

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

Garden Ground Mountain, Summit Bechtel Reserve, Boy Scouts of America

Garden Ground Mountain, Fayette County, West Virginia

(Data Evaluation Period: March 31, 2015 to March 29, 2016)

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

May, 2016

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## **Attachments**

### Attachment A

Site Location Map

Site Photos

*SecondWind* Site Information Form and Checklist

### Attachment B

*Windographer* Monthly Reports

*Windographer* Summary Report

Wind Turbine Energy Output Summaries

## **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 Boy Scouts of America's Summit Bechtel Reserve located near Mt Hope, Fayette County, West Virginia. The SODAR unit was located on a ridgeline associated with Garden Ground Mountain. Wind resource data collection occurred on the site at Latitude 37.88713, Longitude -81.10168, at an elevation of 2,684 feet (818 meters) above mean sea level. Boy Scout activities take place along this ridgeline and throughout the area. A site location map is provided in Attachment A.

The immediately surrounding area consists of maintained grass field on the ridgeline with small bushes and trees (less than 30 feet). At the edge of the field and ridgeline is hardwood forest with trees of various ages. These trees are generally 40 to 60 feet tall. The main access road is a gated gravel road with limited traffic. Any traffic is associated with mowing of field and Boy Scout activities.

### **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 March 31, 2015 and March 29, 2016. 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 conditions (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 Form and Checklist is 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](http://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 was not able to operate from January 22-26, 2016 because of a large snow event. The air pressure sensor malfunctioned in September 2015 and was not repaired while on site but this did not affect wind measurements recorded by the SODAR.

### 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 2.4.13, released in August of 2013, was used for data analysis. Because of inaccurate barometric pressure readings, due to a malfunctioning pressure sensor, these readings were deleted and not used in the program. Without these values, *Windographer* uses the elevation of the site to calculate appropriate values. The Wind speed mean averages at various elevations above the ground surface ranged from 4.74 meters per second (m/s) at 40 meters, increasing consistently to 10.4 m/s at 200 meters. Wind direction was predominantly from the 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 <sup>2</sup> , mean)
40 Meters	4.74	192.8	0.018	152
50 Meters	5.16	199.6	0.022	210
60 Meters	5.39	204.5	0.026	251
80 Meters	5.89	213.1	0.023	302
100 Meters	6.35	218.2	0.002	423
120 Meters	6.91	224	-0.045	546
140 Meters	7.79	229.7	-0.128	838
160 Meters	8.58	234.8	-0.246	1,208
180 Meters	9.46	235.7	-0.42	1,621
200 Meters	10.4	233.6	-0.624	2,134

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 average during the 2<sup>nd</sup> quarter 2015, below average during the 3<sup>rd</sup> quarter 2015, average during the 4<sup>th</sup> quarter 2015, and above average during the 1<sup>st</sup> quarter 2016.

## 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	4.78	7.1	20.2
Vestas V52	850	74	5.71	124.9	14.7
GE 2.5xl	2,500	75	5.74	415.5	16.6

Complete wind turbine comparison summaries are provided in Attachment B.

## 6.0 Conclusions and Recommendations

Wind resource data collection occurred between March 31, 2015 and March 29, 2016. Late Spring and Summer months normally experience lower than yearly average wind speeds; winter and early spring months normally experience the highest wind speeds for a given 1-year period. These expected results were observed at the Garden Ground 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 good. This class of wind turbines are favorable for use by a single business, and/or for residential energy generation use.

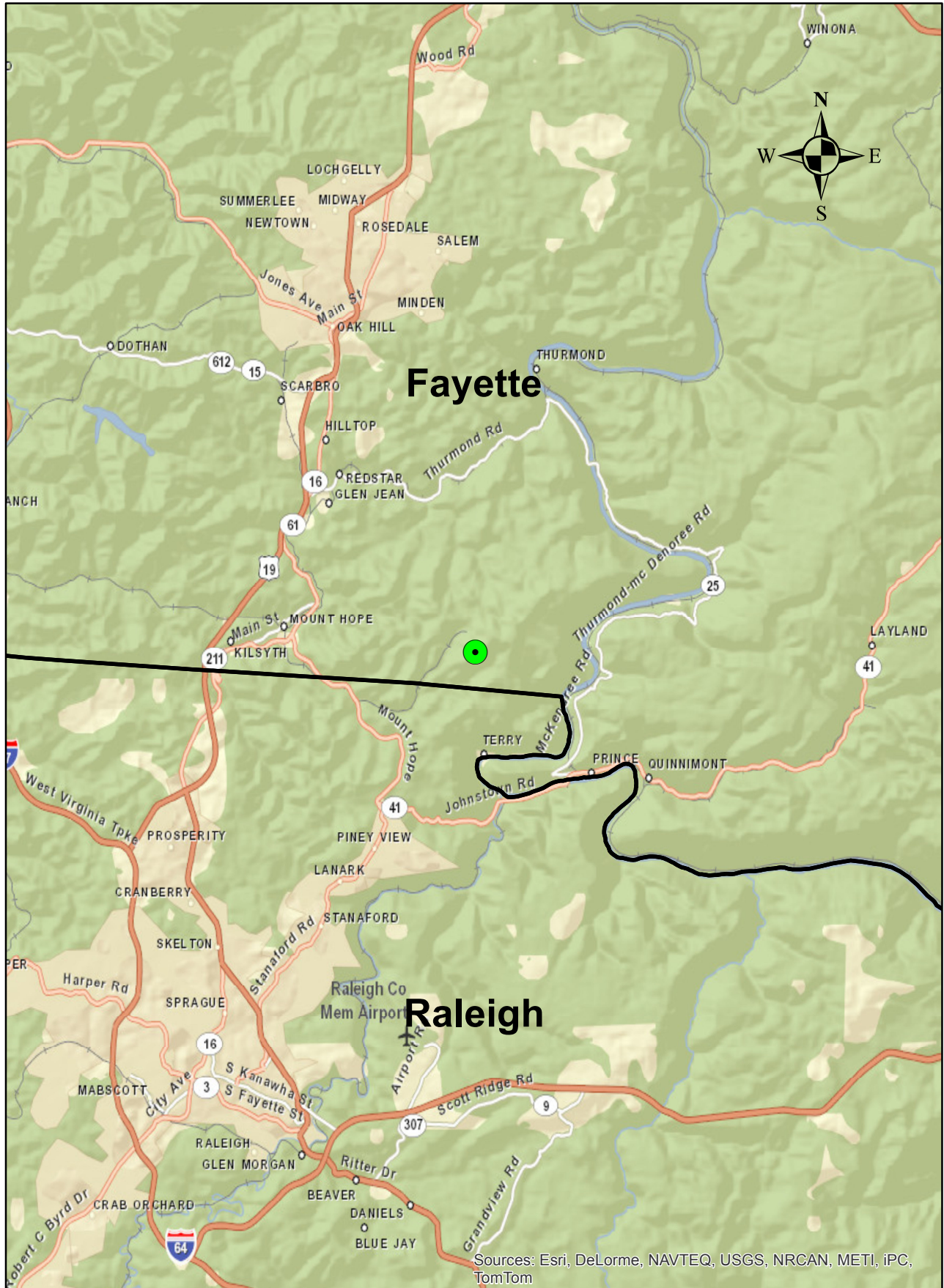
**ATTACHMENT A**

Site Location Map

Site Photos

*SecondWind* Site Information Form and Checklist



# Garden Ground Mountain SODAR Site Map



1.50.75 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





4. Installation Checklist			
Item	✓	Unit	Value
Mechanical Inspection	✓	List Damage/Defects	<b>none</b>
Exterior Warning Sign Cover Removed (Heater Only)	✓	none	
Triton Properly Oriented	✓	Record Azimuth of B-Beam (deg mag)	<b>within ~3 degrees of south</b>
Triton Secured	✓	Method (i.e. earth anchors, trailer, snow platform, etc.)	<b>trailer with fence; locked gate</b>
Batteries Charged (>12.7V)	✓	Record voltage level, V - DC	<b>14.19 volts</b>
Solar Panels Installed, Connected	✓	# of Panels	<b>2</b>
Solar Panels Charging	✓	V - DC	<b>15.3</b>
Antifreeze Fluid Level (Heater Only)	✓	none	
Propane Tanks installed		Tank capacity and level	<b>tanks removed for summer</b>
Propane Leak Test (Heater Only)		none	<b>NA</b>
Operator Panel: GPS	✓	Red/Green/Rapid/Off	
Operator Panel: SENSORS	✓	Red/Green/Rapid/Off	
Operator Panel: SUPPLIES	✓	Red/Green/Rapid/Off	
Operator Panel: SD CARD	✓	Red/Green/Rapid/Off	
Operator Panel: HEATER		Off/NA	<b>NA</b>
Operator Panel: NOTA (self-test)	✓	Red/Green/Rapid/Off/NA	
Operator Panel: ARRAY	✓	Red/Green/Rapid/Off	
Operator Panel: SODAR	✓	Red/Green/Rapid/Off	
Operator Panel: SNR	✓	Red/Green/Rapid/Off	
Operator Panel: INTERNET	✓	Red/Green/Rapid/Off	
Operator Panel: TSP	✓	Red/Green/Rapid/Off	
Operator Panel: SKYSERVE	✓	Red/Green/Rapid/Off	
Take Photos or Videos	✓	Pictures of 360deg site and Anchored Triton	<b>full photo set</b>
Ambient Noise Level	✓	dB	<b>minimal</b>
Ambient Noise Description	✓	(i.e. Birds, Crickets, Highway)	<b>birds, insects (no road noise)</b>
Triton Information (1) Section Complete	✓	none	
Site Information (2) Section Complete	✓	none	
Fixed Obstacle Vista Table (3) Complete	✓	none	

Installer's Signature: \_\_\_\_\_

Date: 31-Mar

Installer's Name (print): George Carico

Installer's ID #: \_\_\_\_\_

Rev5 March 2010

**ATTACHMENT B**

*Windographer* Monthly Reports

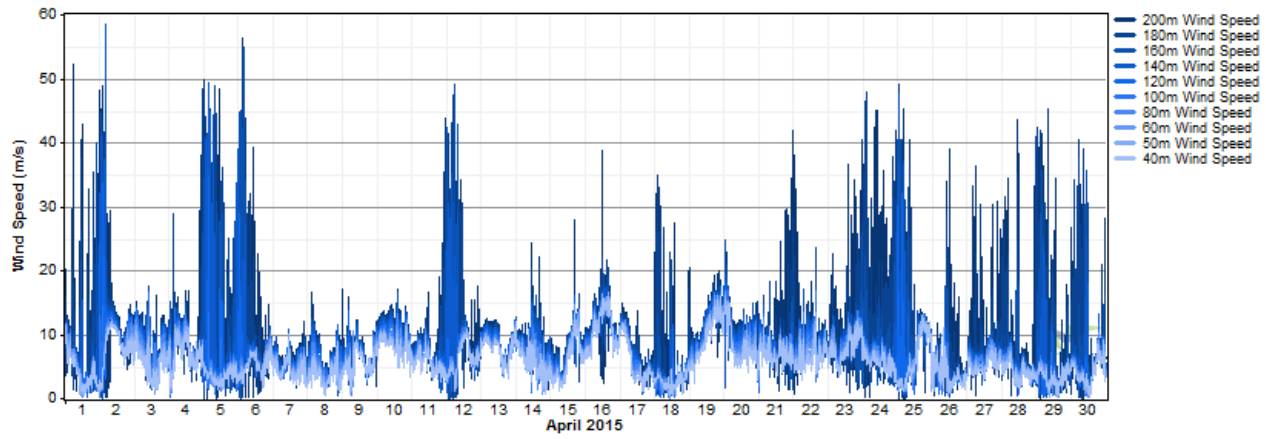
*Windographer* Summary Report

Wind Turbine Energy Output Summaries

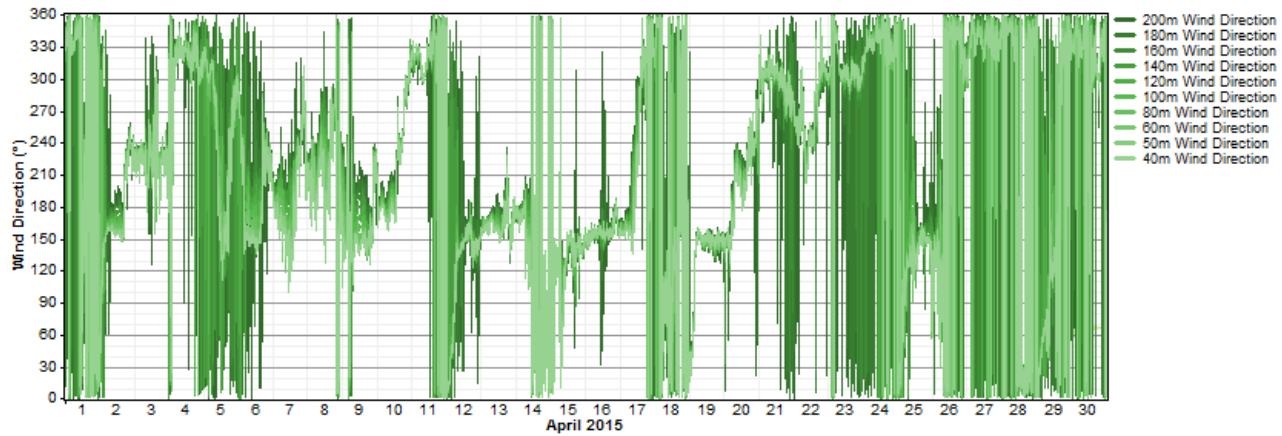
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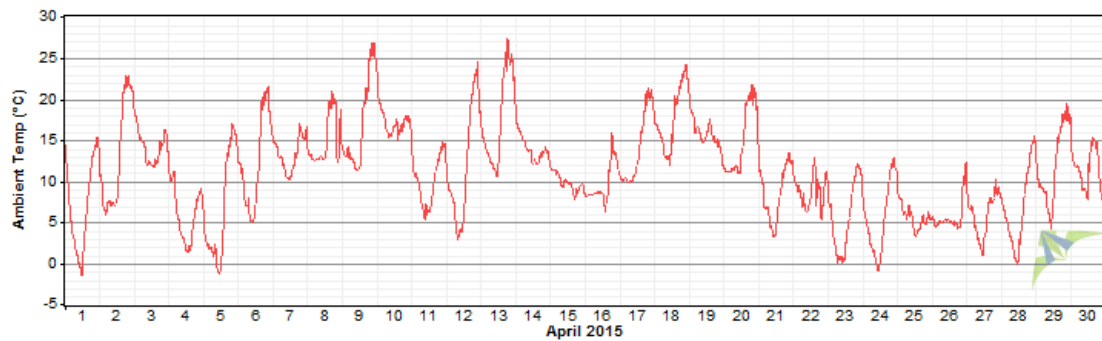
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## Wind Direction Data



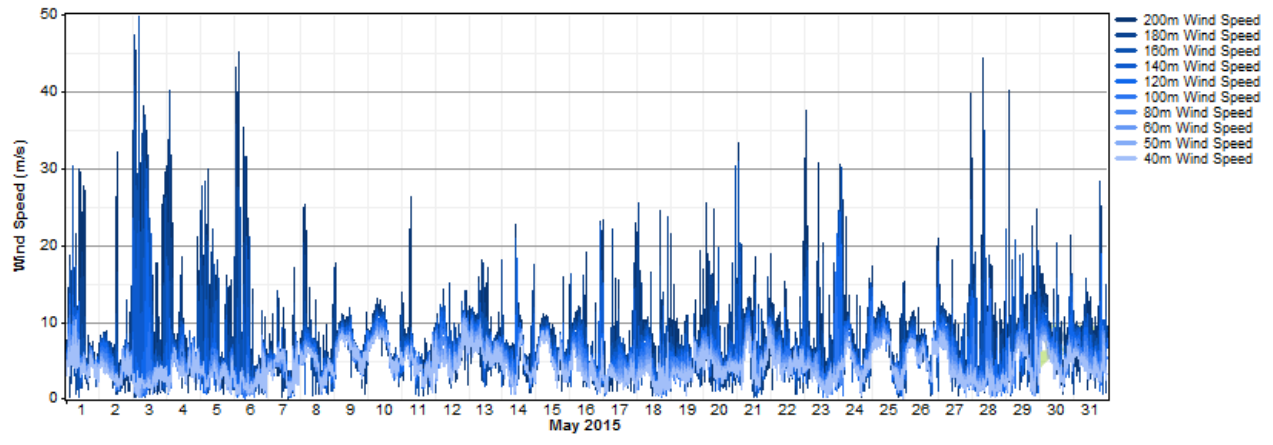
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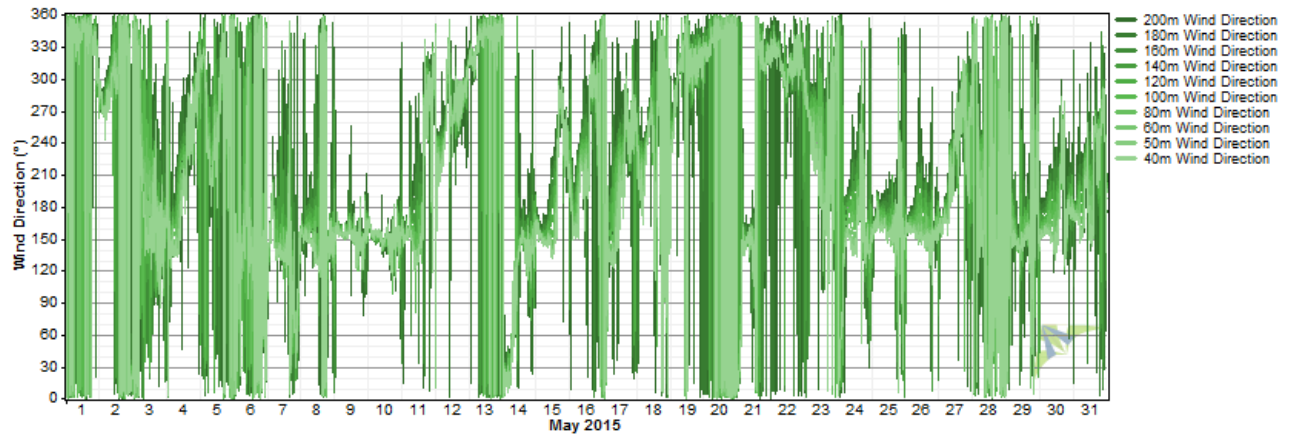
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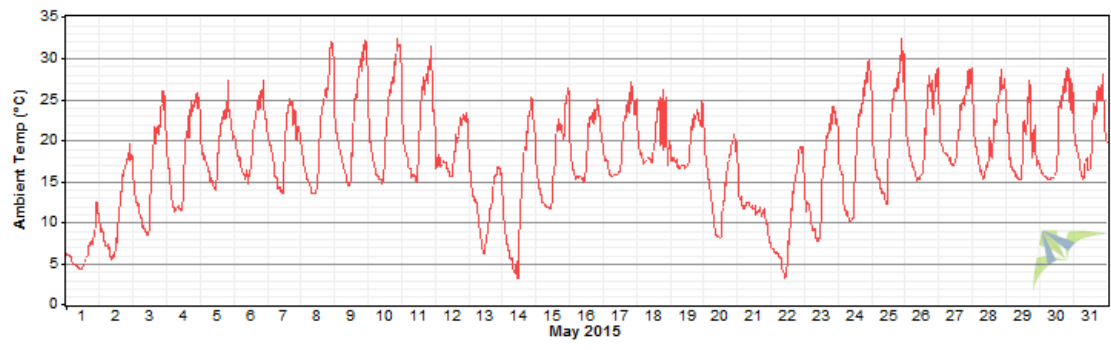
## Wind Speed Data



## Wind Direction Data



## Temperature Data

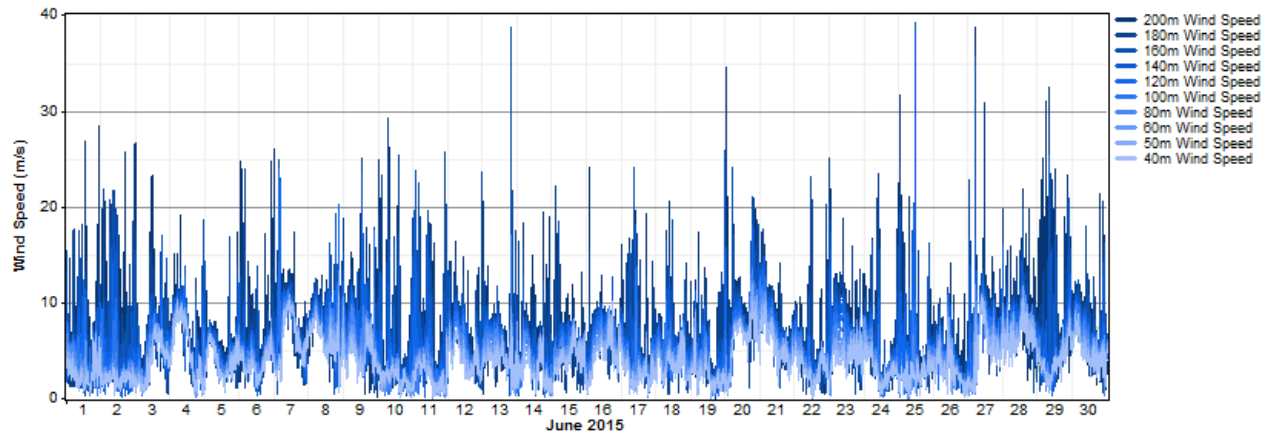




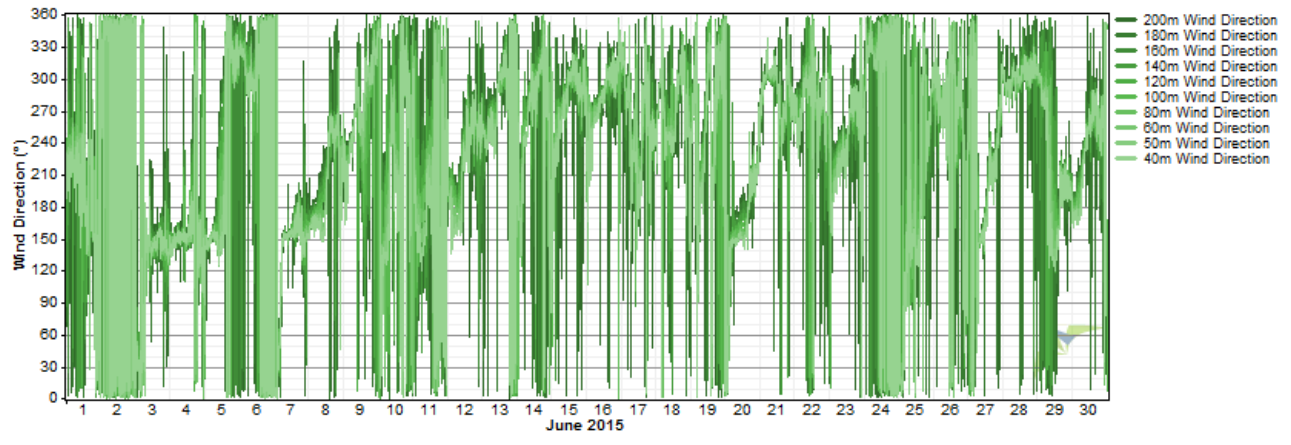
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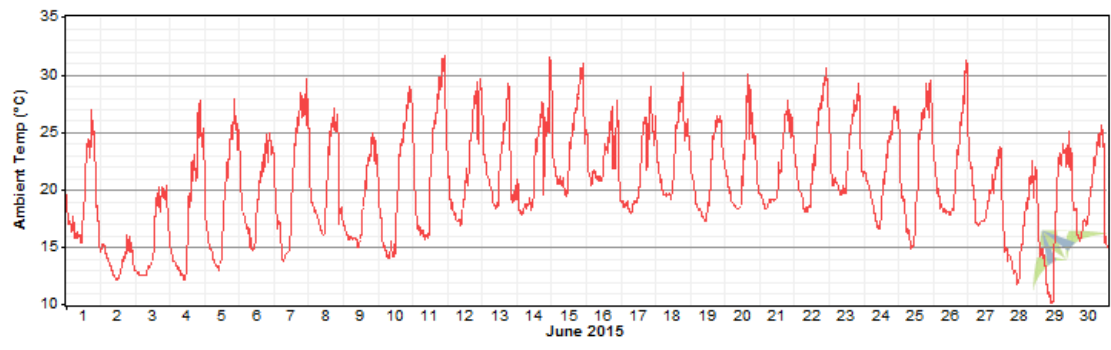
## Wind Speed Data



## Wind Direction Data



## Temperature Data

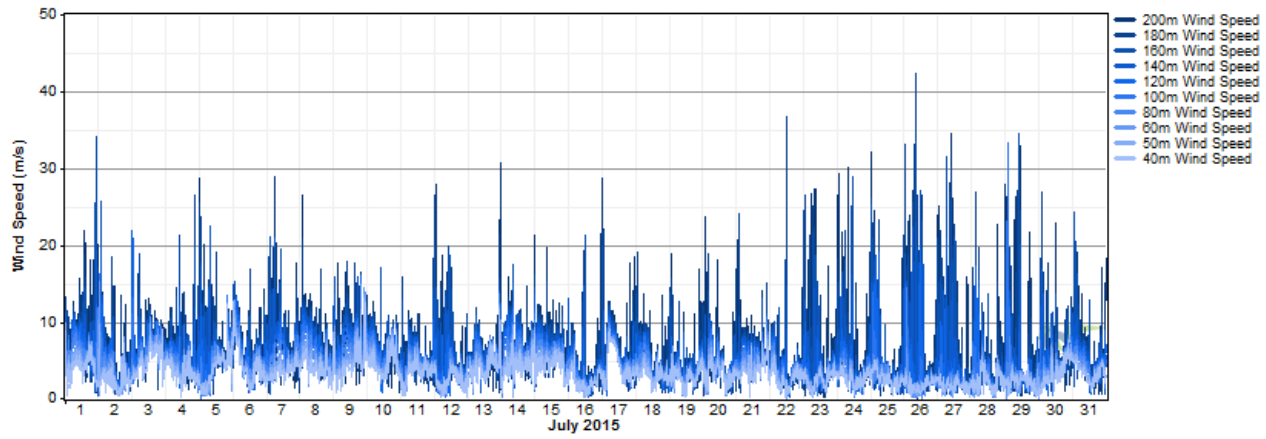




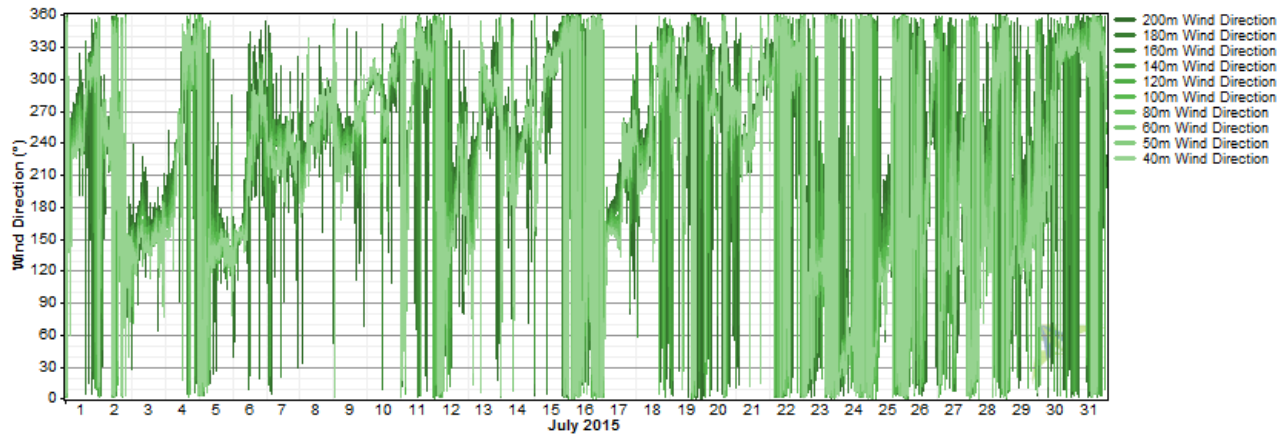
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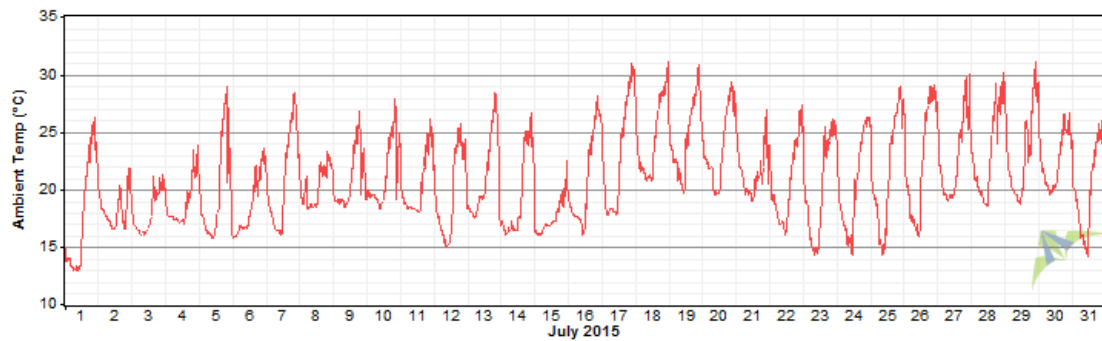
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## Wind Direction Data



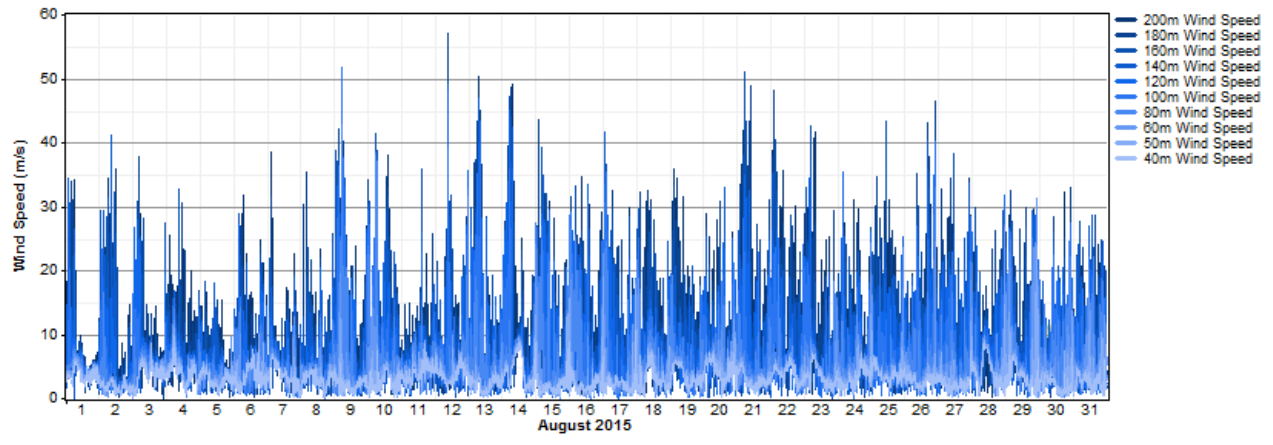
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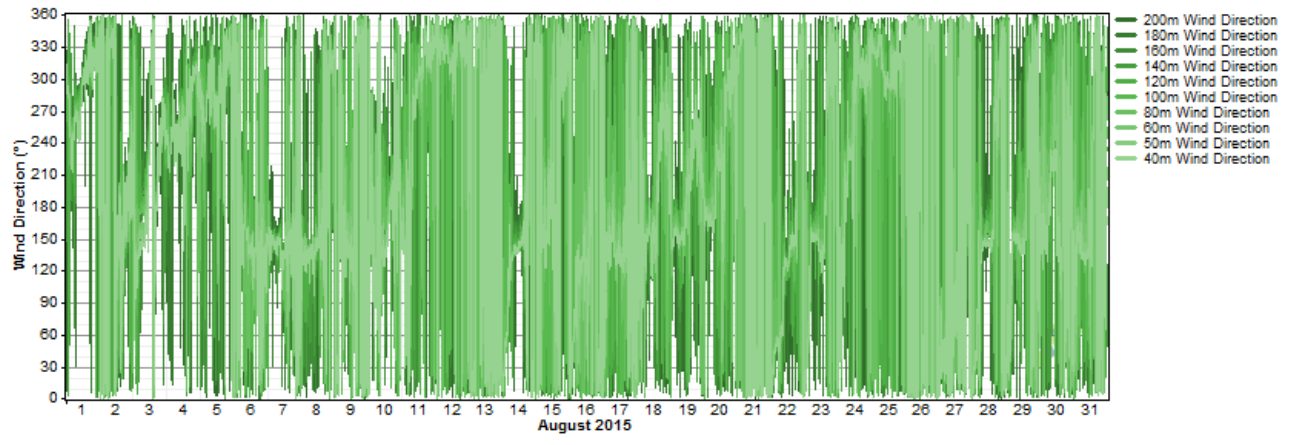
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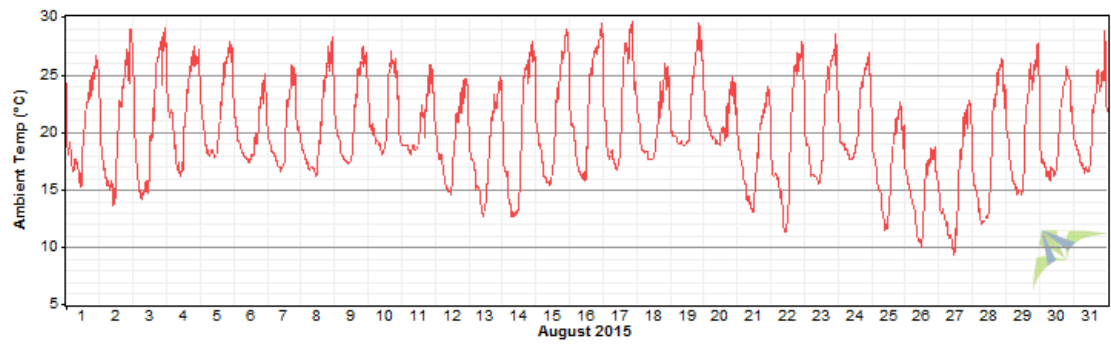
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## Wind Direction Data



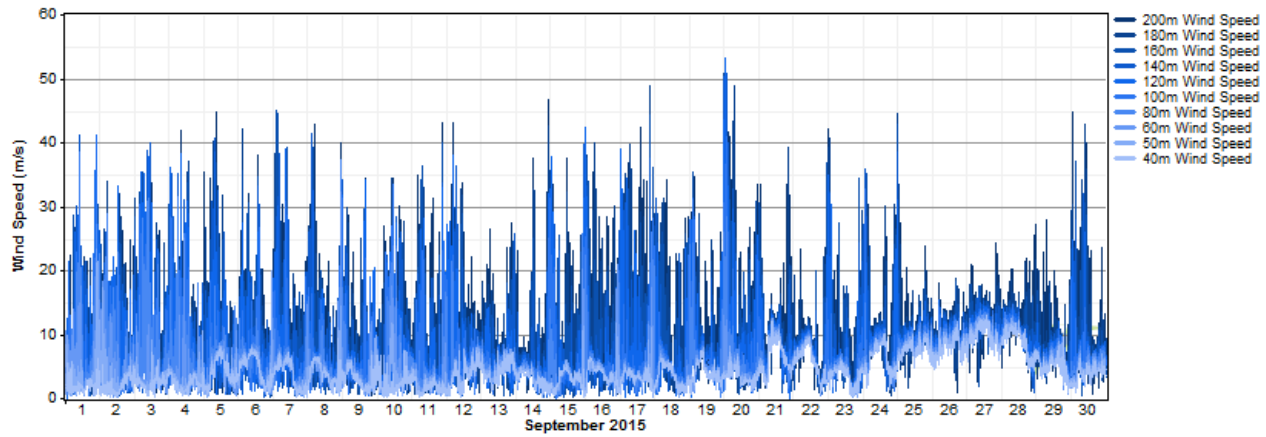
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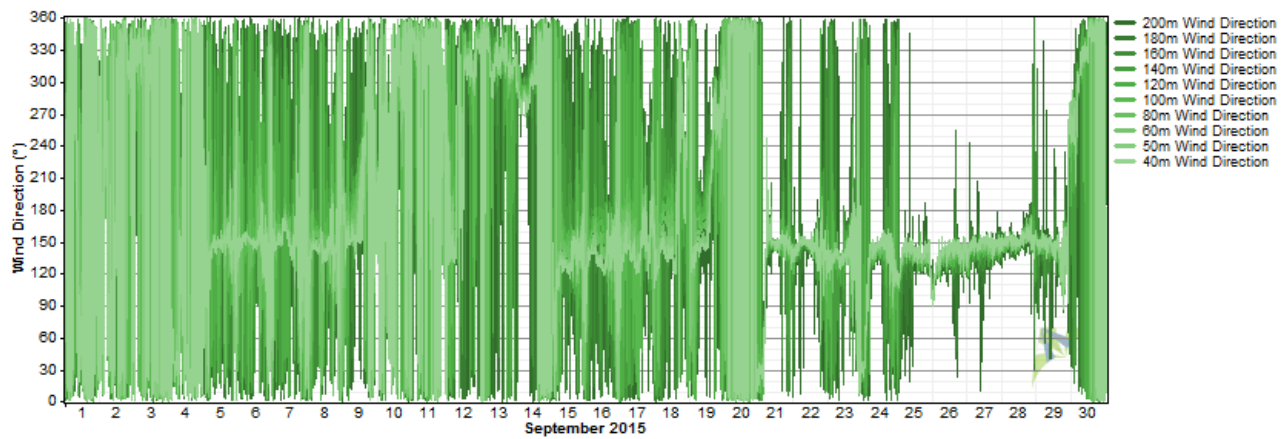
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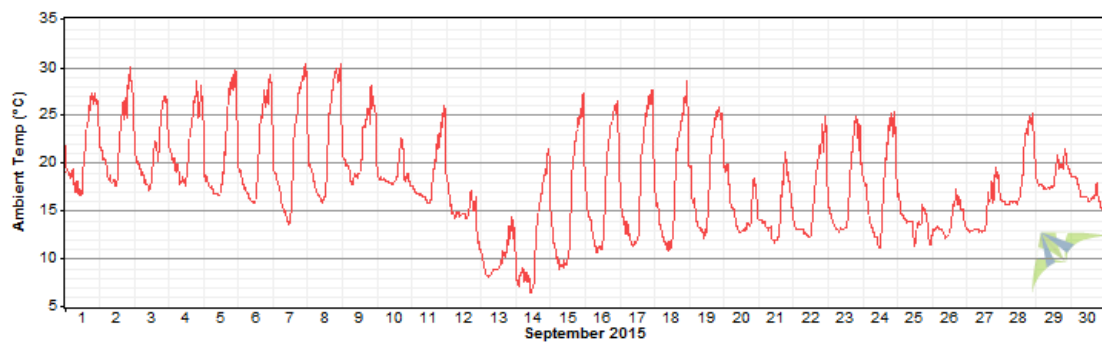
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## Wind Direction Data



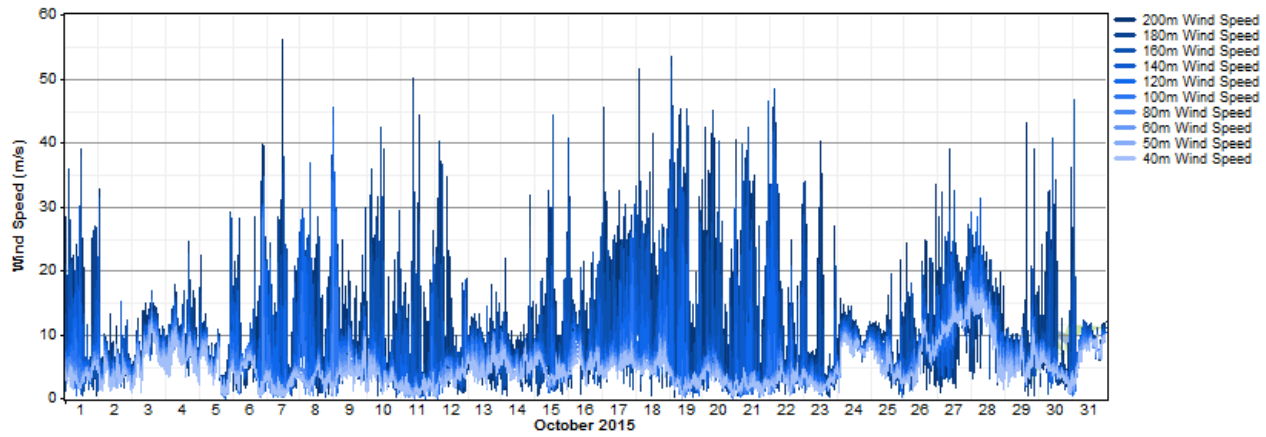
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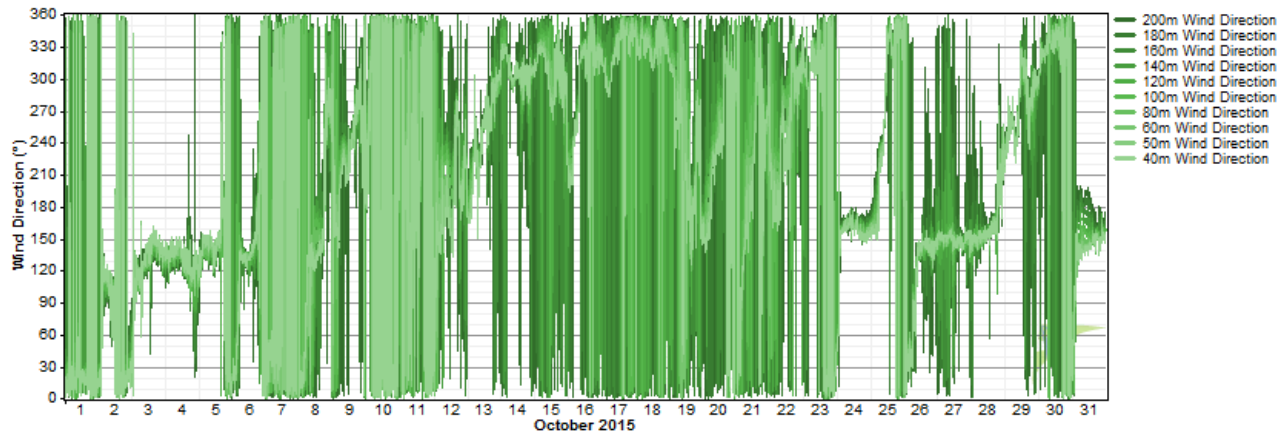
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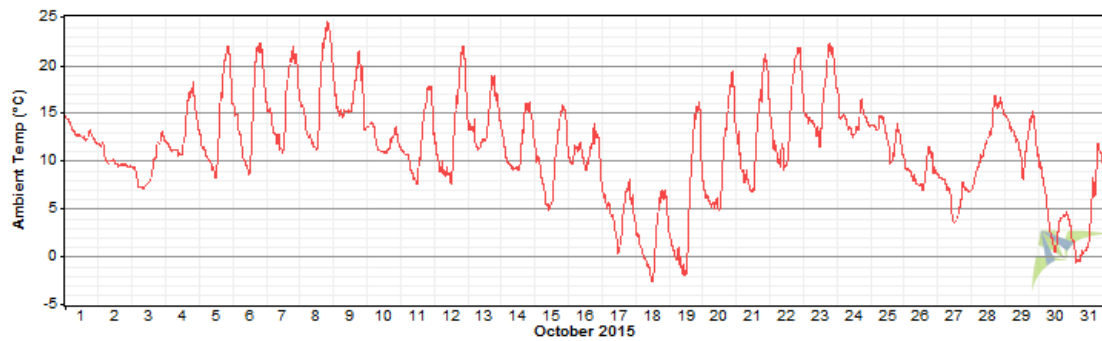
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## Wind Direction Data



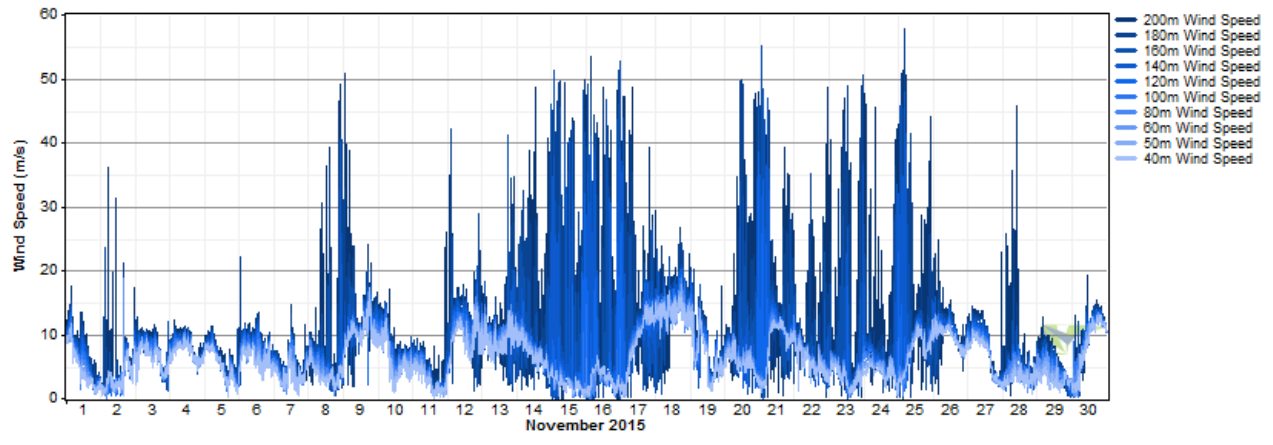
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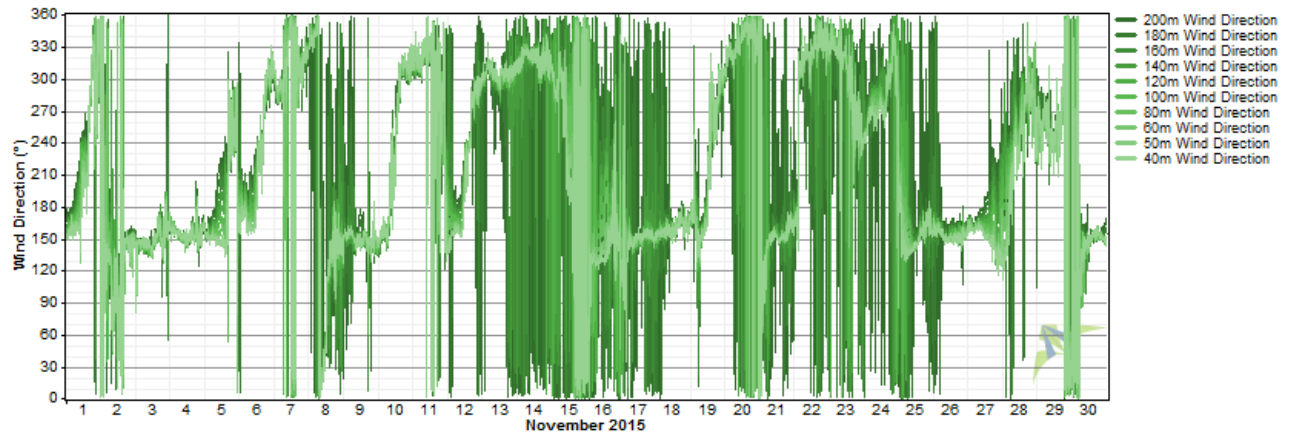
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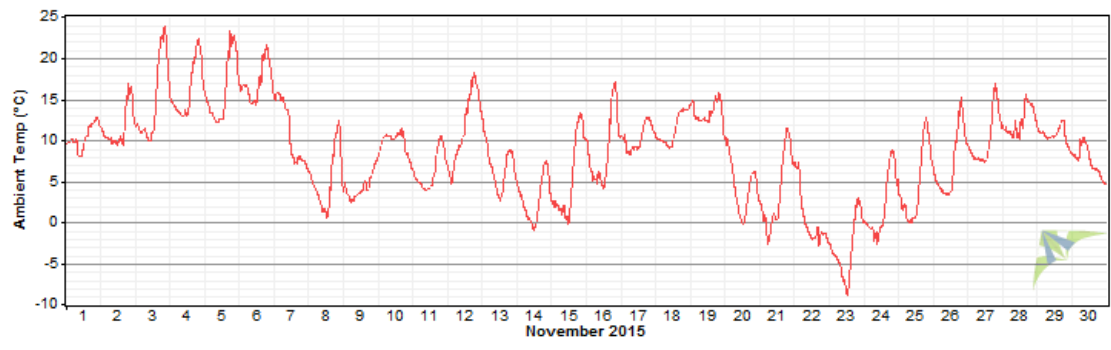
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## Wind Direction Data



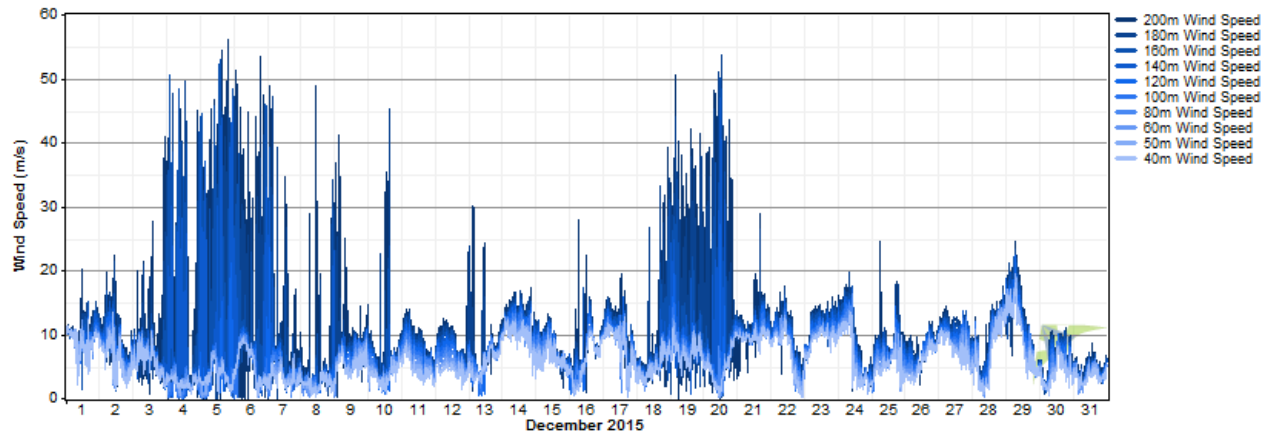
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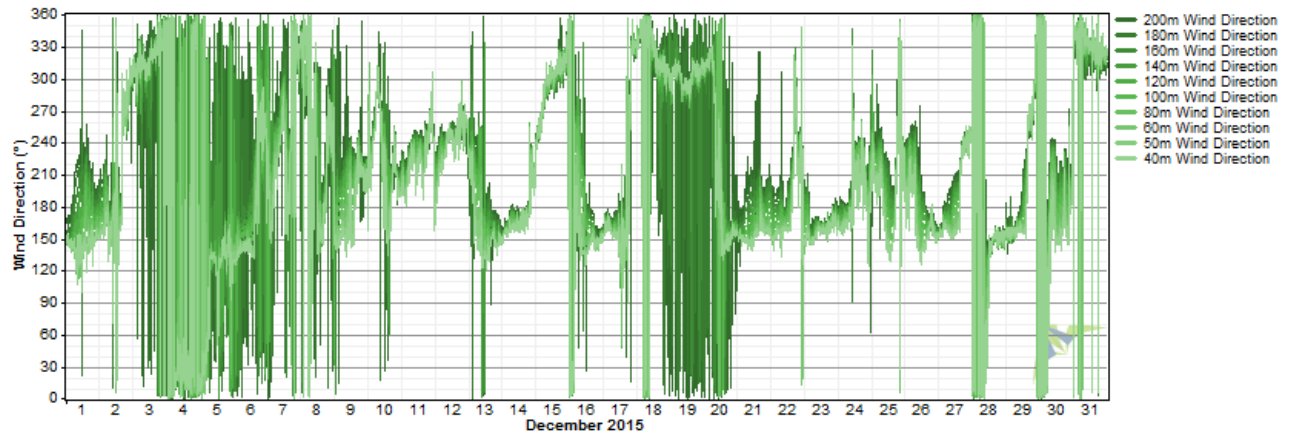
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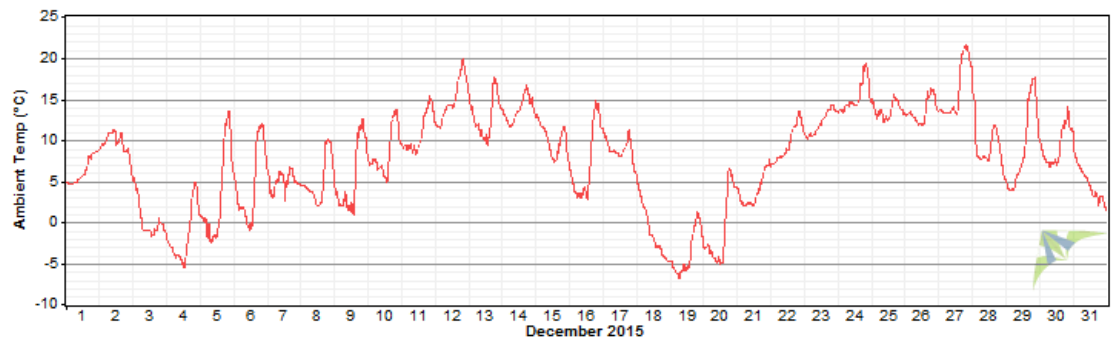
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## Wind Direction Data



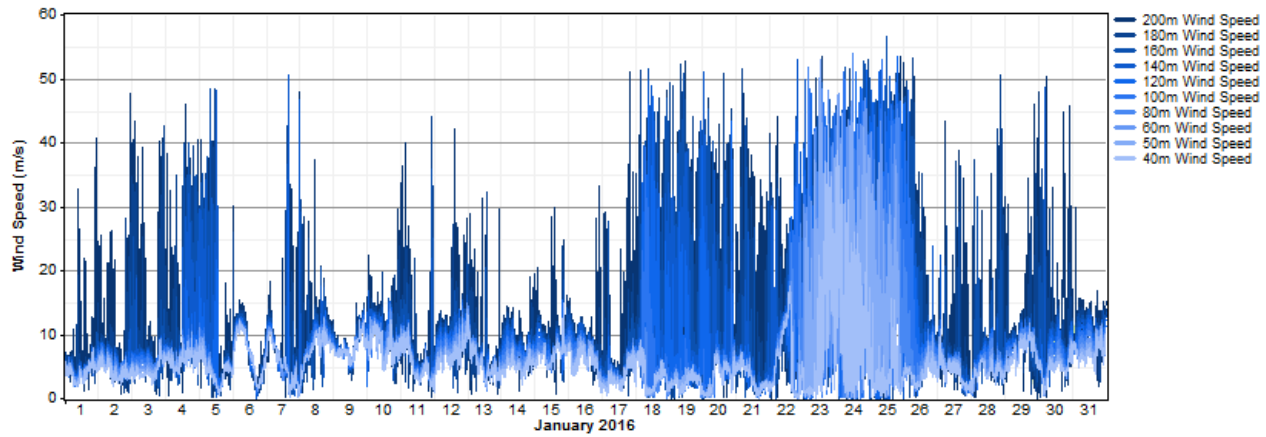
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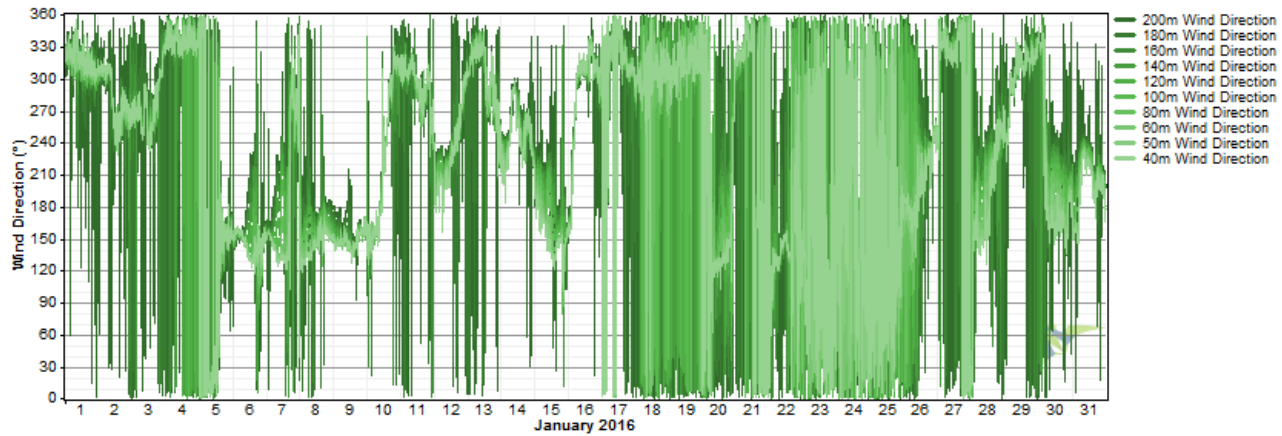
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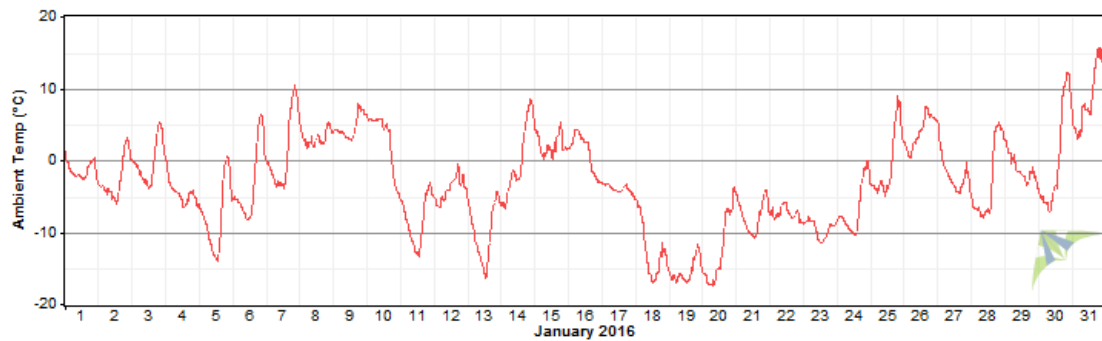
## Wind Speed Data



## Wind Direction Data



## Temperature Data

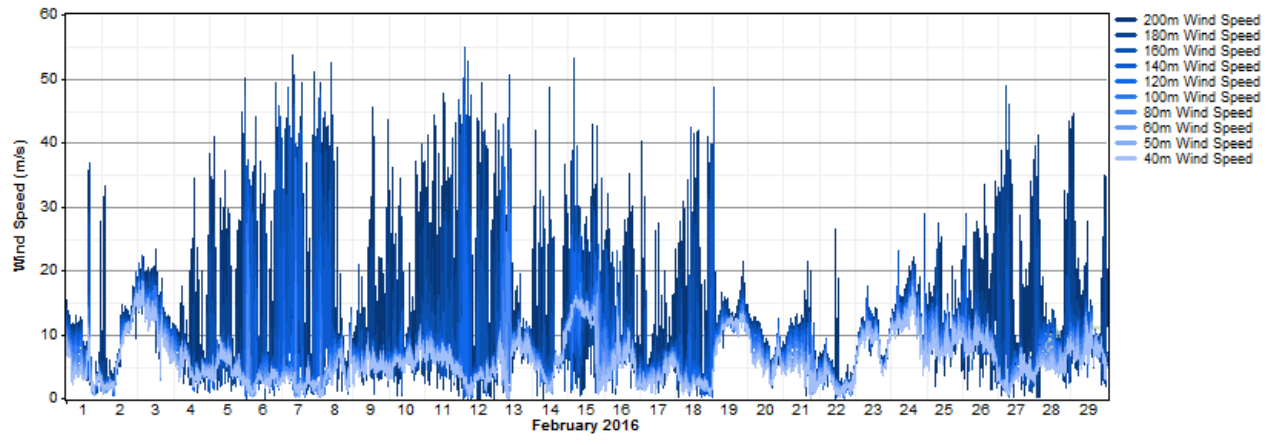




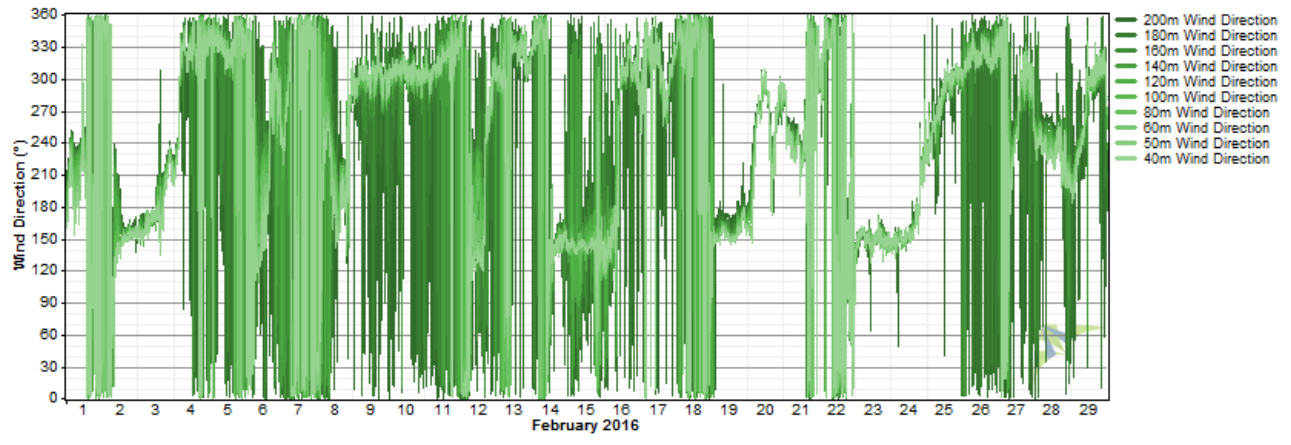
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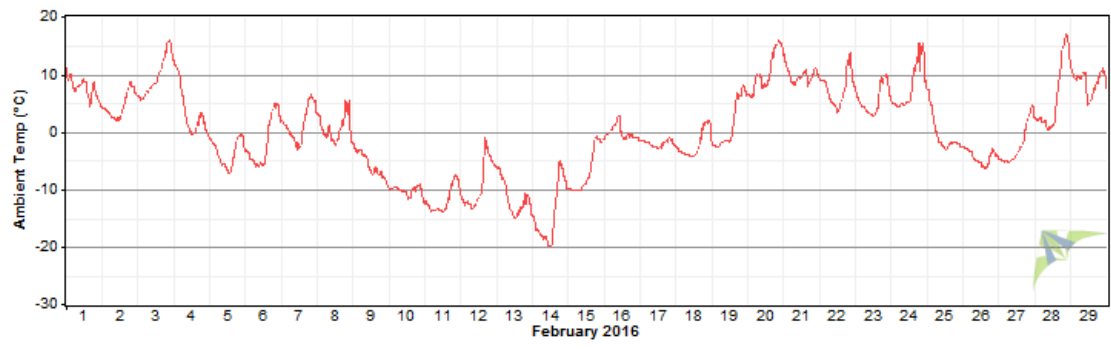
## Wind Speed Data



## Wind Direction Data



## Temperature Data

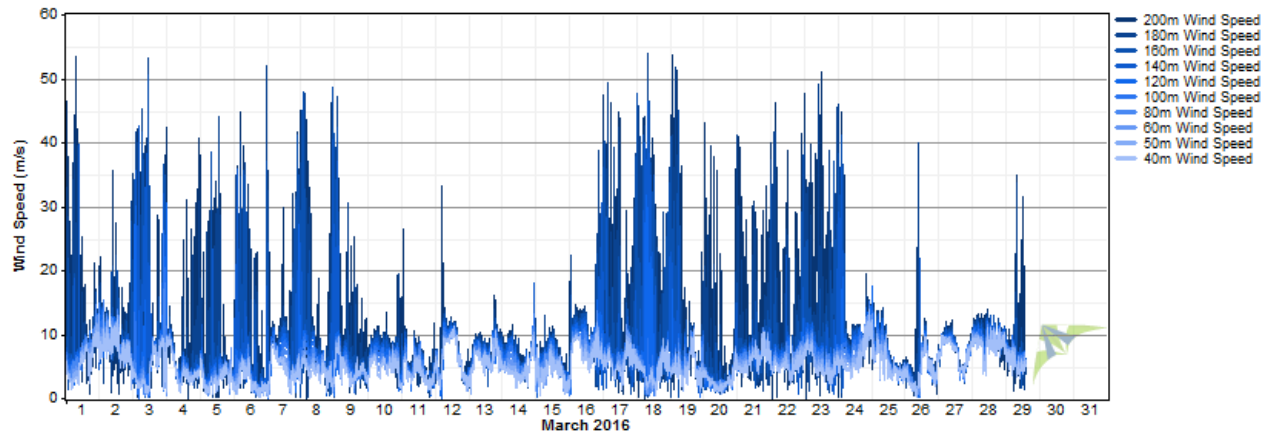




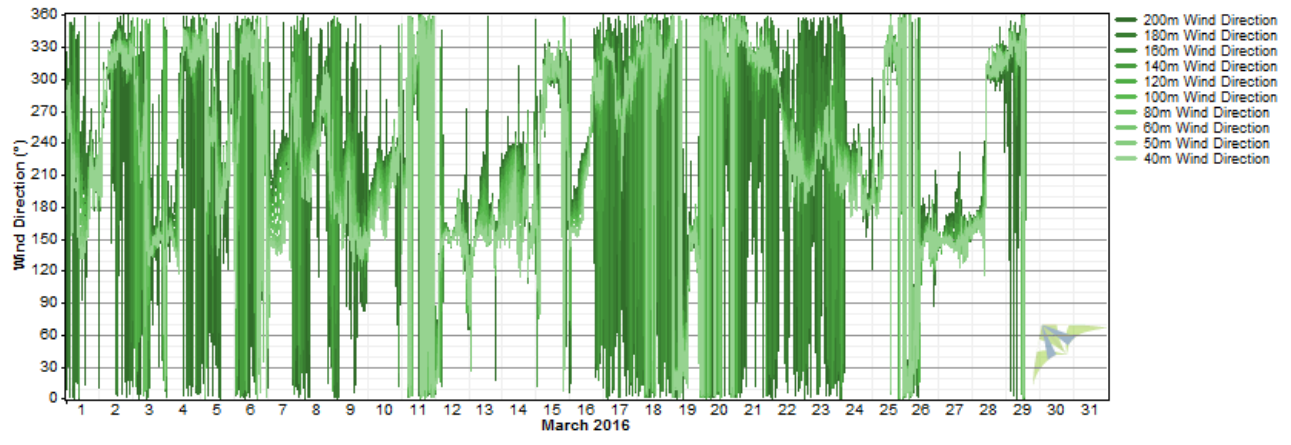
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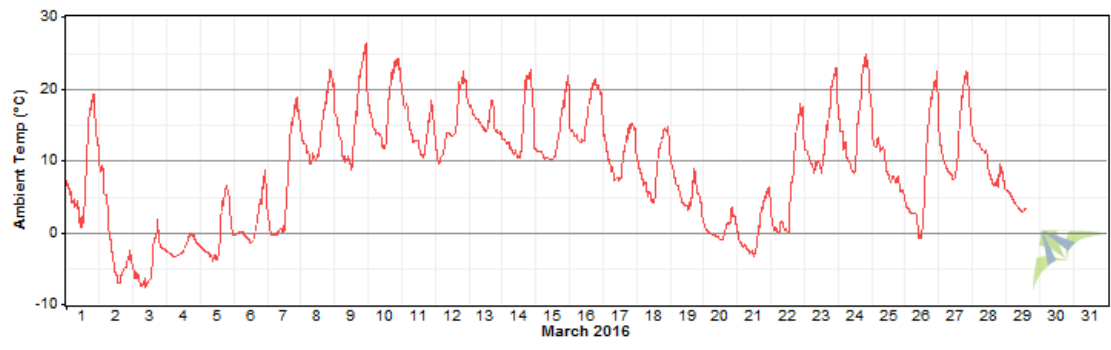
## Wind Speed Data



## Wind Direction Data



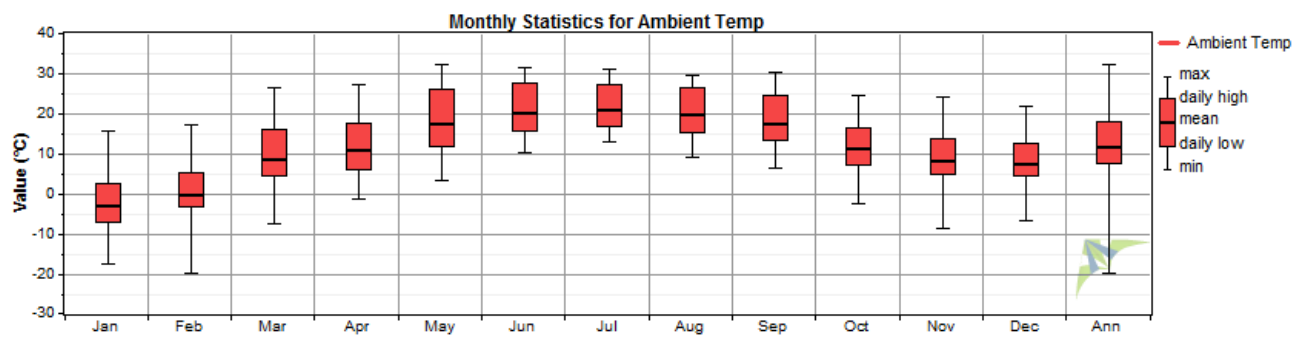
## Temperature Data



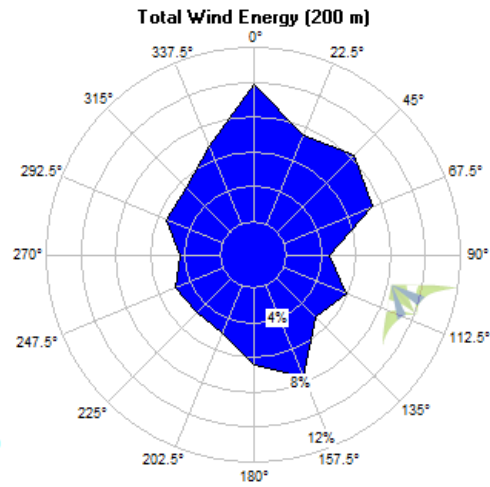
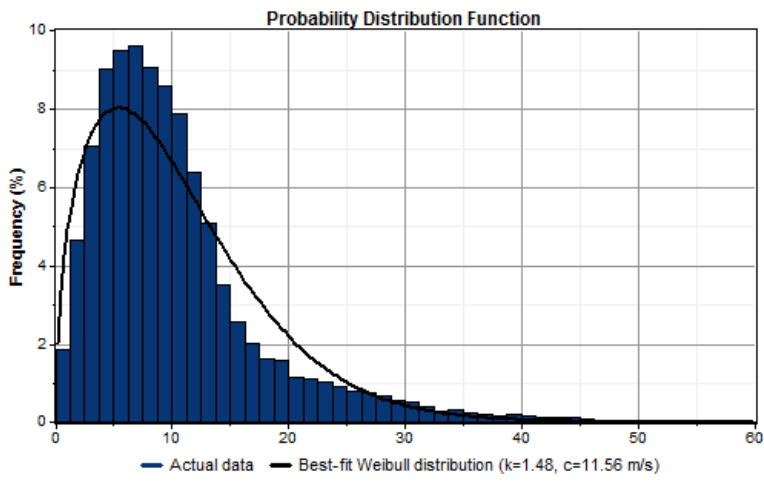
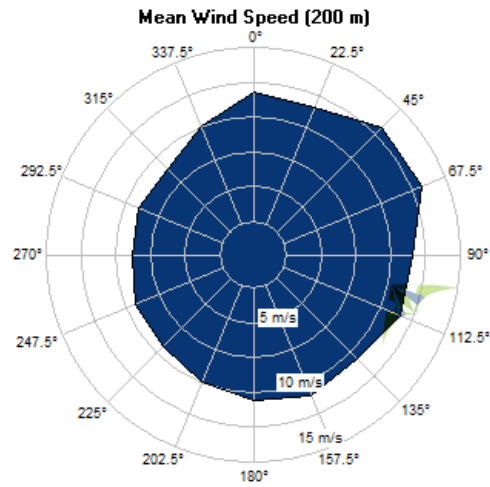
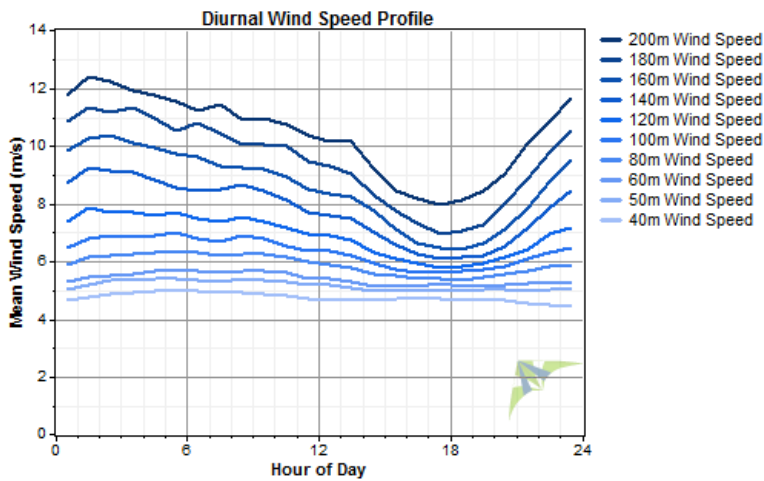
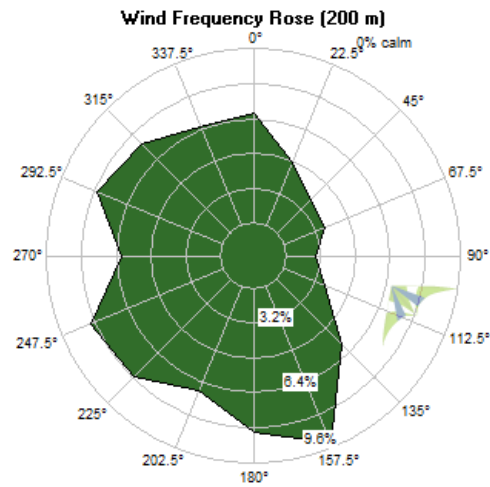
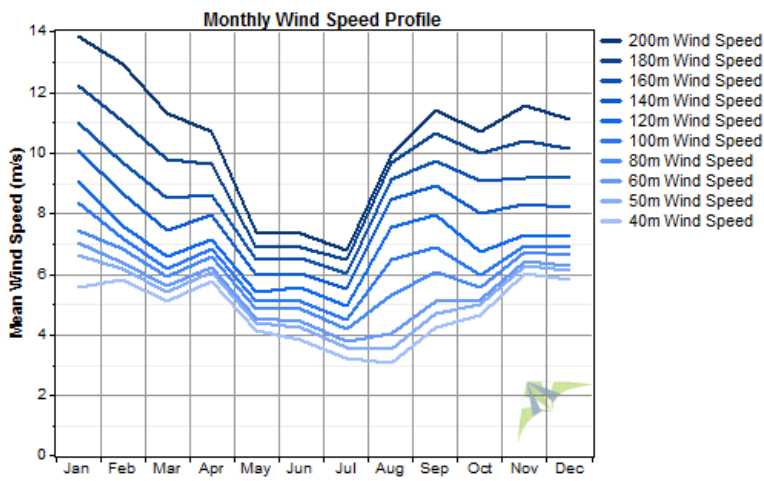
**Data Set Properties**

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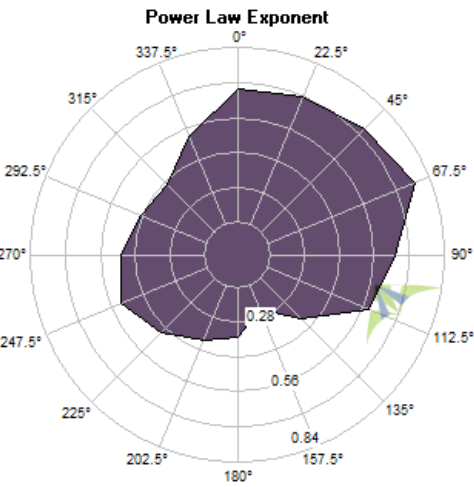
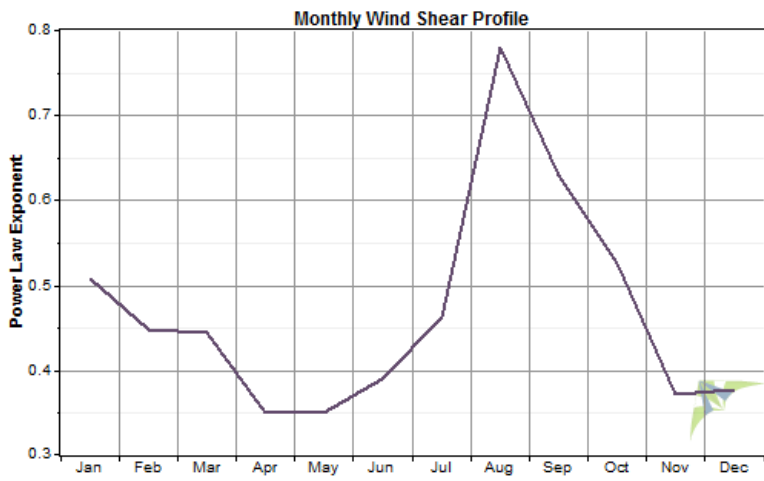
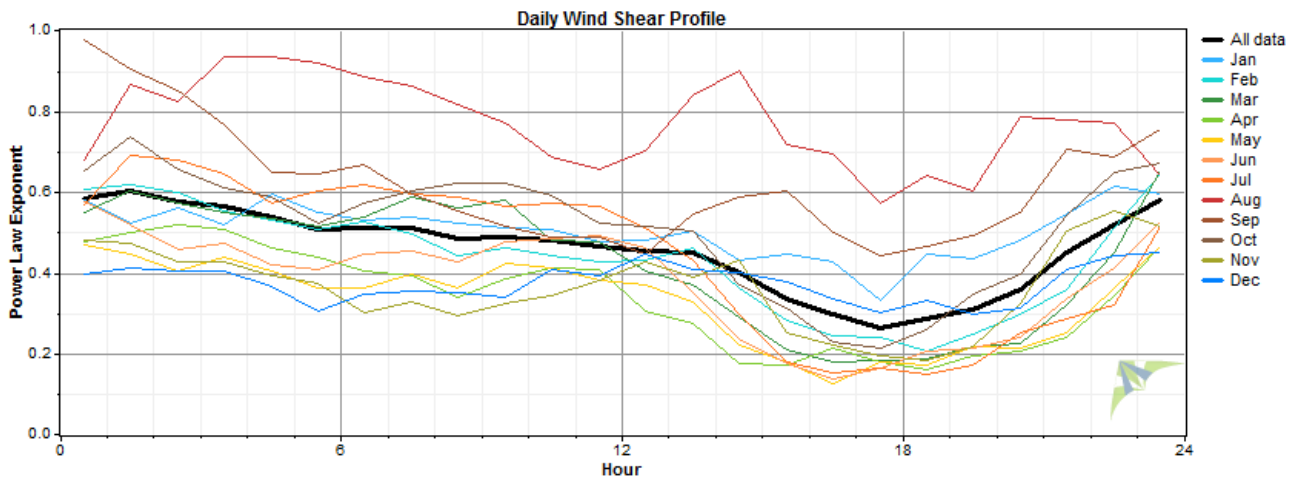
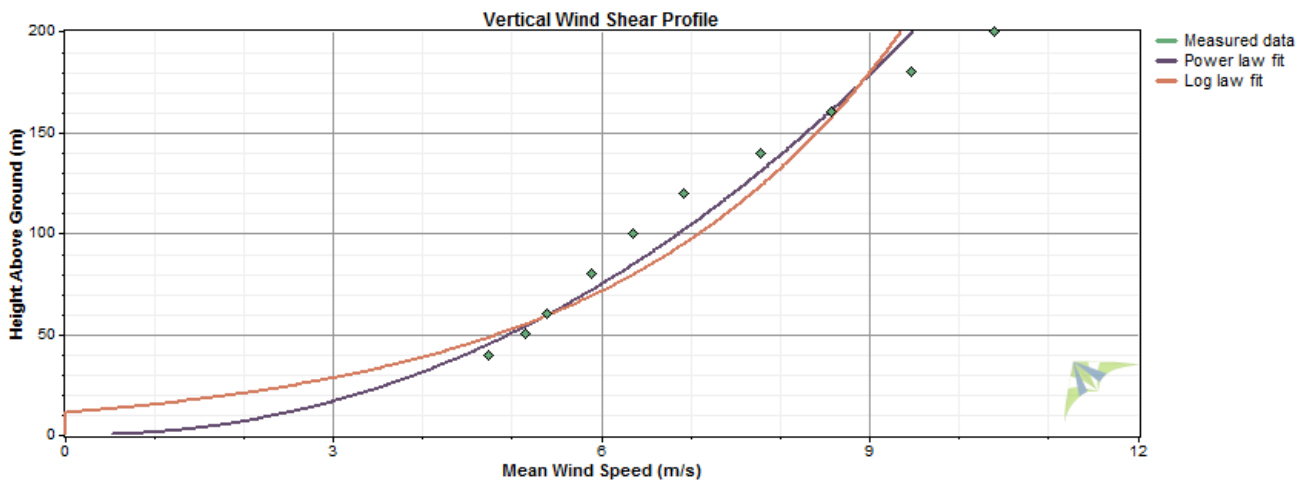
Variable	Value
Latitude	N 37.887130
Longitude	W 81.101680
Elevation	818 m
Start date	3/31/2015 20:10
End date	3/29/2016 14:10
Duration	12 months
Length of time step	10 minutes
Calm threshold	0 m/s
Mean temperature	11.8 °C
Mean pressure	0.000 mbar
Mean air density	1.125 kg/m <sup>3</sup>
Power density at 50m	181 W/m <sup>2</sup>
Wind power class	1 (Poor)
Power law exponent	0.467
Surface roughness	11.4 m
Roughness class	5.93
Roughness description	Urban



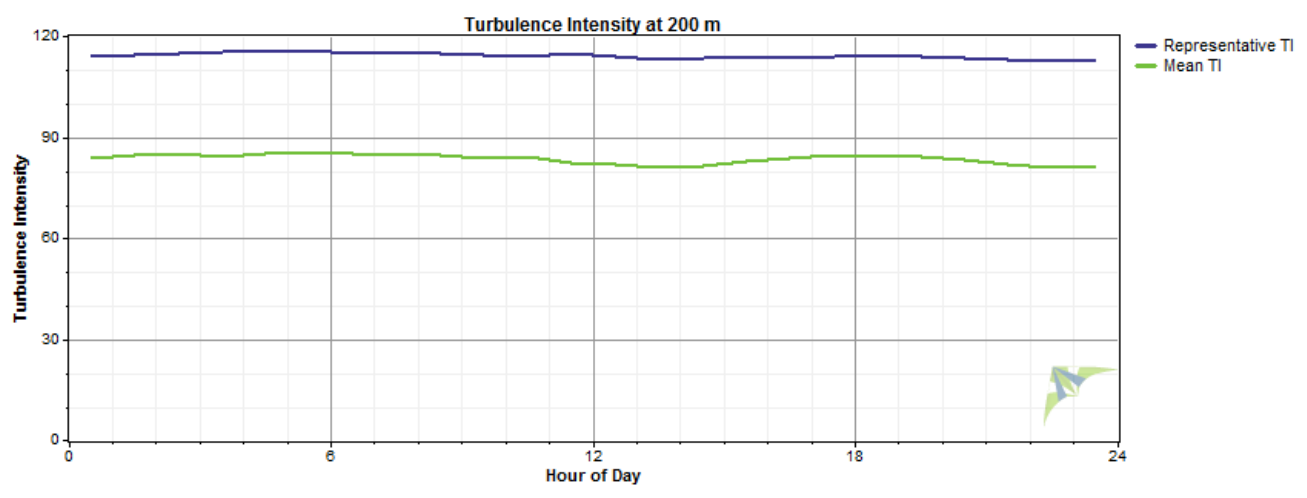
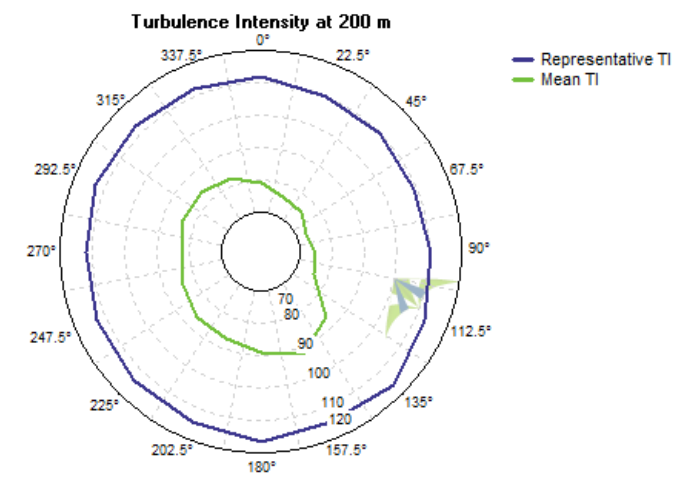
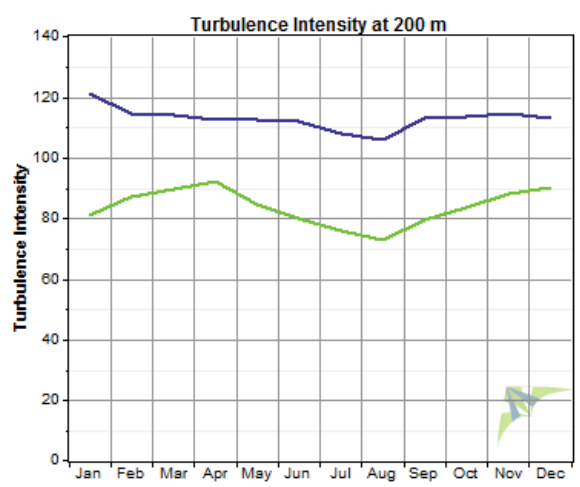
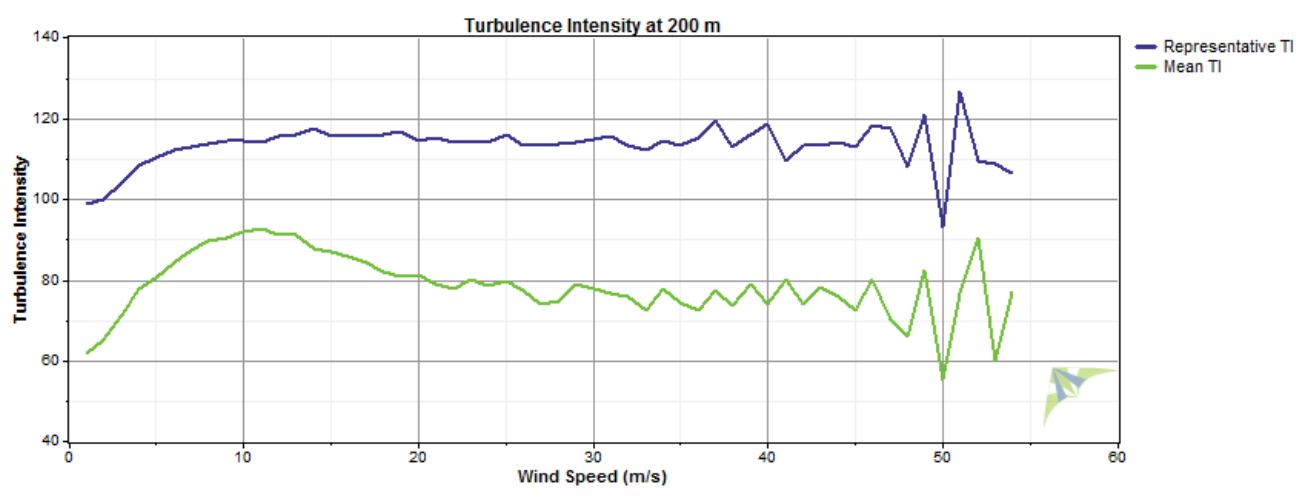
Wind Speed and Direction



Wind Shear



# 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>		52,380	52,380	100.00	6.54	1.00	12.00	3.45
2	Date			52,380	52,380	100.00	15.67	1.00	31.00	8.76
3	40m Wind Direction	°	40 m	52,380	52,354	99.95	192.8	0.0	360.0	95.2
4	40m Wind Speed	m/s	40 m	52,380	52,354	99.95	4.74	0.00	43.22	2.91
5	40m Wind Vert	m/s		52,380	52,354	99.95	0.018	-9.020	3.670	0.778
6	Quality (Station Height 40m)	%		52,380	52,354	99.95	97.1	0.0	100.0	8.8
7	50m Wind Direction	°	50 m	52,380	52,354	99.95	199.6	0.0	360.0	94.6
8	50m Wind Speed	m/s	50 m	52,380	52,354	99.95	5.16	0.00	53.10	3.18
9	50m Wind Vert	m/s		52,380	52,354	99.95	0.022	-9.010	5.340	0.836
10	Quality (Station Height 50m)	%		52,380	52,354	99.95	96.9	0.0	100.0	10.0
11	60m Wind Direction	°	60 m	52,380	52,354	99.95	204.5	0.0	360.0	94.9
12	60m Wind Speed	m/s	60 m	52,380	52,354	99.95	5.39	0.00	49.38	3.35
13	60m Wind Vert	m/s		52,380	52,354	99.95	0.026	-8.970	6.040	0.877
14	Quality (Station Height 60m)	%		52,380	52,354	99.95	96.2	0.0	100.0	11.1
15	80m Wind Direction	°	80 m	52,380	52,354	99.95	213.1	0.0	360.0	95.1
16	80m Wind Speed	m/s	80 m	52,380	52,354	99.95	5.89	0.00	53.90	3.55
17	80m Wind Vert	m/s		52,380	52,354	99.95	0.023	-9.020	7.830	1.003
18	Quality (Station Height 80m)	%		52,380	52,354	99.95	94.3	0.0	100.0	15.1
19	100m Wind Direction	°	100 m	52,380	52,354	99.95	218.2	0.0	360.0	95.3
20	100m Wind Speed	m/s	100 m	52,380	52,354	99.95	6.35	0.00	53.02	4.02
21	100m Wind Vert	m/s		52,380	52,354	99.95	0.002	-9.120	7.860	1.130
22	Quality (Station Height 100m)	%		52,380	52,354	99.95	90.8	0.0	100.0	20.0
23	120m Wind Direction	°	120 m	52,380	52,354	99.95	224.0	0.0	360.0	95.9
24	120m Wind Speed	m/s	120 m	52,380	52,354	99.95	6.91	0.00	53.45	4.43
25	120m Wind Vert	m/s		52,380	52,354	99.95	-0.045	-9.100	8.630	1.277
26	Quality (Station Height 120m)	%		52,380	52,354	99.95	85.3	0.0	100.0	25.6
27	140m Wind Direction	°	140 m	52,380	52,354	99.95	229.7	0.0	360.0	96.2
28	140m Wind Speed	m/s	140 m	52,380	52,354	99.95	7.79	0.00	58.83	5.21
29	140m Wind Vert	m/s		52,380	52,354	99.95	-0.128	-9.120	8.300	1.456
30	Quality (Station Height 140m)	%		52,380	52,354	99.95	77.6	0.0	100.0	31.2
31	160m Wind Direction	°	160 m	52,380	52,354	99.95	234.8	0.0	360.0	97.1
32	160m Wind Speed	m/s	160 m	52,380	52,354	99.95	8.58	0.00	56.70	6.07
33	160m Wind Vert	m/s		52,380	52,354	99.95	-0.246	-9.090	8.440	1.660
34	Quality (Station Height 160m)	%		52,380	52,354	99.95	69.0	0.0	100.0	35.1
35	180m Wind Direction	°	180 m	52,380	52,354	99.95	235.7	0.0	360.0	97.8
36	180m Wind Speed	m/s	180 m	52,380	52,354	99.95	9.46	0.00	57.93	6.82
37	180m Wind Vert	m/s		52,380	52,354	99.95	-0.42	-8.79	8.35	1.88
38	Quality (Station Height 180m)	%		52,380	52,354	99.95	59.7	0.0	100.0	37.6
39	200m Wind Direction	°	200 m	52,380	52,354	99.95	233.6	0.0	360.0	98.5
40	200m Wind Speed	m/s	200 m	52,380	52,354	99.95	10.40	0.00	56.22	7.59
41	200m Wind Vert	m/s		52,380	52,354	99.95	-0.624	-9.250	8.520	2.098
42	Quality (Station Height 200m)	%		52,380	52,354	99.95	51.2	0.0	100.0	38.4
43	40m Wind Turbulence	m/s		52,380	52,354	99.95	0.24	0.00	29.95	0.39
44	50m Wind Turbulence	m/s	40 m	52,380	52,354	99.95	0.24	0.00	52.25	0.51
45	60m Wind Turbulence	m/s	50 m	52,380	52,354	99.95	0.25	0.00	39.87	0.45
46	80m Wind Turbulence	m/s	60 m	52,380	52,354	99.95	0.28	0.00	60.87	0.65
47	100m Wind Turbulence	m/s	80 m	52,380	52,354	99.95	0.31	0.00	49.64	0.69
48	120m Wind Turbulence	m/s	100 m	52,380	52,354	99.95	0.34	0.00	65.54	0.73
49	140m Wind Turbulence	m/s	120 m	52,380	52,354	99.95	0.36	0.00	65.54	0.72
50	160m Wind Turbulence	m/s	140 m	52,380	52,354	99.95	0.40	0.00	65.54	0.96
51	180m Wind Turbulence	m/s	160 m	52,380	52,354	99.95	0.43	0.00	50.16	0.83
52	200m Wind Turbulence	m/s	180 m	52,380	52,354	99.95	0.46	0.00	65.54	0.89
53	Turbu. Quality (Station Height 40m)	m/s	200 m	52,380	52,354	99.95	83.6	0.0	100.0	23.9

Number	Label	Units	Height	Possible Records	Valid Records	Recovery Rate (%)	Mean	Min	Max	Std. Dev
54	Turbu. Quality (Station Height 50m)	%		52,380	52,354	99.95	85.7	0.0	100.0	23.0
55	Turbu. Quality (Station Height 60m)	%		52,380	52,354	99.95	86.1	0.0	100.0	22.9
56	Turbu. Quality (Station Height 80m)	%		52,380	52,354	99.95	86.0	0.0	100.0	23.6
57	Turbu. Quality (Station Height 100m)	%		52,380	52,354	99.95	83.6	0.0	100.0	25.7
58	Turbu. Quality (Station Height 120m)	%		52,380	52,354	99.95	79.4	0.0	100.0	28.8
59	Turbu. Quality (Station Height 140m)	%		52,380	52,354	99.95	73.2	0.0	100.0	32.4
60	Turbu. Quality (Station Height 160m)	%		52,380	52,354	99.95	65.1	0.0	100.0	35.4
61	Turbu. Quality (Station Height 180m)	%		52,380	52,354	99.95	56.5	0.0	100.0	37.3
62	Turbu. Quality (Station Height 200m)	%		52,380	52,354	99.95	48.4	0.0	100.0	37.8
63	Date (1)			52,380	52,380	100.00	2,016	2,015	2,016	1
64	Ambient Temp	°C		52,380	52,354	99.95	11.78	-20.00	32.40	9.55
65	Barometric Pressure	mbar		52,380	0	0.00				
66	Azimuth	Â°		52,380	52,354	99.95	0	0	0	0
67	TiltY	Â°		52,380	52,354	99.95	-1.494	-1.800	-0.900	0.130
68	TiltX	Â°		52,380	52,354	99.95	-0.678	-1.000	-0.200	0.135
69	Humidity	%		52,380	52,354	99.95	69.45	17.00	96.00	14.29
70	Noise Level-A	dB		52,380	52,354	99.95	12.51	5.00	17.20	2.42
71	Noise Level-B	dB		52,380	52,354	99.95	12.58	5.00	17.40	2.47
72	Noise Level-C	dB		52,380	52,354	99.95	12.51	5.00	17.20	2.42
73	Speaker Power	W		52,380	52,354	99.95	3.85	0.10	21.30	2.45
74	Modem Power	W		52,380	52,354	99.95	0.314	0.000	1.400	0.164
75	CPU Power	W		52,380	52,354	99.95	2.317	2.100	3.100	0.138
76	Core Power	W		52,380	52,354	99.95	2.630	2.200	3.000	0.094
77	PWM Power	W		52,380	52,354	99.95	1.225	0.600	2.400	0.186
78	Solar Power	W		52,380	52,354	99.95	0	0	0	0
79	Heater Temp	Â°C		52,380	52,354	99.95	0	0	0	0
80	Internal Temp	Â°C		52,380	52,354	99.95	15.45	-19.00	45.80	11.41
81	CPU Temp	Â°C		52,380	52,354	99.95	0	0	0	0
82	Mirror Temp	Â°C		52,380	52,354	99.95	14.67	-20.60	58.00	12.54
83	VibrationY	g		52,380	52,354	99.95	0	0	0	0
84	VibrationX	g		52,380	52,354	99.95	0	0	0	0
85	Battery	V		52,380	52,354	99.95	12.79	11.50	15.40	0.79
86	Beep Volume	dB		52,380	52,354	99.95	90.1	0.0	100.0	29.8
87	Endurance G-3120 Power Output	kW		52,380	52,354	99.95	8.61	0.00	35.49	10.91
88	Vestas V52 - 850 kW Power Output	kW		52,380	52,354	99.95	151.8	0.0	850.0	199.0
89	GE 2.5xl Power Output	kW		52,380	52,354	99.95	505	0	2,500	666
90	Air Density	kg/m³		52,380	52,380	100.00	1.125	1.048	1.265	0.038
91	200m Wind Speed WPD	W/m²		52,380	52,354	99.95	2,134	0	100,064	6,246
92	180m Wind Speed WPD	W/m²		52,380	52,354	99.95	1,621	0	113,177	5,384
93	160m Wind Speed WPD	W/m²		52,380	52,354	99.95	1,208	0	108,446	4,581
94	140m Wind Speed WPD	W/m²		52,380	52,354	99.95	838	0	116,668	3,510
95	120m Wind Speed WPD	W/m²		52,380	52,354	99.95	546	0	86,691	2,551
96	100m Wind Speed WPD	W/m²		52,380	52,354	99.95	423	0	88,310	2,277
97	80m Wind Speed WPD	W/m²		52,380	52,354	99.95	302	0	95,357	1,516
98	60m Wind Speed WPD	W/m²		52,380	52,354	99.95	251	0	73,687	1,538
99	50m Wind Speed WPD	W/m²		52,380	52,354	99.95	210	0	91,627	1,210
100	40m Wind Speed WPD	W/m²		52,380	52,354	99.95	152	0	49,051	613

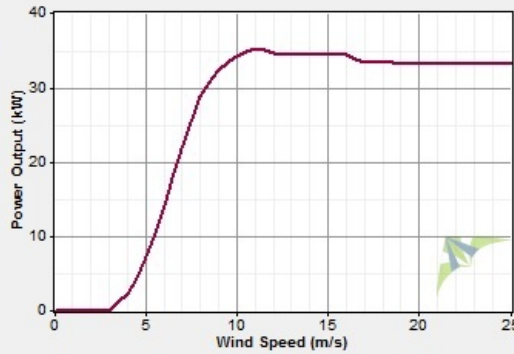
## Wind Turbine Output

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:

### Properties

Manufacturer: Endurance Wind Power  
 Website: [www.endurancewindpower.c](http://www.endurancewindpower.c)  
 Rotor diameter: 19.2 m  
 Rated power: 35 kW  
 Power regulation: Stall control



### Hub height

30.5 m  
 42.7 m  
 Other  m

### Losses

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

- Monthly details  
 Turbine comparison

Month	Valid	Hub Height	Time At	Time At	Mean Net	Mean Net	Net Capacity
	Data	Wind Speed	Zero Output	Rated Output	Power Output	Energy Output	
	Points	(m/s)	(%)	(%)	(kW)	(kWh/yr)	
Jan	4,462	5.74	19.54	0.09	9.6	7,133	27.4
Feb	4,176	5.75	24.50	0.12	10.3	6,949	29.5
Mar	4,137	5.01	21.54	0.00	8.0	5,915	22.7
Apr	4,318	5.68	18.39	0.00	10.1	7,242	28.7
May	4,461	4.11	31.54	0.00	4.8	3,553	13.6
Jun	4,317	3.93	38.55	0.00	4.5	3,216	12.8
Jul	4,459	3.30	47.32	0.00	2.3	1,678	6.4
Aug	4,463	3.36	46.85	0.00	2.3	1,687	6.5
Sep	4,317	4.40	33.12	0.00	5.8	4,179	16.6
Oct	4,462	4.60	32.72	0.00	6.4	4,797	18.4
Nov	4,318	5.86	25.36	0.00	10.9	7,866	31.2
Dec	4,464	5.71	21.62	0.00	10.5	7,834	30.1
Overall	52,354	4.78	30.18	0.02	7.1	62,085	20.2



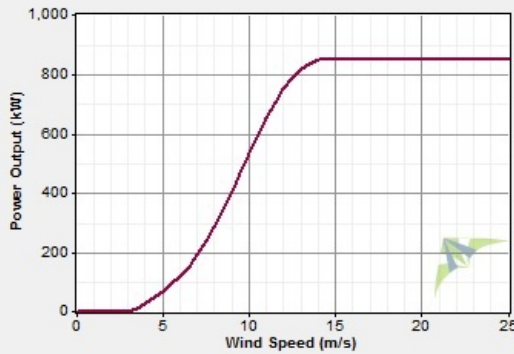
## Wind Turbine Output

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:

### Properties

Manufacturer: Vestas Wind Systems A/S  
 Website: [www.vestas.com](http://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  m

### Losses

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

Monthly details

Turbine comparison

Month	Valid	Hub Height	Time At	Time At	Mean Net	Mean Net	Net Capacity
	Data	Wind Speed	Zero Output	Rated Output	Power Output	Energy Output	Factor
	Points	(m/s)	(%)	(%)	(kW)	(kWh/yr)	(%)
Jan	4,462	6.99	9.66	3.88	182.9	136,101	21.5
Feb	4,176	6.73	13.67	2.23	193.0	129,685	22.7
Mar	4,137	5.92	13.10	0.00	126.6	94,173	14.9
Apr	4,318	6.51	10.44	0.65	165.9	119,437	19.5
May	4,461	4.74	22.17	0.00	64.8	48,187	7.6
Jun	4,317	4.64	28.10	0.00	66.5	47,847	7.8
Jul	4,459	4.02	34.22	0.00	38.5	28,637	4.5
Aug	4,463	4.55	23.97	0.04	58.3	43,412	6.9
Sep	4,317	5.58	16.21	0.09	113.0	81,380	13.3
Oct	4,462	5.59	19.27	1.37	117.3	87,246	13.8
Nov	4,318	6.70	14.98	0.88	194.2	139,852	22.9
Dec	4,464	6.62	13.46	0.81	183.6	136,578	21.6
Overall	52,354	5.71	18.34	0.83	124.9	1,094,181	14.7

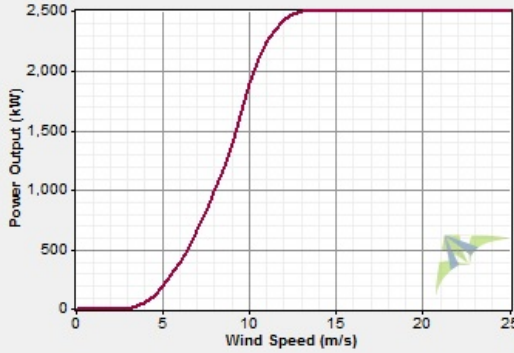
### Wind Turbine Output

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:

**Properties**

Manufacturer: GE Wind  
 Website: [www.gepower.com](http://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  m

**Losses**

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

- Monthly details
- Turbine comparison

Month	Valid	Hub Height	Time At	Time At	Mean Net	Mean Net	Net Capacity
	Data	Wind Speed	Zero Output	Rated Output	Power Output	Energy Output	Factor
	Points	(m/s)	(%)	(%)	(kW)	(kWh/yr)	(%)
Jan	4,462	7.03	9.48	4.86	607.5	451,975	24.3
Feb	4,176	6.76	13.36	5.48	636.8	427,941	25.5
Mar	4,137	5.94	12.98	0.12	429.3	319,413	17.2
Apr	4,318	6.53	10.24	1.69	556.3	400,536	22.3
May	4,461	4.76	21.95	0.00	210.5	156,606	8.4
Jun	4,317	4.67	27.89	0.00	219.1	157,728	8.8
Jul	4,459	4.04	33.86	0.00	121.2	90,199	4.8
Aug	4,463	4.59	23.59	0.40	189.7	141,131	7.6
Sep	4,317	5.62	15.75	0.21	380.6	274,007	15.2
Oct	4,462	5.62	19.03	2.87	385.3	286,656	15.4
Nov	4,318	6.72	14.61	2.55	649.8	467,828	26.0
Dec	4,464	6.65	13.24	1.90	619.5	460,914	24.8
Overall	52,354	5.74	18.06	1.67	415.5	3,639,793	16.6