Selawik, Alaska Wind Resource Assessment Report

Selawik met tower and AOC15/50 wind turbines, photo by Douglas Vaught

February 18, 2016

Douglas Vaught, P.E.
V3 Energy, LLC
Eagle River, Alaska

V3 Energy LLC
Eagle River, Alaska 907.350.5047

Summary

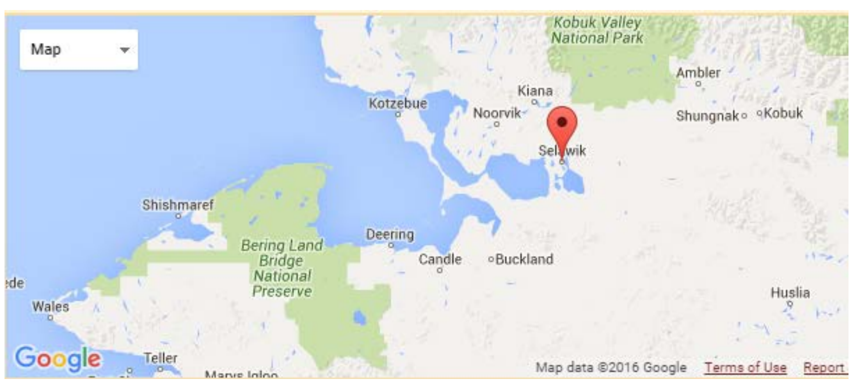
The wind resource measured at the Selawik met tower site is fair to marginal with a mean annual wind speed of 5.62 m/s and a wind power density of 236 W/m^2 at 34 meters above ground level. This confirms the AWS Truepower wind resource map which predicts Class 2 winds in Selawik. Although the wind resource in Selawik is modest compared to nearby Kotzebue, development of renewable power in the village may be viable with turbines specifically suited to lower wind environments. Also of consideration is the high cost of fuel in Selawik and the environmental risk of transporting and storing fossil fuel. Wind power provides a long-term renewable energy alternative for Selawik that has the potential to buffer residents from unpredictable variations of the petroleum market. These and other issues will be explored in a companion wind-diesel study report.

Met tower data synopsis

Data dates	11/04/2014 to 1/4/2016 (14 months)
Wind speed mean, 34 m, annual	5.52 m/s (12.3 mph)
Wind power density mean, 34 m	229 W/m^2
Max. 10-min wind speed	20.8 m/s
Maximum 2-sec. wind gust	25.5 m/s (57.0 mph), February 2015
Weibull distribution parameters	k = 1.60, c = 6.18 m/s
Wind shear power law exponent	0.187 (low)
Surface roughness	0.15 meters (agricultural land)
IEC 61400-1, 3rd ed. classification	Class III-C
Turbulence intensity, mean (at 34 m)	0.075 (at 15 m/s)
Calm wind frequency (at 34 m)	34% (< 4 m/s) (14 mo. measurement period)

Test Site Location

A 34 meter NRG Systems, Inc. tubular-type meteorological (met) tower was installed in Selawik in an open area of NANA Regional Corporation land immediately west of the northernmost AVEC wind turbine on the north side of the community. Selawik is located at the mouth of the Selawik River, where it empties into Selawik Lake, about 90 miles east of Kotzebue. It lies 670 miles northwest of Anchorage. The city is near the Selawik National Wildlife Refuge, a key breeding and resting spot for migratory waterfowl. It is a traditional Inupiat Eskimo village, population of 829 people (2010 data), largely dependent on fishing and subsistence activities (Alaska DCED website). Selawik falls within the arctic climate zone, characterized by seasonal extremes in temperature. Winters are long and harsh, and summers are short but warm. Temperature extremes have been recorded from -50 to 83 °F. The Selawik River is navigable from early June to mid-October.



Site information

Site number	0003
Latitude/longitude	N 66° 36’ 31.29”, W 160° 1’ 13.35”
Time offset	-9 hours from UTC (Yukon/Alaska time zone)
Site elevation	9 meters (29 ft.)
Datalogger type	NRG SymphoniePLUS3, 10 minute averaging time step
Tower type	Tubular, 15 cm (6 in.) diameter, 34 meter (112 ft.) height

Tower sensor information

Channel	Sensor type	Designation	SN	Height	Multiplier	Offset	Orientation
1	NRG #40C anemometer	34 m A	218101	33.9 m	0.747	0.38	090 T
2	NRG #40C anemometer	34 m B	218100	33.7 m	0.753	0.35	270 T
3	NRG #40C anemometer	20 m	219012	20.9 m	0.755	0.34	090 T
7	NRG #200P wind vane	Direction		33.2 m	0.351	180	000 T
4	NRG #110S Temp C	Temp		2.5 m	0.136	86.383	000 T
5	LiCor LI-200 pyranometer	Pyran.	PY80402	3.0 m	1.278	0	180 T
6	RH5X relative humidity	RH		2.0 m	0.097	0	000 T

Tower sensor photographs

North side, up tower

East side, up tower

South side, up tower

West side, up tower

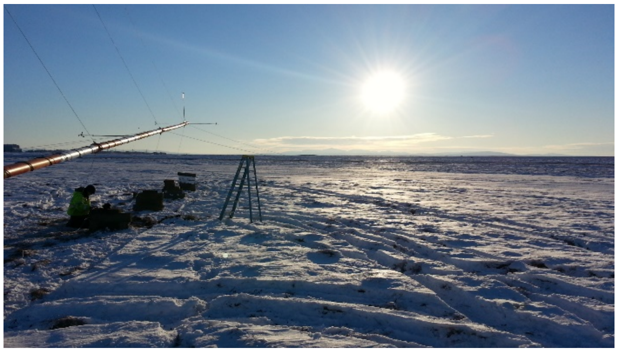
Met tower site photographs


Site view to north


Site view to northeast


Site view to east


Site view to southeast


Site view to south

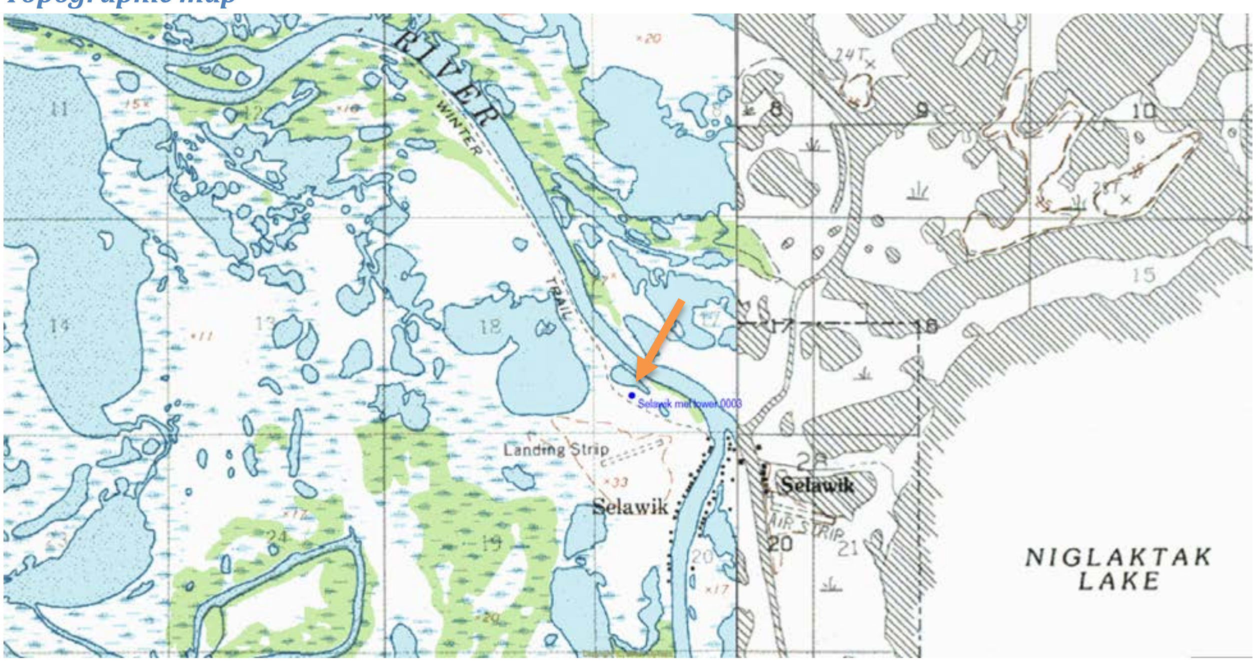

Site view to southwest


Site view to west


Site view to northwest

Google Earth image, Selawik

Topographic map



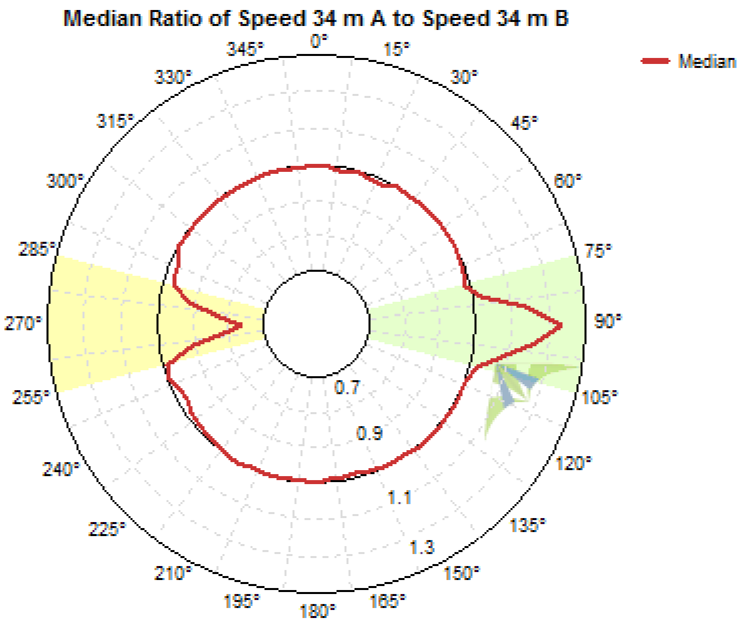
Data Quality Control

Data was filtered to remove presumed icing events that yield false zero wind speed data and non-variant wind direction data. Data that met criteria listed below were automatically filtered. In addition, data was manually filtered for obvious icing that the automatic filter didn't identify, and invalid or low quality data for situations such as logger initialization and other situations.

- Anemometer icing – data filtered if temperature < 1°C, speed SD = 0, and speed changes < 0.25 m/s for minimum 2 hours
- Vane icing – data filtered if temperature < 1°C and vane SD = 0 for minimum of 2 hours
- Tower shading of 34 meter A and B paired anemometers – data filtered when winds from ± 15° of behind tower; refer to graphic below

In general, icing conditions were infrequent indicating minimal concern for wind turbine energy production loss due to ice. With semi-frequent westerly winds, tower shadow affected anemometer 34 m A (channel 1) more often than anemometer 34 m B (channel 2).

Tower shading plot



Sensor data recovery table

Data Column	Possible Records	Valid Records	Recovery Rate (%)	Icing	Invalid	Tower shading
Speed 34 m A	61,478	48,887	79.5%	1,803	783	10,005
Speed 34 m B	61,366	53,055	86.5%	542	786	6,983
Speed 20 m	61,268	60,015	98.0%	470	783	0
Direction 34 m	61,268	57,515	93.9%	2,971	782	0
Temperature	61,268	60,486	98.7%	0	782	0
Pyranometer	61,268	60,488	98.7%	0	780	0

Data Column	Possible Records	Valid Records	Recovery Rate (%)	Icing	Invalid	Tower shading
Relative humidity	61,268	60,486	98.7%	0	782	0

Sensor data recovery rate by month

Year	Month	34 m A	34 m B	20 m	Vane	Temp	Pyran.	RH
2014	Nov	99.3	88.6	100.0	88.4	100.0	100.0	100.0
2014	Dec	82.3	90.9	94.6	46.9	100.0	100.0	100.0
2015	Jan	85.4	80.0	98.4	71.1	100.0	100.0	100.0
2015	Feb	88.4	87.2	100.0	83.5	100.0	100.0	100.0
2015	Mar	69.0	91.4	100.0	91.4	100.0	100.0	100.0
2015	Apr	71.0	83.8	96.4	83.8	100.0	100.0	100.0
2015	May	80.8	87.3	100.0	87.3	100.0	100.0	100.0
2015	Jun	70.3	97.5	100.0	97.5	100.0	100.0	100.0
2015	Jul	70.9	91.1	100.0	91.1	100.0	100.0	100.0
2015	Aug	64.6	95.9	100.0	95.9	100.0	100.0	100.0
2015	Sep	84.1	90.4	100.0	90.4	100.0	100.0	100.0
2015	Oct	83.7	81.7	100.0	81.7	100.0	100.0	100.0
2015	Nov	95.6	83.7	100.0	83.7	100.0	100.0	100.0
2015	Dec	83.2	71.9	92.1	71.9	92.2	92.2	92.2
2016	Jan	0.0	0.0	0.0	0.0	0.0	0.0	0.0
All Data		79.8	86.6	98.0	82.5	98.7	98.7	98.7

Wind Speed

Anemometer data obtained from the met tower, from the perspectives of both mean wind speed and mean wind power density, indicate a moderate wind resource. Note that cold temperatures contributed to a higher wind power density than standard conditions would yield for the measured mean wind speeds. This is reflected in the CRMC (cubed root mean cubed) wind speed, which reflects a calculation of a steady wind speed, at the measured mean air density, that would yield the measured mean wind power density. In other words, the winds in Selawik punch above their weight.

A table following that below presents the same data but with anemometer icing and tower shadow data removed from the data set and then synthesized with Windographer software's gap-filling subroutine. The advantage of gap-filling is that a more representative data set is achieved, especially with inclusion of data from the opposing anemometer when data is filtered for tower shadow (gap-filling synthesizes tower shadow data by this method).

Anemometer data summary (filtered for icing and tower shadow)

Variable	Speed 34 m A	Speed 34 m B	Speed 20 m
Measurement height (m)	33.9	33.7	20.9
Mean wind speed (m/s)	5.78	5.68	5.10
MoMM wind speed (m/s)	5.65	5.62	5.03

Variable	Speed 34 m A	Speed 34 m B	Speed 20 m
Median wind speed (m/s)	5.70	5.60	4.90
Max 10 min avg. wind speed (m/s)	17.60	20.80	18.40
Max gust wind speed (m/s)	23.30	25.50	23.50
CRMC wind speed (m/s)	7.32	7.20	6.52
Weibull k	1.65	1.65	1.68
Weibull c (m/s)	6.38	6.27	5.66
Mean power density (W/m²)	258	245	182
MoMM power density (W/m²)	242	236	172
Mean energy content (kWh/m²/yr)	2,260	2,147	1,591
MoMM energy content (kWh/m²/yr)	2,118	2,065	1,503
Energy pattern factor	2.0	2.0	2.1
Frequency of calms (%) (< 4 m/s)	33.1	33.5	39.4

MoMM = mean of monthly means

CRMC = cubed root mean cubed

Anemometer data summary (gap-filled)

Variable	Speed 34 m A	Speed 34 m B	Speed 20 m
Measurement height (m)	33.9	33.7	20.9
Mean wind speed (m/s)	5.59	5.61	5.10
MoMM wind speed (m/s)	5.49	5.52	5.03
Median wind speed (m/s)	5.50	5.50	4.90
Max 10 min avg. wind speed (m/s)	20.80	20.80	18.40
Max gust wind speed (m/s)	23.30	25.50	23.50
CRMC wind speed (m/s)	7.14	7.18	6.52
Weibull k	1.60	1.60	1.68
Weibull c (m/s)	6.15	6.18	5.66
Mean power density (W/m²)	239	243	182
MoMM power density (W/m²)	225	229	172
Mean energy content (kWh/m²/yr)	2,096	2,128	1,590
MoMM energy content (kWh/m²/yr)	1,972	2,005	1,502
Energy pattern factor	2.1	2.1	2.1
Frequency of calms (%)	34.8	34.6	39.4

MoMM = mean of monthly means

CRMC = cubed root mean cubed

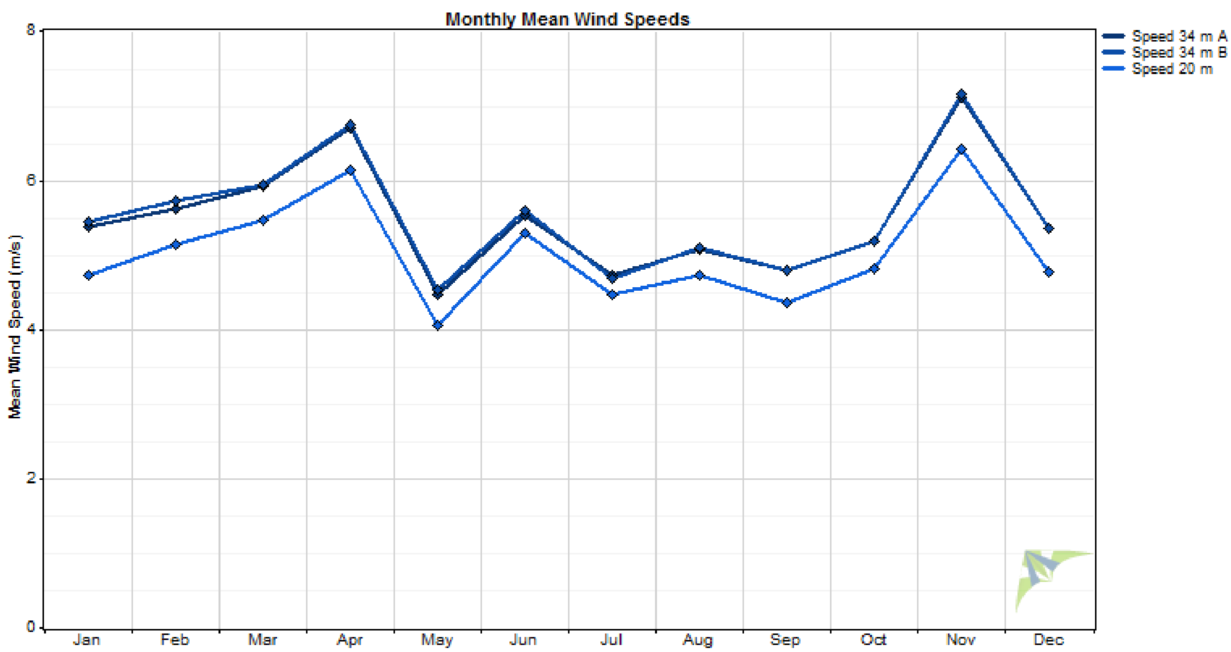
Time Series

Time series calculations indicate higher wind speeds during the winter months compared to the summer months. This correlates well with Selawik's load profile where there is high demand for electricity and heat during winter months and lower energy demand during summer. The daily wind profile (annual basis) indicates relatively even wind speeds throughout the day with slightly higher wind speeds during night hours.

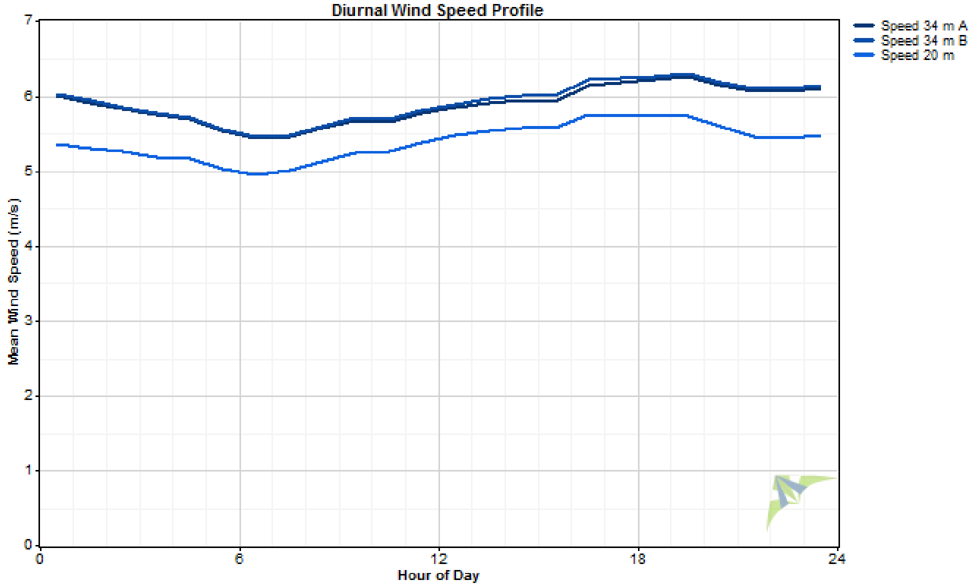
34 m A anemometer data summary

Year	Month	Raw Mean (m/s)	Filtered Mean (m/s)	Gapfilled Mean (m/s)	Max (m/s)	Gust (m/s)	Std. Dev. (m/s)	Weibull k	Weibull c (m/s)
2014	Nov	7.97	8.02	7.97	14.9	17.3	2.56	3.53	8.79
2014	Dec	5.41	6.46	5.84	15.6	19.6	3.38	1.62	6.44
2015	Jan	5.19	5.64	5.39	15.7	20.5	3.51	1.34	5.79
2015	Feb	5.56	5.76	5.63	20.8	21.4	3.95	1.10	5.78
2015	Mar	5.82	6.43	5.94	16.5	18.8	3.20	1.89	6.66
2015	Apr	6.33	7.07	6.70	15.9	18.0	3.25	2.12	7.52
2015	May	4.37	4.50	4.48	13.0	16.6	2.46	1.85	5.03
2015	Jun	5.32	5.42	5.55	14.0	17.3	2.56	2.27	6.24
2015	Jul	4.53	4.30	4.73	11.8	15.2	2.31	2.10	5.31
2015	Aug	4.80	4.47	5.08	15.7	18.0	2.79	1.87	5.71
2015	Sep	4.71	4.76	4.81	12.2	15.9	2.28	2.19	5.41
2015	Oct	5.03	5.92	5.19	12.6	15.9	3.09	1.33	5.51
2015	Nov	6.37	6.53	6.39	17.6	23.3	3.96	1.43	6.92
2015	Dec	4.84	5.20	4.88	16.1	19.6	4.03	0.88	4.59
All Data		5.42	5.78	5.59	20.8	23.3	3.26	1.60	6.15
MoMM		5.32	5.65	5.49					

Monthly time series, mean wind speeds (gap-filled wind data)



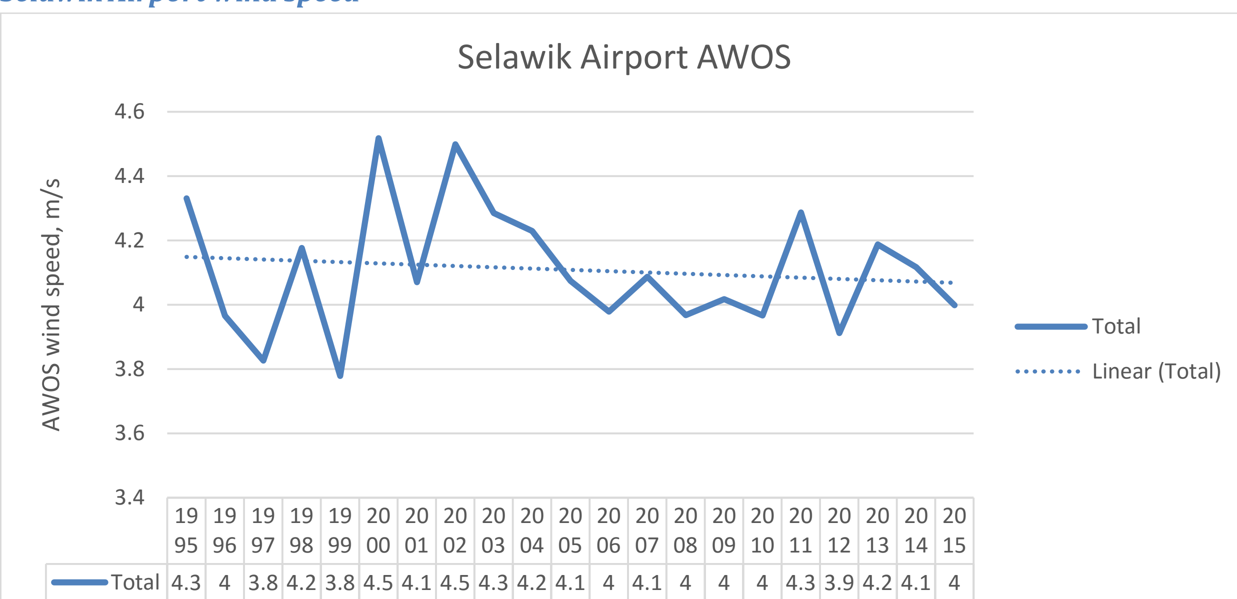
Daily wind profile (annual)



Long-term Wind Speed Average

Comparing the fourteen months of measured wind speed data at the Selawik met tower is possible by reference to the nearby Selawik Airport automated weather station. Data for this station was obtained for the time period of Jan. 1, 1995 through Dec. 31, 2015. For this 21 year time period, the AWOS station recorded an average wind speed of 4.09 m/s (at a 10 meter measurement height). In 2015, which comprises the bulk of the Selawik met tower operating time period, the AWOS station wind speed average was 4.00 m/s, which is 2.2 percent less than the long-term average. Note also a slight declining trend in wind speed over the 21 year period, although this may be misleading given the higher variability encountered year-to-year.

Selawik Airport wind speed

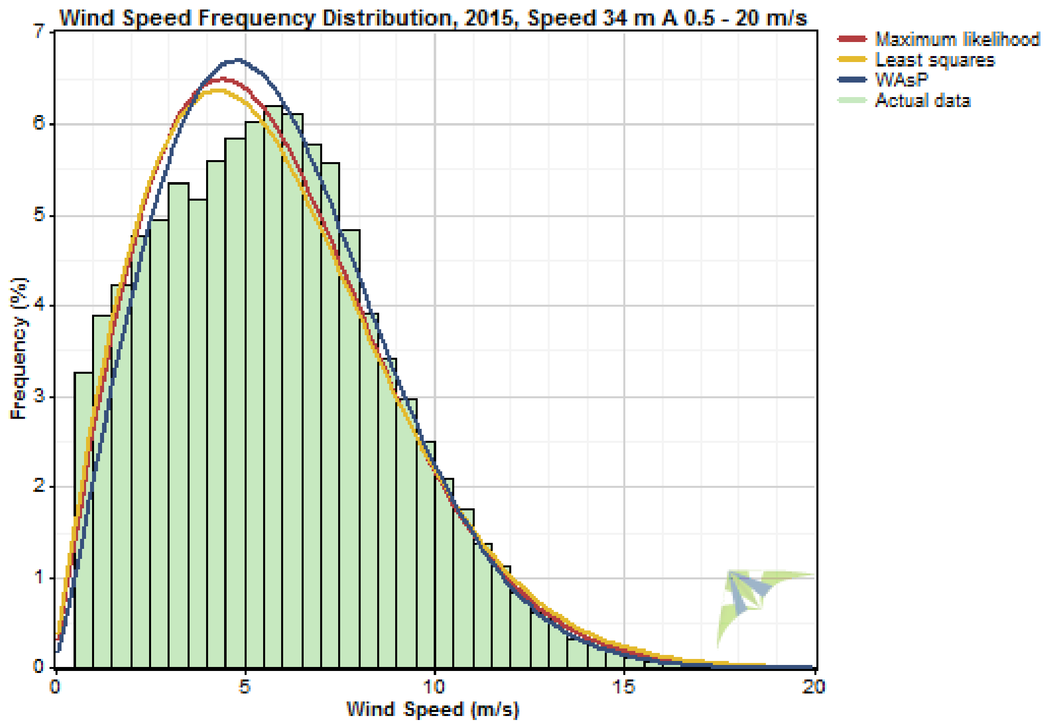


	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total	4.3	4	3.8	4.2	3.8	4.5	4.1	4.5	4.3	4.2	4.1	4	4.1	4	4	4	4.3	3.9	4.2	4.1	4

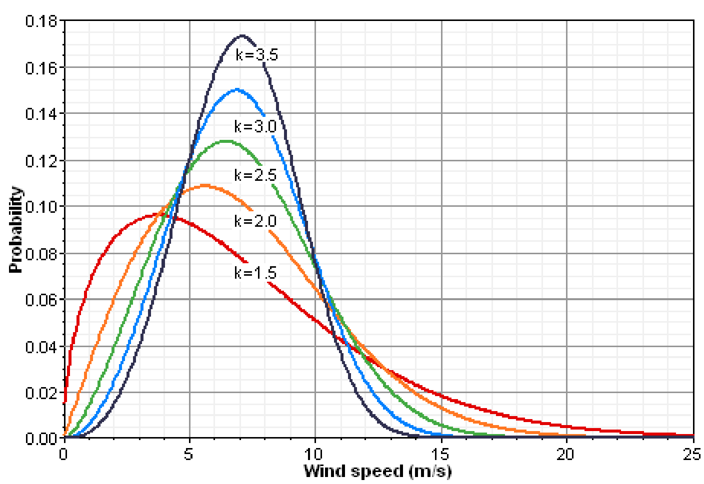
Probability Distribution Function

The probability distribution function (PDF), or histogram, of the Selawik met tower site wind speed indicates a shape curve dominated by moderate wind speeds and is mostly reflective of a "normal" shape curve, known as the Rayleigh distribution (Weibull k = 2.0), which is defined as the standard wind distribution for wind power analysis. As seen below in the wind speed distribution of the 34 meter A anemometer, the most frequently occurring wind speeds are between 3 and 8 m/s with very few wind events exceeding 20 m/s (note that the cutout speed of most wind turbines is 25 m/s; see following Occurrence by wind speed bin table).

PDF of 34 m A anemometer (all data)



Weibull k shape curve table



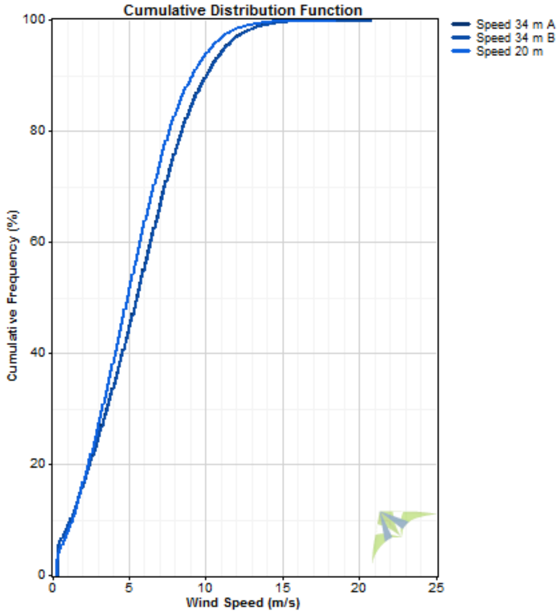
Weibull values table, 34m A anemometer, 2015, 0.5 to 20 m/s

Algorithm	Weibull k	Weibull c (m/s)	Mean (m/s)	Proportion Above 5.711 m/s	Power Density (W/m2)	R Squared
Maximum likelihood	1.923	6.427	5.701	0.451	225.7	0.9672
Least squares	1.868	6.450	5.726	0.451	236.0	0.9696
WAsP	2.070	6.553	5.805	0.471	221.3	0.9556
Actual data			5.711	0.471	221.2	

Occurrence by wind speed bin (34 m A anemometer)

Bin Endpoints (m/s)		Occurrences		Cumulative
Lower	Upper	No.	Percent	Percent
0	1	5,132	8.55%	8.55%
1	2	4,360	7.26%	15.82%
2	3	5,224	8.70%	24.52%
3	4	5,608	9.34%	33.86%
4	5	6,117	10.19%	44.06%
5	6	6,684	11.14%	55.19%
6	7	6,489	10.81%	66.00%
7	8	6,065	10.11%	76.11%
8	9	4,691	7.82%	83.92%
9	10	3,555	5.92%	89.85%
10	11	2,575	4.29%	94.14%
11	12	1,739	2.90%	97.04%
12	13	888	1.48%	98.52%
13	14	457	0.76%	99.28%
14	15	253	0.42%	99.70%
15	16	106	0.18%	99.88%
16	17	40	0.07%	99.94%
17	18	24	0.04%	99.98%
18	19	2	0.00%	99.99%
19	20	7	0.01%	100.00%
20	21	2	0.00%	100.00%

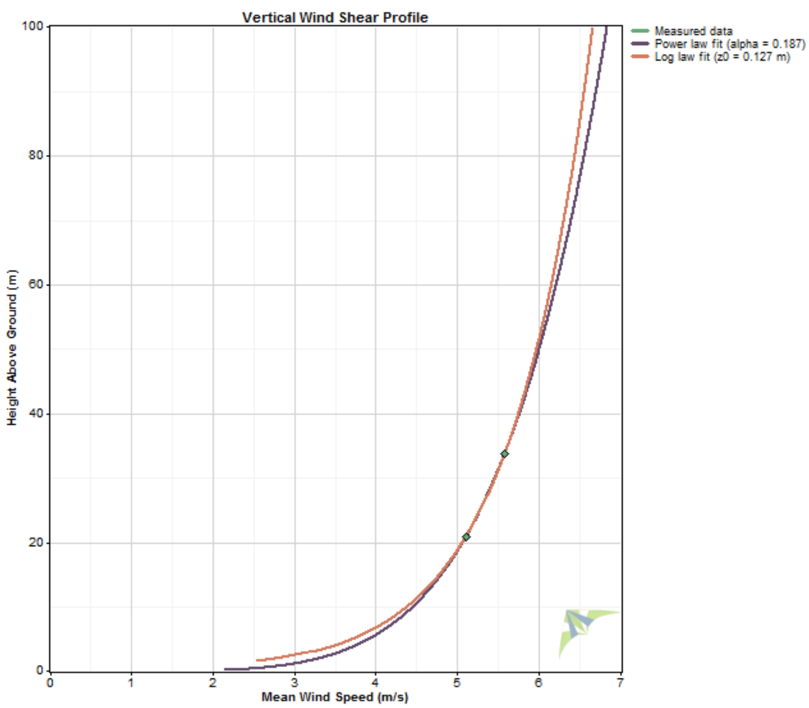
Cumulative distribution function



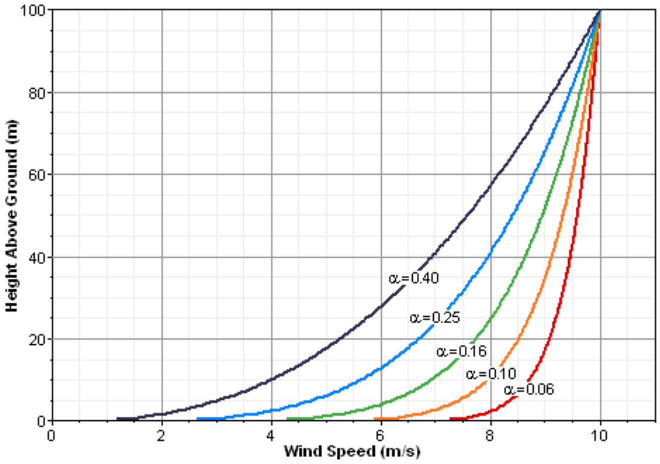
Wind Shear and Roughness

Wind shear at the Selawik met tower site was calculated with the 34 m A and 20 m anemometers, both of which were oriented toward 090° T. The calculated power law exponent of 0.187 indicates a fairly low wind shear at the site. Calculated surface roughness at the site is 0.15 m (the height above ground where wind speed would be zero) for a roughness class of 2.34 (description: agricultural land).

Vertical wind shear profile



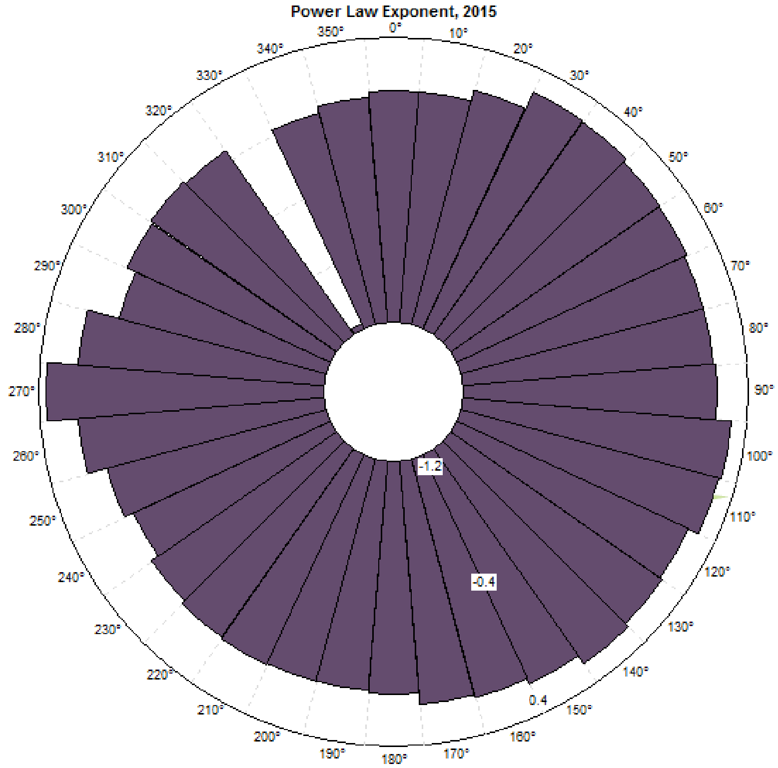
Comparative wind shear profiles



Wind shear by direction sector table

Direction Sector	Time Steps	Mean Wind Speed (m/s) Speed 34 m A	Speed 20 m	Best Fit Power Law Exp.	Surface Roughness (m)
345° - 15°	1,082	3.17	3.03	0.097	0.0009
15° - 45°	3,710	5.38	4.77	0.249	0.4803
45° - 75°	12,127	6.83	6.14	0.222	0.2956
75° - 105°	6,201	4.92	4.38	0.241	0.4165
105° - 135°	2,338	5.00	4.39	0.270	0.6479
135° - 165°	1,379	4.86	4.35	0.231	0.3517
165° - 195°	1,578	5.01	4.72	0.126	0.0095
195° - 225°	2,002	5.13	4.89	0.099	0.0011
225° - 255°	7,509	5.61	5.44	0.065	0.0000
255° - 285°	9,752	5.16	4.60	0.236	0.3794
285° - 315°	2,115	3.69	3.63	0.032	0.0000
315° - 345°	1,561	1.93	2.53	-0.558	

Wind shear by direction sector graph



Extreme Winds

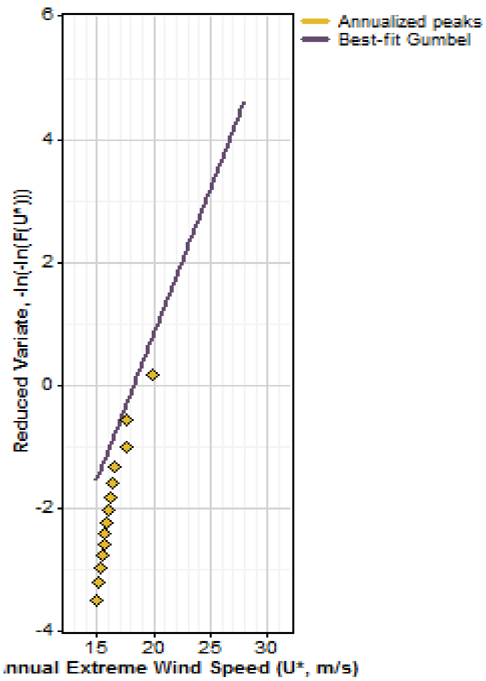
One method to estimate V_{ref}, or the maximum 50 year (10 minute average) wind speed, is a Gumbel distribution analysis modified for monthly maximum winds vice annual maximum winds. Fourteen months of data however are minimal at best and hence results should be viewed with considerable caution. Nevertheless, with data available the predicted Vref in a 50 year return period (in other words, predicted to occur once every 50 years) by this method is 25.8 m/s. This result classifies the site as Class III by International Electrotechnical Commission 61400-1, 3rd edition (IEC3) criteria.

Site extreme wind probability table, 34 m A data

Period (years)	V_{ref} (m/s)	Gust (m/s)	IEC 61400-1, 3rd ed. Class	IEC 61400-1, 3rd ed. V_{ref}, m/s
3	19.7	24.4	I	50.0
10	22.8	28.2	II	42.5
20	23.6	29.2	III	37.5
30	24.9	30.8	S	designer-specified
50	25.8	32.0		
100	27.2	33.6		
average gust factor:	1.24			

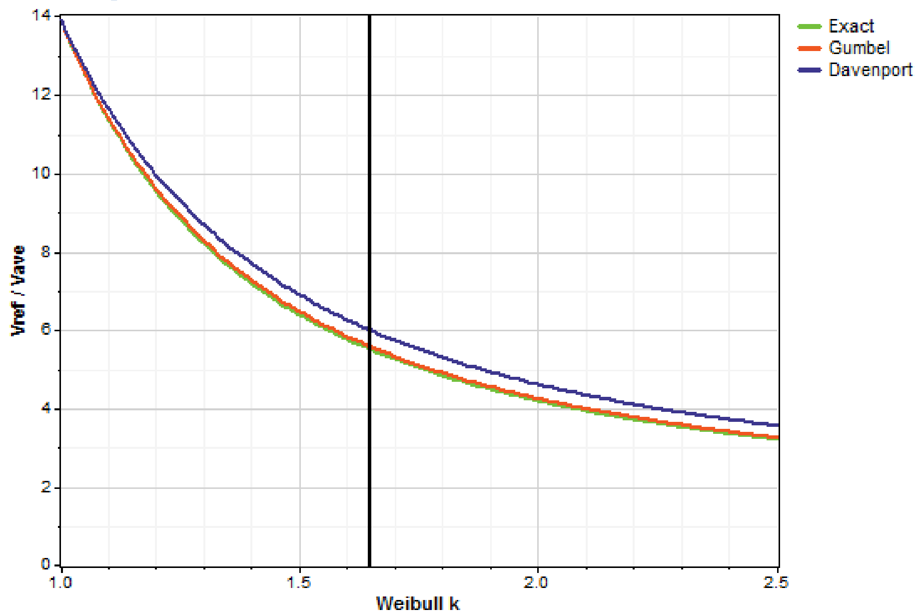
A second technique, Method of Independent Storms, yields a similar calculation for V_{ref} – 26.5 m/s.

Method of Independent Storms



A third method, referred to as EWTS II (European Wind Turbine Standards II) ignores recorded peak wind speeds and calculates V_{ref} from the Weibull k factor. There are three variations of this method and for the Selawik wind data V_{ref} is calculated between 30.8 and 33.6 m/s. As with the modified Gumbel distribution, the Method of Independent Storms and EWTS II methods both estimate an IEC Class III wind regime in Selawik. Note again however the minimal measured wind data for these calculations.

EWTS II plot



Note that IEC extreme wind probability classification is one criteria – with turbulence the other – that describes a site with respect to suitability for particular wind turbine models. Note that the IEC3 Class III extreme wind classification indicates moderate winds and that turbines installed at this location can be rated as IEC3 Class III.

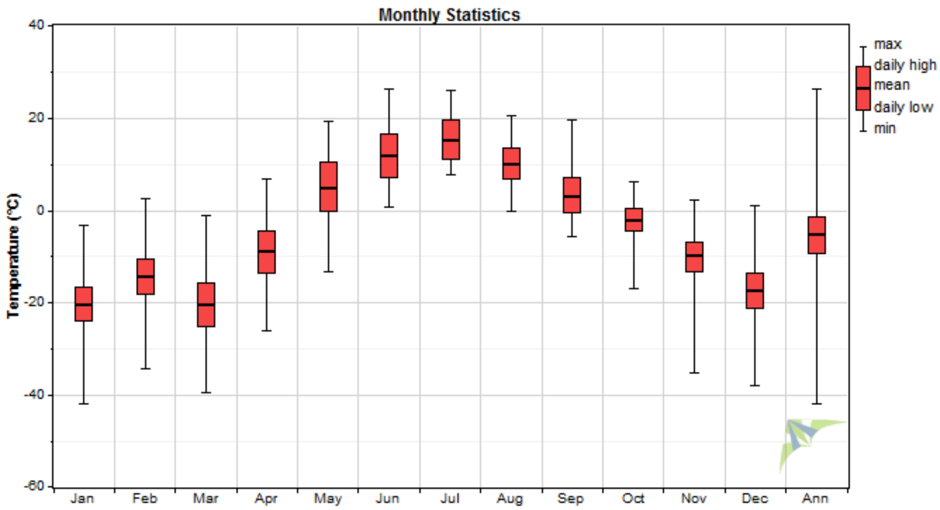
Temperature, Density, and Relative Humidity

Selawik experiences cool summers and cold winters with resulting higher than standard air density. Calculated mean-of-monthly-mean (or annual) air density during the met tower test period exceeds the 1.225 kg/m^3 standard air density for a sea level elevation by 5.8 percent. This is advantageous in wind power operations as wind turbines produce more power at low temperatures (high air density) than at standard temperature and density.

Temperature and density table

	Temp			Temp			Density		
Month	Mean (°C)	Min (°C)	Max (°C)	Mean (°F)	Min (°F)	Max (°F)	Mean (kg/m3)	Min (kg/m3)	Max (kg/m3)
Jan	-20.2	-41.8	-3.1	-4.4	-43.2	26.4	1.380	1.219	1.523
Feb	-14	-34.1	2.5	6.8	-29.4	36.5	1.362	1.276	1.474
Mar	-20.1	-39.5	-1.1	-4.2	-39.1	30.0	1.393	1.294	1.508
Apr	-8.8	-25.9	6.8	16.2	-14.6	44.2	1.333	1.256	1.425
May	5.2	-13.1	19.5	41.4	8.4	67.1	1.264	1.199	1.354
Jun	12.1	0.7	26.4	53.8	33.3	79.5	1.232	1.169	1.285
Jul	15.5	7.7	26.1	59.9	45.9	79.0	1.217	1.170	1.252
Aug	10.1	-0.1	20.5	50.2	31.8	68.9	1.241	1.194	1.289
Sep	3.2	-5.6	19.6	37.8	21.9	67.3	1.273	1.198	1.316
Oct	-1.8	-16.8	6.3	28.8	1.8	43.3	1.298	1.259	1.374
Nov	-9.7	-35.1	2.4	14.5	-31.2	36.3	1.338	1.277	1.480
Dec	-17.3	-37.8	1.1	0.9	-36.0	34.0	1.372	1.219	1.497
Annual	-3.8	-41.8	26.4	25.1	-43.2	79.5	1.308	1.169	1.523

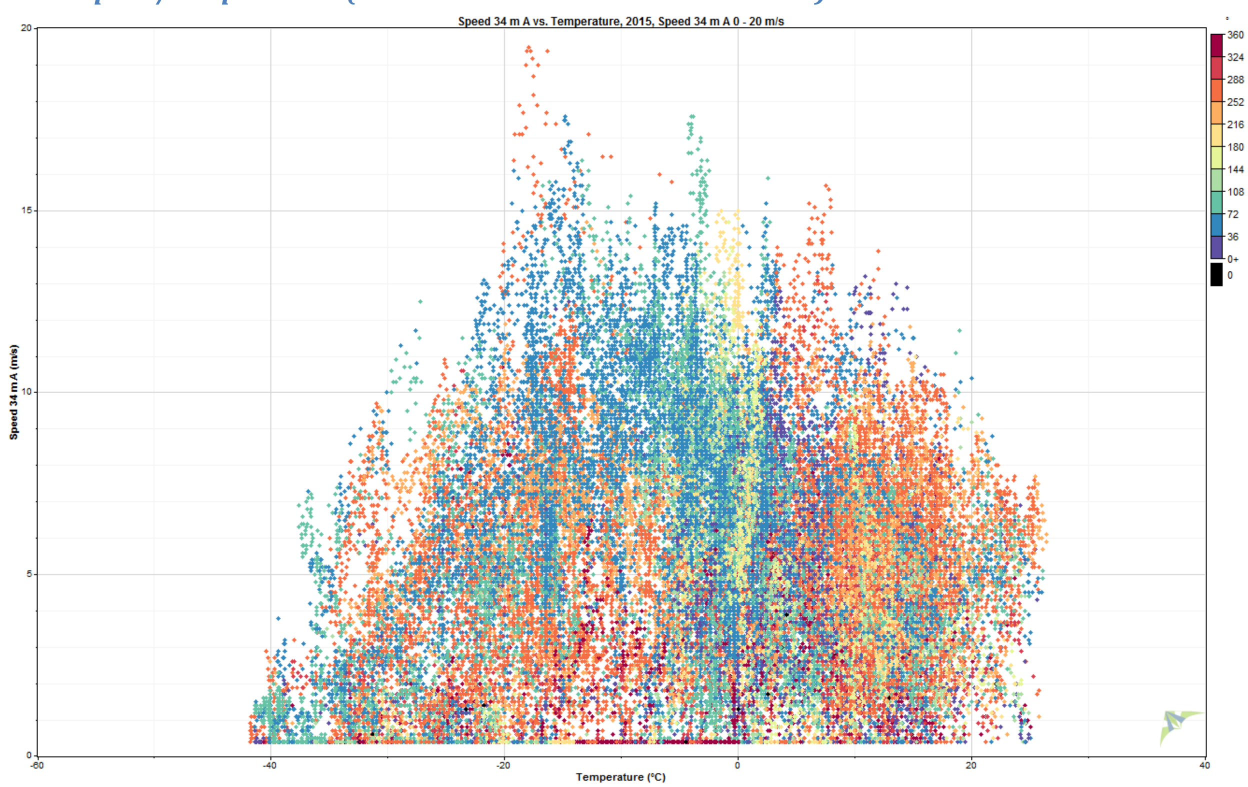
Selawik temperature boxplot graph



Wind Speed Scatterplot

The wind speed versus temperature scatterplot below indicates cold temperatures at the Selawik met tower site with a preponderance of below freezing temperatures. During the met tower test period, temperatures frequently were colder than -20° C (-4° F), the minimum operating temperature for most standard-environment wind turbines. Note that arctic-capable (operational rating to -40°C) wind turbines would be required in Selawik, but note that extreme cold temperatures, although not infrequent, are generally associated with lower wind speeds.

Wind speed/temperature (color code indicates wind direction)



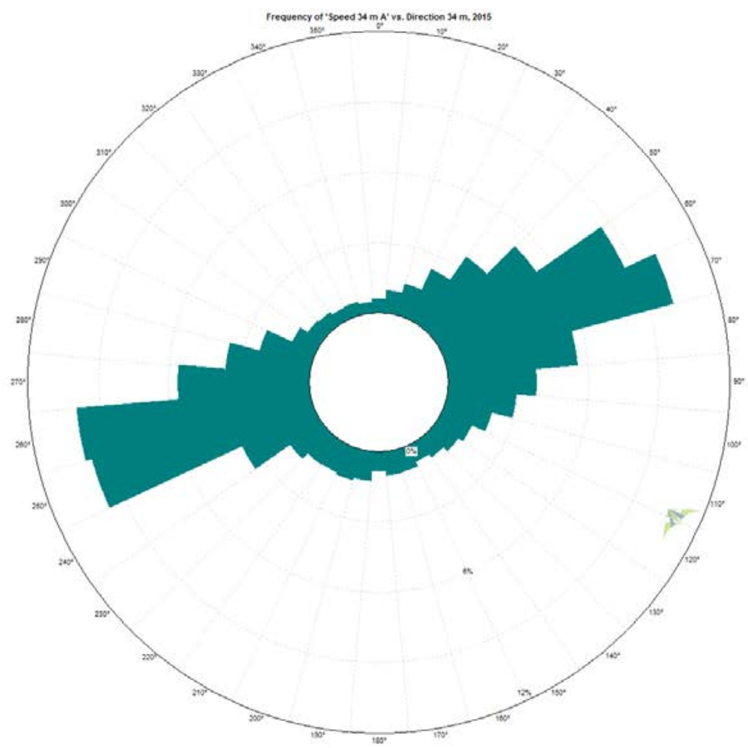
Wind Direction

Wind frequency rose data indicates that winds at the Selawik met tower site are primarily bi-directional, with east-northeasterly and west-southwesterly winds predominating. The mean value rose indicates that ENE winds are of relatively higher intensity than WSW winds, but with more frequent ENE winds, the dominant energy winds are from that direction.

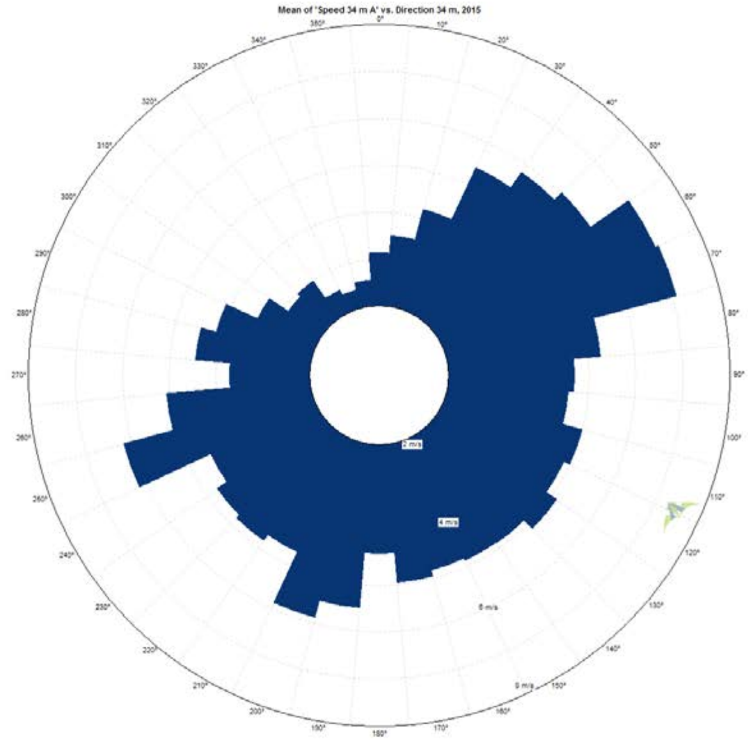
Calm frequency, the percent of time that winds at the 34 meter level are less than 4 m/s, a typical cut-in speed of larger wind turbines, was 34 percent during the 14 month test period.

Note that the measured wind rose at the met tower site correlates well with that that observed by the automated weather station at the nearby Selawik Airport.

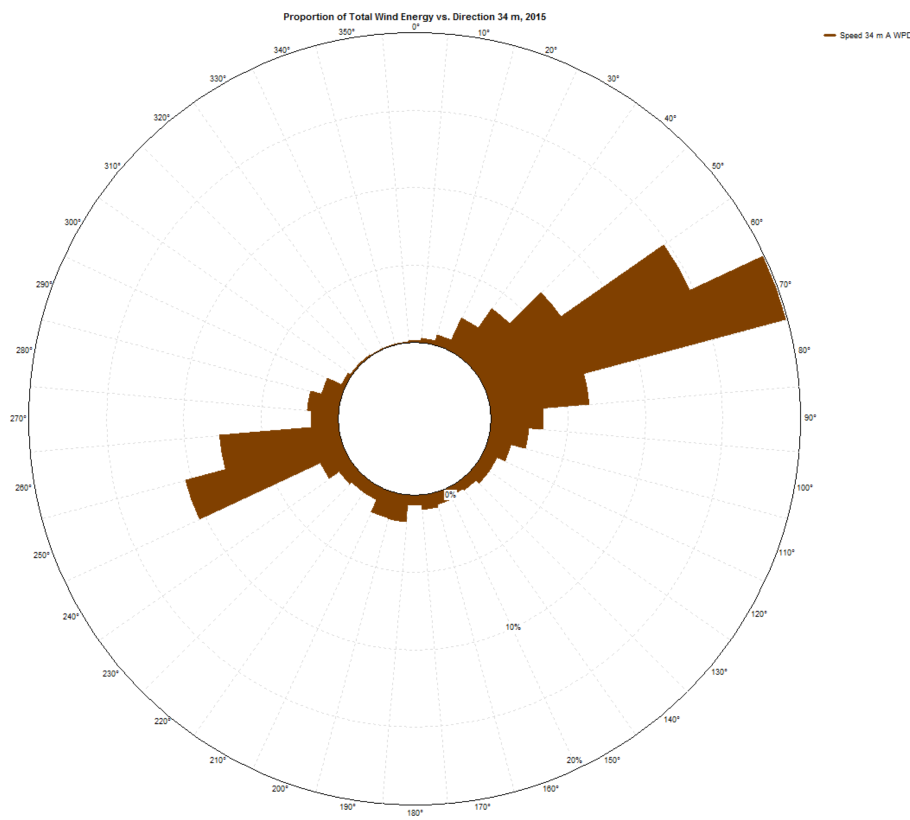
Wind frequency rose



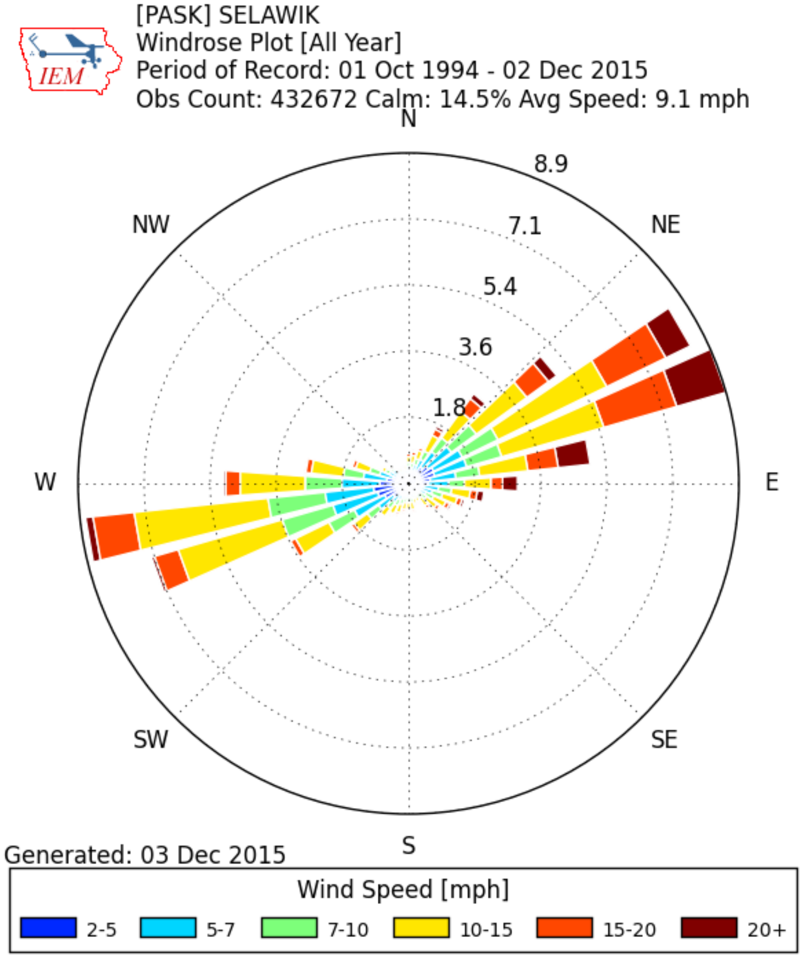
Mean value rose



Wind energy rose



Selawik Airport wind rose



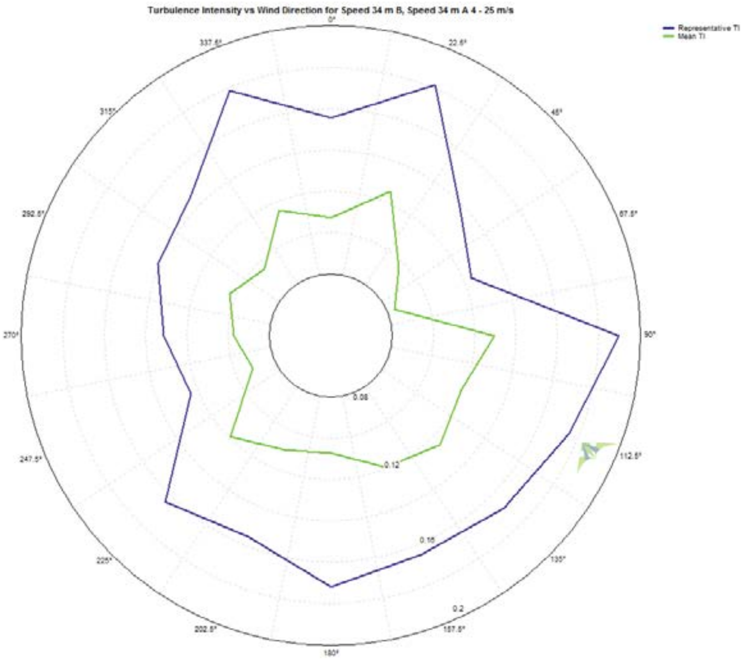
Turbulence

The turbulence intensity (TI) at the Selawik met tower site is very low with a mean turbulence intensity of 0.075 and a representative turbulence intensity of 0.095 at 15 m/s wind speed, indicating smooth air for wind turbine operations. This equates to an International Electrotechnical Commission (IEC) 61400-1, 3rd Edition (2005) turbulence category C, which is the lowest defined category.

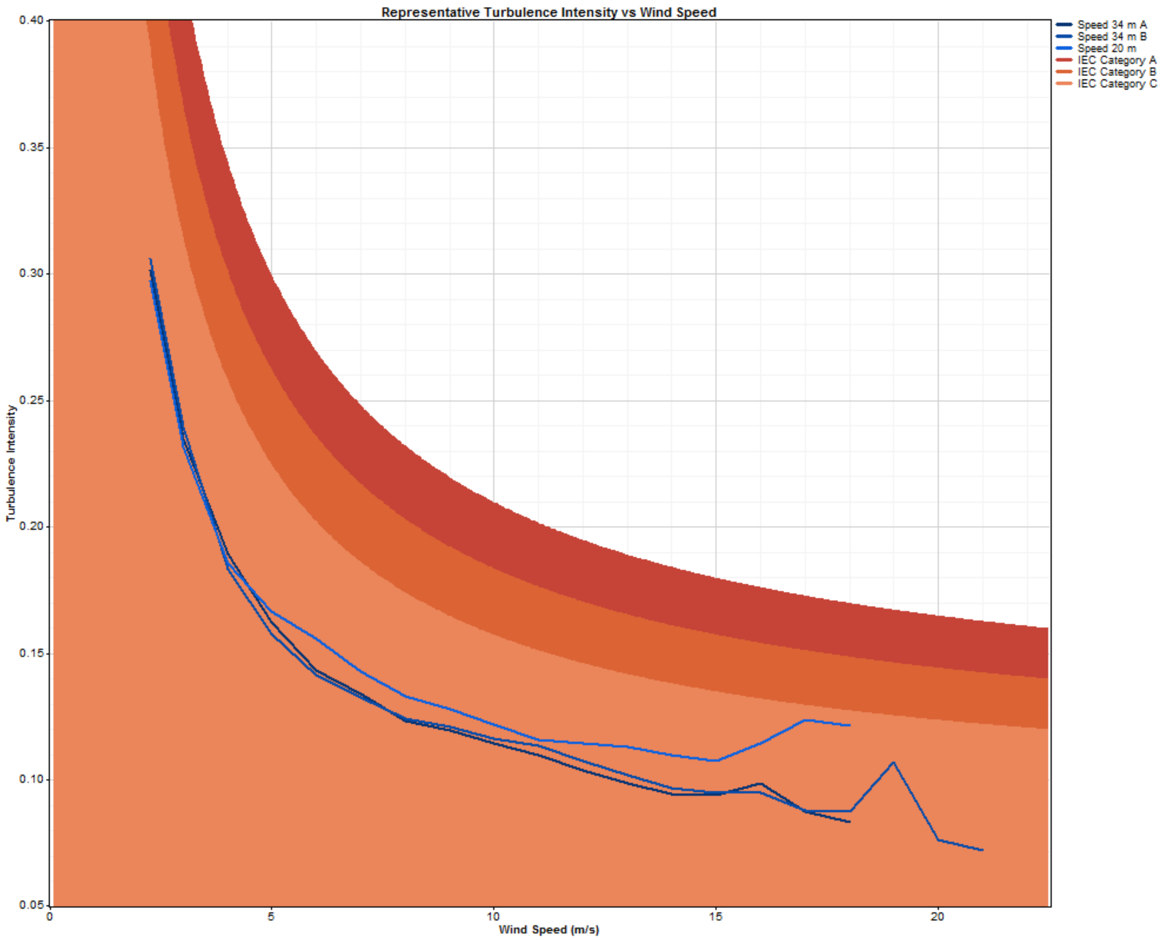
Turbulence synopsis

	34 m A anem.			34 m B anem.			Legend	
Sector	Mean TI at 15 m/s	Repres. TI at 15 m/s	IEC3 Category	Mean TI at 15 m/s	Repres. TI at 15 m/s	IEC3 Category	IEC3 Categ.	Mean TI at 15 m/s
all	0.075	0.094	C	0.075	0.095	C	S	>0.16
315° to 045°	-	-	-	-	-	-	A	0.14-0.16
045° to 135°	0.075	0.095	C	0.073	0.091	C	B	0.12-0.14
135° to 225°	0.071	0.078	C	0.072	0.082	C	C	0-0.12
225° to 315°	0.078	0.090	C	0.084	0.110	C		

Turbulence rose, 34m A anemometer



Turbulence intensity, all direction sectors



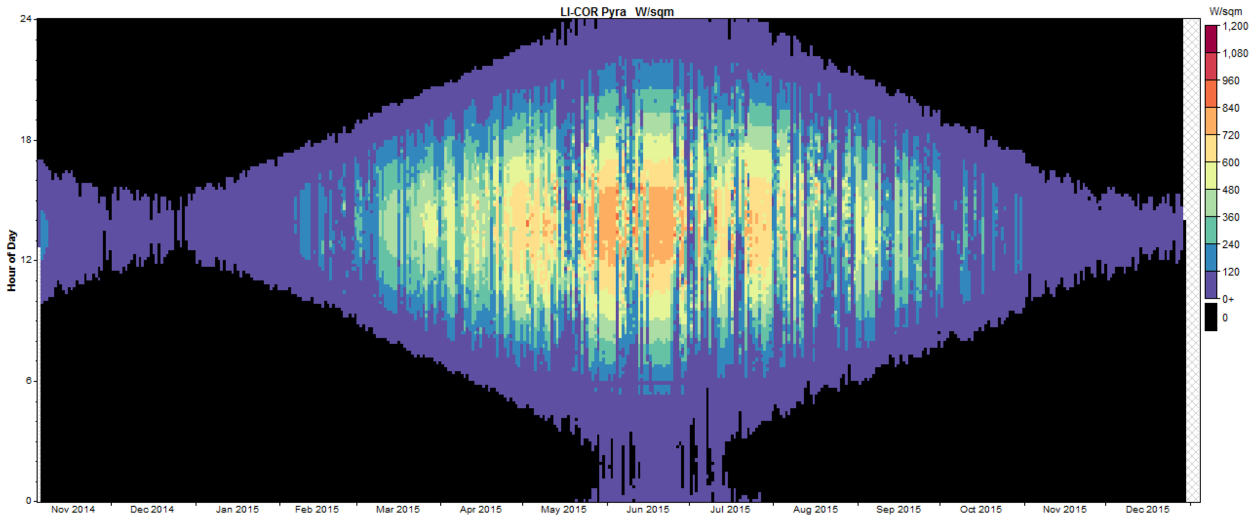
Turbulence table, 34 m A data, all sectors

Bin Midpt. (m/s)	Bin Endpoints Lower (m/s)	Upper (m/s)	Data Points In Bin	Bin Frequency (%)	Mean TI	SD of TI	Represen-tative TI	Peak TI
0.3	0	0.5	2,688	4.581	0.085	0.164	0.294	0.750
1	0.5	1.5	3,905	6.655	0.458	0.148	0.647	1.500
2	1.5	2.5	4,895	8.342	0.244	0.087	0.355	0.833
3	2.5	3.5	5,705	9.722	0.166	0.056	0.237	0.815
4	3.5	4.5	5,825	9.926	0.137	0.045	0.195	0.629
5	4.5	5.5	6,558	11.175	0.118	0.039	0.168	0.566
6	5.5	6.5	6,534	11.135	0.106	0.035	0.150	0.393
7	6.5	7.5	5,929	10.104	0.099	0.032	0.139	0.358
8	7.5	8.5	5,069	8.638	0.091	0.029	0.128	0.276
9	8.5	9.5	4,058	6.915	0.087	0.029	0.124	0.264
10	9.5	10.5	2,929	4.991	0.085	0.026	0.117	0.316
11	10.5	11.5	2,112	3.599	0.082	0.023	0.112	0.257
12	11.5	12.5	1,265	2.156	0.078	0.022	0.107	0.190
13	12.5	13.5	645	1.099	0.077	0.022	0.105	0.178
14	13.5	14.5	298	0.508	0.074	0.018	0.097	0.152
15	14.5	15.5	162	0.276	0.076	0.017	0.098	0.130
16	15.5	16.5	64	0.109	0.084	0.014	0.102	0.116
17	16.5	17.5	27	0.046	0.078	0.013	0.095	0.112
18	17.5	18.5	9	0.015	0.084	0.023	0.114	0.117
19	18.5	19.5	4	0.007	0.083	0.012	0.099	0.100
20	19.5	20.5	1	0.002	0.071	0.000	0.071	0.071

Solar Resource

Although this report addresses the measured wind resource at the Selawik met tower site, the met tower was equipped with a pyranometer to measure solar radiation. With this, one can see that the winter solar power resource in Selawik is very low but has a high peak at summer solstice in late June. Note also that surprisingly high solar power generation in rural Alaska has been obtained in late winter (February thru early May) with sun reflection off foregrounds of snow, in addition to sunlight.

Pyranometer DMap



Pyranometer box plot