# CVEA Wind Assessment Project

May 28, 2015

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# *Executive Summary*

In 2010, CVEA received a $100,000 grant from the State of Alaska to purchase two 50 meter meteorological (MET) towers, install, and evaluate the wind potential within the service territory. The MET towers that CVEA owns have instrumentation installed at the 30, 40, and 50 meter heights. These instruments measure the wind speed using both standard and heated anemometers, wind direction with wind vanes, and the temperature. This data is then collected by a data logger and emailed to CVEA.

In 2011, CVEA began to evaluate the wind within its service territory. The purpose of studying the wind is to find out if the right kind of wind is available for a commercial wind generating project. The ideal wind for a wind project blows in a consistent direction at a constant speed. Wind turbines are very particular with the speed of the wind needed to generate electricity. A typical commercial wind turbine does not begin generating electricity until the wind speeds reach 10 mph, and at that speed it only generates 10 percent of the rated output; i.e., a one megawatt (1,000 kilowatts) turbine would only produce 100 kilowatts. The turbine will shut itself down if wind speeds reach between 45 and 55 mph, depending on the model, to prevent damaging the unit.

The cooperative utilized a third party meteorologist and wind power expert, KB Energy, to analyze and validate the data in order to determine if the site is a viable location. The cooperative also provided the data from each of the MET towers to the Alaska Energy Authority (AEA) for a second opinion.

## 10-Mile

The cooperative installed the first of the two towers at the 10-mile area in Valdez in July 2011. This site was CVEA's second choice, but the first option was removed from consideration due to potential scenic view shed issues voiced by the Valdez Mayor's Energy Task Force. This tower remained installed and collecting data until July 2013.

The final report was generated for the 10-Mile location utilizing wind data from July 2011 to July 2013. The average wind speed at this location was only 10.8 mph. The wind primarily blew from the southeast to the east-northeast directions 44 percent of the time, meaning the wind was blowing in other directions for the other 56 percent of the time. The wind in the southeast to the east-northeast direction accounted for 75 percent of the potential energy production; hence, the wind was not strong enough in the other directions to produce much energy. The wind speeds at this site were too low 54 percent of the time to cause a turbine to spin.

The wind data used for the yearend analysis was measured at the 50 meter height. Normally this data can be extrapolated at the 80 meter height, the height where a wind turbine hub would be. However, due to the topography of this location the lower anemometers are measuring the wind being guided by the valley, while the upper anemometers are measuring wind not affected by the valley. The extrapolated data became so inaccurate that it could not be used.

Typically a wind project would need at least a 30 percent capacity factor to even be considered worth pursuing. Based on the data at the 50 meter height, the GE 1.5 XLE turbine would have had a capacity factor of 23.8 percent and a GE 1.6 of 27.9 percent. A final factor at this location is the turbulence, which was classified at a class A. Class A is the highest level of turbulence, indicating a poor location for a commercial wind turbine.

The report concludes: "While the winter wind speeds are relatively high, these do not really make up for the low wind speeds at the site." Also, "From the tower data, it cannot even be determined where the boundary between these two wind regimes is. This truly makes the site inappropriate for commercial turbines."

This site is a poor location for a commercial wind project:

- Low capacity factor
- Class 3 wind power class (scale 1 to 7 where 1 is poor and 7 is excellent)
- Class A turbulence (highest)
  - Turbulence exceeds the IEC 61400 spec at 18.8 percent (low class A 18 percent)

This tower was decommissioned on July 29, 2013.

Tolsona Ridge

Tolsona Ridge, in the Copper Basin, was the site selected for the second MET tower and was installed in August 2012. Tolsona Ridge is located 20 miles west of Glennallen on the Glenn Highway. The Tolsona Ridge site displays much more consistent wind speeds than the 10-Mile site; however, the wind speeds were still low at only 10.0 mph at the 50 meter height. The wind speeds were too low 44.9 percent of the time to cause a turbine to spin.

The wind primarily blew from the east to southeast directions 20.7 percent of the time, meaning the wind was blowing in other directions for the other 79 percent of the time. The wind in the east to the southeast direction accounted for nearly 45 percent of the potential energy production; hence, the wind was not strong enough in the other directions to produce much energy. The other significant wind blew from west-northwest to north-northwest 24.4 percent of the time but only accounted for 27.2 percent of the potential energy.

Unlike the 10-Mile site, the topography and wind data allows for extrapolation of the wind speeds at elevations higher than the 50 meter tower. Based on the extrapolated data at the 80 meter height the capacity factors for this site were as follows: GE 1.5 XLE capacity factor of 27.4 percent and a GE 1.7 of 35.2 percent. Multiple other turbines were evaluated rating from 1,500 kilowatt to 3,000 kilowatt and had capacity factors ranging from 17.3 to 31.6 percent.

This site is a much better site than 10-Mile for a potential turbine location; however, is not a good location for a commercial wind project:

- Low capacity factor
- Class 1 wind power class (scale 1 to 7 where 1 is poor and 7 is excellent)
- Extremely high wind shear (0.387 where 0.14 is "typical")

This tower was decommissioned on September 24, 2014.

## Gakona Bluffs

The tower that was located at the 10-mile location was redeployed in the Copper Basin near the Gakona Bluffs, two miles north of the Tok Cutoff Junction. CVEA collaborated with Ahtna Inc. and obtained a land use permit to deploy this tower on Ahtna land. The tower was erected on September 27, 2013, and collected data for one year.

The Gakona Bluffs site displayed similar wind characteristics as the Tolsona Ridge location; however, the wind speeds were significantly lower averaging only 7.4 mph at the 50 meter height. The wind speeds were too low 60 percent of the time to cause a turbine to spin.

The wind primarily blew from the south and southwest directions 27.9 percent of the time, meaning the wind was blowing in other directions for the other 72 percent of the time. The wind in the south and southwest direction accounted for nearly 65 percent of the potential energy production; hence, the wind was not strong enough in the other directions to produce much energy.

Based on the extrapolated data at the 50 meter height the capacity factors for this site were as follows: GE 1.5 XLE capacity factor of 9.4 percent and a GE 1.7 of 13.1 percent. Multiple other turbines were evaluated rating from 1,500 kilowatt to 3,000 kilowatt and had capacity factors ranging from 8.4 to 17.1 percent.

This site is a poor location for a commercial wind project:

- Extremely low capacity factor
- Extremely high wind shear (0.349 where 0.14 is "typical")
- Class 1 wind power class (scale 1 to 7 where 1 is poor and 7 is excellent)
- Class A turbulence

The report concludes: "Wind energy development is not recommended in this area unless it is the only choice available for off-grid applications", "Utility scale wind energy development is not recommended at this site".

This tower was decommissioned on September 24, 2014.

## Conclusion

The data has solidified the wind energy maps of Alaska, proving that commercial grade wind that is accessible and feasible for connectivity into the CVEA electrical system does not exist within the CVEA service territory.

Furthermore, with the addition of the Allison Creek Hydroelectric Project the abundance of hydroelectric energy would reduce the need for additional generation in the summer months.

# CVEA 1 Site 6386
# 7/20/11 – 7/3/13 Report

By
Rob Lowrance
CTO, KB Energy

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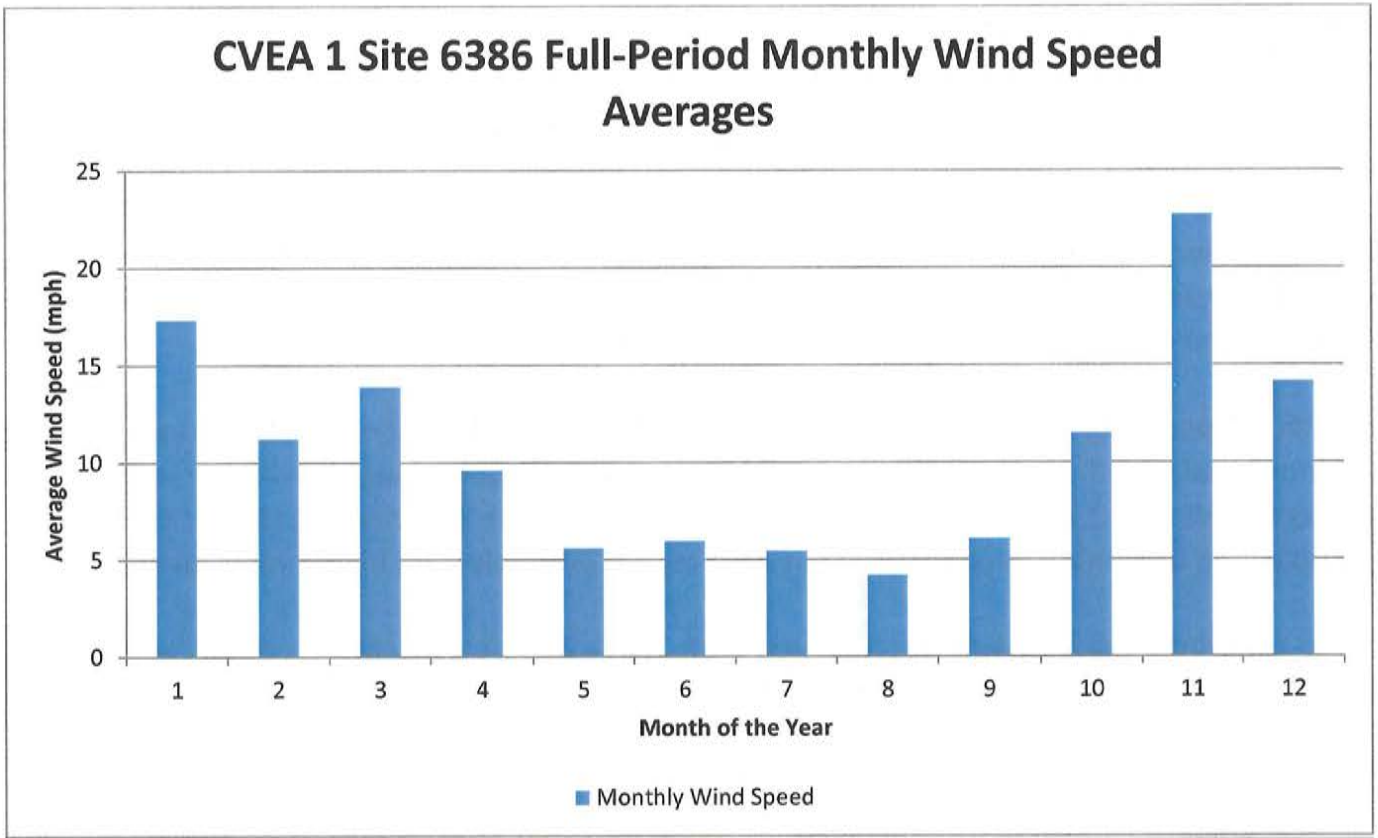
## Monthly Wind Speeds:

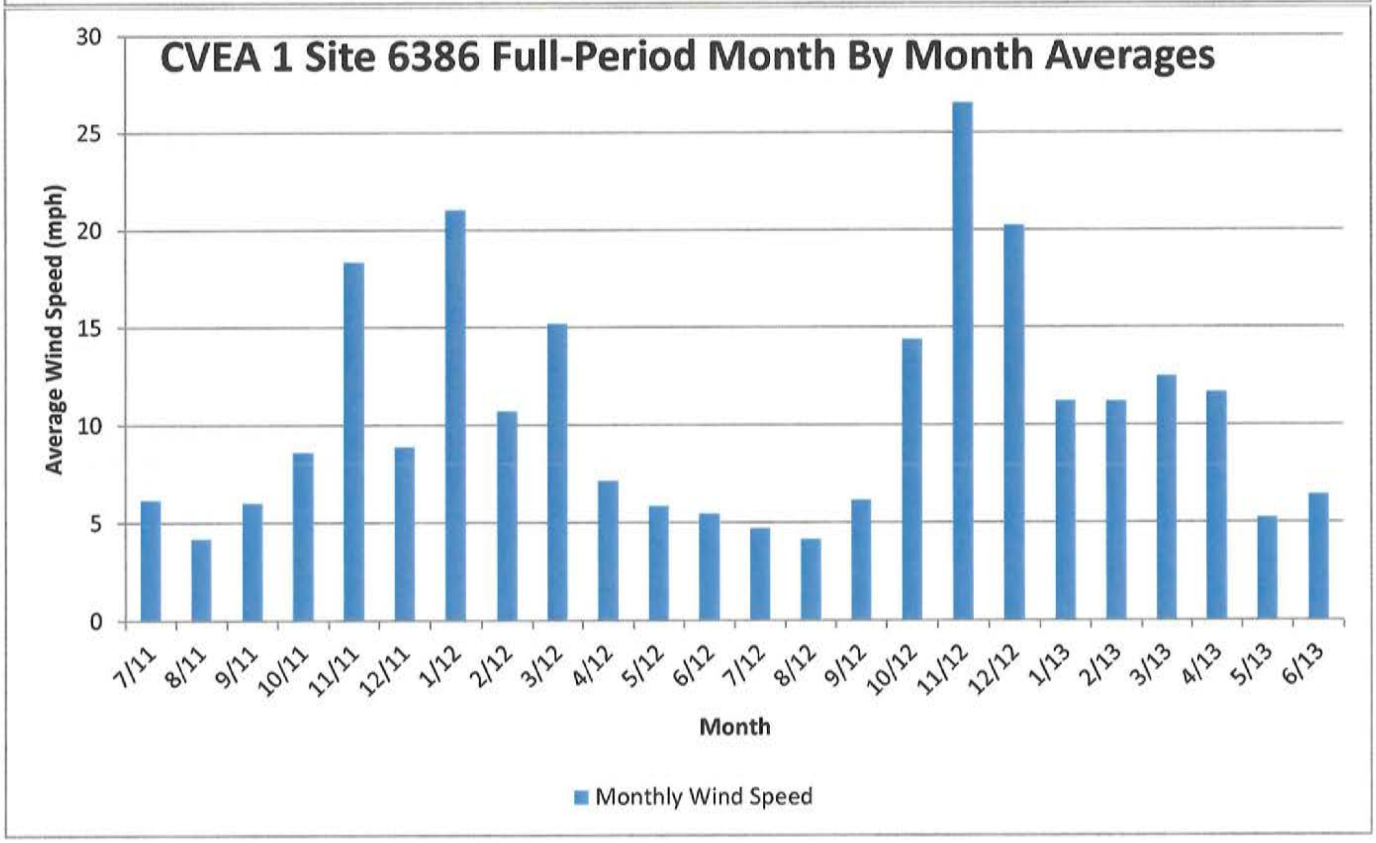
For the full period, the average wind speed was about 10.8 mph. For the first year the tower was up, the average wind speed was about 10.2 mph. For the second year, it was about 11.3 mph.

The lowest wind speed month in absolute terms was August of 2012, with an average wind speed of about 4.2 mph. The highest wind speed month in absolute terms was November 2012, with an average wind speed of about 26.5 mph.

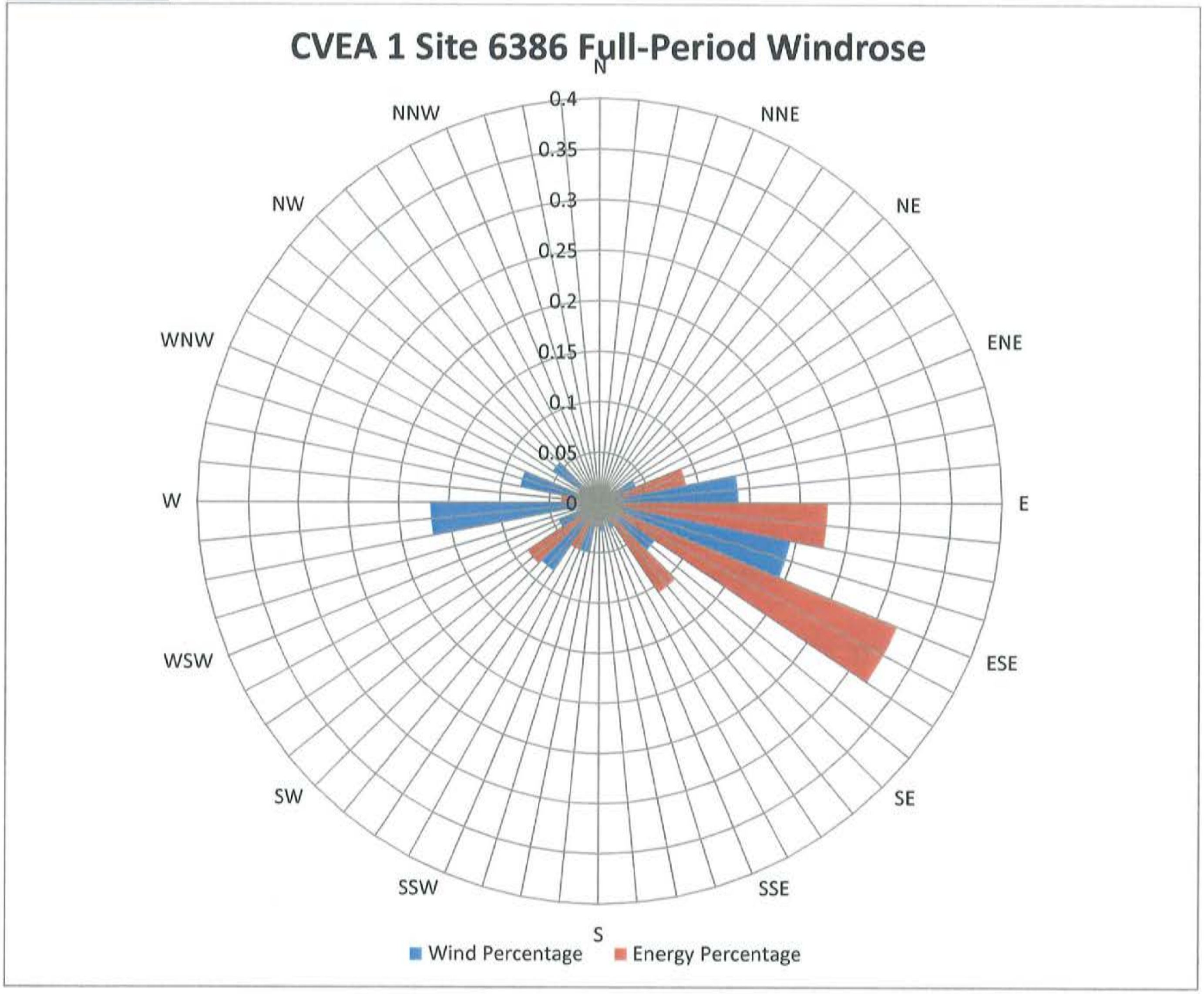
For the full period of data, the lowest wind speed month was August, with an average of about 4.2 mph wind speed. The highest wind speed month for the period was November, with an average of about 22.7 mph. Long-term, this high in November is probably a bit less that this average. The December average of about 14.2 mph is probably a bit higher long-term.

While the winter wind speeds are relatively high, these do not really make up for the low winds at the site. Thus, the site is not well suited for turbines. More on this below.


CVEA 1 Site 6386 Full-Period Monthly Wind Speed Averages
Average Wind Speed (mph)
0
5
10
15
20
25
1
2
3
4
5
6
7
8
9
10
11
12
Month of the Year
■ Monthly Wind Speed


CVEA 1 Site 6386 Full-Period Month By Month Averages
Average Wind Speed (mph)
0
5
10
15
20
25
30
7/11
8/11
9/11
10/11
11/11
12/11
1/12
2/12
3/12
4/12
5/12
6/12
7/12
8/12
9/12
10/12
11/12
12/12
1/13
2/13
3/13
4/13
5/13
6/13
Month
■ Monthly Wind Speed

## Windrose:



Only the full-period Windrose is presented here, as it should be more representative of long-term.

The Windrose presents a situation quite similar to what has been seen before from the tower site. The primary wind producing winds are on average from the SE to the ENE. These account for 74.5% of the potential production, while only accounting for 43.9% of the wind.

SW to WNW contains a significant portion of wind (37.5%), but only accounts for 15.2% of the potential production. This illustrates the problem. The majority of the winds at this site are poor producing. Hence the low capacity factors in the following section.

## Production Analysis:

With the tower data, there is no way to get a reasonable extrapolation of wind speed to hub height. The wind regime for the lower portion of the tower is quite different from the top, due to drainage from a number of different valleys. From tower data, it cannot even be determined where the boundary between these two wind regimes is. This truly makes the site inappropriate for commercial turbines. Long-term correlations have not returned good results, since the long-term data sets are situated in areas quite different topographically from the tower site.

P50 and P95 values were calculate for the 50m height only and appear below.

### GE 1.5 XLE:

#### Second Year:

At 50m, this turbine would have produced about 3300 MWh/year given the second year of data. This corresponds to a capacity factor of 25.1%. This is a bit up from last year, which gave potential production of 2660 MWh/year and a capacity factor of 20.3%.

This corresponds to a P95 of about 2760 MWh/year and a capacity factor of 21.0%. Last year's values were 2530 MWh/year and 19.3%.

Average wind energy for the second year was about 3,380 kWh/m$^2$.

#### Full Period:

At 50m, this turbine would have produced about 3130 MWh/year given the full periods data. This corresponds to 23.8% capacity factor. Average wind energy was 2,960 kWh/m$^2$, which is rather low.

This corresponds to a P95 at 50m for this turbine of about 2610 MWh/year for a capacity factor of 19.9%.

### GE 1.6:

#### Second Year:

At 50m, this turbine would have produced about 4130 MWh/year for a capacity factor of 29.4%. Last year's data gives 3590 MWh/year and 25.6%.

This corresponds to a P95 of about 3450 MWh/year for a capacity factor of 24.6%. For last year, this was 3000 MWh/year or 21.4%.

#### Full Period:

At 50m, this turbine would have produced about 3910 MWh/year or 27.9%.

This corresponds to a P95 at 50m for this turbine of about 3270 MWh/year or 23.3%.

While the GE 1.6 values are higher than those for the GE 1.5 XLE, they are still quite low. Since these two turbines are among the best producers, most other turbines will produce even less well at the proposed site.

The P95 values at 50m are all based on a joint uncertainty of 10%.

## Wind Data Availability:

Even though the correlation done in the previous long-term report appeared to have good correlation, it was found to be a poor predictor of winds at the site. Icing data was found to have little effect on the overall averages when data was recovered through correlation to the IceFree at the same level. When the data was recovered, average wind speeds were actually lower, because a lot of the icing events were associated with low wind speeds.

4.1% data was lost due to icing. All of this was recoverable to within 99% accuracy.

## Wind Speed Histogram:

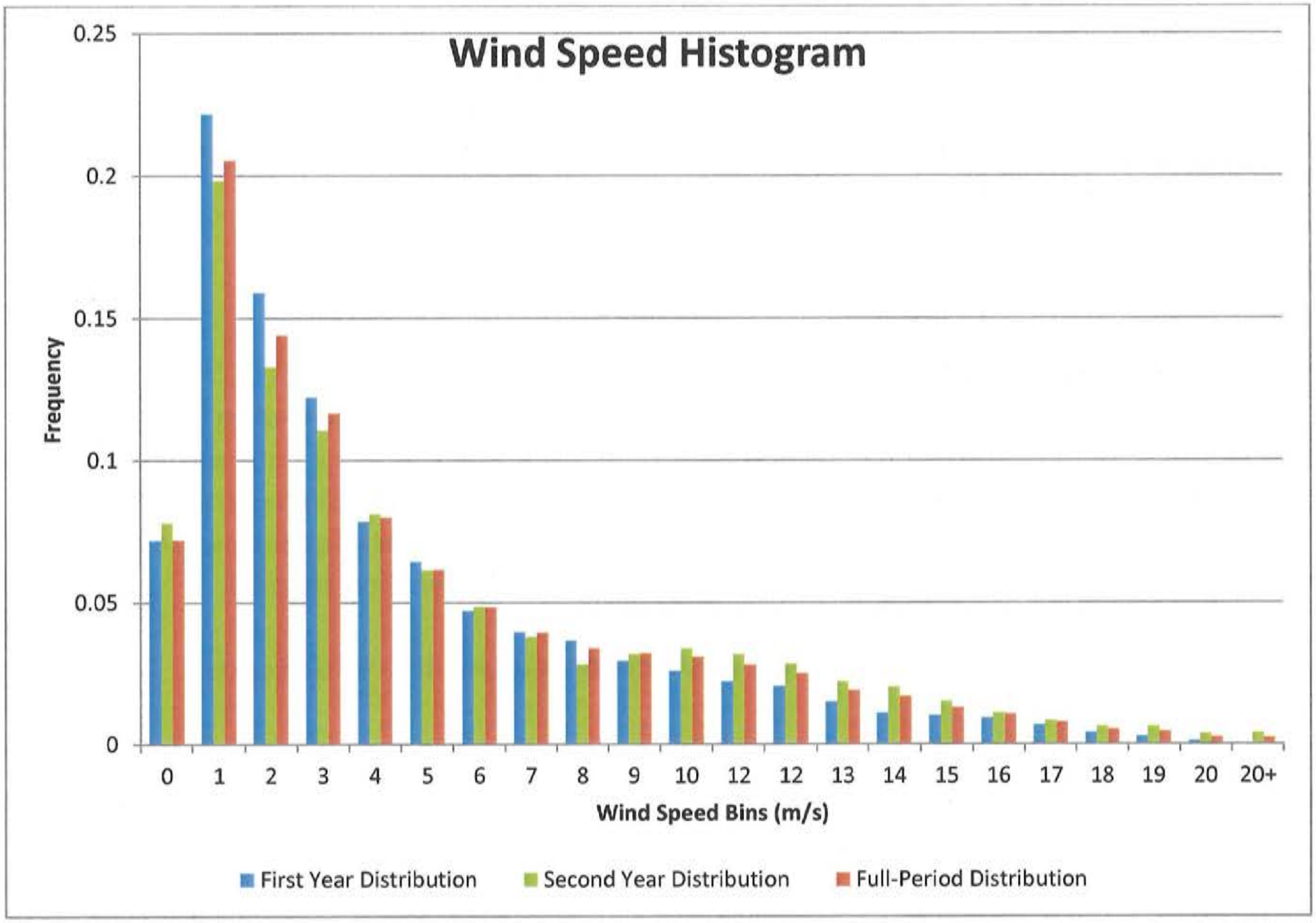
Here we can see how the wind speed distributions have changed over the period the tower was up.

The blue bars represent the first year of data. This year of data has more low-wind speeds than the second year of data (green bars).

The second year of data has a slight increase in the higher wind speeds, but not by much.

The full-period wind speed distribution is shown in red. While there was some difference between the two years, they are both quite close to the average, indicating that long-term behavior at the tower is likely to be quite close to this.

Because the majority of the winds at the tower fall on the low-side of the chart, this tower site is not well suited to turbine placement. Roughly 54% of the winds at the site are below the wind speed needed for a turbine to turn on.



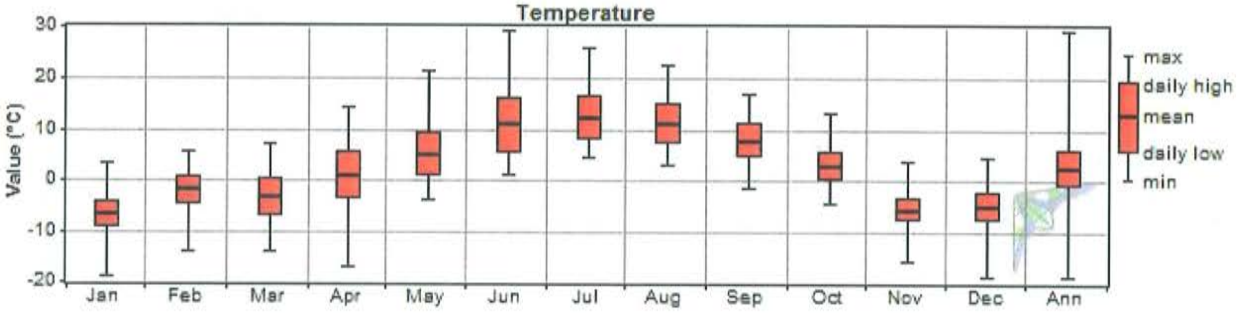
## Summary:

In summary, this site is not well suited to turbines. The wind speeds are skewed towards low wind speeds, with over 50% of the winds being below the cut-in wind speed of a turbine.

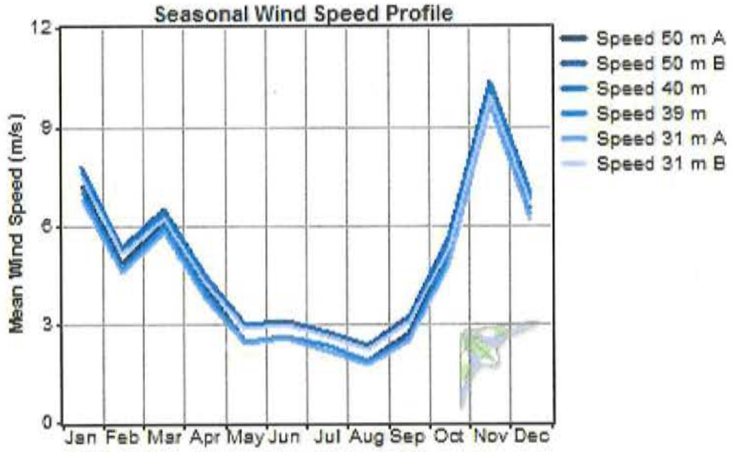
## Data Set Properties

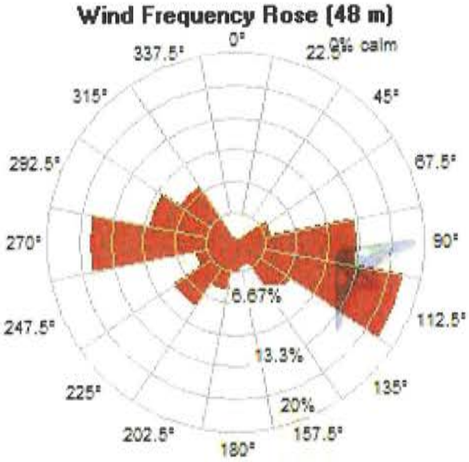
Report Created: 10/7/2013 14:07

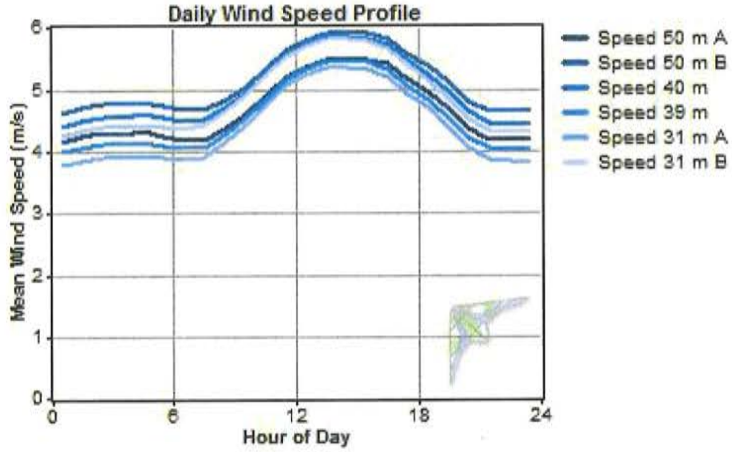
| Variables | Values |
|---|---|
| Latitude | N 61° 3' 0.000" |
| Longitude | W 146° 1' 0.000" |
| Elevation | 64 m |
| Start date | 7/21/2011 10:00 |
| End date | 7/28/2013 00:00 |
| Duration | 24 months |
| Length of time step | 10 minutes |
| Calm threshold | 0 m/s |
| Mean temperature | 2.61 °C |
| Mean pressure | 100.5 kPa |
| Mean air density | 1.271 kg/m³ |
| Power density at 50m | 352 W/m² |
| Wind power class | 3 (Fair) |
| Power law exponent | 0.12 |
| Surface roughness | 0.00958 m |
| Roughness class | 0.77 |
| Roughness description | Rough pasture |

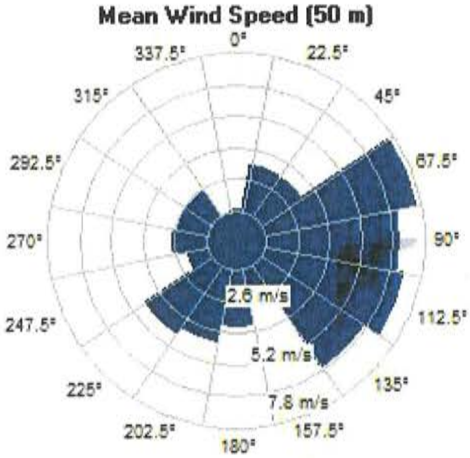


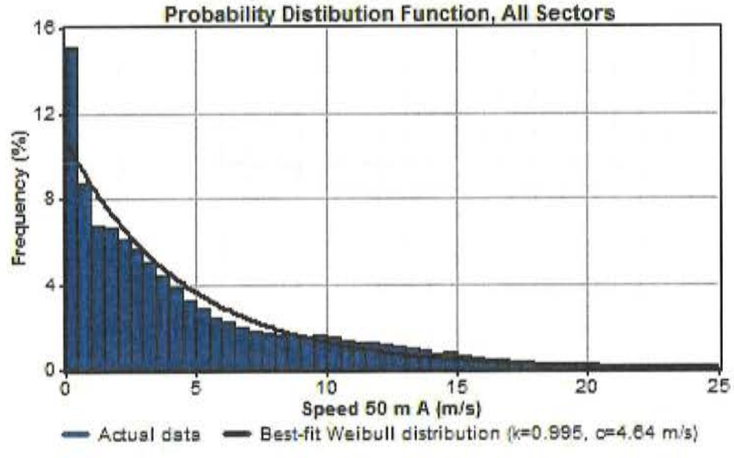
## Wind Speed and Direction

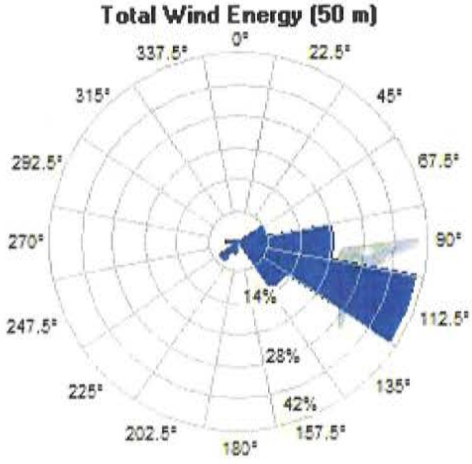

Seasonal Wind Speed Profile


Wind Frequency Rose (48 m)

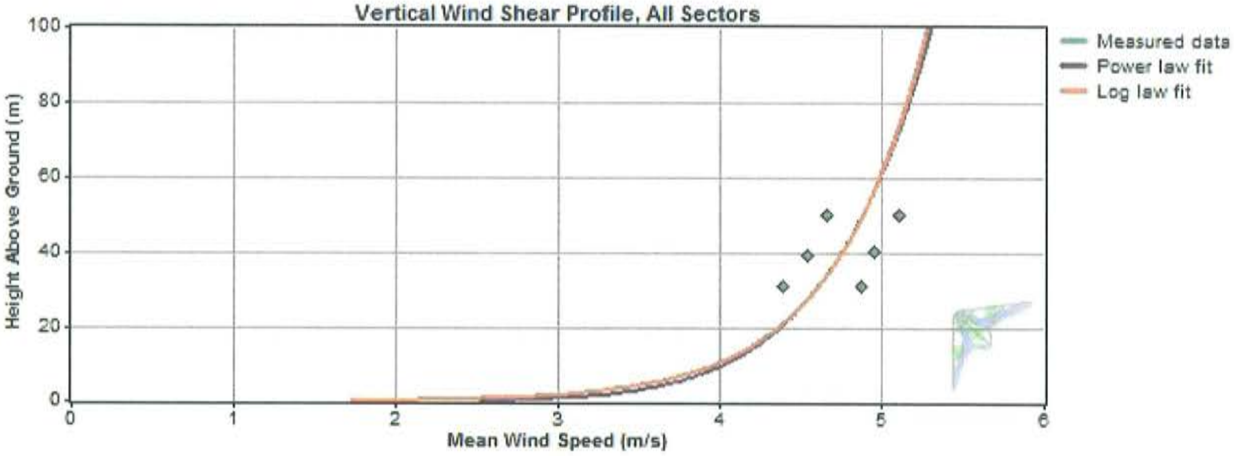

Daily Wind Speed Profile

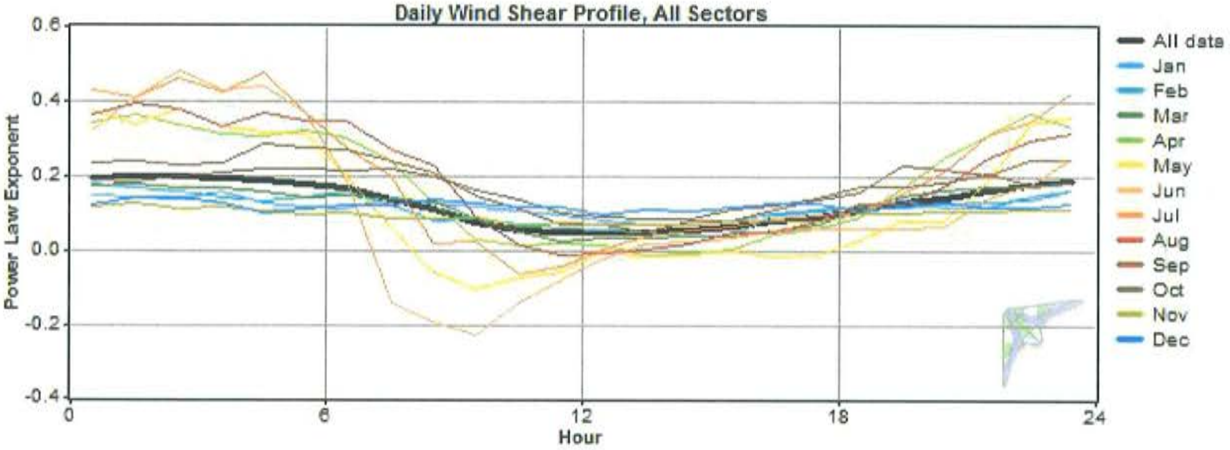

Mean Wind Speed (50 m)

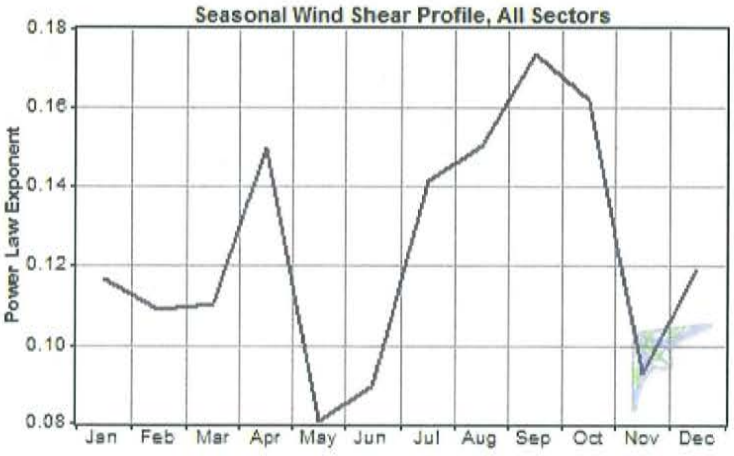

Probability Distibution Function, All Sectors

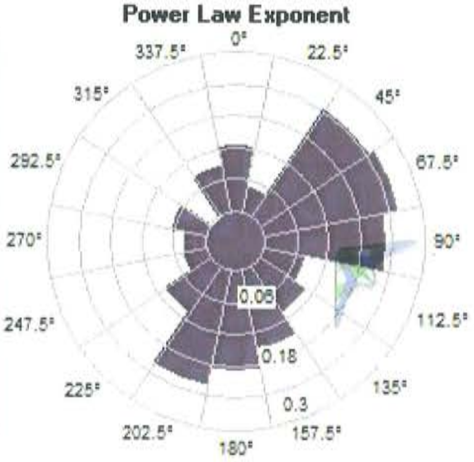

Total Wind Energy (50 m)

## Wind Shear

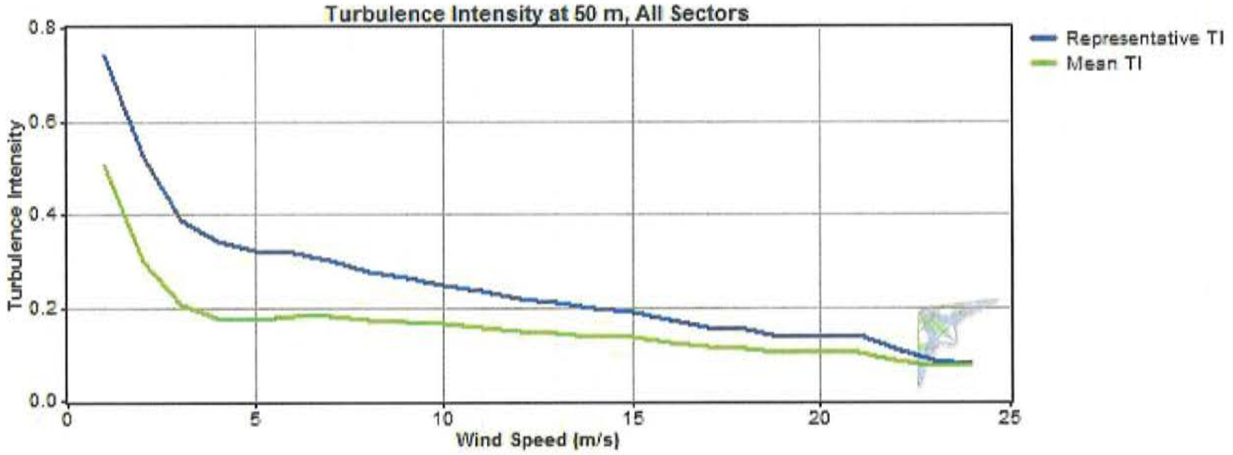

Vertical Wind Shear Profile, All Sectors
Height Above Ground (m)
100
80
60
40
20
0
0
1
2
3
4
5
6
Mean Wind Speed (m/s)
Measured data
Power law fit
Log law fit

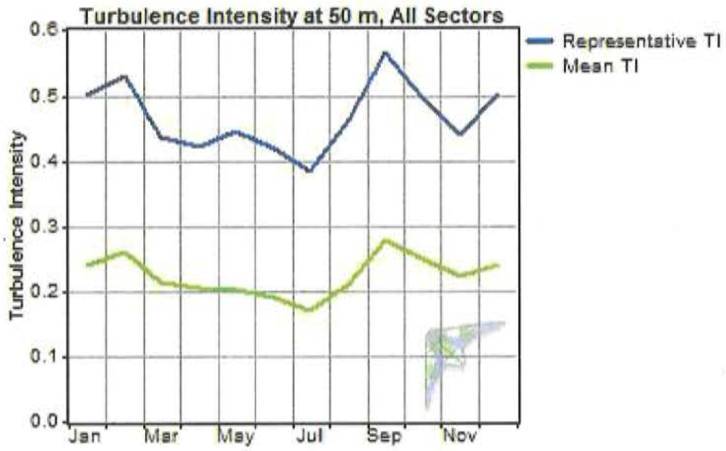

Daily Wind Shear Profile, All Sectors
Power Law Exponent
0.6
0.4
0.2
0.0
-0.2
-0.4
0
6
12
18
24
Hour
All data
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

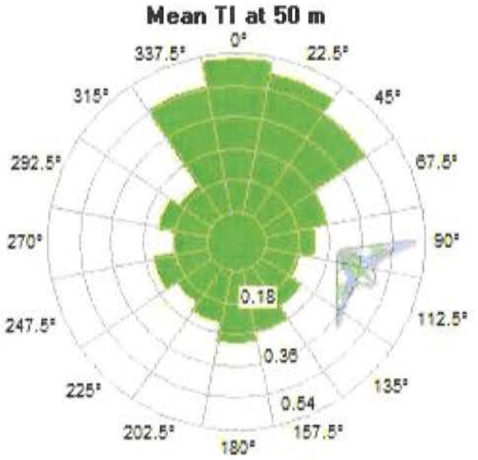

Seasonal Wind Shear Profile, All Sectors
Power Law Exponent
0.18
0.16
0.14
0.12
0.10
0.08
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

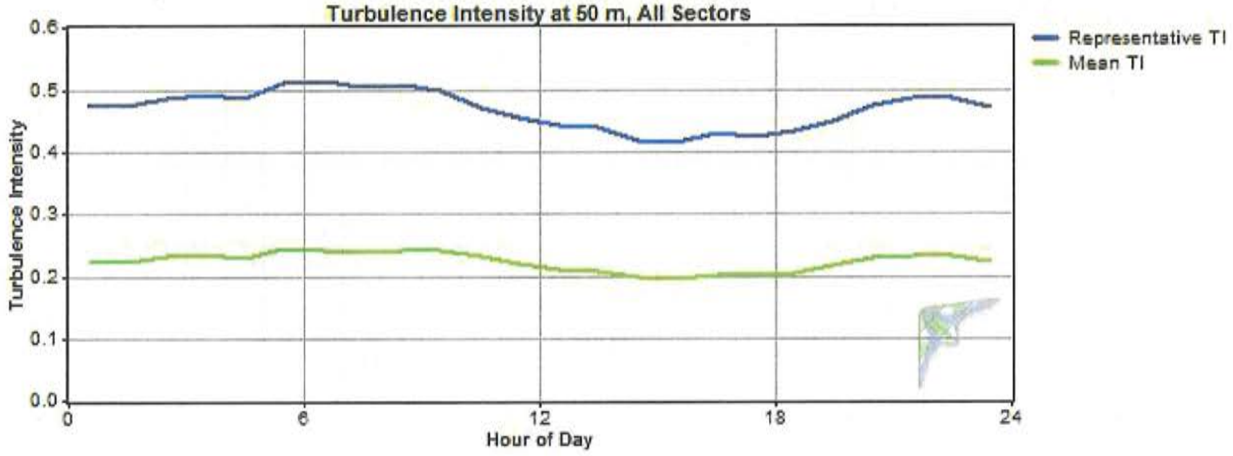

Power Law Exponent
0°
22.5°
45°
67.5°
90°
112.5°
135°
157.5°
180°
202.5°
225°
247.5°
270°
292.5°
315°
337.5°
0.06
0.18
0.3

## Turbulence Intensity









## Data Column Properties

| Label | Units | Height | Possible Records | Valid Records | Recovery Rate (%) | Mean | Min | Max | Std. Dev |
|---|---|---|---|---|---|---|---|---|---|
| Speed 50 m A | m/s | 50 m | 106,212 | 105,960 | 99.76 | 4.66 | 0.40 | 23.70 | 4.54 |
| Speed 50 m A SD | m/s | | 106,212 | 105,960 | 99.76 | 0.812 | 0.000 | 5.600 | 0.739 |
| Speed 50 m A Max | m/s | | 106,212 | 105,960 | 99.76 | 6.69 | 0.40 | 32.30 | 6.05 |
| Speed 50 m A Min | m/s | | 106,212 | 105,960 | 99.76 | 2.76 | 0.40 | 20.10 | 3.06 |
| Speed 39 m | m/s | 39 m | 106,212 | 105,960 | 99.76 | 4.54 | 0.40 | 24.00 | 4.52 |
| Speed 39 m SD | m/s | | 106,212 | 105,960 | 99.76 | 0.820 | 0.000 | 5.800 | 0.754 |
| Speed 39 m Max | m/s | | 106,212 | 105,960 | 99.76 | 6.60 | 0.40 | 30.50 | 6.05 |
| Speed 39 m Min | m/s | | 106,212 | 105,960 | 99.76 | 2.65 | 0.40 | 19.40 | 3.04 |
| Speed 31 m A | m/s | 31 m | 106,212 | 105,960 | 99.76 | 4.39 | 0.40 | 23.50 | 4.40 |
| Speed 31 m A SD | m/s | | 106,212 | 105,960 | 99.76 | 0.796 | 0.000 | 5.600 | 0.742 |
| Speed 31 m A Max | m/s | | 106,212 | 105,960 | 99.76 | 6.29 | 0.40 | 28.90 | 5.94 |
| Speed 31 m A Min | m/s | | 106,212 | 105,960 | 99.76 | 2.46 | 0.40 | 19.00 | 2.93 |
| Direction 48 m | ° | 48 m | 106,212 | 105,960 | 99.76 | 189.4 | 0.0 | 359.0 | 84.4 |
| Direction 48 m SD | ° | | 106,212 | 105,960 | 99.76 | 8.9 | 0.0 | 127.0 | 14.2 |
| Direction 48 m Max | ° | | 106,212 | 105,960 | 99.76 | 0 | 0 | 0 | 0 |
| Direction 48 m Min | ° | | 106,212 | 105,960 | 99.76 | 0 | 0 | 0 | 0 |
| Direction 33 m | ° | 33 m | 106,212 | 105,960 | 99.76 | 211.0 | 0.0 | 359.0 | 79.5 |
| Direction 33 m SD | ° | | 106,212 | 105,960 | 99.76 | 8.1 | 0.0 | 127.0 | 13.5 |
| Direction 33 m Max | ° | | 106,212 | 105,960 | 99.76 | 0 | 0 | 0 | 0 |
| Direction 33 m Min | ° | | 106,212 | 105,960 | 99.76 | 0 | 0 | 0 | 0 |
| Temperature | °C | | 106,212 | 105,960 | 99.76 | 2.61 | -19.00 | 29.10 | 7.83 |
| Temperature SD | °C | | 106,212 | 105,960 | 99.76 | 0.124 | 0.000 | 1.700 | 0.107 |
| Temperature Max | °C | | 106,212 | 105,960 | 99.76 | 2.87 | -18.60 | 29.80 | 7.82 |
| Temperature Min | °C | | 106,212 | 105,960 | 99.76 | 2.43 | -19.20 | 28.50 | 7.85 |
| RM Young | m/s | | 106,212 | 105,960 | 99.76 | -0.015 | -1.300 | 1.600 | 0.172 |
| RM Young SD | m/s | | 106,212 | 105,960 | 99.76 | 0.399 | 0.000 | 2.100 | 0.408 |
| RM Young Max | m/s | | 106,212 | 105,960 | 99.76 | 1.16 | -0.20 | 10.50 | 1.22 |
| RM Young Min | m/s | | 106,212 | 105,960 | 99.76 | -1.178 | -8.900 | 0.200 | 1.200 |
| Voltmeter | volts | | 106,212 | 105,960 | 99.76 | 13.53 | 0.00 | 15.00 | 3.81 |
| Voltmeter SD | volts | | 106,212 | 105,960 | 99.76 | 0.001 | 0.000 | 7.300 | 0.037 |
| Voltmeter Max | volts | | 106,212 | 105,960 | 99.76 | 13.55 | 0.00 | 16.30 | 3.82 |
| Voltmeter Min | volts | | 106,212 | 105,960 | 99.76 | 13.52 | 0.00 | 15.00 | 3.81 |
| Speed 50 m B | m/s | 50 m | 106,212 | 105,960 | 99.76 | 5.11 | 1.00 | 24.20 | 4.44 |
| Speed 50 m B SD | m/s | | 106,212 | 105,960 | 99.76 | 0.758 | 0.000 | 5.700 | 0.740 |
| Speed 50 m B Max | m/s | | 106,212 | 105,960 | 99.76 | 6.98 | 1.00 | 32.50 | 6.01 |
| Speed 50 m B Min | m/s | | 106,212 | 105,960 | 99.76 | 3.40 | 1.00 | 19.90 | 3.02 |

| Label | Units | Height | Possible Records | Valid Records | Recovery Rate (%) | Mean | Min | Max | Std. Dev |
|---|---|---|---|---|---|---|---|---|---|
| Speed 40 m | m/s | 40 m | 106,212 | 105,960 | 99.76 | 4.96 | 1.00 | 24.20 | 4.42 |
| Speed 40 m SD | m/s | | 106,212 | 105,960 | 99.76 | 0.755 | 0.000 | 5.700 | 0.745 |
| Speed 40 m Max | m/s | | 106,212 | 105,960 | 99.76 | 6.84 | 1.00 | 31.90 | 6.00 |
| Speed 40 m Min | m/s | | 106,212 | 105,960 | 99.76 | 3.29 | 1.00 | 19.90 | 3.01 |
| Speed 31 m B | m/s | 31 m | 106,212 | 105,960 | 99.76 | 4.87 | 1.00 | 23.80 | 4.29 |
| Speed 31 m B SD | m/s | | 106,212 | 105,960 | 99.76 | 0.763 | 0.000 | 5.700 | 0.740 |
| Speed 31 m B Max | m/s | | 106,212 | 105,960 | 99.76 | 6.78 | 1.00 | 30.20 | 5.89 |
| Speed 31 m B Min | m/s | | 106,212 | 105,960 | 99.76 | 3.19 | 1.00 | 19.60 | 2.90 |

# CVEA Tolsona Site 6387
# 8/16/12 – 9/20/14 Report

By
Rob Lowrance
CTO, KB Energy

KB
Energy
"Renewable solutions"
Arlington, WY

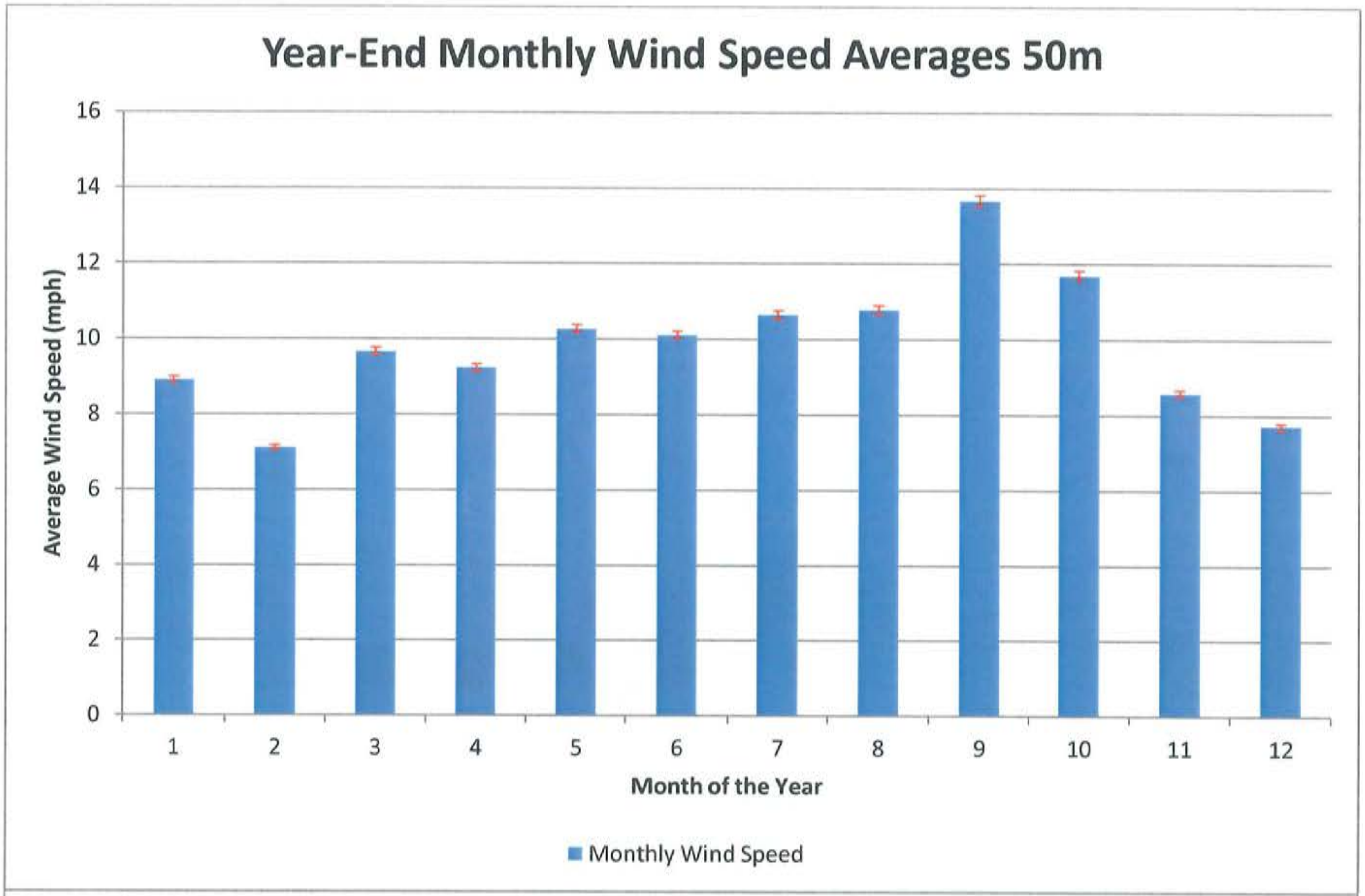
## Monthly Wind Speeds:

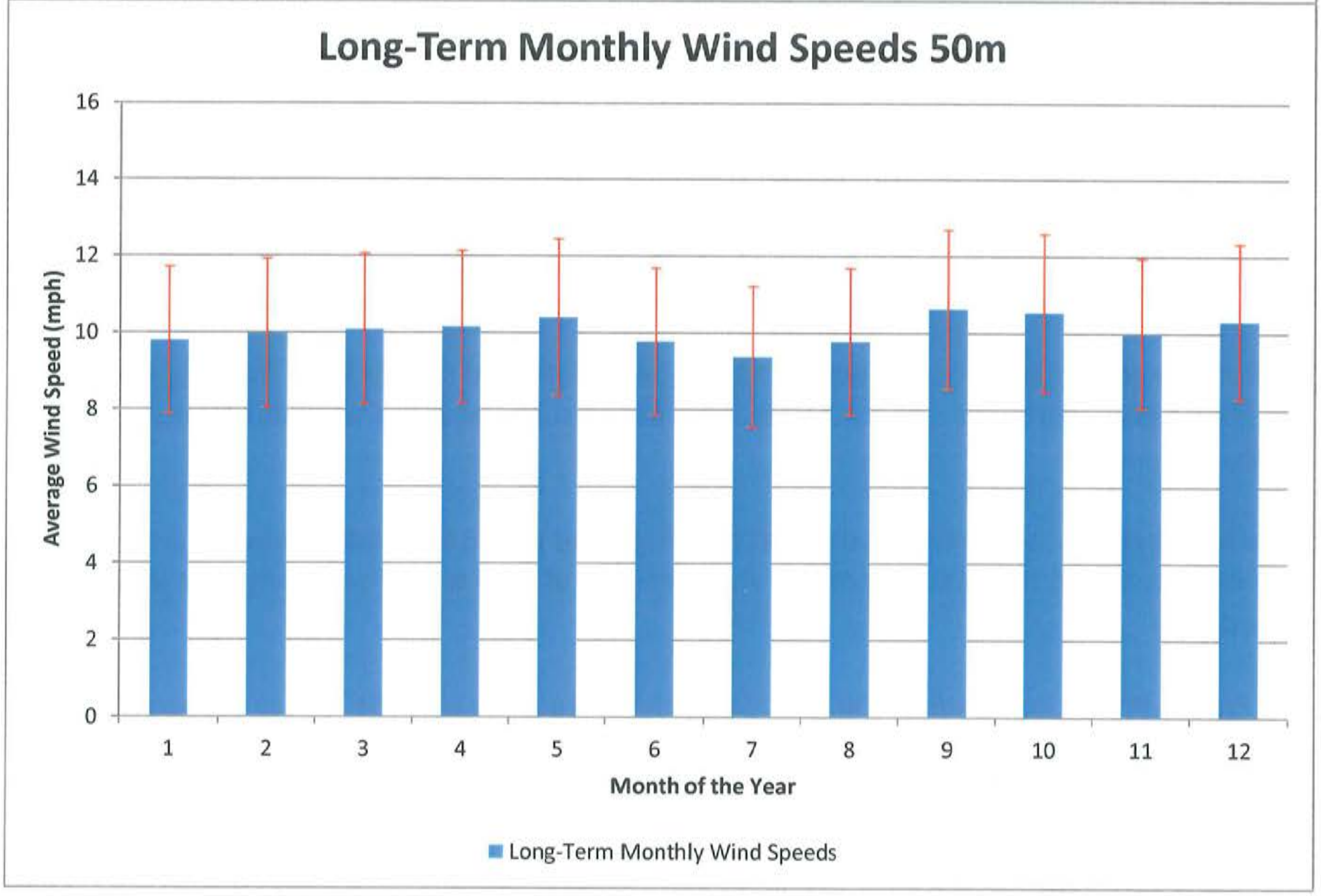
As you can see from the following charts, the year from 8/12 through 9/14 was not typical. At the 50m level, the monthly average wind speed varied from a high of 13.67 mph in September to a low of 7.72 mph in December. The normal range, which is emphasized by the second chart shows that the average swing is more like a high of 10.63 mph and a low of 9.37 mph at 50m.

The period-end average wind speed at 50m, was 10.00 mph, while the long-term correlation indicates that long-term average for the site should be closer to 10.07 mph. In other words, the average winds for this year were better than normal, which makes the site much less attractive from a wind energy perspective.

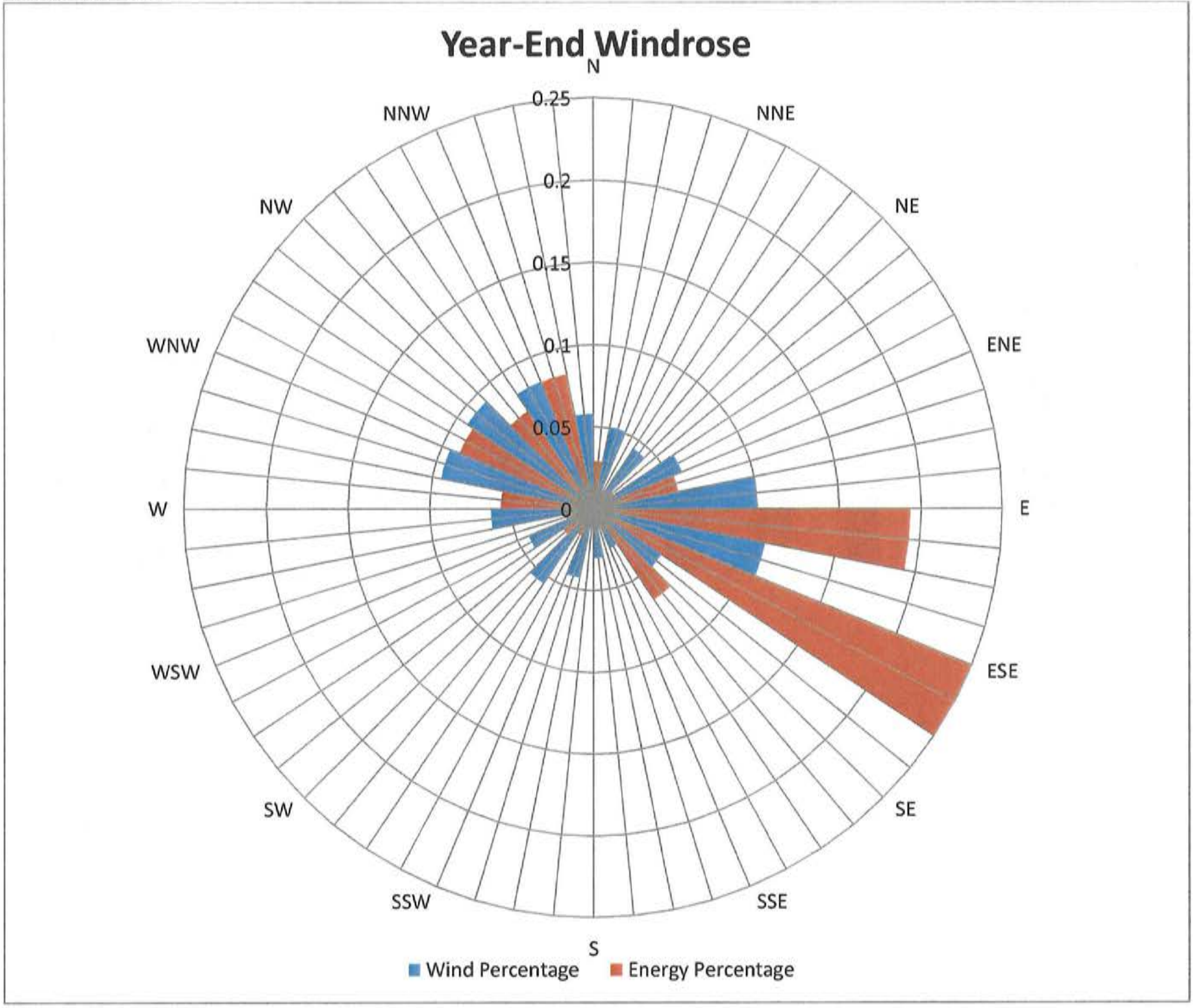
The uncertainty for the tower data is around +/- 1.05%. This includes uncertainty in the instruments themselves and estimates of the uncertainty from tower shadow effect and error added from recovering icing data.

The error bars on the second chart are an indication of the uncertainty in the correlation, plus the uncertainty in the measured winds at 50m. The correlation was good, but the long-term data set could still only account for 80.43% of the wind speed variations at the site. The actual long-term values at the site could easily be +/- 19.57% because of this alone. When the uncertainty from measurement is combined with this, the uncertainty becomes +/- 19.60%. This is what is reflected in the error bars.


Year-End Monthly Wind Speed Averages 50m
Average Wind Speed (mph)
0
2
4
6
8
10
12
14
16
1
2
3
4
5
6
7
8
9
10
11
12
Month of the Year
Monthly Wind Speed


Long-Term Monthly Wind Speeds 50m
Average Wind Speed (mph)
0
2
4
6
8
10
12
14
16
1
2
3
4
5
6
7
8
9
10
11
12
Month of the Year
Long-Term Monthly Wind Speeds

## Windrose:



I am only representing the year-end Windrose here. The wind speeds from the long-term data site gave a good correlation to the tower. I am not so sure about the wind directions at this point.

So, while I believe the long-term data set is giving good wind speed information, I am not yet sure if we can trust the wind directions. Another year of data would definitely help in this regard.

The Energy Producing winds at the site are primarily from the E to ESE. These account for 44.3% of the potential energy production, but only 20.7% of the wind. WNW to NNW account for another 24.4% of potential energy production along with 27.2% more of the wind.

## Production Analysis:

This site was relatively well-behaved, so all of the analysis is based on extrapolation to 80m hub height. However, since the uncertainty at the site was so high, I only performed a P95 analysis on the GE 1.7. The uncertainty in wind speed is 19.60%.

### GE 1.5 XLE:

Yearly Average:

At 80m, this turbine would have produced about 3440 MWh/year given the year's data. This corresponds to 26.2% capacity factor.

P50:

At 80m, compared against a correlation to our long-term data set, the turbine would produce on average 3600 MWh/year. This corresponds to 27.4% capacity factor.

### GE 1.7:

Yearly Average:

At 80m, this turbine would have produced about 5050 MWh/year or 33.9%.

P50:

At 80m, this turbine would have produced about 5250 MWh/year or 35.2%.

P95:

At 80m, this turbine would have produced about 3410 MWh/year or 22.8%. This is significantly lower, because the total uncertainty in energy production is estimated at 21.43%. This amount of uncertainty makes a project at the site problematic.

I have also done some quick comparisons of twelve different turbines for the year-end wind speeds and for the long-term wind speeds.

| Turbine | Rating | Max Production | CP 1 | CP 2 |
|---|---|---|---|---|
| Alstom Wind ECO1670 | 1.67 | 14630 MWh | 22.0% | 23.5% |
| Clipper CW99 Liberty | 2.5 | 21900 MWh | 23.0% | 24.2% |
| ECOTECNIA 3000 | 3.0 | 26280 MWh | 21.7% | 22.3% |
| HYUNDAI HQ2000-WT93 | 2.0 | 17520 MWh | 27.3% | 28.5% |
| KENERSYS K110 | 2.4 | 21024 MWh | 31.6% | 33.9% |
| LAGERWEY LW 72 (2.0) | 2.0 | 17520 MWh | 17.3% | 18.4% |
| NORDEX S77 | 1.5 | 13140 MWh | 23.9% | 25.5% |
| Suzlon S82 | 1.5 | 13140 MWh | 23.8% | 25.0% |
| Suzlon S97 | 2.1 | 18396 MWh | 26.7% | 28.0% |
| VESTAS V82 | 1.65 | 14454 MWh | 23.8% | 24.9% |
| VESTAS V100 | 1.8 | 15768 MWh | 31.0% | 32.3% |

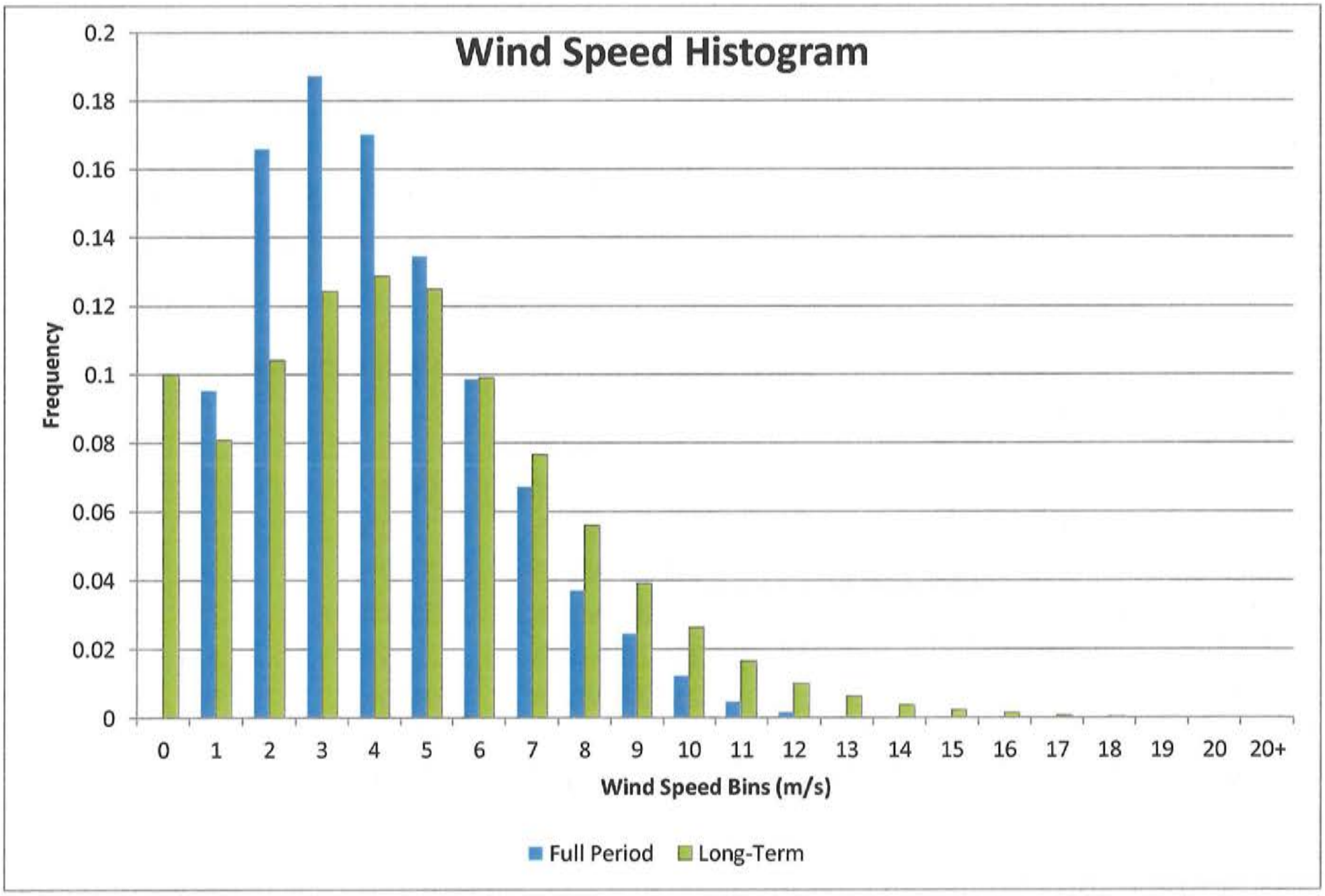
Rating is the turbines rating in MW. Max Production is the maximum production from the turbine in MWh/year. CP 1 is the capacity factor based on the year's data. CP 2 is the capacity factor based on the correlation of the year's data to the long-term data source.

## Wind Data Availability:

All icing data was effectively restored during the process of producing this report. Only a few hours in April were actually lost.

## Wind Speed Histogram:

The following chart gives an idea of how fast the wind blows at the site. The blue bars represent this past two years. As you can see, there were a lot of times that the wind speeds were quite low. In fact, the winds were too low for a turbine to run about 44.9% of the time over this last year. The green bars, which show the winds correlated to the long-term data set, are much better. In this case, the winds would be too low for a turbine to run only about 40.9% of the time. This is part of the reason that the long-term production figures earlier in the report are higher than the ones based on only this last two years' data. However, the long-term data set only accounted for 80.43% of the wind at the site.

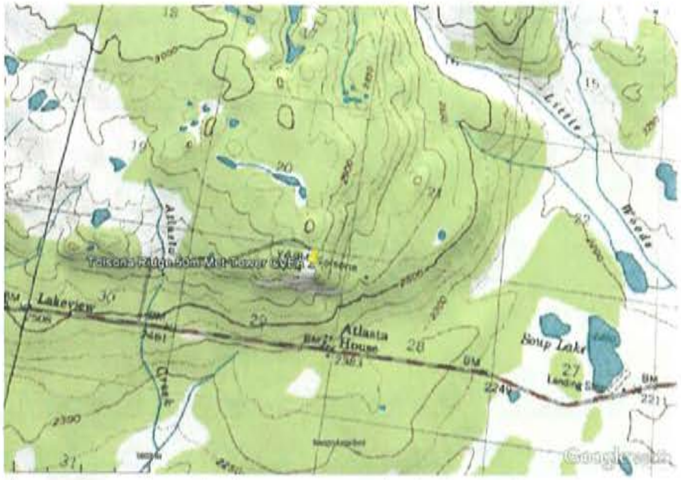


# Tolsona Wind Resource Summary Report

Rich Stromberg
Alaska Energy Authority, Alternative Energy and Energy Efficiency Group

All information contained herein must be treated as confidential unless given permission to use/disseminate by Copper Valley Electric Association.

## OVERVIEW

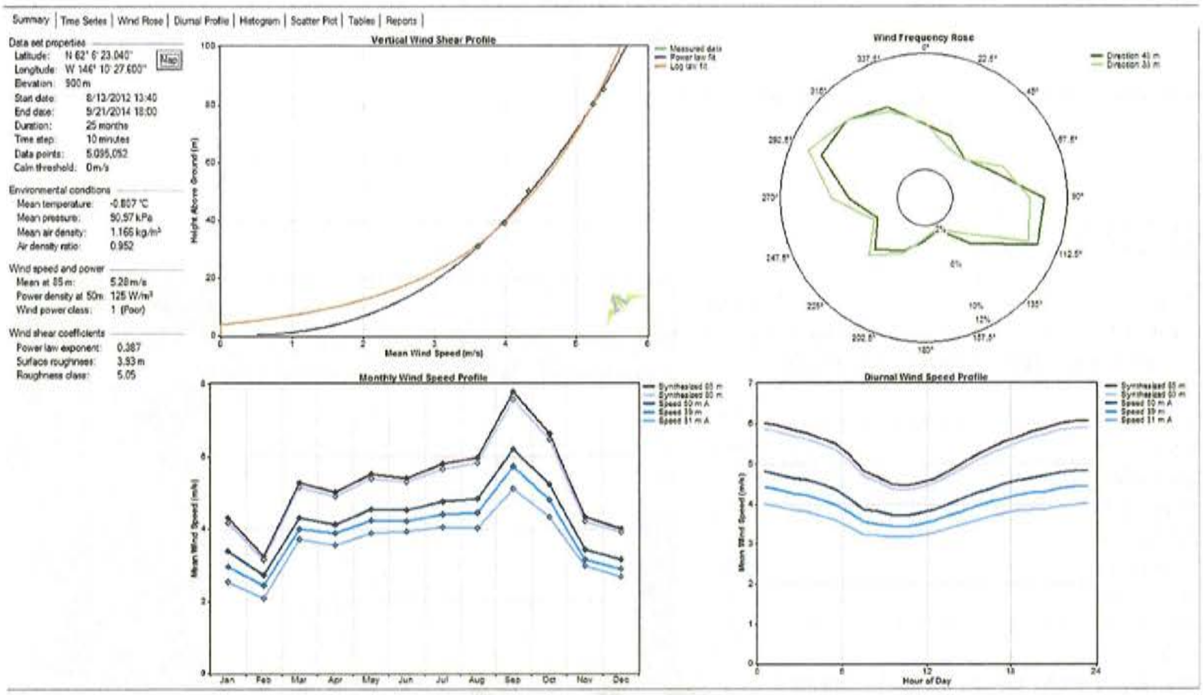


A 25-month wind study was conducted 21 miles west of Glennallen, Alaska at the southern point of a prominent ridge 5 miles north of the Tazlina River drainage ~ 895 meters ASL in 2012-14. Data recovery was very high at 99.8% with a day (Jan. 3, 2014) of missing data during the collection period. The main data anomaly observed was that the zero wind threshold of the NRG IceFreeIII B anemometers at 50, 40 and 31 meters was 1 m/s rather than the standard 0.4 m/s for the #40 NRG A set of anemometers at comparable heights. This does not affect wind turbine output estimates, but does shift the calculated mean values for these sensors slightly upward. Because of the issues observed with the A versus B group of sensors, analysis of wind shear and vertical extrapolation should be done using only a single group – not both. Due to hoar frost signals discussed later, it is recommended that the standard (non-heated) #40 NRG anemometers be used for analysis and wind turbine output prediction.

The wind resource is fair with an expected net capacity factor of 23.23 percent for a GE 1.6 MW turbine with the IEC class III 100-meter rotor. The GE 2.5 MW turbine with 100 meter rotor has a lower expected net capacity factor of 20.53 percent. Due to marginal turbulence on the ridge, the GE1.6-100 turbine would likely not be compatible, so the 20.53 percent net capacity factor estimate should be used as a best case. The higher-than-normal wind shear of 0.387 should further temper wind turbine production estimates at 80 and 100 meters above ground.

| Tolsona Met Tower Study | | |
|---|---|---|
| Application/Grant # | | |
| Average Wind Speed @ 30 m: | 3.625 | m/s |
| Average Power Density @ 50 m: | 125 | W/m^2 |
| Average Power Density @ 30 m: | 66 | W/m^2 |
| Air Density: | 0.951 | kg/m^3 |
| Weibull k: | 1.33 | |
| Shear Factor: | 0.387 | |
| Roughness Class: | 5.050 | |
| Turbulence Intensity @ 15 m/s: | 0.180 | |
| IEC Turbine Class: | II-A | |
| Wind Class @ 30 m: | 1 | |
| Associated CF: | N/A | |
| Predicted CF: | 20.5% | |

## DATA SUMMARY



Data set properties
Latitude: N 62° 6' 23.040"
Longitude: W 146° 10' 27.600"
Elevation: 900 m
Start date: 8/13/2012 13:40
End date: 9/21/2014 18:00
Duration: 25 months
Time step: 10 minutes
Data points: 5,095,052
Calm threshold: 0m/s

Environmental conditions
Mean temperature: -0.807 °C
Mean pressure: 90.57 kPa
Mean air density: 1.166 kg/m³
Air density ratio: 0.952

Wind speed and power
Mean at 85 m: 5.28 m/s
Power density at 50m: 125 W/m²
Wind power class: 1 (Poor)

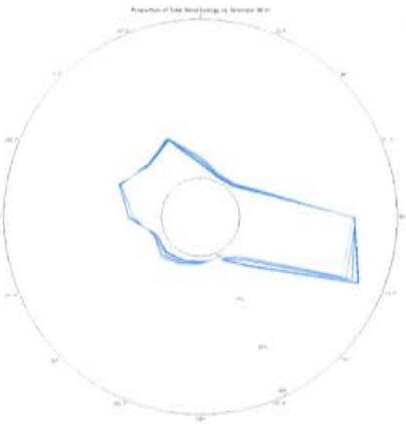
Wind shear coefficients
Power law exponent: 0.387
Surface roughness: 3.93 m
Roughness class: 5.05

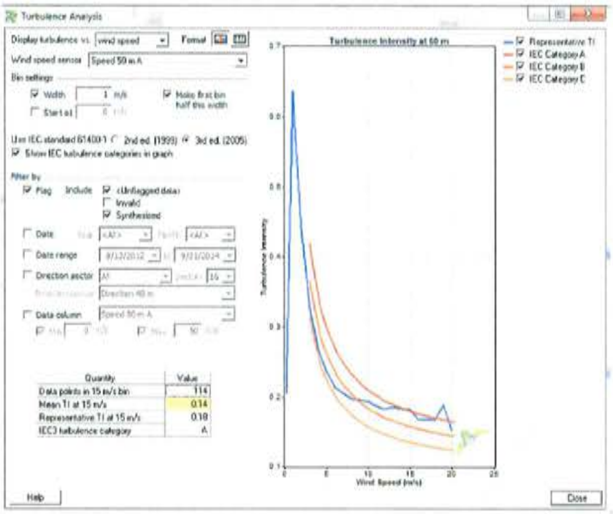
| Variable | Synthesized 85 m | Synthesized 80 m | Speed 50 m A | Speed 39 m | Speed 31 m A |
|---|---|---|---|---|---|
| Measurement height (m) | 85 | 80 | 50 | 39 | 31 |
| Mean wind speed (m/s) | 5.369 | 5.235 | 4.337 | 3.993 | 3.626 |
| MoMM wind speed (m/s) | 5.283 | 5.152 | 4.276 | 3.935 | 3.577 |
| Median wind speed (m/s) | 4.513 | 4.430 | 3.800 | 3.600 | 3.300 |
| Min wind speed (m/s) | 0.400 | 0.393 | 0.400 | 0.400 | 0.400 |
| Max wind speed (m/s) | 25.771 | 25.029 | 19.900 | 18.000 | 15.800 |
| Weibull k | 1.256 | 1.333 | 1.334 | 1.330 | 1.398 |
| Weibull c (m/s) | 5.725 | 5.684 | 4.668 | 4.288 | 3.924 |
| Mean power density (W/m²) | 261 | 239 | 125 | 95 | 68 |
| MoMM power density (W/m²) | 253 | 232 | 121 | 92 | 66 |
| Mean energy content (kWh/m²/yr) | 2,286 | 2,097 | 1,091 | 834 | 594 |
| MoMM energy content (kWh/m²/yr) | 2,214 | 2,031 | 1,058 | 809 | 577 |
| Energy pattern factor | 2.926 | 2.894 | 2.649 | 2.596 | 2.470 |
| Frequency of calms (%) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Possible data points | 110,762 | 110,762 | 110,762 | 110,762 | 110,762 |
| Valid data points | 110,762 | 110,762 | 110,240 | 110,240 | 110,240 |
| Missing data points | 0 | 0 | 522 | 522 | 522 |
| Data recovery rate (%) | 100.00 | 100.00 | 99.53 | 99.53 | 99.53 |

Winds are mild at a mean 50-meter wind power density of 125 watts per square meter. A Weibull K of 1.334 versus a more normal 2.0 is also indicative of a low wind regime. Site elevation reduces the air density (and subsequent power potential) to 95 percent of sea level pressure.

Average winds are modest at 5.3 meters per second estimated for 85 meters AGL. Notable levels of hoar frost were seen during winter months lasting from 2 days to almost two weeks in one instance. The wind shear is quite high such that vertical extrapolations using the 0.387 value should be viewed cautiously. The site has moderate extreme wind estimates that meet IEC turbine type II criteria. Estimated net capacity factor for a 2.5 megawatt wind turbine is 20.53 with no power produced 35 percent of the time. Energy-producing winds are generally out of the east.

Diurnal pattern indicates stronger afternoon winds driven by surface heating along with nighttime stably-stratified flow sinking down into the rotor swept area. Turbulence intensity meets IEC level A – the highest allowable criteria, driven mostly by the easterly winds meeting Tolsona ridge.



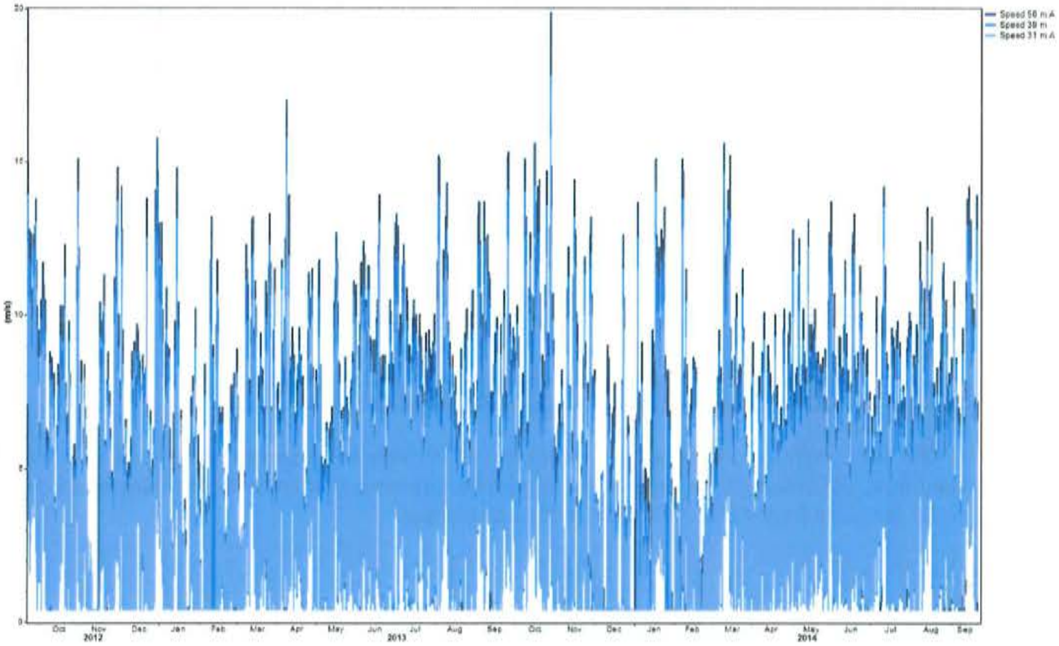


Turbulence Analysis

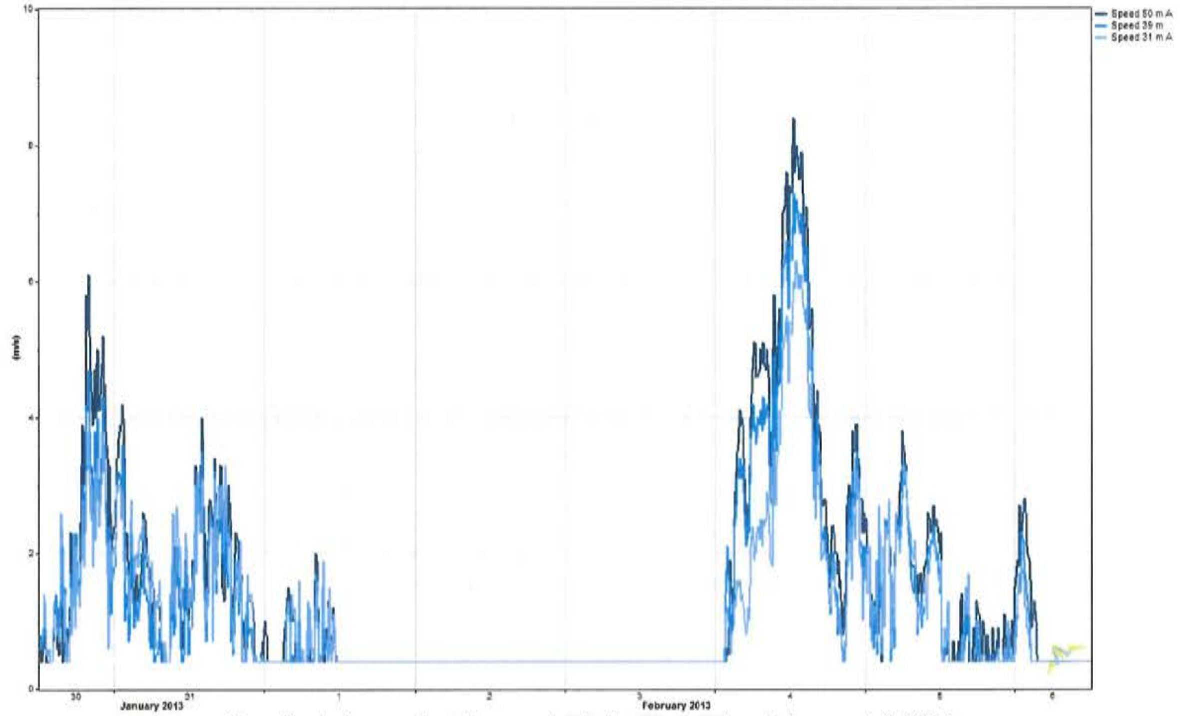
Display turbulence vs. wind speed
Wind speed sensor: Speed 50 m A
Bin settings
☑ Width 1 m/s
☐ Start at 0 m/s
☑ Make first bin half this width
Use IEC standard 61400-1 ○ 2nd ed. (1999) ● 3rd ed. (2005)
☑ Show IEC turbulence categories in graph
Filter by
☑ Flag Include ☑ <Unflagged data> ☐ Invalid ☑ Synthesized
☐ Date <All> <All>
☐ Date range 9/12/2012 9/21/2014
☐ Direction sector All 16
Direction 40 m
☐ Data column Speed 50 m A

| Quantity | Value |
|---|---|
| Data points in 15 m/s bin | 114 |
| Mean TI at 15 m/s | 0.14 |
| Representative TI at 15 m/s | 0.18 |
| IEC3 turbulence category | A |

The wind speed trend indicates a fairly consistent pattern with only a few periods driven by stronger storm-based systems.



While multiple hoar frost events were observed during both winter periods, it is important to use the non-heated, standard #40 anemometer data rather than the heated IceFreeIII anemometers. While this may seem counter intuitive, the practice to use data from the non-heated anemometers is based on a recent study by AEA during the winter of 2014/15 and is grounded in the position that while wind turbine anemometers are heated, wind turbine blades are not. AEA's findings are that wind turbine rotors accumulate disruptive frost and ice in a manner similar to the standard anemometers and experience a resulting drop in aerodynamic lift and energy production. Also, hoar frost tends to form in relatively low wind conditions and will shed off anemometers as the winds pick up to speeds where wind turbine begin production. Using the heated anemometers to predict energy output would overestimate net capacity factor by 1.5-2 percentage points.



Hoar frost observed on the non-heated anemometers February 1-3 2013.

## WIND TURBINE SITING CONSIDERATIONS

Siting constraints will be driven primarily by land ownership issues as well as costs to upgrade the existing single-phase transmission line ½-mile to the south. AEA is not aware of any met tower permitting issues with the FAA or US Fish & Wildlife Service, having not been involved in the permitting process. The height of the met tower did not trigger the requirement for FAA notification, but a wind turbine over 200 feet AGL will trigger FAA notification. Regardless, the high turbulence at this site prevents any project development.

## INTEGRATED POWER SYSTEM CONSIDERATIONS

The size of the CVEA load would allow for several megawatts of variable wind energy on the grid. Average annual wind energy exceeding 8-10 percent of the load would require the presence of more complex integration controls or storage, which could include a hydro-electric facility with dam storage.

## BARRIERS

- A 21-mile transmission line to Glennallen will increase costs to development of a project at this site.

## CONCLUSIONS

Wind energy development is a possibility at this site due to the low cost of project development on Alaska's road system. A high-capacity transmission line would be needed to connect the project site with CVEA's grid. Because the very high wind shear values add uncertainty to the data, AEA recommends either a taller met tower at the site (80-100 meters) or a LIDAR/SODAR unit to quantify the actual expected energy production across the rotor swept area of larger, megawatt-plus scale wind turbines before moving forward with expensive design and permitting of a project.

## CONTACT INFORMATION

Rich Stromberg, Wind Program Manager, Alaska Energy Authority rstromberg@aidea.org 907-771-3053

## ACKNOWLEDGMENTS

Copper Valley Electric Association provided the data set used for analysis.

# CVEA Gakona Site 6386
# 9/28/13 – 9/20/14 Report

By
Rob Lowrance
CTO, KB Energy

KB
Energy
"Renewable solutions"
Arlington, WY

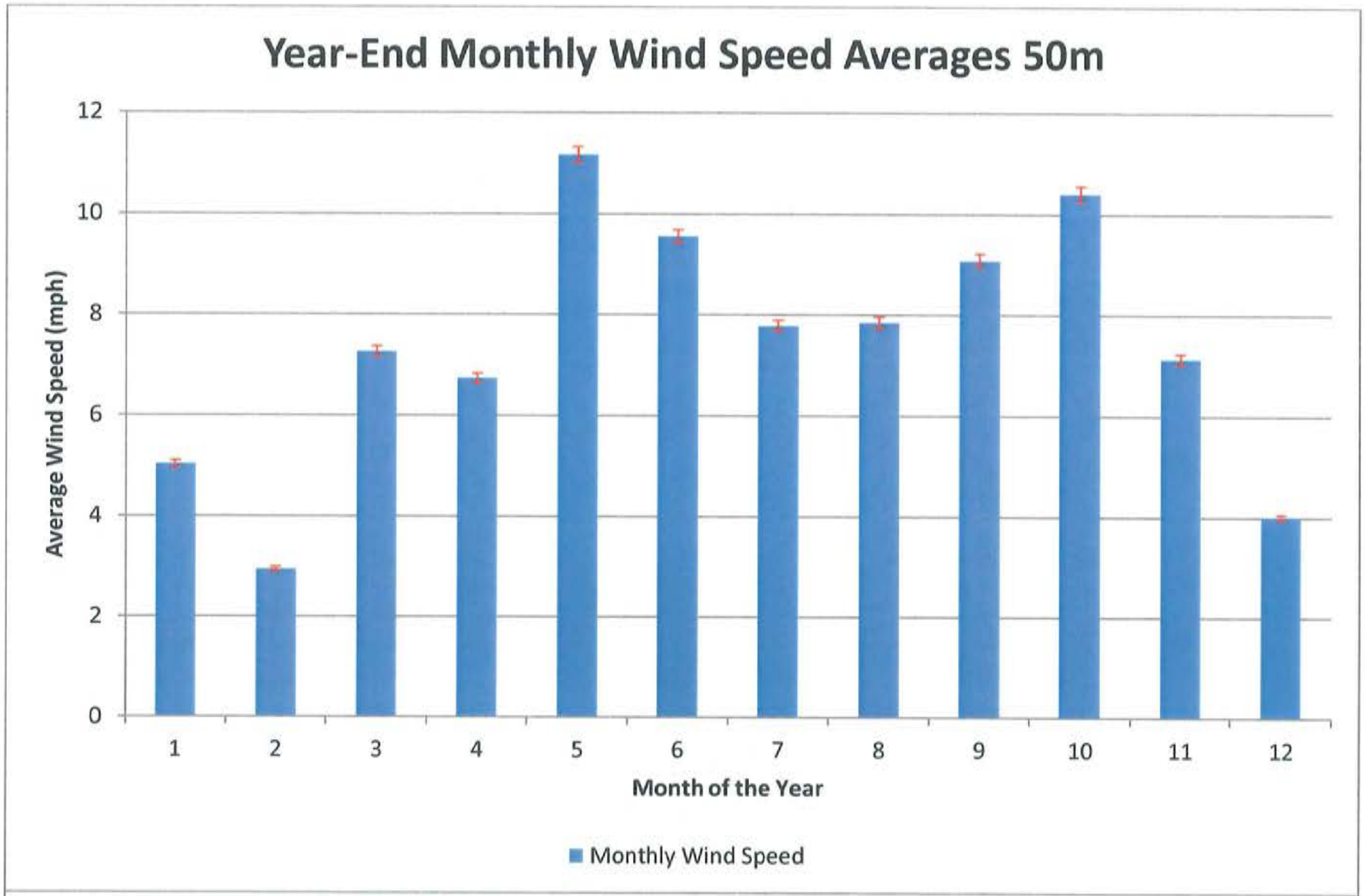
## Monthly Wind Speeds:

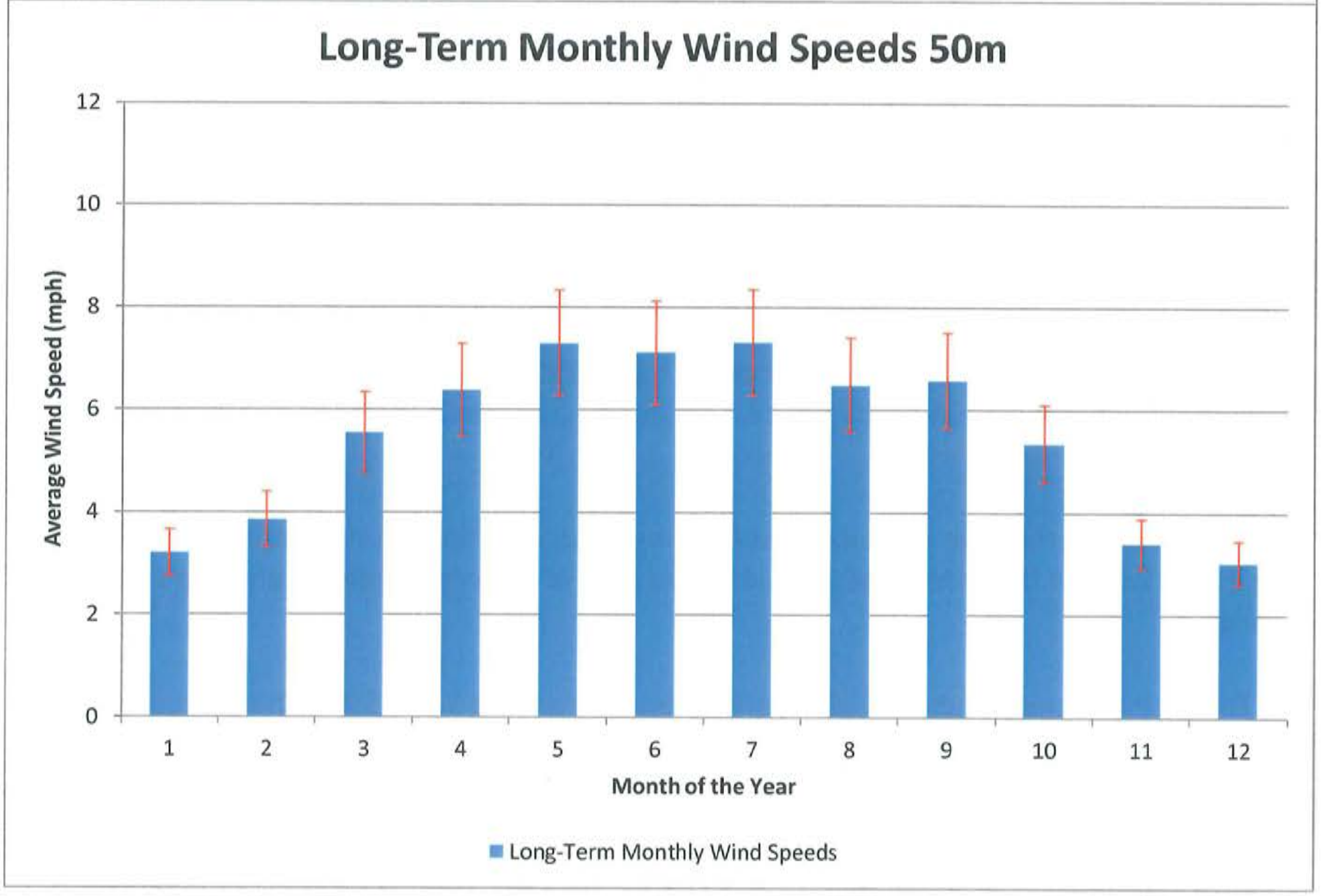
As you can see from the following charts, the year from 9/13 through 9/14 was not typical. At the 50m level, the monthly average wind speed varied from a high of 11.2 mph in May to a low of 3.0 mph in February. The normal range, which is emphasized by the second chart shows that the average swing is more like a high of 7.29 mph and a low of 3.02 mph at 50m.

The year-end average wind speed at 50m, was 7.40 mph, while the long-term correlation indicates that long-term average for the site should be closer to 5.46 mph. In other words, the average winds for this year were better than normal, which makes the site much less attractive from a wind energy perspective.

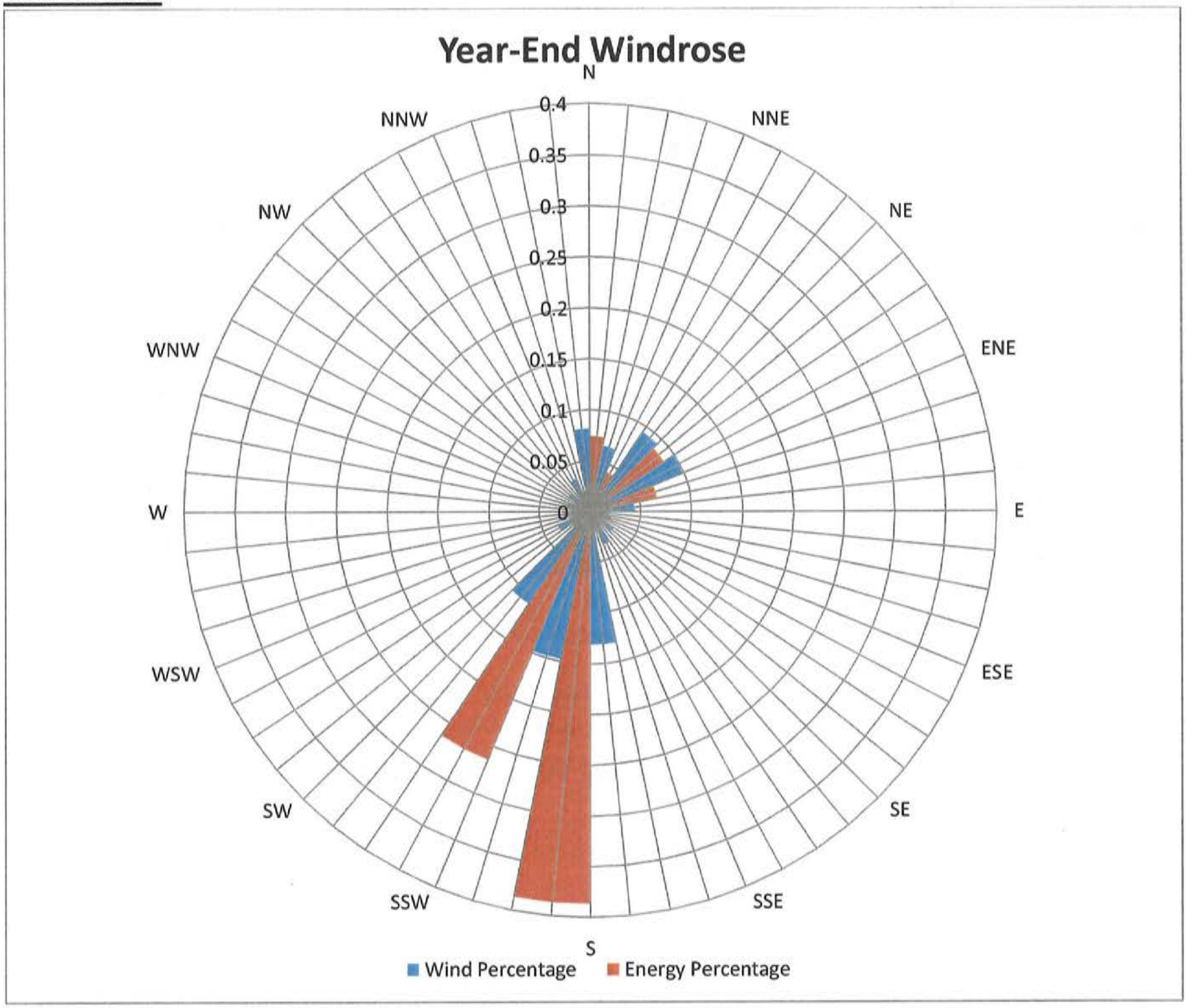
The uncertainty for the tower data is around +/- 1.40%. This includes uncertainty in the instruments themselves and estimates of the uncertainty from tower shadow effect and error added from recovering icing data.

The error bars on the second chart are an indication of the uncertainty in the correlation, plus the uncertainty in the measured winds at 50m. The correlation was good, but the long-term data set could still only account for 85.86% of the wind speed variations at the site. The actual long-term values at the site could easily be +/- 14.14% because of this alone. When the uncertainty from measurement is combined with this, the uncertainty becomes +/- 14.21%. This is what is reflected in the error bars.


Year-End Monthly Wind Speed Averages 50m
Average Wind Speed (mph)
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
11
12
Month of the Year
Monthly Wind Speed


Long-Term Monthly Wind Speeds 50m
Average Wind Speed (mph)
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
9
10
11
12
Month of the Year
Long-Term Monthly Wind Speeds

## Windrose:



I am only representing the year-end Windrose here. The wind speeds from the long-term data site gave a good correlation to the tower. I am not so sure about the wind directions at this point.

So, while I believe the long-term data set is giving good wind speed information, I am not yet sure if we can trust the wind directions. Another year of data would definitely help in this regard.

The Energy Producing winds at the site are primarily from the S and SSW. These account for 65.1% of the potential energy production, but only 27.9% of the wind.

## Production Analysis:

This site was relatively well-behaved, so all of the analysis is based on extrapolation to 80m hub height. However, since the wind speeds at the site were so low, I only performed the P50 Analysis on this site.

### GE 1.5 XLE:

Yearly Average:

At 80m, this turbine would have produced about 1790 MWh/year given the year's data. This corresponds to 13.6% capacity factor.

P50s:

At 80m, compared against a correlation to our long-term data set, the turbine would produce on average 1240 MWh/year. This corresponds to 9.4% capacity factor.

### GE 1.7:

Yearly Average:

At 80m, this turbine would have produced about 2770 MWh/year or 18.6%.

P50s:

At 80m, this turbine would have produced about 1950 MWh/year or 13.1%.

I have also done some quick comparisons of twelve different turbines for the year-end wind speeds and for the long-term wind speeds.

| Turbine | Rating | Max Production | CP 1 | CP 2 |
|---|---|---|---|---|
| Alstom Wind ECO1670 | 1.67 | 14630 MWh | 11.9% | 8.3% |
| Clipper CW99 Liberty | 2.5 | 21900 MWh | 11.5% | 7.9% |
| ECOTECNIA 3000 | 3.0 | 26280 MWh | 11.2% | 7.7% |
| HYUNDAI HQ2000-WT93 | 2.0 | 17520 MWh | 14.3% | 9.8% |
| KENERSYS K110 | 2.4 | 21024 MWh | 17.1% | 11.8% |
| LAGERWEY LW 72 (2.0) | 2.0 | 17520 MWh | 8.4% | 5.7% |
| NORDEX S77 | 1.5 | 13140 MWh | 12.3% | 8.4% |
| Suzlon S82 | 1.5 | 13140 MWh | 12.0% | 8.4% |
| Suzlon S97 | 2.1 | 18396 MWh | 13.9% | 9.7% |
| VESTAS V82 | 1.65 | 14454 MWh | 12.1% | 8.4% |
| VESTAS V100 | 1.8 | 15768 MWh | 16.8% | 11.6% |

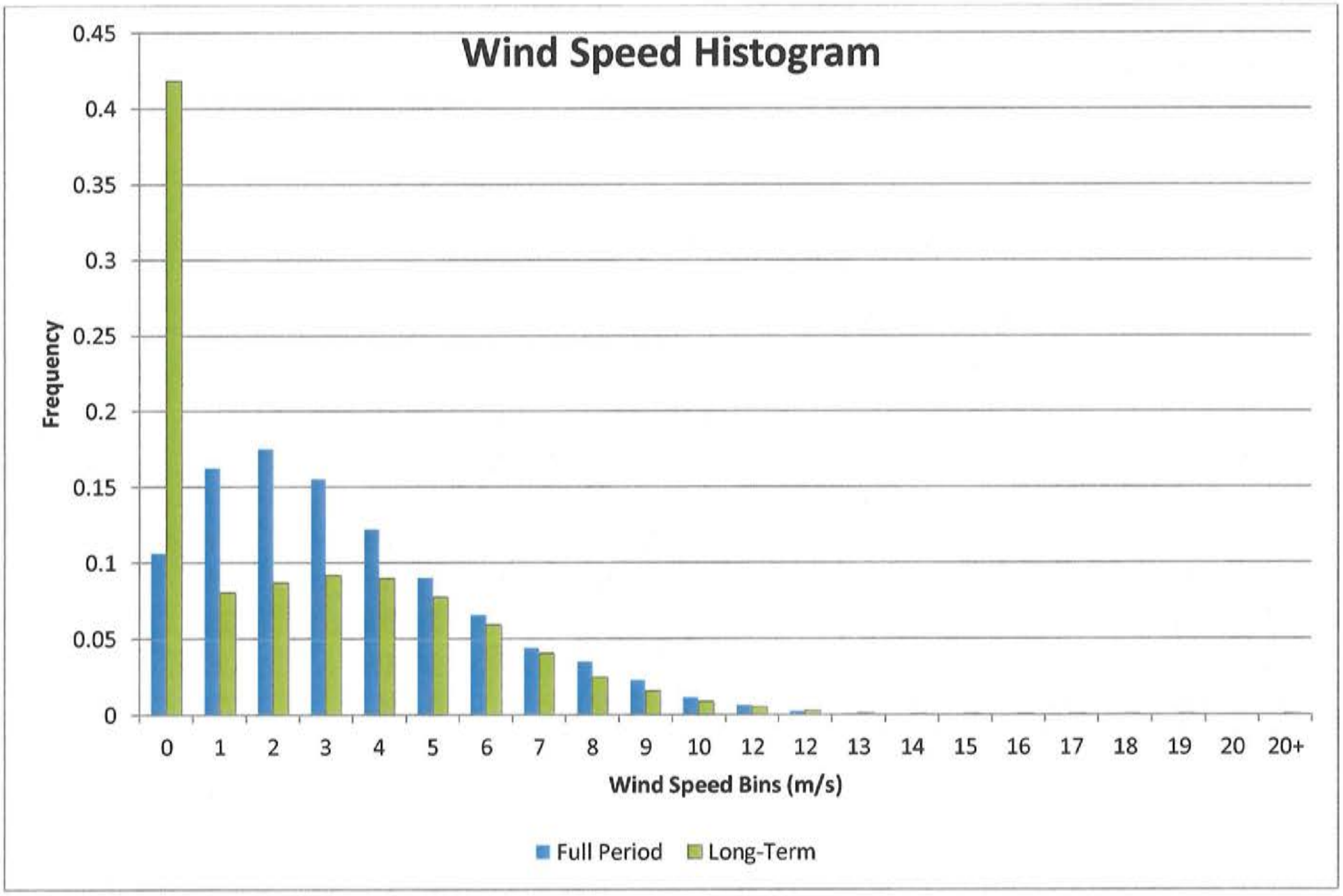
Rating is the turbines rating in MW. Max Production is the maximum production from the turbine in MWh/year. CP 1 is the capacity factor based on the year's data. CP 2 is the capacity factor based on the correlation of the year's data to the long-term data source.

## Wind Data Availability:

All icing data was effectively restored during the process of producing this report. Only a few hours in April were actually lost.

## Wind Speed Histogram:

The following chart gives an idea of how fast the wind blows at the site. The blue bars represent this past year. As you can see, there were a lot of times that the wind speeds were quite low. In fact, the winds were too low for a turbine to run about 60% of the time over this last year. The green bars, which show the winds correlated to the long-term data set, are much better. In this case, the winds would be too low for a turbine to run only about 68% of the time. This is part of the reason that the long-term production figures earlier in the report are so much higher than the ones based on only this last year's data. However, the long-term data set only accounted for 85.86% of the wind at the site.



# Gakona Wind Resource Summary Report

Rich Stromberg
Alaska Energy Authority, Alternative Energy and Energy Efficiency Group

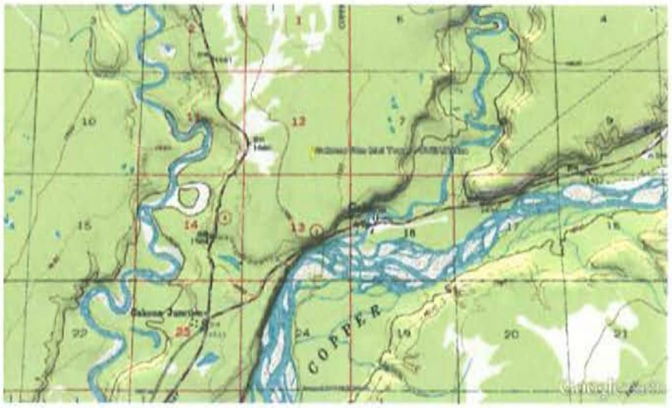
All information contained herein must be treated as confidential unless given permission to use/disseminate by Copper Valley Electric Association.

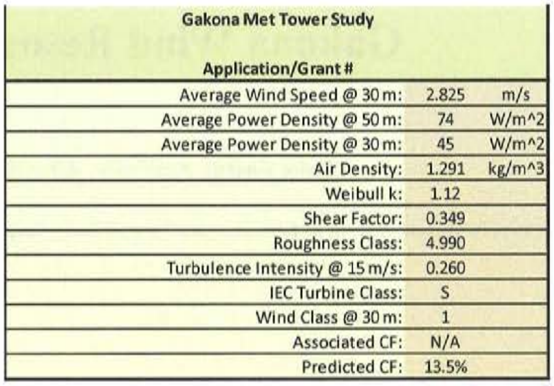
## OVERVIEW

A 12-month wind study was conducted 1 mile northwest of Gakona, Alaska on a plateau above the Copper River ~ 525 meters ASL in 2013/14. Data recovery was very high at 99.814% with less than a day (April 3, 2014) of missing data during the collection period. The main data anomaly observed was that the zero wind threshold of the B anemometers at 50, 40 and 31 meters was 1 m/s rather than the standard 0.4 m/s for the #40 NRG sensor. This does not affect wind turbine output estimates, but does shift the calculated mean values for these sensors slightly upward. The 31 meter B anemometer showed a noticeable departure from the 32 meter A anemometer up until mid-October of 2013. After this time, no significant deviations were seen. Because of the issues observed with the B group of sensors and the high confidence in the A group, analysis of wind shear and vertical extrapolation should be done using only the A group.

The wind resource is marginal with an expected net capacity factor of 15.84 percent for a GE 1.6 MW turbine with the IEC class III 100-meter rotor. The GE 2.5 MW turbine with 100 meter rotor has an even lower expected net capacity factor of 13.52 percent.

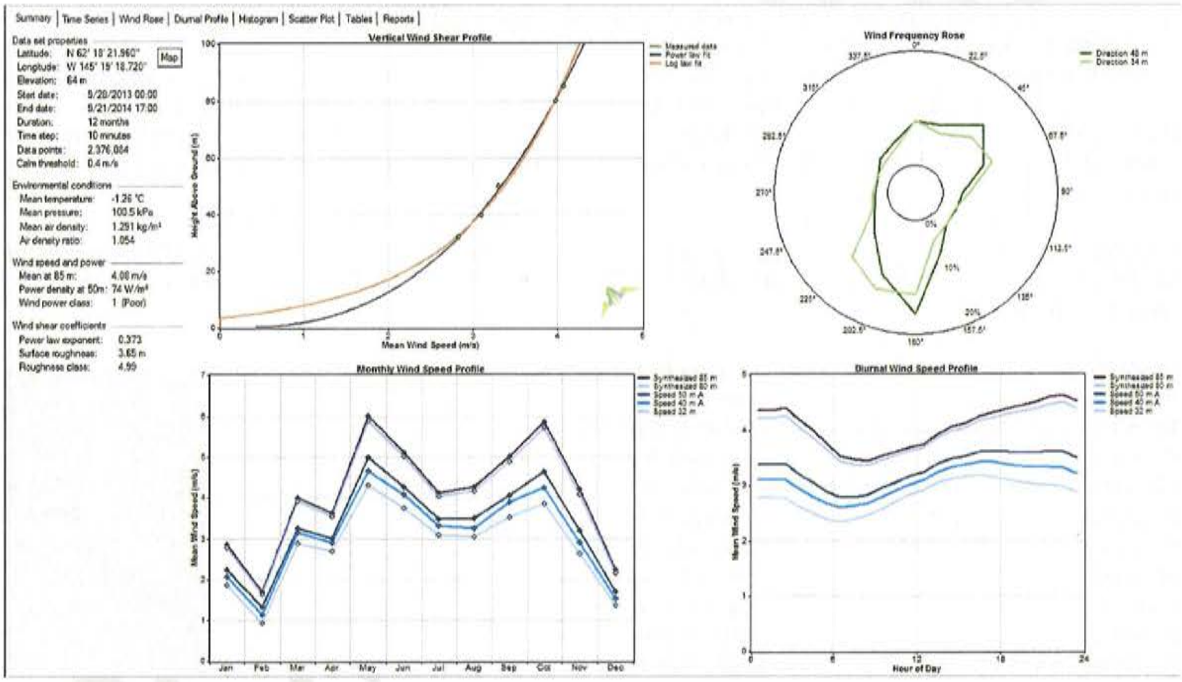
The cliffs dropping down to the Copper River south of the met tower site, combined with predominant winds coming from that direction create both a high wind shear of 0.349 at this location (0.14 being a "typical" value) and a very high turbulence level of 0.26 versus an upper allowable limit of 0.18. Wind energy production is not recommended at this site due to low expected energy output and damaging turbulence where wind turbine manufacturers will not allow placement of their product. Low levels of icing were observed during the short study with extended periods of calm winter winds. Very cold winter temperatures in the Interior tend to create inversion layers and bring these still conditions.





| Gakona Met Tower Study | | |
|---|---|---|
| Application/Grant # | | |
| Average Wind Speed @ 30 m: | 2.825 | m/s |
| Average Power Density @ 50 m: | 74 | W/m^2 |
| Average Power Density @ 30 m: | 45 | W/m^2 |
| Air Density: | 1.291 | kg/m^3 |
| Weibull k: | 1.12 | |
| Shear Factor: | 0.349 | |
| Roughness Class: | 4.990 | |
| Turbulence Intensity @ 15 m/s: | 0.260 | |
| IEC Turbine Class: | S | |
| Wind Class @ 30 m: | 1 | |
| Associated CF: | N/A | |
| Predicted CF: | 13.5% | |

## DATA SUMMARY

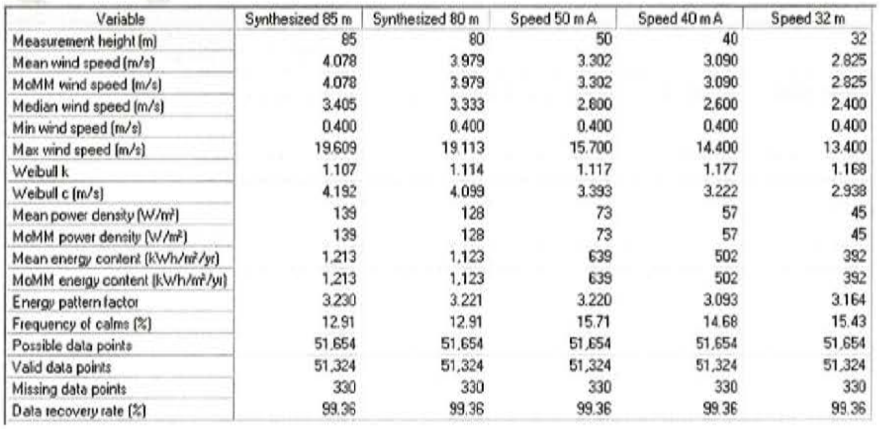


Data set properties
Latitude: N 62° 18' 21.960"
Longitude: W 145° 19' 18.720"
Elevation: 64 m
Start date: 5/20/2013 00:00
End date: 5/21/2014 17:00
Duration: 12 months
Time step: 10 minutes
Data points: 2,376,084
Calm threshold: 0.4 m/s

Environmental conditions
Mean temperature: -1.26 °C
Mean pressure: 100.5 kPa
Mean air density: 1.291 kg/m³
Air density ratio: 1.054

Wind speed and power
Mean at 85 m: 4.08 m/s
Power density at 50m: 74 W/m²
Wind power class: 1 (Poor)

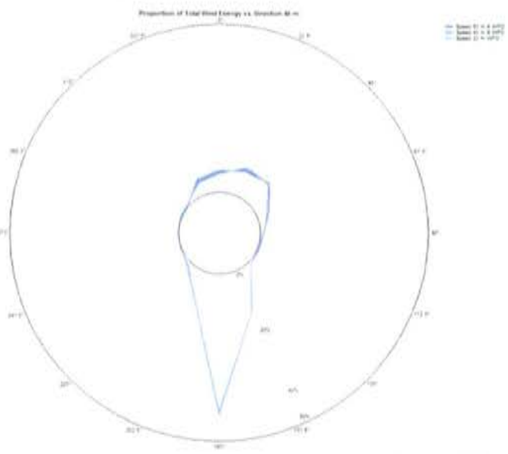
Wind shear coefficients
Power law exponent: 0.373
Surface roughness: 3.65 m
Roughness class: 4.99

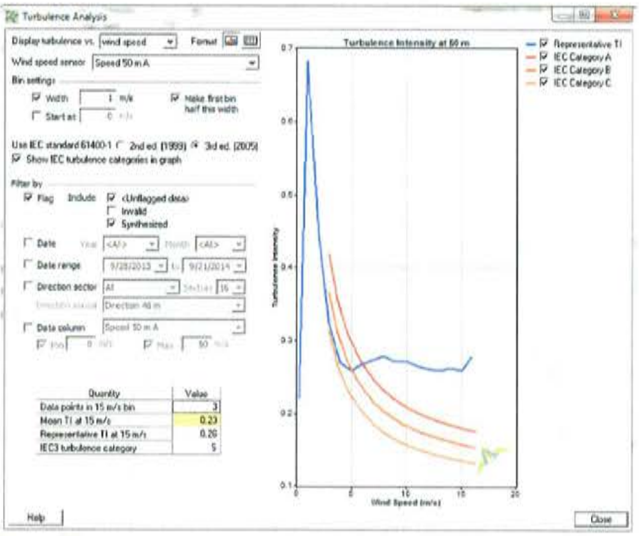


| Variable | Synthesized 85 m | Synthesized 80 m | Speed 50 m A | Speed 40 m A | Speed 32 m |
|---|---|---|---|---|---|
| Measurement height (m) | 85 | 80 | 50 | 40 | 32 |
| Mean wind speed (m/s) | 4.078 | 3.979 | 3.302 | 3.090 | 2.825 |
| MoMM wind speed (m/s) | 4.078 | 3.979 | 3.302 | 3.090 | 2.825 |
| Median wind speed (m/s) | 3.405 | 3.333 | 2.800 | 2.600 | 2.400 |
| Min wind speed (m/s) | 0.400 | 0.400 | 0.400 | 0.400 | 0.400 |
| Max wind speed (m/s) | 19.609 | 19.113 | 15.700 | 14.400 | 13.400 |
| Weibull k | 1.107 | 1.114 | 1.117 | 1.177 | 1.168 |
| Weibull c (m/s) | 4.192 | 4.099 | 3.393 | 3.222 | 2.938 |
| Mean power density (W/m²) | 139 | 128 | 73 | 57 | 45 |
| MoMM power density (W/m²) | 139 | 128 | 73 | 57 | 45 |
| Mean energy content (kWh/m²/yr) | 1,213 | 1,123 | 639 | 502 | 392 |
| MoMM energy content (kWh/m²/yr) | 1,213 | 1,123 | 639 | 502 | 392 |
| Energy pattern factor | 3.230 | 3.221 | 3.220 | 3.093 | 3.164 |
| Frequency of calms (%) | 12.91 | 12.91 | 15.71 | 14.68 | 15.43 |
| Possible data points | 51,654 | 51,654 | 51,654 | 51,654 | 51,654 |
| Valid data points | 51,324 | 51,324 | 51,324 | 51,324 | 51,324 |
| Missing data points | 330 | 330 | 330 | 330 | 330 |
| Data recovery rate (%) | 99.36 | 99.36 | 99.36 | 99.36 | 99.36 |

Winds are very mild at a mean 50-meter wind power density of 73 watts per square meter. A Weibull K of 1.117 versus a more normal 2.0 is also indicative of a low wind regime. The colder air increases the density (and subsequent power potential) by 5.4 percent, but not enough to overcome the general low wind regime at the site.

Average winds are low at 3.3 meters per second. Minimal levels of icing were seen during winter months with modest icing in October. The wind shear is quite high such that vertical extrapolations using the 0.349 value should be viewed cautiously. The site has low extreme wind estimates. Estimated net capacity factor for a 2.5 megawatt wind turbine is 13.53% (poor) with no power produced 45 percent of the time. Energy-producing winds are generally out of the south. Diurnal pattern indicates stronger afternoon winds driven by surface heating. Winds are strongest during the few passing storm systems. Turbulence intensity is IEC level S which exceeds turbine manufacturer upper limits.





Display turbulence vs. wind speed

Wind speed sensor Speed 50 m A

Bin settings

☑ Width 1 m/s ☑ Make first bin half this width

☐ Start at 0 m/s

Use IEC standard 61400-1 ○ 2nd ed. (1999) ● 3rd ed. (2005)

☑ Show IEC turbulence categories in graph

Filter by

☑ Flag Include ☑ <Unflagged data> ☐ Invalid ☑ Synthesized

☐ Date Year <All> Month <All>

☐ Date range 9/28/2013 to 9/21/2014

☐ Direction sector All Sectors 16

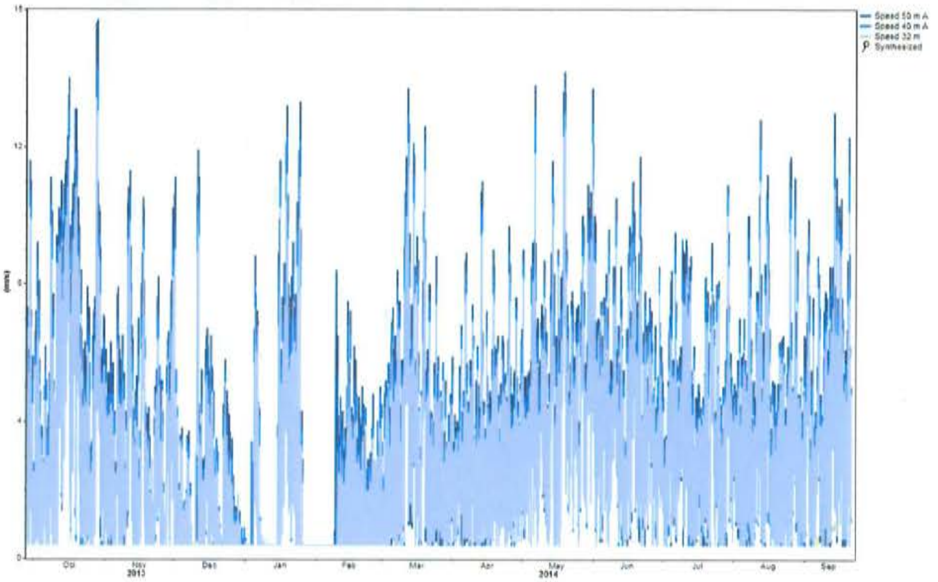
Direction sensor Direction 40 m

☐ Data column Speed 50 m A

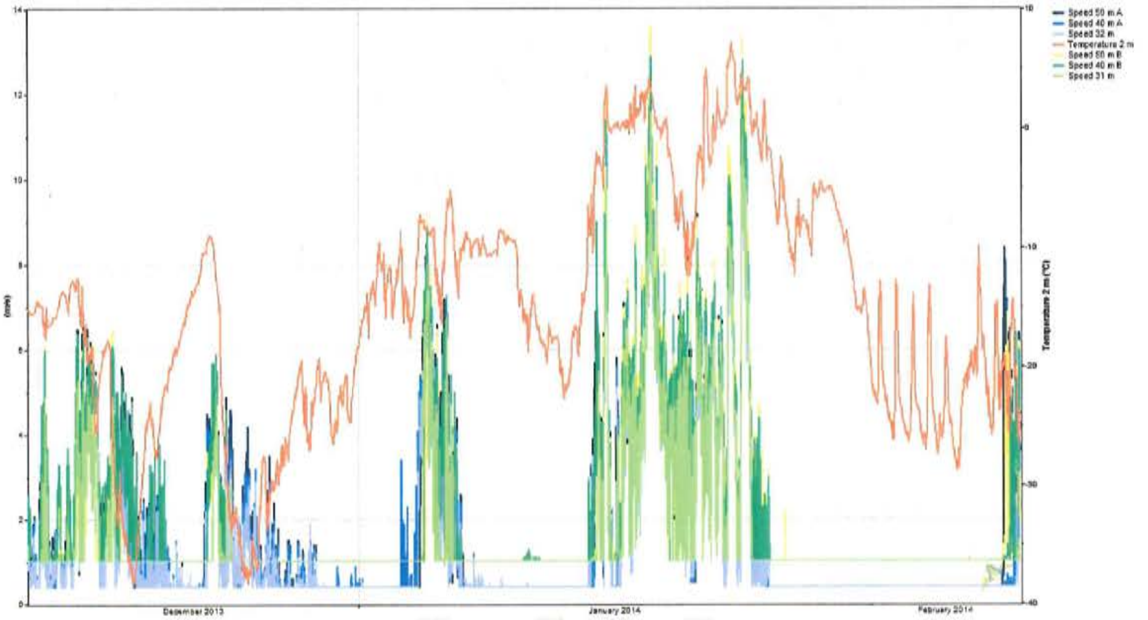
☑ Min 0 m/s ☑ Max 50 m/s

| Quantity | Value |
|---|---|
| Data points in 15 m/s bin | 3 |
| Mean TI at 15 m/s | 0.23 |
| Representative TI at 15 m/s | 0.26 |
| IEC3 turbulence category | S |

The wind speed trend indicates a fairly consistent pattern with only a few periods driven by stronger storm-based systems.

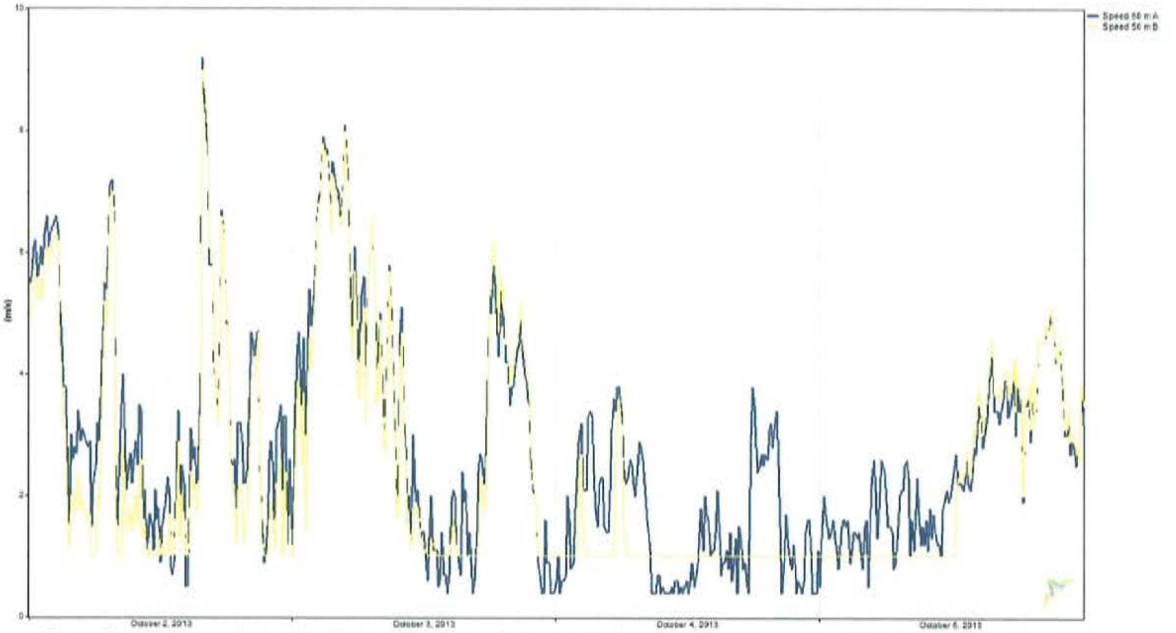


While a cursory review of the data trends might lead the observer to assume a high level of icing events during late December through part of January and much of February, closer study indicates that the temperatures are too cold for ice formation and the sensors at all heights move in concert. This points to periods of low wind rather than ice or hoar frost formation. The data should not be flagged for icing nor should it be deleted and synthesized to predict a higher expected wind turbine output for these periods.



Periods of low wind – not icing

Some periods of hoar frost formation were observed on the B anemometers, but these occur under low wind speed conditions as indicated by the A anemometers. Ironically, it is the B sensor group that is labeled as "NRG IceFreeIII". Hoar frost forms in low to no wind conditions and quickly sheds as the wind speed picks up to the minimum point at which a wind turbine would begin to produce power. Again, no data deletion or synthesizing is recommended in the data set. The consistency of the B sensors reading lower than the A sensor group suggests that they happened to be positioned on the side of the tower that is more prone to hoar frost formation.



Hoar frost observed on 50m B anemometer (yellow) during low wind speeds on the A anemometer (blue)

## WIND TURBINE SITING CONSIDERATIONS

Siting constraints will be driven primarily by land ownership issues as the site was originally chosen due to its close proximity to a transmission line. AEA is not aware of any met tower permitting issues with the FAA or US Fish & Wildlife Service, having not been involved in the permitting process. The height of the met tower did not trigger the requirement for FAA notification, but a wind turbine over 200 feet AGL will trigger FAA notification. Regardless, the high turbulence at this site prevents any project development.

## INTEGRATED POWER SYSTEM CONSIDERATIONS

The size of the CVEA load would allow for several megawatts of variable wind energy on the grid. Average annual wind energy exceeding 8-10 percent of the load would require the presence of more complex integration controls or storage, which could include a hydro-electric facility with dam storage.

## BARRIERS

- The site has a very low wind resource.
- The site has prohibitive turbulence.

## CONCLUSIONS

Wind energy development is not recommended in this area unless it is the only choice available for off-grid applications. Even under this scenario, the project developer should compare cost payback of a wind system with the cost of running a diesel generator.

Utility scale wind energy development is not recommended at this site.

## CONTACT INFORMATION

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## ACKNOWLEDGMENTS

Copper Valley Electric Association provided the data set used for analysis.