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Wind Resource Assessment for DILLINGHAM, ALASKA

Date last modified: 4/14/2006
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SITE SUMMARY

ICAO Station ID:	PADL
NCDC Data Set:	703210
Latitude (NAD27):	59.05
Longitude (NAD27):	-158.517
Magnetic Declination:	15° 59' E changing by 0° 12' W/year
Tower Type:	AWOS
Sensor Heights:	9 meters above ground level
Elevation:	26.2 meters
Monitor Start:	January 1, 1995
Monitor End:	Jan 14, 2006

This report summarizes wind resource data collected from the Automated Weather Observing System (AWOS) in Dillingham, Alaska. The hourly data set from January 1995 and January 2006 was purchased from the National Climatic Data Center. The purpose of this analysis is to assist Dillingham in evaluating the feasibility of utilizing wind energy.

The Dillingham AWOS equipment and surrounding terrain are shown to the right. Dillingham is located at the extreme northern end of Nushagak Bay in northern Bristol Bay, at the confluence of the Wood and Nushagak Rivers.

Image courtesy of Ed Doerr, NOAA

WIND RESOURCE SUMMARY

Annual Average Wind Speed (10m height):	4.5 m/s (8.3 mph)
Annual Average Wind Speed (30m height, estimated):	5.0 m/s(11.2 mph)
Average Wind Power Density (10m height):	110 W/m^2
Average Wind Power Density (30m height, estimated):	150 W/m^2
Wind Power Class (range = 1 to 7):	Class 2
Rating (Poor, Marginal, Fair, Good, Excellent, Outstanding):	Marginal
Prevailing Wind Direction:	North

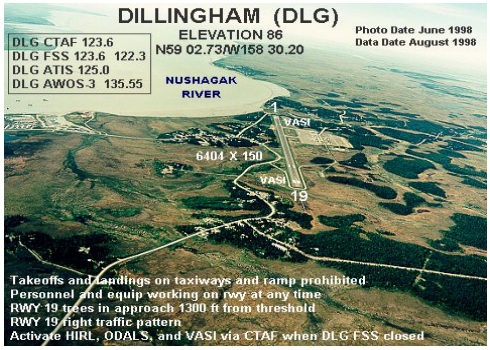
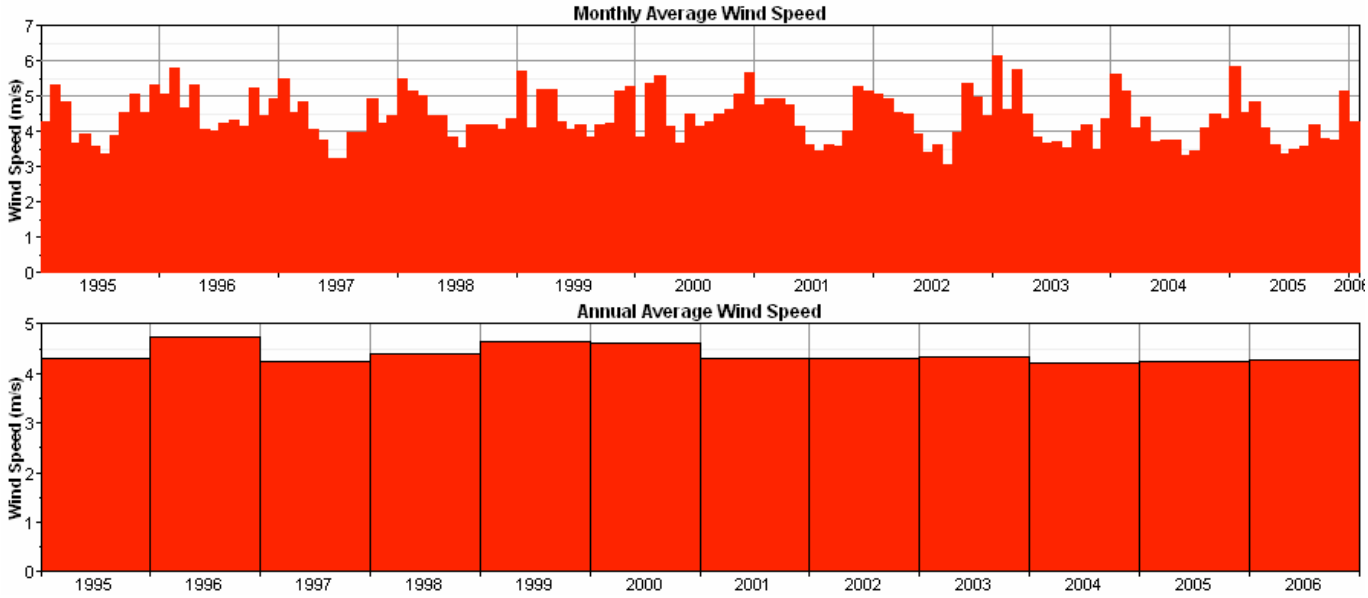


Image taken from: http://www.alaska.faa.gov/fai/airports.htm

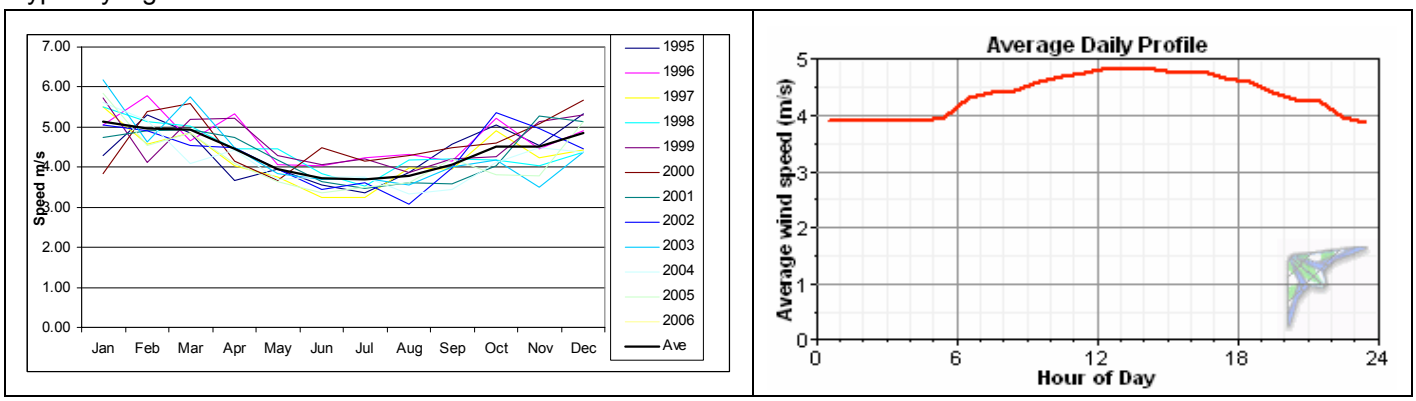
Based on data collected at the AWOS site, Dillingham has a Class 2 wind resource, which is rated as “marginal for wind power development.”

WIND DATA RESULTS FOR DILLINGHAM AWOS SITE

Wind speeds from January 1995 through January 2006 are summarized below. The average wind speed over the 11-year period is 4.4 m/s at a height of 9 meters above ground level. The annual wind speed rarely deviates more than 5% above or below this average.

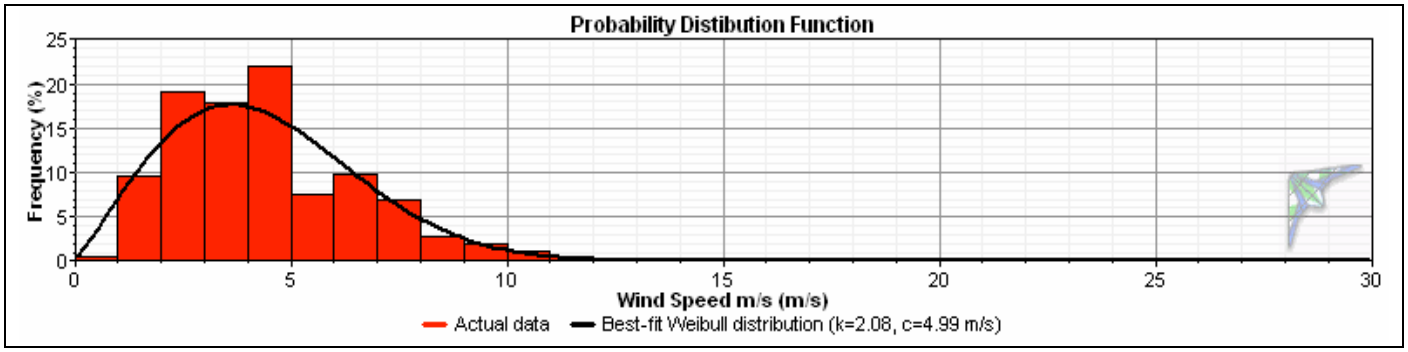


As shown, the highest wind month is typically January and the lowest wind month is typically July. Winds are typically highest in the afternoon.



Average Monthly and Daily Wind Speeds from DILLINGHAM AWOS, 9-m Height

The wind frequency distribution below shows the percent of the year that each wind speed occurs. The measured distribution as well as the best matched Weibull distribution is displayed. The cut-in wind speed of many wind turbines is 4 m/s and the cut-out wind speed is around 25 m/s. The frequency distribution shows that 62% of the wind in Dillingham occurs within this operational zone.

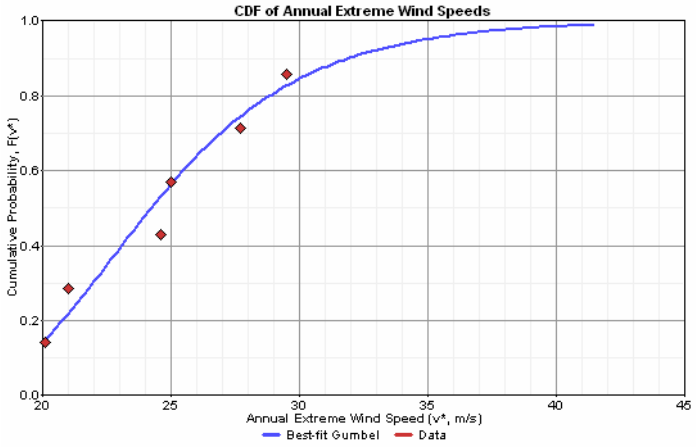


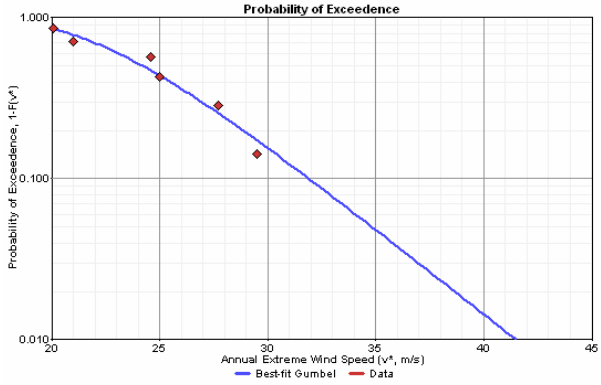
Average Wind Speeds at Dillingham AWOS, 9-m Height (m/s)

Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
0	4.5	4.4	4.7	4.1	3.0	2.9	3.4	3.6	3.6	4.0	3.8	4.5	3.9
1	4.5	5.0	5.0	4.0	3.3	2.8	3.4	3.6	3.2	3.9	4.0	4.1	3.9
2	4.6	4.9	4.5	4.1	3.5	3.1	3.1	3.3	3.8	3.8	4.1	4.1	3.9
3	4.3	4.9	4.2	3.6	3.5	3.3	3.2	3.4	3.9	3.6	4.4	4.4	3.9
4	4.5	4.9	4.4	3.8	3.3	3.4	3.3	3.5	3.8	3.9	4.4	4.7	4.0
5	4.8	4.8	4.5	4.1	3.7	3.9	3.6	3.5	3.9	4.0	4.4	4.6	4.1
6	5.1	4.8	5.0	4.1	3.8	4.1	3.9	3.7	4.3	4.0	4.5	4.4	4.3
7	4.9	4.9	4.9	4.0	4.0	4.3	4.1	3.5	4.2	3.9	4.7	4.8	4.3
8	4.6	5.0	5.0	4.4	4.3	4.3	4.1	3.7	4.6	4.3	4.5	5.2	4.5
9	4.9	4.9	5.2	4.6	4.2	4.3	4.1	3.7	4.5	4.5	4.6	5.2	4.6
10	5.5	4.8	4.8	4.7	4.4	3.9	4.1	3.7	4.3	4.5	5.2	5.3	4.6
11	5.9	5.2	5.1	4.7	4.4	4.1	3.9	3.9	4.4	4.5	5.1	5.4	4.7
12	6.3	5.4	5.1	4.9	4.5	4.0	4.0	4.2	4.3	4.9	4.7	5.5	4.8
13	6.1	5.3	5.6	5.4	4.3	3.9	3.9	4.3	4.3	5.2	4.8	6.1	4.9
14	5.9	4.6	5.7	5.2	4.4	3.9	3.9	4.3	4.5	5.3	4.7	6.2	4.9
15	5.7	5.0	5.5	5.1	4.6	3.8	4.4	4.4	4.1	5.1	4.9	5.8	4.9
16	6.0	5.2	5.5	4.7	4.5	3.8	3.9	4.4	4.0	5.1	5.1	5.7	4.8
17	6.1	5.7	5.7	4.9	4.1	3.9	3.9	4.4	4.5	5.2	5.1	4.8	4.9
18	5.5	5.3	5.3	4.5	4.5	4.0	3.8	4.2	4.3	5.1	4.7	5.0	4.7
19	5.5	5.2	5.2	4.7	4.4	3.9	3.7	3.5	4.2	5.3	4.1	4.6	4.5
20	5.1	4.9	4.7	4.3	3.8	4.0	3.6	3.7	3.9	4.9	3.9	4.0	4.2
21	4.8	5.0	4.9	4.2	3.6	3.7	3.4	3.8	3.9	4.3	4.1	4.2	4.1
22	4.6	4.7	4.8	4.2	3.4	3.8	3.5	3.5	3.9	4.3	4.0	4.4	4.1
23	4.5	4.7	4.6	4.2	3.2	3.4	3.3	3.3	3.7	4.3	4.1	4.5	4.0
Ave	5.2	5.0	5.0	4.4	3.9	3.8	3.7	3.8	4.1	4.5	4.5	4.9	4.4

EXTREME GUST ANALYSIS

Using the Windographer software program (www.mistaya.ca), a Gumbel distribution is fit to the 11 years of wind data to determine the expected extreme wind speed over various periods of time. For example, the maximum gust that can be expected at a height of 9 meters above ground level over the next 100 years is 41.5 m/s.





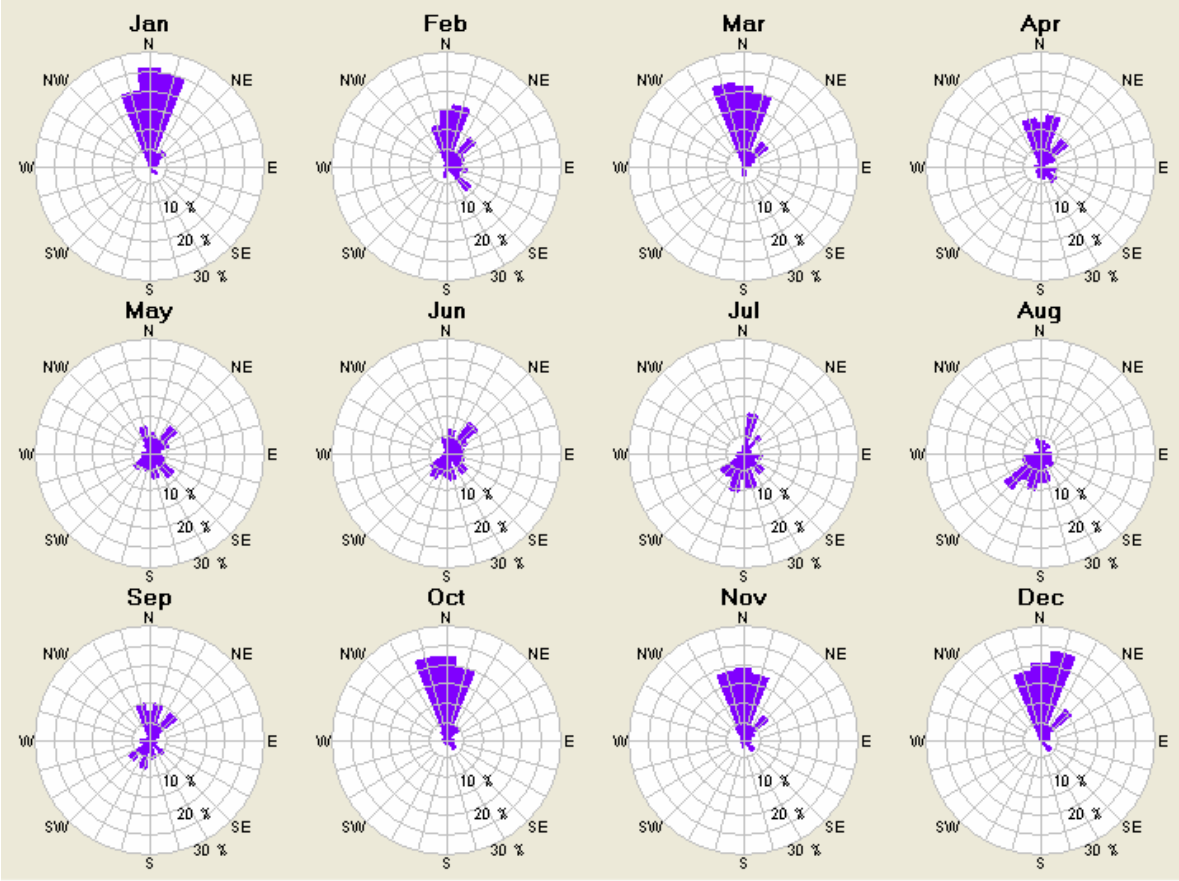
Return Period (yr)	Extreme Wind Speed (m/s)
20	34.8
25	35.8
50	38.6
100	41.5

Gumbel distribution parameters

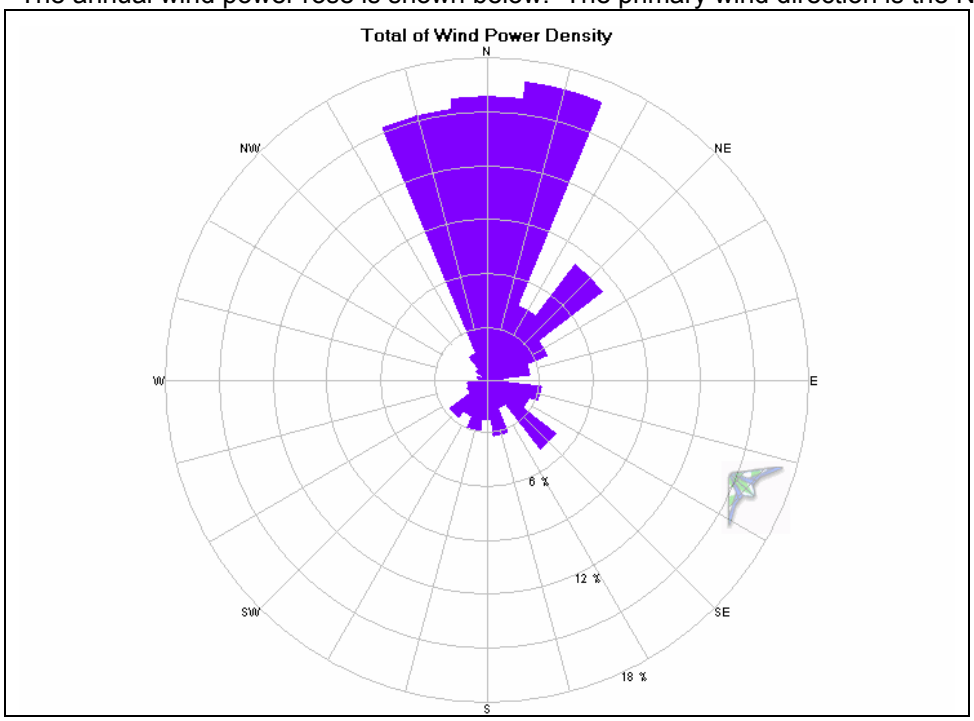
Scale:	4.07 m/s
Mode:	22.7 m/s
r^2	0.956

WIND DIRECTION

The monthly wind power roses, which show the percent of total power available in the wind from each direction, are shown below.

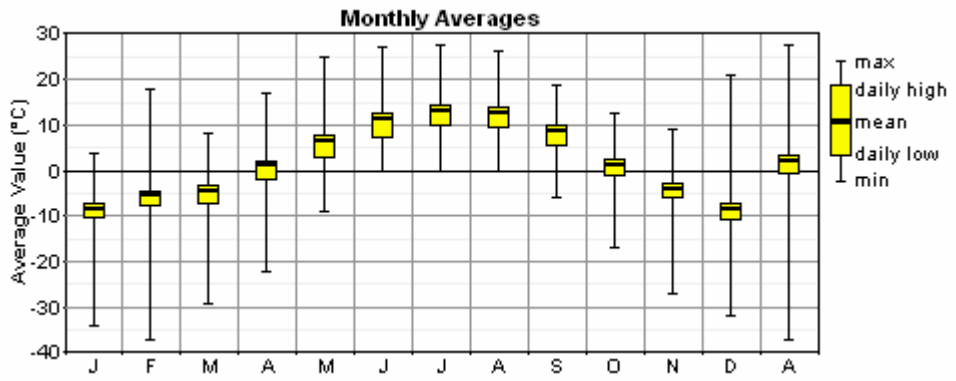


The annual wind power rose is shown below. The primary wind direction is the North.



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 measured at the AWOS site are shown below. Over the 11 year period, the temperature dropped below -25°C less than 1% of the time.



Monthly Average Temperatures at Eagle AWOS, 1995-2006

POTENTIAL POWER PRODUCTION FROM WIND TURBINES IN DILLINGHAM

The power curves from various wind turbines were used to calculate potential energy production in Dillingham. Although different wind turbines are available 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 value of 0.10. Results are shown below.

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, icing of the blades, yaw losses, array losses, and extreme weather conditions can further reduce turbine output. To account for these factors the gross capacity factor is multiplied by about 0.90, resulting in the net capacity factor listed.

CONCLUSION

This report provides a summary of wind resource data collected from January 1995 through January 2006 at the AWOS weather station in Dillingham, Alaska. The long-term annual average wind speed at the site is 4.4 m/s at a height of 9 meters above ground level. Taking the local air density into account, the average wind power density for the site is 100 W/m^2. Dillingham has a Class 2 wind resource, which is rated “marginal” for wind power development. The net capacity factor for wind turbines would range from 11% to 18%.

Power Production Analysis of Various Wind Turbine Models

Wind Turbine Options								
Manufacturer Information	Bergey 10 kW	Fuhrlander FL30 30 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	50 meters	50 meters	50 meters	50 meters	50 meters
Swept Area	38.5 m^2	133 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	2,420 kg	2,380 kg	7,086 kg	4,050 kg	N/A	N/A
Gross Energy Production (kWh/year)								
Jan	1,338	6,445	9,022	18,191	14,793	42,860	38,985	141,562
Feb	1,110	5,366	7,331	14,931	12,085	35,494	32,291	117,797
Mar	1,227	5,949	8,137	16,550	13,383	39,168	35,617	129,766
Apr	840	4,247	5,354	11,202	8,906	27,458	24,626	90,726
May	605	3,123	3,565	7,844	6,084	19,851	17,514	64,339
Jun	498	2,589	2,809	6,362	4,883	16,409	14,346	52,331
July	494	2,564	2,761	6,316	4,819	16,383	14,274	51,735
Aug	532	2,762	3,026	6,820	5,249	17,707	15,518	56,756
Sep	647	3,327	3,911	8,468	6,611	21,245	18,813	69,285
Oct	898	4,530	5,763	12,002	9,557	29,434	26,440	97,621
Nov	907	4,494	5,740	11,968	9,555	29,076	26,212	96,685
Dec	1,157	5,689	7,724	15,687	12,680	37,724	34,077	124,571
Annual	10,253	51,084	65,142	136,339	108,606	332,807	298,712	1,093,171
Annual Average Capacity Factor								
Gross CF	12%	19%	11%	16%	12%	15%	15%	19%
Net CF	11%	18%	10%	14%	11%	14%	14%	17%

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 long-term wind resource measured at the airport ASOS site.