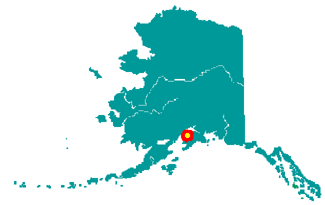
ALASKA ENERGY AUTHORITY
813 W. Northern Lights Blvd.
Anchorage, AK 99503
Phone: 907-269-3000
Fax: 907-269-3044
www.akenergyauthority.org

Wind Resource Assessment for KENAITZE TRIBE, ALASKA

Date last modified: 6/1/2006
Compiled by: Cliff Dolchok & Mia Devine

SITE SUMMARY

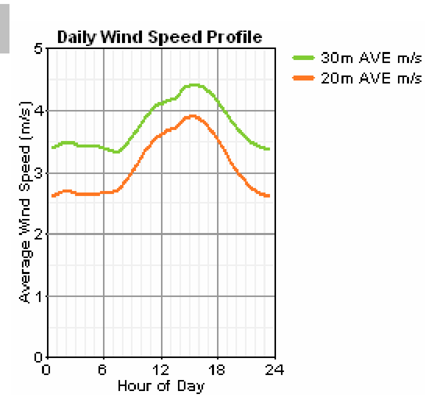


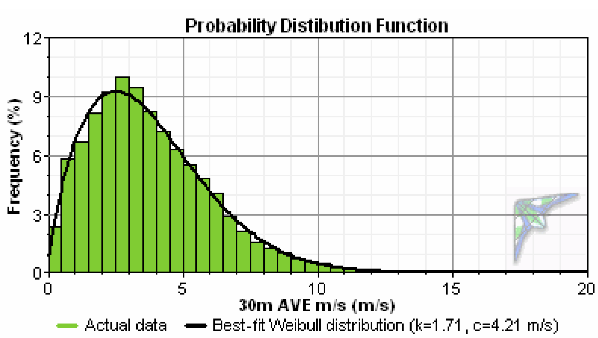
Site #:	5042
Latitude (NAD27):	60˚ 33' 29.8" N
Longitude (NAD27):	151˚ 8' 54.9" W
Magnetic Declination:	19˚ 30' East
Tower Type:	30-meter NRG Tall Tower
Sensor Heights:	30m, 20m
Elevation:	15.2 meters (50 ft)
Monitor Start:	11/27/2004 21:00
Monitor End:	3/30/2006 13:50

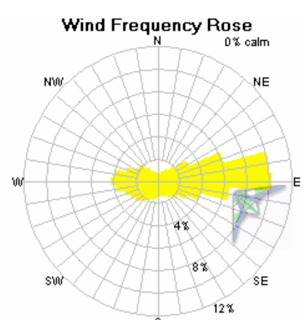
In November 2004, a 30-meter meteorological tower was installed on Kenaitze Tribe land. The purpose of this monitoring effort is to evaluate the feasibility of utilizing wind energy in the community. The measured wind speed and direction data was collected at the site and estimates were calculated for the potential energy production from various types of wind turbines.

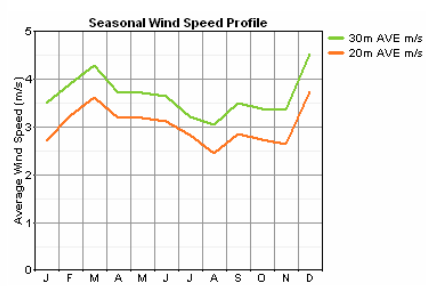
WIND RESOURCE SUMMARY

Annual Average Wind Speed (30m height):	3.8 m/s (8.4 mph)
Average Wind Power Density (30m height):	79 W/m^2
Wind Power Class (range = 1 to 7):	1
Rating (Poor, Marginal, Fair, Good, Excellent, Outstanding, Superb):	Poor
Prevailing Wind Direction:	East
Wind Shear:	0.36
Turbulence Intensity:	0.15



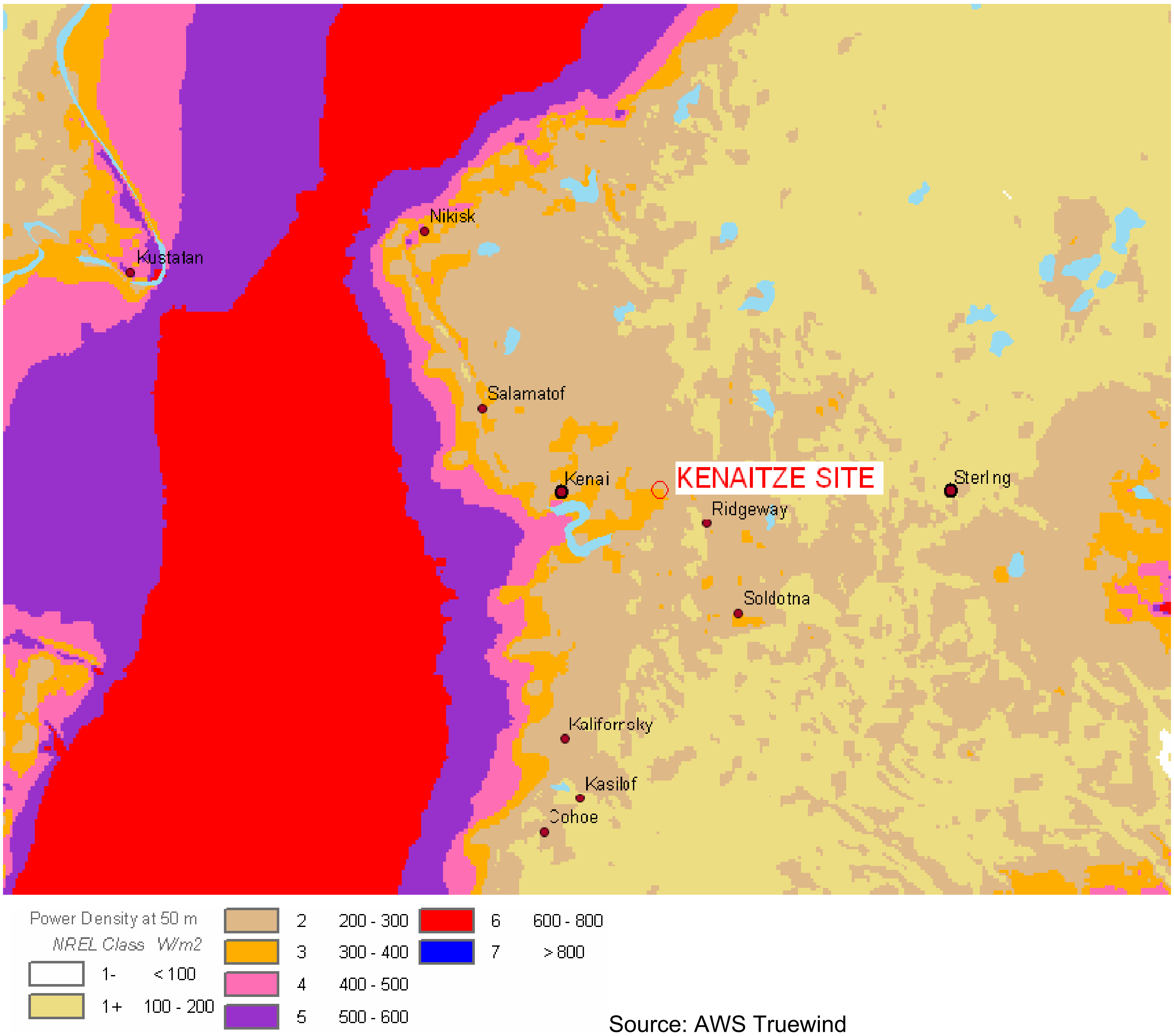






INTRODUCTION

On initial review, the Kenaitze Tribe's property appears to be a "poor" candidate for wind power. The wind resource map below shows that the Kenaitze property is in close proximity to areas with a Class 1 to 2 wind resource. Areas of Class 4 and higher are considered suitable for utility-scale wind power development.



Source: AWS Truewind

Figure 1. Wind Resource Map of Alaska

With support from the Alaska Energy Authority, a 30-meter tall meteorological tower was installed by AEA and Earth Energy Systems on the property belonging to the Kenaitze Tribe. The purpose of this monitoring effort is to verify the wind resource on Kenaitze Tribe land and evaluate the feasibility of utilizing wind energy in the community. This report summarizes the wind resource data collected and the potential energy production of the site.

SITE DESCRIPTION

The photos below document the meteorological tower equipment that was installed on Kenaitze Tribe land.

Figure 2. Photos of the Met Tower Installation on Kenaitze Land

The photos in Figure 3 illustrate the surrounding ground cover and any major obstructions, which could affect how the wind flows over the terrain from a particular direction. As shown, the landscape surrounding the met tower site is and relatively flat and surrounded by trees and shrubs.

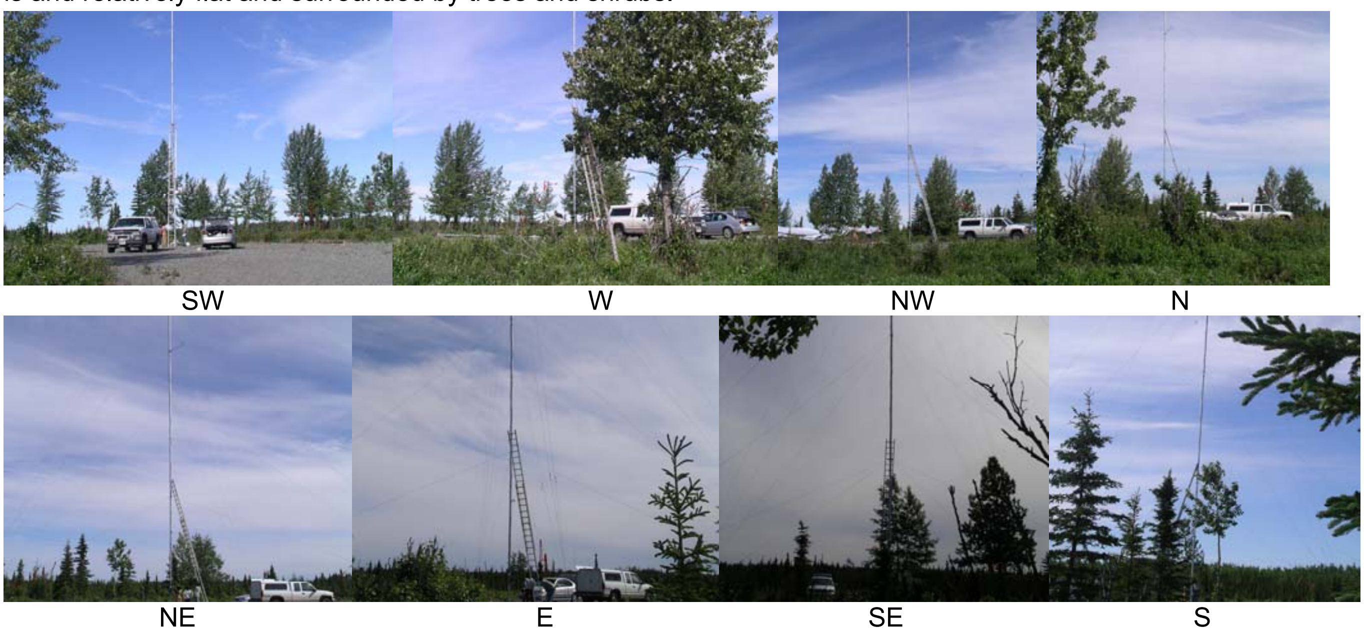
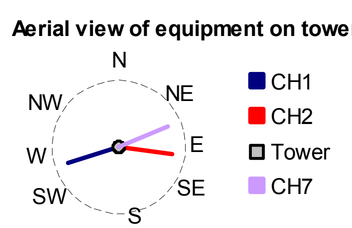


Figure 3. Views Taken from Met Tower Base

Table 1 lists the types of sensors that were used, the channel of the data logger that each sensor was wired into, and where each sensor was mounted on the tower. A pyranometer was also installed to record solar insolation.

Table 1. Summary of Sensors Installed on the Met Tower

Ch #	Sensor Type	Height	Offset	Boom Orientation
1	#40 Anemometer	30 m	NRG Standard	255˚ True
2	#40 Anemometer	20 m	NRG Standard	95˚ True
8	#200P Wind Vane	30 m	255	75˚ True
10	Licor Pyranometer	2 m		
11	#110S Temperature	3 m	NRG Standard	-



WIND DATA RESULTS FOR MET TOWER SITE

Table 2 summarizes the amount of data that was successfully retrieved from the data logger at the met tower site. The wind vane was not working between November 2004 and June 2005, and the temperature sensor was not working from March 2005 to March 2006. Data from all sensors was missing for the month of February and part of March of 2006. Some icing also occurred during the winter months. The software program Windographer (www.mistaya.ca) was used to fill the gaps. Windographer uses statistical methods based on patterns in the data surrounding the gap, and is good for filling short gaps in data.

Table 2. Data Recovery Rate for Met Tower Anemometers

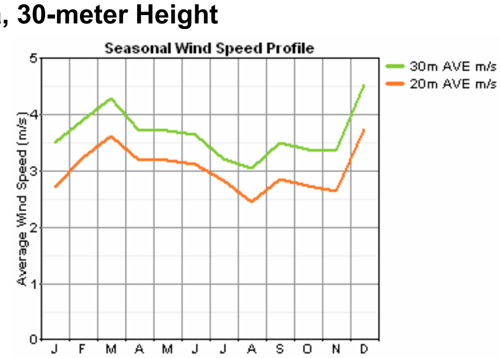
Month	Data Recovery Rate
2004 Nov	92.4%
2004 Dec	95.8%
2005 Jan	94%
2005 Feb	87.2%
2005 Mar	94%
2005 Apr	94.2%
2005 May	98.1%
2005 Jun	100%
2005 Jul	100%
2005 Aug	100%
2005 Sep	95%
2005 Oct	77.7%
2005 Nov	82.1%
2005 Dec	73.2%
2006 Jan	70.9%
2006 Feb	0%
2006 Mar	38.8%

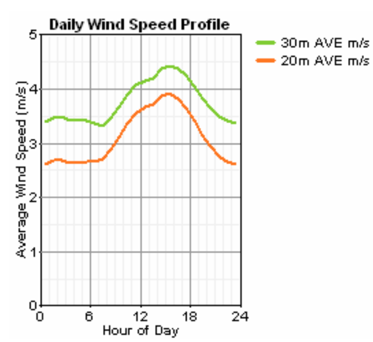
Wind Speed Measurements

The table below summarizes the wind speed data collected at the Kenaitze Tribe land met tower site.

Table 3. Summary of Wind Speed Data, 30-meter Height

Annual Average	3.8 m/s
Highest Month	Dec 2005
Lowest Month	Nov 2004
Hour of Peak Wind	16:00
Max 10-minute average	15.6 m/s
Max gust	22.6 m/s





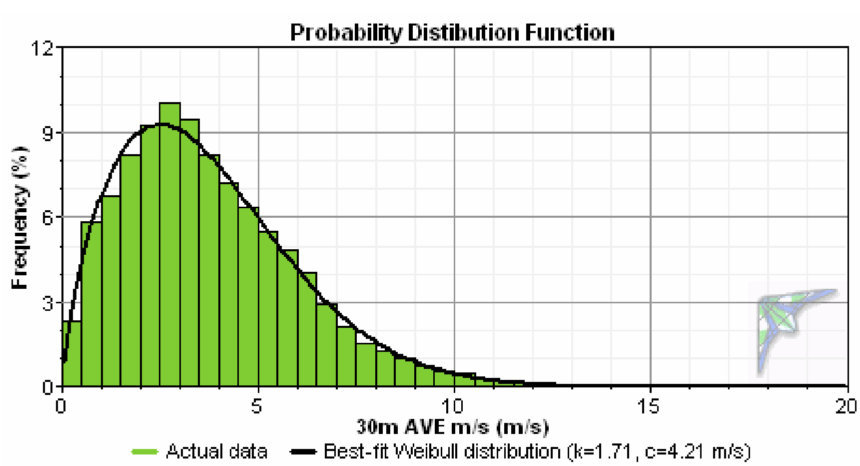
The seasonal wind speed profile shows that the winter months are generally windier than the summer months. The daily wind speed profile shows that wind speeds are typically greater in the afternoon and evening hours and calmer in the morning. The data that makes up these graphs is listed in

Table 4. Average Wind Speeds at Met Tower Site, 30m Height (m/s)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	3.5	3.6	4.1	3.0	2.8	2.6	2.3	2.5	3.2	3.4	3.1	4.6	3.2
1	3.6	4.0	4.0	2.9	2.9	2.6	2.3	2.5	3.3	3.3	3.3	4.6	3.3
2	3.6	4.0	4.1	3.2	2.8	2.7	2.0	2.6	3.3	3.6	3.2	4.7	3.3
3	3.5	3.7	4.0	2.9	2.9	2.8	1.8	2.5	3.2	3.7	3.2	4.8	3.2
4	3.5	4.0	3.9	3.0	2.8	2.6	1.8	2.4	3.2	3.8	3.2	4.7	3.2
5	3.4	4.0	4.1	3.0	2.7	2.4	1.7	2.4	3.0	3.9	3.1	4.9	3.2
6	3.4	3.8	4.2	3.0	2.5	2.2	1.7	2.3	2.9	3.7	3.0	4.9	3.1
7	3.3	3.7	4.1	2.9	2.8	2.5	2.3	2.0	3.0	3.6	2.8	4.6	3.1
8	3.5	3.7	4.0	3.2	3.3	3.0	2.8	2.4	2.9	3.3	3.3	4.7	3.3
9	3.4	3.8	3.9	3.8	4.0	3.4	3.4	2.8	3.2	3.3	3.2	4.7	3.6
10	3.5	4.0	4.4	4.3	4.3	3.9	3.8	3.0	3.8	3.5	3.3	4.4	3.9
11	3.4	3.9	4.6	4.6	4.8	4.5	4.2	3.5	4.0	4.0	3.4	4.3	4.1
12	3.6	4.0	4.5	4.8	4.8	4.8	4.4	3.8	4.1	3.4	3.7	4.3	4.2
13	3.5	4.0	4.5	5.0	4.9	4.9	4.5	3.8	4.1	3.5	3.7	4.5	4.2
14	3.5	4.1	4.9	5.2	5.1	4.9	4.7	4.2	4.2	3.5	3.8	4.7	4.4
15	3.8	4.4	4.9	5.1	5.3	5.0	5.0	4.4	4.2	3.3	3.8	4.3	4.5
16	3.9	4.1	4.8	4.8	5.3	5.1	5.2	4.4	4.3	3.3	3.6	4.4	4.4
17	3.6	4.0	4.9	4.6	4.9	5.0	4.9	4.1	4.2	3.0	3.5	4.5	4.3
18	3.5	4.1	4.6	4.1	4.7	4.8	4.3	3.7	3.7	3.0	3.6	4.3	4.0
19	3.4	4.0	4.3	3.7	4.2	4.5	3.8	3.1	3.2	2.9	3.5	4.4	3.8
20	3.4	3.9	4.0	3.4	3.2	4.1	3.2	2.9	3.1	3.2	3.4	4.6	3.5
21	3.3	3.8	4.1	3.1	2.9	3.3	2.7	2.7	3.1	3.1	3.5	4.6	3.4
22	3.4	3.9	4.2	3.0	2.7	2.9	2.4	2.7	3.3	3.3	3.1	4.3	3.3
23	3.5	3.6	4.2	3.0	2.7	2.7	2.3	2.6	3.3	3.1	3.1	4.3	3.2
Avg	3.5	3.9	4.3	3.7	3.7	3.6	3.2	3.1	3.5	3.4	3.4	4.5	3.7

Wind Frequency Distribution

A common method of displaying a year of wind data is a wind frequency distribution, which shows the percent of time that each wind speed occurs. Figure 4 shows the measured wind frequency distribution as well as the best matched Weibull distribution, which is commonly used to approximate the wind speed frequency distribution.



Bin m/s	Hrs/yr	Bin m/s	Hrs/yr
0.5	205	10.5	41
1	511	11	27
1.5	589	11.5	19
2	718	12	16
2.5	809	12.5	13
3	878	13	10
3.5	831	13.5	6
4	722	14	4
4.5	631	14.5	3
5	555	15	2
5.5	485	15.5	1
6	422	16	0
6.5	356	16.5	0
7	258	17	0
7.5	188	17.5	0
8	137	18	0
8.5	115	18.5	0
9	91	19	0
9.5	67	19.5	0
10	51	20	0

Figure 4. Wind Speed Frequency Distribution of Met Tower Data, 30-meter height

The cut-in wind speed of many wind turbines is 4 m/s and the cut-out wind speed is 25 m/s. The frequency distribution shows that only a small percentage of the wind on the Kenaitze Tribal land site is within this operational zone.

Wind Direction

A wind frequency rose shows the percent of time that the wind blows from each direction, while the wind power roses show the percent of total power that is available in the wind from each direction. The annual wind frequency and wind power rose for the Kenaitze Tribal land met tower site is shown below.

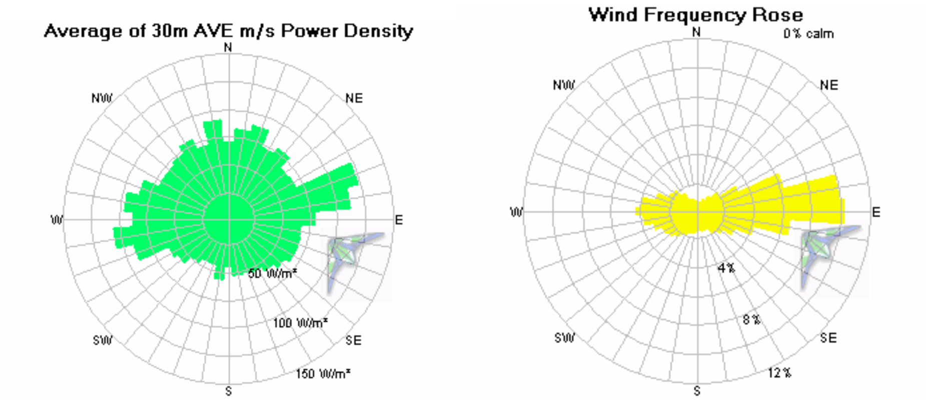


Figure 5. Annual Wind Roses for Kenaitze Tribal Land Met Tower Site

Monthly wind power roses for the Kenaitze Tribal land met tower site are shown below.

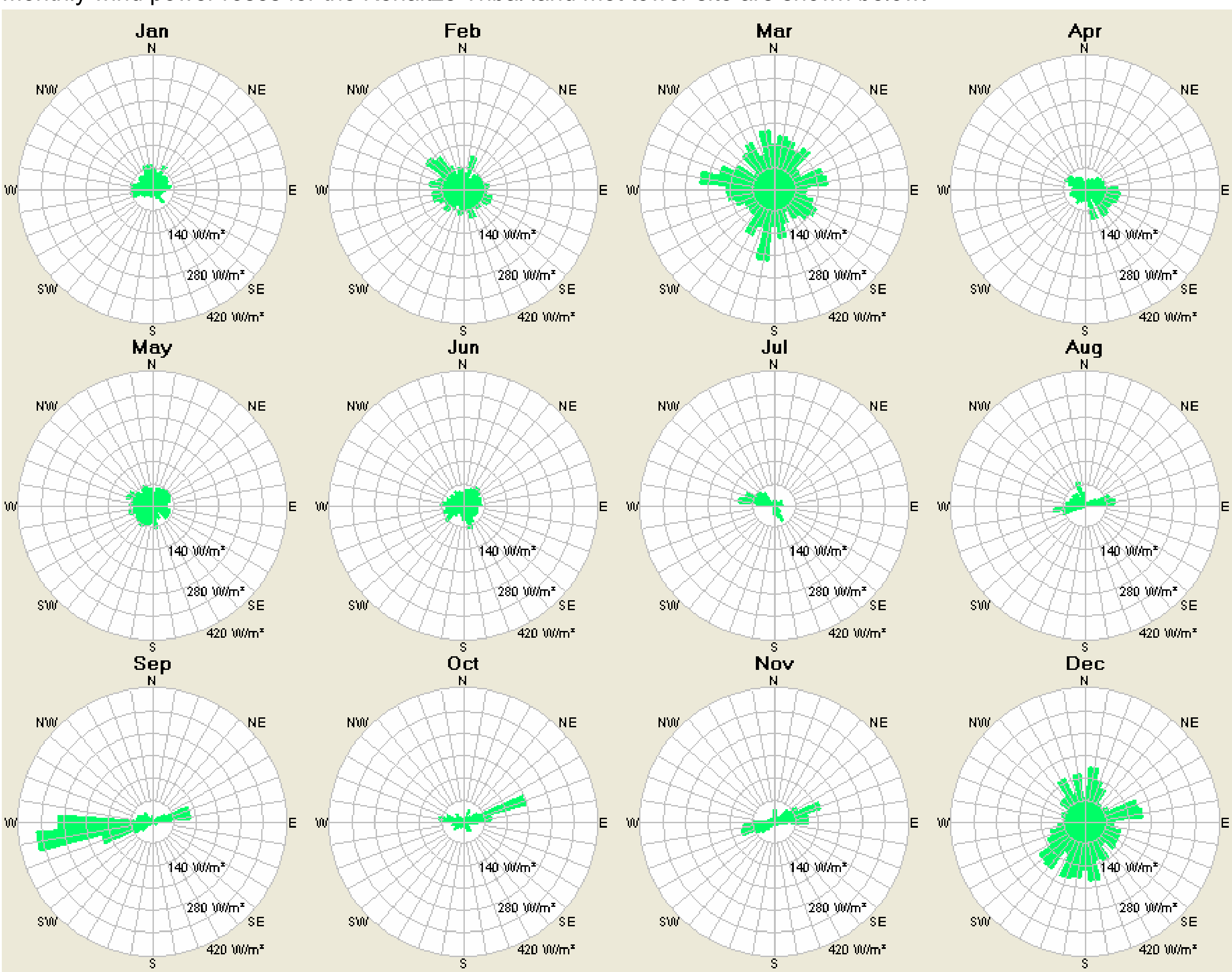


Figure 6. Monthly Wind Power Roses for Met Tower Site

Turbulence Intensity

Turbulence intensity is the most basic measure of the turbulence of the wind. Typically, a turbulence intensity of around 0.10 is desired for minimal wear on wind turbine components. As shown in Figure 7, the turbulence intensity from all directions is low and unlikely to contribute to excessive wear of wind turbines.

Dir	Turbulence Intensity
N	0.14
NE	0.15
E	0.14
SE	0.15
S	0.14
SW	0.16
W	0.16
NW	0.13
Ave	0.15

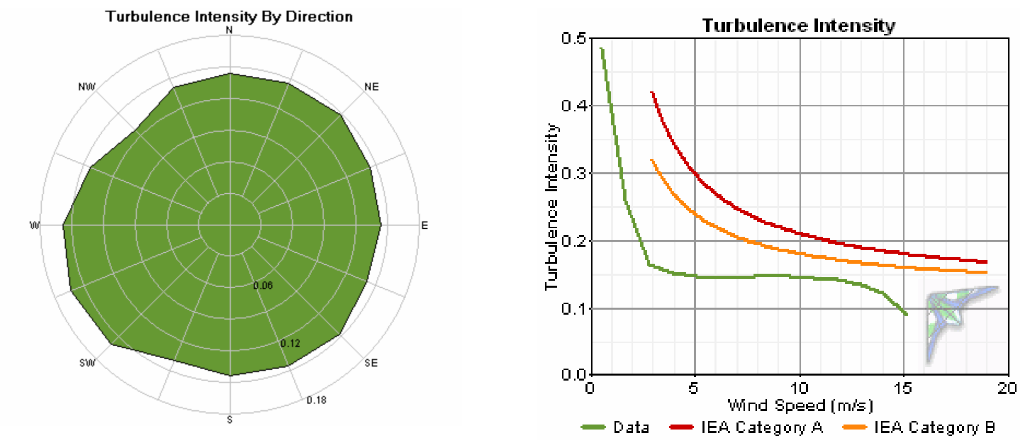


Figure 7. Turbulence Intensity Characteristics of Met Tower Site

Figure 7 plots the average turbulence intensity versus wind speed for the met tower site as well as for Category A and B turbulence sites as defined by the International Electrotechnical Commission Standard 61400-1, 2nd Edition. Category A represents a higher turbulence model than Category B. In this case, the met tower data is less turbulent than both categories across the whole range of wind speeds.

Wind Shear

Typically, wind speeds increase with height above ground level. This vertical variation in wind speed is called wind shear and is influenced by surface roughness, surrounding terrain, and atmospheric stability. The met tower is equipped with anemometers at 20 and 30-meter heights so wind shear can be calculated and used to adjust the wind resource data to heights other than those that were measured. Typical values range from 0.05 to 0.25.

Month	Wind Shear
Jan	0.40
Feb	0.41
Mar	0.33
Apr	0.28
May	0.30
Jun	0.32
Jul	0.32
Aug	0.36
Sep	0.35
Oct	0.37
Nov	0.42
Dec	0.40
Ave	0.36

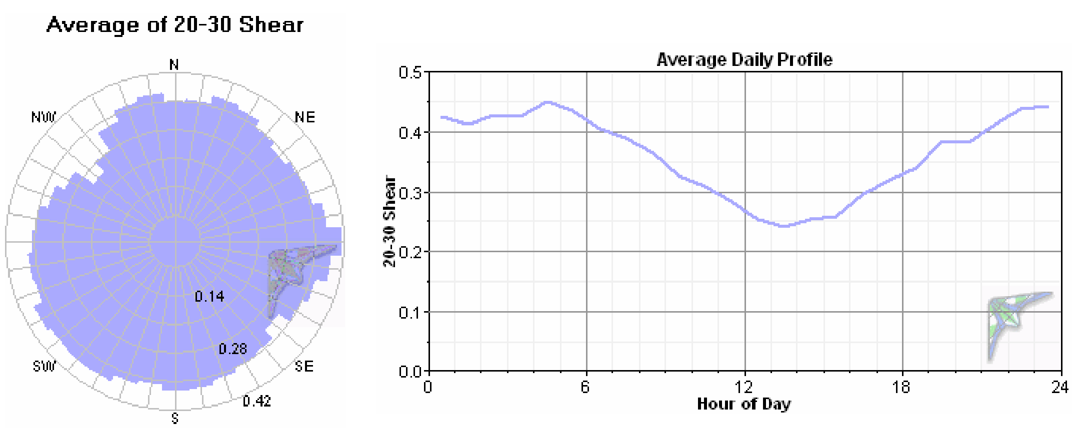


Figure 8. Wind Shear Characteristics of Met Tower Site

As shown, the wind shear varies by month, direction of the wind, and time of day. The average wind shear for the site is 0.36. The high wind shear value means that wind speeds at the 30-meter height are much greater than the 20-meter height, likely due to the tree line suppressing the wind speed at the lower height.

POTENTIAL POWER PRODUCTION FROM WIND TURBINES

Various wind turbines, listed in Table 5, were used to calculate the potential energy production at the met tower site based on the year and a half of data collected. The data has not been adjusted to long-term trends in the area. Although different wind turbines are offered with different tower heights, to be consistent it is assumed that any wind turbine rated at 100 kW or less would be mounted on a 30-meter tall tower, while anything larger would be mounted on a 50-meter tower. The wind resource was adjusted to these heights based on the measured wind shear at the site.

Results are shown in Table 5. Among the results is the gross capacity factor, which is defined as the actual amount of energy produced divided by the maximum amount of energy that could be produced if the wind turbine were to operate at rated power for the entire year. Inefficiencies such as transformer/line losses, turbine downtime, soiling of the blades, yaw losses, array losses, and extreme weather conditions can further reduce turbine output. The gross capacity factor is multiplied by 0.90 to account for these factors, resulting in the net capacity factor listed.

CONCLUSION

This report provides a summary of wind resource data collected from November 2004 through March 2006 on Kenaitze Tribal land in Alaska. Both the raw data and the processed data set are available on the Alaska Energy Authority website.

The annual average wind speed at the site is 3.8 m/s at a height of 30-meters above ground level. The average wind power density for the site is 79 W/m^2. This information means that the Kenaitze Tribe site has a Class 1 wind resource, which is rated “poor” for utility-scale wind power development. The net capacity factor for large-scale wind turbines would range from 4 – 8%.

Table 5. Power Production Analysis of Various Wind Turbine Models

Wind Turbine Options					N/A				
Manufacturer Information	Proven 2.5kW	Proven 6kW	Bergey 10 kW	Fuhrlander FL30 30 kW	Vestas V15* 65 kW	Entegrity 15/50 65 kW	Fuhrlander FL100 100 kW	Northern Power NW100 100 kW	Fuhrlander FL250 250 kW
Tower Height	30 meters	30 meters	30 meters	30 meters	30 meters	30 meters	50 meters	50 meters	50 meters
Swept Area	9.6 m^2	23.8 m^2	38.5 m^2	133 m^2	177 m^2	177 m^2	348 m^2	284 m^2	684 m^2
Gross Energy Production (kWh/year)									
Jan	144	379	303	1,585	1,545	3,832	2,830	10,264	144
Feb	173	464	399	2,072	2,231	5,111	3,916	13,226	173
Mar	239	641	580	2,982	3,482	7,597	5,932	19,209	239
Apr	164	433	361	1,889	1,973	4,646	3,489	12,062	164
May	168	445	367	1,936	1,984	4,696	3,529	12,417	168
Jun	153	406	330	1,751	1,742	4,184	3,119	11,126	153
July	117	307	225	1,214	1,054	2,828	2,024	7,736	117
Aug	101	266	184	1,014	815	2,310	1,632	6,363	101
Sep	138	365	285	1,533	1,446	3,595	2,645	9,779	138
Oct	133	351	271	1,440	1,346	3,418	2,515	9,204	133
Nov	125	330	252	1,339	1,239	3,187	2,331	8,629	125
Dec	273	729	662	3,466	4,239	8,983	7,025	22,536	273
Annual	1,929	5,115	4,221	22,220	23,096	54,384	40,988	142,549	1,929
Annual Average Capacity Factor									
Gross CF	9%	10%	5%	8%	4%	6%	5%	7%	9%
Net CF	8%	9%	4%	8%	4%	6%	4%	6%	8%

Notes: Energy estimates are based on the year and a half of wind resource data measured at the met tower site and has not been adjusted for long-term trends or local air density. These factors are not expected to have a significant impact on increased wind energy production potential of this site.