Sonic Detection and Ranging (SODAR) Data Collection and Evaluation Report

Bolt Mountain, Pocahontas Land Corporation, B&L Excavating

Bolt Mountain, Wyoming County, West Virginia

(Data Evaluation Period: June 25, 2014 to March 31, 2015)

Compiled by:

Marshall University Center for Environmental, Geotechnical and Applied Sciences (CEGAS)

Under Direction of:

West Virginia Division of Energy

Funded by:

Appalachian Regional Commission

West Virginia Division of Energy

July, 2015

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Attachments

1.0 Introduction

Marshall University's Center for Environmental, Geotechnical and Applied Sciences (CEGAS) partnered with the West Virginia Division of Energy to perform initial screening and wind resource data collection to assess wind development opportunities at selected surface mine properties in West Virginia using Sonic Detection and Ranging technologies. Funding for this study provided under joint partnership from the Appalachian Regional Commission and the West Virginia Division of Energy.

1.1 Project Location and Site Conditions

The site is located at the Pocahontas Land Corporation, B&L Excavating quarry operations, located near Bolt, Raleigh County, West Virginia. The SODAR unit was physically in Wyoming County along a ridgeline that forms the Wyoming/Raleigh County border. Wind resource data collection occurred on the site at Latitude 37.777, Longitude -81.457, at an elevation of 3,185 feet (971 meters) above mean sea level. This area is along a ridgeline with active quarry operations. On each side of the ridgeline surface mine operations have taken and are taking place. A site location map is provided in Attachment A.

The immediately surrounding area consists of dormant quarry property with active quarry within quarter of a mine. Minimal ground vegetation is present, and various species of trees cover the ridgeline outside the boundary of the quarry. Trees are at various ages, and are generally 10 to 60 feet tall. The main access road is located northwest of the SODAR location, with occasional traffic and/or related noise from quarry mine operations.

B&L Excavating leases the property for quarry operations. The tract where the SODAR was located is owned by Pocahontas Land Corporation. This property owner owns several thousand acres in the area.

1.2 Data Collection Description

Wind resource data was collected using a Triton Sonic Wind Profiler, manufactured by SecondWind, utilizing Sonic Detection and Ranging (SODAR) technology. Data collection occurred between June 25, 2014 and March 31, 2015. Photos showing the Triton unit and surrounding area are included in Attachment A. The Triton unit was set up per SecondWind recommendations, including leveling of the unit to within operating condition (within 3 degrees of level), and proper directional orientation of the unit using Global Positioning System and magnetic compass equipment. The Triton unit is oriented properly when the south sound beam is positioned to within a few degrees of South. A Site Information Form and Checklist was

completed during initial setup, which records site conditions, including nearby surface features, site noise, and unit operation parameter checks. A copy of the Site Information Forms and Checklists are included in Attachment A.

1.3 SODAR Configuration

The Triton Sonic Wind Profiler utilizes a hexagonal 36-speaker array to transmit high frequency acoustic pulses, or "chirps", and measures how they scatter and return to the unit. Sources of scattering are irregularities in wind velocities, air temperature and density, causing acoustic refractive index changes. By measuring the Doppler shifted frequency of the returned signal or echo, the SODAR determines wind speed and direction at various altitudes. Additional information on Triton Sonic Wind Profiler's operational details is available at: www.vaisala.com.

The SODAR unit saves records on 10-minute intervals. Each record includes data from 10 heights, ranging from 40 meters to 200 meters above ground surface. Data collected includes wind direction, horizontal and vertical wind speeds, turbulence, and general weather parameters, including temperature and barometric pressure.

2.0 SODAR Data Filtering and Performance

Using guidelines provided by Second Wind, SODAR data was filtered to remove low-quality data before analysis was performed. For this study, a 85% wind speed quality factor, as recommended by Second Wind, was used. During the time frame for this study, the SODAR unit operated during most of the period. The unit had a period of off and on operation between mid-December and late February due to mechanical issues. A Vaisala technician worked on the unit on two separate occasions and continuous service was restored in early March.

3.0 Results

All data collected during the study was exported into *Windographer* software for data analysis. *Windographer* is a wind data analysis program that reads data files directly from SODAR wind profilers and performs a number of calculations, including wind shear, turbulence intensity, extreme wind speeds, and wind turbine energy production. *Windographer* software version, Version 2.4.13, released in August of 2013, was used for data analysis. Wind speed mean averages at various elevations above the ground surface ranged from 3.51 meters per second (m/s) at 40 meters, increasing consistently to just over 7.39 m/s at 200 meters. Wind direction

was predominantly from the west, with mean wind directions generally West-Southwest. The following table, summarized from *Windographer* data analysis, provides a summary of wind speed, wind direction, vertical wind speed, and power density estimates at specified elevations from 40 to 200 meters above existing ground surface:

Elevation Above Ground Surface (819 m)	Wind Speed (m/s, mean)	Wind Direction (degrees, mean)	Vertical Wind Speed (m/s, mean)	Power Density (W/m^2, mean)
40 Meters	3.51	277.8	-0.001	56
50 Meters	3.88	273.7	-0.036	71
60 Meters	4.14	270.1	-0.064	83
80 Meters	4.71	262.9	-0.129	117
100 Meters	5.42	257.9	-0.189	167
120 Meters	6.04	255.3	-0.215	220
140 Meters	6.57	254.2	-0.212	273
160 Meters	6.94	253.6	-0.190	319
180 Meters	7.21	251.9	-0.179	366
200 Meters	7.39	249.6	-0.184	407

Monthly wind speed and wind direction graphs are provided in Appendix B. Also in Appendix B is a Data Summary Report, which includes wind frequency, mean wind speed, and total wind energy rose diagrams, plus project period wind speed and diurnal wind speed profiles. A complete SODAR data collection package is available upon request to the West Virginia Division of Energy.

4.0 Wind Trends in Region

During the study time period, AWS Truepower's wind trends bulletin showed that winds in the study region were above average during the 3rd and 4th quarters of 2014 and slightly below average during the 1st quarter of 2015.

5.0 Findings Calculated to Specific Wind Turbine Energy Output

Three wind turbines were selected for comparison of energy output based on the findings from this data collection period. The three units selected are representative of small, medium, and large-scale wind turbines that may be utilized for small to large-scale wind power generation. Each turbine was selected with an appropriate hub height and energy output calculated using *Windographer* software. The following table summarizes turbine properties and associated energy output and related information:

Wind Turbine Model Number	Rated Power (kW)	Hub Height (meters)	Hub Height Wind Speed (m/s)	Mean Net Power Output (kW)	Net Capacity Factor (%)
Endurance G-3120	35	42.7	3.55	3.8	10.8
Vestas V52	850	74	4.48	71.4	8.4
GE 2.5xl	2,500	75	4.51	238.1	9.5

Complete wind turbine comparison summaries are provided in Attachment B.

6.0 Conclusions and Recommendations

Wind resource data collection occurred between June 25, 2014 and March 31, 2015. Late Spring and Summer months normally experience lower than yearly average wind speeds; winter months normally experience the highest wind speeds for a given 1-year period. These expected results were observed at the Bolt Mountain site. Recorded wind resource data and associated net capacity factors were below levels normally associated with commercial wind energy development standards.

Based on data collected, commercial wind energy generation at this site is not recommended. Output from small-scale wind energy generation appears to be similar to commercial scale; however, in remote locations, the use of wind energy may be more economical than establishing traditional power infrastructure. This class of wind turbines are favorable for use by a single business, and/or for residential energy generation use.

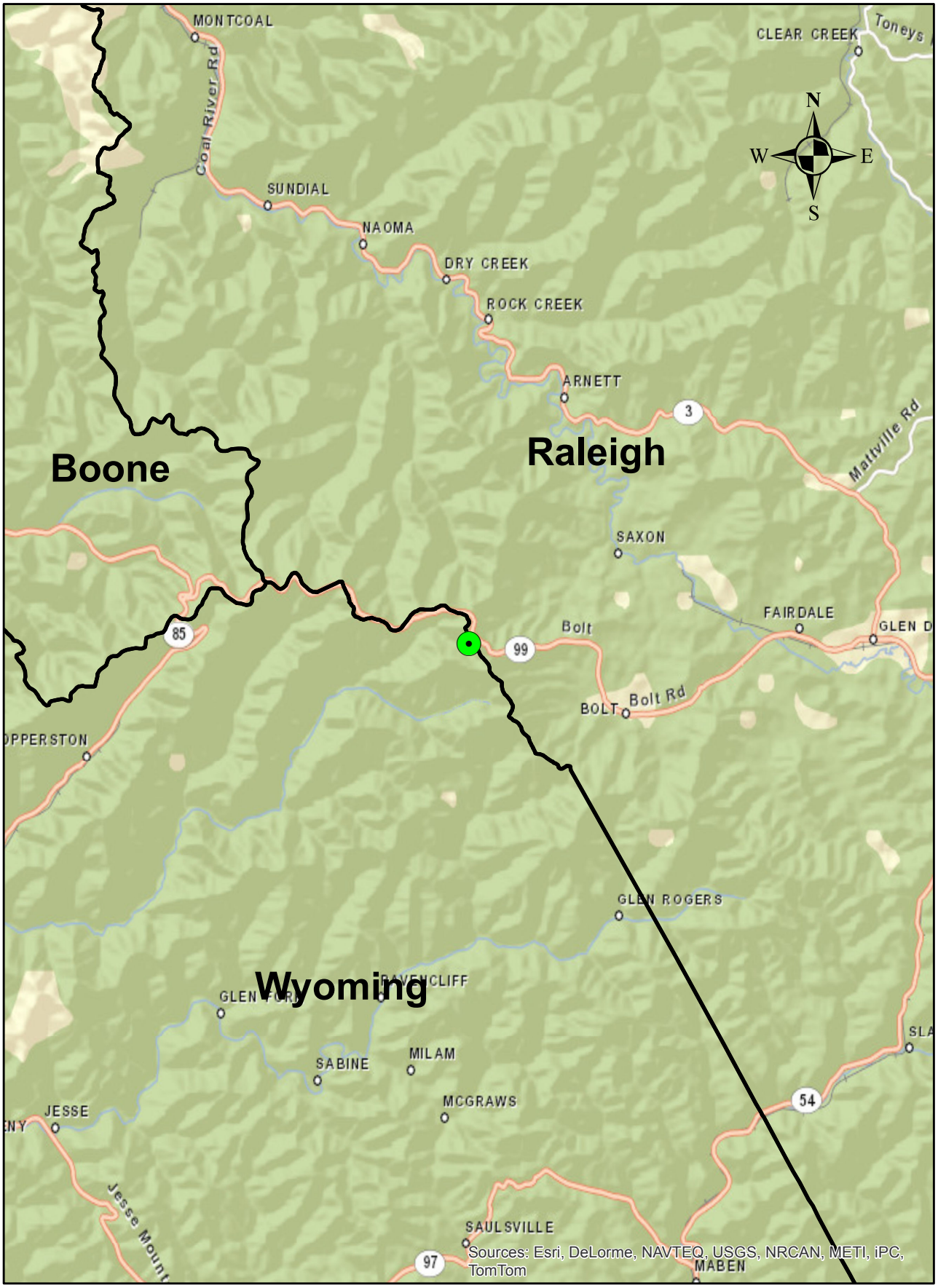
ATTACHMENT A

Site Location Map

Site Photos

SecondWind Site Information Form and Checklist

Bolt Mountain SODAR Site Map



1.5 0.75 0 1.5 Miles

Legend

- SODAR
- County Boundary

Top View: SODAR unit looking North

Bottom View: SODAR unit looking South

Top View: SODAR unit looking East

Bottom View: SODAR unit looking West

SECONDWIND

TRITON SONIC WIND PROFILER

Site Information Form & Checklist

1. Triton Information				
Triton Site Name:	Bolt Mtn. (Wyoming-Raleigh County Border)			
Triton Owner:	Marshall University			
Install Date:				6/25/2014
Triton Serial #:				258
Triton Model:	Circle/Highlight:	STD	HP	HR
Personnel Present:	G. Carico and J. Wolfe (CEGAS), Terry St.Clair (B&L Excavating)			

2. Site Information	
Surrounding Site Description (i.e. Windfarm, Forest, Field etc.)	Rock quarry with forestland surrounding site
Road Access Description (i.e. 4WD required)	Gravel road. 4x4 not required unless heavy snow.
Gate Key Location/Security Details	Locked gate. Access provided by B&L Excavating
Front Door Lock Details (Combo or Key Location)	Master Lock (same key required for security gate entrance)
Property Management Contacts	B&L Excavating, Phone 304-682-5963 (Office in Lynco, WV)

3. Fixed Object Vista Table

Description of Object	Azimuth (Deg)	Distance (ft)	Height of Object (ft)	Relative Elevation to Triton (m)
Rock quarry wall	NW, N & NE	150 ft	60-70 ft	Same
Trees	E	60 ft	About 30 ft max	Same
Trees	SW	90 ft	About 30 ft max	Same

4. Installation Checklist			
Item	✓	**Unit**	**Value**
Mechanical Inspection		List Damage/Defects	**None**
Exterior Warning Sign Cover Removed (Heater Only)		none	**NA**
Triton Properly Oriented		Record Azimuth of B-Beam (deg mag)	**B-beam South**
Triton Secured		Method (i.e. earth anchors, trailer, snow platform, etc.)	**Trailer, Fence**
Batteries Charged (>12.7V)		Record voltage level, V - DC	**13.7**
Solar Panels Installed, Connected		# of Panels	**2**
Solar Panels Charging		V - DC	**15.2**
Antifreeze Fluid Level (Heater Only)		none	**1/2 Full**
Propane Tanks installed		Tank capacity and level	**No (to be installed later in 2014)**
Propane Leak Test (Heater Only)		none	**NA**
Operator Panel: GPS		Red/Green/Rapid/Off	**green**
Operator Panel: SENSORS		Red/Green/Rapid/Off	**Green and then Orange Blinking**
Operator Panel: SUPPLIES		Red/Green/Rapid/Off	**green**
Operator Panel: SD CARD		Red/Green/Rapid/Off	**green**
Operator Panel: HEATER		Off/NA	**NA**
Operator Panel: NOTA (self-test)		Red/Green/Rapid/Off/NA	**green**
Operator Panel: ARRAY		Red/Green/Rapid/Off	**green**
Operator Panel: SODAR		Red/Green/Rapid/Off	**green**
Operator Panel: SNR		Red/Green/Rapid/Off	**green**
Operator Panel: INTERNET		Red/Green/Rapid/Off	**green**
Operator Panel: TSP		Red/Green/Rapid/Off	**green**
Operator Panel: SKYSERVE		Red/Green/Rapid/Off	**green**
Take Photos or Videos		Pictures of 360deg site and Anchored Triton	**Photos on file**
Ambient Noise Level		dB	**minimal**
Ambient Noise Description		(i.e. Birds, Crickets, Highway)	**Birds and occasional vehicles**
Triton Information (1) Section Complete		none	**None**
Site Information (2) Section Complete		none	**None**
Fixed Obstacle Vista Table (3) Complete		none	**None**

Installer's Signature: _____ Date: 6/25/2014

Installer's Name (print): George Carico

Installer's ID #: _____

ATTACHMENT B

Windographer Monthly Reports

Windographer Summary Report

Wind Turbine Energy Output Summaries

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Report Period: June 2014

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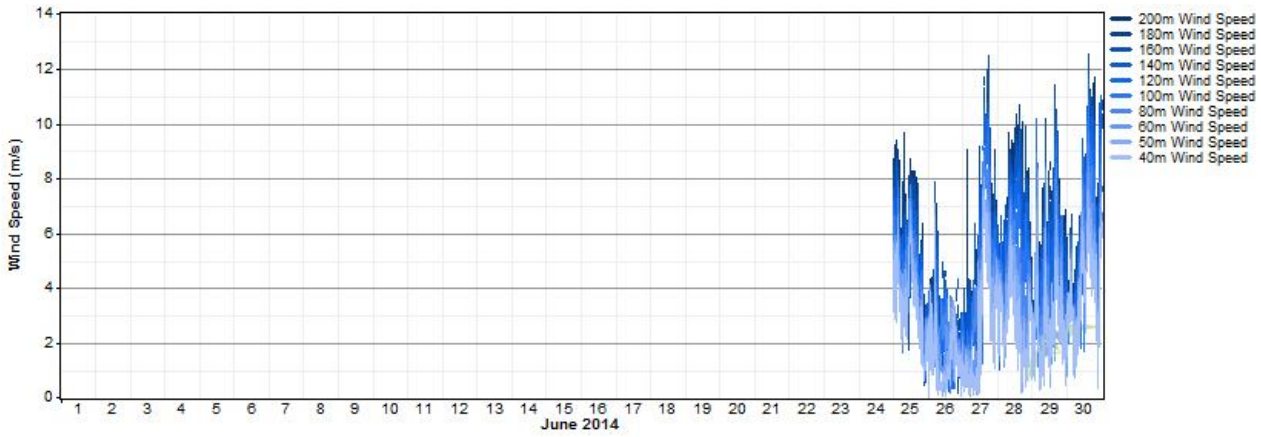

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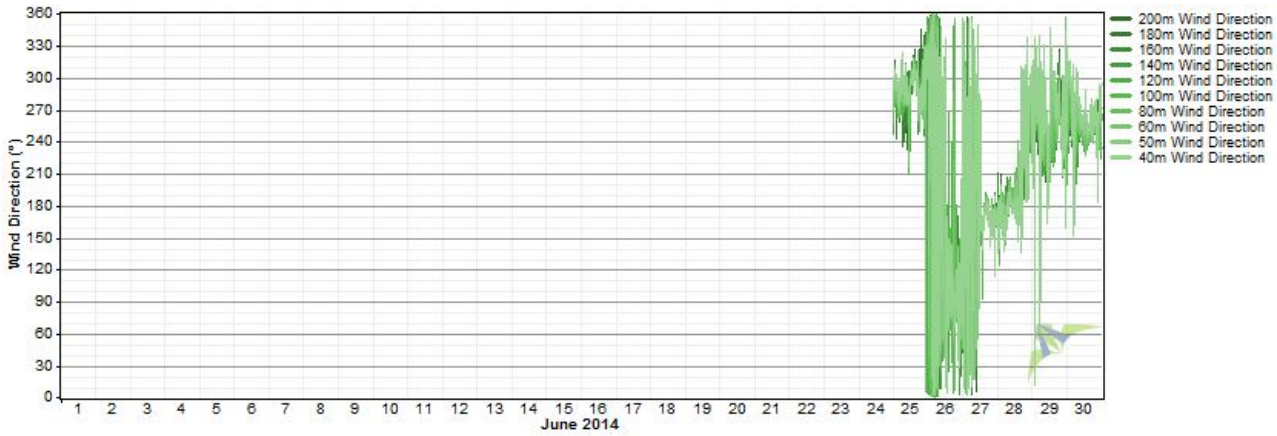

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Report Period: July 2014

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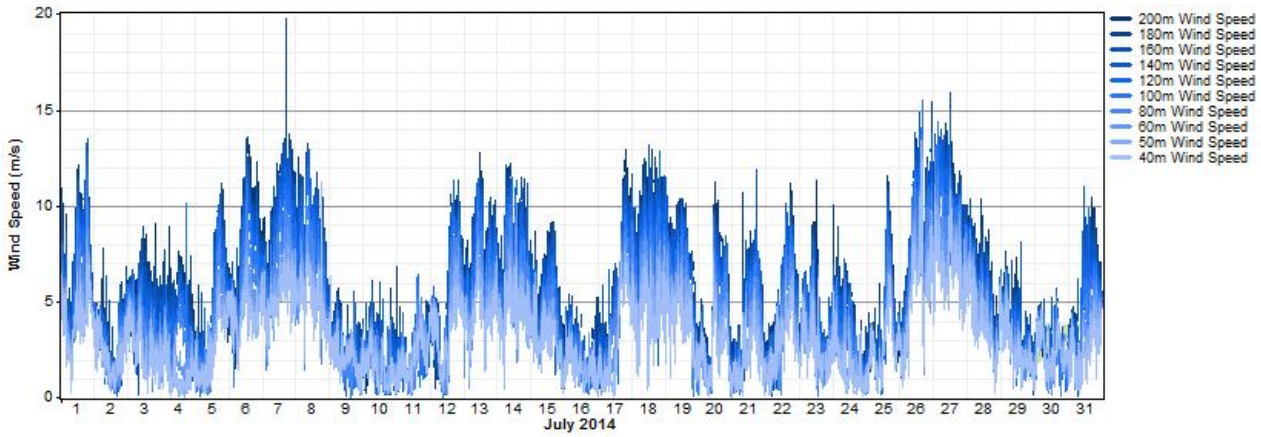

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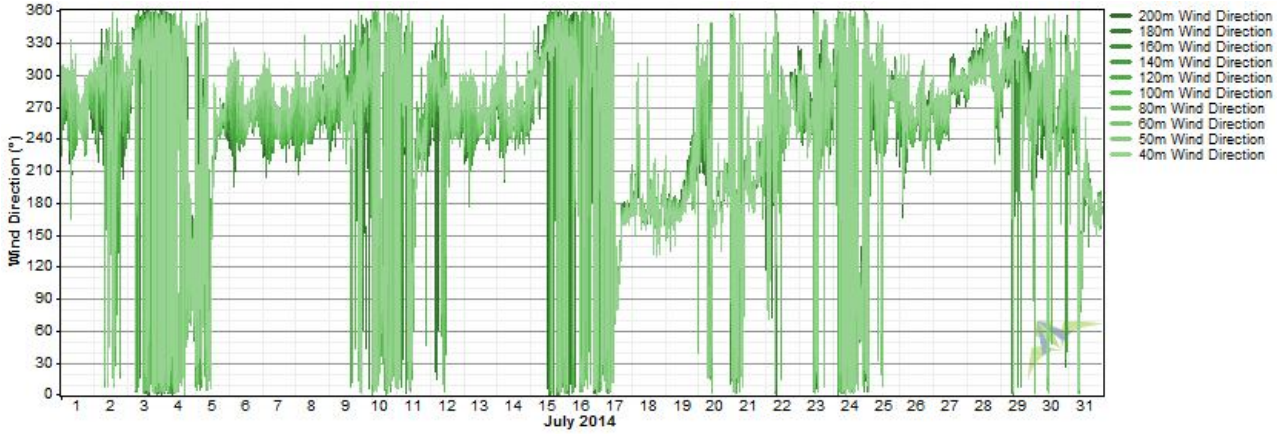

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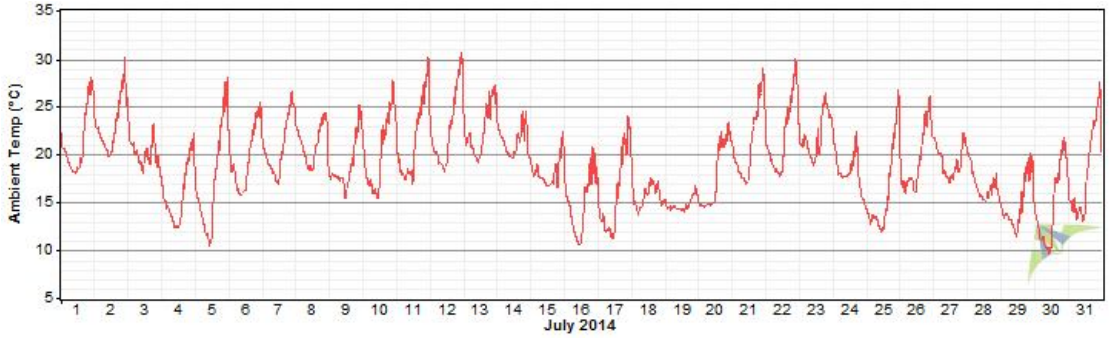

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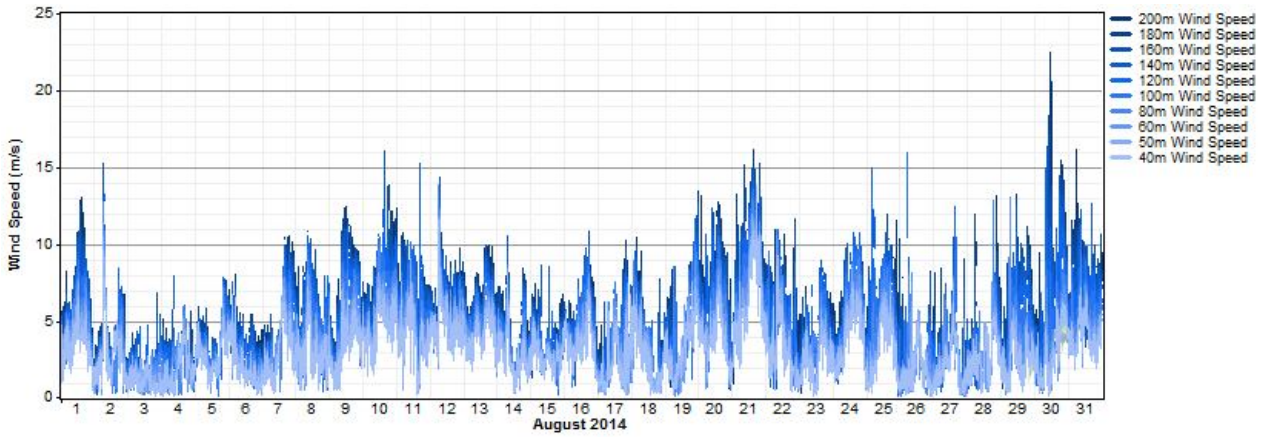

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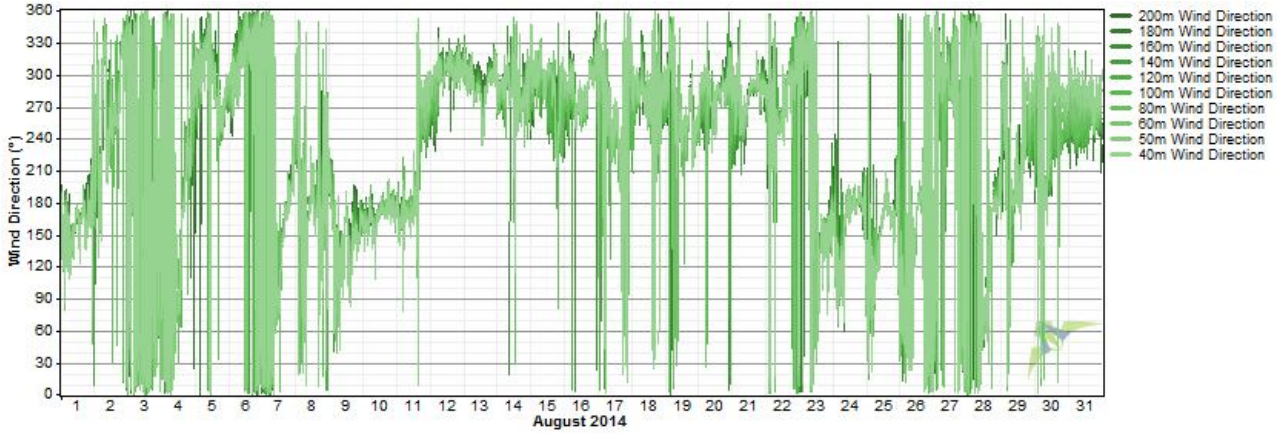

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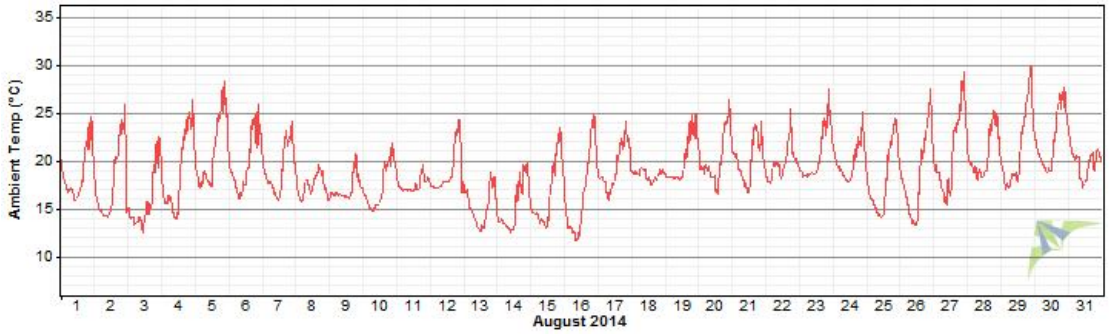

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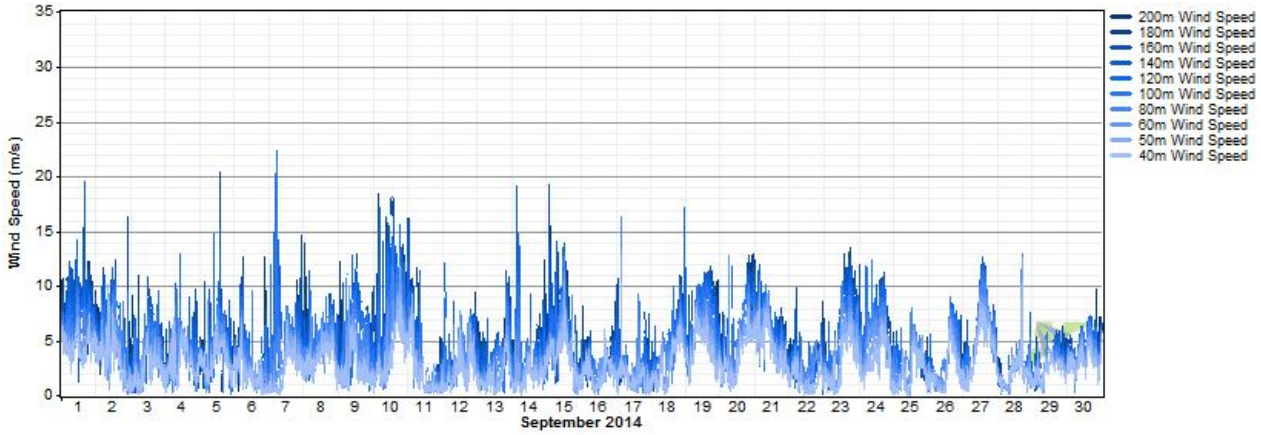

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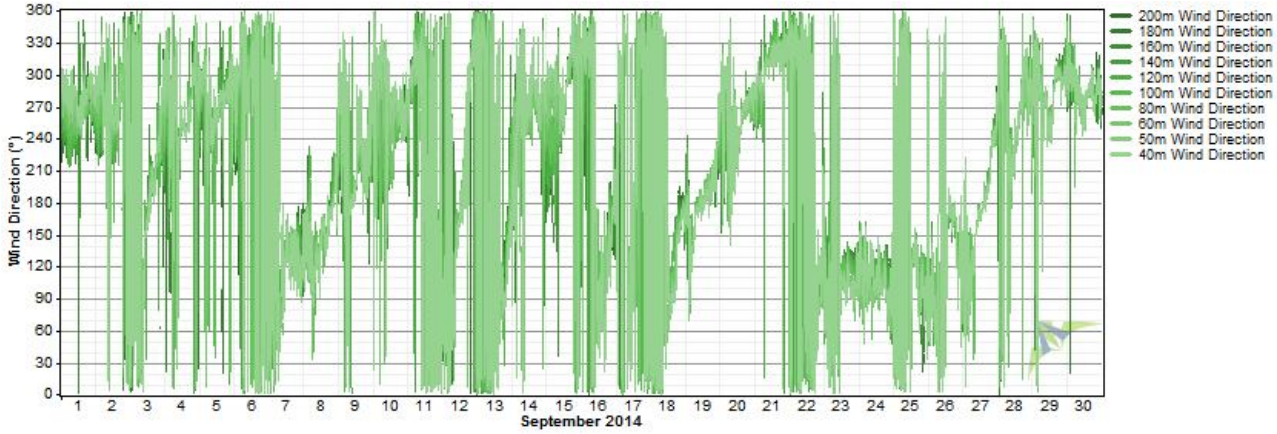

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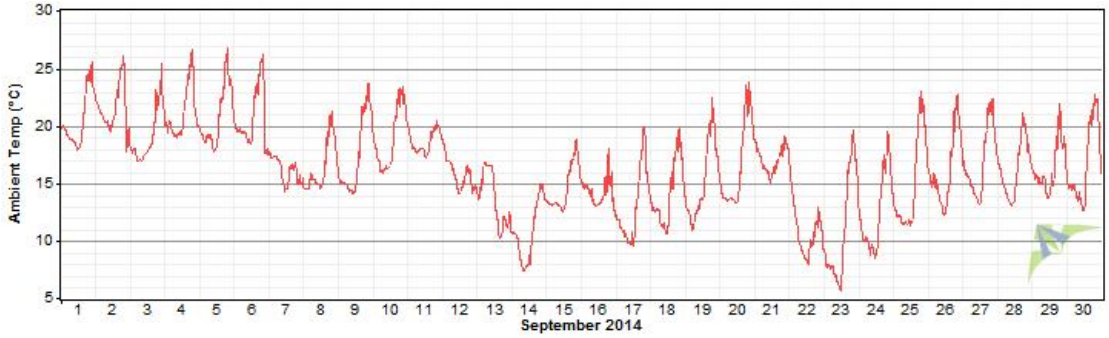

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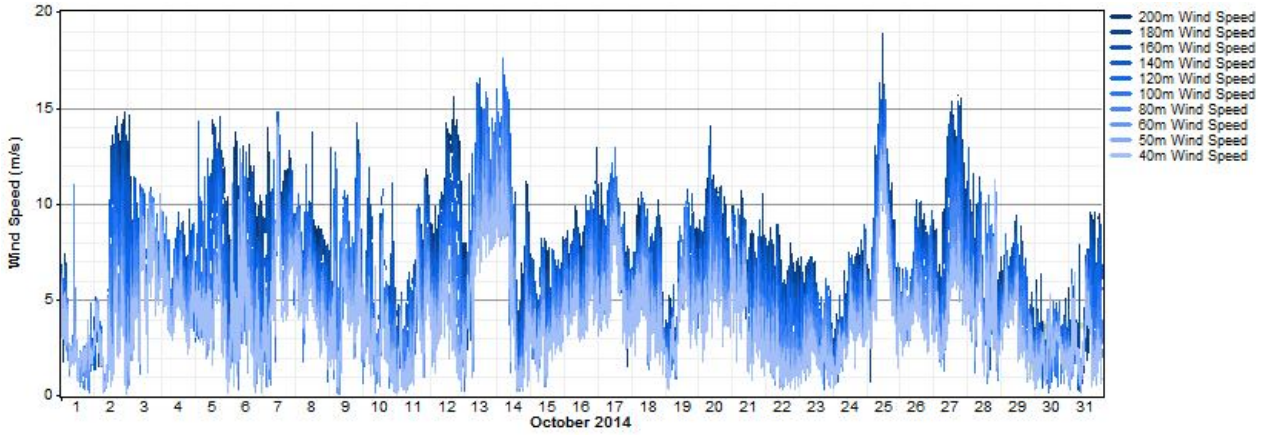

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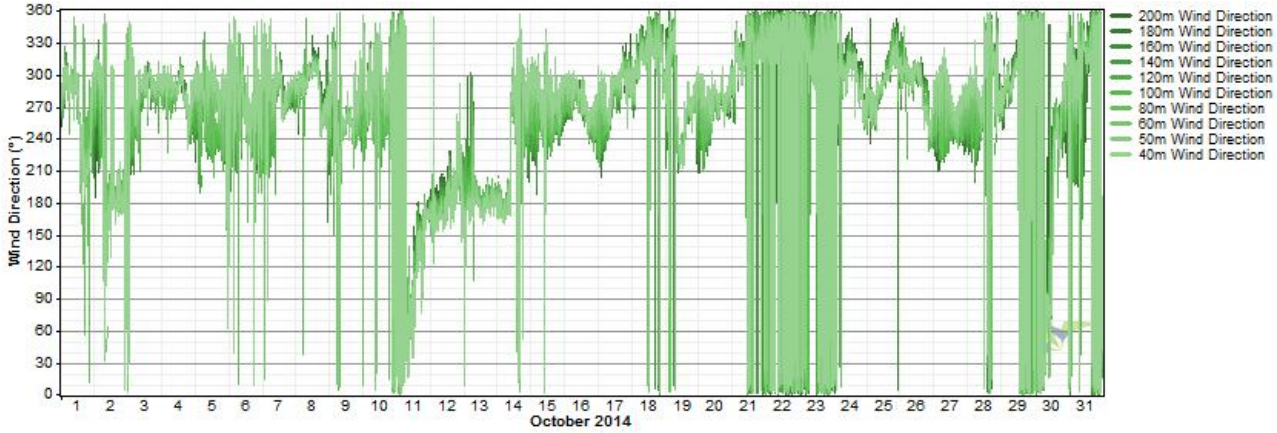

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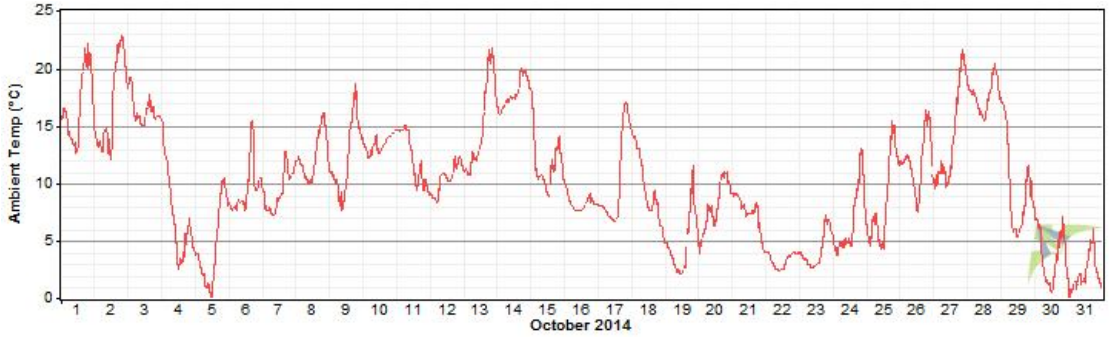

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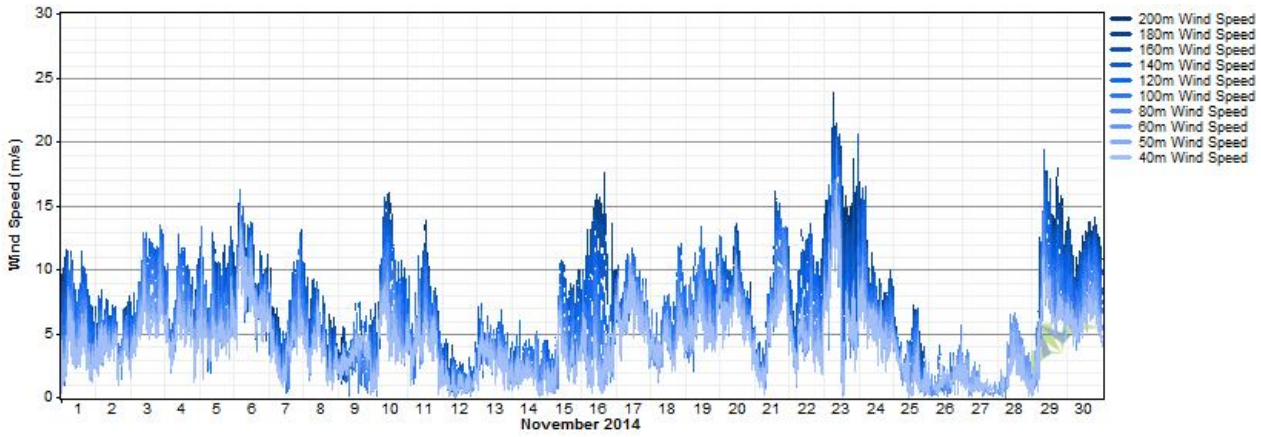

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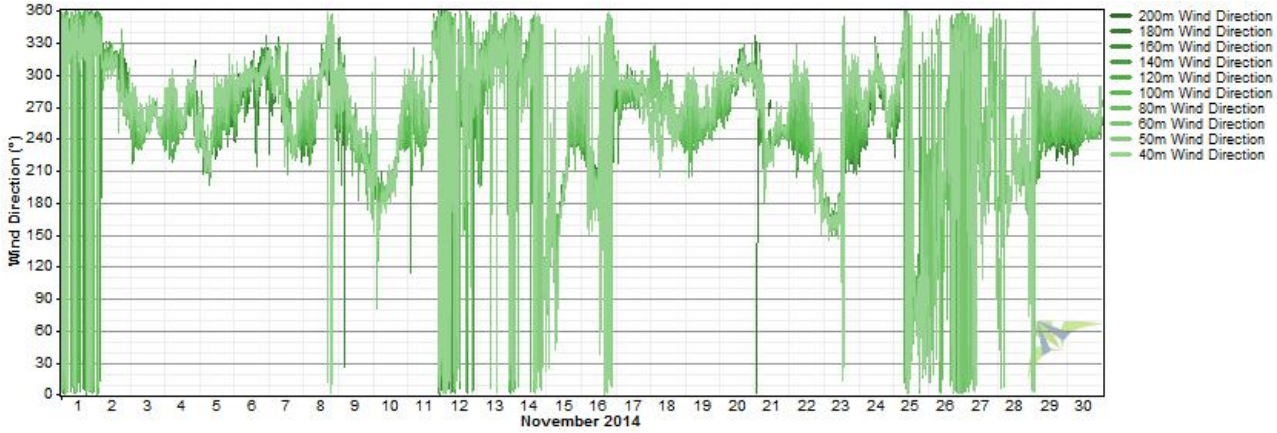

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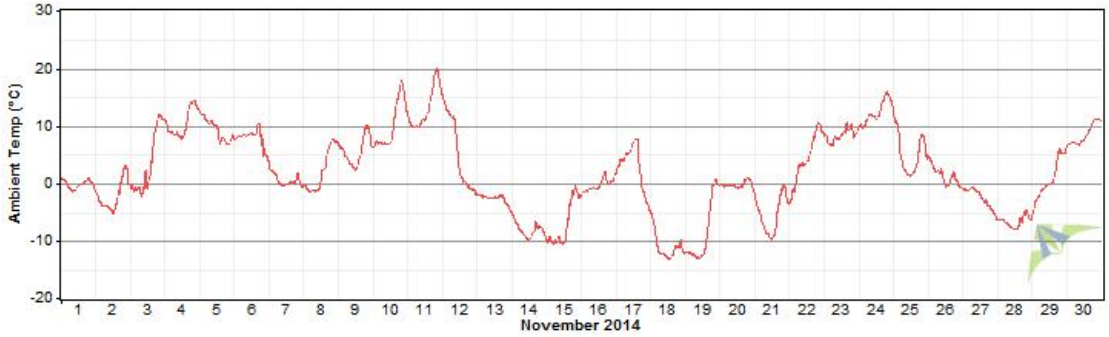

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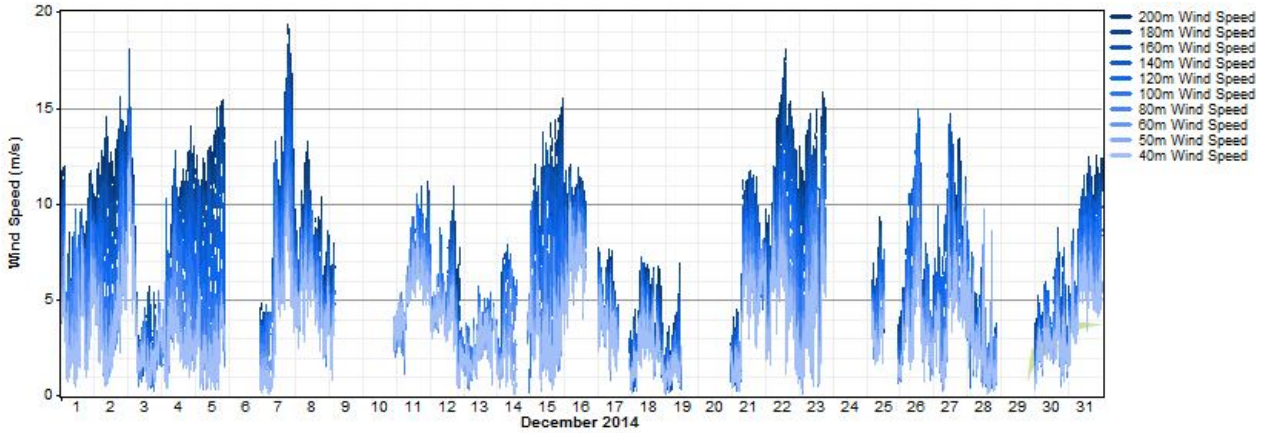

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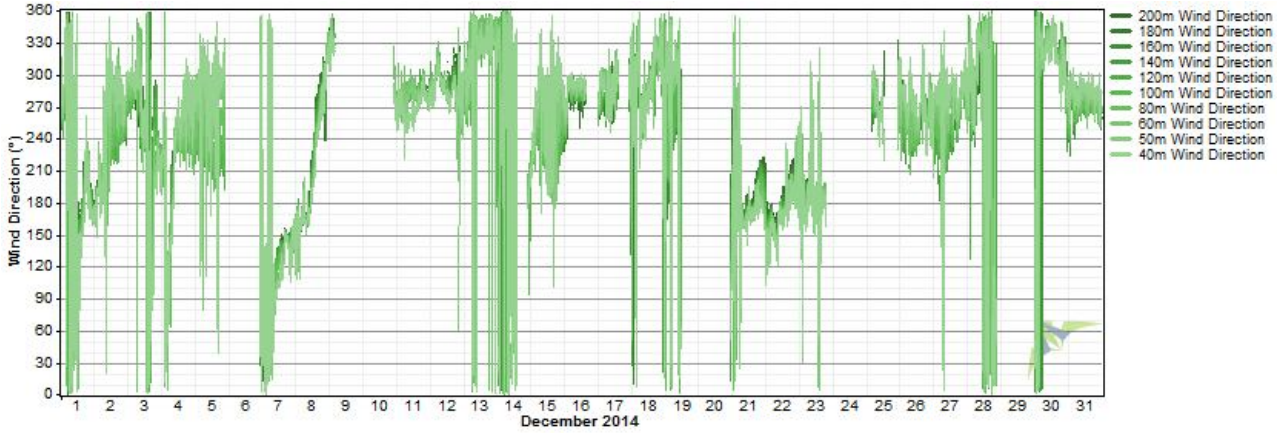

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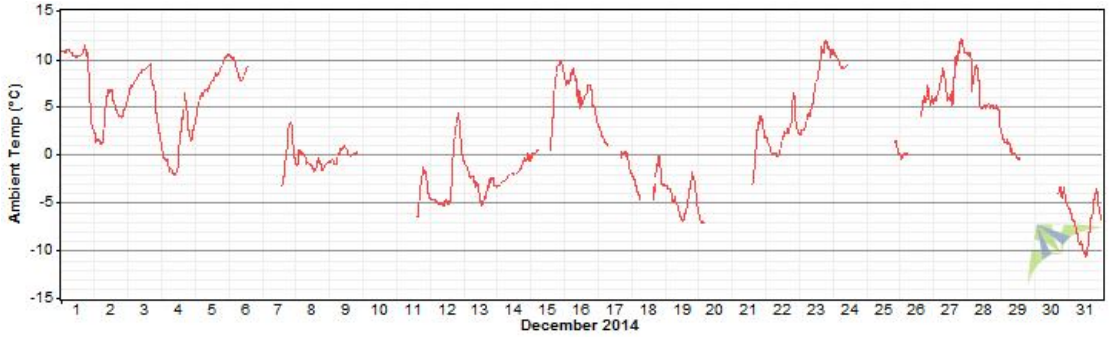

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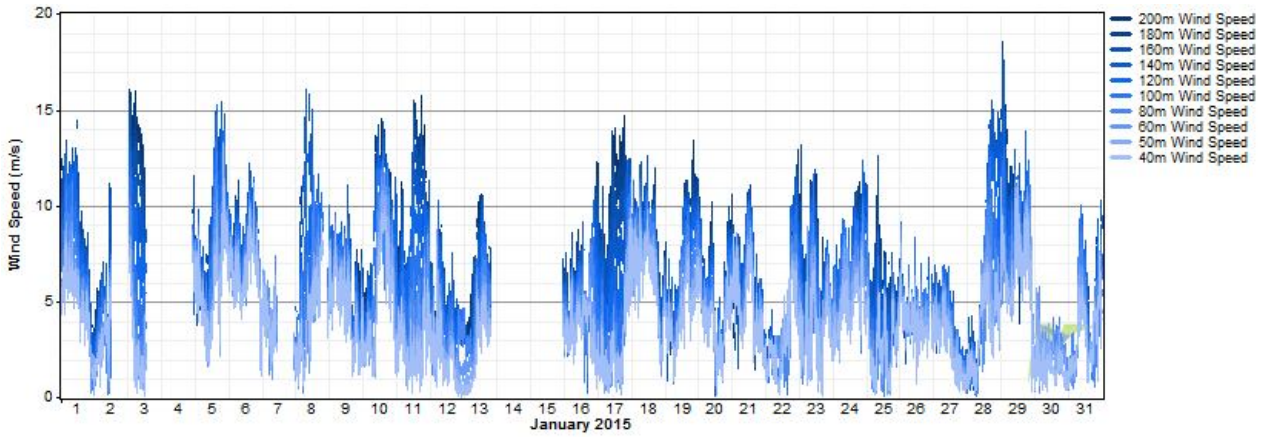

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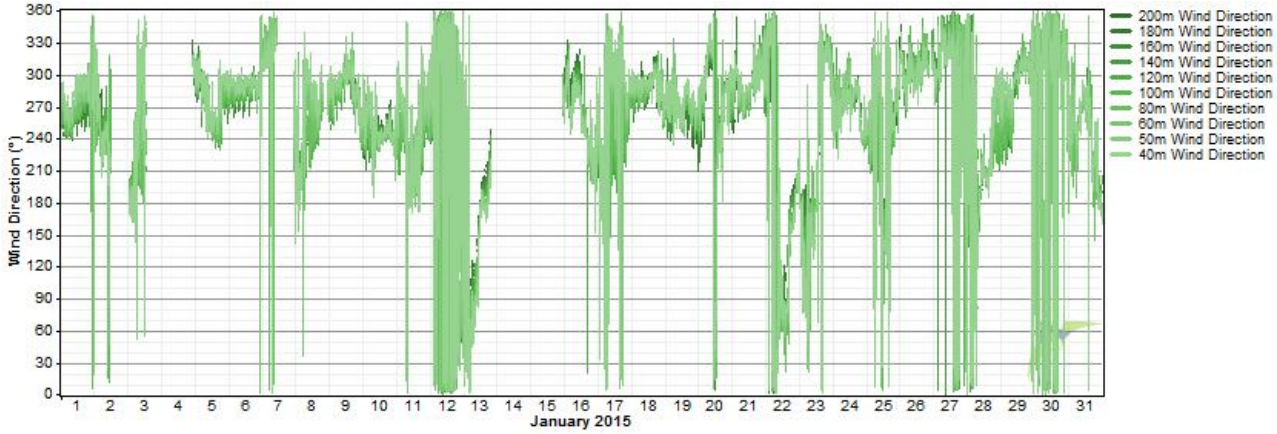

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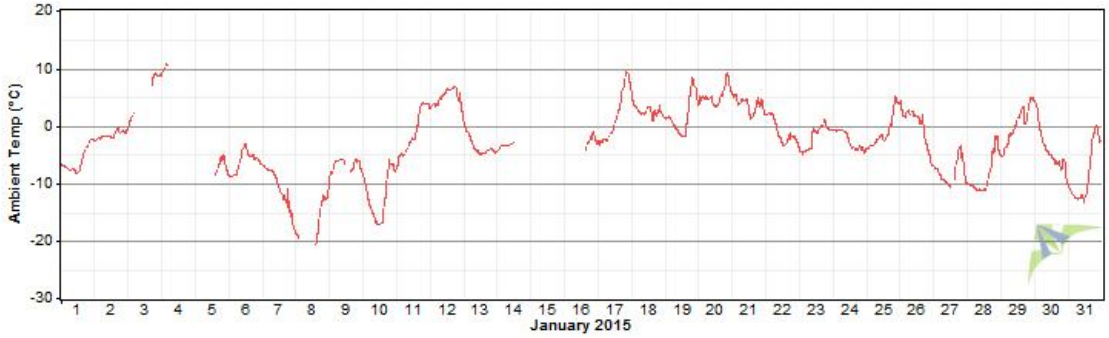

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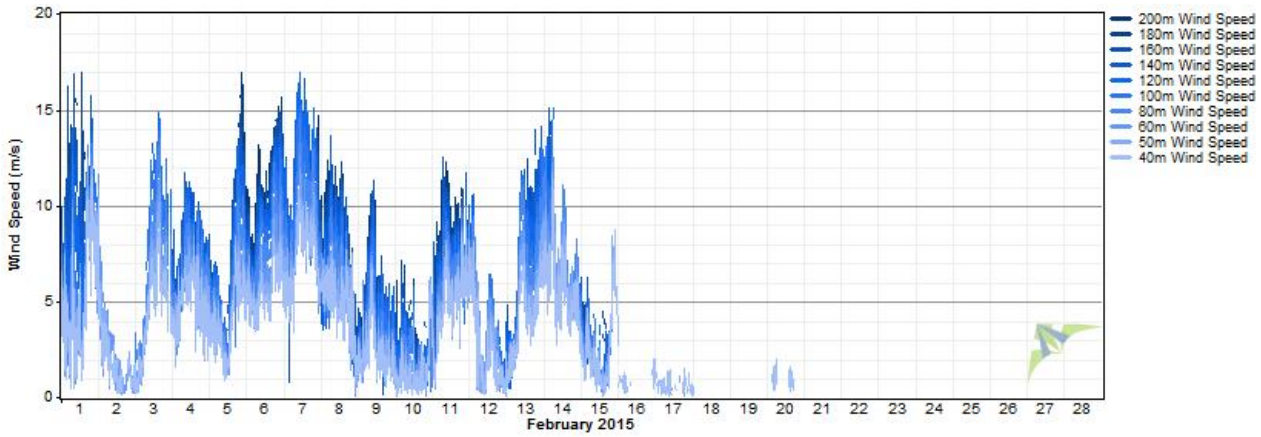

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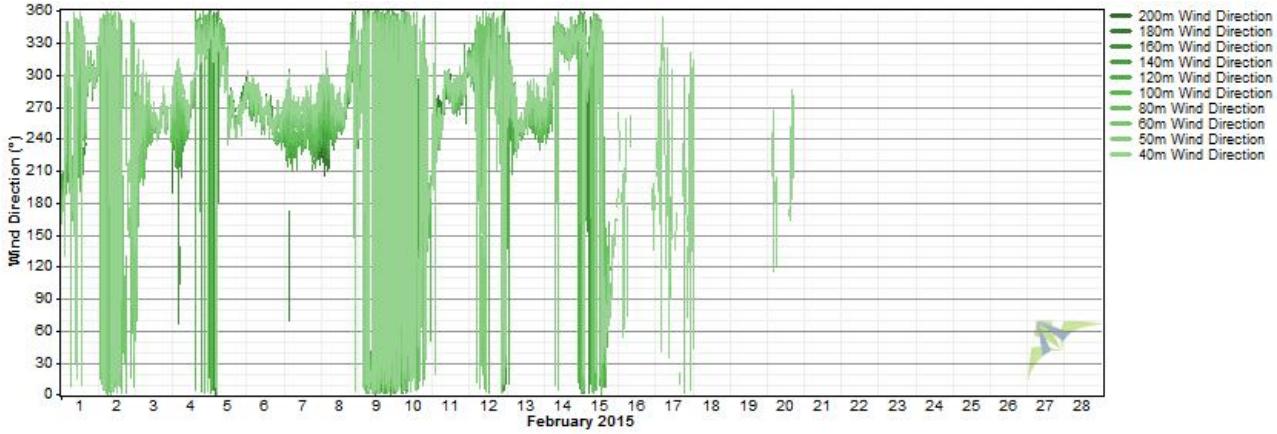

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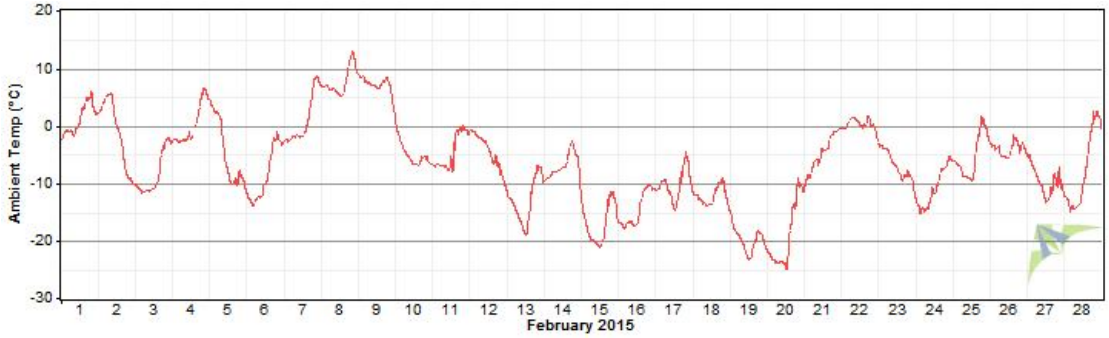

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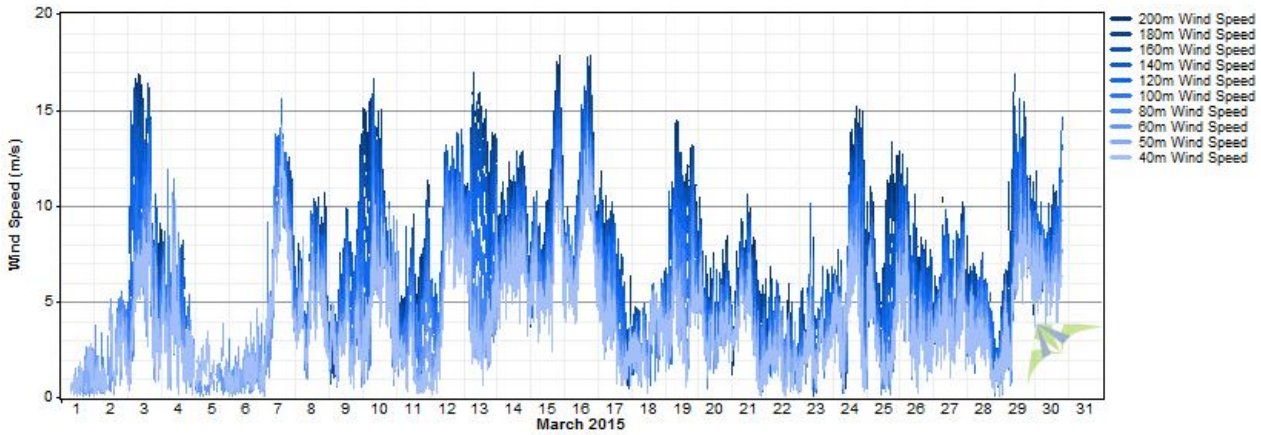

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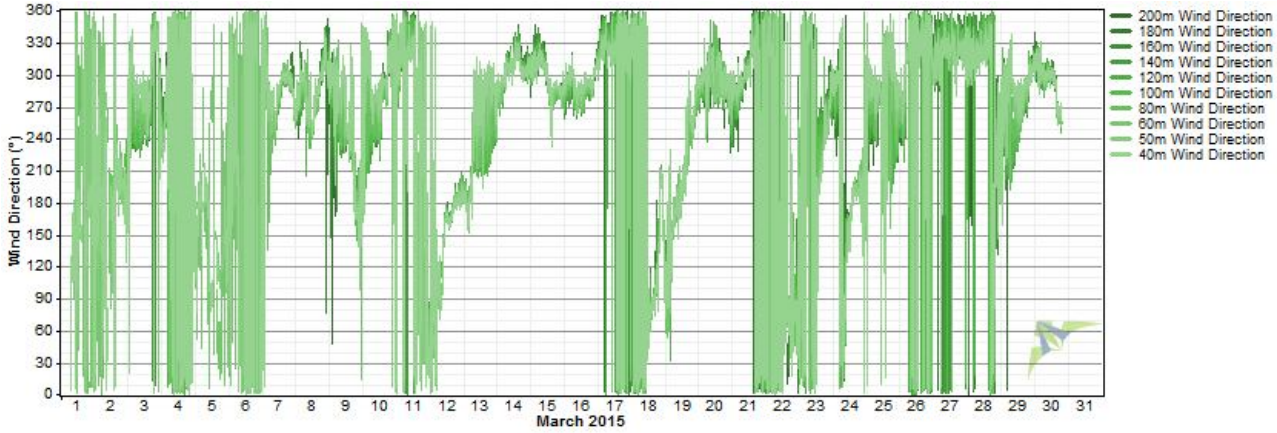

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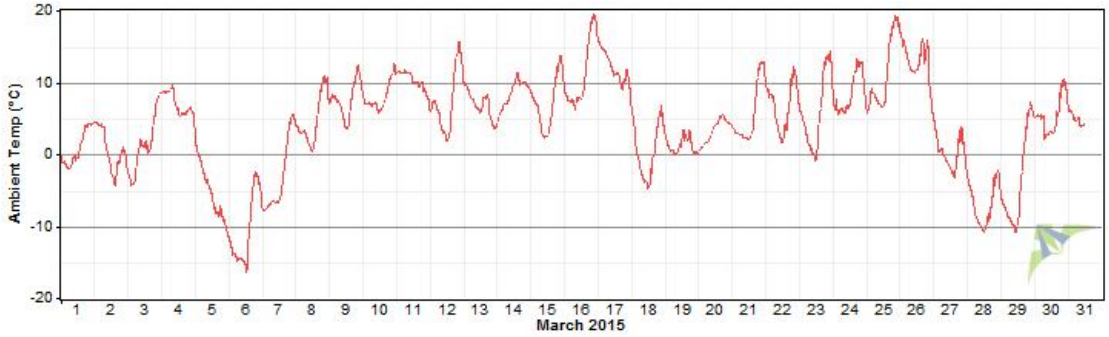

Data Set Properties

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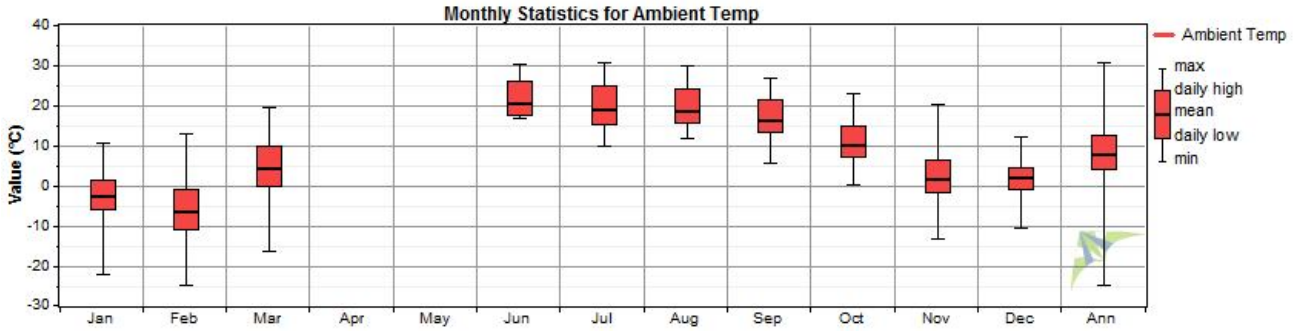
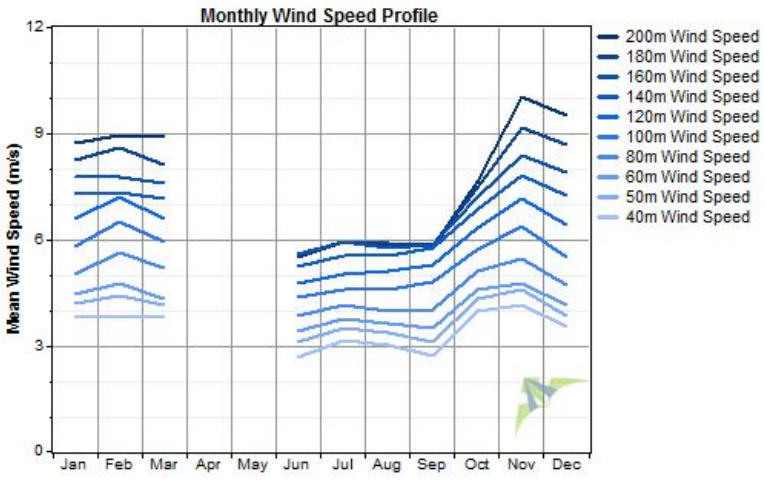
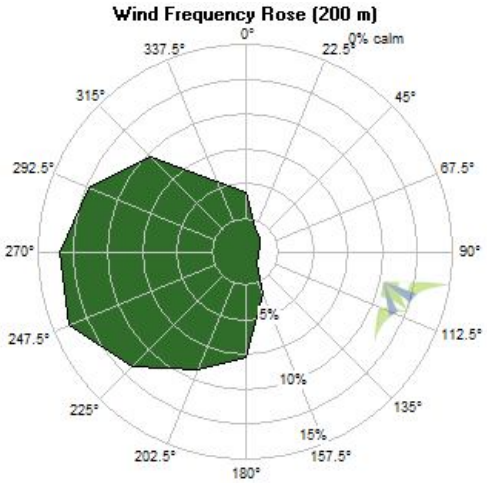
Filter Settings: <Unflagged data>

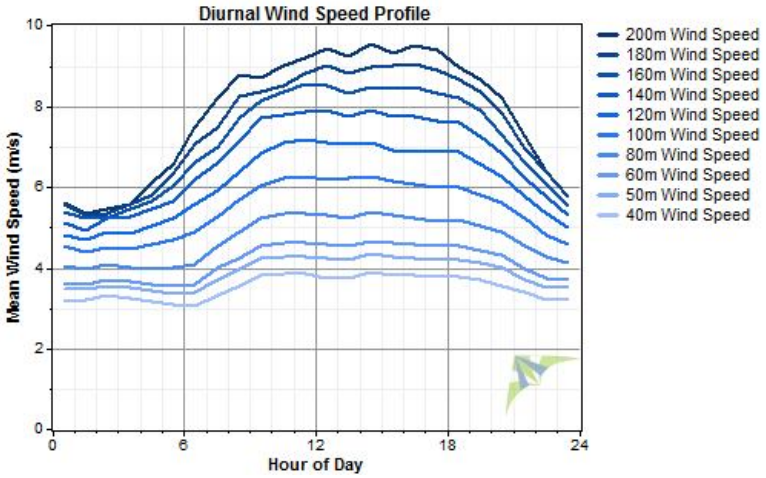
Variable	Value
Latitude	N 37.777510
Longitude	W 81.456530
Elevation	3185 ft
Start date	6/25/2014 00:00
End date	3/31/2015 12:00
Duration	9.2 months
Length of time step	10 minutes
Calm threshold	0 m/s
Mean temperature	7.79 °C
Mean pressure	909.0 mbar
Mean air density	1.128 kg/m³
Power density at 50m	70 W/m²
Wind power class	1 (Poor)
Power law exponent	0.495
Surface roughness	12 m
Roughness class	5.97
Roughness description	Urban

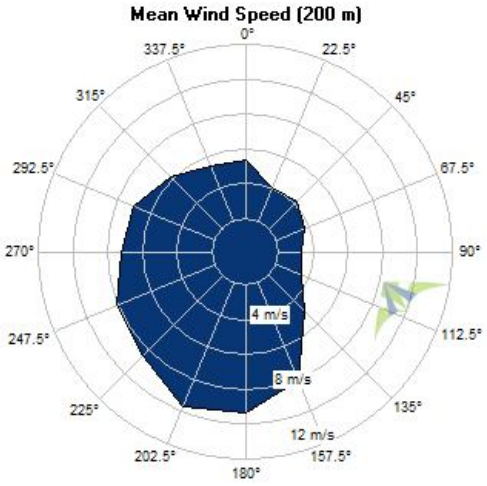


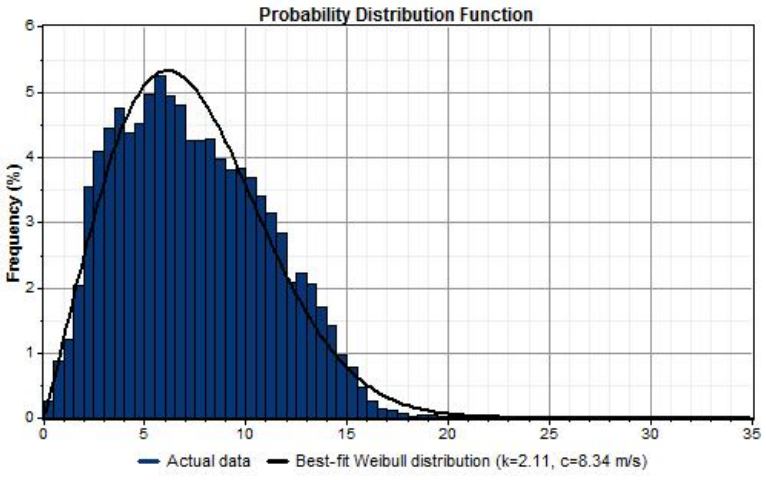
Wind Speed and Direction

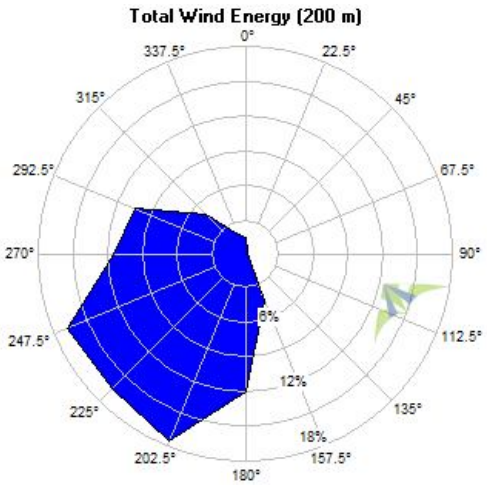




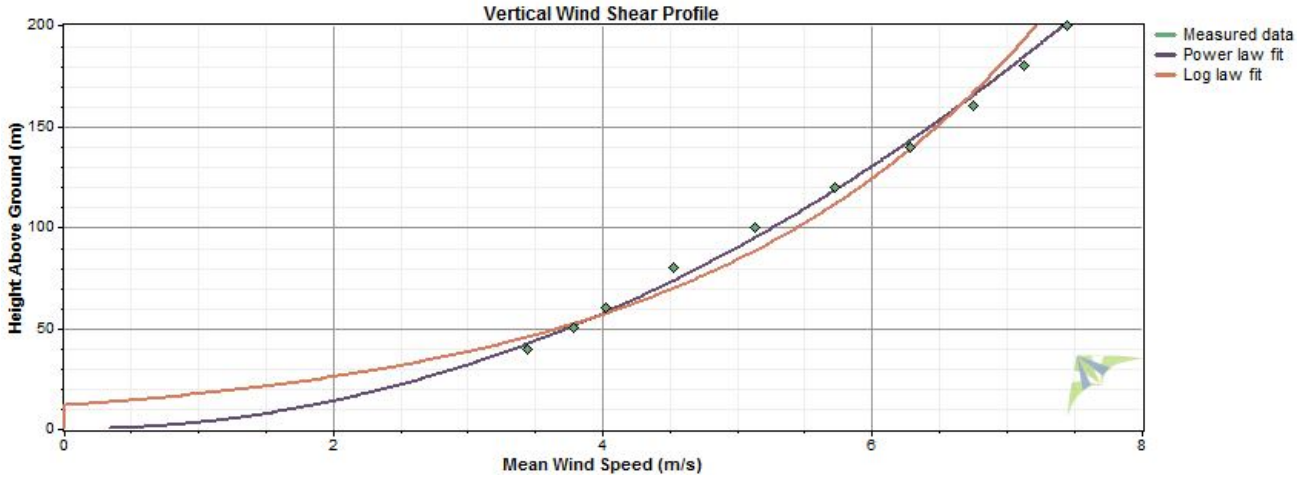


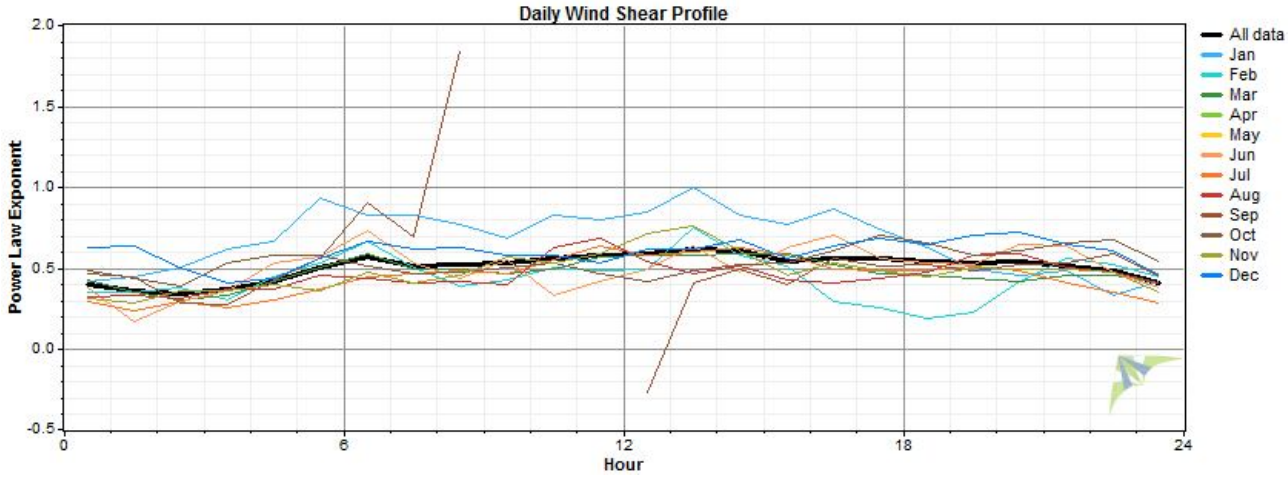


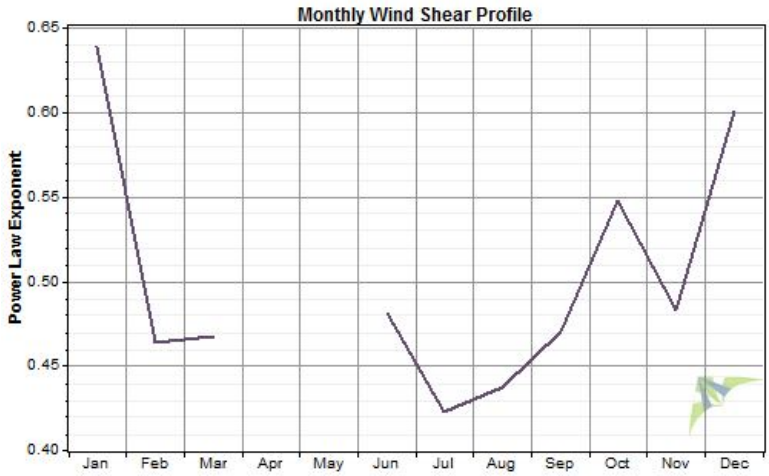


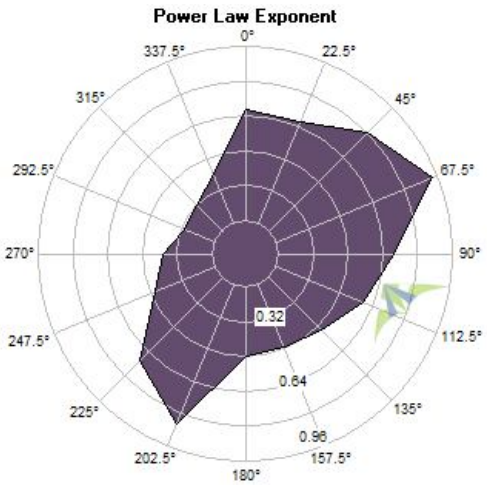


Wind Shear

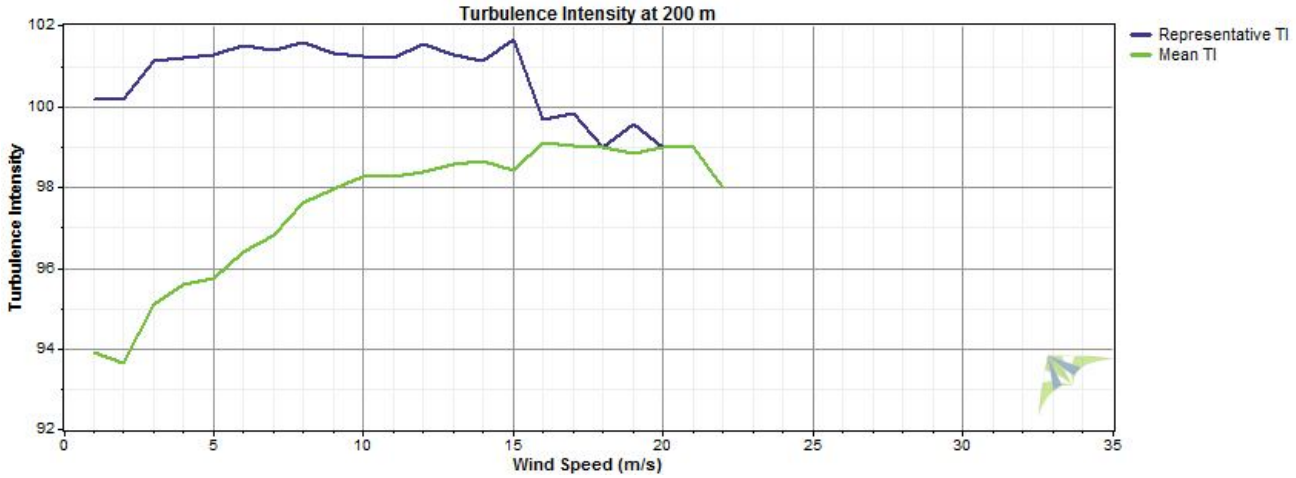

Vertical Wind Shear Profile
Measured data
Power law fit
Log law fit
Height Above Ground (m)
Mean Wind Speed (m/s)
0
50
100
150
200
0
2
4
6
8

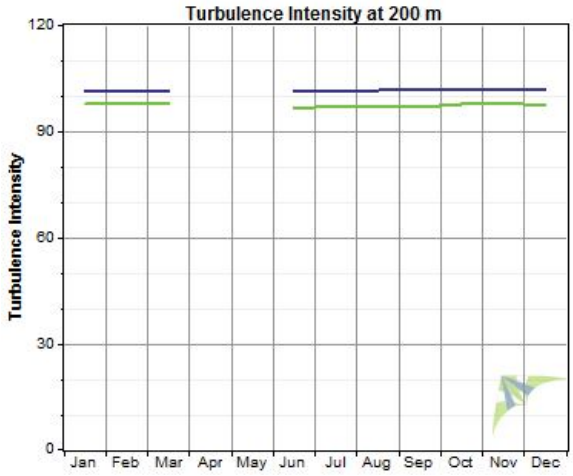

Daily Wind Shear Profile
All data
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Power Law Exponent
Hour
-0.5
0.0
0.5
1.0
1.5
2.0
0
6
12
18
24

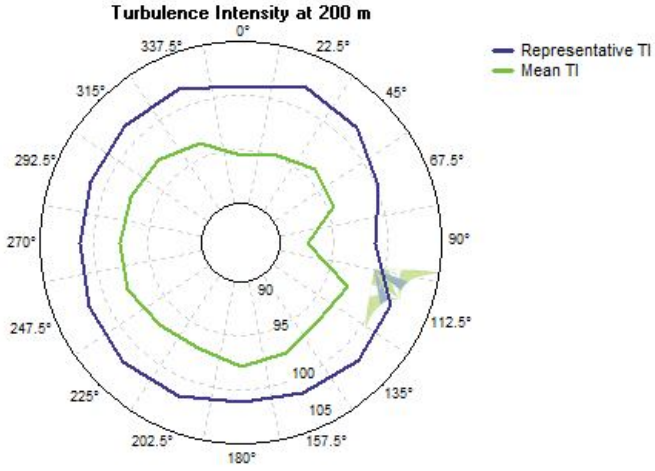

Monthly Wind Shear Profile
Power Law Exponent
0.40
0.45
0.50
0.55
0.60
0.65
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

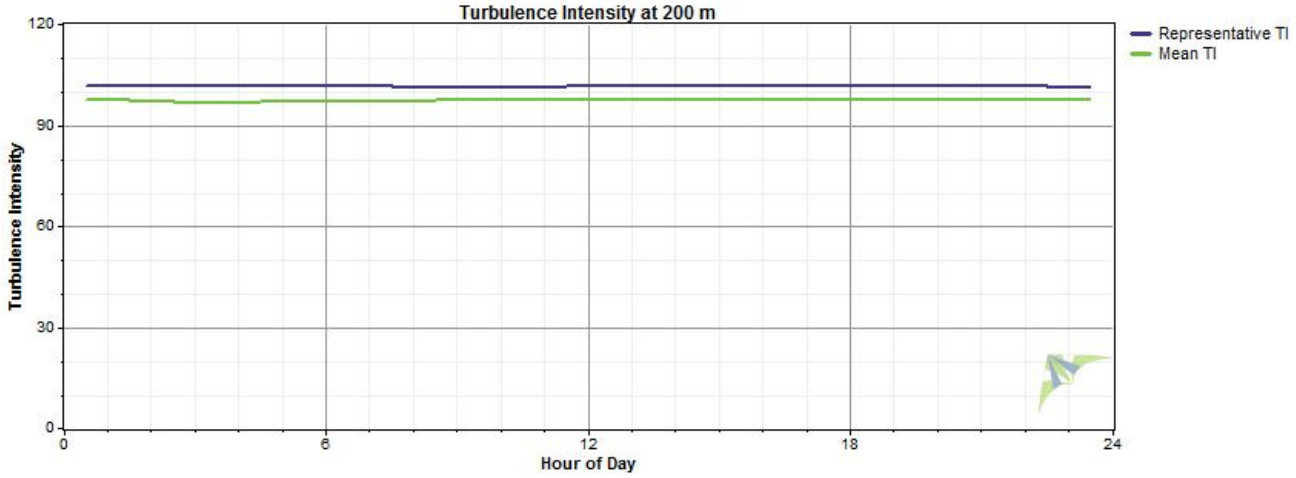

Power Law Exponent
0°
22.5°
45°
67.5°
90°
112.5°
135°
157.5°
180°
202.5°
225°
247.5°
270°
292.5°
315°
337.5°
0.32
0.64
0.96

Turbulence Intensity









Data Column Properties

Number	Label	Units	Height	Possible Records	Valid Records	Recovery Rate (%)	Mean	Min	Max	Std. Dev
1	Date and Time	<Intentionally blank>		40,248	40,248	100.00	7.02	1.00	12.00	3.78
2	Date			40,248	40,248	100.00	15.96	1.00	31.00	8.87
3	40m Wind Direction	°	40 m	40,248	36,079	89.64	277.8	0.0	360.0	83.2
4	40m Wind Speed	m/s	40 m	40,248	36,079	89.64	3.51	0.01	17.22	2.14
5	40m Wind Vert	m/s		40,248	36,079	89.64	-0.001	-8.560	2.180	0.813
6	Quality (Station Height 40m)	%		40,248	36,079	89.64	98.0	85.0	100.0	1.6
7	50m Wind Direction	°	50 m	40,248	35,917	89.24	273.7	0.0	359.9	87.3
8	50m Wind Speed	m/s	50 m	40,248	35,917	89.24	3.88	0.02	17.13	2.25
9	50m Wind Vert	m/s		40,248	35,917	89.24	-0.036	-8.900	2.050	0.818
10	Quality (Station Height 50m)	%		40,248	35,917	89.24	98.2	85.0	100.0	1.6
11	60m Wind Direction	°	60 m	40,248	35,832	89.03	270.1	0.0	360.0	88.2
12	60m Wind Speed	m/s	60 m	40,248	35,832	89.03	4.14	0.01	16.79	2.33
13	60m Wind Vert	m/s		40,248	35,832	89.03	-0.064	-8.780	2.070	0.798
14	Quality (Station Height 60m)	%		40,248	35,832	89.03	97.8	85.0	100.0	2.0
15	80m Wind Direction	°	80 m	40,248	34,629	86.04	262.9	0.0	360.0	84.1
16	80m Wind Speed	m/s	80 m	40,248	34,629	86.04	4.71	0.03	19.36	2.55
17	80m Wind Vert	m/s		40,248	34,629	86.04	-0.129	-8.450	4.850	0.799
18	Quality (Station Height 80m)	%		40,248	34,629	86.04	97.6	85.0	100.0	2.4
19	100m Wind Direction	°	100 m	40,248	32,596	80.99	257.9	0.0	360.0	82.4
20	100m Wind Speed	m/s	100 m	40,248	32,596	80.99	5.42	0.01	21.37	2.79
21	100m Wind Vert	m/s		40,248	32,596	80.99	-0.189	-8.540	3.420	0.801
22	Quality (Station Height 100m)	%		40,248	32,596	80.99	97	85	100	3
23	120m Wind Direction	°	120 m	40,248	29,440	73.15	255.3	0.0	360.0	81.6
24	120m Wind Speed	m/s	120 m	40,248	29,440	73.15	6.04	0.04	22.35	2.97
25	120m Wind Vert	m/s		40,248	29,440	73.15	-0.215	-8.620	6.140	0.774
26	Quality (Station Height 120m)	%		40,248	29,440	73.15	96.4	85.0	100.0	3.3
27	140m Wind Direction	°	140 m	40,248	25,541	63.46	254.2	0.0	360.0	81.4
28	140m Wind Speed	m/s	140 m	40,248	25,541	63.46	6.57	0.09	29.73	3.11
29	140m Wind Vert	m/s		40,248	25,541	63.46	-0.212	-8.630	4.110	0.723
30	Quality (Station Height 140m)	%		40,248	25,541	63.46	95.5	85.0	100.0	3.6
31	160m Wind Direction	°	160 m	40,248	20,958	52.07	253.6	0.0	360.0	80.6
32	160m Wind Speed	m/s	160 m	40,248	20,958	52.07	6.94	0.02	22.31	3.27
33	160m Wind Vert	m/s		40,248	20,958	52.07	-0.190	-7.980	5.390	0.674
34	Quality (Station Height 160m)	%		40,248	20,958	52.07	94.7	85.0	100.0	3.8
35	180m Wind Direction	°	180 m	40,248	16,263	40.41	251.9	0.0	360.0	80.0
36	180m Wind Speed	m/s	180 m	40,248	16,263	40.41	7.21	0.07	23.82	3.49
37	180m Wind Vert	m/s		40,248	16,263	40.41	-0.179	-8.290	4.380	0.651
38	Quality (Station Height 180m)	%		40,248	16,263	40.41	93.9	85.0	100.0	3.9
39	200m Wind Direction	°	200 m	40,248	11,916	29.61	249.6	0.0	360.0	77.4
40	200m Wind Speed	m/s	200 m	40,248	11,916	29.61	7.39	0.07	31.96	3.69
41	200m Wind Vert	m/s		40,248	11,916	29.61	-0.184	-6.790	3.480	0.653
42	Quality (Station Height 200m)	%		40,248	11,916	29.61	93.4	85.0	100.0	3.9
43	40m Wind Turbulence	m/s		40,248	19,285	47.92	0.258	0.060	1.280	0.117
44	50m Wind Turbulence	m/s	40 m	40,248	21,308	52.94	0.249	0.040	1.310	0.121
45	60m Wind Turbulence	m/s	50 m	40,248	22,438	55.75	0.243	0.050	1.130	0.122
46	80m Wind Turbulence	m/s	60 m	40,248	24,002	59.64	0.231	0.040	1.200	0.127
47	100m Wind Turbulence	m/s	80 m	40,248	24,818	61.66	0.218	0.030	1.180	0.127
48	120m Wind Turbulence	m/s	100 m	40,248	23,850	59.26	0.206	0.030	1.200	0.125
49	140m Wind Turbulence	m/s	120 m	40,248	21,505	53.43	0.200	0.030	1.440	0.126
50	160m Wind Turbulence	m/s	140 m	40,248	17,991	44.70	0.199	0.030	1.270	0.129
51	180m Wind Turbulence	m/s	160 m	40,248	13,971	34.71	0.200	0.030	1.300	0.136
52	200m Wind Turbulence	m/s	180 m	40,248	10,173	25.28	0.204	0.030	1.330	0.146

Number	Label	Units	Height	Possible Records	Valid Records	Recovery Rate (%)	Mean	Min	Max	Std. Dev
53	Turbu. Quality (Station Height 40m)	m/s	200 m	40,248	19,285	47.92	97.5	85.0	100.0	3.2
54	Turbu. Quality (Station Height 50m)	%		40,248	21,308	52.94	97.8	85.0	100.0	3.0
55	Turbu. Quality (Station Height 60m)	%		40,248	22,438	55.75	97.5	85.0	100.0	3.0
56	Turbu. Quality (Station Height 80m)	%		40,248	24,002	59.64	97.3	85.0	100.0	3.1
57	Turbu. Quality (Station Height 100m)	%		40,248	24,818	61.66	96.8	85.0	100.0	3.4
58	Turbu. Quality (Station Height 120m)	%		40,248	23,850	59.26	96.2	85.0	100.0	3.6
59	Turbu. Quality (Station Height 140m)	%		40,248	21,505	53.43	95.3	85.0	100.0	3.8
60	Turbu. Quality (Station Height 160m)	%		40,248	17,991	44.70	94.4	85.0	100.0	3.9
61	Turbu. Quality (Station Height 180m)	%		40,248	13,971	34.71	93.7	85.0	100.0	3.9
62	Turbu. Quality (Station Height 200m)	%		40,248	10,173	25.28	93.1	85.0	100.0	3.9
63	Date (1)			40,248	40,248	100.00	2,015	2,014	2,015	1
64	Ambient Temp	°C		40,248	38,248	95.03	7.79	-24.90	30.70	10.57
65	Barometric Pressure	mbar		40,248	38,248	95.03	909.0	890.4	922.1	4.8
66	TiltX	Â°		40,248	38,248	95.03	0.1848	-0.1000	0.8000	0.0941
67	Azimuth	Â°		40,248	38,248	95.03	0	0	0	0
68	TiltY	Â°		40,248	38,248	95.03	-0.1441	-0.5000	0.5000	0.1593
69	Humidity	%		40,248	38,248	95.03	74.77	15.00	98.00	15.50
70	Noise Level-A	dB		40,248	38,248	95.03	12.78	5.00	16.60	1.98
71	Noise Level-B	dB		40,248	38,248	95.03	12.86	5.00	16.80	2.03
72	Noise Level-C	dB		40,248	38,248	95.03	12.77	5.00	16.60	1.97
73	Speaker Power	W		40,248	38,248	95.03	3.88	0.00	18.70	2.47
74	Core Power	W		40,248	38,248	95.03	2.625	2.200	3.100	0.108
75	PWM Power	W		40,248	38,248	95.03	1.223	0.600	2.600	0.195
76	Solar Power	W		40,248	38,248	95.03	0	0	0	0
77	CPU Power	W		40,248	38,248	95.03	2.307	2.000	3.000	0.135
78	Modem Power	W		40,248	38,248	95.03	0.329	0.000	1.400	0.176
79	Heater Temp	Â°C		40,248	38,248	95.03	0	0	0	0
80	Mirror Temp	Â°C		40,248	38,248	95.03	10.43	-24.00	54.80	12.63
81	Internal Temp	Â°C		40,248	38,248	95.03	11.59	-22.30	44.60	11.88
82	CPU Temp	Â°C		40,248	38,248	95.03	0	0	0	0
83	VibrationY	g		40,248	38,248	95.03	0	0	0	0
84	VibrationX	g		40,248	38,248	95.03	0	0	0	0
85	Battery	V		40,248	38,248	95.03	12.49	10.40	15.40	0.91
86	Beep Volume	dB		40,248	38,248	95.03	90.1	0.0	100.0	29.8
87	Air Density	kg/m³		40,248	40,248	100.00	1.128	1.043	1.278	0.041
88	200m Wind Speed WPD	W/m²		40,248	11,916	29.61	407	0	17,839	559
89	180m Wind Speed WPD	W/m²		40,248	16,263	40.41	366	0	7,631	474
90	160m Wind Speed WPD	W/m²		40,248	20,958	52.07	319	0	6,291	404
91	140m Wind Speed WPD	W/m²		40,248	25,541	63.46	273	0	14,383	363
92	120m Wind Speed WPD	W/m²		40,248	29,440	73.15	220	0	6,101	297
93	100m Wind Speed WPD	W/m²		40,248	32,596	80.99	167	0	5,333	249
94	80m Wind Speed WPD	W/m²		40,248	34,629	86.04	117	0	4,095	186
95	60m Wind Speed WPD	W/m²		40,248	35,832	89.03	83	0	2,671	139
96	50m Wind Speed WPD	W/m²		40,248	35,917	89.24	71	0	2,837	124
97	40m Wind Speed WPD	W/m²		40,248	36,079	89.64	56	0	2,882	105

Wind Turbine Output

This window calculates the energy output of a wind turbine in this wind regime. Select a type of wind turbine and a hub height, then click Calculate Output.

Wind turbine: Endurance G-3120 | Details... | Edit... | New... | Delete... | Compare...

Properties

Manufacturer:	Endurance Wind Power
Website:	www.endurancewindpower.c
Rotor diameter:	19.2 m
Rated power:	35 kW
Power regulation:	Stall control

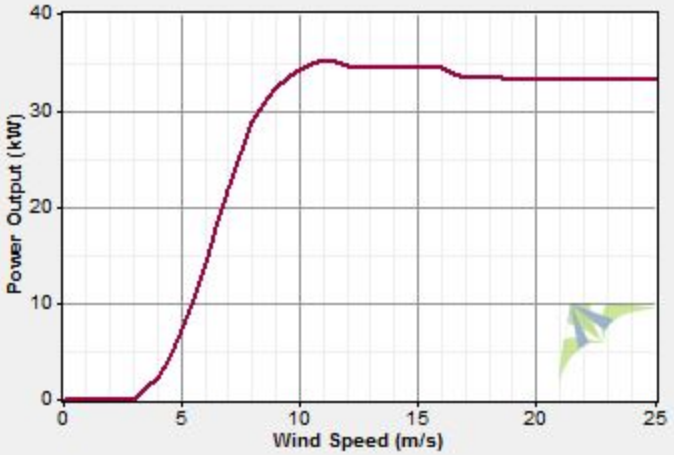
Losses

Downtime losses (%)	6
Array losses (%)	5
Icing/soiling losses (%)	4
Other losses (%)	4
Overall loss factor (%)	17.70

Calculate Output

Hub height

- 30.5 m
- 42.7 m
- Other 70 m



- Monthly details
- Turbine comparison

Month	Valid Data Points	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (kW)	Mean Net Energy Output (kWh/yr)	Net Capacity Factor (%)
Jan	3,776	3.89	38.80	0.00	4.8	3,535	13.6
Feb	2,322	3.81	42.33	0.00	5.4	3,658	15.6
Mar	4,239	3.79	45.39	0.00	4.9	3,659	14.1
Apr	0	n/a	n/a	n/a	n/a	n/a	n/a
May	0	n/a	n/a	n/a	n/a	n/a	n/a
Jun	863	2.83	58.63	0.00	1.7	1,202	4.8
Jul	4,463	3.17	51.69	0.00	2.6	1,934	7.4
Aug	4,464	3.05	53.88	0.00	2.1	1,541	5.9
Sep	4,315	2.83	59.33	0.00	1.9	1,333	5.3
Oct	4,457	4.00	36.48	0.00	4.5	3,382	13.0
Nov	4,316	4.12	35.77	0.00	5.5	3,984	15.8
Dec	3,271	3.57	46.53	0.00	3.6	2,687	10.3
Overall	36,486	3.55	46.16	0.00	3.8	33,052	10.8

Help | Cancel | Add Turbine Output Time Series To Data Set & Close

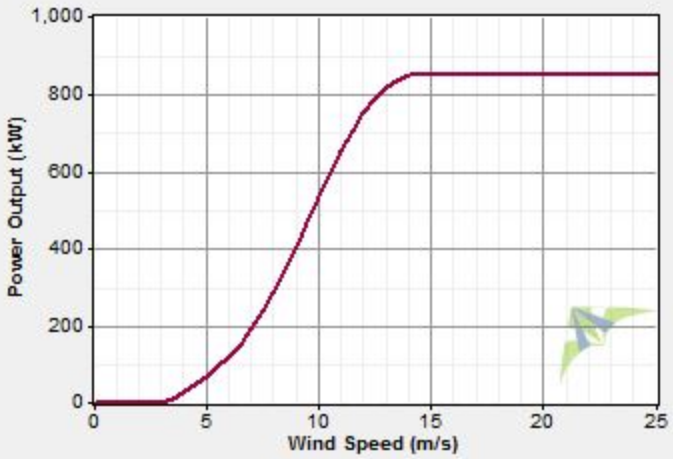
Wind Turbine Output

This window calculates the energy output of a wind turbine in this wind regime. Select a type of wind turbine and a hub height, then click Calculate Output.

Wind turbine: Vestas V52 - 850 kW | Details... | Edit... | New... | Delete... | Compare...

Properties

Manufacturer:	Vestas Wind Systems A/S
Website:	www.vestas.com
Rotor diameter:	52 m
Rated power:	850 kW
Power regulation:	Pitch control



Hub height

- 40 m
- 44 m
- 49 m
- 55 m
- 60 m
- 65 m
- 74 m
- 86 m
- Other 70 m

Losses

Downtime losses (%)	6
Array losses (%)	5
Icing/soiling losses (%)	4
Other losses (%)	4
Overall loss factor (%)	17.70

Calculate Output

- Monthly details
- Turbine comparison

Month	Valid Data Points	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (kW)	Mean Net Energy Output (kWh/yr)	Net Capacity Factor (%)
Jan	3,776	4.88	25.16	0.00	82.5	61,368	9.7
Feb	2,322	4.92	34.28	0.00	109.5	73,611	12.9
Mar	4,239	4.70	32.34	0.00	87.5	65,080	10.3
Apr	0	n/a	n/a	n/a	n/a	n/a	n/a
May	0	n/a	n/a	n/a	n/a	n/a	n/a
Jun	863	3.63	45.65	0.00	32.9	23,691	3.9
Jul	4,463	3.98	43.87	0.00	50.3	37,410	5.9
Aug	4,464	3.85	42.00	0.00	40.9	30,441	4.8
Sep	4,315	3.71	46.10	0.02	39.2	28,239	4.6
Oct	4,457	5.01	23.94	0.02	85.4	63,570	10.1
Nov	4,316	5.17	25.86	0.44	104.7	75,376	12.3
Dec	3,271	4.64	26.81	0.00	70.3	52,296	8.3
Overall	36,486	4.48	33.97	0.06	71.4	625,173	8.4

Help | Cancel | Add Turbine Output Time Series To Data Set & Close

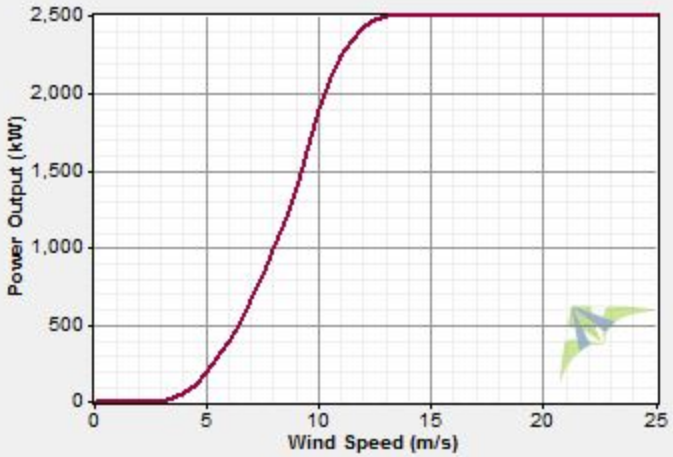
Wind Turbine Output

This window calculates the energy output of a wind turbine in this wind regime. Select a type of wind turbine and a hub height, then click Calculate Output.

Wind turbine: GE 2.5xl | Details... | Edit... | New... | Delete... | Compare...

Properties

Manufacturer: GE Wind
Website: www.gepower.com
Rotor diameter: 100 m
Rated power: 2,500 kW
Power regulation: Pitch control



Hub height

- (•) 75 m
- ( ) 85 m
- ( ) 100 m
- ( ) Other 70 m

Losses

Downtime losses (%)	6
Array losses (%)	5
Icing/soiling losses (%)	4
Other losses (%)	4
Overall loss factor (%)	17.70

Calculate Output

(•) Monthly details
( ) Turbine comparison

Month	Valid Data Points	Hub Height Wind Speed (m/s)	Time At Zero Output (%)	Time At Rated Output (%)	Mean Net Power Output (kW)	Mean Net Energy Output (kWh/yr)	Net Capacity Factor (%)
Jan	3,776	4.91	24.76	0.00	276.7	205,862	11.1
Feb	2,322	4.95	33.89	0.04	374.9	251,955	15.0
Mar	4,239	4.72	31.92	0.12	293.7	218,520	11.7
Apr	0	n/a	n/a	n/a	n/a	n/a	n/a
May	0	n/a	n/a	n/a	n/a	n/a	n/a
Jun	863	3.66	45.31	0.00	104.5	75,265	4.2
Jul	4,463	4.00	43.58	0.00	166.6	123,984	6.7
Aug	4,464	3.87	41.69	0.00	132.2	98,385	5.3
Sep	4,315	3.74	45.72	0.02	128.2	92,331	5.1
Oct	4,457	5.03	23.67	0.22	282.7	210,360	11.3
Nov	4,316	5.20	25.58	0.79	352.5	253,778	14.1
Dec	3,271	4.67	26.51	0.00	234.5	174,451	9.4
Overall	36,486	4.51	33.63	0.14	238.1	2,085,548	9.5

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