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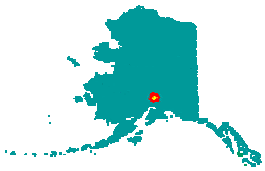
Wind Resource Assessment for PALMER, AK (VCRS SITE)

Date last modified: 7/26/06
Compiled by: Cliff Dolchok & Mia Devine

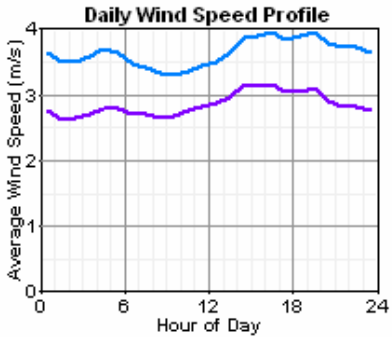
SITE SUMMARY

Site #:	2541
Latitude (NAD27):	61˚ 35' 27.6" N
Longitude (NAD27):	149˚ 12' 49.3" W
Magnetic Declination:	20˚ 35' East
Tower Type:	30-meter NRG 4"
Sensor Heights:	29.6m, 20m
Elevation:	98 meters (300 ft)
Monitor Start:	4/18/2005 0:00
Monitor End:	4/28/2006 12:50

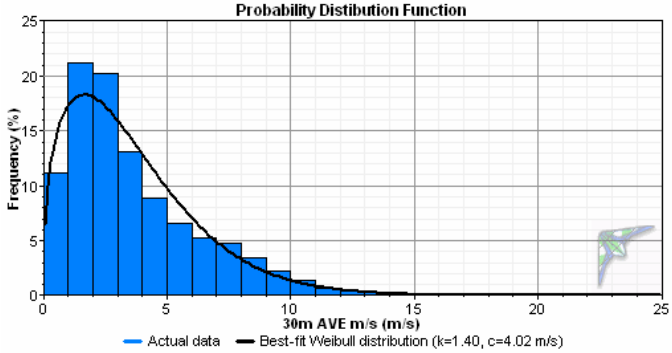


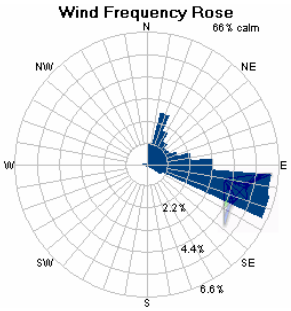
WIND RESOURCE SUMMARY

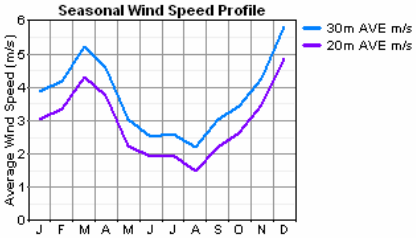
Annual Average Wind Speed (30m height):	3.7 m/s (8.3 mph)
Average Wind Power Density (30m height):	100 W/m^2
Wind Power Class (range = 1 to 7):	1
Rating (Poor, Marginal, Fair, Good, Excellent, Outstanding, Superb):	Poor
Prevailing Wind Direction:	East
Wind Shear:	0.40
Turbulence Intensity:	0.21



In September 2005, a 30-meter meteorological tower was installed in Palmer on the Valley Community for Recycling Solutions land. The purpose of this monitoring effort is to evaluate the feasibility of utilizing utility-scale wind energy in the community. The measured wind speed and direction data at the site was compared to long-term regional trends and estimates were calculated for the potential energy production from various types of wind turbines.

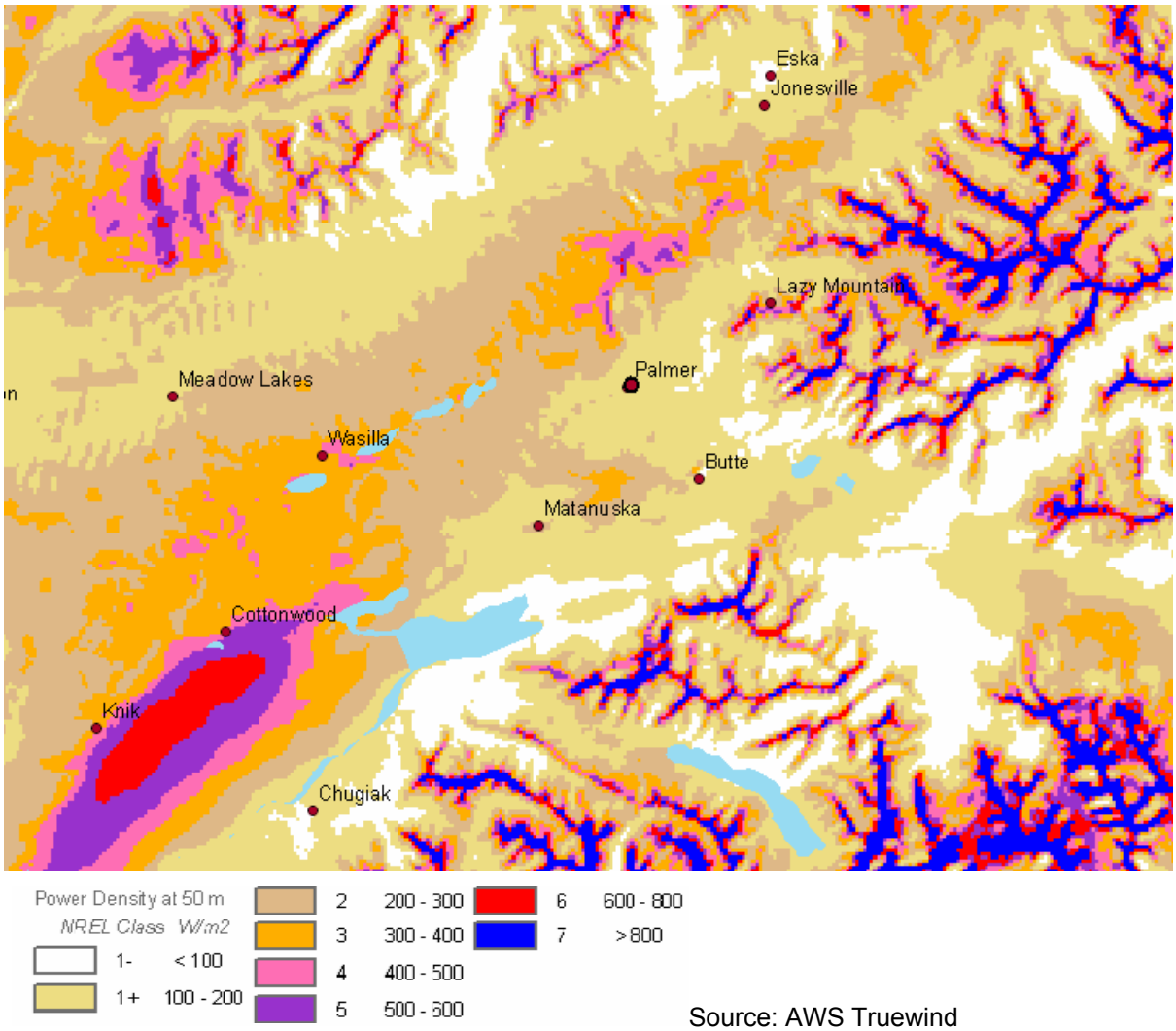






INTRODUCTION

The wind power potential of a site can be categorized in one of seven power classes with areas of Class 4 and higher considered suitable for utility-scale wind power development. The wind resource map below shows that Palmer is in close proximity to areas from a Class 4 to 5 wind resource; however, the majority of locations have a Class 1 to 2 wind resource. Due to the complex terrain, onsite measurement was recommended.



Source: AWS Truewind

Figure 1. Wind Resource Map of Alaska

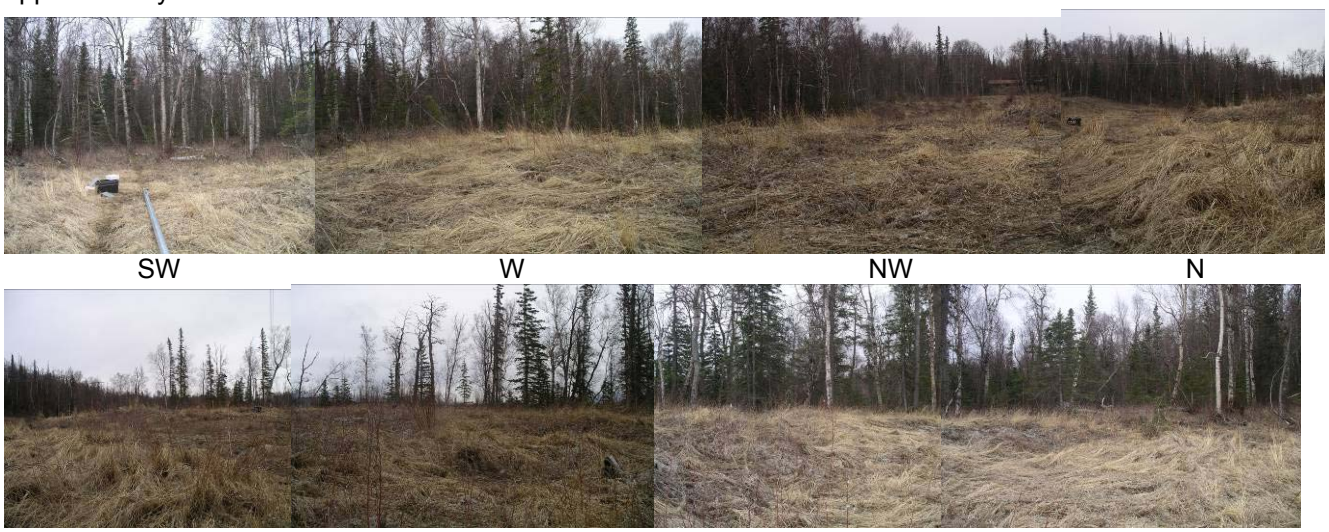
With support from the Alaska Energy Authority, a 30-meter tall meteorological tower was installed in Palmer by AEA, V3 Energy, and members of the community. The purpose of this monitoring effort is to verify the wind resource in Palmer at the Valley Community for Recycling Solutions met tower site and evaluate the feasibility of utilizing utility-scale wind energy in the community. This report summarizes the wind resource data collected and the long-term energy production potential of the site.

SITE DESCRIPTION

The photos below document the meteorological tower equipment that was installed at the Palmer Valley Community for Recycling Solutions site.

Figure 2. Photos of the Met Tower Installation in Palmer at the VCRS Site

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 met tower site is surrounded by trees approximately 30 to 40 feet tall.



SW W NW N

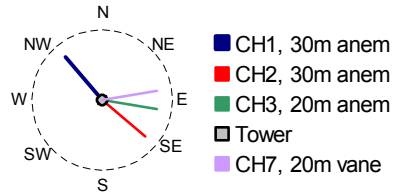
NE E SE S

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.

Table 1. Summary of Sensors Installed on the Met Tower

Ch #	Sensor Type	Height	Offset	Boom Orientation
1	#40 Anemometer	30 m	NRG Standard	320˚ True
2	#40 Anemometer	30 m	NRG Standard	130˚ True
3	#40 Anemometer	20 m	NRG Standard	100˚ True
7	#200P Wind Vane	26 m	255˚ True	75˚ True
9	#110S Temperature	7 m	-	-



Aerial view of equipment on tower

WIND DATA RESULTS FOR VCRS MET TOWER SITE

Table 2 summarizes the amount of data that was successfully retrieved from the data logger at the met tower site. There was minimal data loss due to icing of the sensors, except for November of 2005 and January of 2006. 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

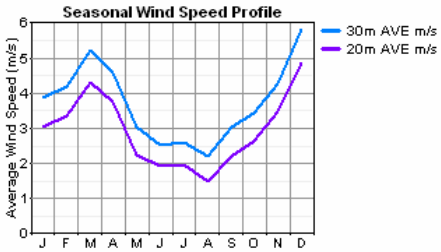
Month	Data Recovery Rate	Data Loss Due to Icing
2005 Apr	100 %	0 %
2005 May	100 %	0 %
2005 Jun	99.8 %	0.2 %
2005 Jul	100 %	0 %
2005 Aug	100 %	0 %
2005 Sep	100 %	0 %
2005 Oct	100 %	0 %
2005 Nov	55.6 %	44.4 %
2005 Dec	92.7 %	7.3 %
2006 Jan	67 %	33 %
2006 Feb	96.4 %	3.6 %
2006 Mar	100 %	0 %
2006 Apr	100 %	0 %

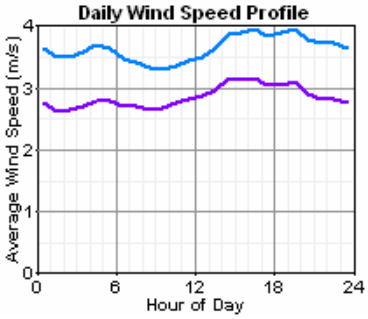
Wind Speed Measurements

Table 3 summarizes the wind speed data collected in Palmer at the Valley Community for Recycling Solutions met tower site.

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

Annual Average	3.6 m/s
Highest Month	December
Lowest Month	August
Hour of Peak Wind	20:00
Max 10-minute average	17.0 m/s
Max gust	26.0 m/s
Auto Correlation Factor	0.828
Diurnal Pattern Strength	0.063
Weibull K Factor	1.404





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.

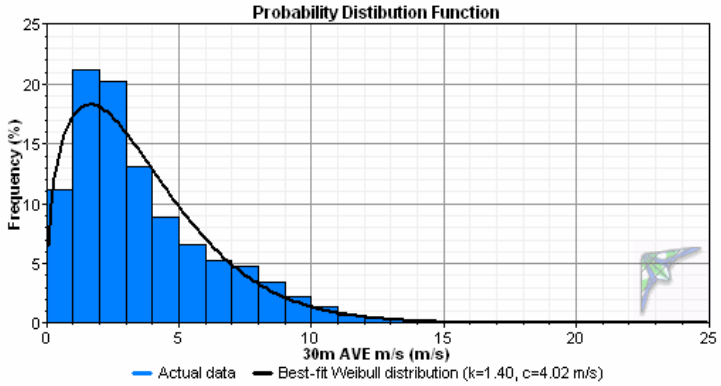
Table 4. Measured Wind Speeds at Met Tower Site, 30m Height (m/s)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
0	4.4	4.6	5.4	4.5	3.0	2.1	2.0	2.0	3.0	3.9	4.0	5.7	3.7
1	4.1	4.2	5.2	4.2	2.8	2.0	2.1	2.2	3.1	3.5	3.7	5.7	3.6
2	3.9	4.4	5.2	4.4	2.6	2.2	2.0	2.1	3.0	3.5	3.9	6.0	3.6
3	4.2	4.3	5.3	4.7	2.7	2.1	2.1	2.2	2.9	3.5	4.5	5.9	3.7
4	4.3	4.3	5.7	5.3	2.6	2.2	2.1	2.2	3.0	3.6	4.8	5.9	3.8
5	4.2	4.4	5.8	5.2	2.2	1.7	2.0	2.3	2.9	3.5	4.9	6.0	3.8
6	3.5	3.9	5.8	5.8	2.0	1.7	1.8	2.0	3.0	3.7	4.7	6.1	3.7
7	3.5	3.9	5.2	4.8	2.1	1.8	1.9	1.7	2.9	3.6	4.7	6.4	3.5
8	3.3	4.0	4.8	4.0	2.1	2.0	2.1	1.9	2.7	3.5	4.5	5.9	3.4
9	3.4	3.7	4.6	4.1	2.6	2.2	2.2	1.9	2.6	3.1	4.4	5.9	3.4
10	3.7	4.0	4.5	4.5	2.9	2.6	2.4	2.1	2.5	2.7	4.0	5.8	3.5
11	3.5	3.6	4.3	4.6	3.0	2.8	2.7	2.3	2.8	2.9	4.1	5.7	3.5
12	3.6	3.7	4.1	4.3	3.3	2.9	2.9	2.4	3.0	3.1	4.1	5.5	3.6
13	3.7	3.7	4.7	4.2	3.7	3.2	3.1	2.4	3.2	3.2	4.0	5.4	3.7
14	4.1	4.1	4.7	4.2	3.9	3.4	3.2	2.5	3.4	3.5	4.4	5.6	3.9
15	4.1	4.2	4.8	4.5	4.1	3.3	3.5	2.7	3.2	3.4	4.5	5.3	4.0
16	3.9	4.1	5.1	4.2	4.0	3.2	3.7	2.6	3.4	3.5	4.7	5.6	4.0
17	3.5	3.9	5.3	4.2	4.0	3.2	3.6	2.6	3.1	3.6	4.0	5.8	3.9
18	3.4	4.3	5.4	4.7	3.9	3.2	3.6	2.3	3.0	3.6	4.3	6.1	4.0
19	4.1	4.5	5.9	4.9	3.6	2.9	3.2	2.2	3.2	3.6	4.8	6.0	4.1
20	4.2	4.4	5.9	4.9	3.2	2.5	2.9	1.9	3.3	3.5	4.0	6.0	3.9
21	4.1	4.7	5.7	4.9	3.0	2.5	2.8	2.0	3.3	3.4	4.0	5.8	3.8
22	4.3	4.7	5.9	4.6	2.9	2.4	2.3	2.1	3.2	3.7	4.0	5.8	3.8
23	4.1	4.8	5.9	4.2	3.0	2.1	2.1	2.1	3.0	3.7	3.9	5.8	3.7
Avg	3.9	4.2	5.2	4.6	3.0	2.5	2.6	2.2	3.0	3.4	4.3	5.8	3.7

The average wind speed from April 2005 to May 2006 is 3.7 m/s (8.3 mph) at a height of 30 meters above ground.

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
1	974
2	1855
3	1775
4	1147
5	776
6	581
7	463
8	413
9	304
10	199
11	121
12	59
13	38

Bin m/s	Hrs/yr
14	27
15	14
16	9
17	3
18	2
19	1
20	1
21	1
22	0
23	0
24	0
25	0
Total:	8760

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

The cut-in wind speed of many wind turbines is 4 m/s, and the cut-out wind speed is usually 25 m/s. The frequency distribution shows that a small percentage of the wind in Palmer at the Valley Community for Recycling Solutions site is within this operational zone.

Wind Direction

Wind power roses show the percent of total power that is available in the wind by direction. The annual wind power rose for the Palmer Valley Community for Recycling Solutions met tower site is shown below.

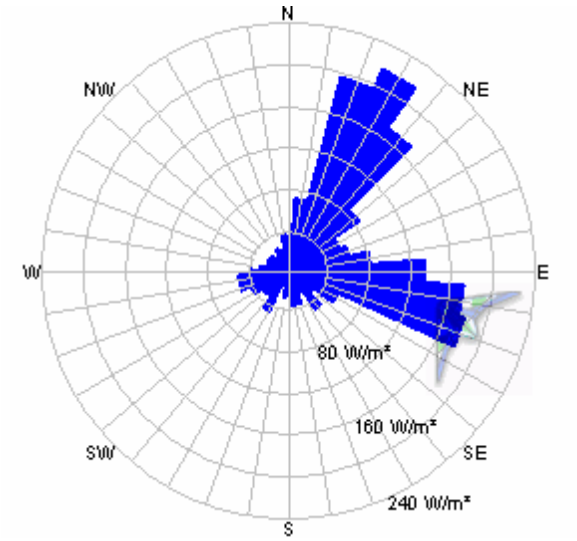


Figure 5. Annual Wind Power Rose for Met Tower Site

Monthly wind power roses for the Palmer (VCRS) met tower site are shown below. The predominant wind direction during the winter months is northeast, while the summer winds tend to come from the north.

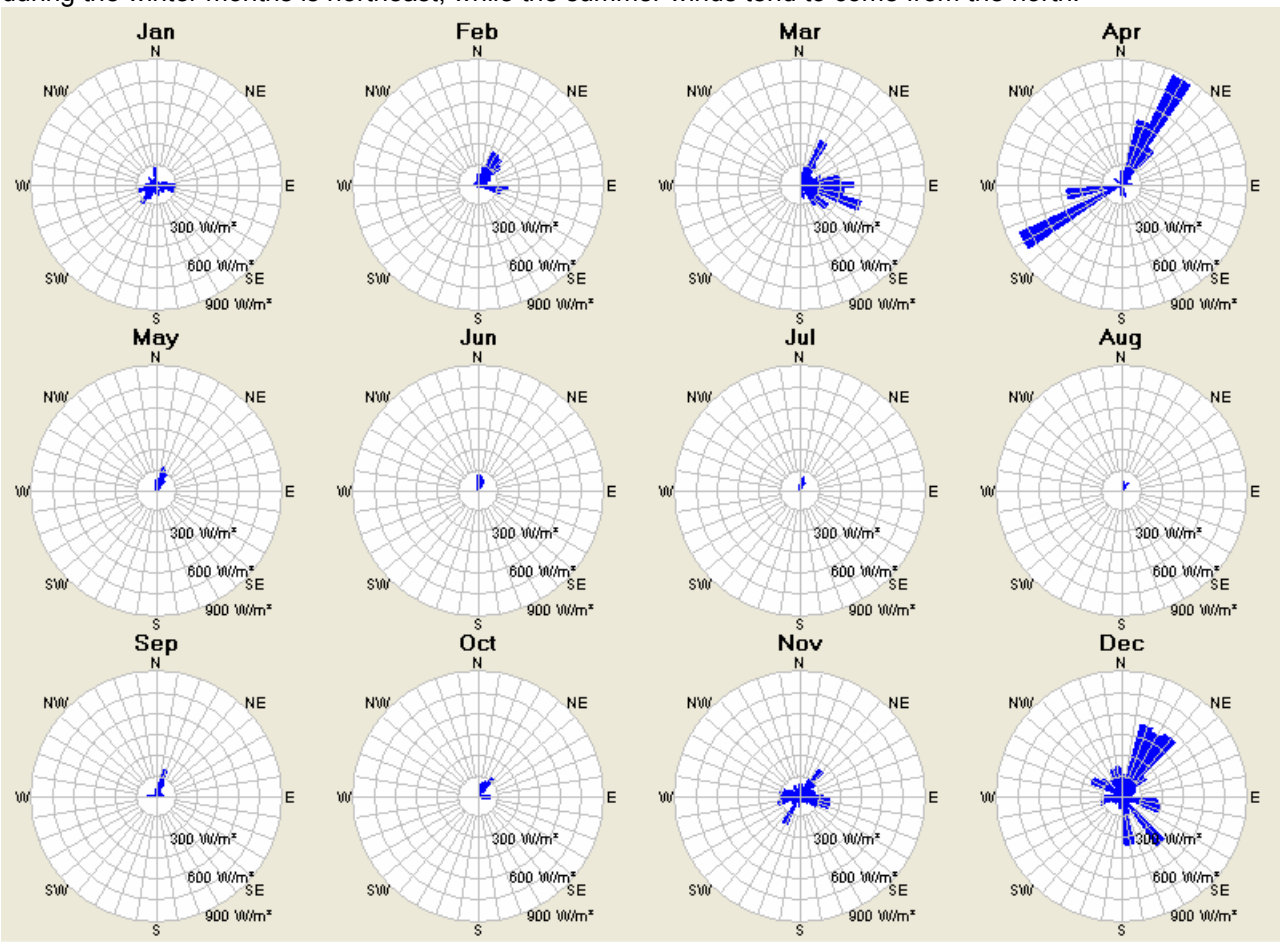
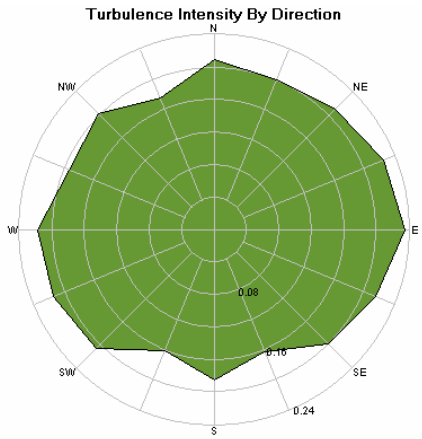


Figure 6. Monthly Wind Power Roses for Met Tower Site

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 high and likely to contribute to excessive wear of wind turbines.

Dir	Turbulence Intensity
N	0.21
NE	0.21
E	0.23
SE	0.20
S	0.19
SW	0.21
W	0.22
NW	0.20
Ave	0.21



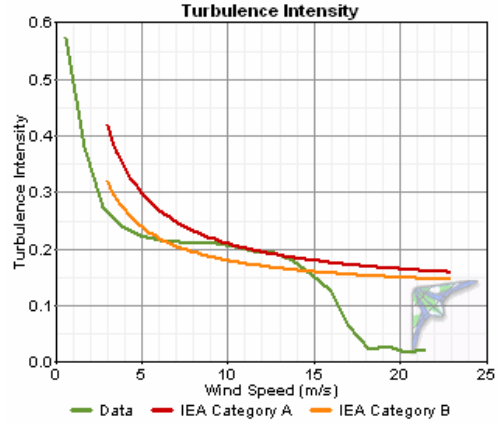


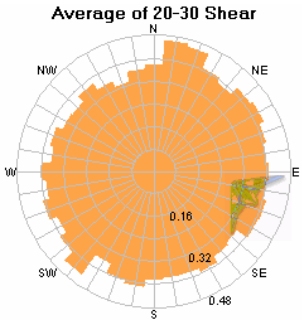
Figure 7. Turbulence Intensity Characteristics of Met Tower Site

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 approaches and exceeds the turbulence intensity limits of Category A and Category B between wind speeds of 6 and 14 m/s.

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 the wind shear exponent can be calculated and used to adjust the wind resource data to heights other than those that were measured. Results are summarized below.

Month	Wind Shear
Jan	0.39
Feb	0.40
Mar	0.37
Apr	0.37
May	0.44
Jun	0.40
Jul	0.41
Aug	0.41
Sep	0.44
Oct	0.38
Nov	0.35
Dec	0.38
Ave	0.40



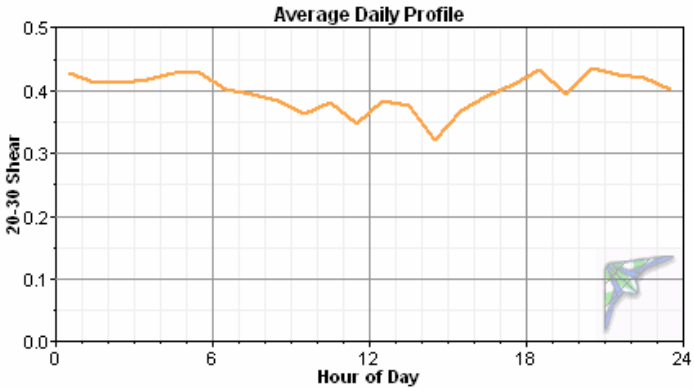
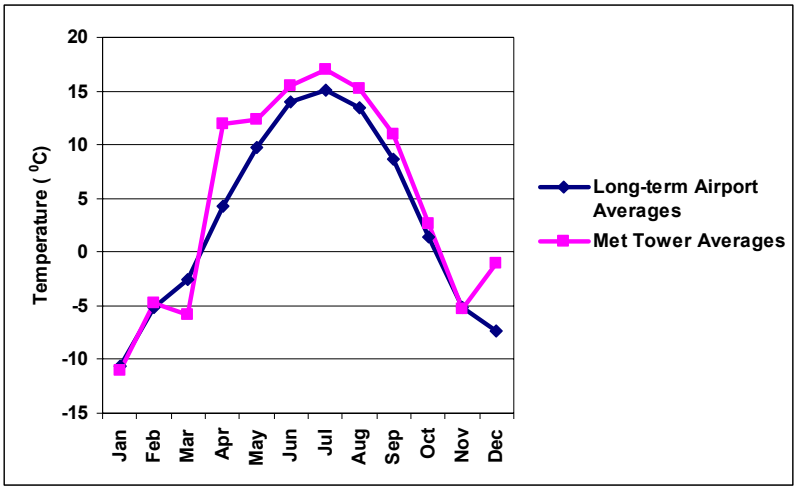


Figure 8. Wind Shear Characteristics of Met Tower Site

As shown, the wind shear varies by month, direction of the wind, and time of day. The average wind shear for the site is 0.40. Typical values range from 0.05 to 0.25. The high wind shear is due to the trees obstructing the measurements at the 20 meter height. The wind shear above the 30 meter height is expected to be lower.

Temperature

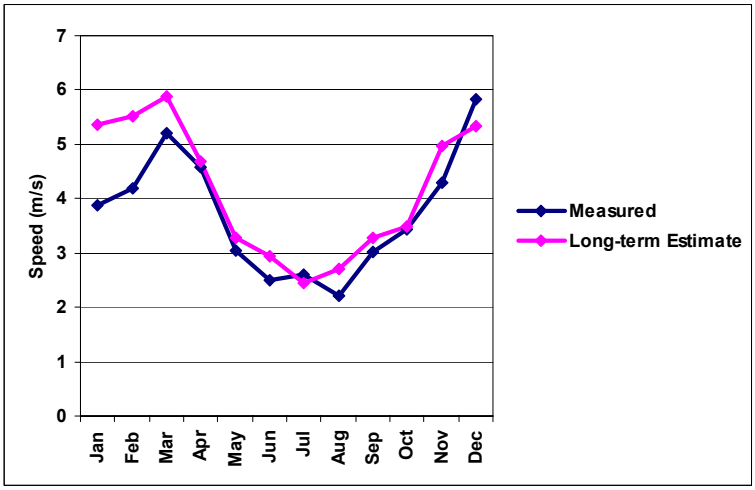
The air temperature can affect wind power production in two primary ways: 1) colder temperatures lead to higher air densities and therefore more power production, and 2) some wind turbines shut down in very cold situations (usually around –25°C). The monthly average temperatures for Palmer (VCRS) are shown below, along with the long-term measurements from the Palmer airport weather station. Typically, the temperature drops below -25°C during 0.2% of the time, or 20 hours per year.



Month	Measured (˚C)	Long-Term (˚C)
Jan	-11.1	-10.7
Feb	-4.7	-5.1
Mar	-5.9	-2.5
Apr	11.9	4.3
May	12.3	9.8
Jun	15.5	14.0
Jul	17.0	15.1
Aug	15.2	13.5
Sep	11.0	8.6
Oct	2.7	1.4
Nov	-5.3	-5.1
Dec	-1.1	-7.3
Ave	4.8	3.0

LONG-TERM REFERENCE STATION

The year of data collected at the met tower site can be adjusted to account for inter-annual fluctuations in the wind resource based on long-term measurements at a nearby weather station. The weather station closest to Palmer (VCRS) is the Palmer Airport AWOS, located about 17 miles to the west. Hourly wind speed measurements from 1995-2006 for this station were purchased from the National Climatic Data Center. The monthly averages between the sites were compared to determine regional trends in the wind speeds. Consistent with narratives from local residents, the months of January through March of 2006 were lower than usual. Therefore, the met tower data was adjusted based on the long term regional data as shown in Figure 9.



Month	Measured (m/s)	Long-Term (m/s)
Jan	3.9	5.4
Feb	4.2	5.5
Mar	5.2	5.9
Apr	4.6	4.7
May	3.0	3.3
Jun	2.5	2.9
Jul	2.6	2.5
Aug	2.2	2.7
Sep	3.0	3.3
Oct	3.4	3.5
Nov	4.3	5.0
Dec	5.8	5.3
Ave	3.7	4.2

Figure 9. Measured Versus Long-Term Wind Speeds in Palmer

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 long-term wind resource data set. 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 a wind shear of 0.20. Also, since wind turbine power curves are based on a standard air density of 1.225 kg/m3, the wind speeds measured at the met tower site are adjusted to create standard wind speed values that can be compared to the standard power curves

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 April 2005 through May 2006 in Palmer, Alaska. The data was compared to airport weather stations in the area and, based on regional trends, estimates were made to create a long-term dataset for the Palmer Valley Community for Recycling Solutions met tower site. Both the raw data and the processed data are available on the Alaska Energy Authority website.

The average wind speed measured at the met tower site was 3.6 m/s. After comparing the met tower data to long term airport data it is estimated that the annual long term average wind speed at the site is 4.2 m/s at a height of 30 meters above ground level. Taking the local air density and wind speed distribution into account, the average wind power density for the site is 157 W/m^2. This information means that Palmer (VCRS) has a Class 1 wind resource, which is “poor” for wind power development. The adjusted wind data set was used to make predictions as to the potential energy production from wind turbines at the site. The net capacity factor for large scale wind turbines would range from 9–15% as shown in Table 5.

Table 5. Power Production Analysis of Various Wind Turbine Models

Wind Turbine Options			N/A						
Manufacturer Information	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	Vestas V27* 225 kW	Vestas V47* 660 kW
Tower Height	30 meters	30 meters	30 meters	30 meters	50 meters	50 meters	50 meters	50 meters	50 meters
Swept Area	38.5 m^2	133 m^2	177 m^2	177 m^2	348 m^2	284 m^2	684 m^2	573 m^2	1,735 m^2
Weight (nacelle & rotor)	N/A	410 kg	N/A	2,420 kg	2,380 kg	7,086 kg	4,050 kg	N/A	N/A
Gross Energy Production (kWh/year)									
Jan	1,256	5,911	8,476	8,762	17,616	14,320	44,740	40,643	141,390
Feb	1,157	5,434	7,932	8,061	16,191	13,155	41,014	37,271	129,698
Mar	1,447	6,791	10,234	10,324	20,589	16,760	51,633	47,126	162,121
Apr	842	4,054	5,232	5,569	11,462	9,220	30,431	27,575	98,001
May	293	1,630	1,571	1,747	4,005	3,011	12,296	10,664	38,025
Jun	213	1,144	1,011	1,133	2,784	2,048	8,703	7,476	25,803
July	122	654	512	565	1,578	1,095	4,951	4,156	13,144
Aug	165	879	711	794	2,109	1,498	6,662	5,609	18,886
Sep	304	1,607	1,555	1,734	3,995	3,027	12,043	10,524	37,429
Oct	388	2,030	2,038	2,285	5,110	3,933	15,299	13,506	48,612
Nov	1,008	4,784	6,545	6,751	13,779	11,157	35,836	32,604	114,905
Dec	1,201	5,654	8,046	8,230	16,653	13,549	42,512	38,683	135,139
Annual	8,395	40,572	53,863	55,955	115,868	92,773	306,116	275,838	963,150
Annual Average Capacity Factor									
Gross CF	10%	16%	10%	10%	13%	11%	14%	14%	17%
Net CF	9%	14%	9%	9%	12%	10%	13%	13%	15%

Notes: The sizes of Vestas turbines listed are no longer available new. Remanufactured turbines are available from various suppliers.
Energy estimates are based on the wind resource measured at the met tower site, adjusted for long-term trends and local air density.