2009-2010 Ohio Anemometer Loan Program (ALP)
March 2010 Monthly Summary Report

Grant No. 08-01

Prepared for:

Ohio Department of Development, Ohio Energy Office
77 South High Street, 26th Floor
Columbus, OH 43216

Ashtabula Port Authority
4717 Main Avenue
Ashtabula, OH 44004

and

Pettisville Local Schools
232 Summit Street
Pettisville, OH 43553

Prepared by:

Emily Sautter, Green Energy Ohio, Wind Program Coordinator
Kemp Jaycox, Green Energy Ohio, Wind Program Manager
7870 Olentangy River Road, Suite 209
Columbus, OH 43235

---

1. Site Status

Data collection continues for the two recipients of the 2009-2010 Ohio Anemometer Loan Program. There have been no data recovery issues for either site for the month of March 2010.

Preliminary results for the month of March 2010 are summarized in Section 2. A short summary of the study to date can be found in Section 3. Specifications for the 2009-2010 ALP sites are included in Appendices A & B (Site Specification Logs).

2. Monthly Data Analysis Summary

Preliminary wind data collected at the ALP sites during the month of March 2010 are summarized below in Tables 1 and 2, and Figures 1 through 4. The data in this section have not been filtered for icing or tower shading.

Table 1: Ashtabula Port Authority Summary of Monthly Average Wind Speed, Power Density and Turbulent Intensity.

Channel	Height (feet)	Height (meters)	Boom Orientation (degrees)	Monthly Average Wind Speed (mph)	Monthly Average Wind Speed (m/s)	Cubic Average Wind Speed (mph)	Cubic Average Wind Speed (m/s)	Monthly Wind Power Density (W/m2)	Monthly Turbulent Intensity
1	98	29.9	135	9.4	4.2	11.8	5.3	92.1	0.21
2	98	29.9	315	9.4	4.2	11.9	5.3	94.5	0.21
3	131	39.9	135	10.5	4.7	13.1	5.9	124.6	0.18
4	131	39.9	315	10.5	4.7	13.2	5.9	126.2	0.18
5	164	50.0	135	11.7	5.2	14.5	6.5	168.7	0.16
6	164	50.0	315	11.7	5.2	14.5	6.5	168.0	0.16
Shear Exponent	**Channels**	**Exponent from Average of Wind Shear Column**	**Exponent from Average Wind Speed**						
Exp1	1 to 3	0.4278	0.3871						
Exp2	3 to 5	0.4957	0.4820						
Exp3	2 to 4	0.3935	0.3682						
Exp4	4 to 6	0.5589	0.4814						

Table 2: Pettisville Summary of Monthly Average Wind Speed, Power Density and Turbulent Intensity.

Channel	Height (feet)	Height (meters)	Boom Orientation (degrees)	Monthly Average Wind Speed (mph)	Monthly Average Wind Speed (m/s)	Cubic Average Wind Speed (mph)	Cubic Average Wind Speed (m/s)	Monthly Wind Power Density (W/m2)	Monthly Turbulent Intensity
1	102	31.1	180	9.8	4.4	12.2	5.4	98.2	0.17
2	102	31.1	332	9.9	4.4	12.2	5.5	100.0	0.16
3	131	39.9	180	10.5	4.7	12.9	5.8	117.1	0.16
4	131	39.9	332	10.6	4.7	12.9	5.8	118.2	0.15
5	164	50.0	180	11.2	5.0	13.7	6.1	138.8	0.15
6	164	50.0	332	11.2	5.0	13.6	6.1	137.2	0.15

Shear Exponent	Channels	Exponent from Average of Wind Shear Column	Exponent from Average Wind Speed
Exp1	1 to 3	0.3192	0.2893
Exp2	3 to 5	0.2753	0.2769
Exp3	2 to 4	0.2953	0.2699
Exp4	4 to 6	0.2025	0.2335

Figure 1: Ashtabula Port Authority Daily Average Wind Speeds for March 2010

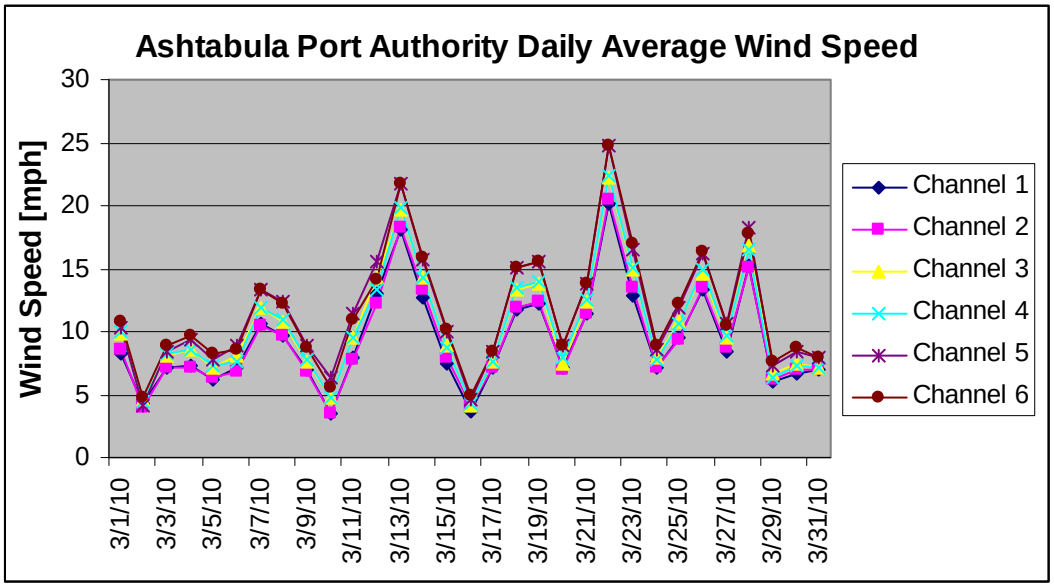


Figure 2: Ashtabula Port Authority Daily Average Wind Power Density for March 2010

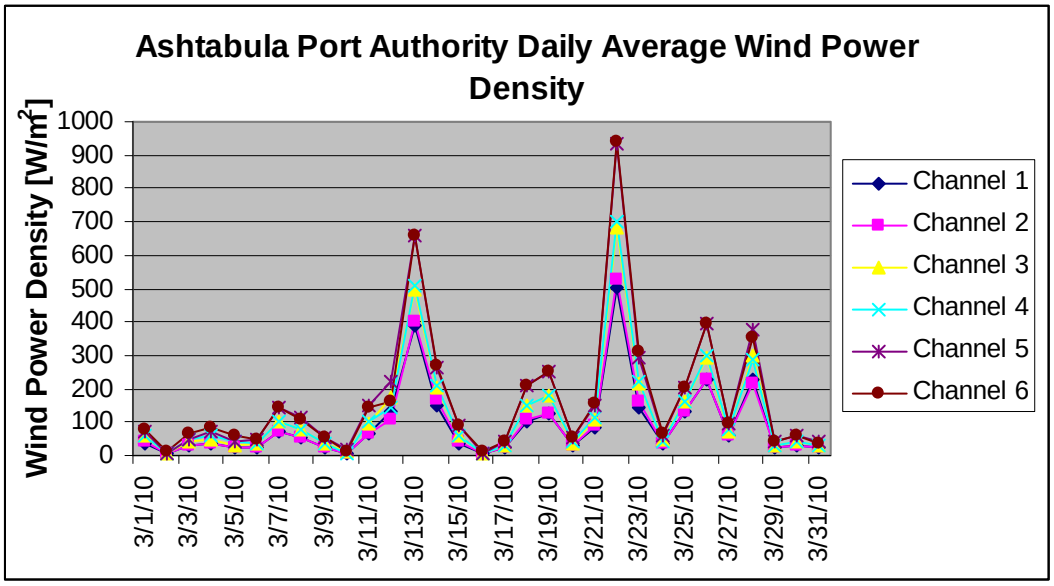


Figure 3: Pettisville Daily Average Wind Speeds for March 2010

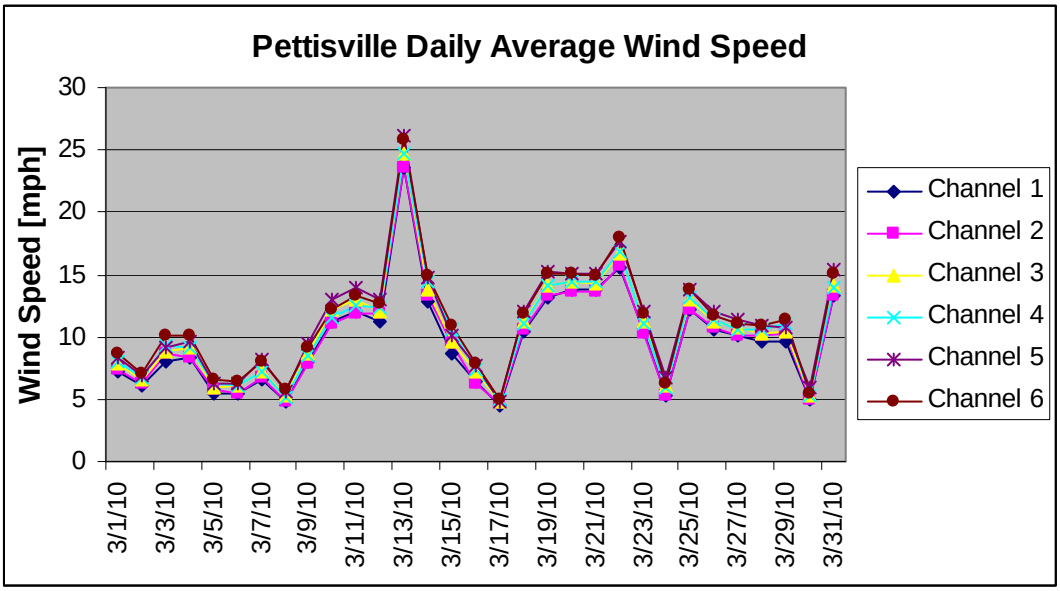
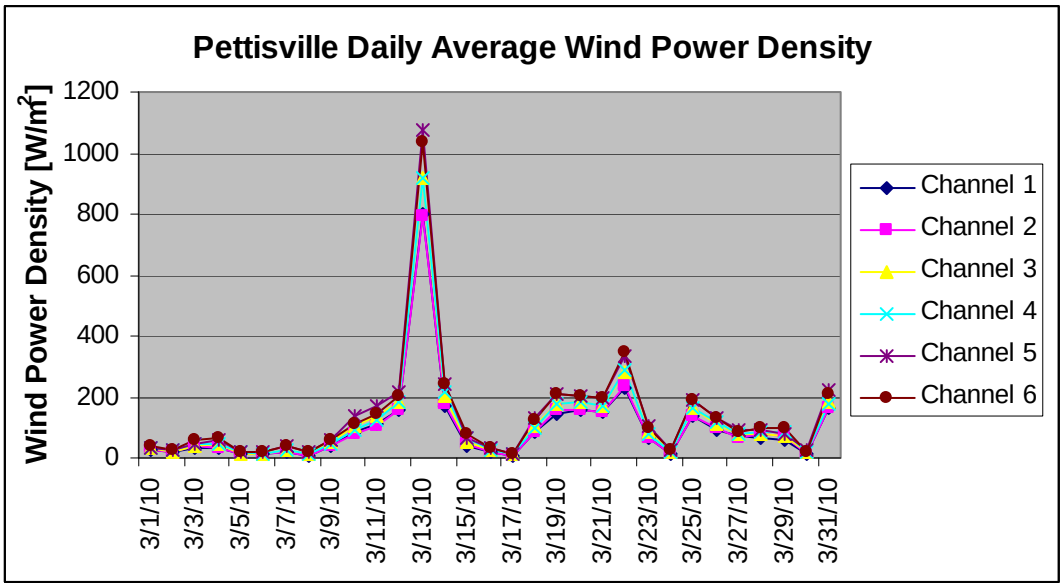


Figure 4: Pettisville Daily Average Wind Power Density for March 2010



3. Data Analysis Summary (study to date)

Figures 3 and 4 display monthly average wind speed data and monthly average wind power density data for the study to date. Thus far, the site at the Ashtabula Water Treatment Plant has reported higher monthly average wind speeds than the site at Pettisville. Wind speeds and wind power density values increased for both sites from September to October 2009. Note that since both sites were commissioned in September, the monthly averages calculated for September did not include data for the whole month, and may not be representative of the entire month.

Wind speeds increased at the Ashtabula site from October to November; however, wind speeds at the Pettisville site decreased during the same time period. Wind power density values decreased for both sites from October to November. Since monthly average wind speeds increased and temperatures decreased (therefore air density increased) at the Ashtabula site from October to November, wind power density should have increased during this time period, as air density and wind speed are the only variables in the calculation of wind power density. The general equation used to calculate power density is:

$$power\ density = \frac{1}{2} \times \rho V^3$$

Here ρ is the air density, and V is the wind velocity. In our model, air density was calculated as a function of the temperature at the site, the elevation of the site and the channel height of the specific anemometer in question:

$$\rho = (353.05/(273 + temperature)) * e^{(-0.034*((elevation+channelheight)/(273+temperature))}$$

Here, temperature is the site temperature in Celsius, elevation is the site elevation in meters, channel height is the height in meters above ground of the anemometer in question, and is the air density in kg/m^3. In this case, the discrepancy of a decreasing wind power density when wind speed is increasing is due to the fact that the wind power density equation cubes the wind speed, thus, it more heavily weights higher wind speeds. Though the average wind speed was greater during November at the Ashtabula site, there was one extremely high wind day on October 7, 2009 (50 meter daily average wind speed of 29.4 mph!), that skewed the monthly wind power density average for October and caused it to be higher than the November average.

Average monthly wind speed and wind power density values increased for both sites from November to December 2009. Wind speeds and wind power density values decreased from December 2009 to January 2010, which is contrary to the historical trend of January being the windiest month of the year in Ohio. Wind speeds and wind power density values also decreased for both sites from January 2010 to February 2010. Wind speeds and wind power densities decreased from February to March 2010 for the site at Ashtabula, while wind speeds remained the same at the 50 meter level for the site at Pettisville. Wind power density values decreased from February to March 2010 for the site at Pettisville, as temperatures are increasing and air density is decreasing.

Figure 5: Monthly Average Wind Speeds (Data Filtered for Icing and Tower Shading)

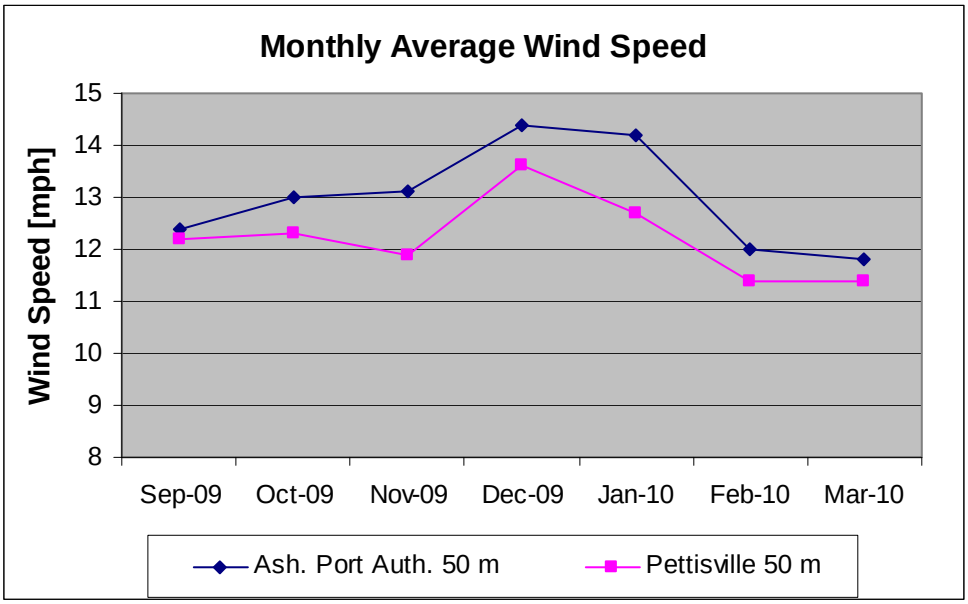
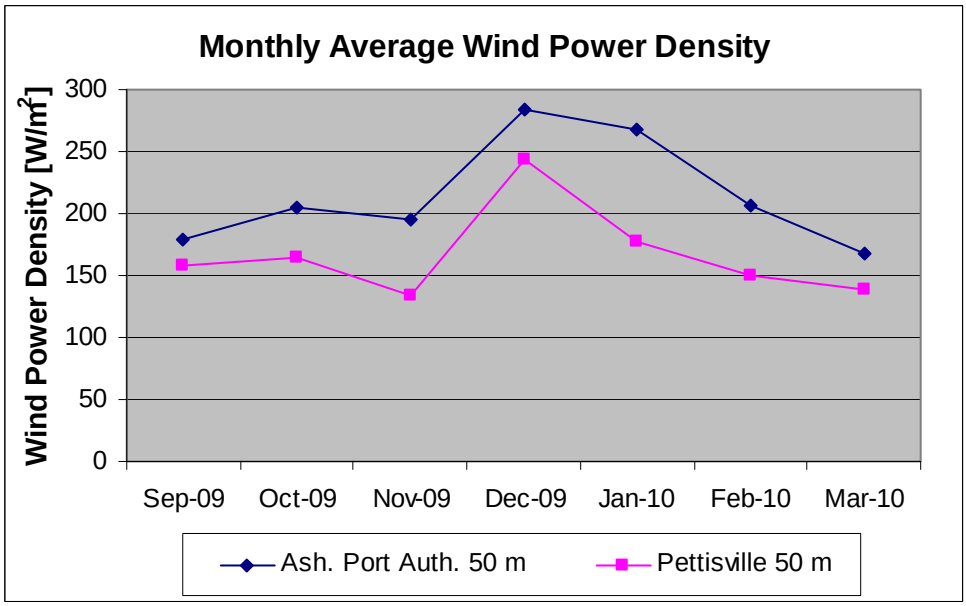


Figure 6: Monthly Average Wind Power Density (Data Filtered for Icing and Tower Shading)



APPENDIX A: SITE SPECIFICATION LOG – ASHTABULA PORT AUTHORITY

SITE

Site Name:	Ashtabula Port Authority
Installation Date:	September 7, 2009
Tower Owner:	Ohio Department of Development (ALP)
Site Location (description):	Tower located on grassy field on the southeast corner of the Ashtabula Water Treatment Plant property (303 Woodland Ave.). Tower is located approx. 205 feet due north of E. 5th St., and approx. 445 feet west of Parkgate Ave. (GPS coordinates): N 41° 54.112'; W 80° 47.162'
Ground Elevation:	625 ft
Prevailing Wind Direction:	WSW (from OPSB Interactive Wind Resource Map)
Site Sponsor Contacts:	Alicia McFarland, 440-992-7154 (Office), 440-813-3076 (Cell), amcfarland@cityofashtabula.com Michael Mearini, 440-964-3030, 440-228-9217, michaelm@cityofashtabula.com
Logger Lock Combination:	356

TOWER

FCC Tower Registration:	None (50m XHD NRG Tall Tower) Tower ground assembly orientation: 0°; boom offsets: anemometers 135° & 315°; vanes 0°
Height of structure:	197 ft
Nominal Boom Heights:	30m, 40m, 50m

INSTRUMENTATION

Data Logger: NRG Symphonie, Serial Number 8064; Site Number 1234

Sensors:

Logger Channel	Instrument	Serial Number	Slope (mph)	Offset (mph)	Height (ft)	Boom Azimuth (degrees)	Deadband Azimuth (degrees)
1	NRG Max 40 Anemometer	15580	1.698	0.76	98	135	
2	NRG Max 40 Anemometer	15581	1.700	0.85	98	315	
3	NRG Max 40 Anemometer	15582	1.702	0.76	131	135	
4	NRG Max 40 Anemometer	15583	1.700	0.76	131	315	
5	NRG Max 40 Anemometer	15584	1.698	0.85	164	135	
6	NRG Max 40 Anemometer	15585	1.698	0.81	164	315	
7	NRG 200P Vane	None	0.351	0	134	360	360
8	NRG 200P Vane	None	0.351	0	161	360	360
9							
10	NRG Temp Sensor	None	0.244	-123.5	9	360	360

INCIDENT LOG:

August 20, 2009: Tower surveying and anchor installation completed. Shifted tower layout to extend N-S anchors for additional stability. Confirmed location of underground utilities along access drive (west of anchors) with Ashtabula Wastewater Treatment Plant and City of Ashtabula personnel. Tested two anchors in west quadrant using TRG dynamometer and small back hoe (3,500 lbs. of force); no pull-out was observed. Excavated 5 ft. x 5 ft. x 2 ft. deep area for base plate to meet engineer's specifications. Lined hole with geotechnical fabric and filled with 4.89 tons of #304 crushed stone. Compacted stone with TRG backhoe. (The Renaissance Group [TRG] & Green Energy Ohio [GEO]).

August 22, 2009: TRG pull-tested the six anchors in the south and west quadrants to 7,000 lbs. using TRG dynamometer and backhoe provided by Ashtabula Port Authority; no pull-out was observed. Based on soil conditions observed during anchor installation activities, the anchors in the north and east quadrants were not tested (TRG).

August 26, 2009: NRG 50 meter MET tower decommissioned from Cuyahoga County Fairgrounds in Berea, OH (TRG & GEO). Tower transported to Ashtabula by TRG.

August 27, 2009: Began tower layout and assembly activities, including sensor prep & testing, boom attachment and logger programming (TRG & GEO).

September 7, 2009: Tower, boom, and instrument assembly completed. Tower raised & straightened and guy wires tightened (TRG). Data collection for anemometers and vanes begins (TRG).

September 8, 2009: Temperature sensor installed and operating correctly.

September 28, 2009: Logger time clock reset from 10:40 to 11:40 to reflect correct time.

January 10, 2010: Icing event affecting channels 7 & 8; began at 4:40 a.m., channel 7 recovered at 6:20 a.m., channel 8 recovered at 5:30 p.m.

January 17, 2010: Icing event affecting channels 7 & 8; began at 8:20 a.m. and ended at 10:40 a.m.

January 18, 2010: Icing event affecting channels 1 & 3; began at 4:00 a.m., channel 1 recovered at 2:40 p.m., channel 3 recovered at 5:50 p.m.

January 18-21, 2010: Icing event affecting channels 4, 7, & 8; began at 4:00 a.m., channel 4 recovered at 11:10 p.m. on January 19th, channel 7 recovered at 9:50 a.m. on January 21st, channel 8 recovered at 10:10 a.m. on January 21st.

February 2-3, 2010: Icing event affecting channels 7 & 8; channel 7 froze at 9:40 p.m., channel 8 froze at 11:00 p.m., both channels recovered at 2:30 a.m. on February 3rd.

February 23, 2010: Icing event affecting channel 3; froze at 4:30 a.m. and recovered at 2:50 p.m.

February 23-24, 2010: Icing event affecting channels 3, 5, 6, 7 & 8; channel 5 froze at 8:00 a.m., channel 6 froze at 8:50 a.m., channel 3 froze at 3:50 p.m., channel 7 & 8 froze at 12:20 a.m. on the 23rd, channel 5 & 6 recovered at 10:10 a.m. on the 24th, channel 3 recovered at 9:50 a.m. on the 24th, channel 7 recovered at 9:20 a.m. on the 24th, and channel 8 recovered at 11:20 a.m. on the 24th.

February 24-25, 2010: Icing event affecting channel 8; froze at 2:40 p.m. on the 24th and recovered at 12:20 p.m. on the 25th.

February 26-28, 2010: Icing event affecting channels 1-8; channels 1-3 & 5 froze at 2:50 p.m. on the 26th, channel 4 froze at 3:20 p.m. on the 26th, channel 6 froze at 3:30 p.m. on the 26th,

channel 8 froze at 12:40 p.m. on the 26th, and channel 7 froze at 1:00 p.m. on the 26th, channel 1 recovered at 12:50 p.m. on the 27th, channel 2 recovered at 10:40 a.m. on the 28th, channel 5 recovered at 12:20 p.m. on the 28th, channels 3 & 4 recovered at 12:40 p.m. on the 28th, channel 6 recovered at 1:00 p.m. on the 28th, channel 8 recovered at 11:20 a.m. on the 28th, and channel 7 recovered at 11:20 a.m. on the 27th.

APPENDIX B: SITE SPECIFICATION LOG – PETTISVILLE

SITE

Site Name:	Pettisville
Installation Date:	September 17, 2009
Tower Owner:	Ohio Department of Development (ALP)
Site Location (description):	Tower located on Dean Genter's property (3902 County Rd. 19 Archbold, OH 43502-9761) in an alfalfa field situated immediately south of Oak Drive and Pettisville School. Tower is located approx. 750 feet south of County Rd. D, and approx. 900 feet east of County Rd. 19 (GPS coordinates): N 41° 31.613'; W 84° 13.561'
Ground Elevation:	755 ft
Prevailing Wind Direction:	WSW (from OPSB Interactive Wind Resource Map)
Site Sponsor Contacts:	Steve Switzer, 419-446-2705 (Office), 419.306.4168 (Cell), pville_s@nwoca.org
	Donna Meller, 419-966-2702 (Cell), pet_aca_dm@nwoca.org
	John Poulson, 419-572-6403 (Cell), pet_aca_jp@nwoca.org
	Paul Bishop, 419-446-2705 x 208, pet_aca_pb@nwoca.org
Logger Lock Combination:	127

TOWER

FCC Tower Registration:	None (50m XHD NRG Tall Tower) Tower ground assembly orientation: 45°; boom offsets: anemometers 180° & 332°; vanes 0°
Height of structure:	197 ft
Nominal Boom Heights:	31m, 40m, 50m

INSTRUMENTATION

Data Logger: NRG Symphonie, Serial Number 8065; Site Number 1235

Sensors:

Logger Channel	Instrument	Serial Number	Slope (mph)	Offset (mph)	Height (ft)	Boom Azimuth (degrees)	Deadband Azimuth (degrees)
1	NRG Max 40 Anemometer	15571	1.700	0.78	102	180	
2	NRG Max 40 Anemometer	15572	1.696	0.89	102	332	
3	NRG Max 40 Anemometer	15573	1.702	0.76	131	180	
4	NRG Max 40 Anemometer	15574	1.698	0.72	131	332	
5	NRG Max 40 Anemometer	15578	1.702	0.83	164	180	
6	NRG Max 40 Anemometer	15579	1.693	0.76	164	332	
7	NRG 200P Vane	None	0.351	0	134	360	360
8	NRG 200P Vane	None	0.351	0	161	360	360
9							
10	NRG Temp Sensor	None	0.244	-123.5	9	360	360

INCIDENT LOG:

September 16, 2009: Tower, boom, and instrument assembly completed (Wind Energy Services & Green Energy Ohio); could not raise tower due to unsafe windy conditions (crosswind > 10 mph).

September 17, 2009: Commissioned tower at Pettisville Schools (Wind Energy Services). Vanes and temp sensor wired incorrectly (white in positive; red in signal).

September 18, 2009: Instructed site sponsor John Poulson to correct wiring of vanes and temp sensor; red in positive; white in signal.

January 17-19, 2010: Icing event affecting channels 4 – 8; channel 8 iced at 8:40 a.m. on the 17th and recovered at 7:50 a.m. on the 19th; channel 7 iced at 10:20 a.m. on the 17th and recovered at 12:10 p.m. on the 18th; channel 5 iced at 9:20 a.m. on the 17th and recovered at 2:40 p.m. on the 18th; channel 6 iced at 12:30 p.m. on the 17th and recovered at 2:40 p.m. on the 18th; channel 4 iced at 12:50 p.m. on the 17th and recovered at 1:30 p.m. on the 18th.

January 22, 2010: Icing event affecting channel 8; began at 3:20 a.m. and ended at 7:00 a.m.

February 2, 2010: Icing event affecting channels 1-8; channels 2 & 6 froze at 10:00 p.m., channels 1, 3, 4, & 5 froze at 10:10 p.m., channels 7 & 8 froze at 10:20 p.m., channels 1-6 recovered at 11:50 p.m., and channels 7 & 8 recovered at 11:40 p.m.

March 29, 2010: MET tower inspection by Kemp Jaycox of GEO and Michael Mearini of the Wastewater Treatment Plant. Two of three anchors on west side had pulled out approximately 3" to 4" – according to Michael this occurred during Feb. 2010. The ground nearby shows evidence of a potential groundhog or woodchuck burrowing. The furthest anchor on the south side also pulled out approximately 4" to 5" – Michael noticed this in Jan. 2010 when removing snow from around the anchors. The remaining anchors on the south, east and north sides were flush with the ground. Kemp marked each anchor with a black Sharpie pen to indicate its location relative to the grass surface. None of the anchors appeared to be loose. Guy wire #1 (closest to ground) on east side was slightly loose. Remaining guy wires appeared to be sufficiently tight. Tower was straight with a slight curve at the top and appeared to be stable. GEO recommended that Michael and the Wastewater Treatment Plant staff continue to monitor the anchors and guy wires closely and notify GEO of any additional changes in the tower's condition.