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January 29, 2021

Via First-Class Mail
and Electronic Filing
Michelle L. Phillips
Secretary to the Commission
NYS Department of Public Service
Three Empire State Plaza
Albany, NY 12223-1350

Re: ***Case No. 14-F-0490: Application of Cassadaga Wind LLC, for a Certificate of Environmental Compatibility and Public Need to Construct a Major Electric Generating Facility in the Towns of Charlotte, Cherry Creek, Arkwright and Stockton, Chautauqua County, New York***

Petition to Amend Certificate

Dear Secretary Phillips:

We represent Cassadaga Wind LLC ("Certificate Holder") in the above referenced matter. Enclosed for filing with the Commission, please find Cassadaga Wind's Petition for an Amendment of the Certificate of Environmental Compatibility and Public Need, with Conditions, issued on January 17, 2018, a Notice of Petition, and an Affidavit of Service indicating that this Petition has been contemporaneously served on the parties required to be served pursuant to 16 NYCRR 1000.16 (b). Per the requirements of 16 NYCRR 1000.16 (b)(5), a notice regarding this amendment is being published in newspapers in the local project area and affidavits of publication will be filed with the Secretary when they are received.

Pursuant to 16 NYCRR § 1000.16, the Petition respectfully requests an amendment to the Certificate to amend its Article 10 Certificate of Environmental Compatibility and Public Need (the "Certificate") to eliminate the long-term sound limit in Condition 80(b) and approve Cassadaga Wind's Sound Monitoring and Compliance Protocol.

As described in the Petition, the requested amendment is consistent with the Siting Board's statutory findings and determinations set forth in the Certificate, will not result in a material increase in environmental impacts, and is consistent with the Siting Board's orders in subsequent Article 10 proceedings. The requested amendment does not have a significant adverse impact on the environment and, therefore should be considered a modification of the Certificate rather than a revision. 16 NYCRR § 1000.16; 6 NYCRR 617.7(c).

Should you have any questions or require anything further in this regard, please do not hesitate to contact me. We look forward to working with the Board or Commission on approval of this Amendment to the Certificate as soon as possible.

Respectfully submitted,

s/ *Jessica Ansert Klami*
Jessica Ansert Klami
James A. Muscato II
Attorneys for Cassadaga Wind LLC

Enclosures

cc: Service List (*enclosed herewith*)

NOTICE OF PETITION TO AMEND CERTIFICATE
January 29, 2021

On January 17, 2018, Cassadaga Wind LLC ("Cassadaga Wind") obtained a Certificate of Environmental Compatibility and Public Need ("Certificate") from the New York State Board on Electric Generation Siting and the Environment. The Certificate authorizes Cassadaga to construct and operate a 126 MW wind-powered electric generating facility and associated project components in the Towns of Cherry Creek, Charlotte, and Stockton Chautauqua County, New York subject to certain conditions. Cassadaga Wind is re-petitioning the Siting Board for an amendment to remove the long-term annual enforceable regulatory sound limits in Certificate Condition 80(b) and for the Siting Board to approve Cassadaga Wind's sound monitoring protocol.

A copy of the petition can be found at the following:

https://www.group.rwe/en/our-portfolio/innovation-and-technology/project-proposals/construction-projects-renewables/cassadaga/cassadaga-wind-article-10-and-ny-state-compliance

Also, the Petition can be found on the Department of Public Service's webpage at http://www.dps.ny.gov/. Click on "search" and enter the Case Number 14-F-0490 in the search bar.

For further information on the Petition, please contact:

Patrick McCarthy
Director of Environmental Affairs and Permitting
Cassadaga Wind LLC
1251 Waterfront Place, 3rd Floor
Pittsburgh, PA 15222
O: 412-253-9419
Patrick.mccarthy@rwe.com

In addition to parties to the original certification proceeding, those wishing to participate in the proceeding on the amendment must advise the Secretary within ten days of this notice:

Michelle L. Phillips
Secretary to the Commission
NYS Department of Public Service
Three Empire State Plaza
Albany, NY 12223-1350

Any comments on the petition must be received by the Secretary no later than 30 days after the date on which this notice was given.

STATE OF NEW YORK
BOARD ON ELECTRIC GENERATION SITING AND THE ENVIRONMENT

Application of Cassadaga Wind LLC, for a Certificate of Environmental Compatibility and Public Need to Construct a Major Electric Generating Facility in the Towns of Charlotte, Cherry Creek, Arkwright and Stockton, Chautauqua County, NY

Case No. 14-F-0490

AFFIDAVIT OF SERVICE

STATE OF NEW YORK)
COUNTY OF ALBANY) ss.:

KAYLEIGH J. ROBINSON, being duly sworn, deposes and says that on the 29th day of January, 2021, she served a copy of the Notice and the Petition for an Amendment to the Certificate of Environmental Compatibility and Public Need dated January 29, 2021, by email to the DMM Party List in this matter, and to all persons identified on the attached Service List to receive electronic copies of these materials

Kayleigh J. Robinson
KAYLEIGH J. ROBINSON

Sworn to me before me this
29 day of January, 2021

Notary Public

TRACY J. POOLE
Notary Public, State of New York
No. 01PO6036309
Qualified in Albany County
Commission Expires Jan. 24, ~~2018~~ 2022

STATE OF NEW YORK
BOARD ON ELECTRIC GENERATION SITING AND THE ENVIRONMENT

Application of Cassadaga Wind LLC, for a Certificate of Environmental Compatibility and Public Need to Construct a Major Electric Generating Facility in the Towns of Charlotte, Cherry Creek, Arkwright and Stockton, Chautauqua County, NY

Case No. 14-F-0490

AFFIDAVIT OF SERVICE

STATE OF NEW YORK)
COUNTY OF ALBANY) ss.:

TRACY POOLE, being duly sworn, deposes and says that on the 29th day of January, 2021, she served a copy of the January 29, 2021 Petition for an Amendment to the Certificate of Environmental Compatibility and Public Need, by mailing a true hard copy via first-class mail upon the recipients identified on the Service List attached hereto to receive paper copies.

____
TRACY POOLE

Sworn to me before me this
29th day of January, 2021

____
Notary Public

LISA GORMAN
Notary Public, State of New York
Qualified in Rensselaer County
No. 01GO6057069
Commission Expires April 9, 20 23

SERVICE LIST - NOTICE OF PETITION TO AMEND CERTIFICATE

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

NAME & ADDRESS	NUMBER OF COPIES
Hon. Michelle L. Phillips Secretary to the Commission New York State Public Service Commission Empire State Plaza Agency Bldg 3 Albany NY 12223-1350 Email: secretary@dps.ny.gov	**1 electronic; 10 print copies via first-class mail**
Basil Seggos, Commissioner NYS Department of Environmental Conservation 625 Broadway Albany NY 12233	**4 print copies via first-class mail**
Abby Snyder, Director NYS Department of Environmental Conservation Region 9 270 Michigan Ave Buffalo NY 14203	**3 print copies via first-class mail**
ATTN: Henry Spliethoff Howard A. Zucker, Commissioner Department of Health Corning Tower, Empire State Plaza Rm 1743 Albany NY 12237 ATTN: William G. Sacks, Counsel's Office Howard A. Zucker, Commissioner NYS Department of Health Corning Tower, Empire State Plaza Albany NY 12237	**2 print copies via first-class mail 1 print copy via first-class mail**
ATTN: Peter Keane, Deputy General Counsel Richard Kauffman, Chair NYSERDA 17 Columbia Circle Albany NY 12203	**2 print copies via first-class mail**

SERVICE LIST - NOTICE OF PETITION TO AMEND CERTIFICATE

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

Eric Gertler, Director **NYS Department of Economic Development** **625 Broadway** **Albany, NY 12245** **ATTN: Vincent Ravaschiere, Senior Vice President, Energy and Incentives Empire State Development** **Howard Zemsky, Commissioner** **NYS Department of Economic Development** **633 Third Ave** **36th Fl** **New York NY 10017**	**2 print copies via first-class mail** **1 print copy via first-class mail**
William Young, Town Supervisor **Town of Cherry Creek** **PO Box 98** **6845 Main St** **Cherry Creek NY 14723**	**1 print copy via certified mail**
Allen Chase, Town Supervisor **Town of Charlotte** **PO Box 994** **8 Lester St** **Sinclairville NY 14782**	**1 print copy via certified mail**
Brian McAvoy, Town Supervisor **Town of Arkwright** **8743 Center Rd** **Cassadaga NY 14718**	**1 print copy via certified mail**

SERVICE LIST - NOTICE OF PETITION TO AMEND CERTIFICATE

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

David Wilson, Town Supervisor Town of Stockton 7344 Rt 380 Stockton NY 14784	**1 print copy via certified mail**
Paul M. Wendel, Jr., County Executive Chautauqua County 3 N Erie St Mayville NY 14757	**1 print copy via first-class mail**
ATTN: Tara Wells Richard Ball, Commissioner NYS Department of Agriculture and Markets 10B Airline Dr Albany NY 12235 ATTN: Jason Mulford NYS Department of Agriculture and Markets 10B Airline Dr Albany NY 12235 ATTN: Michael Saviola NYS Department of Agriculture and Markets 10B Airline Dr Albany NY 12235	**1 print copy via first-class mail 1 print copy via first-class mail 1 print copy via first-class mail**
ATTN: Erin Hogan Rossana Rosado, Secretary of State NYS Department of State Director, Utility Intervention Unit 99 Washington Ave Ste 640 Albany NY 12231	**1 print copy via first-class mail**
Letitia James, Attorney General Office of the Attorney General The Capitol Albany NY 12224-0341	**1 print copy via first-class mail**

SERVICE LIST - NOTICE OF PETITION TO AMEND CERTIFICATE

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

Marie Therese Dominguez, Commissioner **NYS Department of Transportation** **50 Wolf Road, 6th Fl** **Albany NY 12232**	**1 print copy via first-class mail**
Erik Kulleseid, Commissioner **NYS Office of Parks, Recreation, and Historic Preservation** **625 Broadway** **Albany NY 12207** **Mailing Address:** **ATTN: John Bonafide, Director, Technical Preservation Services Bureau** **Erik Kulleseid, Commissioner** **NYS Office of Parks, Recreation, and Historic Preservation** **Division for Historic Preservation** **Peebles Island State Park** **PO Box 189** **Waterford NY 12188-0189** **Delivery Address (Priority Mail - UPS, Fedex, etc.):** **New York State Division for Historic Preservation** **Peebles Island Resource Center** **1 Delaware Ave N** **Cohoes NY 12047**	**1 print copy via first-class mail** **1 print copy via first-class mail**
Cassadaga Branch Library **18 Maple Ave** **Cassadaga NY 14718**	**1 print copy via first-class mail**
Sinclairville Free Library **15 Main St** **Sinclairville NY 14782**	**1 print copy via first-class mail**
Farman Free Library Association of Ellington **PO Box 26** **Ellington NY 14732**	**1 print copy via first-class mail**

SERVICE LIST - NOTICE OF PETITION TO AMEND CERTIFICATE

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

James Denn, Public Information Officer **New York State Public Service Commission** **Email: web.questions@dps.ny.gov**	**1 electronic copy**
Assemblyman Andy Goodell **Assembly District 150** **LOB 545** **Albany NY 12248**	**1 print copy of Notice only via certified mail**
Senator George Borrello **NYS 57th District** **307 Legislative Office Building** **188 State St** **Albany NY 12247**	**1 print copy of Notice only via certified mail**
Gary Abraham **Attorney for Concerned Citizens** **Of the Cassadaga Wind Project** **Email: gabraham44@eznet.net**	**1 electronic copy**
Heather Behnke, Assistant Counsel **NYS Department of Public Service** **Email: Heather.Behnke@dps.ny.gov**	**1 electronic copy**
Jonathan Binder, Associate Attorney **NYS Department of Environmental Conservation** **Email: Jonathan.Binder@dec.ny.gov**	**1 electronic copy**
Kevin Blake **Attorney for County of Chautauqua IDA** **Email: kblake@phillipslytle.com**	**1 electronic copy**
Mary Ann Bommer **33 Lemoine Ave** **Cheektowaga NY 14227**	**1 print copy via first-class mail**

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

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William Duncanson, Town Attorney **Town of Charlotte** **Email: wduncanson@windstream.net**	**1 electronic copy**
Patrick McCarthy, Cassadaga Wind LLC **Director of Environmental Affairs and Permitting** **Email: Patrick.mccarthy@rwe.com**	**1 electronic copy**
Mark Geis **Chautauqua County Department** **of Planning and Economic Development** **Email: geisem@co.chautauqua.ny.us**	**1 electronic copy**
Tina Graziano **Email: tnagraziano@gmail.com**	**1 electronic copy**
Angelo Graziano **Email: anggraz2014@gmail.com**	**1 electronic copy**
Patricia Greenstein **Email: pjmgreenstein@gmail.com**	**1 electronic copy**

SERVICE LIST - NOTICE OF PETITION TO AMEND CERTIFICATE

Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

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Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

Carolyn Rooney, Counsel National Grid **Email: carolyn.rooney@nationalgrid.com**	**1 electronic copy**
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Case No. 14-F-0490: Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need

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Roy Harvey **Email: yoryevrah@gmail.com**	**1 electronic copy**
Karen Engstrom **Email: kengstrom138@gmail.com**	**1 electronic copy**
Christopher Austin, Team Lead **North Atlantic States Regional Council of Carpenters** **Email: nyresearch@nasrcc.org**	**1 electronic copy**

STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

Petition of Cassadaga Wind LLC for Amendment of the Certificate of Environmental Compatibility & Public Need	Case No. 14-F-0490

PETITION OF CASSADAGA WIND LLC FOR AN AMENDMENT TO THE CERTIFICATE OF ENVIRONMENTAL COMPATIBILITY & PUBLIC NEED FOR THE CASSADAGA WIND PROJECT

Dated: January 29, 2021
Albany, New York

James A. Muscato II, Esq.
Jessica Ansert Klami, Esq.
Young/Sommer LLC
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Albany, NY 12304
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Attorneys for Petitioner, Cassadaga Wind LLC

Table of Contents

I. INTRODUCTION

On January 17, 2018, the Siting Board issued an Order granting a Certificate of Environmental Compatibility and Public Need, with Conditions ("Certificate") to Cassadaga Wind LLC ("Cassadaga Wind" or "Certificate Holder"). Cassadaga Wind has submitted the requisite compliance and informational filings required by the Certificate Conditions to commence construction and is in the process of compiling the requisite compliance and informational filings required to commence commercial operations. The Certificate authorizes construction of 48 wind turbines to be located in the Towns of Cherry Creek, Charlotte, and Arkwright, capable of producing up to 126 megawatts ("MW") of electricity (referred to herein as the "Facility").

Relevant to this Petition, the Certificate includes sound limits in Certificate Condition 80. Condition 80 requires the Facility to comply with both short-term sound limits (45 dBA Leq-8-hour at non participating and 55 dBA Leq-8-hour at participating residences) and long-term annual sound limits (40 dBA L_{night} outside non-participating residences and 50 dBA L_{night} outside at participating residences). These limits require post-construction sound monitoring to confirm the Facility is in compliance with the limits per Certificate Conditions 71 and 72.

Pursuant to 16 NYCRR § 1000.16, Cassadaga Wind respectfully requests an amendment to the Certificate to eliminate the long-term annual sound limits in Certificate Condition 80(b). Certificate Condition 80(b) requires that the Facility "[c]omply with a limit of 40 dBA L(night-outside), annual equivalent continuous average nighttime sound level from the Facility outside any existing permanent or seasonal non-participating residence, and a limit of 50 dBA L(night-outside), annual equivalent continuous average nighttime sound level from the Facility outside any existing participating residence."[1] Since the Siting Board issued the Cassadaga Wind Certificate on January 17, 2018, the Siting Board has not required annual sound limits for any other wind

[1] Certificate at p. 35.

project.[2] Cassadaga Wind is requesting that the Siting Board amend the Certificate to remove the annual sound limit from Cassadaga Wind's Certificate as explained further below. In addition, Cassadaga Wind requests that the Siting Board adopt Cassadaga Wind's Sound Monitoring and Compliance Protocol for short-term compliance testing prepared by the Resource Systems Group, Inc. ("RSG"). Attached as **Exhibit A** and **Exhibit B** to this Petition is testimony from Kenneth Kaliski, Senior Director with RSG and Sylvia Broneske, the Principal Acoustics Engineer for RWE Renewables which support why the annual sound limit should be removed from the Certificate.

The Amendment of the Certificate to remove the annual sound limit will not have a significant adverse impact on the environment and therefore, this Petition should not be considered a "revision" but instead should be considered a "modification" of the Certificate. The amendment would not increase any environmental impacts and would make the Cassadaga Wind Certificate Conditions on sound consistent with all other Article 10 Certificates issued to date. As such, this amendment can be authorized by the Siting Board or Commission pursuant to 16 NYCRR 1000.16 for modifications. Under 1000.16, no hearing is required for modifications to a Certificate. After a 30-day public comment period, the Siting Board/Commission can render a decision.

Previously, on November 20, 2020 Cassadaga Wind submitted a Petition requesting similar relief to this Petition, however on January 4, 2021, Cassadaga Wind withdrew that Petition without prejudice in an effort to resolve outstanding issues between Department of Public Service ("DPS") Staff and Cassadaga Wind with respect to sound monitoring. With the submission of this Petition, Cassadaga Wind has submitted a new sound monitoring protocol which is based on DPS Staff's

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[2] Application of Eight Point Wind, Case No. 16-F-0062; Application of Baron Winds, Case No. 15-F-0122; Application of Number Three Wind, Case No. 16-F-0328; Application of Bluestone Wind, Case No. 16-F-0599; and Application of Canisteo Wind, Case No. 16-F-0205; Application of Alle-Catt Wind, 17-F-0282; Application of Atlantic Wind LLC, Case No. 16-F-0267.

most recently proposed Sound Testing Compliance Protocol from the High Bridge Wind Project (Case No. 18-F-0262).

II. OVERVIEW

Cassadaga Wind is the first large-scale renewable wind facility approved by the Siting Board and issued an Article 10 Certificate. The sound design goals and regulatory sound limits were litigated and the parties' positions were part of the record before the Siting Board when it issued the Certificate. However, no party advocated for an annual regulatory sound limit in the proceeding, and the Recommended Decision ("RD") did not recommend any annual regulatory sound limits. Notwithstanding, the Siting Board found "it necessary to apply a longer-term standard consistent with NARUC [National Association of Regulatory Utility Commissioners] of 40 dBA $L_{90\text{-}10\ minute}$ standard as a long term multi week average" and added Condition 80(b) to the Certificate Conditions.[3] Notably, Condition 80(b) of the Certificate is 40 dBA $L_{night,}$ not 40 dBA $L_{90\text{-}10\ minute}$. With this finding, to the best of Cassadaga Wind's knowledge, Cassadaga Wind became the only wind energy facility in the ***world*** with an annual regulatory sound requirement. As no party advocated for an annual sound limit and the RD did not recommend an annual regulatory limit, the issue of applying such a standard was not fully briefed or explored in the record, and therefore the Siting Board was likely unaware of the implications of such a condition.

Subsequent to the issuance of the Cassadaga Wind Certificate, other Article 10 applicants have had the opportunity to present evidence to the Siting Board on the practical implications of requiring an annual regulatory limit like the one required by Cassadaga Wind's Certificate. None of the seven Certificates issued after Cassadaga Wind require the annual regulatory sound limit.

[3] Case No. 14-F-0490 "Order Granting Certificate of Environmental Compatibility and Public Need, With Conditions for Cassadaga Wind LLC," issued January 17, 2018, p. 70.

a) Necessity of Modification

i) Removal of Annual Regulatory Limit Requiring Long-Term Monitoring

As recognized in the Baron Winds Order[4], no standard exists for measuring wind turbine sound as an average sound level for a year. Moreover, the basis stated by the Board for the annual regulatory limit is to minimize the potential for annoyance to and complaints of nearby residents. However, an annual regulatory standard has little effect on annoyance and complaints which are generally related to short-term sound events lasting minutes or hours, not years.[5] Thus, the annual sound limit does not address the potential claimed impact nor minimize the potential for annoyance and complaints.

Short-term regulatory sound limits are the standard method of regulating wind facilities across the world[6], and indeed Cassadaga Wind's Certificate has short-term sound limits in its Certificate. The short-term limits in the Cassadaga Wind Certificate (Condition 80(a)) make certain that sound impacts from the Facility will be avoided or minimized to the maximum extent practicable. Moreover, Cassadaga Wind has designed the project to meet a long-term design goal of 40 dBA $L_{(night\text{-}outside)}$ at night at non-participating homes. The short-term enforceable and measurable sound limits along with the long-term design goal of the Facility ensure sound impacts have been avoided or minimized. There is no need for an additional annual regulatory limit to address impacts, especially because demonstrating compliance with such a limit through post-construction monitoring is difficult and uncertain, as set forth in detail in the testimonies of Kenneth Kaliski and Sylvia Broneske, and has never been required at any other wind facility in the state—or for that matter, the globe.

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[4] The Certificate Holder Baron Winds, LLC is affiliated with Cassadaga Wind LLC and their parent company RWE.
[5] Case 15-F-0122 "Order Granting Certificate of Environmental Compatibility and Public Need, With Conditions for Baron Winds LLC," issued September 12, 2019, p. 120.
[6] *See* Case No. 15-F-0122 Application of Baron Winds LLC for a Certificate of Environmental Compatibility and Public Need, "Applicant's Post-Hearing Initial Brief" submitted April 16, 2019.

As described in detail in the accompanying testimony of Kenneth Kaliski and Sylvia Broneske, accurately monitoring sound emissions from wind turbines over the course of a year can be extremely difficult, time consuming and costly.[7] Sound emissions from wind turbines are constantly changing due to changes in wind speed and direction, and changing propagation characteristics such as temperature, humidity, and atmospheric pressure. An accurate annual sound level measurement from a wind turbine would require a significantly long-term sound monitoring campaign to determine the annual average because weather conditions vary over the year. Moreover, an accurate sound monitoring campaign necessarily involves shutting down turbines to assess turbine only sound levels. Broneske estimates the long-term monitoring protocol would cost between $150,000 to $312,000 to implement depending on the extensiveness of the monitoring conducted. However, this is not the full cost of the monitoring as Kaliski estimates that at least 112 shutdowns would be necessary to implement the monitoring, resulting in both, economic loss due to turbines not operating, as well as the loss of generating potential of renewable energy.[8]

RSG and RWE's internal sound experts, have studied, modeled, and monitored wind farms for over a decade, and are unaware of any jurisdiction in the world implementing an annual regulatory limit requiring long-term monitoring.[9]

Long-term monitoring is also impractical to enforce. Even if the first year of compliance tests were able to accurately demonstrate that the Facility was not in compliance with the annual limit, it could take years of additional compliance tests to demonstrate that measures have brought the Facility into compliance. Noise complaints at wind projects are usually related to certain time periods and weather conditions, all short-term events. Moreover, it is unlikely that Department of

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[7] *See* Case No. 15-F-0122 Application of Baron Winds LLC for a Certificate of Environmental Compatibility and Public Need, "Applicant's Post-Hearing Initial Brief" submitted April 16, 2019.
[8] *Id.*
[9] *Id.*

Public Service staff would be able to undertake a long-term monitoring campaign to confirm the Applicant's monitoring results, which by its nature requires at least weeks – if not months – of monitoring time. Additionally, responding to a complaint regarding "annual or longer-term" sound is impractical. Presumably, responding to such a complaint would take months to a year, and then validating whether mitigation or other measures were effective if a violation has occurred could take another year. In theory, it could be years before a complaint allegedly relating to an annual sound condition is ever resolved.

The difficulty with creating a monitoring program to measure annual sound impacts is demonstrated in the attached testimony. Neither DPS Staff, RWE Renewables, nor RSG, who has extensive expertise in measurement of wind turbine sound and has published work in accredited scientific journals, have ever developed, implemented, or tested a long-term monitoring campaign like the one required for Cassadaga Wind. Again, Cassadaga Wind is the only wind energy facility in the world with an annual regulatory sound requirement.

Despite the complexities with creating a long-term monitoring protocol, in an effort to comply with the Certificate, on February 26, 2018, Cassadaga Wind submitted a Sound Monitoring and Compliance Protocol to DPS Staff for review. This protocol addressed issues identified in the Certificate Order, including adding a protocol for the annual regulatory limit consistent with NARUC's (National Association of Regulatory Utility Commissioners) long term multi week average monitoring methodology given the Siting Board's reference to NARUC's "longer-term" guidance[10]. DPS Staff objected to the use of the NARUC methodology and proposed a method based on ISO 9613-2 or CONCAWE meteorological categories with a "turn-on turn-off" approach to measuring background sound levels.

[10] Case No. 14-F-0490 "Order Granting Certificate of Environmental Compatibility and Public Need, With Conditions for Cassadaga Wind LLC," issued January 17, 2018, p. 70.

Cassadaga Wind accepted DPS Staff's comment to use CONCAWE sound propagation meteorological categories with turbine-on turbine-off testing and filed the Cassadaga Wind Sound Monitoring and Compliance Protocol with the Secretary to the Commission on April 17, 2018 ("April Protocol"). Compliance with DPS Staff's suggestion required the Protocol to be changed to propose measurements under representative meteorological conditions and wind turbine shutdowns to assess background sound levels.

Cassadaga submitted the Protocol within 90 days of the Certificate Order as required by Certificate Condition 71. The Protocol was prepared by RSG and was consistent with the provisions and procedures for postconstruction sound performance evaluation indicated in the Application Protocol with edits to specifically address regulatory conditions of the Certificate, including the long-term monitoring requirement which had not previously been proposed to be included in the proceeding. However, DPS Staff indicated to Cassadaga Wind that they had new comments on the Protocol. Cassadaga and DPS staff have met several times since April 2018 to discuss the comments and finalize the protocol but have been unsuccessful in reaching a resolution in over two years. Much of the disagreement between Cassadaga Wind and DPS Staff involves the long-term monitoring provisions.

In the meantime, the Siting Board has issued another seven Article 10 Certificates to other wind facilities, including Baron Winds. In each of these proceedings the Siting Board has intentionally declined to require an annual sound limit. In the Baron Winds proceeding, the Siting Board specifically held "there is no need to impose a long-term regulatory limit" and "a long-term regulatory limit would be impractical to enforce."[11] The Siting Board's Orders in the other Article 10 proceedings confirms that this requirement should be removed from Cassadaga Wind's Certificate.

[11] Case 15-F-0122 "Order Granting Certificate of Environmental Compatibility and Public Need, With Conditions for Baron Winds LLC," issued September 12, 2019, pp. 122-123.

ii) Sound Protocol

Since the issuance of Cassadaga's Certificate and over the course of the other Article 10 proceedings, DPS Staff has developed a short-term sound testing compliance protocol, the most recent of which DPS Staff submitted in the High Bridge Wind proceeding, Case No. 18-F-0262 (the "DPS Protocol"). Therefore, RSG has taken the DPS Protocol and has developed a protocol for Cassadaga Wind (the "Cassadaga Protocol"). The Cassadaga Protocol generally follows the DPS Protocol but makes edits to clarify provisions and address site specific factors for Cassadaga Wind. For example, the Cassadaga Protocol does not include the addition of 1.5 dB when measuring sound representative of a two-story home. DPS has admitted that this correction is not needed for Cassadaga Wind. (See DPS Staff Initial Brief, Case 18-F-0262 pg. 16).

As explained in the testimony of Kenneth Kaliski the changes made to the DPS Protocol are necessary to ensure accurate, efficient, and reliable monitoring results for both the Certificate Holder and DPS Staff.

For these reasons, the Cassadaga Protocol submitted along with Kenneth Kaliski's testimony, should be adopted by the Siting Board.

b) <u>Impact Analysis</u>

To determine whether a proposed amendment is a modification or a revision, 1000.16(a) states that the criteria for determining significance under 6 NYCRR 617.7(c) shall apply. This criterion includes "a substantial adverse change in existing air quality, ground or surface water quality or quantity, traffic or noise levels".[12] The elimination of the annual regulatory sound limit will not result in a substantial adverse change in noise levels, as the Facility will still be required to comply with the short-term sound levels and the Facility will still be designed to meet the annual sound levels. The elimination of the annual enforceable regulatory sound limits will not increase

[12] 6 NYCRR 617.7(c)(1)(i)

environmental impacts, at all. The Siting Board has held that a short-term limit of 45 dBA Leq-8-hour at non participating and 55 dBA Leq-8-hour at participating residences, and the long-term design goals of 40 dBA L_{night} outside and 50 dBA L_{night} outside at non-participating and participating residences is adequately protective of human health.[13] There is no need for an annual enforceable regulatory sound limit in addition to these standards. None of the criteria in 617(c) will be triggered by the Amendment. Accordingly, the Amendment is not a "revision" and the procedures applicable to modifications shall apply.

III. CONCLUSION

Requiring Cassadaga Wind to comply with an annual regulatory standard is inconsistent with every other Article 10 Certificate and every other operating wind facility in the world. It is impracticable, unrealistic, time consuming and costly, and does little to minimize impacts. Therefore, Cassadaga Wind respectfully requests that the Certificate be modified to eliminate Condition 80(b) and that the Siting Board adopt Cassadaga Wind's Sound Testing Compliance Protocol as submitted along with Kenneth Kaliski's testimony.

Dated: January 29, 2021

Respectfully submitted,

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[13] Case 16-F-0559 "Order Granting Certificate of Environmental Compatibility and Public Need, With Conditions for Bluestone Wind, LCC," issued December 16, 2019, p. 55.

Exhibit 'A'

NEW YORK STATE BOARD ON ELECTRIC
GENERATION SITING AND THE ENVIRONMENT

Case No. 14-F-0490	Application of Cassadaga Wind LLC for an Amendment of its Certificate of Environmental Compatibility and Public Need to Construct a Major Electric Generating Facility in the Towns of Charlotte, Cherry Creek, Stockton, and Arkwright, New York

TESTIMONY OF:

KENNETH KALISKI, SENIOR DIRECTOR

RSG

Q: Please state your name, employer, and business address.

A: Kenneth Kaliski, RSG, 55 Railroad Row, White River Junction, VT 05001.

Q: Please describe your background and professional experience.

A: I am a senior director with Resource Systems Group, Inc. ("RSG"). I have been employed by RSG for 35 years. I am a licensed professional engineer in the states of Vermont, New Hampshire, Michigan, Massachusetts, and Illinois. I am Board Certified through the Institute of Noise Control Engineering ("INCE") and formally served on INCE's Board of Directors and as Vice President of Board Certification. Within INCE I am currently the co-chairman of the Wind Turbine Technical Activity Committee and a member of the Certification Board. I am also a member of the Acoustical Society of America and serve on its Noise Technical Activity Committee. In 2020, I won the INCE William W. Lang Distinguished Noise Control Engineer award for my "… notable contributions to the field of wind turbine acoustics, and use of rigorous analytics and novel approaches to advance the field of noise control engineering."[1] I am also principal author of the National Academies of Sciences, Engineering, and Medicine's National Cooperative Highway Research Report, 882, "How Weather Affects the Noise you Hear from Highways" (2018). This two-year study researched how meteorology changes the propagation of sound from roads. My resume is attached as **Exhibit "A".**

[1] Quotation from the award citation.

Q: Have you appeared in this proceeding before?

A: RSG is the acoustics consultant for Cassadaga Wind LLC and I have previously personally appeared in this proceeding including providing written and oral testimony. All of Cassadaga Wind's Sound Monitoring and Compliance Protocols have been prepared under my direction and control and I am familiar with the facts and circumstances surrounding this proceeding.

Q: What is the purpose of your testimony?

A: I am submitting this testimony in support of Cassadaga Wind's Petition to amend its Article 10 Certificate of Environmental Compatibility and Public Need (the "Certificate") to eliminate the annual sound limit in Condition 80(b) and adopt Cassadaga Wind's Sound Testimony Compliance Protocol attached as **Exhibit "B"** ("Cassadaga Protocol").

Q: What does Condition 80(b) require?

A: Certificate Condition 80(b) requires that the Facility "[c]omply with a limit of 40 dBA L(night-outside), annual equivalent continuous average nighttime sound level from the Facility outside any existing permanent or seasonal non-participating residence, and a limit of 50 dBA L(night-outside), annual equivalent continuous average nighttime sound level from the Facility outside any existing participating residence."

Q: Are you aware of any other wind projects with a condition like 80(b)?

A: I have been involved in modeling and monitoring sound from wind projects since 1993. I am actively involved in research involving wind turbine noise and have written more than a dozen publications on the subject. To the best of my knowledge, Cassadaga Wind is the only wind farm in the world with a requirement like Condition 80(b), an annual regulatory limit necessitating long-term monitoring to demonstrate compliance.

Q: Is there any standard for measuring wind turbine sound for an annual average?

A: No standard exists for measuring wind turbine sound for an annual average as required by Cassadaga's Certificate.

Q: Why should Condition 80(b) be eliminated from Cassadaga's Certificate?

Accurately monitoring sound levels from a wind farm over the course of a year would be extremely difficult, time consuming and costly as well as of questionable accuracy.

- Sound emissions from wind turbines are constantly changing due to variations in wind speed.
- Sound propagation characteristics are constantly changing due to variations in wind profile (which includes the effects of changing wind speed and wind direction by height above ground), temperature lapse rate, turbulence, temperature, humidity, and atmospheric pressure.

- An accurate annual sound level measurement from a wind turbine would require a significantly long sound monitoring campaign to determine the annual average because these weather conditions vary hour by hour over the year and thus monitoring would need to be conducted under many different representative meteorological conditions.
- The results will likely be biased high due to problems measuring wind turbine sound below the background sound level. Any sound level measurement conducted at a residence near an operating wind power project, will include sound from both the wind power project and other background sound present in the area (cars, plants, animals, insects, wind-induced, aircraft, yard maintenance, etc.). To assess turbine-only sound levels, contribution from these other sources needs to be removed. When measuring relatively loud sounds that are well above background, such as roads or airports, these sources can often be neglected, but due to the relatively low overall sound levels produced by wind turbines, this is particularly critical since any of these background sources can produce sound levels that are at least as high as turbine sound. Thus, to accurately measure background sound, all wind turbines within about 1.5 miles of the monitor location are shutdown for a period to allow for measurement of the contribution from these other sources. This method only works if contributions from background sources are below the wind turbine sound

level. Thus, taking measurements during periods with low turbine sound emissions may not be possible. This is usually not a problem with short-term noise limits, as we are focused only on the highest sound levels. But when monitoring for an annual average, we need to accurately monitor all turbine sound levels – high and low.

As a result, it is my expert opinion, that long-term compliance monitoring is an excessive and unreasonable request.

Q: What would sound monitoring for an annual average involve?

Our most current estimate is that there are 60 unique combinations of meteorological conditions that need be represented over the course of a year at the Project. These represent 10 ranges of wind speeds affecting sound emissions from the wind turbines and six sound propagation classes. For the greatest accuracy, all of these conditions would have to be measured.

In a wind turbine sound monitoring campaign, the best way to calculate the wind turbine sound level, is to set out a monitor to collect both wind turbine and background sound. Then, the Project Operator would periodically shut down the wind turbines so that only the background sound is measured. We then subtract the background sound from the total sound level in the hour before and after the shutdown. This yields two hours of turbine-only sound levels for each shutdown.

To obtain the range of meteorological conditions necessary to calculate an annual average sound level, the wind turbines would have to be shut down at least 112 times over at least two seasons (for example, leaf on and leaf off, or spring and fall). Since the occurrence of any particular propagation class is very difficult to forecast in advance, we would consider it necessary to conduct four wind turbine shutdowns at regular intervals per day, over 14 days and two seasons (4 times per day X 14 days X 2 seasons = 112 shutdowns). More shutdowns may be necessary if certain meteorological categories are not represented during the first round of testing.

Q: Do you have concerns about how accurate the results would be?

In addition to the time and cost of setting out long term monitors and shutting down wind turbines, there are issues with the accuracy and bias of the methodology. In particular, the problem lies with the fact that the existing background sound levels are very similar to the Certificate long term noise standard of 40 dBA Lnight. Preconstruction sound monitoring at Cassadaga found that the existing average nighttime sound level ranged from 37 dBA in remote rural areas to 40 dBA in rural agricultural areas of the Project (Cassadaga Wind Preconstruction Noise Impact Assessment, May 21, 2016). However, for a measurement of the wind turbines to be valid, their sound must be greater than the background sound level (ANSI S12.9 Part 3). Thus, for rural agricultural monitoring stations, on average, only turbine sound levels that are greater than 40 dBA would be validly measured.[2] For all other times, the wind turbine sound is less than 40 dBA, the data must be declared invalid.

[2] Actual hourly background sound levels will vary, but the average is 40 dBA.

If the only valid data is 40 dBA or above, the average will be greater than the annual standard of 40 dBA. Thus, the protocol is by design biased to eliminate low wind turbine sound levels from the calculation of an annual average since those are the only levels that are likely to be possible to measure and almost guarantees a violation of the standard where none exists.

Q: What about enforcing long-term monitoring?

A: Long-term monitoring is impractical to enforce, and it is unlikely that DPS Staff will be able to independently confirm compliance with the annual limit due to the complexity and cost of the monitoring protocol. Moreover, if compliance tests were able to accurately demonstrate that the Facility was not in compliance with the annual limit, it would then require another year of additional compliance tests to demonstrate that minimization measures have brought the Facility into compliance. Thus, the time required between complaint and resolution of the complaint is, from the perspectives of the complainant, regulator, and project operator, frustratingly slow.

Complaints related to sound and annoyance are often caused by short-term noise events. An annual regulatory limit is not likely to avoid or minimize impacts beyond those avoided or minimized by the short-term limits already required.

Even if the annoyance is due to annual sound, this annoyance is captured by measuring compliance with the short-term limit of 45 dBA L_{8h}. A recent study found that annoyance to wind turbine sound is somewhat correlated with the short-term sound level (L_{1h}), but not correlated with an adjustment made to represent the long-term average sound level (Haac et al, 2019).[3]

Q: Did Cassadaga Wind attempt to develop a protocol for the annual regulatory limit?

A: Yes. On February 26, 2018, Cassadaga Wind submitted a draft of its Sound Monitoring and Compliance Protocol to the Department of Public Service ("DPS") Staff for review. This protocol addressed issues identified in the Certificate Order, including adding RSG's proposed protocol for the annual regulatory limit.

Despite the difficulties with implementing a long-term monitoring campaign, in an effort to comply with the Siting Board's Order, RSG added to the Board-approved short-term protocol a long-term protocol consistent with NARUC's (National Association of Regulatory Utility Commissioners) long term multi week average monitoring methodology ("Draft Compliance Protocol").

The NARUC methodology in the Draft Compliance Protocol does not require wind turbine shutdowns to calculate background sound levels. Instead, the background would be based on a proxy location placed outside the Cassadaga wind turbine soundscape. Assuming this proxy location had background levels that correlated with the measurement locations within the wind farm, they could be matched hour by hour.

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[3] Annoyance was found to be mostly correlated with subjective factors rather than objective sound levels.

Q: Are their drawbacks with the NARUC methodology?

A: This methodology has several drawbacks. First, there is uncertainly around the correlation of background sound levels for locations that are miles apart. As an extreme example, if someone is mowing their lawn next to the wind farm monitor but not the proxy background monitor, the calculated turbine only sound level would be inaccurately high. In part, we addressed that uncertainty by proposing to conduct a round of monitoring prior to the start of operations at the proxy to determine whether the proxy location was correlated to the subject monitoring location. However, there is no way to completely eliminate the natural variability in background sound that exists between two locations that are one or more miles apart. In addition, NARUC, to some extent, addresses that uncertainty, by eliminating the top five percent of calculated wind turbine sound levels. However, DPS Staff disagrees with this approach.

Furthermore, if the turbine sound level does not exceed the background sound level, then the turbine-only sound level is indeterminate, and that hour is not included in the long-term average. Thus, the method biases the long-term average high.

Q: Did DPS Staff review the protocol?

A: On March 15, 2018, DPS and Cassadaga Wind met to review the Draft Compliance Protocol. On April 12, 2018, following up to the March 15 meeting, DPS provided Cassadaga Wind with comments to the protocol. In their comments, DPS found issue with the NARUC-based method, primarily because the NARUC method calculates a long term mean metric rather than the L_{night} metric, and proposed a method based on ISO 9613-2 or CONCAWE meteorological categories with a wind turbine "turn-on turn-off" approach to measuring background sound levels. Cassadaga Wind incorporated the DPS Staff's proposal to use ISO 9613-2 or CONCAWE sound propagation meteorological categories with turbine-on turbine-off testing into the Cassadaga Wind Sound Monitoring and Compliance Protocol and filed it with the Secretary to the Commission on April 17, 2018 ("April Protocol"). This Protocol changed the method of long-term monitoring to one whereby measurements would be made under representative meteorological conditions and background sound levels measured using wind turbine shutdowns. In this version of the protocol (dated April 13, 2018), RSG proposed a method based on CONCAWE meteorological categories. This method has not been implemented at an operating wind farm to our knowledge, but theoretically would measure background and thus turbine-only sound levels more precisely than the NARUC method.

Q: Did DPS have any further comments on the April Protocol?

A: After the filing of the April Protocol, DPS Staff informed Cassadaga Wind that they still had comments on the April Protocol. In DPS's comments, they considered it too complicated and they recommend another method that eliminated consideration of several meteorological conditions. To the best of my knowledge neither DPS nor the Siting Board or Public Service Commission have approved the April Protocol that was filed on April 17, 2018.

Q: Did Cassadaga Wind and RSG attempt to revise the April Protocol to address DPS Staff's comments?

On June 29, 2018 Cassadaga Wind and RSG again met with DPS Staff to discuss the April Protocol. Based on comments received from DPS staff on June 29, 2018 the April Protocol was revised further, and several changes were made to address DPS Staff comments. The further revised protocol was submitted to DPS for review again on August 13, 2018.

Q: Were Cassadaga Wind and DPS ever able to agree on a protocol?

A: No. After subsequent meetings with DPS staff in November 2018, the Protocol was further revised to address additional DPS comments, adding details to the methodology and examples on how the methodology is implemented. Cassadaga and DPS staff have met several times since November 2018 to discuss whether a resolution can be reached regarding the remainder of DPS Staff's comments but have been unsuccessful in reaching a resolution in over two years. Much of the disagreement between Cassadaga Wind and DPS Staff involves the long-term monitoring provisions.

Q: Has RSG reviewed DPS Staff's recently developed Sound Testing Compliance Protocol in other proceedings?

RSG has reviewed DPS Staff's most recently proposed Sound Testing Compliance Protocol from the High Bridge Wind Project (Case No. 18-F-0262)("DPS Protocol").

Q: Has RSG prepared a new proposed short-term measurement protocol for Cassadaga Wind based on the DPS Protocol?

A: Yes. In an effort to resolve outstanding issues between DPS and Cassadaga Wind with respect to sound monitoring, RSG has taken the DPS Protocol and has developed a protocol specific to Cassadaga Wind (the "Cassadaga Protocol"). Specifically, RSG modified the DPS Protocol to clarify certain provisions, remove inapplicable provisions, and ensure that the Cassadaga Protocol includes a method to accurately, efficiently, and reliably monitor wind turbine sound at the Facility. Attached to my testimony as **Exhibit "B"** is a redline version of the DPS Protocol with RSG's edits and comments which explain the revisions.

Q: Can you explain some of the main revisions you made to the DPS Protocol?

A: Yes.

a. Section 2 Sound Instrumentation.

    i. RSG added the following language to Section 2(i) "Measurement locations will record continuous or triggered audio sounds during turbine-on and background testing periods either with the sound level meters or audio recorders connected to the sound level meters." This language is necessary to ensure that the data collected by either DPS[4] or the Applicant includes the necessary data to confirm other transient events versus wind turbine sound. This way anyone reviewing the data can confirm that the sound is from the turbines and not from some other source. For example, there could be wind gusts or animal sounds that the measurement observer did not notice that contribute to higher sound levels. These could then be first identified using the audio recordings, then removed from the data since they are unrelated to the wind turbine sound. Some sound level meters collect these audio files themselves. But if not, external audio recorders that are relatively inexpensive can be used to collect this data. (See **Exhibit "C"** for an example of one commercially available). We consider collecting such data a best practice and helps ensure that the calculation of the wind turbine-only sound levels are accurate.

b. Section 5 Weather and Testing Conditions

i. RSG has added an additional parameter for evaluation of downwind conditions in Section 5(f). There are difficulties obtaining downwind conditions when a property is in the prevailing upwind direction of a turbine. Under the DPS Protocol you may not get

[4] Pursuant to Section 13(b) of the protocol DPS staff will follow the requirements identified in Section 2 during any monitoring performed by DPS.

enough downwind wind directions to measure in, especially filtering out for other noises such as rain, and periods that are not within 1 dB of the maximum sound power level as required by the protocol. When reviewing hourly wind data from the Cassadaga site, it is very unlikely that these criteria will be met for properties in the southeast to northwest directions of the dominant turbine. Attached as **Exhibit "D"** is a graph depicting the difficulty of measuring the downwind conditions under the DPS Protocol. However, if measurements are permitted under the meteorological conditions provided by the UK Institute of Acoustics "Good Practice Guide on Wind Turbine Noise", then we can include all wind directions if a receptor is within five tip heights of a turbine. Attached as **Exhibit "E"** is a copy of the UK Institute of Acoustics "Good Practice Guide on Wind Turbine Noise". That is, when a receptor is this close to a wind turbine, the difference between upwind and downwind sound levels is usually less than 2 dB and can be ignored for this purpose. Therefore, RSG has added the following language to this section "If an insufficient number of downwind conditions occurring during a two-week monitoring period, then "downwind" can be expanded to any wind direction if the receptor is within five tip heights of any turbine or ±90 degrees of the direction connecting the center of any wind turbine within one mile and the center of the specified receiver. If these conditions are still not met, then the worst-case sound levels will be calculated under any meteorological condition."[5] Without this insertion, it could mean that monitoring would have to occur at some properties for over a year to get some of the rare conditions otherwise required by the Protocol.

c. Section 6 Testing Provision.

i. This section was edited to reflect the testing locations as ordered by the Siting Board. *See* Cassadaga Order Granting Certificate of Environmental Compatibility and Public Need pgs. 78-80. Section 6(e)(v)(2) was also edited to remove the addition of 1.5 dB when measuring sound representative of a two-story home. DPS has admitted that this correction is not needed for Cassadaga Wind. (See DPS Staff Initial Brief, Case 18-F-0262 pg. 16).

d. Section 8 Measurement Procedures

i. RSG has added the definition for when wind turbines are "ON" to the protocol. Without this clarification the protocol could be

[5] This section of the UK Institute of Acoustics has been referred to in prior Article 10 proceedings. For example, DPS witness Miguel Moreno-Cabellaro stated his Baron Winds (Case 15-F-0122) prefiled testimony, "Figure 6 on the same page also shows that for receptors located within 5.25 times the tip height of the turbine … the sound levels downwind and upwind area basically the same and for cross wind conditions, there may be a different of 2 dB in a narrow angle of 20 degree out of 180." In the subsequent question: what are the results and the implications, the response was, "This shows that what may be most important is the wind magnitude only, not the wind direction."

interpreted to mean that ON means all turbines must be turned on and operating at full power. However, there may be times when turbines are not operating owing to various requirements of the Certificate, such as curtailment for threatened and endangered species and shadow flicker restrictions, or due to manufacture's mechanical restrictions associated with wake effects. Turbines that are not operating during these conditions should be considered to be "operating normally" but may not be generating power. Cassadaga should not be required to operate the turbines at full power to conduct the sound testing when they do not normally operate this way, and in fact there will be situations were turning the turbines on full power may cause harm to the turbines, such as in the case of turbulent wake restrictions, or be in violation of permit requirements in the case of curtailments for bats or shadow flicker.

Note that 8(a)(ii) of the Protocol allows for some turbines be to shut off if they do not contribute more than 0.5 dB to the overall sound level. However, our modification to the Protocol allows for wind turbines to be off no matter how much that turbine contributes to the overall sound level, so long as it is part of normal operations, consistent with the Certificate and manufacturer mechanical requirements.

Q: Does the protocol address when/how DPS can conduct monitoring?

A: Section 13 of the Protocol addresses when and how DPS will conduct monitoring. RSG has added one clarification to this section. Section 13(c) governs when DPS Staff can conduct monitoring which requires Cassadaga to modify operation of Facility equipment (e.g. turn off turbines). Given that modifying Facility equipment can affect production, we have added that such monitoring should be limited to situations where a complaint is received. There should be no need for Cassadaga to limit production when there are no complaints, and the Facility has otherwise demonstrated compliance with the Certificate through the other provisions of the protocol.

Q. Are there other changes to the DPS Protocol?

A: Yes. However, these changes are more minor and reflect best practices, such as measuring wind at anemometer height and limiting valid data to wind speeds below 5 m/s, or editorial, such as further explain what is meant by an "applicable receptor". The reasoning for each of these changes is explained as comments adjacent to the redline.

Q: Does this conclude your testimony?

A: Yes.

Attachment ‘A’

KENNETH KALISKI, PE, INCE BD. CERT.

Senior Director

Ken Kaliski has 35 years of experience, having worked in all of RSG's market areas with a focus on engineering and advanced analytics. His technical specialty is in noise control engineering, where he works on projects such as community noise monitoring and modeling, architectural acoustics, transportation noise, and industrial noise control. He also works on complex modeling projects in the fields of market and energy research. Ken is the co-holder of Patent 7,092,853 for an Environmental Noise Monitoring System.

EXPERIENCE

35 years

EDUCATION

BE, Engineering, Thayer School of Engineering, Dartmouth College (2002)

AB, Biological Sciences and Environmental Studies, Dartmouth College (1985)

PROJECT EXPERIENCE

Cassadaga Wind – Project manager for a comprehensive noise impact assessment of the Cassadaga Wind project in western New York. The project included seasonal sound monitoring at six sites, background infrasound monitoring, short- and long-term sound propagation modeling, construction noise modeling, and evaluations of annoyance potential using the Community Noise Rating and published dose-response curves. Designed mitigation to meet project design goals, town standards, and proposed regulatory limits. Prepared prefilled testimony and attended New York State Article 10 hearings on the project.

National Survey of Attitudes of Wind Power Project Neighbors – Project manager for a study of the of the factors that affect audibility and annoyance from wind turbines. This study is based on a national survey of people or live around wind power projects, which was conducted by the Lawrence Berkeley National Laboratory and funded by the U.S. Department of Energy. The result of the study was published as a peer-reviewed paper in the Journal of the Acoustical Society of America (see publications, below).

Black Fork Wind – Conducted a noise assessment of this 100.5 MW wind project in Richland and Crawford Counties in Ohio. Monitored background sound levels over a two-week period for eight locations over an eight-day period. Correlated wind speed measured at project met towers with background wind speeds and assessed the average background sound level over all sites for use in comparing modeled wind turbine sound levels to Ohio's relative sound standard. Presented testimony to Ohio Power Siting Board.

Massachusetts Research Study on Wind Turbine Acoustics – Leading a study on wind turbine sound to help the State of Massachusetts Clean Energy Center and

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Department of Environmental Protection improve the regulation of wind turbines in the State. The study includes detailed data collection around five wind projects in New England, support to the Wind Turbine Technical Advisor Committee of the MassDEP, and quantitative analysis of factors such as infrasound, amplitude modulation, sound levels, and sound propagation modeling.

Highland Plantation Wind Farm – Managed the noise study for the Highland Plantation Wind Farm near Bingham, Maine. The project included long-term sound monitoring at five locations around the site and modeling the 39 turbines proposed for the project. Sound propagation modeling was done to assess conformance with the Maine DEP standards, and mitigation was recommended in a report as part of the permitting proceedings.

Scioto Ridge/Hardin Wind – Managed the pre-construction noise study for the 242 MW Scioto Ridge/Hardin Wind project in Hardin and Logan Counties, Ohio. Oversaw the installation of 13 sound monitors around the project and modeling of sound at all residences around the project from construction, the operating wind turbines, and associated transmission line and substation. Prepared direct testimony for the project for consideration at the Ohio Public Siting Board.

Spruce Mountain Wind, Maine – Conducted assessment of turbulence intensity and potential impacts to amplitude modulation during permitting. During post-construction, management of continuous 24/7/365 compliance monitoring system. Developed software for processing combining 50 ms sound monitoring data with turbine SCADA and met tower instrumentation to assess sound pressure level, amplitude modulation, and tonal sound over 10-minute compliance periods.

Review of Wind Project on Behalf of Oakfield Township – Retained by the Oakfield Township in Maine, reviewed the noise portion of the application of First Wind to construct a wind farm. Provided presentations to the Township on general noise topics and, separately, on the findings of our review. Consulted to the Wind Energy Committee on language for a proposed ordinance.

Deerfield Wind Farm, VT – Prepared a noise study for Vermont's Section 248 filing on a 34 MW wind power project proposed for southern Vermont. The project included background sound monitoring, sound propagation modeling of the wind turbines and substation, and preparation of reports and exhibits. Sound modeling included analyses of 8760 hours of meteorology. A report was prepared and testimony was presented to the Section 248 Board

Kingdom Community Wind – Prepared a noise assessment of a 63 MW wind project in Lowell, Vermont. The project included background sound monitoring at six locations, detailed sound modeling to assessment annualized impacts, testimony before the Public Service Board, and post-construction sound monitoring.

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Kaliski, K., "Wind Turbine Noise Regulation," (webinar) New England Wind Energy Education Project, 2010.

Kaliski, K. "Sound Advice: Evaluating Noise Impacts in a Changing Landscape," American Wind Energy Association Windpower 2009 Conference and Exposition 2009.

Kaliski, K. "Calibrating Sound Propagation Models for Wind Power Projects," *State of the Art in Wind Siting Seminar*, October 2009, National Wind Coordinating Collaborative.

LICENSES, CERTIFICATIONS, MEMBERSHIPS, AWARDS, AND AFFILIATIONS

- Licensed Professional Engineer (PE), States of VT, NH, MA, IL, and MI
- Board Certified, Institute of Noise Control Engineering (INCE)
- William W. Land Distinguished Noise Control Engineer Award (INCE)
- INCE Certification Board
- Co-Chair Wind Turbine Noise Technical Activity Committee (INCE)
- Acoustical Society of America
- Tau Beta Pi Engineering Society

Attachment ‘B’

~~HIGH BRIDGE~~CASSADAGA WIND PROJECT

NY SITING BOARD CASE ~~18~~14-F-~~0262~~0490

SOUND TESTING COMPLIANCE PROTOCOL

Date: ~~July 13, 2020~~January 2021

TABLE OF CONTENTS

1) BACKGROUND

The proposed Project is being developed by ~~High Bridge~~Cassadaga Wind~~,~~ LLC (the "~~Applicant~~Certificate Holder" or ~~"High Bridge") a wholly owned subsidiary of Northland New York Wind LLC.~~ "Cassadaga") The proposed Facility consists of the construction and operation of a commercial-scale wind power project, including the installation and operation of up to ~~25~~37 wind turbines, together with the associated collection/POI substation~~, battery storage~~, collection lines, access roads, meteorological towers, and one operation and maintenance (O&M) building. ~~These turbines and related facilities will be sited within privately-owned leased land within an approximately 28,000-acre Facility Area.~~

To deliver electricity to the New York State power grid, ~~High Bridge~~Cassadaga Wind proposes to construct a collection substation~~, which will include up to 5 MW of battery storage,~~ and a point of interconnection (POI) substation. The collection substation will be ~~located at the end of the Facility's 34.5 kilovolt (kV) collection system and will connect~~connected to the POI substation ~~via~~by a ~~short overhead~~ 115 kV ~~transmission~~generator lead line ~~of approximately 200 feet.~~ The POI substation will ~~interconnect with NYSEG's Jennison to East Norwich 115 kV transmission line in the Town of Guilford~~be owned and operated by National Grid.

Commented [A1]: Edited to reflect Cassadaga

The purpose of this protocol is to outline how adherence to regulatory limits and certificate conditions will be demonstrated, both as a matter of routine post-construction testing and to address specific complaints made through the complaint resolution process outlined in the Noise Complaint Resolution Plan."

2) SOUND INSTRUMENTATION

a) Sound Level Meters (SLMs): All sound level measurements will be conducted using Type-1 integrating SLMs that meet the requirements of ANSI S1.43-1997(R 2007) "Specifications for Integrating-Averaging Sound Level Meters" and/or ANSI/ASA S1.4-2014 / Part 1 / IEC 61672-1-2013, or earlier versions of these standards if sound level meters were constructed prior to these dates.

b) One-Third Octave Band Analyzers: The instruments will have Class-1 one-third octave-band analyzers that meet ANSI S1.11-2004 (R2009) "Specification for Octave- Band and Fractional-Octave-Band Analog and Digital Filters". Alternatively, the instruments will have Class-1~~,~~ one-third octave-band analyzers that meet ANSI S1.11-2014/ Part 1 / IEC 61260-1: 2014, or earlier versions of these standards if sound level meters were constructed prior to these dates.

Commented [A2]: Sound level meters made prior to 2014 meet earlier versions of the ANSI and IEC standards and are equally valid for use in these measurements.

c) Acoustical/field calibrators: Any acoustical calibrator will be a Type-1 precision calibrator that meets the requirements of ANSI S1.40-2006 (R2011) "Specifications and Verification Procedures for Sound Calibrators".

d) Windscreens: The windscreens should be clean, dry, and in good condition. 7-inch diameter windscreens, or equivalent will be used. Measured sound levels will be automatically corrected by the SLMs or manually corrected as relevant for the insertion loss caused by the windscreen.

Insertion losses for windscreens will be documented and included as an appendix to the report as specified in section 14(b) of this protocol. 7" diameter wind foam screens should be used with secondary windscreens (e.g. 300 mm) ,), if commercially available, to reduce the influence of wind noise. Alternatively, single wider foam windscreens can be used (e.g. 300 or 400 mm rhombicuboctahedron windscreens).

e) Sound Floor: SLMs will have a sound floor or self-generated noise (combined electrical and thermal microphone and preamplifier noise) at least 5 dB below the sound pressure levels that are intended to be measured at each one-third frequency band of interest as specified in section 3 (c) of this protocol. Alternatively, SLMs will have self- generated noise levels (Combined electrical and thermal microphone and preamplifier noise levels) lower than or equal to 22 decibels for broadband descriptors and lower than or equal to 10 decibels for all one-third frequency bands of interest. SoundNoise Floor: The noise floor of the sound level meters shall be at most 25 dBA for overall A-weighted measurements and at most 39 dB from 12.5 Hz to 16 Hz, 28 dB from 20 Hz to 31.5 Hz, 20 dB from 40 Hz to 5,000 Hz, and 24 dB above 5,000 Hz for any 1/3 octave band spectrum analyzer. Noise floor characteristics should be documented with information from the manufacturer. When this is not available, soundnoise floor characteristics may be documented with the most recent certificates of calibrations, provided the information was obtained and reported by an independent qualified laboratory. If this information is also unavailable, sound floor may be estimated by measuring sound levels with the SLM running in a very quiet condition such as inside an SLM hard case or inside the calibrator with the calibration tone "off," at an indoor quiet location such as inside a quiet room or a car turned off.

f) Dynamic range: The dynamic range of SLMs will be properly selected (manually or automatically) to avoid any noise floor and overload issues.

g) Temperature and Humidity: SLMs will have operating temperature and relative humidity ranges that comply with the standard listed in section 2(a) of this protocol and are expected to cover the estimated temperature and relative humidity conditions of the site during testing. When this is not possible, testing days and times with forecasted temperature and relative humidity values within the range of the SLMs may be selected. The temperature and humidity ranges from the SLM manufacturer will be reported.

h) Tripods: SLMs will be mounted on tripods, stakes or poles. Operators, if present, will be at least 1.5 meters (5 feet) away from the sound microphone during testing.

i) Measurement locations will record continuous or triggered[1] audio sounds during turbine-on and background testing periods either with the sound level meters or audio recorders connected to the sound level meters.

[1] Audio would be automatically turned on, or triggered, when the measured sound levels reach at or near the compliance limits.

Commented [A3]: The noise floor needs to be sufficient to measure sounds at least 10 dB below the noise limits in the Certificate. The original noise text required very low noise floors that are available in only a select few sound level meters, and unneeded to measure for compliance under the Certificate.

Commented [A4]: These methods are not necessarily suitable for the measurement of the noise floor of a sound level meter, especially at the low noise floor discussed above.

Commented [A5]: Audio is necessary for confirming that the measured sound is from the wind turbines and not from noise events unrelated to the wind turbines. Many sound levels meters measure audio internally, but where this is not the case, an audio recorder can be hooked up to the sound level meter to make the measurements. Audio recorders that are capable of this type of measurements cost about $200.

3) NOISE DESCRIPTORS, WEIGHTING, RESPONSE, AND OTHER SETTINGS

a) Broadband Descriptors: The sound levels of the Leq and L90 broadband descriptors at the residential positions shall be recorded and reported in 10-minute intervals. Alternatively, the Leq broad band descriptor can be recorded at one-second intervals and be reported along with the L90 statistical descriptor, in 10-minute intervals. Additional broadband descriptors may be collected but are not required.

b) One-Third Octave Band Descriptors: The Leq and L90 noise descriptors shall also be recorded at selected residential positions for the one-third octave bands of interest (as specified in section 3(c) of this protocol) and included in the sound compliance test report in 10 minute intervals.

c) Frequency Ranges of Interest: All one-third octave band measurements will include the frequencies from 12.5 Hz through 10,000 Hz. Any full octave band measurements will include the frequencies from 16 Hz through 8,000 Hz.

d) Weighting: Broadband sound levels shall be reported by using the A-weighting scale in the frequency range of interest. Full octave bands and one-third octave band levels shall be reported by using the Z, Linear or un-weighted scale. Sound contaminated by high frequency biogenic sound can be reported using the ANS metric, as defined in ANSI S12.100.

e) Statistical Noise Descriptors ~~Response: The response for determination of any statistical~~: Statistical noise descriptors ~~will~~for any period may be ~~set to "Fast".~~calculated by using the one-second Leq measurements or as described in this Protocol.

f) Settings: All SLM settings will be reported.

4) CALIBRATION REQUIREMENTS

a) Laboratory Calibration: Each SLM and calibrator will have undergone laboratory calibration within two years prior to its use for any sound compliance test. Copies of the calibration certificates will be included as an appendix to the sound compliance test report.

b) Field Calibration: If operators are present, the SLMs will be acoustically calibrated (sensitivity check) in the field at a minimum immediately before the operational sound testing period, and before and after any background sound testing period, according to the procedures given in the SLM instruction manual. Otherwise, SLM's will be calibrated every time operators visit the measurement locations, and at a minimum before and after any sound collection survey.

c) Field calibration differences:

i) If the calibration level after a sound collection differs from the previous calibration level by ±0.5 dB or less, all measurements made with that system shall be adjusted by one-half of the difference. Differences lower than or equal to 0.2 dB are exempt.

ii) Collected data with a difference between the initial and the final calibration exceeding

Commented [A6]: Recording 1 second Leq and then processing these to 10-minute L90 is consistent with ANSI S12.100. This method is preferred, as it allows for the removal of short duration events without excluding entire 10-minute periods. It also allows for better screening of events during post-processing.

Commented [A7]: Rather than eliminating entire records due to birds and/or insects, these high frequency sounds can be eliminated using filtering, consistent with ANSI S12.100 and ANSI S12.9 Part 3.

Commented [A8]: There are no standards requiring fast response settings, other than special cases for amplitude modulation, which is dealt with elsewhere in the Protocol.

±0.5 dB will not be used, and sound collections performed showing such difference will be repeated. In such cases, equipment shall be checked.

iii) Any difference between the acoustical calibrator reference sound level and the SLM calibration reading will be reduced to zero by adjusting the SLM sensitivity in the field, prior to any sound collection.

iv) The calibration sound level results will be documented and reported.

5) WEATHER AND TESTING CONDITIONS

a) Wind speed and wind direction conditions at hub heights will be documented by using the most accurate available information from (a) meteorological tower(s), Lidar measurements, and/or the turbine Supervisory Control and Data Acquisition (SCADA) systems. When SCADA data is used, the wind speed from cut-in wind speed to the wind speed at which rated power is reached, will be derived from the power output using the manufacturers power curve(s). For wind speeds below cut-in wind speed and above rated power wind speed, and for wind direction for all wind speeds, the data from the anemometers on the turbine hubs can be used. Wind magnitude and wind direction as measured at meteorological tower(s), if any, will also be reported.

b) Sky cover and solar radiation or cloud height will be documented with weather information from the most representative (as related to those conditions at the Facility site) National Weather Station or airport's weather advisory service.

c) All meteorological parameters of wind speed, wind direction, temperature, relative humidity, precipitation and atmospheric pressure (optional) will be evaluated at a minimum at one location on site (e.g. Meteorological tower or at a portable weather station). Wind speed will be measured at ~~2 meters~~microphone height +/- 0.~~2~~02 meters above the ground at all locations to be tested.

d) Portable weather stations will be located close to the sound microphones~~, as far as practical from any wind obstructions or vegetation that may affect the wind speed measurements~~.

e) Reasonable efforts will be made to schedule sound tests during a period of time when representative wind conditions (as related to the noise descriptors that need to be evaluated) are forecasted but, in all cases, such tests shall be performed during the weather conditions described in this Protocol.

f) Evaluation of maximum short-term noise limits will be conducted under the worst operational noise emissions (within 1 dB of maximum sound power levels) and downwind conditions (if possible). Downwind conditions exist when the wind direction at hub height is within an angle of ± 45° of the direction connecting the center of ~~the dominant~~any wind turbine within one mile~~sound source (turbine)~~ and the center of the specified receiver, with the wind blowing from source to receiver. If an insufficient number of downwind conditions occurring during ~~the~~a two-week monitoring period, then "downwind" can be expanded to any wind direction if the receptor is within five tip heights of any turbine or ±90 degrees of the direction connecting the center of any wind turbine within one mile and the center of the specified receiver. If these conditions are still not met, then the worst-case sound levels will be calculated under any meteorological

Commented [A9]: The purpose of the anemometer is for screening out periods with the potential for pseudonoise created by wind. As such, the anemometer should be at microphone height.

Commented [A10]: The best conditions for measuring wind turbine noise are when surface winds are low enough to allow clean measurements and hub height speeds are high enough to generate at or near maximum sound power. At these conditions, turbines often drop to just below the maximum sound power. This is normal and is thus allowed under the protocol.

condition. Evaluation of Amplitude Modulation or to address complaints, if necessary, may not be limited to downwind conditions as defined here. Refer to Certificate Conditions of the Order on Amplitude Modulation and section 9(d) in this protocol for details. The dominant sound source is defined as the turbine that produces the maximum sound pressure level contribution at the position to be evaluated. In cases where the most prominent turbine is difficult to discern as related to the noise limit(s) to be evaluated (e.g. Leq-8-h, low-frequency sounds), it will be identified with computer noise modeling or manual calculations.

g) Sound testing will not be conducted during adverse weather conditions such as rain, thunderstorms in the vicinity, ~~snow fall, or under wet road conditions.~~or any precipitation that creates impact noise at the microphone. Any data collected under these conditions will be discarded.

h) Sound testing will not be conducted during periods with microphone height wind speeds in excess of 5 m/s. Any data collected during these periods will be discarded.

6) TESTING POSITIONS

~~a) Sound testing will be conducted at a minimum at the six (6) most potentially impacted positions: four non-participating and two participating residential positions (on private or public space as applicable) considering anticipated sound impacts from computer noise modeling results, any preliminary measurements and complaints, if any.~~

~~b) Three positions to be tested will be selected by the Applicant within 30 days after the start of commercial operations (two non-participating and one participating position) and approved by NYDPS Staff within 60 days after the start of commercial operations. Remaining positions will be selected by DPS Staff within 60 days after the start of commercial operations.~~

a) Sound testing will be conducted at ~~the~~four of the locations -where pre-construction sound level monitoring was conducted. Three additional sound monitoring locations will be identified for monitoring, representing areas where complaints were received during the first full year of operation. If more than three locations received complaints, then three will be selected based on the modeled sound levels of each location and how well a site can represent other complaint locations. Consideration of whether monitoring will be done at a location will also be based on the type of complaint, whether the complaint was due to a continuing operational issue or a non-recurring event, whether the modeled sound level is above 40 dBA (see Section 3.6, below), and whether the landowner cooperates with the study.

b) In addition, the Certificate Holder will test three additional compliance monitoring locations to be selected by DPS staff within 60 days after the commencement of commercial operations of the facility.

c) If permission by the property owner is not granted to access a site chosen by DPS, then the DPS may choose an alternative site, including but not limited to an adjacent private property or public space (such as a road right-of-way). The microphone at this site would be located at a

Commented [A11]: These provisions are added for to allow for worst case meteorological conditions consistent with the UK Institute of Acoustics. If these conditions still do not exist, then the sound levels are calculated using any meteorological condition.

Commented [A12]: For post-construction monitoring, snow and wet road conditions are consistent in the turbine on and off periods, and thus do not need to be excluded. However, precipitation events that create their own pseudo noise by impacting the microphone wind screen directly must be excluded.

Commented [A13]: Wind speeds in excess of 5 m/s at the microphone can create pseudonoise. The 5 m/s limit is recognized in ANSI S12.18 and ANSI S12.9 Part 3. In addition, winds over 5 m/s (11 mph) are often gusty and create wind-induced noise in the surrounding vegetation.

point representative of the site that was intended to be tested, to the extent feasible.

d) Sound microphones will be located at a height of 1.5 meters above the ground.

c) e) Final sound measurement positions will be selected to:

i) Minimize the influence of traffic noise from local roads. Measurement positions should be no closer than 15 meters (50 feet) from the center of any roadway, unless it is not possible to obtain permission from property owner(s) to collect sound information within the private property. In this case, measurement positions can be adjacent to the road, in the public right-of-way.

ii) Avoid or minimize the influence of any mechanical or electrical noise sources from any private or public spaces such as air conditioners, air condensers, heaters, boilers, fans, pumps, transformers, lighting, etc.

iii) Avoid or minimize the influence of sounds from water streams.

iv) Provide a clear sight view of the turbines where possible and minimize the effect of any sound obstruction.

v) Minimize the influence of reflections of any buildings and other small reflective surfaces as follows:

(1) Sound microphones shall not be located closer than 7.5 meters (25 feet) from any reflective surface.

(2) Sound microphones shall not be located closer than 1.5 meters (5 feet) from any reflecting object with small dimensions such as small trees, posts, bushes, etc. The sound level microphone height will be 1.5 ± 0.1020 meters above ground elevation. Sound results for two or more story houses will be corrected by adding 1.5 dB to the results at 1.5 meters in broadband and fractional band basis.

d) f) Positions proposed by the Certificate Holder will be identified with satellite pictures and coordinates and forwarded to DPS for review. Upon approval by NYDPS Staff of residential positions to be tested, the. The Certificate Holder will contact the landowner(s)/tenants(s) to request permission to collect outdoor sound readings close to their residences (if applicable) within the private properties. If permission is not granted or obtained, sound measurements can be taken on public space or an alternate proximal residential position, with the approval of NYDPS Staff.

e) g) At its discretion, NYDPS Staff can conduct sound testing with its own instrumentation at any location selected as specified in sections 6(a) and 6(b) or at any other existing residential location(the latter subject to the Certificate Holder's ability to obtain landowner(s) consent especially if the request is made during the test).

7) SEASONS AND TESTING TIMES

a) Pursuant to Certificate Conditions of the Order, at least two sound compliance tests shall be performed by the Certificate Holder after the commercial operations date of the Facility: One during the "leaf-off" season and one during the "leaf-on" season.

Commented [A14]: This is not consistent with the Board approved protocol, ANSI S12.9 Part 4, ANSI S12.18. Cassadaga's modeling was more conservative than High Bridge, making this provision unnecessary.DPS has admitted that this correction is not needed for Cassadaga Wind. (See DPS Staff Initial Brief, Case 18-F-0262 pg. 16).

Commented [A15]: Micrositing is done at the time the positions are set up. As such, there is no time to have DPS approve the exact location for each property. However, DPS will be notified of each location after they are set up.

Commented [A16]: One of the locations required by the Siting Board is not near a residence.

b) Within the first seven (7) months of the commercial operations date of the Facility, the Certificate Holder shall perform and complete the first Sound Compliance Test and the results shall be submitted to the Board, or the Commission after the Siting Board's jurisdiction has ceased, by filing with the Secretary a report from an independent acoustical or noise consultant, no later than eight (8) months after the commercial operations date, specifying whether or not the Facility is found in compliance with all Certificate Conditions on noise of this Certificate during the "leaf-on" or "leaf-off" season as applicable.

c) The second Sound Compliance Test shall be performed, and results shall be submitted to the Siting Board, or the Commission after the Siting Board's jurisdiction has ceased, by filing with the Secretary subject to the same conditions contained in the Order , but no later than thirteen (13) months after the commencement of operations of the Facility.

8) MEASUREMENT PROCEDURES

Procedures will be as follows:

a) Data Collection Procedure for Operational Sound Testing (All Noise Sources Turned ON plus background sounds)[2]: ON is defined as the turbines operating normally,. Tthere are some cases that turbines may be switched to a lower mode or off owing to normal operation such as to avoid wake effect or other conditions required under the Certificate (shadow flicker, bat curtailment etc.):

 i) Check SLMs calibration. Set any difference to zero at the beginning of the sound survey.
 ii) Verify that all wind turbines from the Wind Generating Facility are turned "ON" and in continuous operation as described in this protocol. If not all turbines are turned "ON", but noise modelling results demonstrate that the inoperable turbines in aggregate do not contribute more than 0.5 dBA to the sound pressure levels (both, at a broadband and low-frequency fractional band basis) at the evaluated position(s), the measurements will still be considered valid if a correction is applied to the measurement results based on the modelling results with and without the inoperable turbines. Differences lower than 0.2 dBA do not require the application of corrections. In all other cases, the measurements will not be valid.
 iii) Report the time that the measurement is started. If operators are present external transient background sounds can be excluded by inhibiting data collection as stated in this section. Sound collections can be restarted or continued after the transient sound ceases.
 iv) Complete one 10-minute cumulative collection. Record and report the time at which each measurement is concluded.
 v) Continue with another 10-minute collection until six 10-minute samples are collected (1-hour).
 vi) Proceed with testing the facility turned off.

Commented [A17]: Normal operations of the Facility may involve the shutting down of turbines for mechanical restrictions. Such shutdowns may occur during periods of high turbulence. These can be planned or unplanned. Planned periods are referred to as "sector curtailment", whereby it is known in advance that under certain wind directions and speeds, upwind turbines create unsafe turbulence to downwind turbines. Under such cases, the upwind turbines are feathered until the event passes. This is part of normal operation of the facility and allowed under the protocol.

[2] Operational sound testing will be conducted 1-hour before and after a shutdown testing event. The wind generating facility can continue operating as needed until the next shutdown occurs.

b) Data Collection procedures for background sound test (with Wind Generating Facility Noise Sources Turned OFF)[3]:

i) ~~Checkf~~For attended monitoring, check SLMs calibration. Set any difference to zero.

ii) Verify that all wind turbines from the Wind Generating Facility within a 1.5-mile radius of any position to be tested are turned OFF.

iii) Complete ~~three~~six 10-minute sound collections at each evaluated position within the hour following the end of the operational sound tests (Wind Generating Facility Noise Sources "ON" plus background sounds).

iv) Record and report the time at which each measurement collection is stopped.

v) If operators are present, check SLMs calibration at the end of the measurements. Record results and set any difference to zero.

vi) Additional Operational Testing may now be conducted using the procedures listed above in section 8(a).

c) Time definitions:

i) the daytime is the time between 7:00 a.m. and 10:00 p.m. EST; and

ii) the nighttime is the time between 10:00 p.m. and 7:00 a.m. EST.

d) Duration of measurements per season:

Measurements for evaluation of short-time noise descriptors (Leq-8-hour, Leq-1-h at 16 Hz, 31.5 Hz, 63 Hz.) will be collected until obtaining a minimum of 24 valid hours per season (a minimum of four hours of valid data for the Leq-8-h descriptor and two hours of valid data for the Leq-1 descriptor, collected at each selected position) ~~at~~within 1 dB of the maximum sound power levels from the turbines and under downwind conditions as specified in section 5(g);

e) Transient Sounds

i) Transient Sounds: Transient sounds are typically sporadic sounds that do not occur continuously during the measurement sounds. Exclusion of transient sounds is limited to external sound sources other than ~~wind~~turbine and ~~wind turbine's~~substation noise sources. Transient noises produced by noise sources within the Wind Generating Facility site will not be inhibited at the time of testing.

ii) Transient sounds can be excluded by operators present, by post processing of the data, or by post processing ~~of the data~~ audio collected through the sound level meter microphone.

iii) For the purposes of this testing, the following sounds will be considered transient:

(1) Sounds caused by cars, trucks, motorcycles, planes and any means of transportation.

(2) Any sounds caused by human activity (e.g. conversations, shouting, music, use of any sound or mechanical equipment).

(3) Any sounds caused by animals such as dogs, birds, peepers, and insects. When animal sounds are unavoidable (such as insect sounds during the summer) instruments

[3] Shutdown events can continue as needed but in all cases background sounds will be measured within the first hour (for correction of operational testing conducted 1-hour before the shutdown test) and the last 1-hour of a shutdown(for correction of operational testing conducted 1-hour after the shutdown test).

Commented [A18]: This calibration is not required for continuous monitoring.

Commented [A19]: Recalibration is only required at the beginning and end of a measurement period, not during.

Commented [A20]: See comment to similar requirement, above.

Commented [A21]: Clarifying the definition of what transient sounds are. That is, wind gusts must be excluded, because they are not continuous sounds that would be the same before and after the wind turbines are shut down.

Commented [A22]: This is added to allow for the post-processing to exclude events using the data collected.

may not need to be paused, provided the sounds can be filtered by post-processing as specified in this protocol.

(4) Transient sounds inhibited during operational sound testing will also be inhibited during background sound testing should they occur. SLMs will have means to inhibit data collection whenever a transient background sound occurs. Operators will pause or hold the sound collection while transient sounds occur and reset or continue the measurement after the transient sound has ceased.

iv) If operators are present, trigger cables are preferred so that operator's sounds and reflections are minimized.

v) SLMs with "delete-back" capabilities are also preferred. If SLMs with "delete-back" capabilities are used, the SLMs can be set up to a maximum deletion of a 10- second sound reading interval.

vi) Sound collection can be restarted or continued after the transient sound ceases.

vii) If operators are present, the Certificate Holder will ensure that personnel are qualified and properly trained to exclude transient events as specified in this protocol so that the need for post-processing is avoided or minimized.

9) BACKGROUND CORRECTIONS AND ANALYSIS OF RESULTS

No corrections for background sounds (noise sources OFF) are necessary if operational sound test results (with the noise sources ON plus the background sounds) comply with certificate conditions in the Order.

a) SHORT-TERM NOISE LEVELS AT RESIDENTIAL POSITIONS.

i) The fractional-band Leq 10-minute background sound levels will be logarithmically subtracted from the fractional-band Leq 10-minute operational sound levels (Wind Generating Facility sound sources ON plus background) for each measurement position in order to determine the Wind Generating Facility contribution to the total A-weighted sound levels. The "exact equation" (Equation 8), as contained in Note 2 of section 6.9 of ANSI/ASA S12.9-2013/Part 3, will be used and applied to the (A) 10-minute operational sound levels. If insect, bird, animal and/or leaf rustle sounds were present, they can be excluded from the measurements by correcting the applicable one-third frequency band sound levels at the frequencies where they occurred as appropriate. Overall corrected Leq (A) 10-minute background and operational sound levels will then be recalculated to obtain both background and operational overall Leq (A) 10- minute corrected sound levels. Both raw and corrected data will be reported with explanations.

ii) If the arithmetic difference between the operational sound levels (Wind Generating Facility noise sources turned ON plus background sounds) and the background sound levels (after turning the Wind Generating Facility noise sources OFF) is less than 3 dB, the calculated result will be reported and a "n/a" note will be added.

iii) Leq-1-h levels will be calculated as the energy-based average of a minimum of three and a maximum of six Leq-10-minute samples collected in a one-hour period.

iv) Leq-8-h levels will be calculated as the energy-based average of a minimum of four and a maximum of eight -valid Leq-1-h samples collected in an eight-hour period. If there are no valid periods using this methodology, then eight-hour averages may be calculated using consecutive valid measurement hours.

Commented [A23]: There is likely to be periods good data cannot be collected all in one night. In such cases, valid data from consecutive valid periods can be combined.

v) Operational noise levels from the Wind Generating Facility only (Leq 8-h), at the selected residential positions (after background corrections are applied), will then be evaluated for compliance with Certificate Conditions of the Order.

b) PROMINENT TONES:

i) Prominent tones will be defined as follows: A prominent discrete tone is identified as present if:

(1) The time-average sound pressure level (Leq) in the one-third-octave band of interest exceeds the time-average sound pressure level (Leq) in both adjacent one-third-octave bands and the threshold of hearing (as indicated in Table 1 of this protocol); and,

(2) The time-average sound pressure level (Leq) in the one-third-octave band of interest exceeds the ~~arithmetic average of the~~ time-average sound pressure level (Leq) for the two adjacent one-third-octave bands by any of the following constant level differences:

(a) 15 dB in low-frequency one-third-octave bands (from 25 up to 125 Hz); or

(b) 8 dB in middle-frequency one-third-octave bands (from 160 up to 400 Hz); or

(c) 5 dB in high-frequency one-third-octave bands (from 500 up to 10,000 Hz).

Commented [A24]: Changed for consistency with ANSI S12.9 Part 4.

ii) Prominent tones will be evaluated by using the Leq-~~1~~10-min sound level results (linear, Z or un-weighted). All collected data will be reported.

Commented [A25]: Under the protocol, the minimum measurement period is 10 minutes. Thus, tonal prominence is measured using a 10 minute period rather than 1 minutes.

(3) The one-third octave band operational sound levels measured at each residential position will be evaluated, to determine if any prominent tones as defined herein were present during testing and caused by operation of the Wind Generating Facility.

(a) Initially, no correction for background sounds will be applied to the operational sound results for this evaluation.

(b) If any prominent tones are found, the operational sound pressure levels of the 1/3-octave bands containing the tones will be evaluated to determine if they exceed the values listed as hearing thresholds in Table 1 of this protocol for the respective frequencies. If they exceed the values, the prominent tones will be denoted as audible and the opposite will be denoted as inaudible. Operational prominent tones that are found being inaudible will be reported as such and may not require further analysis.

(c) If any prominent tones are found to be audible:

(i) The background sound levels Leq (With all Wind Generating Facility sound sources OFF) will be evaluated to determine if the prominent tone was caused by other sound sources in the background rather than noise sources from the Wind Generating Facility. The results of this evaluation will be reported.

(ii) The operational sound levels will then be corrected by using the exact equation listed in note 2 of section 6.9 (equation 8) of ANSI/ASA S12.9-2013/Part 3 to determine operational sound levels from the Wind Generating Facility sources only (Operational sound levels minus background sound levels). If the difference between an uncorrected operational sound level (Wind Generating Facility sound sources ON plus background sounds) and a background sound level is lower than 3 dB the operational sound level from the Wind Generating Facility sources only (background corrected) will be set equal to -99 dB for subsequent calculations (as recommended by section 6.9 d. 1 of ANSI/ASA S12.9-2013/Part 3) and reported with an "n/a" note. Operational noise levels from the Wind Generating Facility noise sources only (background corrected) will then be evaluated for prominent tones. Results will be reported.

(iii) If any prominent tones are found, the operational sound levels from the Wind Generating Facility sources only (background corrected), will then be re- evaluated to determine whether or not the prominent tones are caused by the application of background corrections. In this case, the operational sound level from the Wind Generating Facility noise sources only (Background corrected) at each one-third frequency band of interest will be evaluated for audibility (as specified in section 11.b.3.ii of this protocol) and if found audible, it will be compared to the arithmetic average of the uncorrected operational noise levels (sources ON plus background sounds) of the two adjacent one third octave bands. Results will be reported.

(4) If any audible prominent tones are found at any evaluated residential positions and if they are found to be produced by the operation of the Wind Generating Facility, broadband Wind Generating Facility operational noise level results for that/those position(s) (Leq (A)-10 minute) will be evaluated for compliance with Certificate Conditions of the Order.

(5) Comments about whether or not the Wind Generating Facility is found in compliance with the audible prominent tone condition of the Order will be included in the report.

c) LOW FREQUENCY NOISE

i) Operational and background low frequency sound level measurements will be conducted at the selected residential testing positions as specified in this protocol. Sound levels at these positions will either be reported as extracted from the SLMs for the 16, 31.5 and 63 Hz full octave bands or calculated based on the sound levels from the 12.5 to 80 Hz one-third octave bands as appropriate and applicable.

ii) The Leq-10-min operational sound levels at the 16 Hz, 31.5 Hz, and 63 Hz full-octave bands measured at the selected residential positions will be evaluated to determine if the low frequency noise levels from operation of the Wind Generating Facility (under testing operational conditions) in combination with natural environmental background sounds exceed 65 ~~dB~~dBZ. Initially, no background sound corrections will be made. If operational

Commented [A26]: Unwieghted or "zero" weighted sound levels are expressed as dBZ. This is consistent with the Certificate language.

sound levels (without any background corrections) comply with Certificate Conditions of the Order further analysis may not be needed.

iii) If other sound sources, not related to Wind Generating Facility operation, created or exacerbated low frequency sound levels during the test, measured background Leq-10-min sound levels (Wind Generating Facility noise sources OFF) can be subtracted from the measured operational sound levels (All Wind Generating Facility noise sources ON plus background sounds) at the same specific one-third octave bands where they occurred in order to determine the Wind Generating Facility contribution to low frequency sounds at those bands. Background noise sources will be identified and described, as feasible. The full octave band sound levels will then be recalculated as the energy based average of Leq-10-min samples for each one-hour period. The full octave-band results will be reported. Both raw and corrected data will be reported.

iv) Compliance with, or exceedance of, the 65-~~dB~~dBZ requirement at 16, 31.5, and 63 Hz full octave bands of Certificate Conditions of the Order at selected residential positions and under tested operational conditions, will be evaluated and reported for all Leq-1-h results.

d) AMPLITUDE MODULATION

Evaluation of amplitude modulation will follow the procedures and methods specified by the Institute of Acoustics document: IOA Noise Working Group (Wind Turbine Noise), Amplitude Modulation Working Group, Final Report a method for Rating Amplitude Modulation in Wind Turbine Noise 09 August 2016, Version 1.

10) ADDITIONAL TESTING

This protocol reflects the minimum requirements contemplated for the leaf-on and leaf-off compliance sound tests required by the Order. If additional testing is required, those tests will be performed by following all the provisions of this protocol except as follows:

a) If a violation or non-compliance situation is found at any residences not previously evaluated, those positions will be added to the tests.

b) Seasons and testing times: If a violation or non-compliance situation is found in a specific time frame any retest may need to be conducted to cover approximately the times that the violation or non-compliance situation was found.

c) Scenarios to be tested: The Wind Generating Facility will be retested at approximately the same operational and weather conditions where the non-compliance situation or violation was found.

11) SUBSTATION TESTING

Testing from substation noise will be performed by following this protocol with the following modifications:

a) Sound testing will be conducted at a minimum at the two (2) most potentially impacted non-participating residences (seasonal or full-year, on private or public space as applicable) considering anticipated sound impacts from computer noise modeling results, any preliminary measurements and complaints, if any.
b) Turbines should be operating at low-noise/low-energy production, such as at wind speeds lower than or equal to 5 meters per second at hub height to avoid interference and masking from wind turbine noise. The testing results will report the type of transformer cooling in operation during the measurements (ONAN/ONAF1/ONAF2). If a violation or non-compliance situation is found at other hub-height wind conditions, testing (or retesting) will need to be conducted to cover approximately the operating and weather conditions at which the violation or non- compliance situation was found.
c) Testing will be conducted during minimal nighttime background sound conditions, between 10:00 p.m. and 7:00 a.m. EST. If a violation or non-compliance situation is found in another time frame, any test or retest may need to be conducted to cover approximately the times of the day when the violation or non-compliance situation was found.
d) Since substation noise sources cannot be turned-off to measure background sounds, a proxy location will be selected. Select proxy location(s), far from the influence of the noise from the substation, at a location with similar soundscape than the location(s) that are intended to be tested. A location in the vicinity where noise sources from the substation are blocked by natural barriers (topography) or mand made structures (buildings) can also be selected.
e) Each location will be tested at a minimum for two hours, so that two 1-hour samples are obtained. Complete twelve 10-minute sound collections at each evaluated position at the same times that background sounds are measured at the proxy location(s).
f) Testing of compliance with Certificate Conditions of the Order for substation components will also be conducted by following these provisions.

12) ADDITIONAL PROVISIONS

a) A test plan will be developed as recommended by section 9.1.4 of ANSI S1.13-2005, prior to the test.

b) A final testing schedule will be provided to NYDPS Staff prior to deployment. NYDPS Staff will be notified of any changes to test procedures prior to or during the test, if they occur.

c) To avoid sound interruptions during testing, if communication equipment is used, it will not be operated on speaker/loudspeaker settings and will preferably be set with freehand earphones/microphones. All staff members and personnel will take proper actions to ensure that conversations and communications will not affect the sound collections.

d) All clocks, including any SLMs and weather station meter clocks will be synchronized with the Wind Generating Facility operational time. Any difference between the Wind Generating Facility operational time and the official Eastern Standard Time will be noted and reported.

e) Sound testing will be conducted at each selected residential position over consecutive 10-minute periods for the operational sound tests and the background sound tests.

13) WITNESSING AND NOTIFICATIONS

a) At the discretion of NYDPS, NYDPS Staff representatives may be assigned to witness any sound test.

b) At the discretion of the NYDPS, sound collections can be performed by NYDPS Staff with NYDPS instrumentation at any time, location and operational condition. NYDPS testing instrumentation will comply with the requirements identified in Section 2 of this protocol. NYDPS at its discretion can collect any information related to sounds from the facility and the environment, and weather conditions, including but not limited to any sound levels by using any metric or sound descriptor.

c) ~~If~~If, as the result of a complaint, the facility is required to conduct testing of the Wind Generating Facility at a specific operational condition that would require the Certificate Holders to modify the operation of any Wind Generating Facility equipment or setting any Wind Generating Facility equipment online or offline, NYDPS Staff shall coordinate with the Certificate Holders at least five (5) business days in advance of such testing. This advanced notice and coordination is required so the Certificate Holders can, among other things, ensure: Wind Generating Facility and operational conditions are in-order for testing; that any impact to its customers will be minimal; and that the Certificate Holders, and its customers, can properly notify staff to accommodate the service interruption, and subsequent restoration, if any. If NYDPS Staff desire to conduct sound or vibration testing from the Wind Generating Facility and no modification to operational conditions of Wind Generating Facility equipment are required, no prior coordination is required.

Commented [A27]: See Kaliski Testimony. This is consistent with the Certificate and there is not need to stop production if the Facility is in compliance and there are no complaints.

d) The Certificate Holders will coordinate with NYDPS Staff at least five (5) business days in advance of a tentative date for any sound tests.

e) The Certificate Holders will coordinate with NYDPS Staff on a final date at least two (2) business days prior to any sound tests.

f) The Certificate Holders will notify ~~Towns~~Town officials and ~~applicable~~ residents on whose properties sound level meters will be located about the final dates and times of the compliance tests.

Commented [A28]: Language added to clarify what an "applicable" residence is.

14) REPORTING AND DOCUMENTATION

A report will be prepared that includes at least the following analyses and documentation:

a) A listing of make and model for each SLM, acoustical calibrator, weather station, weather hand-held meter and anemometers (with corresponding serial numbers), and identifying which positions each instrument was used at, along with copies of laboratory calibration certificates for SLMs and calibrators, and any field calibration results (Sensitivity checks). SLM specifications including type, sound floors, humidity and temperature ranges, and settings will be included in the report along with a statement about whether the SLMs and calibrators had undergone laboratory calibration within two years prior to its use in the test. Accuracy for portable weather stations, ~~hand~~ hand- held meters and/or anemometers will be documented along with a statement about whether the portable weather station and the hand-held meters or anemometers used for the tests comply with the accuracy requirements specified in this protocol;

b) The insertion loss of the windscreen as stated by the manufacturer or accredited independent laboratory, for the fractional bands of interest specified in section 3 (c) of this protocol, and whether or not the insertion loss values in dB have been automatically or manually applied to the reported data;

c) The names and qualifications of all personnel who conducted and/or provided direct oversight during the testing. Operators shall be knowledgeable with respect to the operation, performance capabilities and limitations of sound and weather instrumentation, and the specifics of this protocol;

d) All logged A-Weighted (dBA) broadband Leq and L90 data measurements and results by electronic or digital means. If results are corrected, filtered or post-processed, both raw and corrected data will be reported;

e) All logged one-third octave band data and full octave band results for the Leq.

f) All measured and logged data will be reported to the nearest tenth of a decibel in digital and graphical format. Spreadsheet or database (MDB) compatible files will be provided by electronic or digital means;

Commented [A29]: The data can be too voluminous to open in a spreadsheet. In such cases text or database formats must be used.

g) Field data sheets and notes;

h) Meteorological conditions during testing: The report shall include the continuous log of all measurements of meteorological conditions collected including wind speed and wind direction on the ground and at hub height, ambient air temperature, relative humidity, barometric pressure (Optional) and rain fall (Precipitation). Sky cover and general weather conditions will be reported;

i) Broadband and fractional band results by electronic or digital means;

j) Evaluated residential and any sound monitor positions including GPS coordinates and approximate distances to the closest five turbines along with photos and a description of the state of vegetation and whether or not the closest wind turbines are visible from the sound microphone positions;

k) Height of sound microphones as related to the ground along with photos of the residential locations being evaluated and an identification of the number of stories.

l) Figures depicting the sound testing positions in relation to the Wind Generating Facility, property lines, roads and the existing residences as of the date of the Order that were evaluated with the test. Other existing non-residential buildings will be included for reference only.

m) A complete log of the operational load and operational conditions of noise sources from the Wind Generating Facility during testing periods (e.g., turbines, substation transformers). Statements about whether the operational conditions during testing comply with the requirements of this protocol will be included. Any difference between Wind Generating Facility's and Eastern standard time will be reported; and

n) An analysis of results including overall sound levels, prominent tones and low frequency noise levels and whether they were found to comply or exceed the applicable certificate conditions of the Order at any selected residential position and whether or not additional mitigation measures are necessary to comply with Certificate Conditions of the Order.

15) TERMS AND DEFINITIONS

a) Sound and Noise: "Noise" is usually defined as unwanted sound. If "Sound" comprises noises and other sounds, "sound" may be a broader designation. Sound sources within the Wind Generating Facility may be referred as both "noise" and/or "sound". Some animal sounds may be more properly referred to as "sounds" rather than "noise". For the purposes of this protocol the words "sound" or "noise" may be used interchangeably.

b) Background sound: all-encompassing sound associated with a given environment without contributions from the source or sources of interest as specified in this protocol.

c) Continuous background sound: background sound measured during a measurement period, after excluding the contribution of transient background sounds by inhibiting the collection or post-processing. For the purposes of this protocol the term "background sound(s)" is used for both "background sound(s)" and "continuous background sound(s)", interchangeably.

d) Operational sound: Sound that includes both Wind Generating Facility noise sources and background sound unless otherwise noted.

e) Wind Generating Facility sound only: All sounds originating from the Wind Generating Facility without contributions of background sounds as specified in this protocol.

f) Transient background sound: background sound associated with one or more sound events which occur infrequently during the basic measurement period, a measurement interval with or without the source operating, as specified in this protocol.

g) Protocol: Refers to this document, unless otherwise noted.

16) REFERENCES

References listed in this section are for informational purposes only.

a) ANSI S1.4-1983 (R 2006) American National Standard Specification for Sound Level Meters; and Amendment No. 1 in ANSI S1.4A-1985
b) ANSI/ASA S1.11-2004 (R 2009) American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters
c) ANSI/ASA S1.40-2006 (R 2011) American National Standard Specifications and Verification Procedures for Sound Calibrators
d) ANSI/ASA S1.43-1997 (R 2012) American National Standard Specifications for Integrating-Averaging Sound Level Meters
e) ANSI/ASA S12.9-2013/Part 3 (Quantities and Procedures for Description and Measurement of Environmental Sound. Part 3: Short-Term Measurements with an Observer Present)
f) ANSI/ASA S12.9-2005/Part 4 (Quantities and Procedures for Description and Measurement of Environmental Sound – Part 4: Noise Assessment and Prediction of Long-term Community Response).
g) ANSI/ASA S12.18-1994 (R 2009) American National Standard Procedures for Outdoor Measurement of Sound Pressure Level.
h) ISO 226: 2003, Acoustics – Normal equal-loudness contours.

Table 1: Thresholds of human hearing for evaluation of audibility of tones

1/3 Octave Band Center Frequency [Hz]	**Threshold of Hearing [dB] (most sensitive 95 % of population)**
20	68.5
25	58.7
31.5	47.3
40	40.4
50	33.9
63	28.6
80	24.0
100	19.9
125	15.9
160	11.7
200	8.1
250	5.1
315	2.4
400	0.3
500	-1.4
630	-3.0
800	-4.2
1,000	-4.7
1,250	-4.2
1,600	-6.5
2,000	-9.7
2,500	-12.5
3,150	-14.0
4,000	-13.4
5,000	-9.8
6,300	-2.8
8,000	3.1
10,000	3.6

The threshold levels are intended to account for the hearing threshold of 95% of the public. Values from 31.5 Hz to 10,000 Hz inclusive are taken from P05 in Table 2 of Kenji Kurakata, Tazu Mizunami and Kazuma Matsushita, Percentiles of normal hearing-threshold distribution under free-field listening conditions in numerical form, Acoustical Science and Technology Journal (published by Acoustical Society of Japan) Volume 26, Number 5 (2005), pp. 447-449. At 25 Hz the threshold level is 10 dB below the ISO 226:2003 median value and is also believed to account for the hearing threshold of 95% of the public.

Attachment 'C'

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- Bluetooth control and low latency wireless monitoring lets you control and listen to content using supported smart devices and Bluetooth speakers
- One-touch templates for instant setup in any recording scenario
- Built-in speaker for convenient playback anywhere
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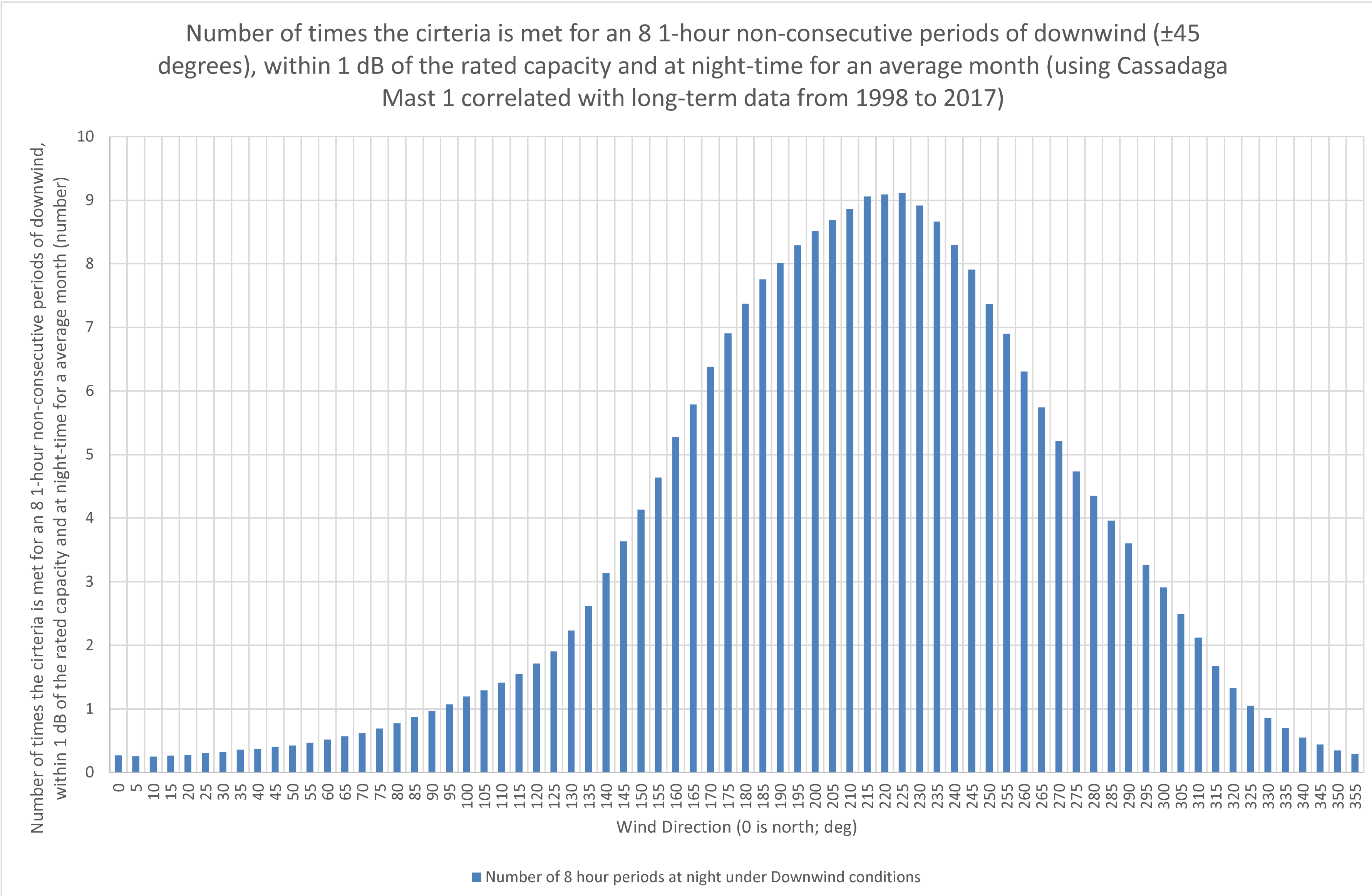
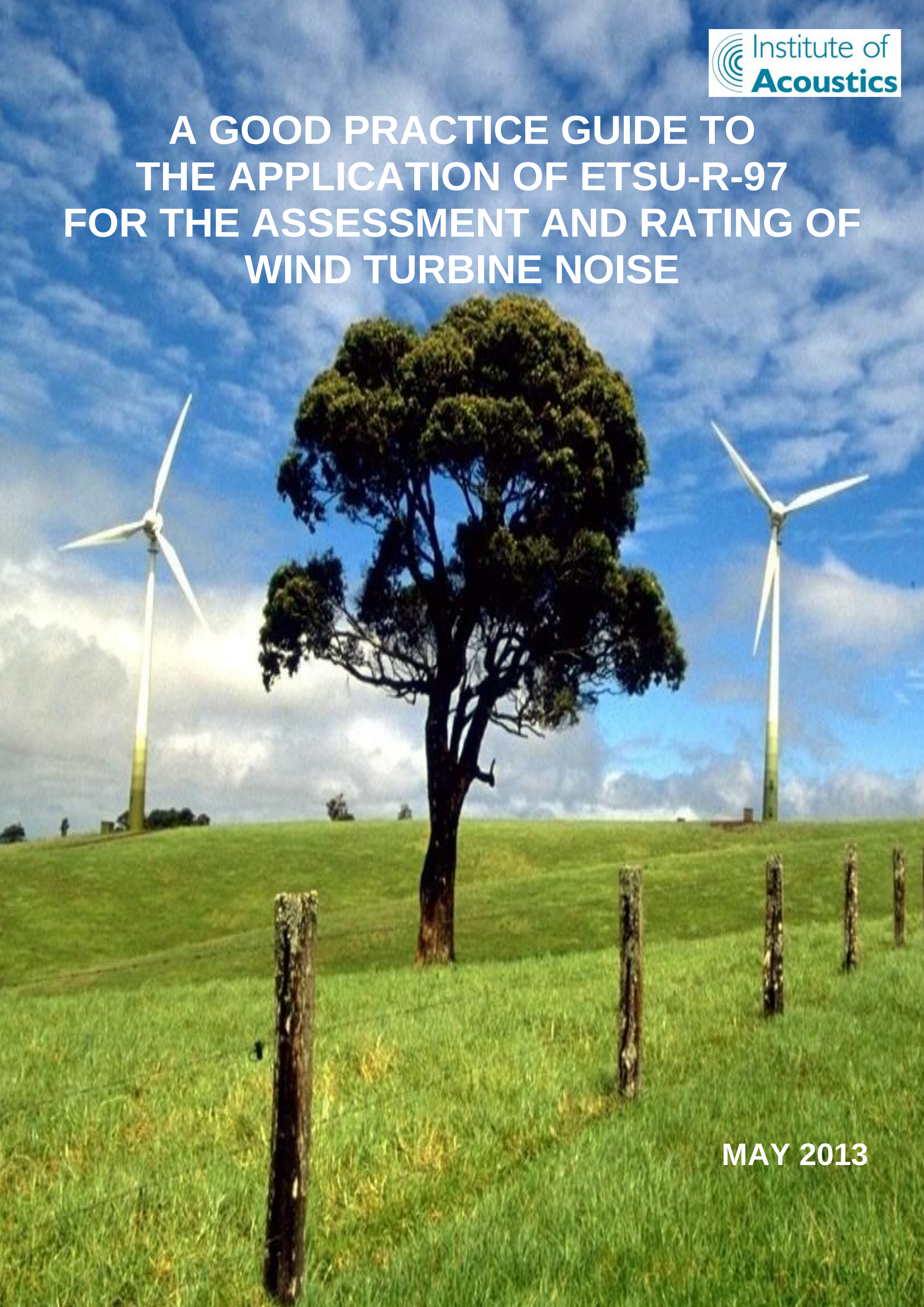

Number of times the cirteria is met for an 8 1-hour non-consecutive periods of downwind (±45 degrees), within 1 dB of the rated capacity and at night-time for an average month (using Cassadaga Mast 1 correlated with long-term data from 1998 to 2017)
Number of times the cirteria is met for an 8 1-hour non-consecutive periods of downwind, within 1 dB of the rated capacity and at night-time for a average month (number)
Wind Direction (0 is north; deg)
Number of 8 hour periods at night under Downwind conditions

Attachment 'E'

Institute of Acoustics

A GOOD PRACTICE GUIDE TO THE APPLICATION OF ETSU-R-97 FOR THE ASSESSMENT AND RATING OF WIND TURBINE NOISE



MAY 2013

PREFACE

This document has been produced by a working group on behalf of the Institute of Acoustics consisting of the following members:

Matthew Cand	Hoare Lea Acoustics
Robert Davis	RD Associates
Chris Jordan	Northern Group Systems (Environmental Health)
Malcolm Hayes	Hayes McKenzie Partnership Ltd.
Richard Perkins	Parsons Brinckerhoff Ltd.

This good practice guide is the output of a process to capture and report good practice in the application of the ETSU-R-97 methodology, which included a 10 week consultation and two peer reviews. The terms of reference for the work and the consultation discussion document can be found at: http://www.ioa.org.uk/about-us/news-article.asp?id=260 (Checked 14.05.13).

Prior to publication of this good practice guide, a peer review was undertaken by a separate group consisting of the following members:

Jeremy Bass	Renewable Energy Systems Ltd
Dani Fiumicelli	Temple Group
Gavin Irvine	ION Acoustics
Eoin King	Infrasonic
Toby Lewis	Huntingdonshire County Council
James Mackay	TNEI Services
Rod McGovern	Farm Energy Consulting
Andy McKenzie	Hayes McKenzie Partnership Ltd

RenewableUK's Noise Working Group

Additional comments were received from members of a Government Oversight Group, with thanks to Hilary Notley, Yvette Hood and Stephen Turner of the Noise and Nuisance Technical Team at DEFRA.

Any comments on this document should be sent to ETSUCONSULT@IOA.ORG.UK. The IOA will keep the document under review, and consider updating when significant changes to current good practice have occurred.

On a personal note, I would also like to take this opportunity to thank all of those individuals not mentioned above who have given their time to assist with the development of this document, through participation at the workshops in London and Dublin, and responding to the consultation.

Richard Perkins
Working Group Chairman & Editor.

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CONTENTS

1 Context

1.1 Background

1.1.1 In response to a request from the Department of Energy and Climate Change (DECC), the Institute of Acoustics (IOA) set up a noise working group (IOA-NWG) to take forward (where possible) the recommendations of the Hayes McKenzie Partnership Report[i] on 'Analysis of How Noise Impacts are considered in the Determination of Wind Farm Planning Applications' Ref HM: 2293/R1 dated 6th April 2011. This good practice guide is the output of a process to capture and report good practice in the application of the ETSU-R-97 methodology, which included a 10 week consultation and two peer reviews.

1.1.2 This guide will be of relevance to:

i. Acoustics consultants;
ii. Local Planning Authority (LPA) Environmental Health and Planning departments;
iii. Developers;
iv. The Planning Inspectorate or equivalent regulating authority;
v. The general public.

1.2 Scope of the Document

1.2.1 This guide presents current good practice in the application of the ETSU-R-97 assessment methodology for all wind turbine developments above 50 kW, reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published. The noise limits in ETSU-R-97 have not been examined as these are a matter for Government.

1.2.2 Smaller developments such as single turbines warrant a simplified procedure (either based on ETSU-R-97 or other method agreed with the LPA), commensurate with the size and impact of the project. Local Planning Policies should also be checked for any variations to methodologies or limits. Where in place, some turbines types may fall under permitted development orders, and assessment methods contained in those orders should be used.

1.2.3 Summary points in the guide appear in the blue boxes, labelled as numbered Summary Boxes (SB). Additional *Supplementary Guidance Notes*, published separately to this guide, expand on some of the aspects considered in the guide to further illustrate the general principles. This guide represents good practice as of the date of publication, and does not exempt further advances from being used. It is anticipated that a regular review of this document will be undertaken, and a new version produced when significant changes have occurred. A Glossary of Terms is included in **Annex A**.

1.3 Statutory Context

1.3.1 This Good Practice Guide has been approved by the IOA Council for use by IOA Members and others involved in the assessment and rating of wind turbine noise using ETSU-R-97. It covers technical matters of an acoustic nature which the IOA-NWG believes represent current good practice. The approval of this guide by the IOA Council should not be seen as an endorsement of the noise limits within the ETSU-R-97 document since the setting of these noise limits is a policy matter for Government. An example planning condition is included in **Annex B**, but legal advice should be sought to ensure it is appropriately applied.

1.4 The ETSU-R-97 Noise Assessment Procedure

1.4.1 The assessment procedure (represented graphically in Figure 1) consists of the following steps:

- Predict noise levels from all turbines (existing and proposed) at the nearest receptors;
- Determine a study area;
- Identify potentially affected properties;
- (If required) Undertake a measurement survey consisting of simultaneous measurement of background noise levels at representative properties with wind speed and direction at the proposed turbine site;
- Analyse the data to remove rain affected and atypical data, and derive the noise limits for the scheme;
- Update noise predictions & assess compliance with the noise limits for a candidate turbine, and provide design advice if compliance with the limits is considered unlikely.

1.4.2 The main purpose of this procedure is to set out the noise data required, and the subsequent analysis needed to allow a decision maker to make an informed decision to assess compliance with ETSU-R-97.

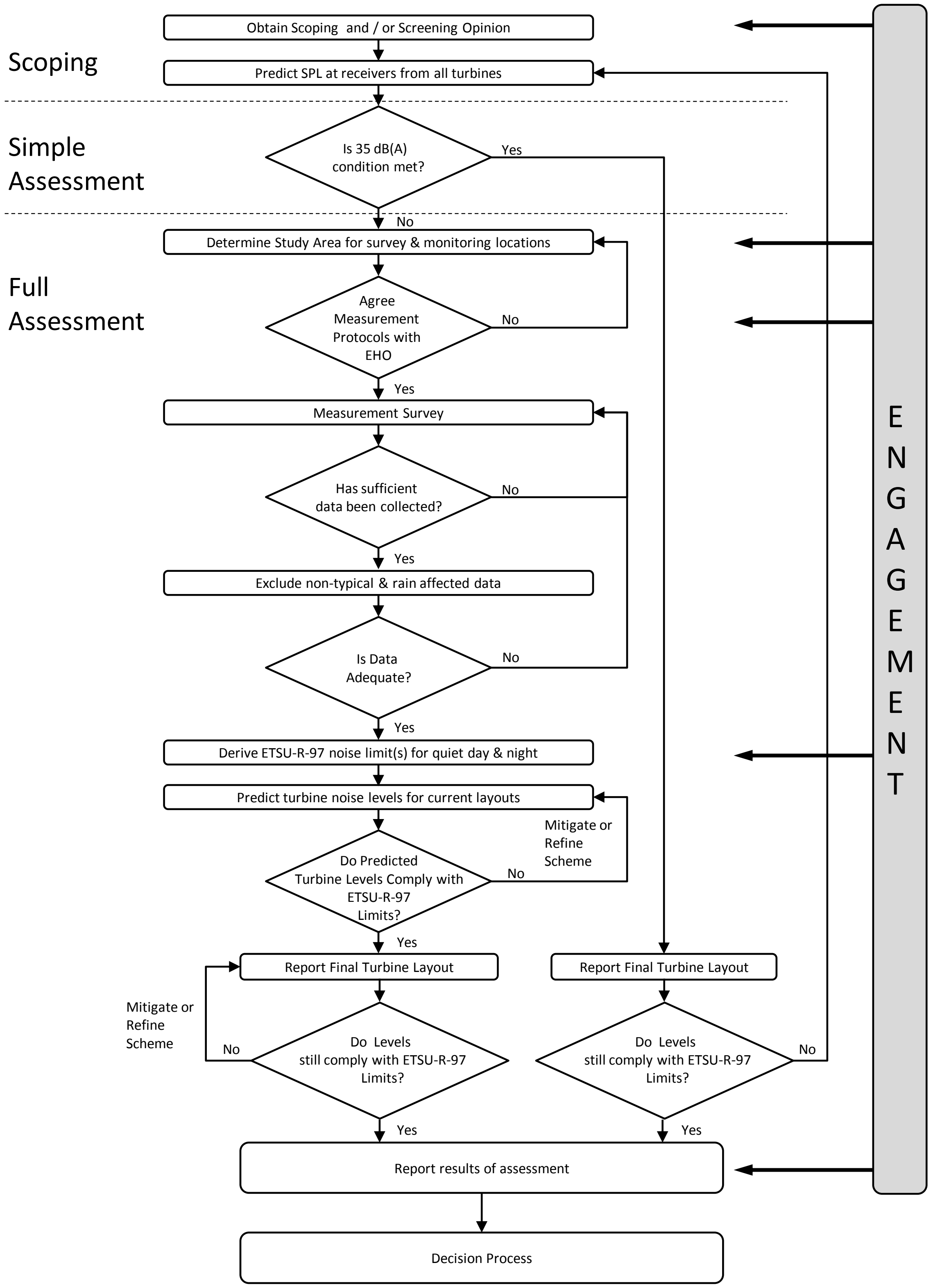

Figure 1 – Wind Turbine Noise Assessment Procedure

1.5 Engagement

1.5.1 ETSU-R-97 states at page 83 that "*During the planning stage of a wind farm, discussions are likely to have been held with the local Environmental Health Officer (EHO) with respect to agreeing acceptable levels of noise from the proposed site...the prevailing background noise level at sensitive dwellings will need to be agreed with the local EHO so that noise limits at different turbine operating wind speeds can be set.*"

1.5.2 Engagement of all of the relevant parties at an early stage in the project and continuation of that engagement throughout the project is desirable from site scoping to the drafting of conditions. This will include the local residents potentially affected by the proposed wind farm, and the respective LPA. It is normal for all developments subject to an Environmental Impact Assessment (EIA) to request a Scoping Opinion to be sought from the respective LPA, however current good practice is that this should not be the extent of the consultation on the part of the wind farm developer, or their consultants. Sub-EIA developments would also be expected to undertake engagement.

1.5.3 A significant aspect of the consultation should be whether surveys are required, and if they are, agreement on the number and position of background noise level measurement locations should be sought. Such agreement will benefit all parties, as background noise level measurements can be an area of considerable debate, and targeting resources at this early stage in the development process should provide dividends in the future by reducing the likelihood of protracted arguments and potentially the need for additional background noise level measurements.

1.5.4 It is encouraged that a LPA representative accepts any invitation from the wind farm developer to witness the installation of background noise level measurement equipment. It is considered good practice for developers to give ample opportunity for a LPA to respond at the respective stages described throughout the process. It is further recognised that the LPA have finite resources which need to be prioritised to where they are most needed, and may not be in a position to respond.

1.5.5 Engagement should be viewed as an ongoing process. This will assist in keeping both local residents and the LPA informed regarding the progress of the application and helps develop trust between all involved.

> **SB1:** Engagement of all of the relevant parties from an early stage and throughout the project is desirable. This includes from site scoping to the drafting of planning conditions.

2 Background Data Collection

2.1 Introduction

2.1.1 In some cases, the ETSU-R-97 procedure for setting noise limits for wind turbines requires typical background noise levels to be determined at noise-sensitive locations in the vicinity of the proposed site. This guidance develops the recommendations in ETSU-R-97 (page 59 – "*The assessment of typical background noise levels"*) in the light of collective experience of carrying out background noise surveys and analysing the data obtained.

2.2 Scoping for Background Noise Surveys

Definition of Study Area

2.2.1 The 'study area' for background noise surveys (and noise assessment) should, as a minimum, be the area within which noise levels from the proposed, consented and existing wind turbine(s) may exceed 35 dB L_{A90} at up to 10 m/s wind speed. (Note: unless stated, in this document the wind speed reference for noise data is the 10 metre standardised wind speed, derived from the wind speed at turbine hub height as explained in Section 2.6). It should be borne in mind that at the survey scoping stage the definition of the 35 dB L_{A90} contour is often preliminary, because (for example) the precise positions and type of wind turbines are not finalised. In specific cases it may be necessary to incorporate the ETSU-R-97 tonal penalty into these predicted noise levels.

> **SB2:** The study area should cover at least the area predicted to exceed 35 dB L_{A90} at up to 10 m/s wind speed from all existing and proposed turbines.

Other Wind Turbines

2.2.2 Particular care should be taken with planning surveys where there are other wind turbines in the area. The contribution to background noise levels of existing wind turbines has to be discounted in determining the background noise levels: the relevant background noise levels for the purpose of setting noise limits for a new installation are the levels with no existing wind turbines operating. Several approaches are described in section 5.2; one or a combination of these may be appropriate.

SB3: Any contribution to background noise levels of noise from an existing wind farm must be excluded when assigning background noise and setting noise limits for a new development.

Numbers and positions of measurements

2.2.3 In many cases there will be significant variation in general background noise levels within the study area, because of topography and the varying influence of existing noise sources such as roads. In rural or semi-rural areas, noise generated by wind in trees is generally a dominant noise source at higher wind speeds and therefore the proximity of the monitoring location to trees and vegetation, and the type of such vegetation, may be significant. Noise from streams and other watercourses can also be a local factor.

2.2.4 Background noise measurements should preferably be made in the vicinity of noise-sensitive receptors, principally houses (existing or for which planning consent is being sought / has been given) and any building used for long-term residential purposes (such as a nursing home). Where there are only a small number of isolated properties (perhaps 4-5) within the study area the selection process is simplified since it is practicable to make measurements close to all receptors. A common situation is where there are groups of houses and the objective is to identify, for each group, a 'representative' location within the curtilage of one property such that the background noise levels measured there can be reliably assigned to all other houses in the group. At the survey planning stage it may not be possible to gain access to gardens, but candidate locations can usually be identified from roadside views, supported by aerial images on website map pages.

2.2.5 When choosing a location that will serve as a proxy for others, the basis for selection is that it can reasonably be claimed, from inspection and observation, to be representative of the non-surveyed locations, in line with the criteria of Section 2.5. Measurement locations outside a property's curtilage (such as an adjacent field) may be used when access to a representative property cannot be obtained, provided that such a location can be justified as being representative. No general guidance can therefore be given on the number of measurement locations as this will be site-specific.

2.2.6 On some occasions a monitoring location may be found to be unsuitable only after the data from this location has been analysed: for example, it may be found that the data is contaminated by noise from a non-typical source. Repeat measurements or use of alternative data should then be considered.

SB4: The background noise monitoring locations within the study area should be selected on the basis of professional judgment, with the objective of collecting sufficient data to enable the background noise levels at each noise-sensitive receptor within the study area to be characterised.

Engagement with the Local Planning Authority and Residents

2.2.7 An EHO may be invited to be involved in the selection of monitoring locations: local knowledge of factors such as the variability of local noise sources can assist in the process, and an EHO may also be willing to liaise with residents when requesting access to properties.

2.2.8 When potential monitoring locations within a property's curtilage have been identified, access to install equipment has to be requested. Obtaining access for noise monitoring may be the first time residents hear about the development, therefore any requests for access should ideally be made by the land-owner or project representative and may be accompanied by written material describing the development and if necessary the noise monitoring process with a photo of a typical installation. This may include a note that the risks of theft/damage of the equipment are carried by the consultant/developer and not the householder. It is considered to be good practice to provide the noise and meteorological data available to the resident upon request.

SB5: The LPA (most usually the Environmental Health Department) should be informed of the plan to carry out background noise surveys and invited to become involved. Landowners or project representatives should make the initial approach to arrange access for monitoring. A description of the monitoring process should ideally be provided to residents in writing.

2.3 Timing of Surveys

2.3.1 Background noise levels at any location may be subject to seasonal variations and (for a given reference wind speed) will be expected to vary with atmospheric factors including wind shear and, at some locations, wind direction. However, there is no compelling evidence that it is necessary to carry out background noise surveys at any particular time of year, or over two or more separate periods. The only common exception is when a measurement position is close to a running watercourse which is a significant noise source.

Although noise from such a source is part of the background noise environment, the effect may be localised. Also, water flow rates and resulting noise levels vary seasonally, and as high flow rates may persist for some days after rainfall, this will be significant in relatively wet periods. Because the objective is to define *typical* background noise levels, the influence of such sources on measured noise should be limited to the levels that would be expected to prevail during drier periods of the year. This might require surveys to be carried out in summer months, although in most cases the influence of non-typical noise can be minimised by selection of monitoring location (see Section 2.5) and/or by selection and exclusion of affected data at the analysis stage (see Section 3.1).

SB6: Background noise surveys may be carried out at any time of the year provided that seasonal effects leading to raised noise levels can be excluded by selection of measurement position or by exclusion of non-typical data during analysis.

2.4 Noise Measuring Equipment

2.4.1 Noise measurement equipment (excluding the microphone windscreen) and field calibrators should meet Class 1/Type 1 precision standards. Microphones should be housed within enhanced-performance windscreens to reduce the effects of flow-generated noise at the microphone. Standard windshields of a diameter of less than 100 mm cannot be relied upon to provide sufficient reduction of wind noise in most circumstances. Where windscreen/microphone combinations are not certified by the manufacturer as meeting Type 1/Class 1 precision standards, which is generally the case where non-proprietary windscreens are used, the windscreen should have an insertion effect of no greater than +/- 1.0 dB in any octave band from 63 Hz to 4000 Hz inclusive[ii]. This should be confirmed by test data. See **Supplementary Guidance Note 1** for more detail.

Calibration

2.4.2 Systems should have independent calibration to manufacturer's specification carried out no longer than two years prior to the survey completion date (one year for field calibrators). The system should be check-calibrated on installation, at each battery change, at intervals of no longer than 4 weeks during the survey, and prior to removal from site. Check-calibration should be carried out using a Type 1 acoustic calibrator, subject to independent calibration annually. Remote calibration (e.g. mid-survey) is acceptable provided that the calibration system is equally compliant.

2.4.3 All calibrations should be reported, along with any drift. A calibration drift greater than 0.5 dB but less than 1.0 dB need not disqualify the measured data, provided that subsequent calibration to manufacturer's specification confirms that there is no defect in the system, and that the recorded time history does not exhibit any anomalies that might indicate more significant excursions in system sensitivity during the survey. Subject to these qualifications, measurements should be corrected by the amount of the calibration shift but only if such a correction results in lower noise levels. Where the system exhibits a calibration shift greater than 1.0 dB, those measurements should be discarded.

SB7: Noise measurement equipment and calibrators used on site should comply with Class 1/Type 1 of the relevant standard(s). Enhanced microphone windscreens should be used. Standard windshields of a diameter of less than 100 mm cannot be relied upon to provide sufficient reduction of wind noise in most circumstances.

2.5 Siting Noise Measuring Equipment

2.5.1 Where possible, measurements should be made in the vicinity of a dwelling in an area frequently used for rest and recreation. This is a flexible definition, and the way people use their garden areas varies widely. Identifying the most appropriate measurement positions must be a matter of professional judgment and experience but the following guidelines are offered:

2.5.2 Equipment should be placed at outdoor positions where noise levels are representative of typical 'low' levels likely to be experienced in the vicinity of a dwelling (or group of dwellings if the measurements are intended to be applied to more than one dwelling). The overriding consideration is that it can reasonably be claimed, from inspection and observation, that there are no other suitable noise-sensitive locations, in the vicinity of any selected location and close to a dwelling, where background noise levels would be expected to be consistently lower than the levels at the selected position. This is a matter of judgment: the objective is to measure 'typical' or 'indicative' not 'absolute lowest' levels of background noise (which could only be determined by extended measurements at a large number of locations over a long period which is neither necessary nor practicable). See **Supplementary Guidance Note 2** for more detail.

2.5.3 Ideally the position should be one which would be exposed to noise from the wind turbines whilst being best-screened from other noise sources such as nearby roads or vegetation.

2.5.4 The background surveys provide the basis for setting both daytime and night-time noise limits: the measurement position must therefore reasonably represent external areas (for daytime noise) and also building facades containing windows (for night-time noise).

2.5.5 In most locations, background noise levels will be determined by wind in trees and vegetation and noise sources external to the property such as traffic noise. The presence of local noise sources such as boiler flues, garden fountains, domestic drains, watercourses and farm equipment should be identified. Such sources are variable (and may not be significant at other dwellings in the vicinity) and their effects should be excluded where possible by selection of measurement position. Other noise sources influencing the measurements may not be so apparent; for example boiler flues and water features operating at low sound pressure levels and only at certain times of the day or night. Such sources would ideally be identified at the time of selecting the measurement locations or installing equipment. However, they might affect measurements to a degree which may only become evident from detailed inspection of the data.

2.5.6 Where it is not possible to exclude the influence of variable local noise sources by selection of monitoring position, it is generally possible to identify such data from inspection of noise level time histories and therefore to exclude it from the data set used to derive noise limits (see Section 3). Periodic downloading of data during service visits can assist with informing the survey length if this arises.

2.5.7 In all cases, microphones should be supported at a height of 1.2 – 1.5 metres above the ground and no closer than 3.5 metres to any significant reflecting surface (such as a building or fence), except the ground. The position should be within 20 metres of the dwelling unless there are particular reasons for measuring at a more distant position (such as the presence of vegetation or denial of access); if so, the reasons should be explained.

2.5.8 A resident at a selected property may request that measurements are made at a position which is considered inappropriate; perhaps because the preferred location(s) are inconvenient (it might obstruct lawn mowing, for example). In this situation the consultant should explain clearly the reasons why the measurements could be compromised; if no agreement can be reached, an alternative property or location should be sought. The assistance of the EHO may help to resolve these situations.

Other Considerations

2.5.9 During site visits, observations should be recorded of the subjective impression of the ambient noise climate: such observations are helpful in building-up a full picture of the various noise sources affecting the site and may assist in data analysis. However, site visits to install, maintain or remove equipment are usually made during the day, which therefore generally does not allow the noise climate during the amenity hours or night-time periods, which are the only periods relevant to the noise assessment, to be directly observed. Where possible, residents in properties where equipment is located should be consulted on particular noise events (such as local building work, harvesting etc.) and particular weather conditions (e.g. fog, snow, heavy frost, wet roads) that can happen during the survey. This can assist data analysis by identifying anomalous data and informing a decision on excluding such data.

2.5.10 Photographs of the equipment showing its position relative to the dwelling or other conspicuous features should also be provided, to inform the assessment and to enable the survey to be repeated at the same location if necessary. Permission to use these photos should be sought.

SB8:

Measurements should be made in amenity areas between 3.5 and 20 metres from a dwelling.

The measurement position should permit measurement of ‘background noise levels judged to be typical/ indicative of the area around the associated dwelling and any other dwellings for which the measurement location will serve as a proxy.

The influence of noise from local sources should be taken into account when selecting measurement locations.

The person selecting background noise monitoring positions and visiting these locations should record subjective impressions of sources contributing to local ambient noise levels.

Residents should be consulted to establish the occurrence of unusual noise events during the monitoring period

Photographs showing the positions of measuring equipment should be provided.

2.6 Wind Speed Measurement

2.6.1 The noise levels recorded in each 10 minute interval are correlated with the concurrent wind speed at a reference position on the proposed wind turbine site. On sites with multiple turbines, the wind monitoring location should be selected to be reasonably representative of the range of wind speeds considered to be experienced at the wind farm site.

2.6.2 The standard procedure should be to reference noise data to standardised 10 metre wind speed. The standardised 10 metre wind speed is obtained from the turbine hub height wind speed by correcting it to 10 metre height using a ground roughness factor of 0.05: see **Annex A**. Hub height wind speed can either be measured directly or derived from wind speeds measured at different heights, using conventional mast-based anemometers or ground-based SODAR/LIDAR systems.

2.6.3 Three methods of wind speed measurement may be adopted:

a) Direct measurements at hub height using either:

i. A met mast carrying one or more anemometer(s) at the proposed turbine hub height.

ii. A SODAR or LIDAR system (installed in a suitable location) to determine hub height wind speed directly, or at the two nearest heights to allow hub-height wind speed to be derived using an exponential profile.

b) A met mast lower than hub height, but carrying anemometers at two different heights: these are then used to calculate the hub height wind speed, using an exponential profile[1] (see **Annex A**). A meaningful extrapolation should be undertaken, and this would be achieved with the upper anemometer (2) being at a height not less than 60% of the hub height of the proposed turbine and the lower anemometer (1) at least 15 metres below it. Within those requirements, the two measurement heights closest to the hub height should be used.

c) A met mast carrying anemometer(s) at a height of 10 metres (with wind shear corrections to be determined as explained in Section 4.5).

2.6.4 Figure 2 illustrates the different wind speed measurement methods, and how they relate to “standardised” wind speed. The figure shows mast-based and ground based methods.

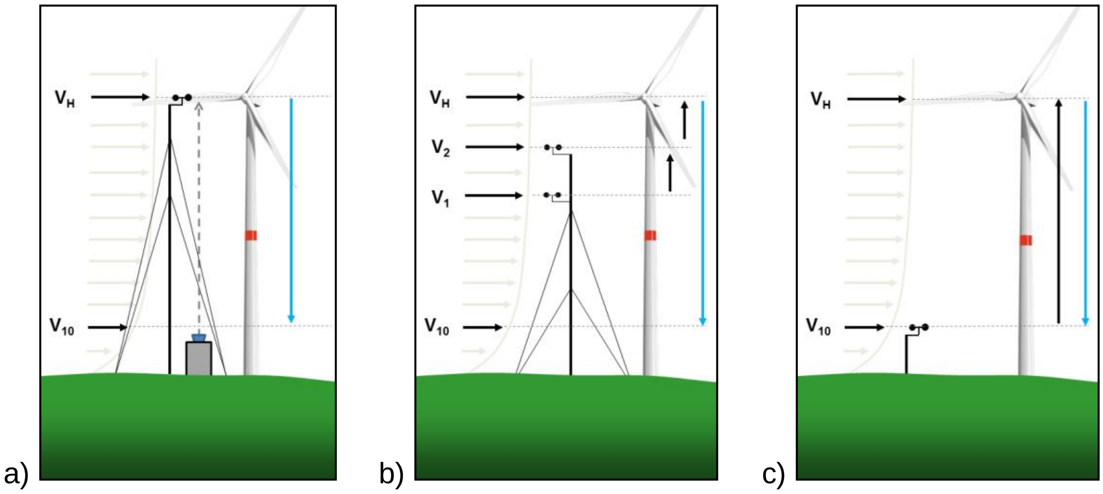

Figure 2 – schematic representation of the methods used for estimating hub height wind speeds during background surveys, which are then standardised (blue arrow) to 10 m height. In case (c), an estimate of the corresponding hub height wind speed is effectively required for calculating the required corrections (as illustrated).

2.6.5 Methods (a) or (b) are preferred. Method (c), using a 10 m mast erected only for the purpose of the background noise survey, should only be adopted for smaller-scale developments for which the installation of a tall met mast or deployment of a SODAR or LIDAR system at the planning stage might not be justified economically.

[1] In cases of negative instantaneous shear, assuming zero shear (constant wind speed with height) is considered good practice.

2.6.6 If method (c) is used, a correction to take account of the wind shear characteristics on the site should be applied. This is discussed in **Supplementary Guidance Note 4** (wind shear). Such corrections can be made on the basis of long-term anemometry data, although this would not be available if a tall anemometry mast is not justified economically. A simplified correction method is described in Section 4.5. In no circumstances should wind speed measurements at a height less than 10 metres be used.

2.6.7 Whichever method is employed, it is crucial that the wind speed reference (hub height, standardised 10 metre, or measured 10 metre) for noise levels and noise limits is clearly and consistently defined, particularly when drafting conditions or assessing compliance.

2.6.8 The highest available wind vane should be used to determine mean wind direction for the purposes of relating background noise levels to wind direction, where relevant.

2.6.9 In some wind directions, anemometers at intermediate heights on a mast will be downwind of the mast and may not indicate the correct wind speed. Information on the angular positions of anemometers should be sought from the mast installer and taken into account. Where two anemometers at the same height are used, the average of the two data sources should be used.

2.6.10 The standard of calibration of the wind measurement system used to provide reference data for background noise monitoring should be in accordance with the requirements of BS EN ISO 61400-11 for determination of sound power levels, which are as follows:

- The anemometer and its signal processing equipment shall have a maximum deviation from the calibration value of ±0.2 m/s in the wind speed range from 4 m/s to 12 m/s.
- The wind direction transducer shall be accurate to within ±6°.

2.6.11 It is recommended that anemometers should have been calibrated within 24 months of the end of the noise survey on temporary masts. It is recognised that this may be too onerous for long term met mast deployments.

2.6.12 Although not yet widely employed, remote measurement of wind speed and direction using ground–based equipment (SODAR, LIDAR) is proving to be a viable alternative to conventional anemometry in most circumstances. Current good practice for installation, operation and data analysis should be followed: guidance in the use of SODAR systems is provided in "Recommended Practices for SODAR in Wind Energy Resource Assessment" (draft), IEA, July 2011, published on http://www.iedat.com/sodar.html and an equivalent draft is available from the IEA covering LIDAR measurements. Some of these ground-based systems are powered by generators: their location relative to noise monitoring positions must be carefully selected to avoid contamination of noise data by generator noise. Similarly, SODAR systems emit a regular "chirping" noise, which is generally inaudible at typical separation distances between the SODAR and the measurement locations but this should be verified on site.

SB9: Noise measurements should be correlated with values of standardised 10 metre wind speed, calculated from hub height wind speed. Hub height wind speed is either measured directly or calculated from measurements made at two heights with the higher measurement height being no lower than 60% of hub height.

Remote-sensing methods (SODAR or LIDAR) may be used as alternatives to mast-mounted anemometers. The operator of such equipment and the person analysing the data should have appropriate experience of these operations.

An anemometer on a 10 metre mast may be used to provide wind speed data for smaller developments. If 10 metre mast data is used, corrections must be made to allow for wind shear characteristics at the turbine site, and these are generally applied to the predicted turbine noise levels.

2.7 Rain Measuring Equipment

2.7.1 Noise measurements affected by rainfall should be excluded. The use of one or more recording rain gauges is preferred. Simple tipping bucket gauges with a typical tip resolution of 0.25 mm are adequate. Rain gauges are most conveniently placed close to noise monitoring positions, but should be installed in an exposed location and not placed under trees or close to a building or other vertical structure.

2.7.2 Other sources such as Met Office weather radar may provide rainfall information, but must be used with care as it may provide only a limited spatial or temporal coverage of the site. SODAR/LIDAR systems can also provide indication of rainfall, although of uncertain reliability at the current state of the art.

2.7.3 Snow fall is not detected by rain gauges (until snow melts). If there is any likelihood that snow has fallen during a survey period then measurement made during snowfall (or when there was significant snow cover) should be identified as far as possible (using weather radar data, local observations, examination of noise level time histories etc) and affected data excluded from the data set, as this data is generally considered to be atypical.

> **SB10:** A recording rain gauge should be deployed (or other methods can be used with care) to identify noise data affected by rainfall

2.8 Synchronisation of Noise, Wind and Rainfall Measurements

2.8.1 It is important that noise and wind speed measurements are synchronised, so that the 10-minute averaging periods (average 10 minute wind speeds and $L_{A90,10min}$) correspond meaningfully. In consultation with the supplier of the measured wind data, it is crucial to establish:

- The time reference used (GMT/BST in the UK, for example). The former is often used by anemometry suppliers to avoid issues with daylight savings during summertime, but separation of data into the ETSU-R-97 time periods must be based on local time.
- The clock reference used to set the time: for example, GPS receivers provide an accurate source of universal time reference.
- The time reference convention: this may refer to the start or the end of the 10-minute averaging period.

2.8.2 The aim should be that the measurement intervals are synchronised to within 15 seconds at the start of the survey. A synchronisation drift of more than 1 minute over the duration of the survey should be reported and best avoided. In many cases, the review of time histories of wind and measured noise levels (using other parameters such as L_{Aeq} if required) can indicate the progression of a synchronisation drift and allow data to be time-shifted to correct a significant synchronisation error.

2.8.3 Synchronisation of rainfall data with noise data is less critical because of the inherent limitations of rainfall measurements in identifying noise data that may have been affected by rain at any particular measurement position. However, synchronisation within 1 minute is a reasonable objective.

> **SB11:**
>
> Measurement intervals for wind speed, noise level and rainfall should be synchronised to within at most one minute over the survey period. Logging devices may use different time references (GMT or BST) and the logging protocol may apply a time marker at either the start or end of a measurement interval. Such differences must be taken into account. Synchronisation of rainfall measurements is less critical.

2.9 Durations of Surveys

2.9.1 The duration of a background noise survey is determined only by the need to acquire sufficient valid data over the range of wind speeds (and directions, if relevant). It is unlikely that this requirement can be met in less than 2 weeks. The possibility of equipment malfunction should also be borne in mind. This section lists relevant factors.

Required range of wind speeds

2.9.2 ETSU makes a positive recommendation "*It must be ensured that during the survey period wind speeds over the range zero to at least 12 m/s and a range of wind directions that are typical of the site, are measured*". The 'at least 12 m/s' requirement was intended to address the (then current) use of stall-regulated turbines with a hub height of around 25-30 metres, to provide background noise data (and hence derived noise limits) up to high wind speeds. With increasing hub heights a modern pitch-regulated turbine may achieve its maximum sound power level at a standardised wind speed of 7-8 m/s. In such cases acquisition of background noise data at wind speeds up to 12 m/s is not considered necessary. Also, on some UK sites the occurrence of standardised wind speeds above 7-8 m/s is relatively unusual and acquisition of data at higher wind speeds might require an unnecessarily protracted survey period. Further, neither conventional anemometers nor remote sensing devices (LIDAR or SODAR) can measure wind speeds close to zero. In any event, it is not necessary to measure wind speeds significantly below the cut-in speed of wind turbines (generally 2-4 m/s at hub height).

2.9.3 Therefore the recommended minimum wind speed range (10 m standardised) for background noise surveys is:

- For pitch-regulated turbines: between cut-in wind speed and the wind speed corresponding to its maximum sound power level.
- For stall-regulated turbines: between cut-in wind speed and 12 m/s.

2.9.4 The recommended approach to deriving noise limits for wind speeds outside the range of available background noise data is addressed in Section 3.

Required size of data set

2.9.5 As a guideline, the survey should be of sufficient duration to acquire no fewer than 200 valid data points for each of the amenity hours and night periods in the wind speed range required and no fewer than 5 valid data points in any 1 m/s wind speed 'bin' within this range. These guidelines are not prescriptive: more data points may be required if the data shows large scatter; fewer may be sufficient if data points are tightly grouped. Further information on this can be found in **Supplementary Guidance Note 3**.

2.9.6 The other factor influencing survey duration is the effect of wind direction. At some locations background noise levels are strongly dependent on wind direction. Section 3 discusses specific situations in which these circumstances may be applicable. Where it is considered likely to be appropriate to 'directionally filter' the background noise data for wind direction, a data set comprising no fewer than 100 data points and 3 data points in any wind speed bin, in each of the amenity hours and night-time assessment periods, may be adequate.

SB12:

The survey duration is determined entirely by the requirement to collect sufficient valid data over an adequate range of wind speeds. For pitch-regulated turbines, data should cover the range of wind speeds between cut-in and the speed at which maximum sound power level is achieved.

As a guideline, no fewer than 200 valid data points should be recorded in each of the amenity hours and night time periods, with no fewer than 5 valid data points in any 1 m/s wind speed bin. In specific cases (described in Section 3) where background noise levels are dependent on wind direction and data is to be 'filtered' into two or more datasets then a minimum of 100 valid data points and 3 valid data points per 1 m/s bin in each data set may be adequate.

These guidelines are not prescriptive: more data points may be required if the data shows large scatter; fewer may be sufficient if data points are tightly grouped.

3 Data Analysis & Noise Limit Derivation

3.1 Analysis of Background Noise Data

3.1.1 The purpose of data analysis is to provide a representative background noise level across a range of wind speeds for the Amenity and Night-time Hours and thereby help define appropriate noise limits for a proposed wind energy development.

3.1.2 To obtain a typical representation of the existing noise environment, analysis of the collected data should minimise the influence of atypical noise sources for a representative measurement location (or other locations for which a proxy is being applied) during the period of noise measurement.

Temporal Filtering

3.1.3 ETSU-R-97 requires the filtering of noise, wind and rain data for the Amenity Hours and Night-time Hours.

SB13:

Amenity Hours are defined as:	Night-time Hours are defined as:
18:00 – 23:00 hrs Monday – Sunday;	23:00 – 07:00 (weekday and weekend)
13:00 – 18:00 Saturday and 07.00 to 18.00 Sunday	
(All times are local)	

Data Filtering

3.1.4 ETSU-R-97 proposes that measured $L_{A90,10\ minute}$ noise levels and average 10 minute wind speed data pairs are plotted on a scatter plot. To minimise the influence of atypical noise sources, filtering the data is likely to be required. Reviewing the time histories of noise and wind data for the survey period will also assist in atypical noise identification.

3.1.5 Despite careful selection of measurement locations, it should be expected that noise sources which are not typical of the environment can occur during the survey. Such sources may be unidentified boiler flue noise, fish pond pumps, bore-hole water pumps, water features, idling engines, etc. The use of the L_{A90} index will minimise the influence of transient noise sources which could raise the measured noise levels, e.g.. low flying military jets, bird scarers.

3.1.6 When a measurement location is used to represent locations at which measurements are not undertaken, then removal of site-specific noise sources should be undertaken. See **Supplementary Guidance Note 2** for more detail.

> **SB14:** The presence of noise sources which are not common to the representative measurement locations and neighbouring noise sensitive properties should be removed from the data, using a review of time histories and scatter plots.

3.1.7 The dawn chorus (marked increase in noise due to birds which can occur at sunrise) has been found to be a significant source of noise for some measurement locations. If present, it is apparent in time histories of the measured levels. It is related to sunrise which will vary for time of year and location. Therefore consideration needs to be given to when this may occur for the noise survey data under analysis, and removed where appropriate.

> **SB15:** Where appropriate, clear dawn chorus effects should be removed from night-time data.

Rainfall

3.1.8 Data collected during periods of rainfall are required to be removed from the data. ETSU-R-97 states the following with respect to rainfall: "*Measurements should not be used for periods of heavy rainfall when noise levels will be high due to the noise of rain itself, and more important, due to the increased water flow in nearby streams and rivers".*

3.1.9 Tipping bucket rain gauges tip when the bucket has become full. This filling of the bucket can take more than a single ten minute period. Therefore, it is considered that at least the 10 minute period which contains the registered bucket tip and the preceding 10 minute period should be excluded.

3.1.10 Rain gauges with greater sensitivity may only require the period when a drip is detected to define when the sample period should be rejected.

3.1.11 The influence of rain-induced noise upon a measurement location should also be considered. Noise from streams which dominate the noise environment at a measurement location can vary in level by 20 – 30 dB L_{A90} depending upon whether the stream is in flood or drought conditions.

3.1.12 Care should be taken when assessing such situations to provide a noise environment which is representative of the location. Periods of drought are to be considered atypical in a similar manner to periods of flood. During meteorological drought periods, i.e. in the UK normally defined as at least 15 consecutive days or more where there is less than 0.2 mm (0.008 inches) of rainfall, noise levels associated with streams may be minimised. However, this may not be representative of typical conditions for some areas of the Country, e.g.. Wales, Western Scotland and Cumbria..

3.1.13 Reasonable efforts should be made to avoid periods of atypical rainfall: in most stream-affected areas, this would be satisfied by including, during, or immediately before the measurement, a period of 5 days or more without significant rainfall. Periods of elevated stream noise levels following heavy rainfall should be excluded to derive more representative levels. Noise from larger rivers and water courses will tend to be less affected by past levels of rainfall, and may be consistent and therefore typical of specific noise environments.

3.1.14 Rainfall may also affect noise generated by traffic passing along wet roads. In these circumstances, it may be appropriate to remove data following rain periods for up to an hour or more after the last registered rainfall period for locations where traffic noise is the dominant noise source.

> **SB16:** Exclude any data directly affected by rainfall, or when rainfall has resulted in atypical levels.

Traffic Noise

3.1.15 Locations where traffic noise is dominant may show little or no relationship between wind speed and noise level. In such circumstances, a single fixed level across the wind speed range would be considered appropriate.

3.1.16 Rush hour traffic noise that occurs for a measurement location all year round should be considered within the data to be analysed, as recommended in ETSU-R-97. However, such a noise source may significantly influence the derived night-time background noise level. The assessment should consider whether this is representative of the "typical situation". If, for example, the rush hour varies significantly from day to day, such as occurs close to ferry ports in relation to their schedule, then some consideration should always be given as to whether inclusion of such data is appropriate. If the rush hour traffic is not considered to be typical, then it should be excluded.

SB17: ETSU-R-97 allows the inclusion of rush hour traffic in the night period where it is a significant feature in the noise environment. If this does not routinely occur, it should be removed.

Derivation of Wind Speed & Background Noise Plots

3.1.17 ETSU-R-97 states that noise levels should be plotted against wind speed to determine the prevailing background noise levels at a measurement position. However, there is no indication in ETSU-R-97, when determining the prevailing background noise levels through regression analysis, whether a linear fit or a polynomial best fit line should be adopted.

3.1.18 The degree of correlation between measured noise level and wind speed on site is not an indication of the appropriateness of the noise survey data. Locations that are dominated by wind induced noise in rural landscapes should be expected to have a greater degree of correlation than locations where noise is not associated with wind effects, i.e. developed areas or generally noisy areas. However, a lack of relationship between noise and wind speed does not invalidate the noise survey but is indicative of a noise environment which is not wind induced.

3.1.19 Unless there is a specific noise source which requires consideration through linear regression analysis (heavy traffic noise may be an example), a polynomial fit will be most appropriate. In many cases third order polynomials should provide sufficient information to allow a reasonable representation of the prevailing background noise levels during the survey period.. Higher or lower order polynomials (up to fourth order) may be appropriate depending upon the nature of the noise environment. The equation of the regression polynomial used should be provided in the assessment (showing coefficients to 4 significant figures). See **Supplementary Guidance Note 2** for some examples.

SB18: ETSU-R-97 states that noise levels should be plotted against wind speed to determine the prevailing background noise levels at a measurement position. The order of regression analysis to use (linear to fourth order) will depend upon the nature of the noise environment.

Potential Consequences of Limited Data Range

3.1.20 The derived prevailing background noise polynomial curve should not be extended beyond the range covered by adequate data points. Where a noise limit is required at higher wind speeds; it should be restricted to the highest derived point.

3.1.21 A similar correction to the curve should be undertaken for the prevailing background noise polynomial curve for low wind speed conditions, i.e. the lowest derived background noise level is adopted for all wind speeds below where this derived minimum occurs. Both of these considerations are illustrated in Figure 3.

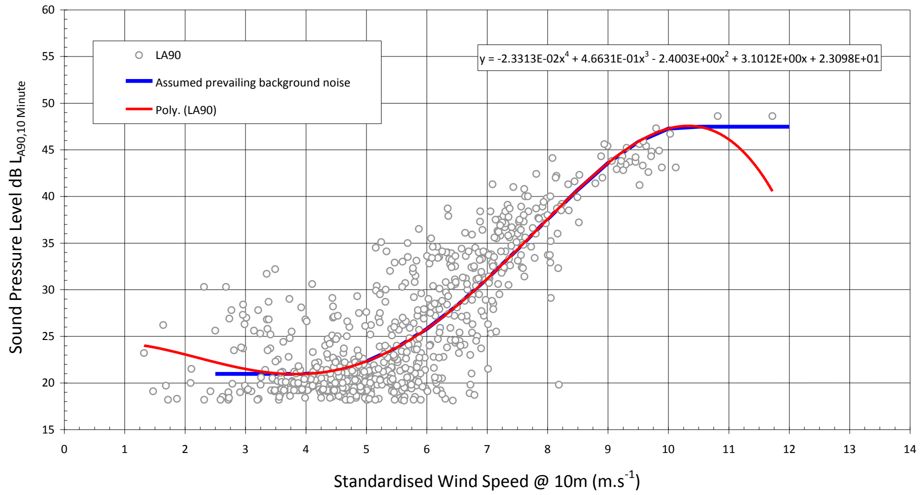

Figure 3: An example of limiting lower and upper prevailing background noise levels

The Need for Directional Analysis

3.1.22 ETSU-R-97 refers to directional analysis when considering the issue for sheltered receptors located close to a proposed site and the need for special consideration of the wind condition that affords the property maximum shelter. The assumption is that during this wind condition the potential greatest noise impact may occur because background noise levels may be lower for this condition than for the wind direction averaged prevailing background noise level.

3.1.23 A similar situation can arise with wind direction and certain distant noise sources which are a significant contributor to the background noise environment. Such noise sources might include: large industrial sources (e.g. oil refinery), motorways, large conurbations and the sea. The propagation of noise is subject to the effects of the wind. The noise environment at a receptor location upwind of a noise source is generally quieter than the receptor noise environment downwind of the noise source. Therefore, the background noise environment can change due to wind direction in the presence of a distant noise source. In these circumstances, a change in wind direction between upwind and downwind of the dominant noise source could result in a 5 – 15 dB L_{A90} difference in levels.

3.1.24 Therefore, there may be circumstances where consideration of wind direction when assessing the prevailing background noise level needs to be taken into account. This effect is illustrated in Figure 4. In the first scenario, the receiver is downwind of both the turbine and the nearby road, and no filtering is required. However, in the second scenario, the situation in which the receiver is upwind of the road could require filtering particularly when this corresponds to a prevailing wind direction, as the receiver would be systematically downwind of the turbines in the same wind conditions.

SB19: Directional analysis of prevailing background noise levels may be necessary in specific circumstances, where a wind farm is located upwind of a receptor but a significant contributor to the background noise environment is downwind of the receptor in the same wind conditions.

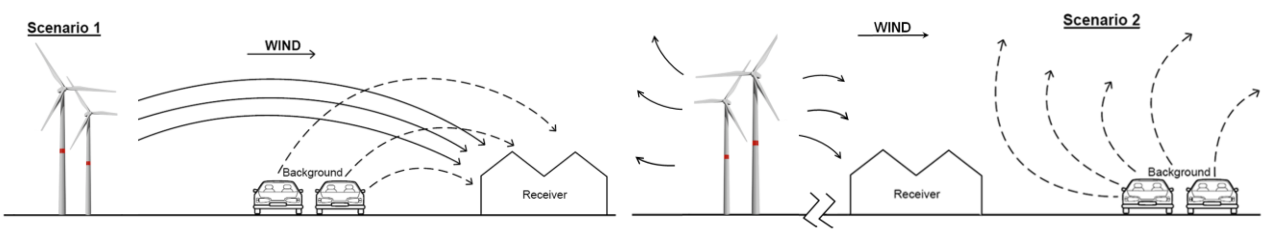

Figure 4: Illustration of upwind and downwind propagation in the presence of a key source

3.2 Determining the ETSU-R-97 Limit

ETSU-R-97 Noise Limit

3.2.1 The complete noise limit for each property is obtained from a combination of the respective fixed limit and the derived relative limit (prevailing background curve + 5 dB).

Determining the Fixed Part of the Daytime Amenity Noise Limit

3.2.2 The day amenity noise limits have been set in ETSU-R-97 on the basis of protecting the amenity of residents whilst outside their dwellings in garden areas. The daytime amenity noise limits are formed in two parts: Part 1 is a simple relationship between the prevailing background noise level (with wind speed) with an allowance of +5 dB; Part 2 is a fixed limit during periods of quiet. ETSU-R-97 describes three criteria to consider when determining the fixed part of the limit in the range of 35 dB to 40 dB L_{A90}, all of which should be considered. They are:

1) the number of noise-affected properties;
2) the potential impact on the power output of the wind farm; and
3) the likely duration and level of exposure.

3.2.3 The rationale for a choice of this limit, or factors which would assist the determining authority in this respect should be set out in the assessment. It is beneficial to the decision maker to display both sets of limits to illustrate the range available and/or the noise limit for the development if agreed previously with the LPA.

3.2.4 Current practice on the three criteria is as follows:

1. The number of neighbouring properties will depend on the nature of the area, (rural, semi-rural, urban) and is sometimes considered in relation to the size of the scheme and study area. The predicted 35 dB L_{A90} contour (at maximum noise output up to 12 m/s) can provide a guide to the dwellings to be considered in this respect.
2. This is in practice mainly based on the relative generating capacity of the development, as larger schemes have relatively more planning merit (for noise) according to the description in ETSU-R-97. In cases when the amenity fixed limit has little or no impact on the generating capacity (i.e. noise is not a significant design constraint) then a reduced limit may be applied.
3. This last test is more difficult to formulate. But ETSU-R-97 notes that the likely excess of turbine noise relative to background noise levels should be a relevant consideration. In rural areas, this will often be determined by the sheltering of the property relative to the wind farm site. Account can also be taken of the effects of wind directions (including prevailing ones at the site) and likely directional effects. For cumulative developments, in some cases the effective duration of exposure may increase because of cumulative effects.

3.2.5 It can be argued that assessing these factors do not represent an acoustic consideration but ultimately a planning consideration, and therefore are difficult for noise consultants to fully determine. However this is described as part of ETSU-R-97 and therefore represents a relevant consideration when determining applicable noise limits. Furthermore, it is necessary, as part of the EIA process to evaluate the noise impacts, which is arguably not fully possible without a complete determination of the ETSU-R-97 limits. Finally, consideration of cumulative noise impacts may require the determination of partial noise limits which may be difficult to obtain unless the amenity noise limit is precisely determined.

3.2.6 Other planning considerations, such as the identification in local planning policy of areas of preferred wind farm development, may also influence or determine the choice of the absolute fixed amenity noise limit.

Night-Time Noise Limit

3.2.7 ETSU-R-97 indicates that for the protection of sleep of occupants within buildings an external free-field level of 43 dB L_{A90} is appropriate when background noise levels are low. When background noise levels are sufficiently high, then the noise limits are set to the prevailing background + 5 dB, in the same manner as that used for the Amenity Hours.

3.2.8 It is noted that ETSU-R-97 states (page 63) that: "*Where the local authority and the developer are in agreement that the background noise levels do not vary significantly between the amenity periods and the night-time, then a single lower fixed limit of 35 – 40 dB(A) can be imposed based upon background noise levels taken during the amenity periods and the night analysed together*."

3.2.9 There is no definition of what is considered significant in this context, but where the amenity and night-time derived background noise levels differ by the order of 3 dB or less, over the key wind speed range between cut-in to when the turbines reaches their maximum level of noise emissions, it could then be appropriate to apply this clause of ETSU-R-97. An example is included in **Supplementary Guidance Note 2**.

Financially Involved Noise Limit

3.2.10 ETSU-R-97 considers it appropriate to allow a higher level of incident noise associated with turbine operation for properties with occupants that have an interest in the development, both as a higher fixed level (45 dB) and/or a higher level above the prevailing background noise level. It is considered that the occupants of a financially involved property should be direct beneficiaries to allow an increase to the fixed limit noise levels.

4 Noise Predictions

4.1 Introduction

4.1.1 ETSU-R-97 does not describe a method to predict the immission levels at the nearest residential properties resulting from the operation of the wind farm, but clearly, estimates of the likely noise impact at the nearest receptors are required in any planning situation, and this must be reliable and robust.

4.1.2 The general study of outdoor noise propagation has received extensive attention in the past, but there has also been additional research undertaken specifically on the subject of wind turbine noise propagation in recent years and since the publication of ETSU-R-97. An overall review of the subject is presented in Chapter 3 of the book "Wind Turbine Noise"[iii].

4.1.3 Several recent studies focused on the application of engineering methods to the prediction of noise from wind turbines. Wind turbines are elevated large sources, and calculations are often required at distances of 1 km or more, which may fall outside of the stated scope of well-recognised standards such as ISO 9613-2. The range of meteorological conditions which need to be considered are also more varied and significant than for many other applications. Therefore several relatively recent studies have involved detailed measurements using elevated loudspeaker sources or operational wind turbines: see Bullmore et al. 2009[iv], Søndergaard / Plovsing 2009[v], Evans and Cooper 2011[vi].

4.1.4 The outcome of this research has demonstrated that the ISO 9613-2 standard in particular, which is widely used in the UK, can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagation conditions (i.e. sound speed gradients due to downwind conditions or temperature inversions), but only provided that the appropriate choice of input parameters and correction factors are made. In particular, the use of "soft-ground" factor should be avoided, and the full theoretical effects of terrain screening will usually not be achieved.

4.1.5 It should be recognised that the choices which are made in the calculation parameters adopted for the prediction calculation can have a significant bearing on the outcome results, and can lead to unrealistic estimates. In addition, as not all wind turbine sound power level data is defined in the same manner, care needs to be exercised before any calculations can be performed. The choices which are made in the calculation parameters adopted for the prediction calculation should be clearly outlined and detailed in any noise assessment so that they can be reviewed by any assessor.

4.1.6 Whilst some developments may already have a preferred turbine selection, most sites will not at this stage of the project, and it is therefore standard practice to consider a "candidate turbine" at the planning stage, which is representative of the range of turbines which may be installed at the site, to provide an appropriate estimate. The suitability of the final turbine model (post-consent) can be secured through the imposition of adequate planning conditions.

4.2 Turbine Source Noise Data

4.2.1 The testing of turbine source levels, in terms of overall dB(A) sound power, is defined in the international IEC 61400-11 standard.

4.2.2 Different types of emission data can be found in practice, subject to availability and confidentiality restrictions:

- **Tested sound power data in accordance with IEC 61400-11.** Test reports should normally state the measurement uncertainty[2] σ, these being typically around 1 dB(A) although sometimes up to 2 dB(A). Test data may not however present results over the entire operating range of the turbine,

[2] Determined in accordance with Annex D of the IEC 61400-11 standard. This annex notes that σ = 0.9 dB would be typical.

which may require some assumptions to be made. Some of the test data may also be derived from tests on superseded prototype units which have features such as tonality which would not be present in other units. In some cases, only test summaries are provided with no indication of test uncertainties.

- **Declared sound power values** are derived in accordance with the TS IEC 61400-14 technical specification. This procedure is based on considering the average of several individual IEC 61400-11 test results, with the addition of an expanded uncertainty factor. In practice, this is rarely directly available from manufacturers, but can be derived from several test reports (if available) using the method specified in TS IEC 61400-14.
- **Manufacturer warranted values** represent values which the manufacturer will guarantee not to be exceeded (sometimes subject to conditions). They are therefore often higher than “raw” tested values, and incorporate uncertainty margins comparable to typical measurement uncertainty; however this is not always the case and warranty conditions can sometimes indicate that uncertainties need to be added in the test procedure itself. This may vary from one document to the next for the same turbine. Warranted data should therefore be used with caution, but data is often more generally provided over a wider range of wind speeds than individual test reports. The presence or absence of a margin of uncertainty in the data can be established by comparing the warranty with available test reports (see below).
- **Manufacturer specification values** may also incorporate a margin of uncertainty in some cases, or in others be closer to average tested values, and the same note of caution applies.

4.2.3 A third edition of IEC 61400-11 has been approved to replace the current version of the standard. This will introduce several changes including in particular the use of hub height wind speed as a main reference, with the application of the standardisation at 10 m height obtained as a second step (possibly optional). It also includes an additional section which is applicable to smaller wind turbines, with an adapted test methodology.

4.2.4 RenewableUK (formerly BWEA) previously issued guidance in 2008 which described a sound power test procedure adapted to the characteristics of small turbines[3], and which includes an allowance for measurement uncertainty. This is likely to be superseded by the specific procedure set out in the third edition of IEC 61400-11. It must equally be recognised that for many small turbine models, no such data may be available. Noise emission data measured in accordance with older or less rigorous methods should be interpreted with care.

4.2.5 The source sound power levels determined according to IEC 61400-11 are provided in terms of L_{Aeq}. To obtain the L_{A90} parameter required by ETSU-R-97, it is necessary to apply a correction to the prediction results. Based on the experience of the IOA-NWG and recent research[vii], the assumption described in ETSU-R-97 in this regard continues to remain valid. A correction of -2 dB is commonly applied.

4.2.6 IEC 61400-11 test reports provide spectral data which should be used as input to the predictions unless unavailable. As such spectra are usually only given for a limited number of wind speeds, the spectrum provided for a single, reference wind speed, can be scaled in relation to the overall A-weighted sound power at other wind speeds. If a range is available, the data should be chosen for the wind speed corresponding to the highest level of noise emissions; typically 8 m/s is used. Where available, specific tested spectra for each wind speed can be used.

Tonality

4.2.7 It is highly unlikely that any specific information on tonality at representative receptor separation distances in accordance with the ETSU-R-97 methodology will be available at the planning application stage. When such information is available, it should be appropriately applied. It is standard to control the potential presence of tones in practice through the use of suitable planning conditions.

4.3 Noise Propagation Model and Input Parameters

4.3.1 Noise propagation prediction is the process of calculating the noise (immission) levels at the nearest receptors, which takes into account the sound power of the turbines, the distances between the turbines and the receptors, and the various propagation factors that influence the spread of sound, such as ground effects and air absorption.

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[3] Small turbines are defined as having a rotor swept area of 200 m^2 or less. In a horizontal-axis wind turbine this equates to a rotor diameter of approximately 16 m.

4.3.2 The following applies to predictions for the assessment of on-shore wind turbine noise. They are relevant to the application of the (widely-used) ISO 9613-2 standard. The guidance provided below does not cover long-distance propagation over sea such as will be relevant to off-shore wind farms (which are considered in **Supplementary Guidance Note 6**).

4.3.3 Equation (9) of the ISO 9613-2 standard should be used to calculate ground effects for different octave bands, based on the turbine emission spectra. In the absence of representative spectral data, instead of applying equation (10) of the standard, a conservative calculation should be made using Agr = -3 dB (effectively hard ground), and the air absorption rate corresponding to the 250 Hz octave band.

4.3.4 A soft ground factor (G=1.0) should not be used. Although a ground factor[4] of G=0.0 is commonly used, as it will tend to provide robust predictions in most situations, this can over predict noise levels. For consistency it is recommended to use a ground factor of G=0.5.

4.3.5 If the majority of the propagation between source and receiver occurs over paved ground (such as may occur in urban environments) or over large bodies of water such as wide rivers or lakes, the use of G=0.0 is advised.

4.3.6 When using G=0.5, sound power levels (see 4.2 above) should incorporate an allowance for measurement uncertainty. The following sets out data types which can be used, with guidance for accounting for uncertainties in turbine emission data. Examples are shown in **Supplementary Guidance Note 3**.

- **Declared sound power** (in accordance with TS IEC 61400-14, on the basis of two or more tests): this can be used directly.
- **Warranted or specified manufacturer data** can be used provided that a margin to account for uncertainty has been included. This is more likely the case for warranted data than for specifications. If not, a correction factor to allow for uncertainty needs to be added to the values provided, and this should clearly be explained in the assessment. The presence of such an uncertainty margin can be established through comparison with at least one measurement report.
    - When comparing warranted/specified data with results of a representative test report, obtained in accordance with the IEC 61400-11 standard, with a reported test uncertainty σ, a margin of 1.645 σ (between 1 and 2 dB(A)) between the tested and stated values over the majority of wind speeds represents a clear indication that suitable uncertainties have been incorporated.
    - If the document prescribes a value of uncertainty or a correction factor applicable to the data then this can be added to the values stated, unless the above test is already satisfied;
    - If no data on uncertainty or test reports are available for the turbine then a factor of +2 dB should be added.
- **Tested sound power**: in the absence of the above, the results of a test made in accordance with the IEC 61400-11 standard, including a reported test uncertainty σ, can be referenced. The reported sound power with the addition of a margin equal to 1.645 σ can be used[5]. In the absence of test uncertainty being stated in the report, then 2 dB should be added[6].

4.3.7 Although such source information is subject to change, as noted above, predictions are indicative and usually based on a candidate model. The source of the data used should be clearly set out with a statement on how robust it is considered to be. Any reduced mode operation for the turbines (if used) should be clearly explained.

4.3.8 The adoption of a receiver height of 4.0 m is recommended (regardless of time of day), as it has the effect of reducing the potential over-sensitivity of the calculation to the receiver region ground factor compared to lower receiver heights. Atmospheric conditions of 10^{o}C and 70% humidity are recommended to represent a reasonably low level of air absorption. Calculations should be made at points representative of the relevant outdoor amenity area (as defined in ETSU-R-97) at locations nearest to the proposed wind farm development;

[4] Used as input to the formulae of Table 3 of ISO 9613-2.

[5] The factor of 1.645 applied to the uncertainty σ reflects a wider confidence interval, which is used in TS IEC 61400-14 albeit in a different context.

[6] For a typical value of σ = 0.9 dB then 1.645 σ = 1.5 dB, therefore 2 dB will represent a reasonable assumption in the absence of specific data.

4.3.9 A further correction of +3 dB (or +1.5 dB if using G=0.0) should be added to the calculated overall A-weighted noise level for propagation "across a valley", i.e. a concave ground profile, or where the ground falls away significantly, between the turbine and the receiver location. The following criterion[viii] of application is recommended:

$$h_m \geq 1.5 \times (abs(h_s - h_r)/2)$$

where h_m is the mean height above the ground of the direct line of sight from the receiver to the source (as defined in ISO 9613-2, Figure 3), and h_s and h_r are the heights above local ground level of the source and receiver respectively. This may be calculated using standard topographic data with a resolution of 50 m or less. Care needs to be exercised when evaluating this condition, as small changes in distance and height may trigger (or not) the criterion when the actual situation has not changed significantly. Examination of ground profiles between sources and receivers can assist in determining its application.

4.3.10 This increase can be explained by the reduced ground effect and the potential for additional reflection paths that may exist (as illustrated in Figure 5), and is supported by recent studies[vi].

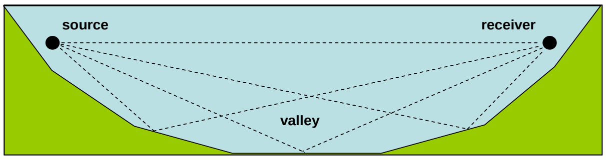


Figure 5: Schematic diagram of multiple reflection paths for sound propagation across concave ground

4.3.11 Topographic screening effects of the terrain (ISO 9613-2, Equation 12) should be limited to a reduction of no more than 2 dB, and then only if there is no direct line of sight between the highest point on the turbine rotor and the receiver location. If significant screening from a landform barrier is present in close proximity to the receiver, higher barrier attenuation values of up to -10 dB(A) may be appropriate, but any such cases are uncommon and should be fully justified in the assessment.

SB20:

Whilst it is acknowledged that some of the source documents for sound power levels may be confidential, numerical values of the source data should be clearly set out in any assessment and it is good practice to reference the data sources used.

L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB.

Predictions should be based on octave band frequency data whenever available.

Current good practice is that tonal issues for wind farms are generally best dealt with through a suitable planning condition.

When applying the ISO 9613-2 standard:

- Equation 9 of the standard should be used to calculate ground effects; if no representative spectral data can be obtained, Agr = -3 dB should be used and the air absorption rate corresponding to the 250 Hz octave band;
- A ground factor of G=1 should not be used;
- With the exception of propagation over large bodies of water or in urban areas, it is recommended to use a ground factor of G=0.5, in combination with emission levels which include a margin of uncertainty;
- The input data used should be clearly set out with reference to its source, and a statement on how robust it is considered to be;
- Any assumed reduced mode operation for the turbines should be clearly set out;
- A receiver height of 4.0 m, and atmospheric conditions of 10°C and 70% humidity should be used.

Topographic screening effects of the terrain (ISO 9613-2, Equation 12) should be limited to a reduction of no more than 2 dB, and then only if there is no direct line of sight between the highest point on the turbine rotor and the receiver location.

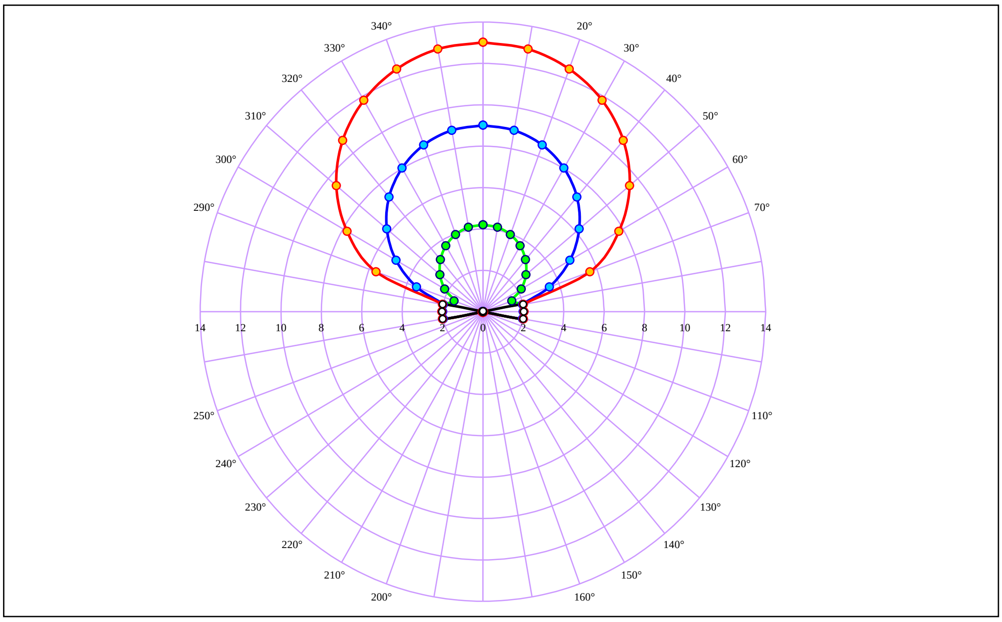
A further correction of +3 dB should be added to the calculated overall A-weighted noise level for propagation across a concave ground profile.

4.4 Propagation Directivity

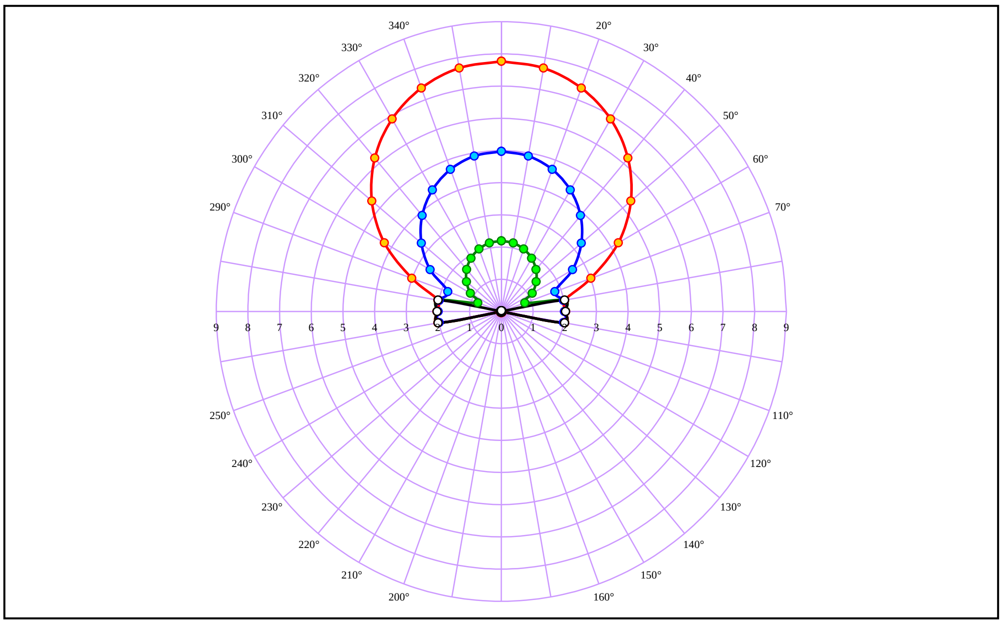
4.4.1 Predictions made using the ISO 9613-2 standard relate to "worst-case" conditions (typically downwind propagation from source to receiver and/or downward refraction under temperature inversions). When considering cumulative noise impacts, the effects of propagation in different wind directions can be considered. Any such direction attenuation factors, if used, should be clearly stated in any assessment.

4.4.2 Based on evidence from the Joule project[viii] in conjunction with advice in BS 8233 and ISO 9613-2, current practice suggests that for a range of headings from directly downwind (0°) up to 10 degrees from crosswind (80°), there may be little to no reduction in noise levels; once in crosswind directions (90°) then the reduction may be around 2 dB(A); and when at sufficient distance upwind the reduction would be at least 10 dB(A). For intermediate directions between crosswind to upwind, a simple linear or polynomial interpolation can be used. Such reductions (due to "shadow zone" refraction effects) will in practice only progressively come into play at distances of between 5 and 10 turbine tip heights.

4.4.3 Reference can also be made to the work undertaken for NASA described by Shepherd and Hubbard[ix] and in the Wyle Report[x]. Examples of the resulting propagation directivities are shown in Figure 6a for flat landscapes, and in Figure 6b for complex landscapes.



a)



b)

Figure 6: Example of assumed relationship of the change of noise levels with wind direction, 180° is where the receptor is downwind of the turbine and 0° where the receptor is upwind of the turbine. a) Flat Landscapes b) Complex Landscapes. Black = <5.25 Tip Height; Green = 7.5 Tip Height; Blue = 11 Tip Height; Red = 18 Tip Height

4.5 Wind Shear Corrections

4.5.1 Basing the predictions on sound power data tested in accordance with the IEC 61400-11 standard (or equivalent) should mean that the wind reference used corresponds to hub height wind speeds, standardised to 10 m height using a fixed correction (see **Annex A**). These predictions can then be compared to background levels and/or associated noise limits derived using an equivalent wind speed reference, which will have wind shear taken into account directly.

4.5.2 When this is not the case, for example when considering background data measured against direct wind speed measurements at 10 m height, it is necessary to apply corrections to account for this. Any such corrections should be clearly outlined and detailed in any noise assessment so that they can be reviewed by any assessor. The assessment should be made using the most detailed information available.

4.5.3 Examples of methods which can be used to correct predictions to account for wind shear effects, when only using a 10 m mast, are included in **Supplementary Guidance Note 4** (wind shear). This note presents methods to calculate corrections on the basis of long-term data measured at different heights, but as such data may not be available for a specific site, typical shear values are also presented. Alternatively, similarly derived corrections representing typical (average) shear values can be applied to the wind speed reference used for the derived typical background noise levels.

4.5.4 The following simplified method is proposed for ease of use: applying a fixed correction by subtracting the following factors from the wind speed reference used in the turbine predictions: 1 m/s for turbine hub heights of up to 30 m, 2 m/s for hub heights of up to 60 m and 3 m/s for hub heights of more than 60 m. Such a generic approach would be suitable in the context of a study made using a 10 m mast to limit costs, in the absence of site-specific data.

4.5.5 If it can be demonstrated that the predicted levels are below the applicable lower fixed limits regardless of wind speed, it can be seen that wind shear would not have an effect on the assessment and this may form the basis of a suitable planning condition.

5 Cumulative Issues

5.1 Cumulative Noise Assessment Principles

5.1.1 ETSU-R-97 states at page 58, *"…absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area which contribute to the noise received at the properties in question…"*

5.1.2 The HMP Report[i] states that "*If an existing wind farm has permission to generate noise levels up to ETSU-R-97 limits, planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts to breach ETSU-R-97 limits (except in such cases where a higher fixed limit could be justified)"*. Such an approach could prevent any further wind farm development in the locality, and a more detailed analysis can be undertaken on a case by case basis.

5.1.3 As with the assessment of noise for all wind farm developments, sequential steps need to be taken, but such steps require more detailed attention due to the added complexity of cumulative noise impacts. The advice of the EHO could be invaluable to this part of the assessment.

Cumulative impact assessment necessary

5.1.4 During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. If the proposed wind farm produces noise levels within 10 dB of any existing wind farm/s at the same receptor location, then a cumulative noise impact assessment is necessary.

5.1.5 Equally, in such cases where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary.

5.2 Acquisition of Background Noise and Concurrent Wind Speed Measurements

5.2.1 In the case of wind farms that may have cumulative effects, further aspects need to be considered in establishing appropriate background noise levels.

5.2.2 Where a new wind farm is proposed and a receptor is also within the area acoustically affected by an already operational wind farm, then noise from the existing wind farm must not be allowed to influence the background noise measurements for the proposed development.

5.2.3 In the presence of an existing wind farm, suitable background noise levels can be derived by one of the following methods:

- switching off the existing wind farm during the background noise level survey (with associated significant cost implications);
- accounting for the contribution of the existing wind farm in the measurement data e.g. directional filtering (only including background data when it is not influenced by the existing turbines e.g. upwind of the receptor, but mindful of other extraneous noise sources e.g. motorways) or subtracting a prediction of noise from the existing wind farm from the measured noise levels;
- utilising an agreed proxy location removed from the area acoustically affected by the existing wind farm/s; or
- utilising background noise level data as presented within the Environmental Statement/s for the original wind farm/s (the suitability of the background noise level data should be established).

5.2.4 If the developer wishes to utilise previously presented background noise level data, care should also be taken with respect to any differences in wind speed conditions between the original and proposed site. The underlying principle of ETSU-R-97 requires that the background noise levels at any given location must be correlated with the wind speeds measured on the wind farm site of interest. Where a systematic difference exists between the wind conditions on the two sites, then a correction will need to be applied, meaning that the derived background noise curves for the two sites will be different.

5.3 Derivation of the Appropriate Amenity Lower Fixed Limits

5.3.1 A decision on the amenity lower fixed limit for the proposed wind farm cumulatively with any other wind farms in the locality should be agreed. Cumulatively, the power generation will have increased due to proposed additional wind turbines, as well as potential noise impact. It is suggested that the various wind farms be considered as a single entity in the setting of the amenity lower fixed limit for the cumulative noise impact. The amenity lower fixed limit for the existing individual wind farms would remain as granted.

5.3.2 The consideration of the various wind farms as a single entity may result in the cumulative amenity lower fixed limit relating to the proposed wind farm in combination with the existing wind farms, differing from the existing individual wind farm's amenity lower fixed limit. However, the proposed wind farm's individual amenity lower fixed limit (which most likely will form the basis of the noise conditions) should still be determined on an individual basis.

5.4 Derivation of the Relative Noise Limits

5.4.1 In setting appropriate noise limits, the most frequent scenarios are discussed.

Concurrent applications

5.4.2 Concurrent applications with no pre-existing wind farms permit the apportionment of the ETSU-R-97 limits on an energy basis to each wind farm from the outset. LPAs may wish to bring together concurrent wind farm applicants, such that apportionment can be discussed and agreed in conjunction with the applicants. Noise limits for all the wind farms operating cumulatively are derived at all noise sensitive receptors, just as they would be if one wind farm were being considered. Having derived noise limits for the cumulative effects of all the contributing wind farms, the wind farm developers can then work together to 'apportion' the noise limits for each wind farm operating in isolation such that the cumulative effects of all wind farms operating together cannot cause the cumulative noise limits derived in accordance with ETSU-R-97 to be exceeded. Thus the noise limits which meet with the requirements of ETSU-R-97 could only be exceeded if one or more of the wind farms were to operate above its own apportioned noise limits. This is illustrated in Figure 7.

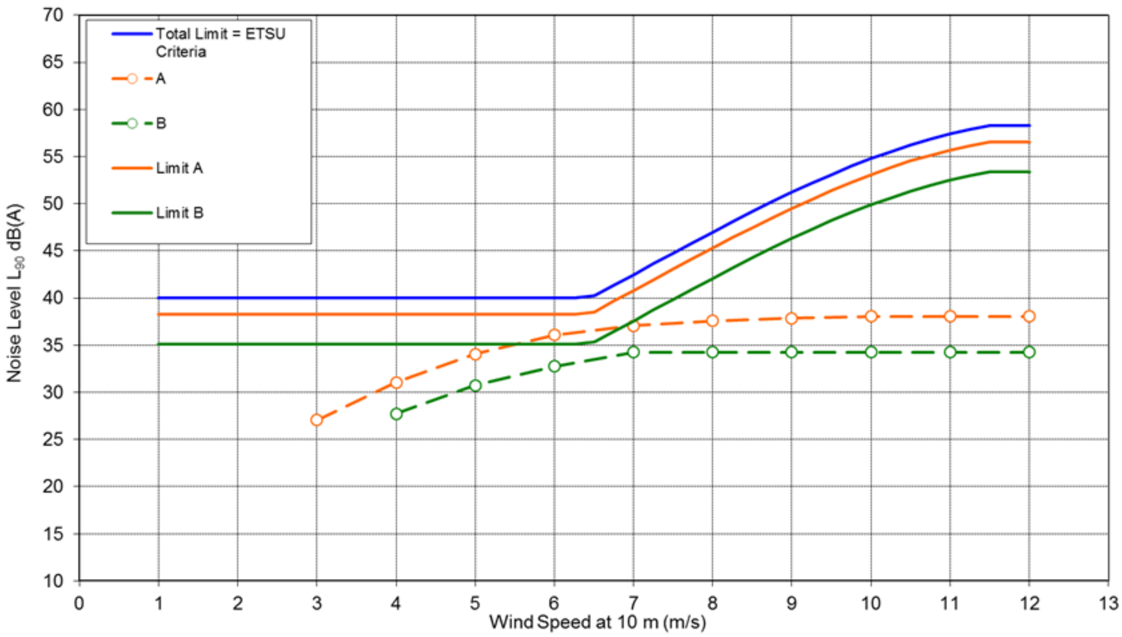


Figure 7: Apportionment of ETSU-R-97 limits between two wind farms

5.4.3 Examples of the apportionment of concurrent applications in practice are included within Appeal ref: GDBC/001/00245C Middlemoor, North Charlton, Alnwick, Northumberland and Appeal ref: APP/J0540/A/08/2083801 Land at Nutsgrove Farm, Scolding Drive, Thorney.

<u>Existing wind farm/s consented with less than total ETSU-R-97 limits</u>

5.4.4 If an existing wind farm is consented to noise limits of less than the total ETSU-R-97 limits, a future wind farm applicant can then use these limits as a base within their predictions. Whether the existing wind farm is currently operating or not is immaterial to the assessment, as it will not be able to exceed its own conditions. It is becoming more common to apply noise limits which are less than total ETSU-R-97 limits because of cumulative considerations.

5.4.5 This should be undertaken in consultation with the LPA and relevant applicant(s). An example of this in practice is the apportionment of the ETSU-R-97 noise limit between concurrent applications. It may be the case that conditioning the scheme to the exact predicted noise levels (at all wind speeds) for the candidate turbine presented within the submitted noise impact assessment may constrain the applicant in future turbine procurement options. Therefore, a constant margin above the predicted noise levels (or below the total ETSU-R-97 limits) could be chosen which provides the applicant with procurement options but in combination with the neighbouring wind farm/s can still achieve the ETSU-R-97 limits.

<u>Existing wind farm/s, consented to the total ETSU-R-97 limits, currently operating</u>

5.4.6 In the first instance, the consented noise limits should be used within the cumulative noise impact calculations unless otherwise agreed with the local authority. Provided the sum of the noise limits derived for the proposed site when added to those already consented for the operational sites does not exceed the limits that would otherwise be within the requirements of ETSU-R-97 for the cumulative impact, then the noise limits derived for the proposed site can be applied directly. However, if the sum of the noise limits for all the sites exceeds those within the requirements of ETSU-R-97, then further consideration and a more detailed review of the existing noise impact will be necessary. It may be the case that the existing wind farm is not utilising the total ETSU-R-97 limits, and hence headroom might be present. Undertaking measurements of the actual noise levels emanating from the existing wind farm would provide direct evidence of any potential headroom; however this would require both consent and information from the existing wind farm operator, as well as direct access to specific residential locations, which is rarely available.

5.4.7 If consent is not forthcoming from the existing wind farm operator to measure the noise impact from the existing wind farm, then the second wind farm developer is left with no option but to predict the noise impact from the existing wind farm. However, as the existing wind farm operator has the right to produce noise to their consented total ETSU-R-97 limits, even if it can be demonstrated that headroom currently exists, it may not be the case that that headroom will be present indefinitely.

5.4.8 For the development to proceed, the presented 'headroom' needs to be maintained (permitted other mitigating factors such as critical controlling properties or significant separation distance, described below, are not relevant); this could be achieved via the 'cumulative conditioning' or 'negotiation' methods described in Section 5.7. There is however limited experience of either approach being applied in practice.

"Controlling" property

5.4.9 It may be the case that for the existing wind farm to operate to the total ETSU-R-97 noise limits at a key cumulative receptor it would have to breach the noise limit at another receptor (i.e. a receptor closer to the existing wind farm than the key cumulative receptor). Consideration could then be given to the available 'headroom' at the key cumulative receptor such a scenario permits.

5.4.10 This is illustrated in Figure 8. In this example, wind farm A is conditioned to the same noise limit at properties R2 and R3; however, it could not produce noise levels equal to the limit at property R2 without breaching this limit at property R3 which is closer. Therefore lower immission levels can be assumed at R2 than at R3, and there may be sufficient headroom for wind farm B to use.

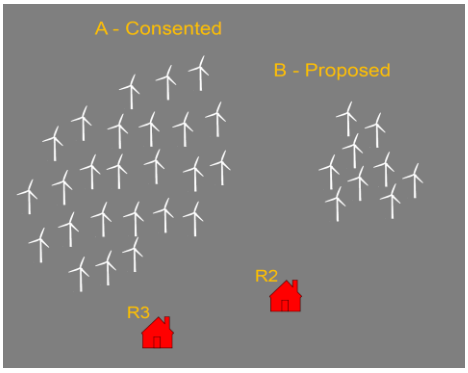


Figure 8: Controlling Property example

Significant presented headroom

5.4.11 In cases where there is significant headroom (e.g. 5 to 10 dB) between the predicted noise levels from the existing wind farm and the total ETSU-R-97 limits, where there would be no realistic prospect of the existing wind farm producing noise levels up to the total ETSU-R-97 limits, agreement could be sought with the LPA as to a suitable predicted noise level (including an appropriate margin to cover factors such as potential increases in noise) from the existing wind farm to be used to inform the available headroom for the cumulative assessment without the need for negotiation or cumulative conditioning. This may be the case particularly at low wind speeds.

<u>Permitted wind farm, consented to total ETSU-R-97 limits, but not yet constructed</u>

5.4.12 This situation replicates the above, in that the second wind farm developer will have to predict the noise impact from the existing wind farm. To ensure that predictions are as accurate as possible the existing wind farm developer would have had to have chosen their wind turbine to be installed. If the existing wind farm developer had yet to choose their wind turbine, it is recommended that a worst case scenario be undertaken utilising the highest sound power level data (or a combined "envelope") for wind turbines that would fit within the dimensional confines and noise limits of the permission granted.

5.5 Comparison of Cumulative Noise Impacts with Derived Noise Limits

5.5.1 If suitable predictions are used as a basis for the assessment, it should be borne in mind that in many situations receptors will not be downwind of different wind farms simultaneously and consideration of wind directional effects can be included within cumulative noise impact predictions to present more realistic impacts.

5.5.2 Consideration should also be given to wind speed referencing within existing noise conditions when endeavouring to consider cumulative noise impact. A number of existing wind farm noise limits are governed by actual 10 m height wind speeds whilst other existing wind farms are governed by hub height wind speeds standardised to 10 m height. The amalgamation of these two separate limits is difficult and the onus is on the proposed wind farm developer to demonstrate that such reconciliation can be reasonably performed.

5.6 Wording and Validity of Planning Conditions

5.6.1 The wording of conditions will be reflective of the cumulative scenario presented. For 'concurrent applications' and 'existing wind farm consented to less than the total ETSU-R-97 limits', the conditions will be worded as per an individual wind farm, except that the noise limit will be the apportioned limit relevant to the individual scheme.

5.7 Additional Means of Resolving Cumulative Noise Issues

5.7.1 Due to the legacy of conditioning wind farm developments to the total ETSU-R-97 limits, difficulties have arisen with regards to additional wind farm developments in the locality of existing wind farms. Some of the following suggestions have been considered or applied as a means of progressing developments.

Strategic planning

5.7.2 In considering individual applications, if the local planning authority was aware of other wind farm developments within the locality, a strategic approach to conditioning could be undertaken. Apportioned limits could be calculated for each wind farm that will ensure that cumulatively, ETSU-R-97 limits are not exceeded at any particular dwelling. LPAs could adopt local policies within their Development Plans to support the use of lower than the total ETSU-R-97 limits for strategic reasons. This would ensure that headroom would be maintained under the total ETSU-R-97 limits and hence any developers wishing to construct an additional wind farm in the locality would not necessarily need to negotiate with the original wind farm developer. This would require a review of current practice and could not be back dated to those wind farms that have already gained consent to the total ETSU-R-97 noise limits.

5.7.3 An example of such strategic planning can be found for Strategic Search Area A in Wales: Denbighshire County Council and Conwy County Borough Council examined the issues associated with the cumulative impact of wind farms within their relevant Strategic Search Area (Clocaenog Forest) contained within TAN 8[7]. A framework was developed to assess individual applications in the context of their cumulative effect.

Negotiation

5.7.4 Where an existing wind farm has the total ETSU-R-97 limits applied, but in reality the actual noise output from the existing wind farm is below the total ETSU-R-97 limits, the second wind farm developer may approach the existing wind farm operator to negotiate (e.g. through financial remuneration, become a partner in the existing wind farm etc.) a review of the original noise limits. Further to agreement, the existing wind farm operator would apply to get their original planning conditions amended, such that the noise limits would be reduced. Subsequently, the second wind farm developer would then be able to take advantage of the headroom under the total ETSU-R-97 limits, in progressing their particular wind farm development. However, there is limited experience of this happening in practice to date. In the case of an extension of an existing wind farm, the process is simplified in that the developer would simply have to apply to get the condition amended as opposed to having to negotiate with a competing operator.

Cumulative Conditioning

5.7.5 There may be scenarios where the existing wind farm operator cannot negotiate with subsequent wind farm developers, even though in reality the actual noise output from the existing wind farm is below the total ETSU-R-97 limits. In this situation, it has been suggested that a planning condition could be constructed that places cumulative impacts responsibilities on any subsequent wind farm developers, i.e. if noise levels from the existing wind farm increase (but are maintained within the existing wind farm's noise conditions) then noise levels from the second wind farm will have to reduce in compensation to ensure that cumulative noise limits are not breached. Such an approach places considerable risk on the second wind farm developer and to date the IOA-NWG is not aware of it being accepted in practice.

5.7.6 The cumulative conditioning approach was proposed in respect to the Rowantree Wind Farm, which required the Rowantree developer to not only meet individual noise limits but also cumulative noise limits in combination with the existing wind farm. The decision is due at the time of publication. However, it is recognised that the Planning Inspector with respect to the Brechfa Forest West Wind Farm determined that the construction of such a condition was '*not straightforward, with potential difficulties of enforceability*' and '*is questionable whether such a requirement would meet the tests which are applicable to planning conditions'*.

SB21:

Whenever a cumulative situation is encountered, the noise limits for an individual wind farm should be determined in such a way that no cumulative excess of the total ETSU-R-97 noise limit would occur.

[7] Planning Policy Wales, Technical Advice Note 8: Planning for Renewable Energy, 2005

6 Reporting Results of the Noise Assessment

6.1 Reporting

6.1.1 Table 1 suggests key points which good practice suggests should be included in such assessments.

Consultations	Consultation with Local Planning Authority EHO input into selection of Background Noise Measurement Equipment
Background Measurements	Number of Monitoring Locations Map Showing Monitoring Locations; Description of Monitoring Locations Description of Noise Environment; Photos of Monitoring Locations Monitoring Period; Description of Noise Measurement Equipment Wind Shield; Certification / Calibration of all Equipment Used & any Calibration Drift ; Wind (speed and direction) & Rainfall Measurement Data Sources Clear Representation of Excluded Data In Time Histories or Scatter Plots; Chart Showing Distribution of Wind Speeds & Direction; Cumulative Issues in Background Measurements
Noise Predictions	Prediction Methodology; Candidate Turbine Model Turbine Source Noise Data (including noise-reduced modes if used) Turbine Source Octave Band Noise Levels Description of Noise Propagation/Attenuation Factors Atmospheric Attenuation - Assumed Temperature and Relative Humidity Ground Effects – Assumed Ground Factor Assumed Receiver Height; Barrier/Screening Attenuation Wind Direction Filtering (if considered); Noise Contours
Assessment	Wind Shear Assessment Method; Derivation of Prevailing Background Noise Type, Order and Coefficients of Regression Line Scatter Data Shown on Plots; Derivation of Noise Limits & Numerical Values Amenity Noise Limit; Justification for Amenity Noise Limit if Chosen Night-Time Noise Limit; Financially Involved Noise Limit Capping of Noise Limits at Highest Wind Speed Measured Comparison of Predicted Noise Level with Derived Noise Limits Correction from L_{Aeq} to L_{A90} ; Potential Tonal Content Properties Covered by Assessment Incorporated Mitigation (Turbines Running in Low Noise Mode) (if relevant) Cumulative Issues

Table 1: Suggested key points for inclusion in a wind turbine noise assessment report

6.1.2 This list does not preclude other methods of presenting the data, as long as the data is available. For example, larger developments subject to EIA are submitted with a short summary chapter in the EIA, accompanied by a lengthy technical report in the Appendix.

7 Other Matters

7.1 Planning Condition

7.1.1 All developers, consultants and decision making bodies will at some stage have to discuss appropriate planning conditions to be placed on the development if permission is granted. Typical conditions and agreements that existed up to 1996 were reviewed and reported in ETSU-R-97, but these have been developed, iterated and moved on with current practice.

7.1.2 This Guide cannot provide definitive guidance on this issue, not least because ultimately it will be for the legal process to verify if a planning condition is fit for purpose on a case by case basis. However, a sample planning condition is enclosed in **Annex B**.

7.2 Amplitude Modulation

7.2.1 The evidence in relation to “Excess” or “Other” Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM.

7.3 Post Completion Measurements

7.3.1 Information on post completion measurements is contained in **Supplementary Guidance Note 5**.

7.4 Supplementary Guidance Notes

7.4.1 More detailed information on topics covered within this guide can be found in the following separately published Supplementary Guidance Notes:

Number	Title	Information
1	**Data Collection**	Equipment specifications; measurement surveys: Practical considerations and set-up guidance and examples.
2	**Data Processing & Derivation of ETSU-R-97 background curves**	Data filtering, processing and regression analysis for different types of noise environments.
3	**Sound Power Level Data**	Manufacturer’s data and warranties analysis.
4	**Wind Shear**	Wind speed references and long-term data analysis.
5	**Post Completion measurements**	Examples, considerations and strategies.
6	**Offshore Wind**	Noise propagation over large bodies of water.

Table 2: Supplementary Guidance Notes

ANNEX A

Glossary of Terms & Reference

Glossary of Terms

A-weighting	a filter that represents the frequency response of the human ear
Amenity Hours	ETSU-R-97 defines the amenity hours as 18.00 to 23.00 Monday to Friday, 13.00 to 23.00 on Saturdays and 07.00 to 23.00 on Sundays
Amplitude Modulation	a sound is modulated in amplitude when its level exhibits periodic fluctuations.
Attenuation	the reduction in level of a sound between the source and a receiver due to any combination of effects including: distance, atmospheric absorption, acoustic screening, the presence of a building façade, etc.
A.G.L.	abbreviation for above ground level
Background noise	the noise level rarely fallen below in any given location over any given time period, often classed according to day time, evening or night time periods
Bin	subset or group into which data can be sorted; in the case of wind speeds, bins are often centred on integer wind speeds with a width of 1 m/s. For example the 4 m/s bin would include all data with wind speeds of 3.5 to 4.5 m/s.
Dawn Chorus	noise due to birds which can occur at sunrise
dB	abbreviation for 'decibel'
dB(A)	abbreviation for the decibel level of a sound that has been A-weighted
Decibel	the unit normally employed to measure the magnitude of sound
Directivity	the property of a sound source that causes more sound to be radiated in one direction than another
Equivalent continuous sound pressure level	the steady sound level which has the same energy as a time varying sound signal when averaged over the same time interval, T, denoted by $L_{Aeq,T}$
Environmental Health Officer	employee of the local planning authority responsible for noise and vibration matters in relation to statutory nuisance and advice on planning matters
Environmental Impact Assessment	an environmental impact assessment is an assessment of the possible positive or negative impact that a proposed project may have on the environment, submitted to support a planning application at the planning approval stage of a project
External noise level	the noise level, in decibels, measured outside a building
Filter	a device for separating components of an acoustic signal on the basis of their frequencies; *or*, the selection of data for exclusion or analysis.
Frequency	the number of acoustic pressure fluctuations per second occurring about the atmospheric mean pressure (related to the 'pitch' of a sound)
Frequency analysis	the analysis of a sound into its frequency components
Ground effects (G)	the modification of sound at a receiver location due to the interaction of the sound wave with the ground along its propagation path from source to receiver. Described using the term 'G', and ranges between 0 (hard) and 1 (soft).
Hard Ground	the ISO 9613-2 standard considers that for propagation over surfaces such as paving, water, ice, concrete, or tamped ground around industrial sites, the ground should be considered hard, as represented by the factor G = 0.0.
Hertz	the unit normally employed to measure the frequency of a sound, equal to cycles per second of acoustic pressure fluctuations about the atmospheric mean pressure
L_{Aeq}	the abbreviation of the A-weighted equivalent continuous sound pressure level
L_{A10}	a noise level exceeded for 10% of the time during a measurement period, often used for the measurement of road traffic noise
L_{A90}	a noise level exceeded for 90% of the time during a measurement period, often used for

	the measurement of background noise
Level	the general term used to describe a sound once it has been converted into decibels
Local Planning Authority	a local planning authority is the local authority or council that is empowered by law to exercise statutory town planning functions for a particular area
Masking	the effect whereby an otherwise audible sound is made inaudible by the presence of other sounds
Night Time Hours	ETSU-R-97 defines the night time hours as 23.00 to 07.00 every day.
Noise	sound that evokes a feeling of displeasure in the environment in which it is heard, and is therefore unwelcomed by the receiver
Noise emission	the noise emitted by a source of sound
Noise immission	the noise to which a receiver is exposed
Octave band frequency analysis	a frequency analysis using a filter that is an octave wide (the upper limit of the filter's frequency band is exactly twice that of its lower frequency limit)
Percentile exceeded sound level	the noise level exceeded for n% of the time over a given time period, T, denoted by $L_{An,T}$
Receiver	a person or property exposed to the noise being considered
Residual noise	the ambient noise that remains in the absence of the specific noise whose effects are being assessed
Soft (or Porous) Ground	the ISO 9613-2 standard considers that for propagation over surfaces such as ground covered by grass or trees (or other vegetation), and farming land, the ground should be considered soft or porous as represented by the factor G = 1.0.
Sound	physically: a regular and ordered oscillation of air molecules due to a source of vibration which creates fluctuating positive and negative acoustic pressure above and below atmospheric pressure. Subjectively: the sensation of hearing caused by the ear being excited by the acoustic oscillations described above
Sound level meter	an instrument for measuring sound pressure level
Sound pressure amplitude	the root mean square of the amplitude of the acoustic pressure fluctuations in a sound wave around the atmospheric mean pressure, usually measured in Pascals
Sound pressure level	a measure of the sound pressure at a point, in decibels
Sound power level	the total sound power radiated by a source, in decibels
Spectrum	a description of the amplitude of a sound as a function of frequency
Standardised wind speed	a wind speed measured at a height different than 10 m (generally measured at the turbine hub height) which is expressed to a reference height of 10 m using a roughness length of 0.05 for standardisation purpose (in accordance with the IEC 61400-11 standard)
Third-octave band frequency analysis	a frequency analysis using frequency bands one third of an octave wide
Threshold of hearing	the lowest amplitude sound capable of evoking the sensation of hearing in the average healthy human ear (0.00002 Pa, equivalent to 0 dB)
Tone	the concentration of acoustic energy into a very narrow frequency range
Wind shear	the increase of wind speed with height above the ground

Shear exponent profile:	this uses the following equation: $U = U_{ref} \cdot \left[\frac{H}{H_{ref}}\right]^m$ Where: U calculated wind speed. U_{ref} measured wind speed H height at which the wind speed will be calculated H_{ref} height at which the wind speed is measured m shear exponent = $\log(U/U_{ref})/\log(H/H_{ref})$
Roughness length (or logarithmic) shear profile:	$U_1 = U_2 \cdot \frac{\ln\left(H_1/z\right)}{\ln\left(H_2/z\right)}$ Where: H_1 The height of the wind speed to be calculated (10 m) H_2 The height of the measured wind speed U_1 The wind speed to be calculated U_2 The measured wind speed z The roughness length A roughness length of 0.05 m is used to standardise hub height wind speeds to 10m height in the IEC 61400-11:2003 standard, regardless of what the actual roughness length seen on a site may have been. This 'normalisation' procedure was adopted for comparability between test results for different turbines.

REFERENCE

[i] Hayes McKenzie Partnership Ltd. Report on "Analysis of How Noise Impacts are considered in the Determination of Wind Farm Planning Applications" Ref HM: 2293/R1 dated 6th April 2011

[ii] "Noise Measurements in Windy Conditions", R.A. Davis & M.C. Lower, ISVR Consultancy Services. ETSU Report W/13/00386/REP (1996).

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[iv] A. Bullmore, J. Adcock, M. Jiggins, M. Cand, Wind Farm Noise Predictions and Comparison with Measurements. Proc. Wind Turbine Noise 2009 Conference, Aalborg Denmark, June 2009.

[v] B. Søndergaard, B. Plovsing, Prediction of noise from wind farms with Nord2000, Part 1 and 2, Proc. Wind Turbine Noise 2009 Conference, Aalborg Denmark, June 2009.

[vi] T. Evans and J. Cooper, Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms, Proceedings of ACOUSTICS 2011, 2-4 November 2011, Gold Coast, Australia (The Australian Acoustical Society).

[vii] T. Evans and J. Cooper, Comparison of compliance results obtained from the various wind farm standards used in Australia, Proceedings of ACOUSTICS 2011, 2-4 November 2011, Gold Coast, Australia (The Australian Acoustical Society).

[viii] JOR3-CT95-0091 'Development of a Wind farm Noise Propagation Prediction Model', Bass J H, Bullmore A J, Sloth E, Final Report for EU Contract JOR3 CT95 0051, 1998

[ix] Shepherd, K. P.; Hubbard, H. H. Wind Turbine Acoustics, NASA Technical Paper (TP) 3057, Dec 1990.

[x] Measurement and Evaluation of Environmental Noise From Wind Energy Conversion Systems in Alameda and Riverside Counties, Wyle Research Report WR 99-19,1988

ANNEX B

Example Planning Condition

N.B. the following is an example condition, with attached guidance notes, the form of which has been the basis for the control of noise for several larger-scale UK wind farm developments, for example at recent planning appeals. More concise conditions may be acceptable, particularly for smaller-scale developments, and it is recommended that legal advice is sought.

The condition below assumes noise limits were referenced to standardised 10 metres height wind speed (derived from hub height). If considering noise limits referenced to measured 10 metres height, the condition should be modified appropriately: see in particular the Tables and Guidance Note 1 (d).

Example Planning Condition

The rating level of noise immissions from the combined effects of the wind turbines (including the application of any tonal penalty) when determined in accordance with the attached Guidance Notes (to this condition), shall not exceed the values for the relevant integer wind speed set out in, or derived from, the tables attached to these conditions at any dwelling which is lawfully existing or has planning permission at the date of this permission and:

a) The wind farm operator shall continuously log power production, wind speed and wind direction, all in accordance with Guidance Note 1(d). These data shall be retained for a period of not less than 24 months. The wind farm operator shall provide this information in the format set out in Guidance Note 1(e) to the Local Planning Authority on its request, within 14 days of receipt in writing of such a request.

b) No electricity shall be exported until the wind farm operator has submitted to the Local Planning Authority for written approval a list of proposed independent consultants who may undertake compliance measurements in accordance with this condition. Amendments to the list of approved consultants shall be made only with the prior written approval of the Local Planning Authority.

c) Within 21 days from receipt of a written request from the Local Planning Authority following a complaint to it from an occupant of a dwelling alleging noise disturbance at that dwelling, the wind farm operator shall, at its expense, employ a consultant approved by the Local Planning Authority to assess the level of noise immissions from the wind farm at the complainant's property in accordance with the procedures described in the attached Guidance Notes. The written request from the Local Planning Authority shall set out at least the date, time and location that the complaint relates to and any identified atmospheric conditions, including wind direction, and include a statement as to whether, in the opinion of the Local Planning Authority, the noise giving rise to the complaint contains or is likely to contain a tonal component.

d) The assessment of the rating level of noise immissions shall be undertaken in accordance with an assessment protocol that shall previously have been submitted to and approved in writing by the Local Planning Authority. The protocol shall include the proposed measurement location identified in accordance with the Guidance Notes where measurements for compliance checking purposes shall be undertaken, whether noise giving rise to the complaint contains or is likely to contain a tonal component, and also the range of meteorological and operational conditions (which shall include the range of wind speeds, wind directions, power generation and times of day) to determine the assessment of rating level of noise immissions. The proposed range of conditions shall be those which prevailed during times when the complainant alleges there was disturbance due to noise, having regard to the written request of the Local Planning Authority under paragraph (c), and such others as the independent consultant considers likely to result in a breach of the noise limits.

e) Where a dwelling to which a complaint is related is not listed in the tables attached to these conditions, the wind farm operator shall submit to the Local Planning Authority for written approval proposed noise limits selected from those listed in the Tables to be adopted at the complainant's dwelling for compliance checking purposes. The proposed noise limits are to be those limits selected from the Tables specified for a listed location which the independent consultant considers as being likely to experience the most similar background noise environment to that experienced at the complainant's dwelling. The rating level of noise immissions resulting from the combined effects of the wind turbines when determined in accordance with the attached Guidance Notes shall not exceed the noise limits approved in writing by the Local Planning Authority for the complainant's dwelling.

f) The wind farm operator shall provide to the Local Planning Authority the independent consultant's assessment of the rating level of noise immissions undertaken in accordance with the Guidance Notes within 2 months of the date of the written request of the Local Planning Authority for compliance measurements to be made under paragraph (c), unless the time limit is extended in writing by the Local Planning Authority. The assessment shall include all data collected for the purposes of undertaking the compliance measurements, such data to be provided in the format set out in Guidance Note 1(e) of the Guidance Notes. The instrumentation used to undertake the measurements shall be calibrated in accordance with Guidance Note 1(a) and certificates of calibration shall be submitted to the Local Planning Authority with the independent consultant's assessment of the rating level of noise immissions.

g) Where a further assessment of the rating level of noise immissions from the wind farm is required pursuant to Guidance Note 4(c), the wind farm operator shall submit a copy of the further assessment within 21 days of submission of the independent consultant's assessment pursuant to paragraph (d) above unless the time limit has been extended in writing by the Local Planning Authority.

Table 1 – Between 07:00 and 23:00 – Noise limits expressed in dB $L_{A90,10\ minute}$ as a function of the standardised wind speed (m/s) at 10 metre height as determined within the site averaged over 10 minute periods.

Location	Standardised wind speed at 10 meter height (m/s) within the site averaged over 10-minute periods											
	1	2	3	4	5	6	7	8	9	10	11	12

Table 2 – Between 23:00 and 07:00 – Noise limits expressed in dB L_{A90},10-minute as a function of the standardised wind speed (m/s) at 10 metre height as determined within the site averaged over 10 minute periods.

Location	Standardised wind speed at 10 meter height (m/s) within the site averaged over 10-minute periods											
	1	2	3	4	5	6	7	8	9	10	11	12

Table 3: Coordinate locations of the properties listed in Tables 1 and 2.

Property	Easting	Northing

Note to Table 3: The geographical coordinate references are provided for the purpose of identifying the general location of dwellings to which a given set of noise limits applies.

Guidance Notes for Noise Conditions

These notes are to be read with and form part of the noise condition. They further explain the condition and specify the methods to be employed in the assessment of complaints about noise immissions from the wind farm. The rating level at each integer wind speed is the arithmetic sum of the wind farm noise level as determined from the best-fit curve described in Guidance Note 2 of these Guidance Notes and any tonal penalty applied in accordance with Guidance Note 3. Reference to ETSU-R-97 refers to the publication entitled “The Assessment and Rating of Noise from Wind Farms” (1997) published by the Energy Technology Support Unit (ETSU) for the Department of Trade and Industry (DTI).

Guidance Note 1

(a) Values of the $L_{A90,10\ minute}$ noise statistic should be measured at the complainant’s property, using a sound level meter of EN 60651/BS EN 60804 Type 1, or BS EN 61672 Class 1 quality (or the equivalent UK adopted standard in force at the time of the measurements) set to measure using the fast time weighted response as specified in BS EN 60651/BS EN 60804 or BS EN 61672-1 (or the equivalent UK adopted standard in force at the time of the measurements). This should be calibrated in accordance with the procedure specified in BS 4142: 1997 (or the equivalent UK adopted standard in force at the time of the measurements). Measurements shall be undertaken in such a manner to enable a tonal penalty to be applied in accordance with Guidance Note 3.

(b) The microphone should be mounted at 1.2 – 1.5 metres above ground level, fitted with a two-layer windshield or suitable equivalent approved in writing by the Local Planning Authority, and placed outside the complainant’s dwelling. Measurements should be made in “free field” conditions. To achieve this, the microphone should be placed at least 3.5 metres away from the building facade or any reflecting surface except the ground at the approved measurement location. In the event that the consent of the complainant for access to his or her property to undertake compliance measurements is withheld, the wind farm operator shall submit for the written approval of the Local Planning Authority details of the proposed alternative representative measurement location prior to the commencement of measurements and the measurements shall be undertaken at the approved alternative representative measurement location.

(c) The $L_{A90,10\ minute}$ measurements should be synchronised with measurements of the 10-minute arithmetic mean wind and operational data logged in accordance with Guidance Note 1(d), including the power generation data from the turbine control systems of the wind farm.

(d) To enable compliance with the conditions to be evaluated, the wind farm operator shall continuously log arithmetic mean wind speed in metres per second and wind direction in degrees from north at hub height for each turbine and arithmetic mean power generated by each turbine, all in successive 10-minute periods. Unless an alternative procedure is previously agreed in writing with the Planning Authority, this hub height wind speed, averaged across all operating wind turbines, shall be used as the basis for the analysis. All 10 minute arithmetic average mean wind speed data measured at hub height shall be ‘standardised’ to a reference height of 10 metres as described in ETSU-R-97 at page 120 using a reference roughness length of 0.05 metres . It is this standardised 10 metre height wind speed data, which is correlated with the noise measurements determined as valid in accordance with Guidance Note 2, such correlation to be undertaken in the manner described in Guidance Note 2. All 10-minute periods shall commence on the hour and in 10- minute increments thereafter.

(e) Data provided to the Local Planning Authority in accordance with the noise condition shall be provided in comma separated values in electronic format.

(f) A data logging rain gauge shall be installed in the course of the assessment of the levels of noise immissions. The gauge shall record over successive 10-minute periods synchronised with the periods of data recorded in accordance with Note 1(d).

Guidance Note 2

(a) The noise measurements shall be made so as to provide not less than 20 valid data points as defined in Guidance Note 2 (b)

(b) Valid data points are those measured in the conditions specified in the agreed written protocol under paragraph (d) of the noise condition, but excluding any periods of rainfall measured in the vicinity of the sound level meter. Rainfall shall be assessed by use of a rain gauge that shall log the occurrence of rainfall in each 10 minute period concurrent with the measurement periods set out in Guidance Note 1. In specifying such conditions the Local Planning Authority shall have regard to those conditions which prevailed during times when the complainant alleges there was disturbance due to noise or which are considered likely to result in a breach of the limits.

(c) For those data points considered valid in accordance with Guidance Note 2(b), values of the $L_{A90,10\ minute}$ noise measurements and corresponding values of the 10- minute wind speed, as derived from the standardised ten metre height wind speed averaged across all operating wind turbines using the procedure specified in Guidance Note 1(d), shall be plotted on an XY chart with noise level on the Y-axis and the standardised mean wind speed on the X-axis. A least squares, "best fit" curve of an order deemed appropriate by the independent consultant (but which may not be higher than a fourth order) should be fitted to the data points and define the wind farm noise level at each integer speed.

Guidance Note 3

(a) Where, in accordance with the approved assessment protocol under paragraph (d) of the noise condition, noise immissions at the location or locations where compliance measurements are being undertaken contain or are likely to contain a tonal component, a tonal penalty is to be calculated and applied using the following rating procedure.

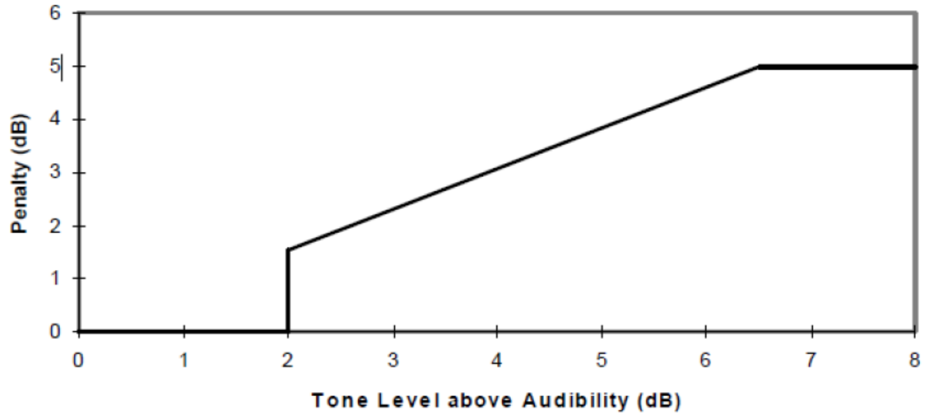
(b) For each 10 minute interval for which $L_{A90,10\ minute}$ data have been determined as valid in accordance with Guidance Note 2 a tonal assessment shall be performed on noise immissions during 2 minutes of each 10 minute period. The 2 minute periods should be spaced at 10 minute intervals provided that uninterrupted uncorrupted data are available ("the standard procedure"). Where uncorrupted data are not available, the first available uninterrupted clean 2 minute period out of the affected overall 10 minute period shall be selected. Any such deviations from the standard procedure, as described in Section 2.1 on pages 104-109 of ETSU-R-97, shall be reported.

(c) For each of the 2 minute samples the tone level above or below audibility shall be calculated by comparison with the audibility criterion given in Section 2.1 on pages 104109 of ETSU-R-97.

(d) The tone level above audibility shall be plotted against wind speed for each of the 2 minute samples. Samples for which the tones were below the audibility criterion or no tone was identified, a value of zero audibility shall be used.

(e) A least squares "best fit" linear regression line shall then be performed to establish the average tone level above audibility for each integer wind speed derived from the value of the "best fit" line at each integer wind speed. If there is no apparent trend with wind speed then a simple arithmetic mean shall be used. This process shall be repeated for each integer wind speed for which there is an assessment of overall levels in Guidance Note 2.

(f) The tonal penalty is derived from the margin above audibility of the tone according to the figure below.



Guidance Note 4

(a) If a tonal penalty is to be applied in accordance with Guidance Note 3 the rating level of the turbine noise at each wind speed is the arithmetic sum of the measured noise level as determined from the best fit curve described in Guidance Note 2 and the penalty for tonal noise as derived in accordance with Guidance Note 3 at each integer wind speed within the range specified by the Local Planning Authority in its written protocol under paragraph (d) of the noise condition.

(b) If no tonal penalty is to be applied then the rating level of the turbine noise at each wind speed is equal to the measured noise level as determined from the best fit curve described in Guidance Note 2.

(c) In the event that the rating level is above the limit(s) set out in the Tables attached to the noise conditions or the noise limits for a complainant's dwelling approved in accordance with paragraph (e) of the noise condition, the independent consultant shall undertake a further assessment of the rating level to correct for background noise so that the rating level relates to wind turbine noise immission only.

(d) The wind farm operator shall ensure that all the wind turbines in the development are turned off for such period as the independent consultant requires to undertake the further assessment. The further assessment shall be undertaken in accordance with the following steps:

(e). Repeating the steps in Guidance Note 2, with the wind farm switched off, and determining the background noise (L3) at each integer wind speed within the range requested by the Local Planning Authority in its written request under paragraph (c) and the approved protocol under paragraph (d) of the noise condition.

(f) The wind farm noise (L1) at this speed shall then be calculated as follows where L2 is the measured level with turbines running but without the addition of any tonal penalty:

$$L_1 = 10\log\left[10^{L_2/10} - 10^{L_3/10}\right]$$

(g) The rating level shall be re-calculated by adding arithmetically the tonal penalty (if any is applied in accordance with Note 3) to the derived wind farm noise L1 at that integer wind speed.

(h) If the rating level after adjustment for background noise contribution and adjustment for tonal penalty (if required in accordance with note 3 above) at any integer wind speed lies at or below the values set out in the Tables attached to the conditions or at or below the noise limits approved by the Local Planning Authority for a complainant's dwelling in accordance with paragraph (e) of the noise condition then no further action is necessary. If the rating level at any integer wind speed exceeds the values set out in the Tables attached to the conditions or the noise limits approved by the Local Planning Authority for a complainant's dwelling in accordance with paragraph (e) of the noise condition then the development fails to comply with the conditions.

Institute of
Acoustics

Exhibit 'B'

NEW YORK STATE BOARD ON ELECTRIC
GENERATION SITING AND THE ENVIRONMENT

Case No. 14-F-0490	Application of Cassadaga Wind LLC for an Amendment of its Certificate of Environmental Compatibility and Public Need to Construct a Major Electric Generating Facility in the Towns of Charlotte, Cherry Creek, Stockton, and Arkwright, New York

TESTIMONY OF:

SYLVIA BRONESKE

RWE RENEWABLES

Q: Please state your name, employer, and business address.

A: Sylvia Broneske, RWE Renewables UK, Windmill Hill Business Park, Whitehall Way, Swindon, SN5 6PB, UK.

Q: Please describe your background and professional experience.

A: I am the Principal Acoustic Engineer and Technical Lead of the Acoustics Team for RWE Renewables, the parent company of Cassadaga Wind LLC. I have been working with wind turbines for more than 20 years in Germany, the United Kingdom and worldwide. I have worked for DNV GL as student and the wind turbine manufacturer Enercon in Germany after graduation with the German equivalent of a MSc in Environmental Engineering. I have been a Senior Acoustic Consultant and Head of Turbine Testing at the renowned UK acoustic consultancy Hayes McKenzie Partnership, during which time I obtained my MSc in Sound and Vibration at the University of Southampton/UK part-time. I have been an invited speaker, speaker/presenter at various conferences, I serve on the organizing committee of the biennial international conference on Wind Turbine Noise (organized by INCE-Europe) and I have been a panelist at numerous wind turbine conferences, speaking recently at the AWEA Wind Project Siting & Environmental Compliance Virtual Summit about international standardization. I am a participating member of two IEC[1] committees, one ISO[2] committee and several

[1] International Electrotechnical Commission
[2] International Standards Organization

national standardization committees at BSI[3]. I am the Secretary of the IEC project team IEC/PT61400-11-2 who is currently drafting the Technical Specification IEC/TS 61400-11-2: *Wind Energy Generation Systems – Part 11-2: Measurement of wind turbine noise characteristics in receptor position* where I work together with internationally renowned wind turbine acoustic experts such as employees from NREL and Jacobs from the USA, Aercoustics from Canada/USA and many others from Denmark, Germany, India to name but a few. I am also a member of the UK Institute of Acoustics where I regularly participate in their meetings and consultations. My resume is attached as **Exhibit "A".**

Q: What is the purpose of your testimony?

A: I am submitting this testimony in support of Cassadaga Wind's Petition to amend its Article 10 Certificate of Environmental Compatibility and Public Need ("Certificate") to eliminate the long-term sound limit (Condition 80(b)) and adopt Cassadaga Wind's Sound Monitoring and Compliance Protocol which is attached to the Testimony of Kenneth Kaliski ("Final Protocol").

Q: What does Condition 80(b) require?

A: Certificate Condition 80(b) requires that the Facility "[c]omply with a limit of 40 dBA L(night-outside), annual equivalent continuous average nighttime sound level from the Facility outside any existing permanent or seasonal non-participating

[3] British Standards Institution

residence, and a limit of 50 dBA L(night-outside), annual equivalent continuous average nighttime sound level from the Facility outside any existing participating residence."

Q: Are you aware of any other wind projects with a condition like 80(b)?

A: I have been involved in modeling and monitoring sound from wind projects all over the world for more than 16 years. I am working with international wind turbine acoustic experts in IEC and ISO standardization, and I regularly attend and present at the only international conference "Wind Turbine Noise" (https://www.windturbinenoise.eu) organized by INCE-Europe and attended by renowned international experts in the field. I am the Technical Lead of the Acoustics Team at RWE Renewables and we participate regularly in research internally and externally with respect to wind turbine acoustic.

To the best of my knowledge, Cassadaga Wind is the only wind farm in the world with an annual regulatory limit requiring long-term monitoring at the receptor position to demonstrate compliance.

Q: Is there any standard for measuring wind turbine sound for an annual average?

No (international or national) standard nor guidance exists for measuring annual average wind turbine sound immissions as required by Cassadaga's Certificate. Accurately monitoring sound immissions from a wind farm over the course of a year will be extremely difficult, time consuming and costly, even under the long-term protocol developed by RSG (April 17, 2018 Protocol).

Q: Has RWE estimated how much a long-term protocol will cost?

A: With regards to costs, we estimate that the long-term protocol will cost between $150,000 and $312,000 to implement, depending on the total number of shut downs required and whether the protocol requires attended monitoring, which DPS Staff has requested. Attended monitoring will require multiple field staff to be present at the same time. In addition to the monitoring cost, we will also incur extended loss of electricity production. It makes little sense to lose out on clean electricity production to accommodate an unprecedented and uncertain monitoring campaign with questionable outcome with regards to the protection of residents and human response to wind farm noise (which is not an annual average response but a shorter-term response). This cannot be in anyone's interest.

By way of comparison the short-term protocol proposed by RSG in their affidavit requires 28 hours of shutdowns and costs $89,000 for monitoring only. Notwithstanding the cost, the uncertainty of the measurement and inaccuracy of the results are a much bigger issue.

Q: Is long-term sound monitoring for annual noise limits suitable for wind farm sound?

A: Requiring long-term sound monitoring for annual noise limits is not industry best practice and is not advocated by experts in the wind turbine acoustics field. I have spoken with my colleagues and fellow experts at the IEC wind turbine acoustic expert group, and we all agree that annual noise limits and long-term monitoring at the receptor position to show compliance with an annual noise limit are not suitable for wind farm sound. It should be noted that the **international expert group** at IEC/PT61400-11-2 has decided **not** to include a reference to the annual average metric L_{den}[4] or L_{night} or annual measurements for compliance in the draft IEC Technical Specification IEC/TS 61400-11-2[5]. The IEC Technical Specification will recommend short-term L_{Aeq} or L_{A90} measurements (1 minute or 10 minute average) as the appropriate measure to assess the impact of wind farm sound at receptor position. (This statement relates to the current draft of the TS and the relevant discussions as of November 10th, 2020)

Q: Are you aware of any other wind projects with a condition like 80(b)?

A: No. To my knowledge, Norway and The Netherlands are the only countries worldwide, that we currently operate in, that have annual noise limits also adopted for wind turbines but neither of these countries require receptor monitoring to demonstrate compliance.

a. In The Netherlands, annual noise limits do apply to the source 'wind turbine' (and other sources of noise) and are defined in *Staatscourant Nr*

[4] "den" stands for day/evening/night to describe a different time weighting of measured/predicted noise levels depending on time of day

[5] Expected to be submitted to IEC national member committees in 2021 for consultation and publication in 2022 the latest.

19592 23 December 2010. It states, translated from Dutch, in Section 2.6 of Appendix 4: “Enforcement by means of immission measurements is not really possible due to the influence of [other] noise and problems with regard to representativeness. That is why enforcement measurements are focused on **monitoring the sound power [level]**.”

Sound power level measurements in accordance to IEC 61400-11 are carried out in the vicinity of an individual wind turbine, approximately at a distance of hub height plus half a rotor diameter in downwind direction on a hard board on the ground. These are short-term measurements with a measurement period of 10 sec which is appropriate at the wind turbine to capture the fluctuation of sound emissions directly at the source. The determination of the sound power level of the source is then used to show compliance with the noise limits by modeling the sound level at the receptor with the measured data as input and long-term predictions of the meteorological conditions in the same way as when showing compliance with noise limits for the permit application.

b. In Norway *Veileder til retningslinje T-1442 Behandling av støy i arealplanleggingen* (last revision 2020) defines noise limits and guidance for wind turbine noise. It states in section 9.8.5, translated from Norwegian, that “Long-term immission measurements are demanding, expensive to carry out and there is **great uncertainty** associated with the result due to

> background noise, among other things. This type of measurement is therefore **not recommended** to check whether the license conditions are met. Immission measurements can, however, be used to document "instantaneous values", i.e. average values over a relatively short period of time."

> Immission measurements are the measurements of sound pressure levels at the receptor location.

Q: Why should Condition 80(b) be eliminated from Cassadaga's Certificate?

A: As part of the evidence submitted for the Baron Winds (Case 15-F-0122, information request DOH-1), the response submitted by Dr. Krispian Lowe and Charles Readling (January 15, 2019), listed the reasons against an annual average noise limit. The subsequent Baron Winds Article 10 certificate omitted any reference to long-term annual average noise limits and any corresponding monitoring requirements.

Even, the WHO[6] has stated that the annual metrics L_{den} and L_{night} are poor acoustic measures for wind turbines as follows: "Based on all these factors, it may be concluded that the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a **poor characterization** of wind turbine noise and may limit the ability to observe associations between wind turbine noise and health outcomes."

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[6] World Health Organization

The factors supporting this conclusion are set forth in detail in Section 3.4.2.3 of the WHO 2018 Guidelines (pp. 84-86).

Moreover, no guidance has been given by the WHO on the use of wind data to obtain a L_{den} and L_{night} from wind farms, which is a noise source where magnitude is highly dependent on wind speed and for the receptor also wind direction. This is variability of source strength which is not predictable like a train or airplane timetable, has not been considered and is unlike other noise sources included in the WHO document. Most importantly **no guidance** has been given on the enforcement and measurement of such a limit.

In conclusion, as articulated in the WHO 2018 Guidelines, "…the acoustical description of wind turbine noise by means of L_{den} or L_{night} may be a poor characterization of wind turbine noise…" As a result, providing an assessment with L_{night} for Cassadaga Wind Farm would not add any value to the already submitted noise studies. There is no guidance nor requirement of long-term immission measurements in any of the few countries known to us, that has implemented long-term L_{den} noise limits. On the contrary, their legislation **unanimously** points out, that the **measurement is not representative** nor repeatable, costly and afflicted with a great uncertainty. There is no value in carrying out such long-term measurements if the result has an unknown uncertainty and cannot be considered to be repeatable and representative of the sound source nor of human response to wind farm sound.

Q: Does this conclude your testimony?

A: Yes.

Attachment ‘A’

CURRICULUM VITAE

Name:	Sylvia BRONESKE	Date of Birth: 27/04/76
Education:	1995-1999	University of Stuttgart, Germany Environmental Engineering, Intermediate Examination
	1999-2004	University of Applied Sciences Hamburg, Germany Diplom-Ingenieur (Environmental Engineering)
	2009-2015	University of Southampton, Institute of Sound and Vibration Research (ISVR), UK MSc Sound and Vibration, part-time
Employment:	2002-2004	Windtest Kaiser-Wilhelm-Koog GmbH, Germany (subsequently part of GL Garrad Hassan, which is now DNV GL) STUDENT CONSULTANT/ENGINEER *Noise measurements and noise impact assessment for wind farm developments in Germany. Wind turbine source noise measurements.*
	2004-2007	Enercon GmbH, Germany ENGINEER/CONSULTANT *Noise and shadow impact assessment for wind farm developments. Supervising noise measurements of Enercon wind turbines. Advising co-workers, authorities, clients/developers and wind farm neighbours in wind turbine noise-related issues. Solving complaints about wind farm noise and optimisation of noise critical wind farm sites. Calculating periods of shadow flicker and programming ENERCON shadow shutdown system to prevent shadow flicker at surrounding properties.*
	2007-2016	Hayes McKenzie Partnership Ltd, Salisbury/UK SENIOR CONSULTANT and HEAD OF TURBINE TESTING *Project management and preparation of Environmental Impact Assessments for wind farm developments in the U.K. and Republic of Ireland. Measurement and assessment of wind farm noise for planning purposes and compliance with planning conditions. Evaluation of turbine types for consented wind turbine projects. Source noise measurements on wind turbines, particularly small wind turbines. Managing wind turbine source noise data base. Health and Safety. Assistance with evidence for Public Inquiry. Expert Witness at Appeal Hearing in Scotland.* *Successful implementation of IEC 61400-11:2012 for all size of wind turbines. Main focus on certification measurements of small wind turbines in UK and warranty testing of larger wind turbines.* *Head of Turbine Testing Department. 2016 certification as measurement laboratory to ISO 17025 (only two labs obtained this certification in 2016 in the UK) for IEC 61400-11 sound power level measurements* *Presentations of various subjects in relation with wind farm noise at national and international conferences.*

Organiser of workshop on the implementation of IEC 61400-11 Ed.3 at the Wind Turbine Noise Conference 2013 in Denver and 2015 in Glasgow.

2016-present innogy Renewable UK Ltd., Swindon/UK (innogy SE), since July 2020 under new name RWE Renewables
PRINCIPAL ACOUSTICS EXPERT
TECHNICAL LEAD ACOUSTICS TEAM
Conducting country specific noise impact assessment, technical due diligence worldwide, acoustic advise at all project stages (development, construction, operation and de-construction). Provision of specialist expertise and internal coordination of acoustic related issues. Complaints investigation. Supervision and technical coordination of sound power and immission measurements on RWE wind parks worldwide. Managing and conducting of internal monitoring, third-party requirements. Noise assessment of battery storage units and transformer. Support of the Offshore wind in compliance with noise regulation during construction in particular of onshore facilities. Acoustic consultancy services for other (RWE) business units. Contract negotiations with equipment manufacturers (sound warranties). Expert witness in wind turbine acoustic matters.
Responsibility for the Acoustics Team in all technical decisions. Integration of the Acoustics Team into the new RWE organisation.

Publication: Vick, Brian and Broneske, Sylvia: EFFECT OF BLADE FLUTTER AND ELECTRICAL LOADING ON SMALL WIND TURBINE NOISE, Reference: RENE4937, Journal title: Renewable Energy, Final version published online: 26-SEP-2012 Full bibliographic details: Renewable Energy (2013), pp. 1044-1052 DOI information: 10.1016/j.renene.2012.08.057

Presentations: Several Institute of Acoustics One-Day Conferences on Wind Turbine Noise, Environmental Noise and Measurement Equipment

Small Wind Turbine Noise at Renewable UK Conference 2012

Wind Turbine Noise Conference 2009 in Denmark (*Comparison of Wind Turbine Manufacturer's Noise Data for Use in Wind Farm Assessments*), Wind Turbine Noise Conference 2013 in USA, Invited Speaker at Internoise 2014 in Australia, Wind Turbine Noise Conference 2017 in The Netherlands (Co-Author of presentation), Wind Turbine Noise Conference 2019 in Lisbon/Portugal,

Several workshops at KCE Academy in Germany for Local Authorities and Developers

Professional Bodies: Member, Institute of Acoustics IOA
Member, Verein Deutscher Ingenieure VDI (Institute of German Engineers)

Member of the organising committee for the Wind Turbine Noise Conference since 2015 organised by INCE Europe

Standardisation: Chairperson of BSI[1] shadow sub-committee PEL88/-/08 to IEC[2] 61400-11 MT11 and PT11-2 (Wind Turbine Acoustics

Secretary of IEC PT61400-11-2 (*Immission Measurements of Wind Turbine Noise*)

Member of IEC MT61400-11 (*Sound Power Level Wind Turbines*)

Member of BSI EH/1/3 sub-committee (*Residential and industrial noise*)

Member of ISO[3] working group ISO/TC 43/SC 1/WG 45 (*Description and measurement of environmental noise – ISO 1996 series*)

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[1] British Standards Institution
[2] International Electrotechnical Commission
[3] International Standards Organization