Howe Gastmeier Chapnik Limited
2000 Argentia Road, Plaza One, Suite 203
Mississauga, Ontario, Canada L5N 1P7
t: 905.826.4044

SPRING ACOUSTIC AUDIT - IMMISSION REPORT

St. Columban Wind Energy Project

St. Columban, Ontario

Prepared for:

St. Columban Energy Inc.
222 – 3rd Avenue S.W.
Suite 900, Livingston Place, South Tower
Calgary, AB
T2P 0B4

Prepared by

Waqas Sajid

Digitally signed by Waqas Sajid
DN: cn=Waqas Sajid, o=HGC Engineering, ou, email=wsajid@hgcengineering.com, c=CA
Date: 2016.12.22 08:40:09 -05'00'

Waqas Sajid, BASc, EIT.

and

Ian Bonsma

Digitally signed by Ian Bonsma
DN: cn=Ian Bonsma, o=HGC Engineering, ou, email=ibonsma@hgcengineering.com, c=CA
Date: 2016.12.22 08:40:54 -05'00'

Ian R. Bonsma, PEng

December 22, 2016

EXECUTIVE SUMMARY

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by St. Columban Energy Inc. to complete an acoustic immission audit of the St. Columban Wind Energy Project. The project includes 15 Siemens wind turbine generators, rated at 2.3 MW, 2.221 MW and 2.126 MW. The acoustic immission audit is required as a condition of Renewable Energy Approval number 7042-96FQB7 issued by the Ontario Ministry of the Environment and Climate Change ("MOECC") on July 2, 2013 and amended on July 11, 2016. HGC Engineering has assessed the acoustic impact against the acoustic criteria of the MOECC in accordance with the requirements of the MOECC's Compliance Protocol for Wind Turbine Noise. The spring measurement campaign was completed between March 11 and October 14, 2016.

The sound level measurements and analysis, as performed in accordance with the MOECC's Compliance Protocol for Wind Turbine Noise, indicate that the project meets the applicable sound level limits at the chosen receptor locations. Details of the measurements and analysis are provided herein.

TABLE OF CONTENTS

1 INTRODUCTION

Howe Gastmeier Chapnik Limited ("HGC Engineering") was retained by St. Columban Energy Inc. to complete an Acoustic Audit – Immission of the St. Columban Wind Energy Project. The project is located north of the town of St. Columban, Ontario and consists of 15 Siemens wind turbine generators, rated at 2.3 MW, 2.221 MW and 2.126 MW and with a hub height of 99.5 m.

The audit is required as part of the Renewable Energy Approval ("REA") number 7042-96FQB7 [1] issued for the project by the Ontario Ministry of the Environment and Climate Change ("MOECC"), dated July 2, 2013 and amended on July 11, 2016 [2]. Specifically, this report summarizes measurements that were conducted in the spring in order to satisfy the second of two seasonal audits required under Condition E of the REA.

2 MONITORING LOCATIONS

The Noise Assessment Report prepared by Zephyr North [3] provided sound level predictions for locations within 1500 m of the project wind turbine generators. Condition E1 (2) in the REA requires that measurements be completed at two monitoring locations which are selected using the following criteria:

- The monitoring locations should represent the location of the greatest predicted noise impact.
- The monitoring locations should be in the direction of prevailing winds from the facility.

A number of locations were considered for use as sound level monitoring locations for the audit, as shown in Table 1.

Table 1: Potential Monitoring Locations

ID	Distance to Nearest Turbine [m]	Nearest turbine ID	Calculated Sound Pressure Level at Receptor [dBA] at Selected Wind Speed [m/s]					Wind Direction	Comments
			6	7	8	9	10		
V662	698	T3	39.9	39.9	39.9	39.9	39.9	Crosswind	Permission Not Granted
V663	760	T2	39.6	39.6	39.6	39.6	39.6	Crosswind	Permission Not Granted
R3	551	T9	39.3	39.3	39.3	39.3	39.3	Downwind	Selected Location
V659	697	T3	39.3	39.3	39.3	39.3	39.3	Crosswind	Too many large trees
V664	788	T3	39.3	39.3	39.3	39.3	39.3	Crosswind	Active farm field
V596	597	T9	39.2	39.2	39.2	39.2	39.2	Upwind	
V660	718	T3	39.2	39.2	39.2	39.2	39.2	Crosswind	Active farm field
R50	763	T3	38.9	38.9	38.9	38.9	38.9	Crosswind	Too many large trees
V658	725	T3	38.9	38.9	38.9	38.9	38.9	Upwind	
R202	555	T11	38.8	38.8	38.8	38.8	38.8	Upwind	
V680	629	T11	38.8	38.8	38.8	38.8	38.8	Upwind	
V661	836	T13	38.6	38.6	38.6	38.6	38.6	Downwind	Selected Location
R22	681	T3	38.5	38.5	38.5	38.5	38.5	Downwind	Too many large trees
R33	678	T9	38.5	38.5	38.5	38.5	38.5	Upwind	
V645	635	T8	38.5	38.5	38.5	38.5	38.5	Middle	Too many large trees
V646	660	T8	38.5	38.5	38.5	38.5	38.5	Middle	Too many large trees

The monitoring locations were selected based on their downwind location, predicted sound level, and consultation with the land owners. The annual wind rose for the area is provided in Appendix A. Photos of the selected monitoring locations can be found in Appendix B.

Monitoring location R3 is a single storey home located on the north side of the project with turbines T09 and T10 at a distance of approximately 550 m to the south. The sound level meter was installed at a fence line on the southwest side of the residential property, approximately

475 m from T10. The microphone was placed at a height of 4.5 m, consistent with the receptor height utilized in the Noise Assessment Report.

Monitoring location V661 is an agricultural field located centrally within the project. The closest turbine, T13, is approximately 830 m to the southwest of receptor V661. The sound level meter was installed approximately 30 m northeast of Hydro Line Road in an open area of the field, 775 m from T13.

The project area is generally rural in nature with infrequently travelled gravel and asphalt roads.

3 INSTRUMENTATION

The MOECC document, *Compliance Protocol for Wind Turbine Noise – Guidelines for Acoustic Assessment and Measurement* [4] ("Compliance Protocol") provides requirements for instrumentation for Acoustical Audits of wind energy projects. Instrumentation used for this acoustic audit satisfies the requirements of the Compliance Protocol.

Audio frequency sound levels were measured using two Svantek 977 sound level meters, each connected to ½" microphones. The microphones were set at a height of approximately 4.5 m and equipped with 175 mm diameter windscreens to minimize wind-induced microphone self-noise.

The energy-equivalent average sound level, denoted L_{EQ}, and also the L_{90} sound level, the level exceeded 90% of the time during the measurement, were recorded by the instrumentation. The L_{90} sound level is commonly used to represent the background or steady-state sound level because it minimizes transient sounds such as occasional human voices, brief animal activity, and car or train noise. The audio-frequency measurements are presented as A-weighted sound levels as they are intended to represent the loudness of sounds as perceived by the human ear. The overall audio-frequency sound level monitoring results are summarized in this report.

In addition to the acoustic instrumentation, meteorological instruments were used. A Davis weather station was deployed at R3 to collect ground weather conditions including temperature, humidity, and precipitation. NRG anemometers and wind vanes were used to collect 10 m height wind speed and direction at the monitoring locations.

The various instruments deployed by HGC Engineering are summarized in Table 2, and their relative locations are shown in Figures 1a and 1b.

Table 2: Measurement Instrumentation

Monitoring Location	Instrumentation Make and Model	Serial Number
R3	Svantek 977 sound level meter	36426
	NRG#08 anemometer connected to a Campbell Scientific datalogger	179500244813
V661	Svantek 977 sound level meter	36439
	NRG#09 anemometer connected to a Campbell Scientific datalogger	179500244824

The sound level meters were configured to measure and document spectral (frequency-dependent) 1 minute L_{EQ} and 10 minute L_{90} sound level measurements. For identification of dominant sources, the sound level meters also recorded audio files.

Correct calibration of the acoustic instrumentation was verified using an acoustic calibrator manufactured by Brüel & Kjær (B&K). Calibration verification was carried out on a weekly basis throughout the measurement period.

Windscreens were used on the microphones, consistent with the requirements of MOECC technical publication NPC-103, *Procedures* [5]. A large wind screen, 175 mm in diameter, was used on each sound level monitor to minimize wind-induced microphone self-noise at higher wind speeds. Sound level data included herein has not been adjusted for the sound insertion loss of the large wind screen.

All equipment was within its annual calibration, and the calibration certificates can be found in Appendix C.

4 ASSESSMENT CRITERIA

The MOECC publication *Noise Guidelines for Wind Farms – Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities* [6] indicates the applicable sound level limit for wind energy projects. Additionally, the Compliance Protocol document and the REA approval include the same sound level limits which are shown in Table 3.

Table 3: Wind Turbine Noise Criteria [dBA]

Wind Speed at 10 m Height [m/s]	4	5	6	7	8	9	10
Wind Turbine Sound Level Limits Class 3 Area [dBA]	40.0	40.0	40.0	43.0	45.0	49.0	51.0

It should be noted that the sound level limits of the MOECC apply only to the sound level contribution of the sound source under assessment, in this case the sound from the wind turbine generators. Thus, where a sound level measured at the monitoring location includes significant sound due to the relevant sound source and unrelated background sound sources (i.e., road vehicles, trains, air traffic, farming machinery, wind, etc.), some form of evaluation must be made to determine the sound level contribution of the source under assessment in the absence of the background sounds. Methodology prescribed by the MOECC to complete an assessment of wind energy projects is discussed in the following section.

5 METHODOLOGY

The REA requires the acoustic audit be completed in accordance with Part D of the Compliance Protocol for Wind Turbine Noise. Part D includes requirements for instrumentation, measurement and data reduction procedures to assist with determining compliance.

A series of one-minute energy equivalent sound level measurements are conducted with (ON) and without (OFF) the turbines operating. Simultaneously, wind speed and direction at 10 m height are measured in one minute intervals. The measured sound level data is separated into integer wind speed “bins” where the sound levels corresponding to each integer wind speed are arithmetically averaged to determine the average sound level when the wind turbines are operational and when they are parked. The ambient L_{EQ} (turbines parked) is logarithmically subtracted from the overall L_{EQ} (turbines operational) to determine the sound level contribution of the wind turbines alone. Supplementary data including wind speed at turbine hub height, wind speed at noise measurement height, turbine electrical power output, temperature, humidity, and statistical noise indices (Ln) can also be measured during the monitoring campaign to aid in the analysis.

The MOECC protocol requires at least 120 one minute intervals be measured for each 10 m height wind speed between 4 and 7 m/s when the turbines are operating and at least 60 one minute intervals be measured for each 10 m height wind speed between 4 and 7 m/s when the turbines are parked. Prior to determining the number of data points measured in each wind speed bin, the data is filtered to only include night time hours (between 22:00 and 05:00), data outside of rainfall (no rain within an hour of the measurement interval), and the maximum wind speed measured at a 10 m height should not differ from the average by more than 2 m/s.

The MOECC protocol allows for the removal of individual events to improve the signal to noise ratio. A review of the audio recordings allows for the identification of the dominant noise source within a given one minute interval, and the subsequent removal of data points that contain interference.

Adjustments to the measured sound levels may be required based on wind turbine tonality, if any. If during the acoustic measurement campaign the project wind turbines exhibit tonal characteristics (a whine, screech, buzz or hum) then an assessment of the tonal audibility is required according to International Standards Organization 1996-2 [7]. The average tonal audibility correction must be determined for each integer wind speed and the correction added to the final noise contribution of the wind turbine at those wind speeds.

6 TONALITY ASSESSMENT

Based on our site observations and measurements up close to the wind turbine generators there is the potential for tones to be generated by the wind turbines. The *Compliance Protocol for Wind Turbine Noise* requires that “if a tone is identified at any of the wind speeds, the average tonal audibility correction shall be added to the final noise contribution of the wind turbine at those speeds.”

The audio recordings captured during the measurement campaign were analyzed utilizing a Larson Davis 831 (S/N 0001865) to conduct narrow band frequency analysis of the recordings. Fast Fourier Transform (“FFT”) analysis was utilized to convert the recordings to frequency domain spectra. Tones identified in this way were analysed following ISO standard 1996-2 Annex C “*Objective Method for assessing the audibility of tones in noise – Reference method*”. The MOECC *Compliance Protocol for Wind Turbine Noise* assesses tonality as per ISO 1996-2 rather than the tonality analysis included within IEC 61400-11 where a tonality determination is made within close proximity of the turbine.

As per the MOECC’s Compliance Protocol, five one-minute recordings closest to each integer wind speed bin were selected for each monitoring location. Data were filtered to include points where the monitoring location was downwind of the closest turbine and the closest turbine was operating near rated electrical output. Table 4 summarizes the average tonal audibility (ΔLta) and the tonal adjustment (Kt) from the assessed data points for each monitoring location. No tones were found at either of the receptor locations.

Table 4: Summary of Tonality Assessment [dB]

Monitoring Location	10 m Wind Speed							
	4 m/s		5 m/s		6 m/s		7 m/s	
	ΔLta	Kt	ΔLta	Kt	ΔLta	Kt	ΔLta	Kt
V661	< 0	0	< 0	0	< 0	0	< 0	0
R3	< 0	0	< 0	0	< 0	0	< 0	0

7 MEASUREMENTS AND RESULTS

Sound level measurements were conducted between March 11, 2016 and October 14, 2016. The weather during the monitoring period varied, including several days with rain and snow. Temperatures ranged from -10 to 35° Celsius. Wind speeds at 10 m in height ranged from 0 m/s up to 20 m/s. The prevailing wind direction during the measurement campaign was from the southwest, consistent with the historical wind rose. Figures 2a through 3b show the wind roses for the monitoring locations during the ON and OFF conditions.

The analysis herein uses sound level data for turbine operation (ON), and ambient sound level data (OFF) collected during various project shutdowns between March 11 and October 14, 2016.

The sound level summary for data collected at location V661 is shown in Tables 5a and 5b.

Table 5a: Receptor V661 - Sound Level Summary L_{EQ} [dBA]

	10 metre Wind Speed							
Leq Sound Level [dBA]	**4 m/s**		**5 m/s**		**6 m/s**		**7 m/s**	
Average Operating (ON) / std dev.	38	3.1	39	2.8	41	2.2	43	2.1
Average Ambient (OFF) / std dev.	32	3.7	35	3.7	38	2.9	43	3.8
Wind Project Only / std dev.	37	3.8	37	3.6	38	2.5	34[1]	2.4
Criteria	40		40		40		43	
Excess	**0**		**0**		**0**		**0**	

[1] The calculated sound level does not represent the contribution of the wind project at this location, as the operating and ambient sound levels are essentially equivalent.

Table 5b: Receptor V661 - Summary of Valid Data Points

	10 metre Wind Speed			
Wind Project Condition	**4 m/s**	**5 m/s**	**6 m/s**	**7 m/s**
Operating (ON)	2861	1332	742	425
Ambient (OFF)	453	470	127	64

Based on the data presented above and in Figures 4a and 4b, the St. Columban Wind Energy Project is compliant with the MOECC sound level criteria at monitoring location V661.

The sound level summary for data collected at location R3 is shown in Tables 6a and 6b.

Table 6a: Receptor R3 - Sound Level Summary L_{EQ} [dBA]

	10 metre Wind Speed							
Leq Sound Level [dBA]	**4 m/s**		**5 m/s**		**6 m/s**		**7 m/s**	
Average Operating (ON) / std dev.	40	3.0	41	2.2	43	2.0	45	2.1
Average Ambient (OFF) / std dev.	29	3.5	33	4.2	39	3.9	43	2.7
Wind Project Only / std dev.	40	4.6	41	3.7	41	2.4	41	2.2
Adjusted Wind Project Only*	39		40		40		40	
Criteria	40		40		40		43	
Excess	**0**		**0**		0		**0**	

* Wind project only sound level adjusted to actual receptor location.

Table 6b: Receptor R3 - Summary of Valid Data Points

	10 metre Wind Speed			
Wind Project Condition	**4 m/s**	**5 m/s**	**6 m/s**	**7 m/s**
Operating (ON)	3926	2336	1305	805
Ambient (OFF)	424	318	84	82

The sound level monitoring location for receptor R3 is approximately 75 m closer to turbines T09 and T10 than the residential dwelling, equating to a sound level adjustment of -1 dBA to the Wind Project Only sound level. Based on the data presented above and in Figures 5a and 5b, the St. Columban Wind Energy Project is compliant with the MOECC sound level criteria at monitoring location R3.

Appendix C includes a statement from St. Columban Energy Inc. indicating the wind turbines were operating normally from March 11 to October 14, 2016.

8 CONCLUSIONS AND RECOMMENDATIONS

The measurements and analysis, performed in accordance with the methods prescribed by the Ontario Ministry of the Environment and Climate Change in publication *Compliance Protocol for Wind Turbine Noise* indicates that the St. Columban Wind Energy Project is operating within compliance of the MOECC's sound level criteria at the monitoring locations.

REFERENCES

1. Ontario Ministry of the Environment Renewable Energy Approval Number 7042- 96FQB7, July 2, 2013.
2. Ontario Ministry of the Environment and Climate Change, Amendment to Renewable Energy Approval Number 7042-96FQB7, July 11, 2016
3. Zephyr North, *Noise Assessment Report, St. Columban Wind Project*, January, 2013.
4. Ontario Ministry of the Environment, *Compliance Protocol for Wind Turbine Noise Guideline for Acoustic Assessment and Measurement*.
5. Ontario Ministry of the Environment Publication, NPC-103, *Procedures.*
6. Ontario Ministry of the Environment Publication, *Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*, October 2008.
7. International Standards Organization 1996-2, *Acoustics – Description, assessment and measurement of environmental noise – Part 2: Determination of environmental noise levels*, 2007.
8. Environment Canada, *Wind Atlas*. August 20, 2015. Retrieved from http://www.windatlas.ca/en/rose.php?field=EU&height=80&season=ANU&no=24&ni=930&nj=189

Figure 1a: Monitoring Location V661

Figure 1b: Monitoring Location R3

Figure 2a: Wind Direction - St Columban Wind Energy Project

Receptor V661,10 m Height, Wind Speeds 4-7 m/s
ON Condition, March 11, 2016 to October 14, 2016

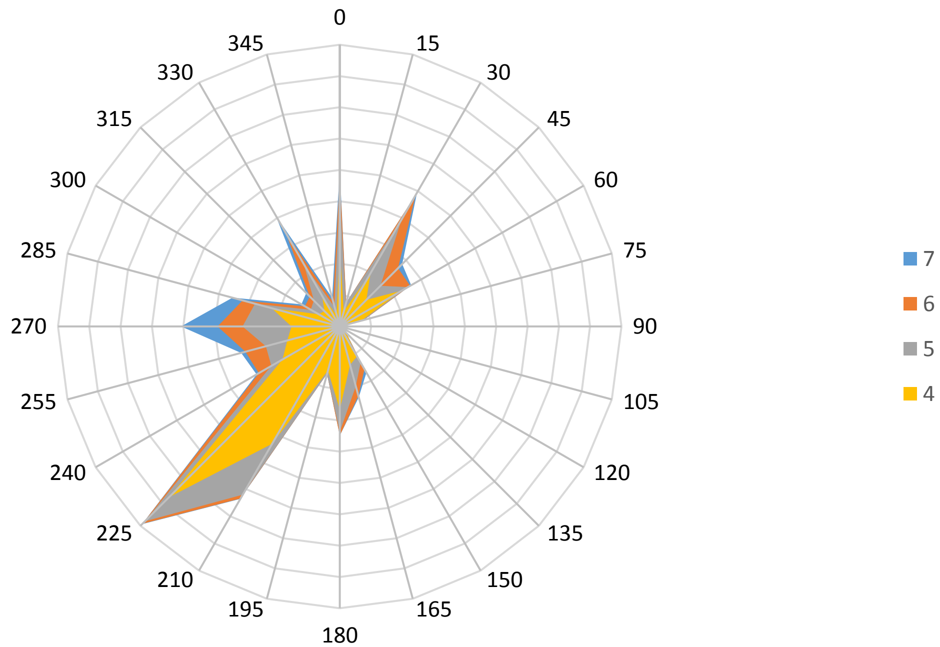


Figure 2b: Wind Direction - St Columban Wind Energy Project

Receptor V661, 10 m Height, Wind Speeds 4-7 m/s
OFF Condition, March 11, 2016 to October 14, 2016

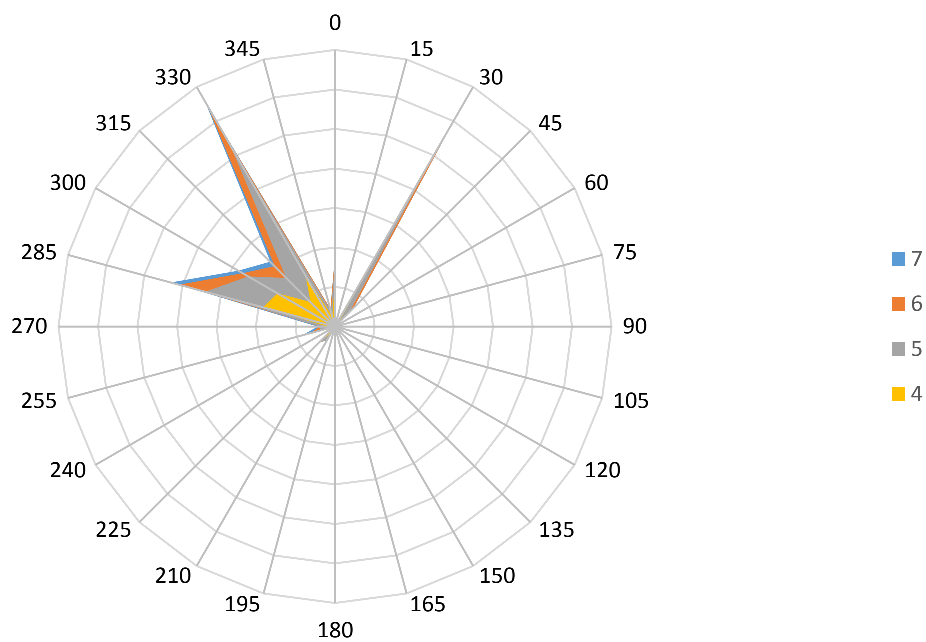


Figure 3a: Wind Direction - St Columban Wind Energy Project
Receptor R3, 10 m Height, Wind Speeds 4-7 m/s
ON Condition, March 11, 2016 to October 14, 2016

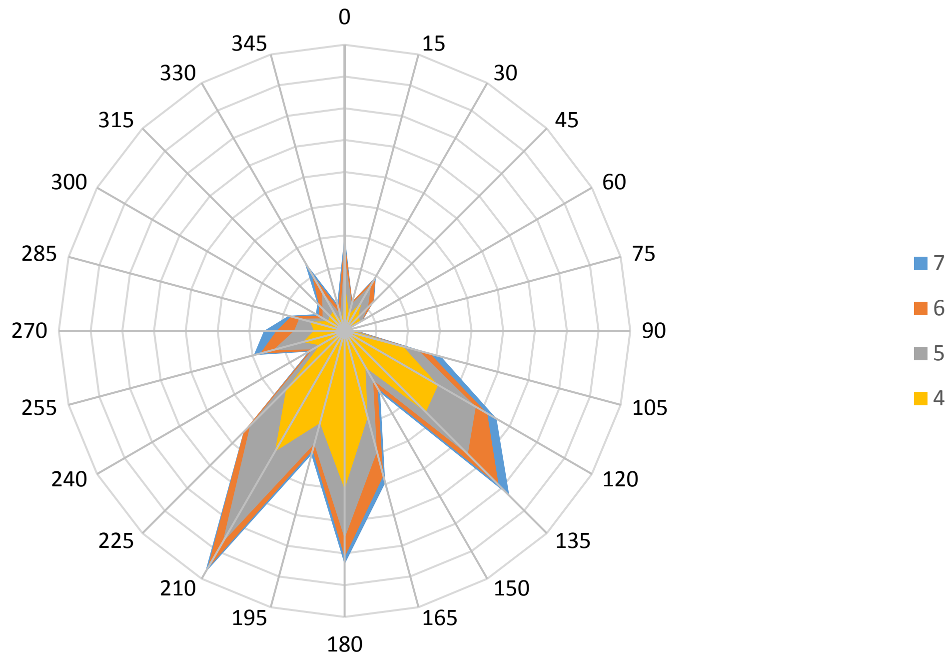


Figure 3b: Wind Direction - St Columban Wind Energy Project
Receptor R3, 10 m Height, Wind Speeds 4-7 m/s
OFF Condition, March 11, 2016 to October 14, 2016

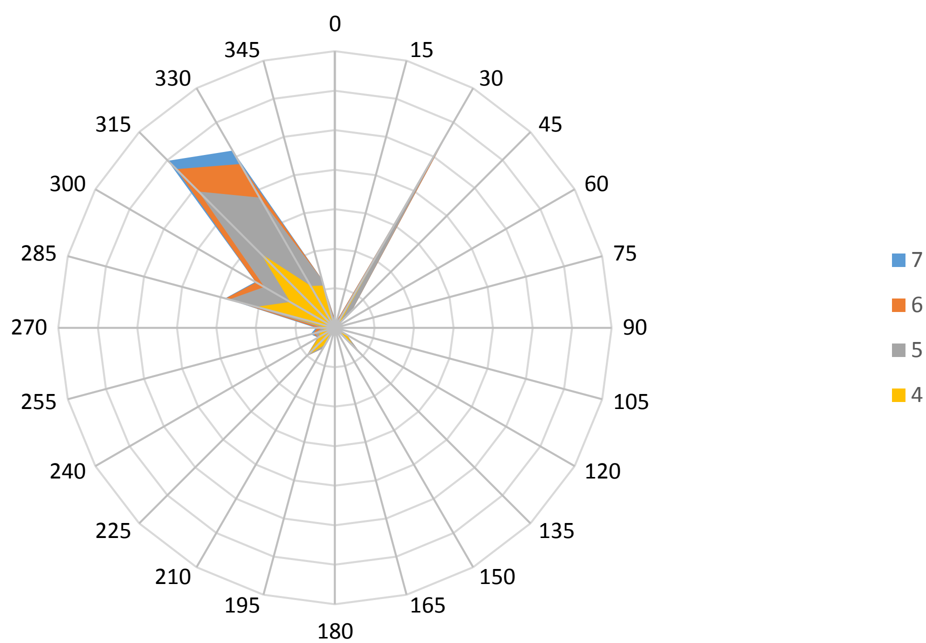
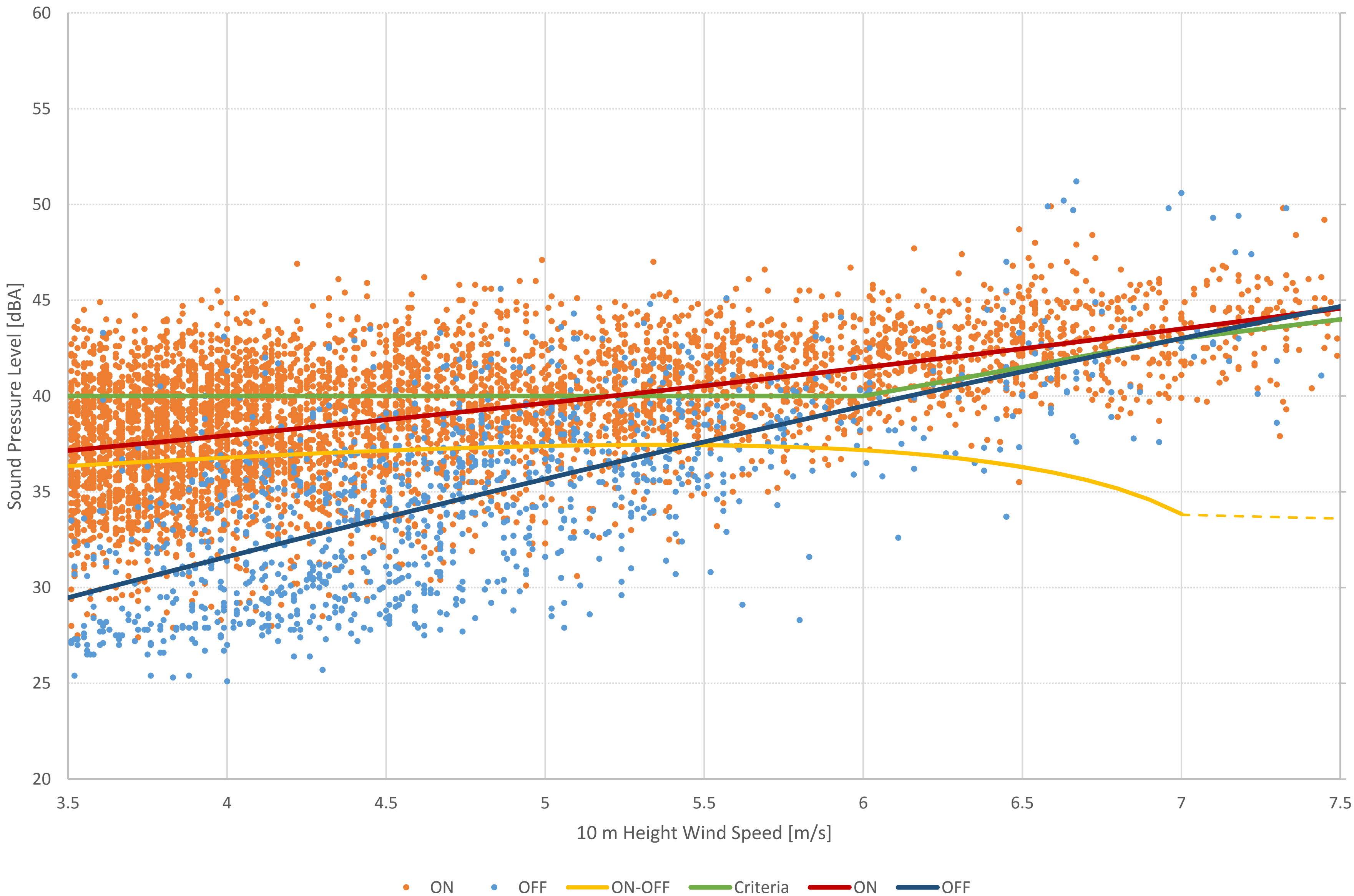


Figure 4a: St Columban Wind Project, Spring Immission Results

Receptor V661, March 11, 2016 to October 14, 2016

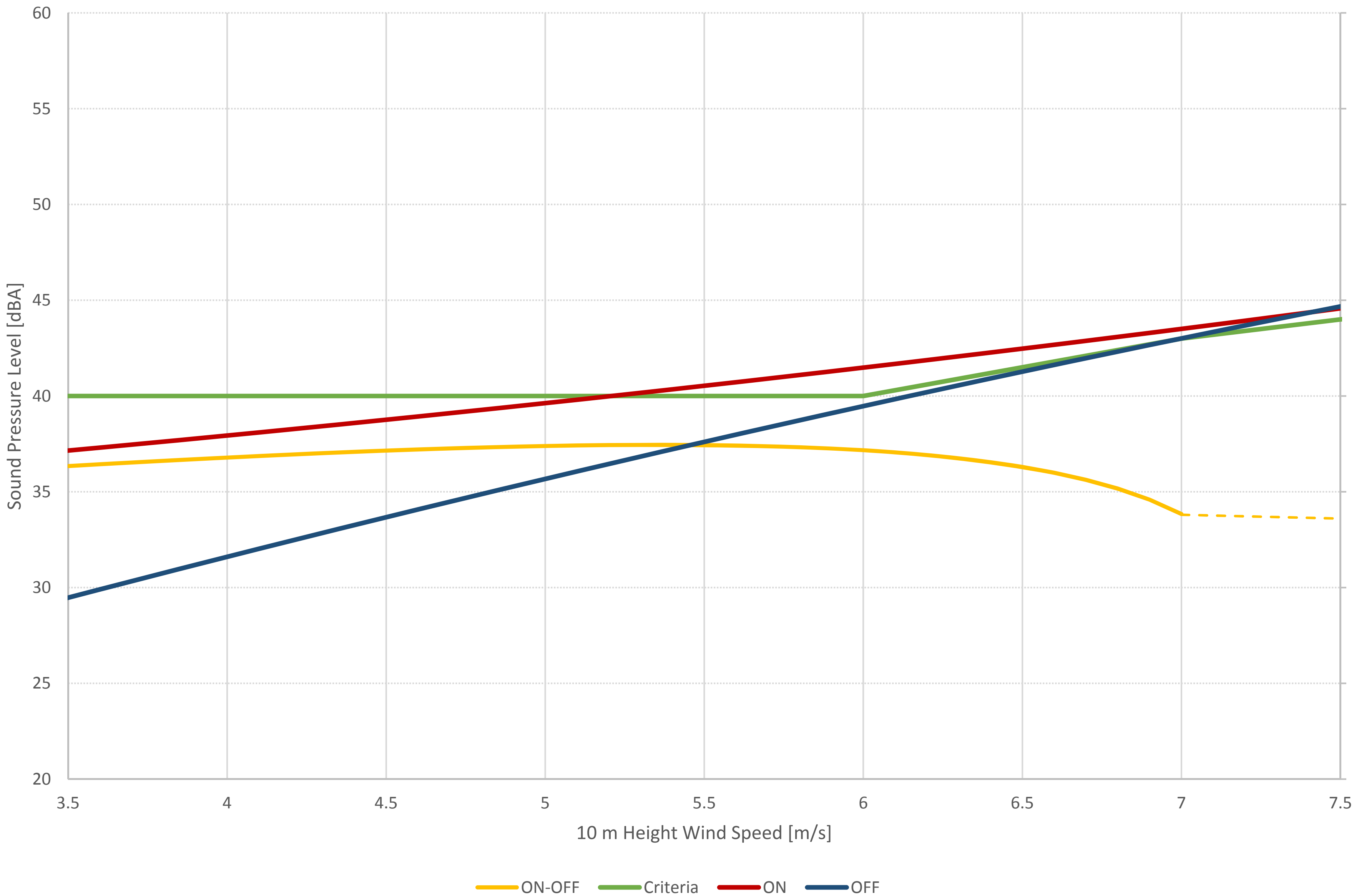


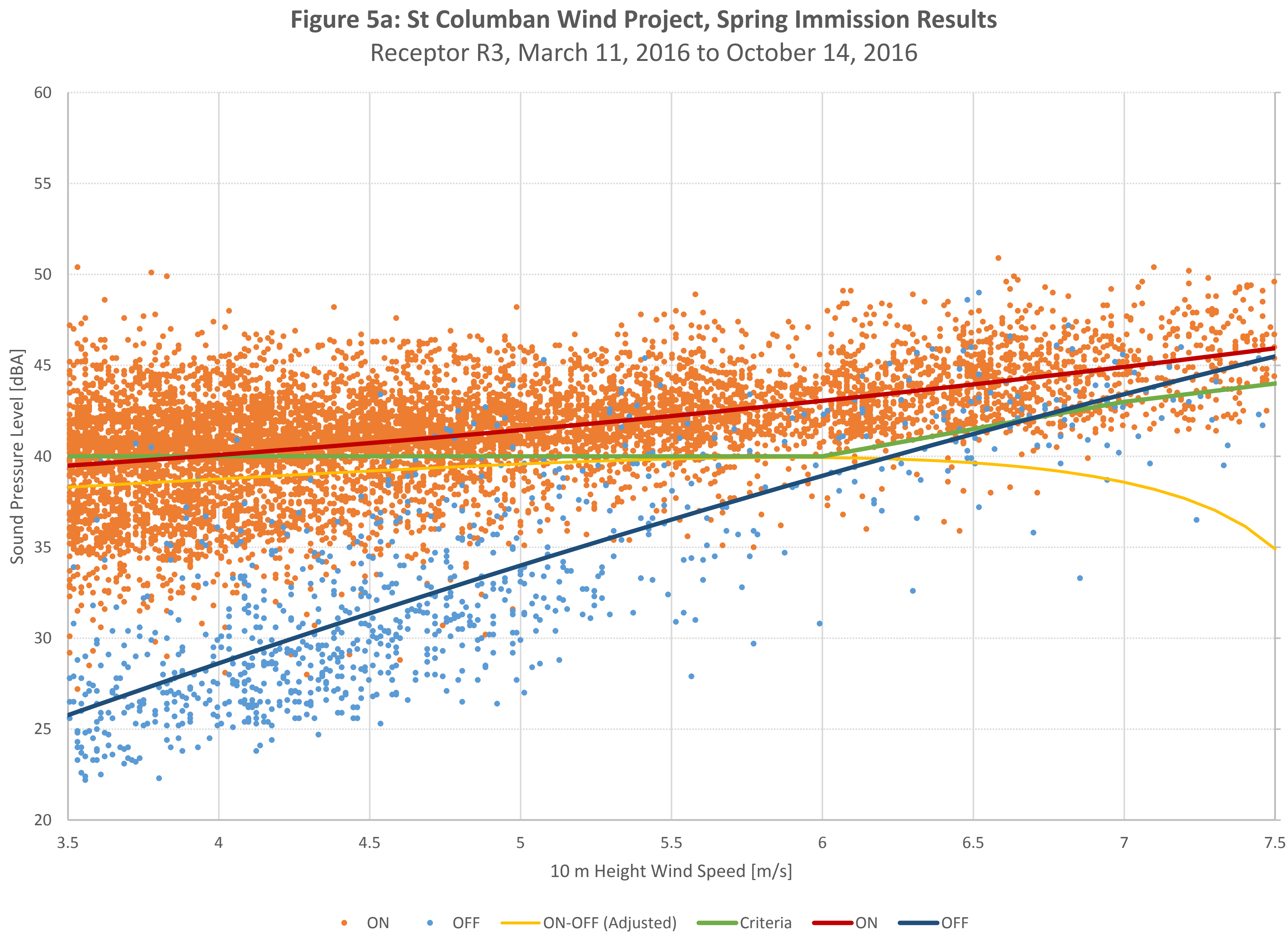
ACOUSTICS NOISE VIBRATION

www.hgcengineering.com

Figure 4b: St Columban Wind Project, Spring Immission Results

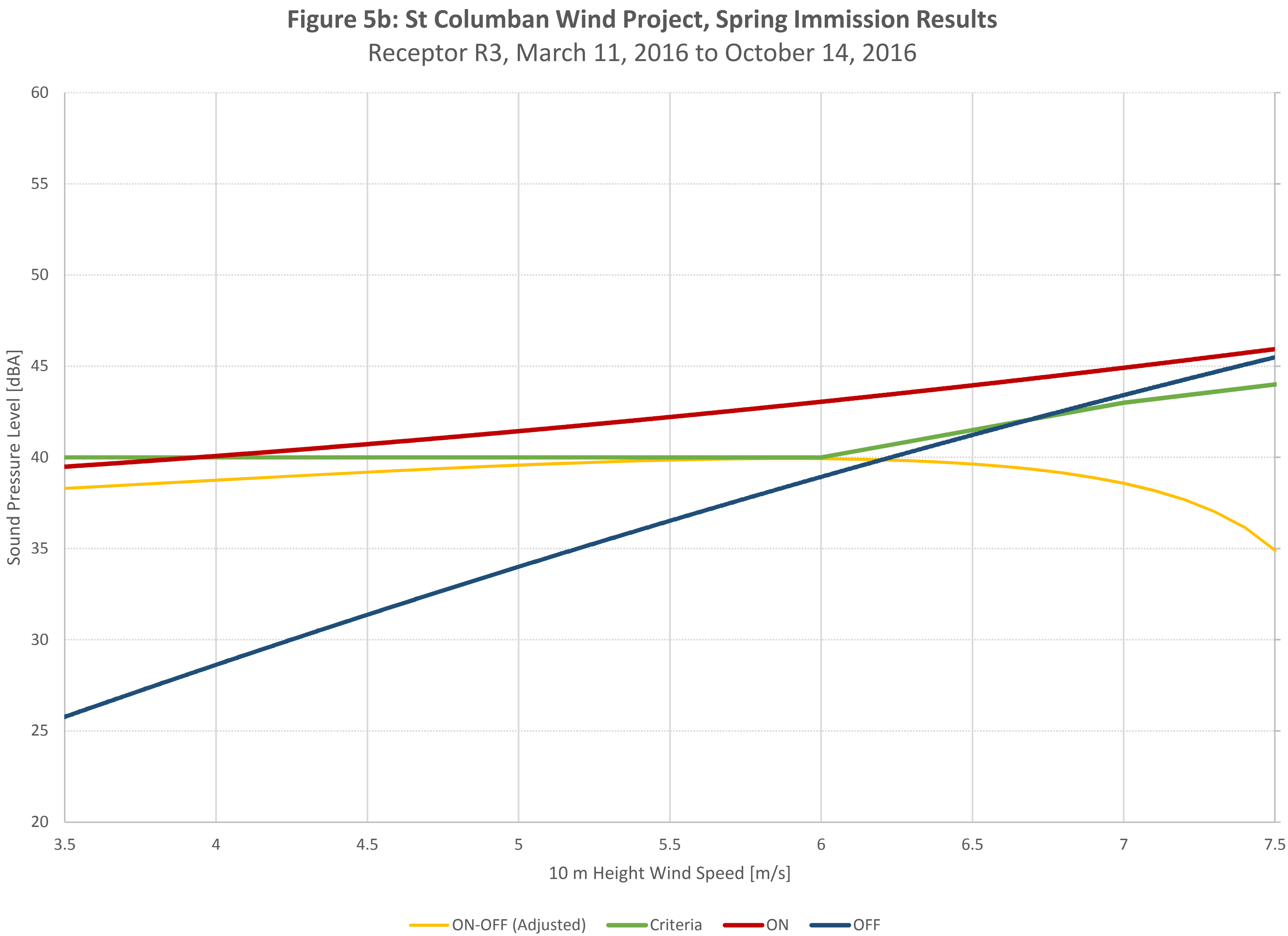
Receptor V661, March 11, 2016 to October 14, 2016





ACOUSTICS NOISE VIBRATION

www.hgcengineering.com

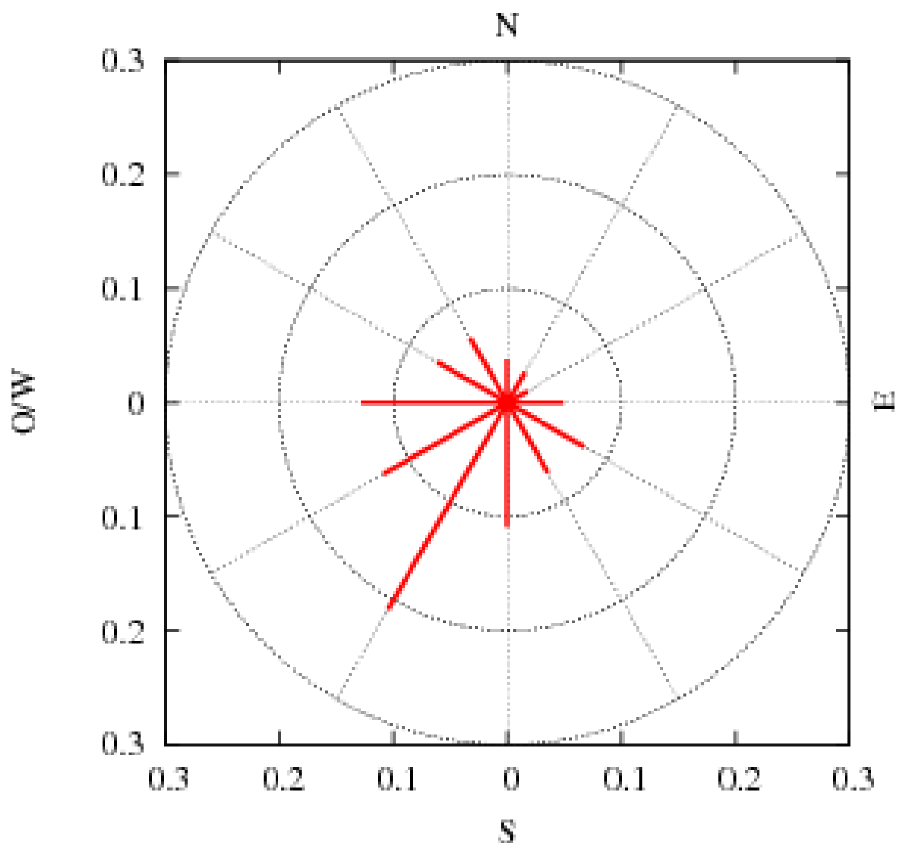


ACOUSTICS NOISE VIBRATION

www.hgcengineering.com

APPENDIX A:
HISTORICAL WIND ROSE

Figure A1: Annual Wind Rose [8]



APPENDIX B:

MONITORING LOCATION PHOTOS

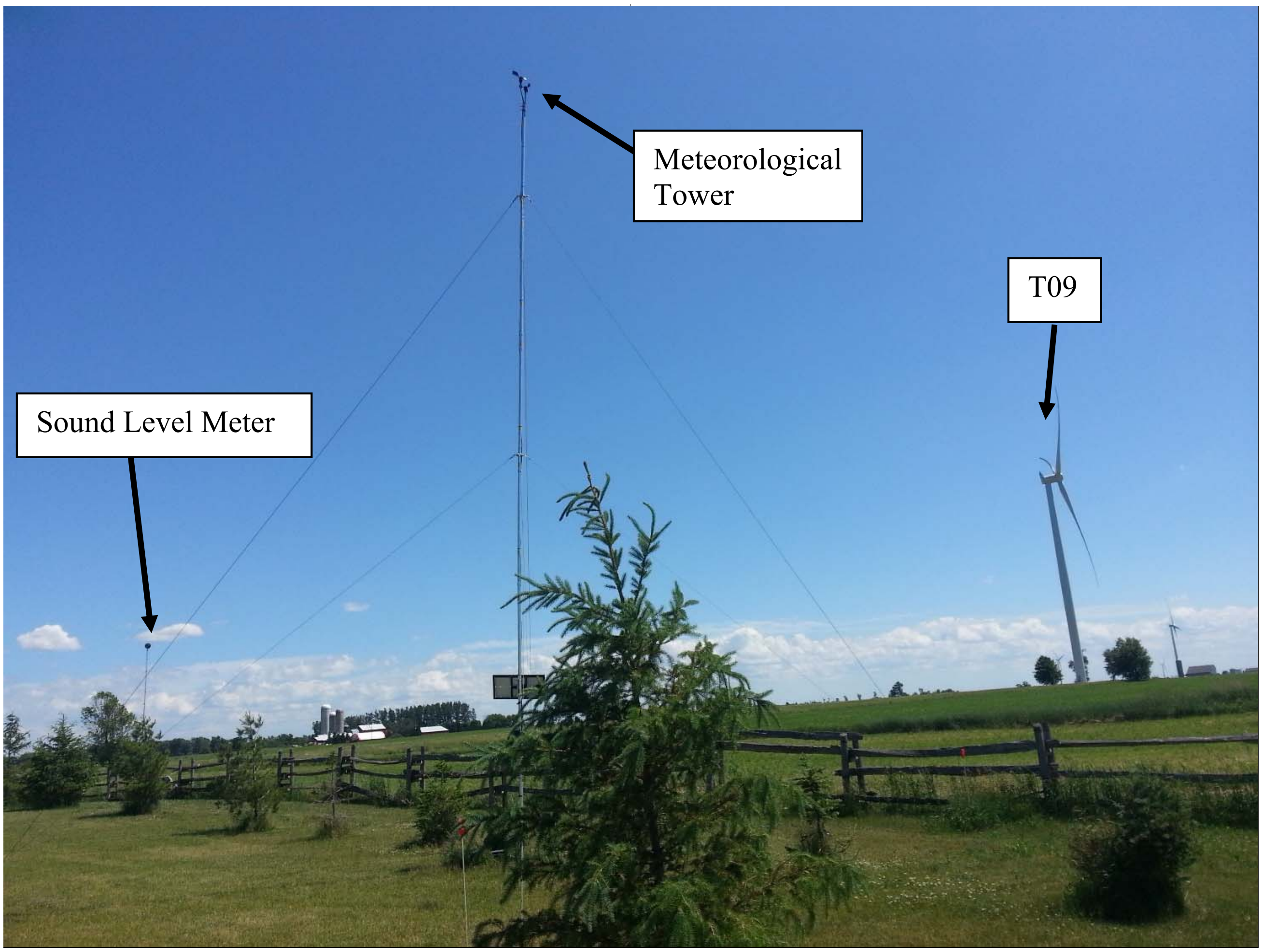


Photo of Instrumentation at Receptor R3

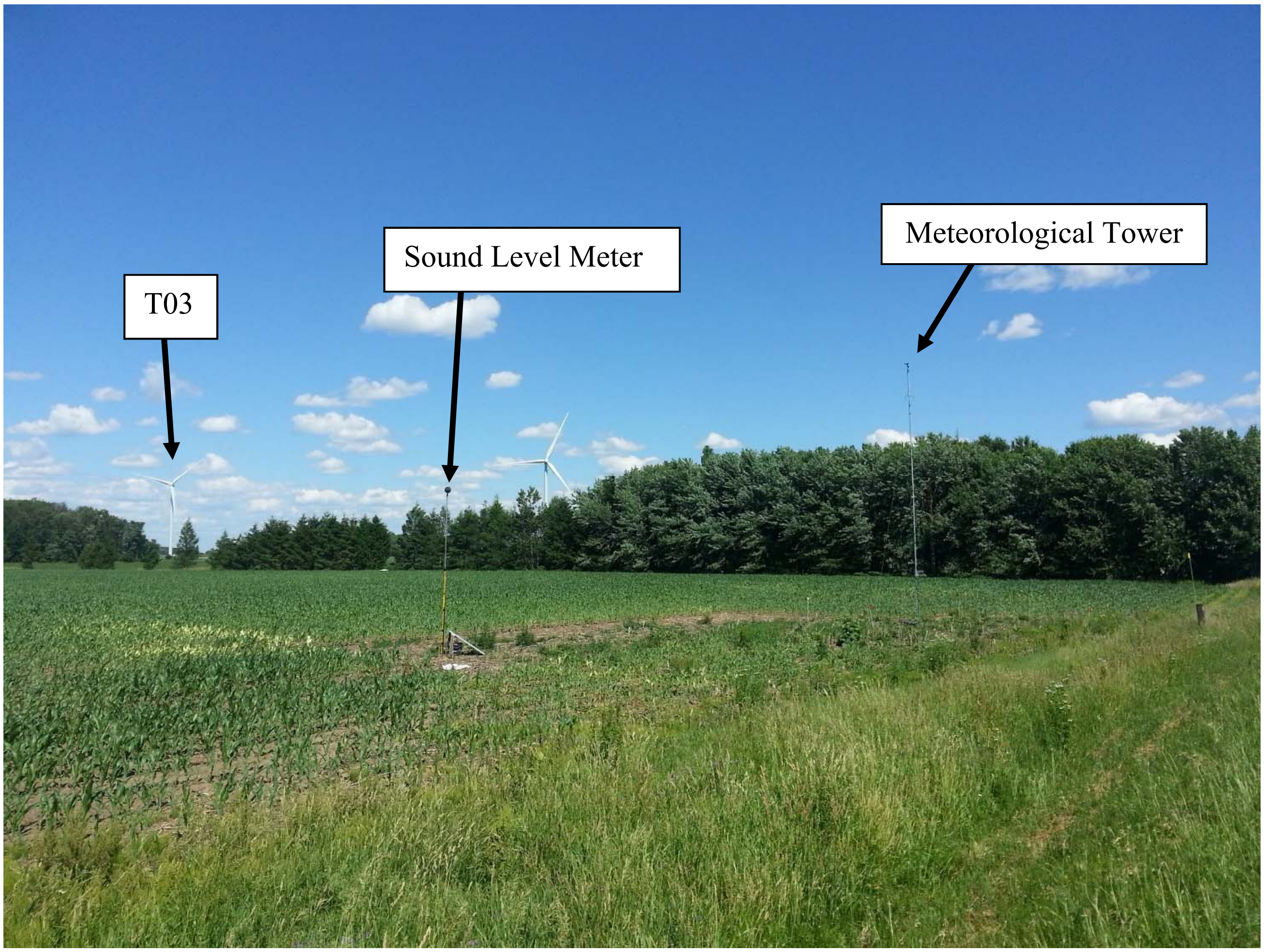


Photo of Instrumentation at Receptor V661

APPENDIX C:

CALIBRATION CERTIFICATES

CERTIFICATE of CALIBRATION

Make :	Svantek	Reference # :	142676
Model :	SVAN977	Customer :	HGC Engineering Mississauga, ON
Descr. :	Sound Level Meter Type 1		
Serial # :	36426	P. Order :	Sean Richardson
Asset # :	SV977-2		

Cal. status : Received in spec's, no adjustment made.

24 FEB 2016

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Feb 18, 2016 By :

Cal. Due : Feb 18, 2017 T. Beilin

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7 http: // www.navair.com
Phone : 905 565 1584 Fax: 905 565 8325 e-Mail: navair @ navair.com

CERTIFICATE of CALIBRATION

Make : Svantek

Model : SVAN977

Descr. : Sound Level Meter Type 1

Serial # : 36439

Asset # : SV977-4

Reference # : 142679

Customer : HGC Engineering
Mississauga, ON

P. Order : Sean Richardson

Cal. status : Received in spec's, no adjustment made.

24 FEB 2016

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Feb 18, 2016

Cal. Due : Feb 18, 2017

By : T. Beilin

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 905 565 1584 Fax: 905 565 8325
http: // www.navair.com
e-Mail: navair @ navair.com

Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK
TEL: (+45) 33 25 38 38 · WWW.SOHANSEN.DK

WIND ENGINEERING FLUID DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

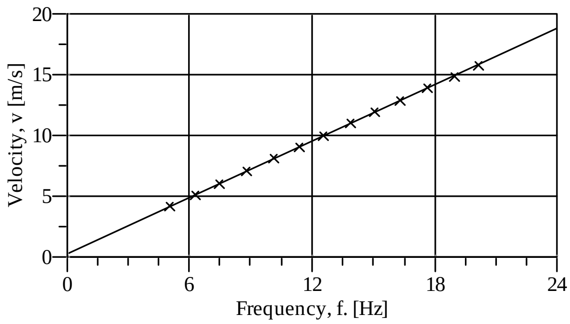
Certificate number: 15.02.04174
Date of issue: June 15, 2015
Type: NRG #40
Serial number: 179500244813
Manufacturer: Renewable NRG Systems, Inc., 110 Riggs Road, Hinesburg, VT 05461, USA
Client: Renewable NRG Systems, Inc., 110 Riggs Road, Hinesburg, VT 05461, USA

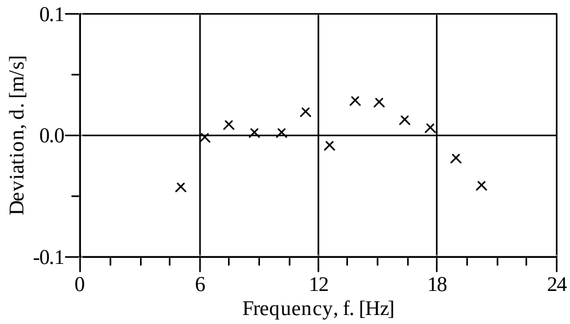
Anemometer received: December 15, 2014
Anemometer calibrated: June 8, 2015
Calibrated by: efs
Procedure: MEASNET, referring to IEC 61400-12-1
Certificate prepared by: cea
Approved by: Calibration engineer, jsk

Calibration equation obtained: v [m/s] = 0.77254 · f [Hz] + 0.29995
Standard uncertainty, slope: 0.00180
Standard uncertainty, offset: 0.06232
Covariance: -0.0000243 (m/s)²/Hz
Coefficient of correlation: $\rho = 0.999982$
Absolute maximum deviation: -0.042 m/s at 4.156 m/s

Barometric pressure: 1025.5 hPa
Relative humidity: 26.3%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.15	29.6	24.5	4.156	5.0456	-0.042	0.021
4	15.54	29.4	24.4	5.140	6.2666	-0.001	0.025
6	21.71	29.3	24.4	6.075	7.4637	0.009	0.029
8	29.62	29.2	24.4	7.094	8.7918	0.002	0.033
10	38.75	29.1	24.4	8.114	10.1117	0.002	0.038
12	48.57	29.1	24.4	9.083	11.3446	0.019	0.042
13-last	58.93	29.0	24.4	10.005	12.5716	-0.008	0.046
11	71.65	29.1	24.4	11.033	13.8543	0.030	0.051
9	84.54	29.1	24.4	11.985	15.0887	0.028	0.055
7	98.61	29.2	24.4	12.946	16.3526	0.013	0.060
5	114.20	29.3	24.4	13.934	17.6400	0.006	0.064
3	130.84	29.5	24.5	14.918	18.9451	-0.018	0.069
1-first	147.59	29.7	24.5	15.851	20.1831	-0.041	0.073





EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
1256	Control cup anemometer.
-	Mounting tube, D = 25 mm
t3	PT100 temperature sensor, wind tunnel.
t4	PT100 temperature sensor, control room.
1501197	PPC500 Furness pressure manometer
Z0420014	HMW71U Humidity transmitter
U4220037	PTB100AVaisala analogue barometer.
PS1	Pitot tube
HB2835279	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

Traceable calibrations of the equipment are carried out by external accredited institutions: Furness (PPC500) and Exova Metech. A real-time analysis module within the data acquisition software detects pulse frequency.

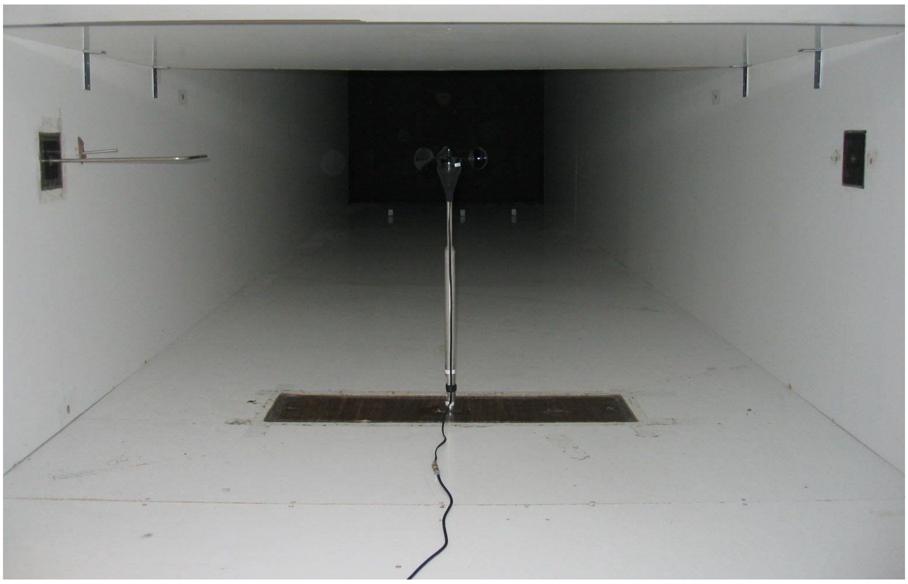


Photo of the wind tunnel setup (hxb = 0.85x1.75 m). The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 “MEASNET - Test report on the calibration campaign” for further details.

Certificate number: 15.02.04174

Svend Ole Hansen ApS

SCT. JØRGENS ALLÉ 5C · DK-1615 KØBENHAVN V · DENMARK
TEL: (+45) 33 25 38 38 · WWW.SOHANSEN.DK

WIND
ENGINEERING
FLUID
DYNAMICS

CERTIFICATE FOR CALIBRATION OF CUP ANEMOMETER

Certificate number: 15.02.04163 **Date of issue:** June 15, 2015

Type: NRG #40 **Serial number:** 179500244824

Manufacturer: Renewable NRG Systems, Inc., 110 Riggs Road, Hinesburg, VT 05461, USA

Client: Renewable NRG Systems, Inc., 110 Riggs Road, Hinesburg, VT 05461, USA

Anemometer received: December 15, 2014 **Anemometer calibrated:** May 26, 2015

Calibrated by: jjj **Procedure:** MEASNET, referring to IEC 61400-12-1

Certificate prepared by: cea **Approved by:** Calibration engineer, jsk

Calibration equation obtained: v [m/s] = 0.76523 · f [Hz] + 0.33154

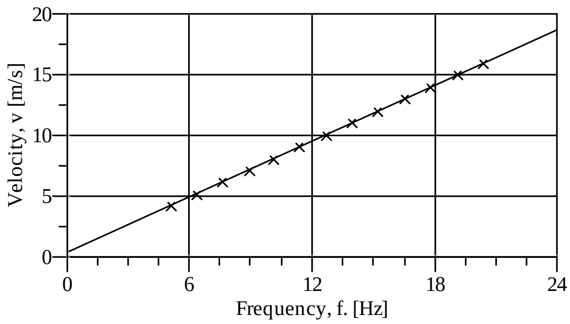
Standard uncertainty, slope: 0.00211 **Standard uncertainty, offset:** 0.06619

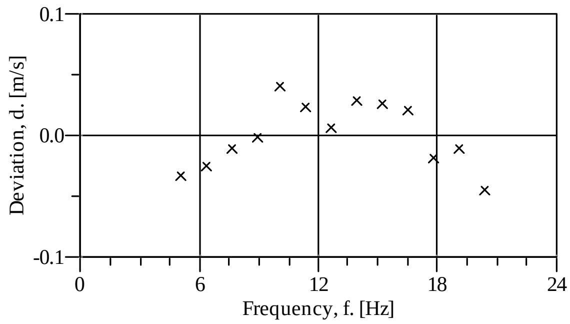
Covariance: -0.0000332 (m/s)²/Hz **Coefficient of correlation:** $\rho = 0.999975$

Absolute maximum deviation: -0.045 m/s at 15.890 m/s

Barometric pressure: 1010.4 hPa **Relative humidity:** 23.7%

Succession	Velocity pressure, q. [Pa]	Temperature in wind tunnel [°C]	Temperature in control room [°C]	Wind velocity, v. [m/s]	Frequency, f. [Hz]	Deviation, d. [m/s]	Uncertainty u_c (k=2) [m/s]
2	10.20	31.3	23.0	4.209	5.1107	-0.033	0.021
4	15.48	31.2	23.0	5.186	6.3764	-0.025	0.025
6	21.76	31.1	23.0	6.146	7.6116	-0.010	0.029
8	29.41	31.1	22.9	7.145	8.9058	-0.001	0.033
10	37.73	31.0	22.9	8.092	10.0889	0.040	0.038
12	47.42	30.9	22.9	9.071	11.3895	0.023	0.042
13-last	58.13	30.9	22.9	10.042	12.6814	0.006	0.046
11	70.27	31.0	22.9	11.042	13.9586	0.029	0.051
9	82.83	31.0	22.9	11.989	15.2002	0.026	0.055
7	97.35	31.1	23.0	12.999	16.5267	0.021	0.060
5	112.15	31.2	23.0	13.954	17.8262	-0.019	0.064
3	128.68	31.2	23.0	14.949	19.1166	-0.011	0.069
1-first	145.34	31.3	23.0	15.890	20.3912	-0.045	0.073





DANAK
CAL Reg.nr. 452

Accreditation to ISO 17025

EQUIPMENT USED

Serial number	Description
-	Boundary layer wind tunnel.
1256	Control cup anemometer.
-	Mounting tube, D = 25 mm
t1	PT100 temperature sensor, wind tunnel.
t2	PT100 temperature sensor, control room.
9904031	PPC500 Furness pressure manometer
X4650038	HMW71U Humidity transmitter
X4350042	PTB100AVaisala analogue barometer.
PS1	Pitot tube
HB2835279	Computer Board. 16 bit A/D data acquisition board.
-	PC dedicated to data acquisition.

Traceable calibrations of the equipment are carried out by external accredited institutions: Furness (PPC500) and Exova Metech. A real-time analysis module within the data acquisition software detects pulse frequency.

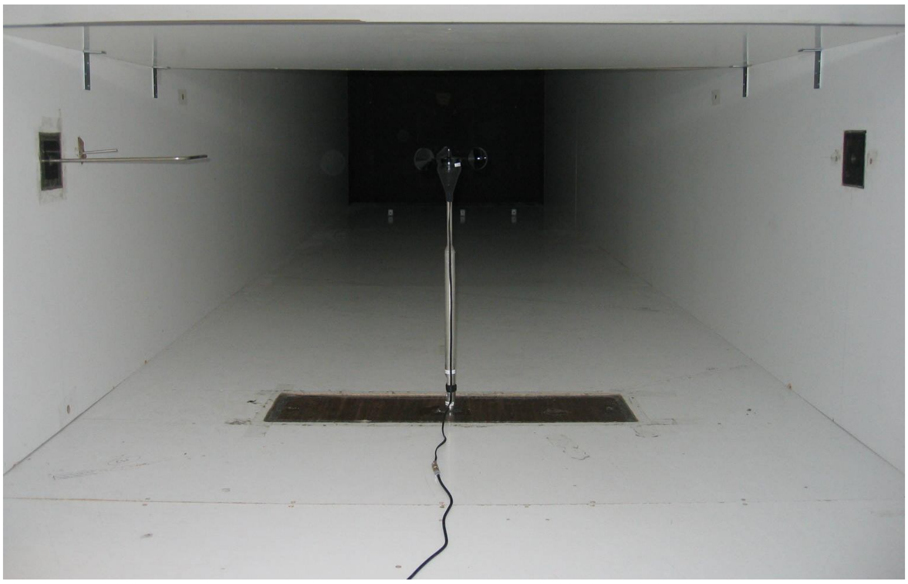


Photo of the wind tunnel setup (hxb = 0.85x1.75 m). The shown anemometer is of the same type as the calibrated one.

UNCERTAINTIES

The documented uncertainty is the total combined uncertainty at 95% confidence level (k=2) in accordance with EA-4/02. The uncertainty at 10 m/s comply with the requirements in the MEASNET procedure that prescribes an absolute uncertainty less than 0.1 m/s at a mean wind velocity of 10 m/s, that is 1%. See Document 97.00.004 “MEASNET - Test report on the calibration campaign” for further details.

Certificate number: 15.02.04163

APPENDIX D:

STATEMENT OF OPERATION

November 30, 2016

Sent via Email

Re: Statement of Operation
St. Columban Wind Energy Project, St. Columban, Ontario

To whom it may concern,

This letter is to confirm that the wind turbine generators at the St. Columban Wind Energy Project were functioning in their standard operational mode during the post-construction acoustic audit, conducted between March 11 and October 14, 2016.

Yours Truly,

David Hayles
Operations Coordinator
St. Columban Wind Energy Project