Consumers Energy

LAKE WINDS ENERGY PARK

William A. Schoenlein

Manager of Hydro & Renewable Generation

To: Mary Reilly, Zoning and Building Director, Mason County Planning and Zoning Department

From: William Schoenlein, Manager of Hydro & Renewable Generation, Consumers Energy

Subject: Consumers Energy Sound Mitigation Plan (Revised)

Date: April 18, 2014

Dear Ms. Reilly:

Please consider this an official response to your Jan. 9 letter requesting that Consumers Energy submit a sound mitigation plan for the Lake Winds Energy Park and subsequent discussion regarding the plan previously submitted on Feb. 6.

Lake Winds Energy Park has operated in compliance with the sound requirements of Mason County's zoning ordinance. However, Consumers Energy submits the following plan pending the resolution of an appeal before the Mason County Circuit Court.

The company reserves the right to revise, supplement or discontinue this plan based on future developments, including — but not limited to — the outcome of the appeal.

Background

On Sept. 19, 2013, the Mason County Planning Commission notified Consumers Energy that Lake Winds Energy Park failed to comply with the sound requirements in its zoning ordinance, requiring the company to submit a sound mitigation plan.

The county based this action on information provided by Howe Gastmeier Chapnik Limited (HGC), which gathered data allegedly showing Lake Winds Energy Park violated the 45 dBA limit for sound at the property line of an unpooled parcel.

Specifically, the alleged violations involved HGC test locations 1, 2, 6 and 7 covered in follow-up answers submitted on Sept. 12, 2013, and reflected alleged overages of 0.9, 1.2, 0.3, and 1.1 dBA, respectively, at each of those locations.

However, HGC sound measurements included background noise. Section 17.70 (17.a.4) of the zoning ordinance states sound limits "apply to the contribution from the wind energy system only and do not include contributions from background ambient sounds."

Thus, Consumers Energy appealed the decision to the Mason County Zoning Board of Appeals. On Dec. 18, 2013 the zoning board of appeals upheld the planning commission's conclusion that Lake Winds Energy Park violated the sound limit under the Mason County zoning ordinance, requiring submission of a sound mitigation plan.

Consumers Energy has appealed the decision. Meanwhile, the company is presenting a mitigation plan as required by Mason County.

Summary

Consumers Energy has a three-step sound mitigation plan:

(1) Perform acoustic modeling of the impacted locations to identify turbines where modified operations may be required.
(2) Implement the mitigation plan to selected turbines.
(3) Conduct follow-up acoustic testing to determine the new sound levels after the mitigation plan implementation (See Appendix 2 for protocol details).

As part of the third step, Consumers Energy will be able to verify that Lake Winds Energy Park complies with the ordinance requirements while operating under the mitigation plan, and also will be able to determine the actual effect of plan implementation that can be compared to the anticipated effects discussed below. In this way, the testing can be used to validate the projections used to develop this plan.

The alleged violations at locations 1, 2, 6, and 7 can be corrected by modified operation of select turbines to obtain sound reductions of at least 0.9, 1.2, 0.3, and 1.1 dBA, respectively. Through acoustic modeling with the Cadna-A software utilized in the permitting process, wind turbines 6, 15, 20, 23, 28, 32, and 35 were identified as candidates for modified operations by placing those turbines in Mode 2 as described in Section 2.3 of the Vestas General Specification previously provided during permitting (Appendix 3). Modeling the modified operation of these wind turbines shows the plan will achieve decibel reductions greater than HGC's alleged violations at each of the test locations.

Consumers Energy will then implement the mitigation plan at the seven selected turbines and verify the predicted sound reductions through testing. Consumers Energy will certify, in writing, that the subject wind turbines were operating in NRO mode 2 during the entire duration of the mitigation testing, and will include a similar confirmation with its annual certification provided to Mason County. In addition,

Consumers Energy will make its turbine-operating system available to the Mason County Zoning and Building Director for visual inspection to confirm that mitigated turbines remain in NRO mode 2.

Methods

Consumers Energy retained acoustic consultant Tech Environmental, Inc. (TE) to investigate the alleged ordinance violations. The sites with the alleged violations were locations 1, 2, 6 and 7 as shown in Table 1 (data presented by HGC on Sept. 12, 2013). The table displays measured L_{eq} and estimated L_{eq} values for all eight sites. It is important to note all data presented in Table 1 improperly includes background noise and the listed sound levels do not represent turbine-only sound that is relevant to determining ordinance compliance. The purported violations are listed in the final column. The goal is to reduce the sound level of the respective locations at least by purported excess.

Table 1: Shows HGC's measured and calculated data. Note: Background noise is included in all measured L_{eq} and L_{90} data.

Location	Type	Measured Night time L90 (23:00 - 07:00)		Estimated night time Leq	Measured night time Leq	Criteria	Excess based on lower of estimated and measured
		Mean	Standard Deviation	L90 + 2 dB	Mean	Leq	dB
1	Unpooled	43.9	1.8	45.9	47.0	45.0	0.9
2	Unpooled	44.4	1.6	46.4	46.2	45.0	1.2
3	Pooled	44.4	1.6	46.4	46.2	55.0	none
4	Unpooled	41.5	1.9	43.5	45.0	45.0	none
5	Unpooled	45.9	3.5	47.9	47.8	45.0	suspect data
6	Unpooled	43.3	1.7	45.3	46.0	45.0	0.3
7	Unpooled	44.1	1.8	46.1	46.2	45.0	1.1
8	Pooled	45.5	2.4	47.5	48.7	55.0	none

Source: Brian Howe, HGC Engineering

Modeling

The reduction of sound levels at test locations 1, 2, 6 and 7 were calculated using the Cadna-A acoustic model. This model was used to generate the pre-construction sound levels[1] provided to the planning commission during the permitting process, and reviewed and approved by the commission's consultant, Epsilon Associates. The acoustic modeling results are conservative. A complete list of conservative assumptions is provided in Appendix 1.

From the Cadna-A model, select turbines were investigated as candidates for modified operations. The selected turbines for Mode 2 operations are those closest to the four test locations where HGC claims

1. *Acoustic Study of the Lake Winds Energy Park, Mason County, Michigan, Report on Acoustic Modeling, rev. June 2011.*

Lake Winds Energy Park failed to comply. By varying turbine sound power assumed in the model, Tech Environmental determined the modifications necessary to produce the desired sound reductions.

Findings

The Cadna-A model demonstrates that modifying turbine operations can achieve reductions at each of the four test locations cited by HGC. The wind turbines closest to those locations are: 6, 15, 20, 23, 28, 32, and 35.

Table 2 shows the Canda-A model's projections for normal and modified operations of the selected wind turbines. The model results show the proposed mitigation plan will create reductions in dBA levels acceptable to meet the mitigation requirements for each test location. In all cases, the dBA reductions are greater than the required mitigation to eliminate the HGC alleged violations.

Table 2: Shows the Canda-A model predicted sound reduction from selected modified operations

Location	Predicted Sound Levels w/o Modified Operations (dBA)	Predicted Sound Levels with Modified Operations (dBA)	Sound Level Reduction[2] (dBA)	HGC Alleged Exceedance (dBA)	Reduction Met?[2]
1	42.9[3]	41.8	-1.1	0.9	Yes
2	44.9	43.6	-1.3	1.2	Yes
6	42.8	41.2	-1.6	0.3	Yes
7	44.9	43.5	-1.4	1.1	Yes

2. *'Reduction met' condition: |Sound Level Reduction| ≥ HGC Alleged Exceedance for the respective locations; Sound Level Reduction <0 i.e negative. The negative implies a sound reduction from the respective referenced value. Thus, 'Reduction is met' is only valid for negative input values.*

3. *Model predictions of 43.5 dBA (from Acoustic Study of LWEP, Report on Acoustic Modeling rev. 2011) and 42.9 dBA are both correct, as they correspond to different places on the Morrill property line. The predicted value of 42.9 dBA corresponds to the SE corner where HGC took their measurements. This mitigation plan addresses the alleged violation at the HGC monitoring location. Thus, 42.9 dBA is the correct predicted value without Modified Operations and 41.8 dBA is the correct predicted value at this same location with Modified Operations, and the reduction of 1.1 dBA is more than the alleged exceedance of 0.9 dBA. Lastly, the reported 43.5 predicted value includes a 0.5 dBA adder, which was added for conservatism.*

Conclusions

Modifying operations of turbines (6, 15, 20, 23, 28, 32, and 35) can mitigate alleged compliance failures at locations 1, 2, 6 and 7. The HGC-claimed sound level reductions for test locations 1, 2, 6, and 7 are 0.9, 1.2, 0.3, and 1.1 dBA, respectively. Acoustic modeling of modified turbine operations shows reductions greater than these targets at the test locations.

If required to do so, Consumers Energy would implement the sound mitigation plan at the seven selected turbines. Consumers Energy would subsequently verify the predicted sound reductions through sound testing as describe further in Appendix 2.

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Appendix 1

1. All wind turbines were assumed to operate simultaneously.
2. All wind turbine sound power levels correspond to the IEC 61400-11 maximum sound power level plus an uncertainty factor.
3. The acoustic model assumed the most favorable conditions for sound propagation, corresponding to a ground-based temperature inversion, or during a downwind condition.
4. No attenuation from trees or other vegetation was assumed.
5. Winter frozen ground conditions were assumed for minimal ground absorption. (G=0.5 in the model, representing a mixed ground surface that is midway between completely absorptive and reflective. Most of the year, the ground surface in the project area is highly absorptive).
6. Excess attenuation from wind shadow effects and daytime air turbulence were ignored.
7. The maximum sound power level for a Vestas V100 is 105.0 dBA17 (IEC 61400-11 test value), to which a K-factor of 2.0 dBA was added to represent measurement and turbine production uncertainty, yielding a total sound power level of 107.0 dBA for normal operations.

Appendix 2

Mitigation Plan Sound Testing Protocol

Item 3 of the Consumers Energy Mitigation Plan states that Consumers Energy will "Conduct follow-up acoustic testing to determine the new sound effects after the mitigation plan implementation, as well as with the turbines operating without restrictions imposed by the mitigation plan." Details for the testing can be found below.

Testing Methodology

The testing will be conducted in full compliance with the Mason County Zoning Ordinance ("Zoning Ordinance") and will follow the procedures of ANSI Standard S12.9/Part 3 with an observer present and Standard S12.18. The compliance test procedure will use alternating series of turbine-on and turbine-off 10-minute L_{eq} measurements. These tests will involve three operating conditions shown below in Table 3.

Table 3 [1]**:** Shows the mode of operation, sound power level reduction for mitigated turbines and hub height winds speed for max sound power.

Test	Turbines	Turbine Operation Mode	Sound Level Reduction[2]	Hub Height wind speed at Max Sound Power
Mitigated Test	6,15,20,23,28,32, and 35	Mode 2	2dB reduction	8.6 m/s
Turbines Off	8000 ft. radius from test locations	N/A	N/A	N/A

1. *All other turbines not listed for mitigated testing will remain in mode 0. The design wind speed is the lowest hub height wind speed at which maximum sound power is generated by the Vestas V100 under normal operations (Mode 0). The seven turbines operating under modified operations (Mode 2) will reach their maximum sound power level at a lower wind speed of 8.6 m/s. Modified Operations will be for all wind speeds and directions during the Mitigated Test.*
2. *Data from Vestas General Specifications, § 12.1.3 and §12.3.3 .*

The testing protocol will be as follows:

1. The 10 minute average A-weighted turbine-only L_{eq} sound level will be determined by logarithmically subtracting the 10 minute average A-weighted sound level measured during an applicable off period from the 10 minute average A-weighted sound level measured during a related on period in accordance with ANSI S12.9 Part 3, Clauses 6.7.2, 6.8, 6.9, 7.2, 7.3.2 and 7.3.3. The testing will not be conducted under either of the simplified procedures contained in ANSI S12.9 Part 3, Clauses 6.5 and 6.6. With regards to corrections for uncertainty of the background sound (Clauses 7.3.2 and 7.3.3 of ANSI S12.9), Consumers Energy will report the turbine-only L_{eq} sound level calculated for each valid measurement period with the uncertainty factor subtracted from background sound. Consumers Energy understands that HGC will report the turbine-only L_{eq} sound level calculated for each valid measurement period based upon the uncertainty factor subtracted from background sound.
2. The background sound level will be determined without the contribution of the turbine's cooling fans. Intermittent sound caused by the turbines during off testing due to the "hydraulic pump", "yaw", or other intermittent mechanical sounds produced by the turbines will be noted and subtracted from the data in the 10-second interval in which it occurred. If the cooling fans run continuously through the testing period, the measurement period will be extended (if practicable) until the fans shut down.
3. Turbines within an 8,000 foot radius of a testing site will be on with the prescribed noise mitigation plan implemented and then turned off during each on-off testing sequence.
4. Preventative maintenance and scheduled shutdowns within 8,000 feet of a test site during testing (8 pm to 6 am on the chosen nights) shall be rescheduled. Schedule shutdowns for regular or preventative maintenance will not occur for all of LWEP for the testing time periods (8 pm to 6 am on the chosen nights).
5. Consumers Energy will notify the Zoning Administrator and HGC as soon as reasonably practicable under the circumstances (and within two hours if at all possible) of an unscheduled shut down of any LWEP turbine(s) during the testing time periods.
6. The Planning Commission, through its Sound Consultant, and Consumers Energy, through its Sound Consultant, will complete sound measurements and cooperate with each other regarding logistics of coming on and off the site to minimize disturbance and noise such as dogs barking or cars entering or leaving the site. Such cooperation will include Consumers Energy's Sound Consultant having the same access routes as the Planning Commission's Sound Consultant to the test locations so that both teams can enter and leave together as much as possible.
7. The Planning Commission's Sound Consultant will develop a detailed test plan (dates, shut down times, test instrumentation, test procedures, calibration, etc.), following the procedures in ANSI S12.9 Part 3, ANSI S12.18, and this document, in consultation with Consumers Energy's acoustical consultant for the tests.
8. Consumers Energy will cooperate with the County on follow up acoustic testing as per the appended Mitigation Test Procedure to determine new turbine-only L_{eq} sound levels at HGC Engineering's 2013 test locations 1, 2, 5^3, 6, and 7 under maximum electrical power (as defined below) after the defined mitigation has been implemented. If the maximum 10 minute average A-weighted turbine-only L_{eq} sound level exceeds 45 dBA, the mitigation plan shall be adjusted

and retested at any of those locations that do not comply with the 45 dBA limit with a similar protocol as outlined in this appendix.

Monitoring Locations and Schedule

Attended on-off testing will primarily be performed during nighttime hours (between 8 pm and 6 am). Six nights of testing (two periods of three consecutive nights each) will be completed with the turbines near a test location shut down for a period of at least one hour at a predetermined time each night. Measurements at two test locations will be conducted at the same time.

Full electrical power shall be defined as the nearest mitigated turbine(s) to a test location producing at least 80% of rated electric power in the applicable Mode 2, or 90% for the nearest turbine operating in NRO Mode 0 (test site 5 only). If testing under full electrical power, and suitable weather/ambient-sound conditions, is not achieved in six nights, the testing shall be extended at the expense of Consumers Energy.

Test Equipment and Field Procedures

Type 1/Class 1 (precision grade) real-time sound analyzers (Bruel & Kjaer Model 2250 or equivalent) will be setup to record sound pressure levels at the monitoring locations 1, 2, 5, 6 and 7. Testing at locations 1 and 2 will be done simultaneously as they share a common turbine shutdown list. All equipment will have been laboratory-calibrated to NIST standards within the previous 12 months and will be field calibrated with an ANSI Type 1 calibrator, both before and after the measurements. Microphones will be tripod mounted approximately 1.5 m above the ground and 7-inch ACO-Pacific wind screens (or equivalent) will be used to screen out contaminating wind noise. Surface wind speeds will be measured continuously with a 2-meter anemometer (HOBO H21-002 micro-weather station anemometer or equivalent) setup near the sound analyzer.

The analyzers will log 10 second equivalent-continuous (L_{eq}) and maximum (L_{max}) sound pressure levels in A-weighted decibels (dBA). The sound analyzers will be time-synchronized to the clock of the LWEP SCADA system. The acoustic engineers will use hub-height wind speed and direction data from the LWEP Control Center to guide the field program. During the testing, the acoustic engineer attending each sound analyzer will listen for any loud background noise that would bias the measurements, such as a motor vehicle passing by, aircraft flying overhead, dogs barking, farm machinery, or impulse noise from wind gusts, and the engineer will record his observations in a field log.

Data Analysis

Under the same conditions as the previous compliance testing performed in 2013, Consumers Energy will provide HGC Engineering with the following data in ten-minute intervals: hub height wind speed, hub height wind direction and electrical power generation data, for the entire test period (8 pm to 6 am on the chosen nights). Consumers Energy will certify, in writing, that the subject wind turbines were operating in NRO mode 2 during the entire duration of the mitigation testing.

Consumers Energy's Sound Consultant will organize 10 second measurements and field observations into a master spreadsheet with data on surface and hub-height wind speeds and turbine power production (kW). For each monitoring location, the 10 second L_{eq} and L_{max} data will be reviewed using field engineer notes, and segments with unusual or loud background noise will be excluded from the 10-minute L_{eq} measurements, following ANSI S12.9/Part 3 data screening procedures. Then, the turbine-off L_{eq} measurements will be subtracted from the turbine-on L_{eq} measurements on an energy basis to remove long-term background sound per ANSI S12.9/Part 3 procedures. The resulting turbine-only L_{eq} sound levels, for both modified and normal operations if applicable, will be compared to the 45-dBA limit in the Mason County Zoning Ordinance for an Unpooled Parcel property line. A report will be prepared that summarizes all data, results and conclusions.

Further Analysis

Once a suitable mitigation plan is determined through testing to be successful, Consumers Energy shall further develop the plan to take into consideration the need to demonstrate compliant sound levels at all other unpooled properties in the project area. Details concerning any need for operating additional turbines in selected NRO modes shall be provided to the County as well as the expected sound levels at each unpooled property in a similar format to the June 2011 acoustic-modeling study that Consumers Energy submitted during the permitting process. The County and/or its acoustic consultant will review the plan. The Planning Commission shall approve the plan prior to implementation. Additional testing may be required to confirm the mitigation plan.

Appendix 3

Excerpts from Vestas General Specifications (§ 12.3, Mode 2)

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Type: T05 – General Description

General Specification
Appendices

Date: 2010-05-17
Class: 1

12.3 Mode 2

12.3.1 Mode 2, Power Curves

Mode 2, Power curves														
Air density kg/m³														
Wind speed [m/s]	1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	13	9	9	9	10	10	11	11	11	12	12	13	14	15
3.5	53	34	36	38	39	41	43	45	46	48	50	52	55	57
4	112	80	83	86	89	92	95	98	101	104	106	109	115	118
4.5	181	136	140	144	148	152	156	160	165	169	173	177	185	189
5	260	198	203	209	215	220	226	231	237	243	248	254	265	271
5.5	353	270	278	285	293	300	308	315	323	330	338	345	360	367
6	462	355	365	375	384	394	404	413	423	433	442	452	471	481
6.5	581	443	455	468	480	493	506	518	531	543	556	568	594	606
7	735	563	579	594	610	626	642	657	673	688	704	720	751	766
7.5	908	697	717	736	755	774	793	812	831	851	870	889	926	945
8	1090	840	863	886	909	932	954	977	999	1022	1045	1067	1113	1135
8.5	1271	981	1008	1034	1061	1087	1113	1140	1166	1192	1218	1244	1297	1323
9	1437	1112	1142	1172	1201	1231	1261	1290	1320	1349	1379	1408	1465	1494
9.5	1580	1227	1260	1293	1325	1358	1390	1423	1455	1487	1518	1549	1607	1634
10	1689	1331	1367	1402	1437	1473	1506	1540	1573	1607	1634	1661	1709	1729
10.5	1757	1425	1462	1499	1536	1573	1604	1635	1666	1697	1717	1737	1768	1780
11	1792	1512	1549	1585	1622	1659	1683	1708	1732	1757	1768	1780	1797	1802
11.5	1805	1592	1624	1657	1690	1722	1738	1755	1771	1787	1793	1799	1808	1811
12	1811	1666	1691	1715	1740	1764	1774	1783	1792	1802	1805	1808	1812	1813
12.5	1813	1726	1742	1757	1773	1789	1794	1799	1804	1809	1810	1812	1814	1814
13	1814	1765	1774	1784	1793	1802	1805	1807	1810	1812	1813	1814	1815	1815
13.5	1815	1786	1791	1797	1803	1808	1810	1811	1813	1814	1815	1815	1815	1815
14	1815	1802	1805	1808	1811	1813	1814	1814	1814	1815	1815	1815	1815	1815
14.5	1815	1812	1812	1813	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
15	1815	1813	1813	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815
15.5	1815	1814	1814	1814	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16.5	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17.5	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Mode 2, Power curves														
Air density kg/m^3														
Wind speed [m/s]	1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
18	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18.5	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19.5	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Table 12-7: Mode 2, power curve.

12.3.2 Mode 2, C_t values

Mode 2, C_t values														
	Air density kg/m^3													
Wind speed [m/s]	1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874	0.874
3.5	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891	0.891
4	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877	0.877
4.5	0.847	0.847	0.847	0.847	0.847	0.846	0.847	0.847	0.847	0.847	0.847	0.847	0.847	0.847
5	0.818	0.818	0.818	0.818	0.818	0.817	0.818	0.818	0.818	0.818	0.818	0.818	0.818	0.818
5.5	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801
6	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796	0.796
6.5	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811	0.811
7	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
7.5	0.783	0.783	0.783	0.783	0.783	0.782	0.783	0.783	0.783	0.783	0.783	0.783	0.783	0.783
8	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747	0.747
8.5	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695	0.695
9	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634	0.634
9.5	0.569	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.570	0.569	0.567	0.565
10	0.505	0.513	0.513	0.513	0.513	0.513	0.513	0.513	0.512	0.512	0.509	0.507	0.500	0.496
10.5	0.441	0.462	0.462	0.462	0.462	0.462	0.460	0.458	0.456	0.454	0.450	0.445	0.435	0.428
11	0.381	0.417	0.416	0.415	0.415	0.414	0.410	0.407	0.403	0.400	0.394	0.388	0.375	0.368
11.5	0.330	0.377	0.375	0.373	0.371	0.369	0.364	0.359	0.354	0.349	0.342	0.336	0.323	0.317
12	0.287	0.342	0.339	0.335	0.331	0.328	0.322	0.316	0.311	0.305	0.299	0.293	0.281	0.275
12.5	0.251	0.310	0.305	0.300	0.295	0.290	0.285	0.279	0.273	0.267	0.262	0.257	0.246	0.241
13	0.222	0.279	0.274	0.268	0.263	0.258	0.252	0.247	0.241	0.236	0.231	0.226	0.217	0.213
13.5	0.197	0.250	0.245	0.240	0.235	0.229	0.224	0.220	0.215	0.210	0.206	0.201	0.193	0.189
14	0.176	0.225	0.220	0.215	0.210	0.205	0.201	0.196	0.192	0.187	0.184	0.180	0.173	0.169
14.5	0.158	0.203	0.198	0.193	0.189	0.184	0.180	0.176	0.172	0.168	0.165	0.161	0.155	0.152
15	0.142	0.182	0.178	0.174	0.169	0.165	0.162	0.158	0.155	0.151	0.148	0.145	0.140	0.137
15.5	0.129	0.165	0.161	0.157	0.153	0.150	0.146	0.143	0.140	0.137	0.134	0.132	0.127	0.124
16	0.117	0.150	0.146	0.143	0.139	0.136	0.133	0.130	0.127	0.125	0.122	0.120	0.115	0.113
16.5	0.107	0.137	0.133	0.130	0.127	0.124	0.121	0.119	0.116	0.114	0.112	0.109	0.105	0.103
17	0.098	0.125	0.122	0.119	0.116	0.114	0.111	0.109	0.107	0.104	0.102	0.100	0.097	0.095
17.5	0.091	0.115	0.112	0.109	0.107	0.104	0.102	0.100	0.098	0.096	0.094	0.092	0.089	0.087
18	0.084	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.087	0.085	0.082	0.081
18.5	0.077	0.097	0.095	0.093	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.079	0.076	0.075

Mode 2, C_t values														
	Air density kg/m³													
Wind speed [m/s]	1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
19	0.072	0.090	0.088	0.086	0.084	0.082	0.081	0.079	0.078	0.076	0.075	0.073	0.071	0.069
19.5	0.067	0.084	0.082	0.080	0.078	0.077	0.075	0.074	0.072	0.071	0.069	0.068	0.066	0.065
20	0.062	0.078	0.076	0.075	0.073	0.071	0.070	0.069	0.067	0.066	0.065	0.063	0.061	0.060

Table 12-8: Mode 2, C_t values.

12.3.3 Mode 2, Sound Power Levels

Sound Power Level at Hub Height, Mode 2		
Conditions for Sound Power Level	**Verification standard: IEC 61400-11 Ed. 2. Wind shear 0.15 Max turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2° Air density: 1.225 kg/m³**	
Hub Height	80 m	95 m
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	93.8 4.2	93.8 4.3
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	96.0 5.6	96.4 5.7
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	100.1 7.0	100.7 7.2
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 8.4	103.0 8.6
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 9.8	103.0 10.0
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 11.2	103.0 11.5
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 12.6	103.0 12.9
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 13.9	103.0 14.3
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 15.3	103.0 15.8
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 16.7	103.0 17.2
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.0 18.1	103.0 18.6

Table 12-9: Sound power level at hub height: Mode 2.