints		Records	SD of Wind	Mean	Standard Deviation	Characteristic
Midpoint (m/s)	Lower (m/s)	Upper (m/s)	In Bin	Speed (m/s)	Turbulence Intensity	of Turbulence Intensity	Turbulence Intensity
1	0.5	1.5	2517	0.338	0.359	0.160	0.519
2	1.5	2.5	4939	0.347	0.178	0.094	0.272
3	2.5	3.5	7687	0.375	0.127	0.058	0.185
4	3.5	4.5	9988	0.418	0.106	0.046	0.151
5	4.5	5.5	10511	0.474	0.096	0.038	0.134
6	5.5	6.5	10494	0.544	0.092	0.033	0.125
7	6.5	7.5	8962	0.621	0.090	0.032	0.121
8	7.5	8.5	6743	0.706	0.089	0.030	0.119
9	8.5	9.5	4828	0.787	0.088	0.027	0.115
10	9.5	10.5	3851	0.868	0.087	0.025	0.112
11	10.5	11.5	3067	0.959	0.088	0.024	0.112
12	11.5	12.5	2396	1.060	0.089	0.023	0.112
13	12.5	13.5	1601	1.159	0.090	0.022	0.112
14	13.5	14.5	1057	1.228	0.088	0.022	0.110
15	14.5	15.5	759	1.308	0.088	0.021	0.109
16	15.5	16.5	445	1.369	0.086	0.020	0.106
17	16.5	17.5	314	1.456	0.086	0.021	0.107
18	17.5	18.5	247	1.516	0.085	0.020	0.104
19	18.5	19.5	136	1.644	0.087	0.019	0.106
20	19.5	20.5	123	1.784	0.090	0.019	0.109
21	20.5	21.5	82	1.830	0.088	0.016	0.104
22	21.5	22.5	43	1.886	0.086	0.015	0.100
23	22.5	23.5	45	1.889	0.082	0.015	0.097
24	23.5	24.5	32	2.153	0.090	0.012	0.102
25	24.5	25.5	18	2.400	0.096	0.014	0.110
26	25.5	26.5	7	2.171	0.084	0.010	0.094
27	26.5	27.5	3	2.567	0.096	0.013	0.108
28	27.5	28.5	4	2.675	0.096	0.020	0.116
29	28.5	29.5	4	2.775	0.096	0.011	0.107
30	29.5	30.5	3	2.733	0.091	0.007	0.098
31	30.5	31.5	3	3.300	0.107	0.014	0.121
32	31.5	32.5	2	3.050	0.095	0.006	0.101
33	32.5	33.5	5	3.340	0.102	0.010	0.112

Air Temperature and Density

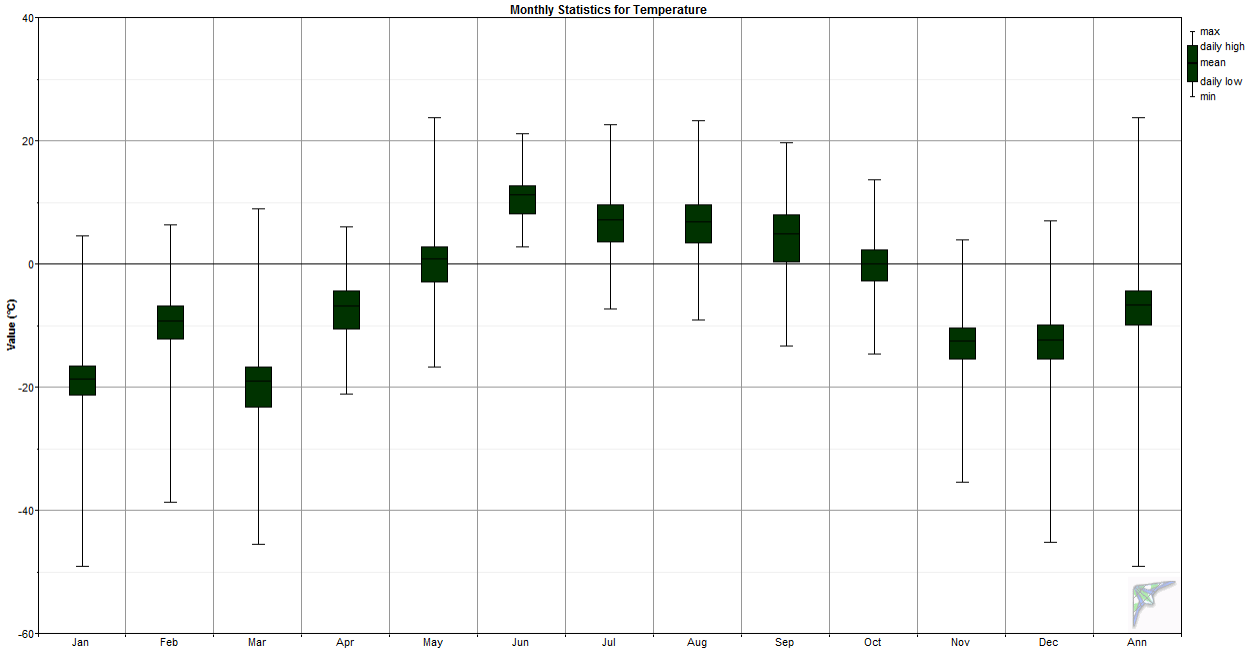
Over the reporting period, Quinhagak had an annual average temperature of -3.9 degrees C. The minimum recorded temperature during the test period was -49.1° C (see below; possibly incorrect) and the maximum temperature 23.8° C.

Note that on July 7, 2006 the temperature sensor experienced an unusual fault in that although it continued to record what appeared to be normal variations of temperature, the offset suddenly changed by approximately 30° C. This offset change (-32.8° C exactly) was added to subsequent temperature data in order to produce a best likely temperature record of Quinhagak, but because the nature of the fault is unknown, the corrective measure may be faulty to some extent. Hence, it is unlikely that the extreme low temperature data readings of -40° C and lower during the winter months of 2006/07 are completely accurate, although 2006/07 was a very cold winter in general. Despite the likelihood of error with the post 7/7/06 temperature data, it is more accurate for power density and turbine performance estimates to insert a corrective offset than to delete the faulty temperature data altogether.

Consequent to the rather cool average temperature in Quinhagak, air density is rather high, boosting the nominal performance of wind turbines. The average air density in Quinhagak is 1.326 kg/m^3, approximately eight percent higher than standard sea level atmospheric air density of 1.225 kg/m^3. This density variance from standard *is* accounted for in turbine performance predictions in this report. Note that the density estimates, because they are based on calculations using temperature data and not direct measurement, are likely a few percent lower than actual.

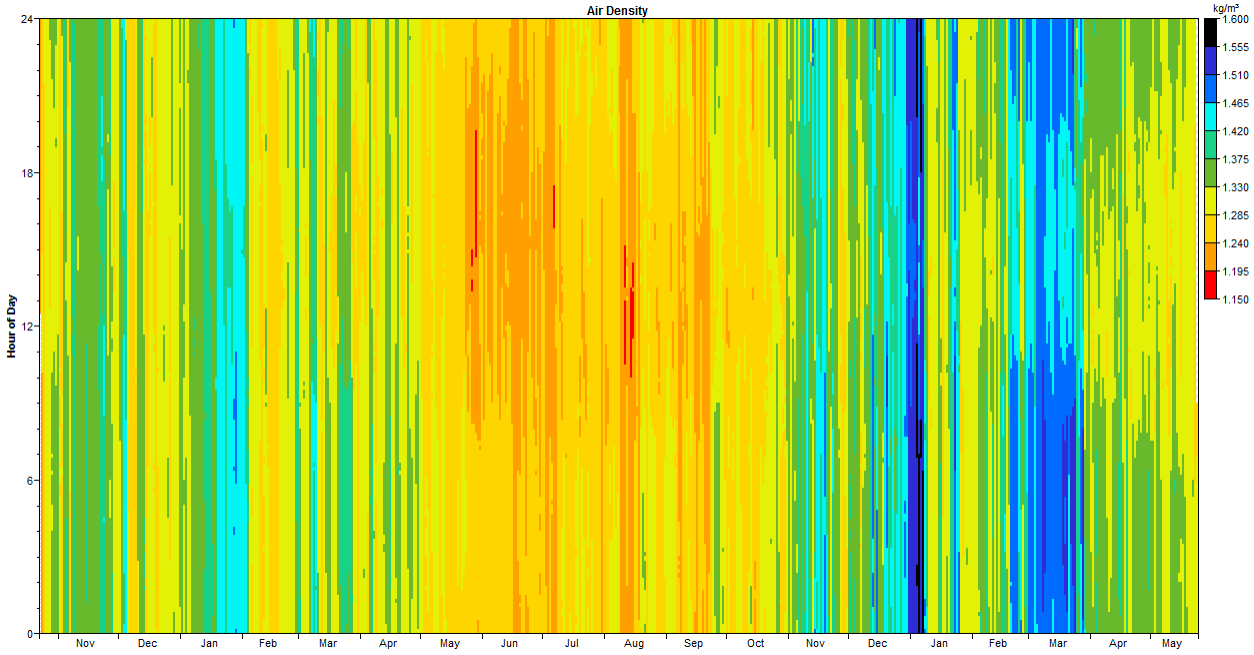
	Temperature				Air Density			
	Mean (m/s)	Min (m/s)	Max (m/s)	SD (m/s)	Mean (kg/m^3)	Min (kg/m^3)	Max (kg/m^3)	SD (kg/m^3)
Jan	-18.6	-49.1	4.6	13.1	1.389	1.270	1.574	0.0730
Feb	-9.2	-38.6	6.5	11.0	1.339	1.261	1.504	0.0579
Mar	-18.9	-45.5	9.1	14.4	1.392	1.250	1.549	0.0787
Apr	-6.7	-21.0	6.1	5.6	1.324	1.263	1.399	0.0278
May	0.9	-16.7	23.8	7.4	1.288	1.188	1.375	0.0344
Jun	11.4	2.9	21.3	3.3	1.240	1.198	1.278	0.0144
Jul	7.3	-7.3	22.7	5.1	1.258	1.192	1.327	0.0227
Aug	6.9	-9.0	23.4	7.0	1.260	1.189	1.335	0.0314
Sep	5.0	-13.2	19.7	7.3	1.269	1.205	1.357	0.0336
Oct	0.1	-14.6	13.7	5.4	1.290	1.224	1.364	0.0274
Nov	-12.5	-35.4	4.0	8.4	1.355	1.273	1.484	0.0441
Dec	-12.3	-45.1	7.1	11.7	1.355	1.259	1.547	0.0624
Annual	-3.9	-49.1	23.8	13.6	1.326	1.188	1.574	0.0701

Note: low temperature and max air density data likely faulty; see explanation in text



DMap

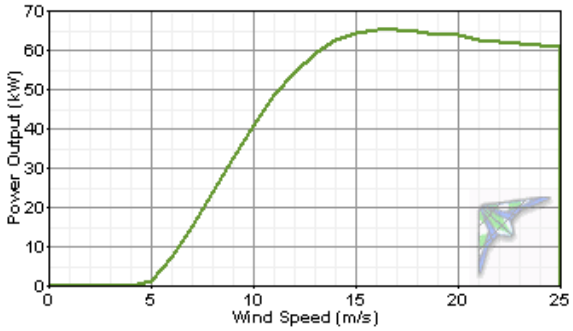
This DMap is a visual representation of air density by time of day and month. As one would expect, air densities are higher during the middle of the day and summer months than nighttime and winter months. Higher air densities increase rotor blade lift and hence one can expect marginally higher turbine performance for equivalent wind speeds during periods of cold air temperature/high air density.



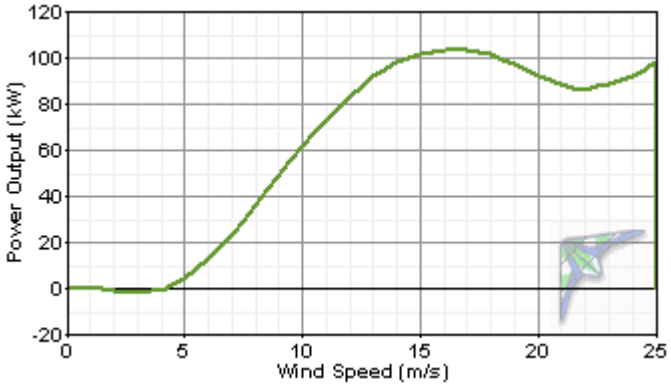
Turbine Power Prediction

Turbine performance is predicted for two wind turbines now placed in several Alaska Village Electric Cooperative villages in Alaska: the Entegrity eW-15 (60 Hz) and the Northern Power Northwind NW100/20. These turbines are rated at 65 kW and 100 kW maximum power output respectively.

Entegrity eW-15: 65 kW rated power output, 15 meter rotor, stall-controlled (power curve provided by Entegrity Energy Systems)



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)



eW-15, 31 meters, 90% availability

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	5.79	39.8	6.4	13.3	9,903	20.5
Feb	7.78	21.1	10.1	21.7	14,593	33.4
Mar	7.07	22.0	7.8	20.8	15,486	32.0
Apr	6.06	26.2	2.3	13.0	9,382	20.0
May	5.90	25.8	1.0	11.6	8,604	17.8
Jun	5.94	26.1	0.1	11.8	8,484	18.1
Jul	6.35	22.0	1.5	13.8	10,300	21.3
Aug	5.65	31.9	0.0	10.8	8,054	16.7
Sep	5.09	41.5	1.8	8.0	5,721	12.2
Oct	7.06	21.2	6.4	18.6	13,827	28.6
Nov	7.30	17.9	8.2	21.1	15,167	32.4
Dec	5.65	28.5	1.2	11.1	8,257	17.1
Annual	6.30	27.0	3.9	14.6	132,888	22.5

eW-15, 31 meters, 100% availability

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	5.79	39.8	6.4	14.8	11,004	22.8
Feb	7.78	21.1	10.1	24.1	16,215	37.1
Mar	7.07	22.0	7.8	23.1	17,206	35.6
Apr	6.06	26.2	2.3	14.5	10,424	22.3
May	5.90	25.8	1.0	12.8	9,560	19.8
Jun	5.94	26.1	0.1	13.1	9,427	20.1
Jul	6.35	22.0	1.5	15.4	11,445	23.7
Aug	5.65	31.9	0.0	12.0	8,949	18.5
Sep	5.09	41.5	1.8	8.8	6,357	13.6
Oct	7.06	21.2	6.4	20.6	15,363	31.8
Nov	7.30	17.9	8.2	23.4	16,852	36.0
Dec	5.65	28.5	1.2	12.3	9,174	19.0
Annual	6.30	27.0	3.9	16.2	147,653	25.0

NW100, 32 meters, 90% availability

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	5.82	39.5	5.3	19.9	14,838	19.9
Feb	7.82	20.9	8.0	32.4	21,757	32.4
Mar	7.11	21.9	6.9	30.9	22,963	30.9
Apr	6.10	25.9	2.0	19.5	14,016	19.5
May	5.94	25.5	1.0	17.2	12,822	17.2
Jun	5.97	25.8	0.1	17.5	12,591	17.5
Jul	6.39	21.7	1.6	20.5	15,256	20.5
Aug	5.68	31.5	0.0	16.2	12,018	16.2
Sep	5.13	41.0	1.8	12.1	8,745	12.1
Oct	7.11	20.9	6.2	27.8	20,709	27.8
Nov	7.35	17.5	7.3	31.4	22,578	31.4
Dec	5.69	27.9	1.2	16.7	12,397	16.7
Annual	6.34	26.6	3.4	21.8	198,276	21.8

NW100, 32 meters, 100% availability

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	5.82	39.5	5.3	22.2	16,487	22.2
Feb	7.82	20.9	8.0	36.0	24,174	36.0
Mar	7.11	21.9	6.9	34.3	25,515	34.3
Apr	6.10	25.9	2.0	21.6	15,574	21.6
May	5.94	25.5	1.0	19.1	14,247	19.1
Jun	5.97	25.8	0.1	19.4	13,990	19.4
Jul	6.39	21.7	1.6	22.8	16,951	22.8
Aug	5.68	31.5	0.0	17.9	13,353	17.9
Sep	5.13	41.0	1.8	13.5	9,717	13.5
Oct	7.11	20.9	6.2	30.9	23,010	30.9
Nov	7.35	17.5	7.3	34.8	25,087	34.8
Dec	5.69	27.9	1.2	18.5	13,775	18.5
Annual	6.34	26.6	3.4	24.3	220,306	24.3