WIND DATA REPORT
FOR THE
YAKUTAT
JULY 2004 – APRIL 2005

Prepared on

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For

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INTRODUCTION

This report summarizes new data taken from late July 2004 through May 2005 at three locations in Yakutat. The report contains a description of the site, instruments installed, data collection and equipment performance. The report will also discuss site climatology based on the analysis of a nearby long-term reference location at nearby upper air Rawindsonde site at Yakutat airport. The purpose of this climatology is to put the validation period into context as to the degree of normality of the climatic conditions during the study period.

DESCRIPTION OF THE AREA

Yakutat is surrounded on three sides by water: to the north by Yakutat Bay, to the west the Pacific Ocean and to the northeast by Russell Fiord (see Figure 1). To the north and northeast, are the peaks of the St. Elias Range, which rise to heights of between 14,000 and 20,000 feet. This higher terrain means that southeasterly flow circulating around the Aleutian Low is a barrier that first slows the onshore winds and then lifts them, and then dropping heavy precipitation in the Yakutat area. The annual precipitation of around 150 inches is one of the greatest in the state (see Table 1). Figure 2 shows a three dimensional view of the area and from this view it is clear that the only direction the winds can come from are the east though SSW all other directions are blocked by higher terrain.

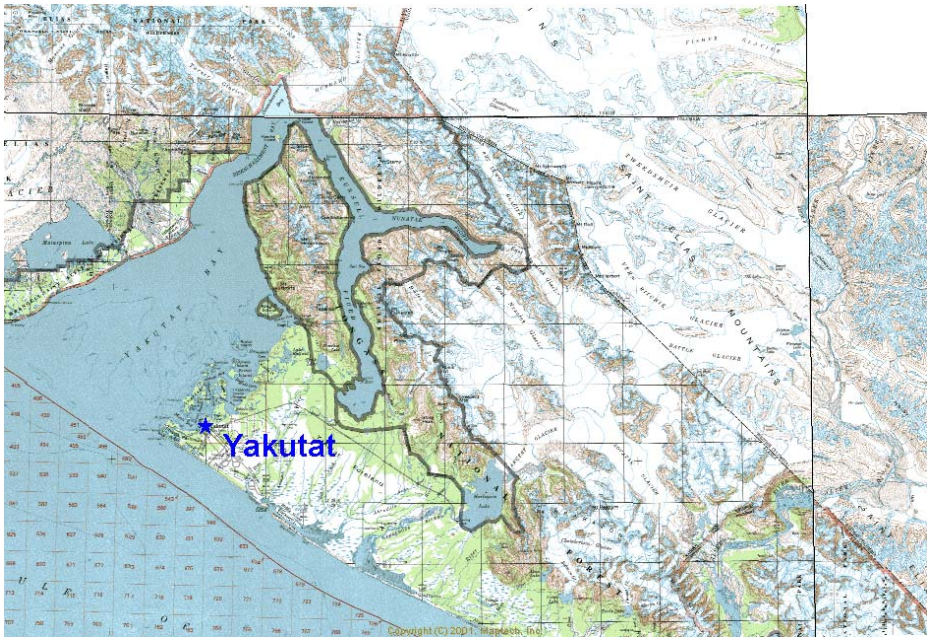

Figure 1 The Yakutat area.

Table 1 Meteorological Statistics for the Yakutat Airport.

Yakutat	unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature	F	25.1	28	31	36.3	43.3	49.4	53.6	53.2	48.2	40.9	31.3	27.1	39
Precipitation	(inches)	12.2	10.7	10.7	9.9	9.7	7.3	8.2	11.5	18.6	23	14.5	14.9	151
Snowfall	inches	37.1	36.8	37	16.6	1.4	0.05	0	0	0.05	5.5	22	37.6	194
Speed	mph	7.3	7.6	7.1	7.2	7.6	7.1	6.7	6.5	7	7.9	7.4	8	7.3

The warmest month is July, with an average temperature of 53.6 degrees Fahrenheit and the highest temperature recorded in any month was 86 degrees in August. The coldest month is January, with average temperatures of 25.1 degrees F. The coldest temperature recorded (-24 degrees Fahrenheit) occurred in the month of December.

The winds are generally easterly from September to April and from May to August east-southeast. The average wind speed is 6-8 miles per hour. During the spring, fall, and winter, frequent low-pressure systems, originating near the Aleutian Islands, pass through the gulf, south of Yakutat. These storms are often accompanied by high winds, clouds, and heavy precipitation. The highest wind speed recorded in Yakutat occurred in January (81 mph). The winds from the upper air site provide data on winds unaffected by local round level obstructions. Closer to the surface the winds are more east-northeast to east-southeast and aloft are more east to southeast. There is no evidence of strong westerly or northwesterly winds.

The annual air density for this area, assuming an 80 meter hub height turbine, with an average elevation of 10 meters, and a 90 meter annual temperature of 3.3 degrees Centigrade is 1.263 kg/m^3.

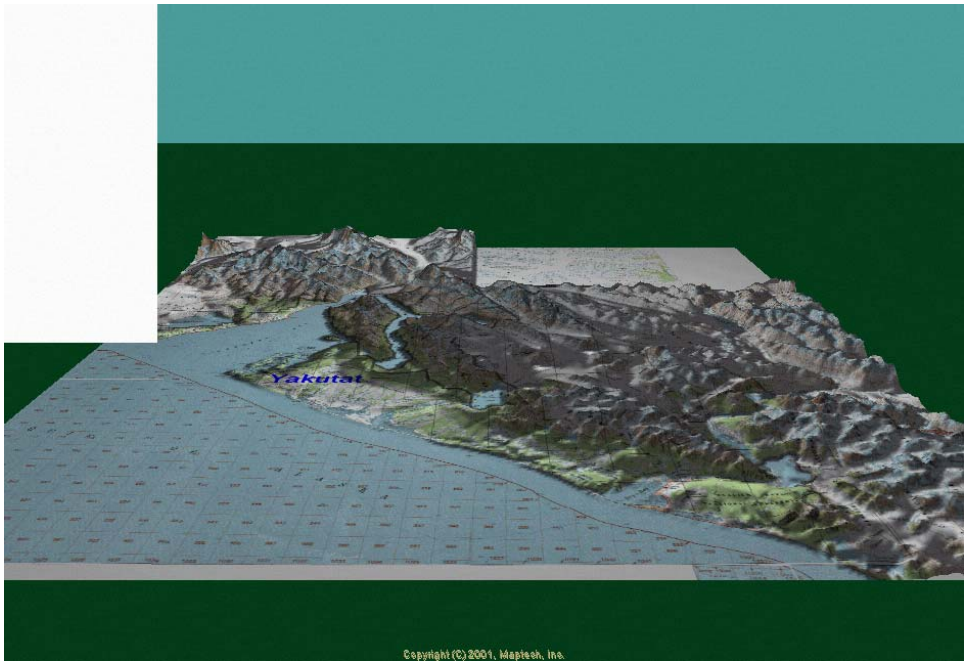

Figure 2 A three dimensional view of the Yakutat area.

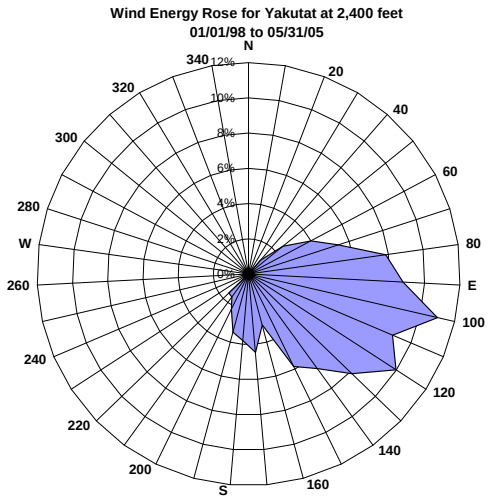

Figure 3 The energy producing wind directions at around 2,400 feet.

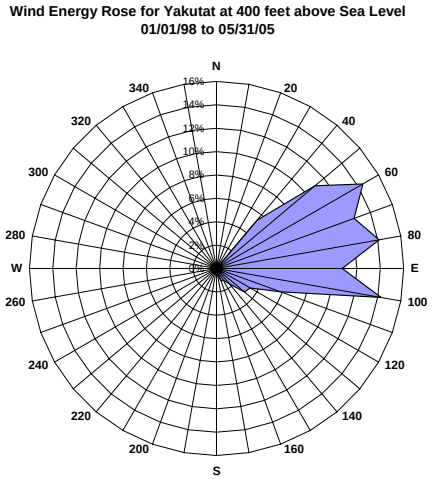

Figure 4 The energy producing wind directions at around 400 feet.

DESCRIPTION OF THE DATA AND METEOROLOGICAL EQUIPMENT

There are three meteorological towers all instrumented at 20 and 30 meters. Sensors used for measuring wind speed are Maximum 40 cup anemometers with protective terminal boots. Wind direction is measured with a 200P-wind direction sensor. The tower is grounded with a lightening spike, 35 meters of copper grounding wire, and ground rod. All sensors are connected to the logger with shielded 20-gauge cable.

The Maximum cup anemometer on each revolution generates two sine wave cycles that are linearly proportional to the wind speed. Anemometer voltage varies between 0.5 and 6 volts

VAC. The transfer constant to convert the Maximum 40P output to wind speed is a multiplier of 1.711 with a 0.78 mph offset.

Each site is equipped with a NRG Symphonie Data Logger with an internal cellular phone interface with a local internet provider. A 5-watt photovoltaic panel powers the sensors and loggers. A terminal reader is supplied to program the logger on-site and view data. Having a separate display increases the logger's low temperature-operating threshold and provides security so that only authorized personnel can view the output. The data logger is backed up with non-volatile "flash" memory cards. Table 2 describes the site characteristics and Figure 5 shows the locations of the met towers.

Table 2. Site Description for Yakutat Sites.

Site Name: A Ocean Cape Site 002 **Latitude**: 59° 32.502' N **Longitude:** 139° 51.738' W **Map Datum:** WGS 84 **Elevation**: 40 feet. **Terrain:** Small escarpment on coastal headland. **Roughness**: Spruce and Red Cedar. **Prevailing Wind Direction:** SE – SW **Magnetic Declination**: 25 degrees East **Tower Height**: 30 meters **Sensor Levels**: 30 and 20 meters **Logger**: 4410
Site Name: B YakMet Beach 001 **Latitude**: 59° 32.881' N **Longitude:** 139° 48.525' W **Elevation**: 6 feet. **Terrain:** Gradually sloping beach **Roughness**: Spruce and Cedar **Prevailing Wind Direction:** East -Southeast **Magnetic Declination**: 25 degrees East **Tower Height**: 30 meters **Sensor Levels**: 30 and 20 meters **Logger:** 4409
Site Name: C YakCoast Guard 003 **Latitude**: 59° 32.881' N **Longitude:** 139° 48.525' W **Elevation**: 20 feet. **Terrain:** Gradually sloping beach **Roughness**: Spruce and Cedar **Prevailing Wind Direction:** Southeast -Southwest **Magnetic Declination**: 25 degrees East **Tower Height**: 30 meters **Sensor Levels**: 30 and 20 meters **Logger:** 4408

DATA COLLECTION

Data is sent by email to this consultant office in Portland, Oregon. The Portland Oregon office is equipped with NRG data collection software and stores binary and ASCI data files for further analysis. The averaging interval of the data logger is 10-minutes, but the data analysis uses hourly data. The raw data remains in 10-minute intervals.

DATA RECOVERY

Data recovery was over 97% for the entire period of record from late July 2004 through early April 2005 for the three sites.

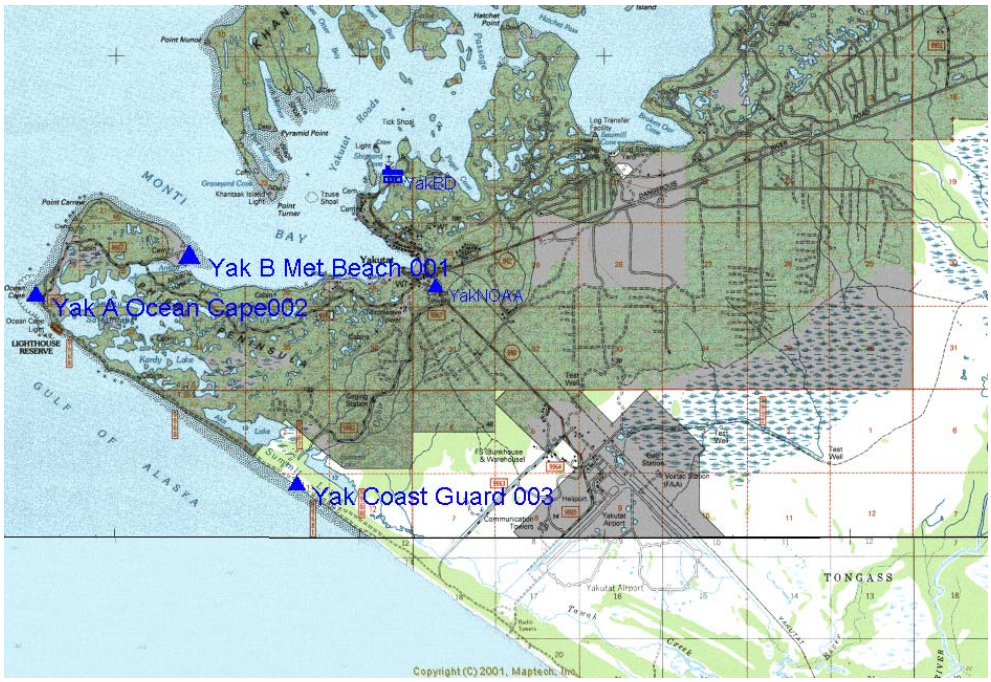

Figure 5 Met tower locations.

CLIMATOLOGY

A climatological analysis is an important part of the wind resource validation study. Typically a wind resource assessment is conducted for a period of only one to two years prior to installing wind turbines. A general rule is that a year of data is sufficient to estimate the mean annual wind speed to within ±10% at the 90% confidence level. This means that the annual energy output may be off by 20 to 25%. To increase the confidence in the relatively short record of data at the candidate site, data at a nearby long-term reference site can be analyzed.

The approach in the climatological analysis is to select a nearby reference station with a long-term record that would provide information on annual and seasonal variation in the wind resource. For this report the near surface (400 foot) and free air wind climatologies were used to determine a correction for seasonality and interannual variation. Table 3 and 4 show that the two levels disagree somewhat on both the seasonal and interannual correction factor. However, the combination of seasonal and interannual is exactly the same for both levels. The data for the period of record needs to be corrected 7% lower.

Table 3 Upper Air Data at 400 feet.

				400 foot data									
year	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Mean**
1998	2.7	4.1	2.6	4.5	4.8	3.2	3.6	4.6	3.7	3.2	2.1	3.9	3.8
1999	2.5	3.3	3.5	4.8	4.0	3.5	3.6	4.5	5.7	5.5	3.7	6.8	4.3
2000	3.4	2.9	3.9	3.8	3.8	3.6	3.0	3.8	4.5	3.6	4.8	4.8	3.8
2001	5.4	3.0	4.6	3.7	4.3	2.9	3.7	2.5	4.3	3.6	4.2	3.0	3.7
2002	4.7	3.7	5.1	3.2	3.3	3.9	3.7	3.7	3.6	4.8	5.6	2.6	4.0
2003	3.4	3.7	4.2	3.0	3.3	3.3	3.1	3.4	3.4	3.9	3.0	3.5	3.4
2004	3.9	4.7	4.3	4.3	2.9	3.1	2.9	2.8	4.1	4.3	3.9	5.2	3.8
2005	3.5	4.9	4.8	3.4	3.1	2.8							3.8
Mean	3.7	3.8	4.1	3.8	3.7	3.3	3.4	3.6	4.2	4.1	3.9	4.3	3.8
Period of Measurement													
2004								2.8	4.1	4.3	3.9	5.2	
2005	3.5	4.9	4.8	3.4									**4.1**
Longterm	3.7	3.8	4.1	3.8				3.6	4.2	4.1	3.9	4.3	**3.9**
Departure from Normal	-6%	30%	16%	-11%				-22%	-2%	4%	0%	23%	**4%**
Percent of Annual													**103%**
Correction to data													**-7%**

Table 4 Upper Air Data at 2,400 feet.

				2400 foot data									
year	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**Mean**
1998	7.3	7.4	5.8	7.4	5.6	3.8	2.9	9.0	6.6	8.1	8.3	7.8	7.3
1999	8.4	7.7	7.6	7.1	5.9	4.3	4.4	7.2	10.6	11.8	8.9	10.5	7.8
2000	6.9	6.7	8.5	7.0	4.6	4.3	4.3	6.9	8.7	8.9	9.0	9.6	7.1
2001	11.8	6.5	8.5	7.4	6.5	3.7	6.0	5.5	8.6	9.1	8.2	10.0	7.7
2002	9.4	8.3	5.8	4.6	5.3	5.9	5.3	6.4	5.9	9.0	10.5	7.3	7.0
2003	8.9	6.0	7.5	5.5	5.5	4.7	4.9	5.8	6.7	8.4	6.5	10.3	6.8
2004	7.1	10.7	8.5	7.3	4.3	4.3	4.1	3.7	7.4	7.9	8.4	9.6	6.9
2005	6.7	9.1	9.3	6.3	4.9	4.3							7.0
Mean	8.3	7.8	7.7	6.6	5.3	4.4	4.5	6.4	7.8	9.0	8.5	9.3	7.1
Period of Measurement													
2004								3.7	7.4	7.9	8.4	9.6	
2005	6.7	9.1	9.3	6.3									**7.6**
Longterm	8.3	7.8	7.7	6.6				6.4	7.8	9.0	8.5	9.3	**7.9**
Departure from Normal	-19%	17%	21%	-4%				-41%	-5%	-12%	-2%	3%	**-4%**
Percent of Annual													**111%**
Correction to data													**-7%**

DATA ANALYSIS

Tables 5-7 and Figures 6-8 summarize the important statistics measured to date. In addition to measured average speed, wind direction, temperature and extreme wind speed, other statistics derived measurements such as shear, turbulence, and 60 and 80 meter wind speeds. Several statistics stand out, first of all for sites with very poor mean wind speeds, the extreme wind speeds are very high. At only one of the three sites is the wind at 30 meters stronger than the wind measured at 10 meters at the airport. The vertical wind variation is large at all but the beach site, which is right near the bay. The turbulence intensity is high at all three sites. The wind roses show that there is no wind flow from the north down the bay and no onshore flow from the west. Based on the data collected so far, a modern wind turbine, like a GE 1500 kW, machine would only achieve a gross Capacity Factor (CF) of less than 20% at three sites and the net CF would be less than 18%.

Table 5 Statistics for Met A Ocean Cape site.

mon	30m V	Max Gust	Red 30m V	20m V	Temp	Shear	60m V m/s	80m V m/s	Count	Recovery Rate
Jul	6.05	38.5	6.60	6.32	57.6	0.058	2.99	3.22	216	100%
Aug	5.73	41.9	6.28	5.81	59.6	0.157	2.99	4.98	744	100%
Sep	9.23	60.6	9.72	9.17	50.9	0.100	4.69	6.02	717	100%
Oct	9.24	58.9	9.72	8.38	48.4	0.415	5.36	5.86	215	29%
Nov	9.09	62.5	9.63	8.43	37.6	0.419	5.22	6.41	657	91%
Dec	10.32	58.9	10.76	9.55	34.9	0.360	5.77	5.03	738	99%
Jan	7.42	59.8	7.97	6.75	32.3	0.455	4.46	5.11	731	98%
Feb	9.31	54.6	9.77	8.43	32.9	0.431	5.44	6.14	671	100%
Mar	8.56	52.1	9.03	7.95	38.4	0.332	4.86	5.40	742	100%
Apr	5.08	15.3	5.89	5.35	35.4	0.235	2.79	3.08	14	100%
Average	8.00	50.31	8.54	7.61	42.8	0.296	4.46	5.12	5445	92%
Corrected Annual	**7.44**		**7.94**	**7.08**			**4.14**	**4.77**		

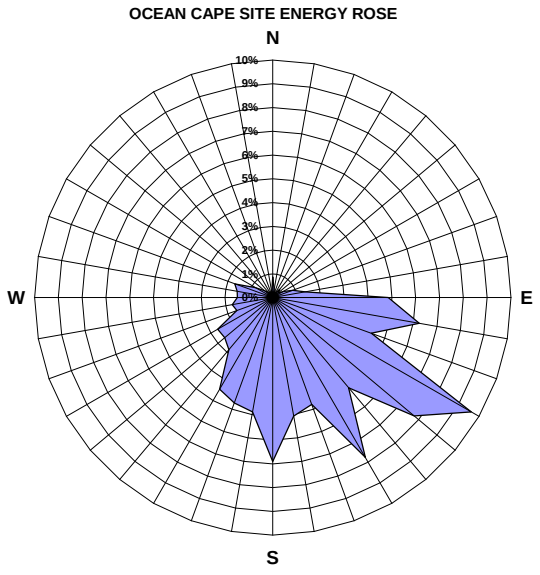

Figure 6 Energy Rose for Ocean Cape site 1

Table 6 Statistics for Met B Beach site.

mon	30m V	Max Gust	TI	Red 30m V	20m V	Shear	60m V m/s	80m V m/s	Count	Recovery Rate
Jul	6.3	35.9	0.139	6.51	6.35	0.004	2.9	2.9	175	100%
Aug	4.5	41.0	0.156	4.89	4.66	0.047	2.1	2.1	744	100%
Sep	7.4	51.3	0.161	7.45	7.34	0.060	3.5	3.6	718	100%
Oct	7.9	55.5	0.145	7.82	7.81	0.062	3.7	3.8	737	99%
Nov	8.9	51.3	0.156	8.64	8.50	0.106	4.3	4.5	720	100%
Dec	8.6	45.2	0.165	8.42	8.22	0.128	4.2	4.4	744	100%
Jan	6.2	44.4	0.140	6.04	6.00	0.137	3.1	3.2	744	100%
Feb	8.4	52.9	0.146	8.50	8.47	0.073	4.0	4.1	672	100%
Mar	8.8	42.7	0.151	8.61	8.60	0.098	4.2	4.4	739	99%
Apr	4.5	18.7	0.150	4.20	4.56	-0.009	2.0	2.1	22	100%
Mean	7.14	43.9	0.151	7.11	7.05	0.071	3.4	3.5	602	100%
Corrected Annual	**6.64**			**6.61**	**6.56**		**3.16**	**3.26**		

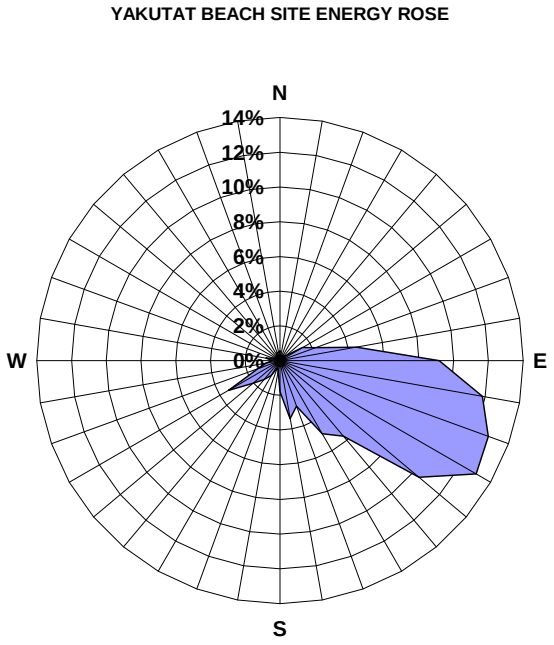

Figure 7 Energy Rose for Beach site 2.

Table 7 Statistics for Met C Coast Guard site.

mon	30m V	Max Gust	TI	Red 30m V	20m V	Temp	Shear	60m V m/s	80m V m/s	Count	Recovery Rate
Jul	6.1	38.5	0.200	5.8	5.7	57.1	0.169	3.2	3.5	198	100%
Aug	5.2	40.1	0.140	4.8	4.4	58.7	0.426	3.3	3.9	742	100%
Sep	8.6	60.6	0.151	8.1	7.2	49.4	0.472	5.2	6.1	719	100%
Oct	7.7	58.9	0.184	7.2	6.1	42.2	0.572	5.1	6.1	742	100%
Nov	8.9	65.7	0.154	8.4	7.3	36.7	0.615	5.7	6.8	718	100%
Dec	9.7	53.8	0.122	9.1	8.2	33.4	0.564	5.9	6.9	713	96%
Jan	7.1	54.6	0.147	6.3	5.4	28.9	0.655	5.0	6.2	725	97%
Feb	9.0	59.8	0.167	8.3	7.3	31.7	0.592	5.8	6.8	658	98%
Mar	8.4	50.4	0.195	8.1	7.1	37.6	0.472	5.1	5.9	734	99%
Apr	4.4	17.9	0.095	4.0	3.7	32.9	0.403	2.5	2.9	20	100%
Mean	**7.5**	**65.7**	**0.156**	**7.0**	**6.2**	**40.9**	**0.494**	**4.7**	**5.5**	**2137**	**98.9%**
Corrected Annual	**6.99**			**6.53**	**5.80**			**4.37**	**5.12**		

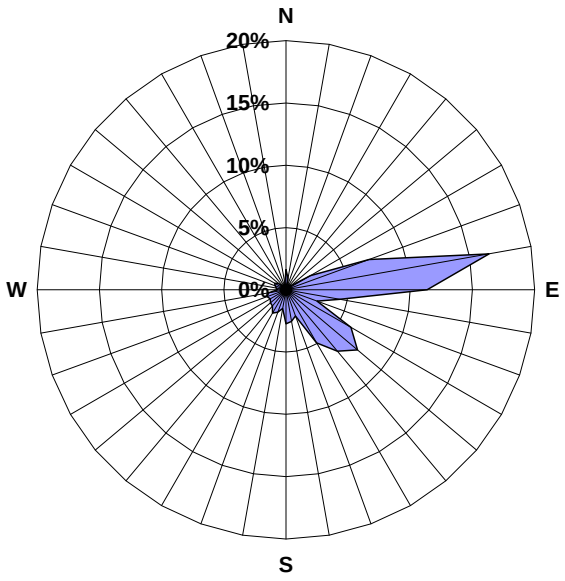

Figure 8 Energy Rose for Coast Guard site 3.

Diurnal Variation

The diurnal variation of wind speed shows very little amplitude, even in the summer months, when thermal effects generally create large diurnal variations (see Figure 9). In the summer the peak is later in the day then in the spring or fall. Winter characteristically is a season of little diurnal variation , which is true at Yakutat.

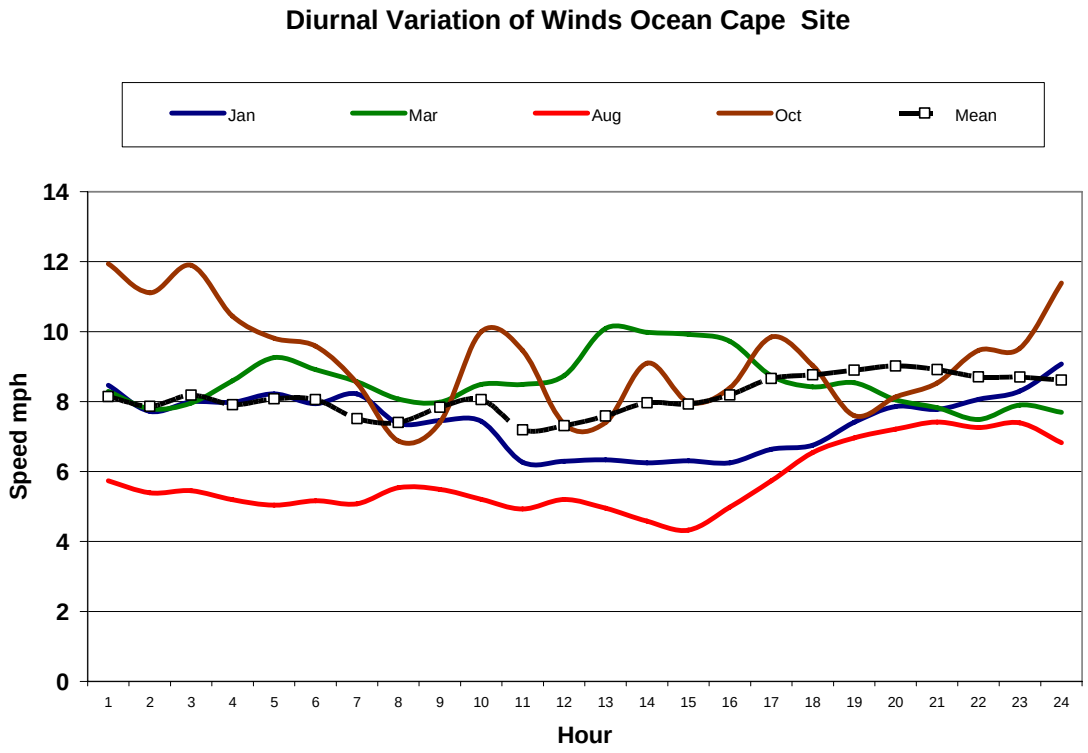

Figure 9 Hourly Wind Speed Variations

Conclusions and Recommendations

Although less than a year of data has been collected, the mean annual wind speed has been corrected to an annual value using nearby upper air data. Based on the data collected so far, a modern wind turbine like a GE 1500 kW machine would achieve a gross Capacity Factor (CF) of less than 20% at all three sites and the net CF would be less than 18%. It also appears to me that a better wind resource may be southeast of the airport.