Received 1/28/16

Planning Commission testimony: Chopin Wind Project Jan. 28,2016

Planning Commissioners, has an in-depth evaluation of historical data on the farming practice of aerial spray application of surrounding lands/farms been done? Do the Project features force a significant change in the farming practice of aerial chemical application? Or costs associated? Consideration of agricultural spray pilot safety and associated risks should be included.

Applicant response to UCDO 152.061:

"Agricultural operations on the ground would go on unabated by the Project features." "Traditional farming practices have continued unabated regardless of the addition of wind farms."

UCDO 152.061

("(A) Will not force a significant change in accepted farm or forest practices on surrounding lands devoted to farm or forest use; and
"(B) Will not significantly increase the cost of accepted farm or forest practices on lands devoted to farm or forest use.")

Commissioners, Wind farms *have already forced* change in the practice of aerial spray application. How significant is this? The assertion made by the Applicant is misleading. In fields with wind turbines, farmers, and their farming neighbors, have been forced to make other choices in fields they once used aerial spray applications.

Noise Measurement Standard:

Planning Commissioners, it appears that the Applicant will be relying on a 6 year old noise study done by Channel Islands Acoustics. Attachment 3, Noise Letter Report from Bruce Walker, INCE (retired) confirms this. The noise study was modeled on International Standardization Organization (ISO) 9613 Acoustics as implemented in SoundPlan software. In a SoundPlan Company overview of all software noise modules (see Attachment #1), no mention at all of the *use of this software for noise predictions or noise modeling for wind turbines.*

The Chopin noise study asserts that: *"Modern wind turbines have been designed to very effectively suppress mechanical tones and this can be demonstrated by examining International Electro-technological Commission (IEC) 61400-11 test results, which require reporting of any tones that are greater than 3 dB below the masking level of broadband noise."*

The Applicant should supply this record of "reporting" and methodology in regards to the IEC 61400-11 test results, as part of the Noise Study.

Document 1. ***<u>Problems Related to the Use of the Existing Noise Measurement Standards When Predicting Noise from Wind Turbines and Wind Farms, authors: Vestas, Delta and Bonus Energy</u>***
The Vestas document states: ***"Noise Measurement (IEC 61400-11) does not correct for: Actual inflow angles, actual air density, actual wind shear, actual turbulence intensity and ALL parameters that are known to influence the sound emission."***
The document goes on to say that the wind turbine is used as a "wind speed meter" through a power curve measured on an *<u>ideal site</u>* (IEC 61400-12). They further state, ***"wind turbines are almost always raised at sites where roughness differ from the standardized completely flat measurement site."*** **The noise warranties (used in IEC 61400-11) are generated at flat factory sites, and the noise warranties may *not* be the same level of noise emission in the actual wind farm terrain. Vestas say,** ***"The result is a fairly good tool for verification of warranties, but not a good tool for predicting noise at emission points where people actually can get annoyed."***
Other parameters influence the noise level: relative humidity, turbulence, inflow angle, wind shear, turbine pitching are not accounted for. All of the above deviations can (and do) result in understated noise emission predictions. Once the wind farm is operational, the noise level may be higher than was accounted for in the model.

The Chopin noise study used the ISO 9613-2 simplified ground test standard. Noise measurement standards currently used are all derived from the ISO 9613 standard. IEC 61400-11, Computer Aided Noise Abatement (CADNA/A) and SoundPlan software are used as tools for noise models and noise prediction levels. The IEC 61400-11 standard is incorporated into Oregon Administrative Rule (OAR) 340-035-0035 applied by the Oregon Dept of Energy (ODOE) and the Energy Facility Siting Council (EFSC) for noise compliance.

The origins of the ISO 9613 standard became established through the World Health Organization (WHO). The WHO was the first body of medical doctors who recognized that noise was connected to human

4641

health. At the beginning of the Industrial Age, noise limits were needed, as factories were being built in densely populated areas. The ISO 9613-2 standard was developed to measure *__industrial noise below 30 meters.__* The original design constraints are:
Near ground - 30 meters or below
Non-wind related
Without turbulent wake

The end result: Application outside of the design parameters are invalid.
Application creep accounts for the use of the ISO 9613 standard in measuring wind turbine noise today.
Document 2. *__"Neglect of Wind Shear in Assessing Long Range Propagation of Wind Turbine Noise" author, M. W. Toft__*
This document effectively demonstrates the parameters that are breached when the ISO 9613-2 models are used as noise measurement and modeling for wind turbine noise.
Henrich A. Metzen of DataKustik GmbH, based in Munich, Germany, maker of CADNA/A software confirms: *"long range propagation including atmospheric refraction is not part of the standards used for (normal, "standard") noise calculations. It is known that atmospheric refraction may cause sound to be refracted downwards again and contributing strongly to the level at long distances. The atmosphere in the standards existing is just homogeneous above height."*

It is known that there is no accepted algorithms to predict these refractions, sound propagation models cannot evaluate conditions that have vertical or horizontal turbulence even though it is known they can add, significant sound at a "noise sensitive receiver" when present. The result, is sound levels that are understated in the noise models.

An example of this is Willow Creek wind project sited by neighboring Morrow County. The Applicant, Invenergy, submitted noise modeling that met County noise compliance standards and was awarded a site certificate. Once in operation, the project exceeded noise limits. The residents affected, hired noise expert, Kerry Standlee, to test the noise limits. The Applicant hired a firm out of Maine. Both experts found the project to be out of compliance. The County argued that this was "*unusual or infrequent event*". It was proven untrue. The residents sued

the County and the Applicant and won. The Applicant and the County demanded a non-disclosure clause as part of the settlement.
In Herkimer County, New York, 60 residents sued Iberdrola for damages after the Hardscrabble Wind Project became operational. Again, noise testing revealed that the 50 dBA noise limit was breached and levels as high as 72 dBA were recorded. This lawsuit is in the settlement stage but not completely finalized.
In New Hampshire, a veteran, suffering from PTSD, won a lawsuit against Iberdrola after the Groton project became operational. Non-compliant noise levels, exacerbated his PTSD and health issues. Legal recourse has become increasingly common for non-compliance on noise. Unfortunately, the public is deprived of this information. It is standard wind industry practice to force litigants to sign non-disclosure contracts for their settlements.

Document 3. *"A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions" author, Dr. Neil Kelley*
The Kelley study scientifically documents that wind turbines do indeed load neighboring structures with low-frequency infra-sound emissions. The Noise Letter Report (Attachment 3) submitted by the Applicant states: *"It should be noted that various explanations and theories are being posited for explaining the subjective impact of turbine infrasound. Much of the lore is based on studies conducted at signal amplitudes many, sometimes thousands, of times greater than experienced at reasonable distances from wind turbines."*
Commissioners, I urge you, to thoroughly read the Kelley document. The methodology and conclusions are sound. This scientific research on infra-sound was commissioned by the U.S. Dept. of Energy.

Low-frequency infra-sound leads to a host of human health issues: sleep deprivation, headaches, nausea, dizziness.
In Oregon, Governor Kitzhaber, commissioned the *"Strategic Health Impact Assessment On Wind Energy Development in Oregon"*.
In Jan. 2012, the findings were released: Noise
1. *"Sound from wind energy facilities in Oregon could potentially impact people's health and well-being if it increases background sound levels by more than 10dBA."*
2. *"The potential impacts from wind turbine sound could range from*

464

moderate disturbance to serious annoyance, sleep disturbance and decreased quality of life. Chronic stress and sleep disturbance could increase risks for cardiovascular disease, decreased immune function, endocrine disorders, mental illness, and other effects. Many of the possible long-term effects may result from or be exacerbated by sleep disturbance from night-time wind turbine sound."

Document 4. ***"Hearing Officer Report on Brush Canyon Wind Project (March 11,2014)" author, Hearing Officer J. Kevin Shuba, ODOE***

In January of 2013, I submitted documents #2 and #3 at a ODOE hearing on Brush Canyon Wind Project. Commissioners, I am submitting the same documents #2 and #3 for the record tonite.
In the Hearing Officer Report on the testimony presented on Brush Canyon Wind Project, Hearing Officer Shuba's response to the testimony and documents that I added to the record:
"Ms. Severe commented that the Applicant's modeling incorporated standards that are inapplicable to the noise generated by a turbine. Her points were that the modeling incorporated assumptions not true of turbines. Two stand-out aspects of her comments were that turbine noise is low frequency and generated at point elevated above the ground. She claims these facts invalidate the noise-related representations of the Applicant because low frequency waves are longer wavelength, higher energy and travel further. Also the height at which they are generated contribute to the distance at which the noise can be detected." Further stated, "This issue may raise legal as well as factual issues regarding the noise modeling calculated and provided by the Applicant as part of the application." **The software relied on for the Brush Canyon application was the CADNA/A and the IEC 61400-11 standard.**

Planning Commissioners, the Chopin application noise study is over 6 years old. The standards used have great uncertainty given the design constraints. The software company makes no mention of software that predicts or measures noise from wind turbines. This presents factual and/or legal challenges for the County. Site certificates and conditional use permits that may be granted on the existing noise measurement standards are open to public scrutiny for due diligence in the siting process. Commissioners, I urge you to reject the Chopin application as it is presented.

Thanks to the Planning Commission and Umatilla County Planning Dept. for your time.

Thank you,

Cindy Severe
82422 Vansycle Rd
Helix, OR 97835

(a) The in-use motor vehicle standards specified in **Table 2** and **3** have been determined by the Department to be substantially equivalent to the 25 foot stationary test standards set forth in 1977 Oregon, Laws, Chapter 273;

(b) Tests shall be conducted according to the procedures in **Motor Vehicle Sound Measurement Procedures Manual (NPCS-21)** or to standard methods approved in writing by the Department.

[ED. NOTE: The Table(s) referenced in this rule are not printed in the OAR Compilation. Copies are available from the agency.]

[Publication: The Publication(s) referred to or incorporated by reference in this rule are available from the agency.]

Stat. Auth.: ORS 467
Stats. Implemented: ORS 467.030
Hist.: DEQ 75, f. 7-25-74, ef. 8-25-74; DEQ 119, f. & ef. 9-1-76; DEQ 135, f. & ef. 6-7-77; DEQ 147(Temp), f. & ef. 12-1-77; DEQ 2-1978, f. & ef. 3-1-78; DEQ 7-1983, f. & ef. 4-22-83

340-035-0035

Noise Control Regulations for Industry and Commerce

(1) Standards and Regulations:

(a) Existing Noise Sources. No person owning or controlling an existing industrial or commercial noise source shall cause or permit the operation of that noise source if the statistical noise levels generated by that source and measured at an appropriate measurement point, specified in subsection (3)(b) of this rule, exceed the levels specified in **Table 7**, except as otherwise provided in these rules.

(b) New Noise Sources:

(A) New Sources Located on Previously Used Sites. No person owning or controlling a new industrial or commercial noise source located on a previously used industrial or commercial site shall cause or permit the operation of that noise source if the statistical noise levels generated by that new source and measured at an appropriate measurement point, specified in subsection (3)(b) of this rule, exceed the levels specified in **Table 8**, except as otherwise provided in these rules. For noise levels generated by a wind energy facility including wind turbines of any size and any associated equipment or machinery, subparagraph (1)(b)(B)(iii) applies.

(B) New Sources Located on Previously Unused Site:

(i) No person owning or controlling a new industrial or commercial noise source located on a previously unused industrial or commercial site shall cause or permit the operation of that noise source if the noise levels generated or indirectly caused by that noise source increase the ambient statistical noise levels, L10 or L50, by more than 10 dBA in any one hour, or exceed the levels specified in Table 8, as measured at an appropriate measurement point, as specified in subsection (3)(b) of this rule, except as specified in subparagraph (1)(b)(B)(iii).

(ii) The ambient statistical noise level of a new industrial or commercial noise source on a previously unused industrial or commercial site shall include all noises generated or indirectly caused by or attributable to that source including all of its related activities. Sources exempted from the requirements of section (1) of this rule, which are identified in subsections (5)(b) - (f), (j), and (k) of this rule, shall not be excluded from this ambient measurement.

(iii) For noise levels generated or caused by a wind energy facility:

(I) The increase in ambient statistical noise levels is based on an assumed background L50 ambient noise level of 26 dBA or the actual ambient background level. The person owning the wind energy facility may conduct measurements to determine the actual ambient L10 and L50 background level .

(II) The "actual ambient background level" is the measured noise level at the appropriate measurement point as specified in subsection (3)(b) of this rule using generally accepted noise engineering measurement practices. Background noise measurements shall be obtained at the appropriate measurement point, synchronized with windspeed measurements of hub height conditions at the nearest wind turbine location. "Actual ambient background level" does not include noise generated or caused by the wind energy facility.

(III) The noise levels from a wind energy facility may increase the ambient statistical noise levels L10 and L50 by more than 10 dBA (but not above the limits specified in Table 8), if the person who owns the noise sensitive property executes a legally effective easement or real covenant that benefits the property on which the wind energy facility is located. The easement or covenant must authorize the wind energy facility to increase the ambient statistical noise levels, L10 or L50 on the sensitive property by more than 10 dBA at the appropriate measurement point.

(IV) For purposes of determining whether a proposed wind energy facility would satisfy the ambient noise standard where a landowner has not waived the standard, noise levels at the appropriate measurement point are predicted assuming that all of the proposed wind facility's turbines are operating between cut-in speed and the wind speed corresponding to the maximum sound power level established by IEC 61400-11 (version 2002-12). These predictions must be compared to the highest of either the assumed ambient noise level of 26 dBA or to the actual ambient background L10 and L50 noise level, if measured. The facility complies with the noise ambient background standard if this comparison shows that the increase in noise is not more than 10 dBA over this entire range of wind speeds.

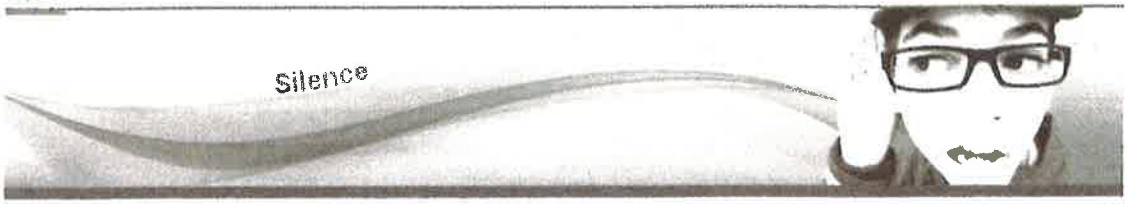
(V) For purposes of determining whether an operating wind energy facility complies with the ambient noise standard where a landowner has not waived the standard, noise levels at the

4169

Please enter search word

Attachment #1

Products and Services | SoundPLAN Acoustics | SoundPLAN Air Pollution | Consulting | Seminars and conferences | About us



- SoundPLAN
- SoundPLAN Modules
  - Geo-Database / Manager / Library
  - Road / Railway / Distributed Computing
  - Industrial Noise Indoors / Outdoors
  - Noise Maps - Grid / Facade / Meshed
  - Aircraft Noise
  - Tools / Documentation / Interfaces
  - Graphics Concepts / Modules
- SoundPLAN Packages
- SoundPLAN essential
- News, SoundPLAN Info, Announcements
- Highlights
- Picture Book
- SoundPLAN Concepts
- SoundPLAN Support
- Demo versions

SoundPLAN Acoustics   SoundPLAN Modules

Overview of all modules

The **Geo-Database** is the place where the most time is spent building the noise model. With the DXF and ASCII interfaces, a lot of common data from external sources can be imported and included in a comprehensive noise model. It is also possible to load a geo-referenced bitmap into the background and digitize on this canvas. DXF, ASCII interface and the background bitmap are all part of the Geo-Database. The data created in the Geo-Database are stored in an unlimited number of Geo-Files. To keep order in the multitude of Geo-Files, a sub-structure called "Situations" organizes the files in folders in a manner similar to how files are stored in folders in the Windows Explorer. An extensive collection of Geo-tools, view operations, and selection and manipulation tools make the Geo-Database a highly sophisticated GIS type data entry and manipulation instrument. The Geo-Database is the base of SoundPLAN and comes along with the modules SoundPLAN Manager (the project administration tool), the Library (the general storage area of data to be used in multiple projects), the basic Calculations, the Result Tables (the producer of printed documentation on the findings of a single calculation run), the Spreadsheet (for comparing multiple calculation runs) and the non-modular Graphics (for making overview graphics for presentations).

Click here for more detailed information about:

GeoDatabase, SoundPLAN Manager, Library, Calculation, Spreadsheet, Result Tables

Road Noise Propagation contains all the tools and objects needed for generating roads and calculating their emission values. Part of the road data is the geometrical description of the lanes, the road width and bridges. The emission is calculated in accordance to the user selected road noise model (at present 17 road noise models are available in SoundPLAN). The emission values for the requested noise assessment (Lden, Lmax, Leq day¦.) are stored with the geometry in the Geo-Files. The SoundPLAN Calculations feed the source data into the propagation model. Various outputs, ranging from single point receivers to Grid Noise Maps, Façade Noise Maps and Meshed Noise Maps, can be generated. The Documentation, the Spreadsheet and the Graphics prepare various forms of output from the calculations. An optimization of noise control walls can be found in the Wall Desgin module.

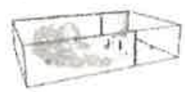
Click here for detailed information about road noise

Railway Noise Propagation supplies all the railway relevant tools and objects so railway lines can be entered, the noise calculated and the results presented in the Documentation, Spreadsheets and Graphics. An optimization of noise control walls can be found in the Wall Design module.

Click here for detailed information about railway noise

Industry Noise Propagation enables the user to create sources describing industrial usage. The source types are point, line and area sources, and the industrial building. The emissions of the sources need to be entered with the sound power for a single frequency or for an octave or third octave band. Source definitions describe line and area sources as total sound power or as sound power per meter/square meter of the source. For the industrial building, it is possible to enter the sound pressure inside and calculate the transmission from the inside to the outside, or to define the sound power per square meter on the outside surface. In collaboration with the Indoor Factory Noise module, the sound pressure on the inside of the building can also be simulated. The library has functions to convert sound pressure measurements into the equivalent sound power. The library also contains a materials library for the transmission losses and the absorption coefficients. Industrial sources can also be associated with various directivities, and for time variable sources, with a day history. Results can be post processed in

Overview



470

industrial noise can be found in the module Expert System for Industrial Noise.

Click here for detailed information about industry noise

Indoor Factory Noise calculates noise inside factory buildings. The model is based on the German VDI 3760. Point, line, and area sources describe the sources; inside walls and absorption areas describe the objects inside the factory building. The industrial building itself has provisions for the geometry and for describing the absorption on the outside walls and the scattering inside the building. Calculations generate feed data for the transmission to the outside environment or to display a sound propagation curve inside the building, or are used for the final data for printed and plotted output.

Click here for detailed information about indoor noise modeling

Aircraft Noise Propagation simulations are in accordance to the various European aircraft noise regulations. Enter your model, calculate Grid Noise Maps, and combine the results of the noise from flying aircraft with the noise from ground operations, traffic sources, etc.

Click here for detailed information about the aircraft noise: aircraft noise and radar tracks

Distributed Computing speeds up lengthy calculations by distributing the application on any number of PCs found in the network. Install a regular version or the demo version as a calculation server and scale your application to the speed you need. With just this module on one PC, there is no limit to the number of PCs used for mapping calculations. Multi-Threading is also an option to speed up calculations on a multi core PC. This option is included in the most basic packages.

Click here for detailed information about Distributed Computing

Noise Mapping Toolbox is useful for calculating big noise maps. It allows the user to convert the project into a tiled project with a tile size of usually1x1 km or 2x2 km. With this technique, there is no limit to the size of the noise model you can process. All of Germany has been processed this way in a single project for the German END type railway noise map. The Noise Mapping Toolbox not only allows big noise maps to be processed in a tiled environment, but also allows full access to the SoundPLAN Spreadsheet for free GIS type processing and combining results from calculations with number of inhabitants through to the assessment of cost / benefit in noise control measures.

Click here for detailed information about the Noise Mapping Toolbox.

Grid Noise Map follows the terrain with a noise map calculated at a user specified height above the ground. Powerful tools allow the results of the Grid Noise Map to be processed into noise contour maps. Color the contour lines or the fill pattern in accordance to the user defined scale. Contour lines can be output as straight lines or Bezier curves. Multiple Grid Noise Maps can be used in the same project and displayed in the same or multiple different drawings. If users have access to both the Grid Noise Map and the Façade Noise Map, a third noise map, the Meshed Map, automatically becomes available.

Click here for detailed information about the Grid Noise Map.

Grid Cross-sectional Noise Map calculates and displays a grid type noise map on top of a given cutting line. Resolution and maximal height above terrain are user defined. One Cross-sectional Noise Map can be displayed in the graphics, but one or multiple maps can be shown in the 3-D Graphics.

Click here for detailed information about the Grid Cross-Sectional-Noise Map.

Facade Noise Map is the perfect tool for generating the base data for END statistics. Calculations are carried out for every floor of all enabled (mainly residential) buildings. The program can create receivers with a constant spacing along the façade or with a fixed number per façade. The post processing can be done in the SoundPLAN Spreadsheet for numerical answers or in the Graphics for color coded display of the answers. In the top view, it is possible to color each façade with the maximum noise level found on the façade, or to mark facades that excede the noise limit or that are quiet facades. In the 3-D Graphics, a niche display is to place a color blob in the place of each receiver and have the color coordinated with the noise scale. Other options are a full area display of the façade areas. If users have access to the Grid Noise Map and the Façade Noise Map, a third noise map, the Meshed map, automatically becomes available.

Click here for detailed information about the Facade Noise Map

Cartography extends the customizing capabilities of the plotted (color printer) result. Cartography makes it possible to generate contoured maps from user measured data depicting any topic from noise levels to annual rainfall.

Click here for detailed information about the module Cartography

3-D Graphics can create wire frame and solid models from your graphics. Objects for display are the input geometry of the noise models plus derived, calculated data such as Digital Ground Models, Grid Noise Maps, Grid Cross-sectional Noise Maps, Meshed Maps and Façade Noise Maps. The program is capable of displaying multiples of each noise map type. It is also possible to "stretch" a bitmap from the planning process over the DGM and display it as a 3-D Graphic. Operations in the 3-D Graphics are zoom, move, tilt and rotate, so you can see your model from any direction. Preparing the 3-D Graphics for presentation in another graphics unfortunately requires converting it into a bit map. Open GL does not contain a way to output it to the printer directly. Higher print resolutions than the screen supplies are possible.

Click here for detailed information about the 3D Graphics

3-D Graphics Animations are an extension of the normal 3-D Graphics. This module allows you to create a film sequence to move along a given road or other path, and to view the model from the perspective of a driver on the road. A second animation type is available to make a moving noise map for trains, where the maximum noise calculation intermediate results are displayed, resulting in the production of noise maps in time steps. This film sequence can be displayed on line or saved to an AVI file.

Click here for detailed information about the 3D Animation

The **ArcView Shape File Interface** allows the import and export of data in the ArcView Shape file format. As this interface format involves a flexible database format, each imported file can contain coordinates as well as descriptive attributes. However, each object type requires a file of its own. If you want to import buildings and roads, 2 imports are required; one for the buildings and one for the roads.

Click here for detailed information about the Shape File Interface

The **TNM Interface** allows users that have access to the US-TNM 2.5 software to export entire SoundPLAN models to TNM and to import TNM models. (TNM is a trademark of the US government; SoundPLAN is not endorsed by the Federal Government or any of its branches.)

Click here for detailed information abut the TNM Interface

Wall Desgin is the perfect tool for SoundPLAN users who need to dimension noise protection walls. A pre-calculation for single receivers or a Façade Noise Map iterates the height of a noise control wall (or the height of a berm) and records the reductions of noise levels per change in wall height. The automatic part of the optimization selects elements of the noise barrier in accordance to the reduction potential of the element. The optimization is a true optimization; it not only makes a suggestion for a single receiver, but also attempts to deliver a solution where the number of meters along the façade that are above the noise limit, are minimized. A hands on part of the optimization allows the final customization of the wall not only for acoustical parameters but also for the aestehtics of the wall. A specialty of the optimization is to compare cost to benefits for any size of wall for an almost unlimited number of receivers. The optimized form of the wall can be saved and used for further calculations such a Grid Noise Maps where before and after scenarios are presented.

Click here for detailed information about the WallDesign

Window Dimensioning is a simple application in spreadsheet format to associate receivers on the outside of a building with the room type and the noise levels inside. If the actual noise level exceeds the limit, suggestions about noise control windows are made in accordance to the size of the façade, the rooms usage and the type and size of the window.

Building Acoustics Outside was created for customers who need to assess and document noise levels inside a building. Walls and windows are included in the assessment of the transmission and the optimization of a noise control concept. The data are organized in buildings, floors, apartments and rooms. The scope of this module includes assessing the indoor noise levels in a room on a straight façade with one outside noise level, to assessing corner rooms exposed to 2 directions of noise, to administrative tasks such as keeping track of apartment owners and building owners, through to knowing the geometry of the apartment. Scanned plans help identify locations, etc.

Click here for detailed information about Building Acoustics Outside

The **Expert System for Industry Noise** is tasked with documenting the status quo of an industrial area, ranking the noise sources in accordance to their contribution at various noise sensitive receivers and then finding the proper solution of silencers, dampers, etc. Costs and performance of the noise control measures are set in relation with each other and function as a guide for the optimization of industrial noise control.

Click here for detailed information about the Expert System for Industry Noise

472

Noise Allotment helps consultants to assign noise contingents to plots to be designated industrial areas. The aim is to maximize the noise allocation to each one of the plots without infringing upon the noise limits at the neighboring plots.

473

Document #1

9

Vestas

BONUS Energy A/S

Problems related to the use of the existing noise measurement standards when predicting noise from wind turbines and wind farms.

Erik Sloth Vestas

Niels Christian Møller Nielsen VESTAS
Ejler Kristensen BONUS Energy
Bo Søndergaard DELTA

DELTA

474

475

Overview

- Noise Measurements (IEC 61400-11:2002)
  - Short description of the measurement method
  - Use of measurement results, including influence on inaccuracy.
- Noise prediction
  - Terrain and meteorology influence on the actual emitted sound
  - Methods used in noise calculations
- Noise assessment
  - Descriptors
  - Noise limits
  - Further investigations needed

Document #1

Noise Measurements (IEC 61400-11:2002)

We correct for:

Air pressure
Air temperature

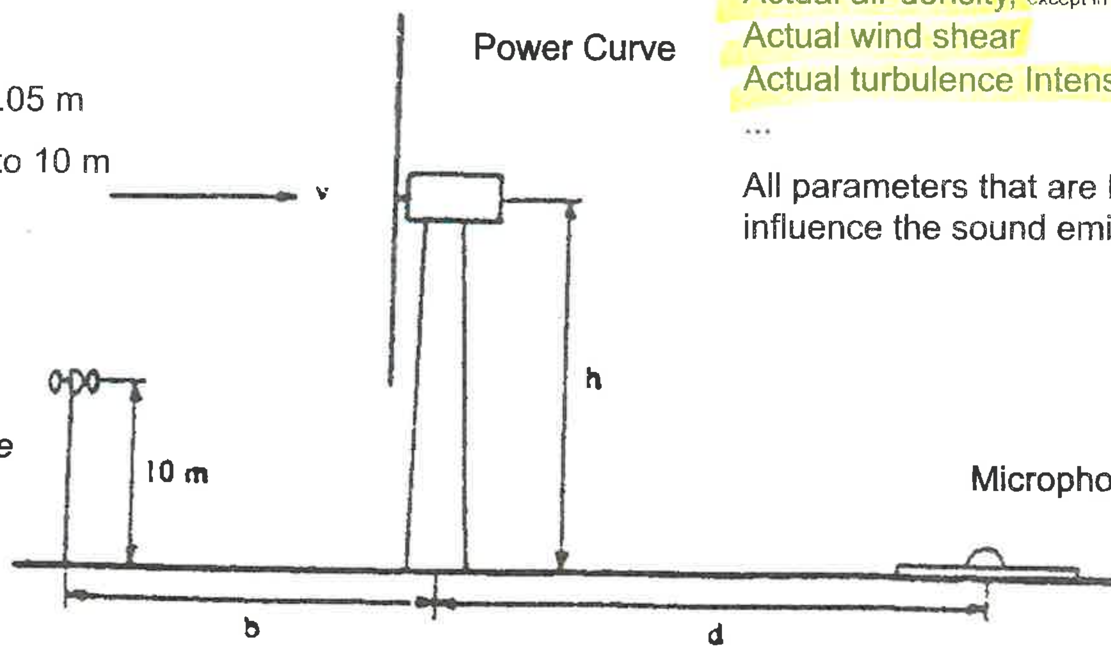
Standard terrain roughness z = 0.05 m

All recalculated to 10 m wind speed

We do not correct for

Actual inflow angels
Actual air density, except in the power curve
Actual wind shear
Actual turbulence Intensity
...

All parameters that are known to influence the sound emission



476

477

Noise Measurement

- The results are standardized noise levels, which are fairly comparable from measurement to measurement on a given turbine type.
- The wind turbine is used as a wind speed meter through a power curve measured on an ideal site (IEC 61400-12) OBS impossible if actual terrain does not fulfill conditions
- Other parameters influence the noise level: relative humidity, turbulence, inflow angle, wind shear, turbine pitching are not accounted for.

- The result is a fairly good tool for verification of warranties, but not a good tool for predicting noise at imission points where people actually can get annoyed.

- The Sound Power Level related to the produced power or at least the sound power level as a function of hub height wind speed could be a more basic relationship

Typical problems in using the measurement results

- Where do we see the major deviations from standardized conditions during actual use of measurement results

- The wind turbines are almost always raised at sites where roughness differ from the standardized completely flat measurement site.

- Further we see different air density
- different wind shear
- different turbulence in inflow air
- different inflow angles

- Finally we often see other hub heights than used during documentation

479

Use of measurement results

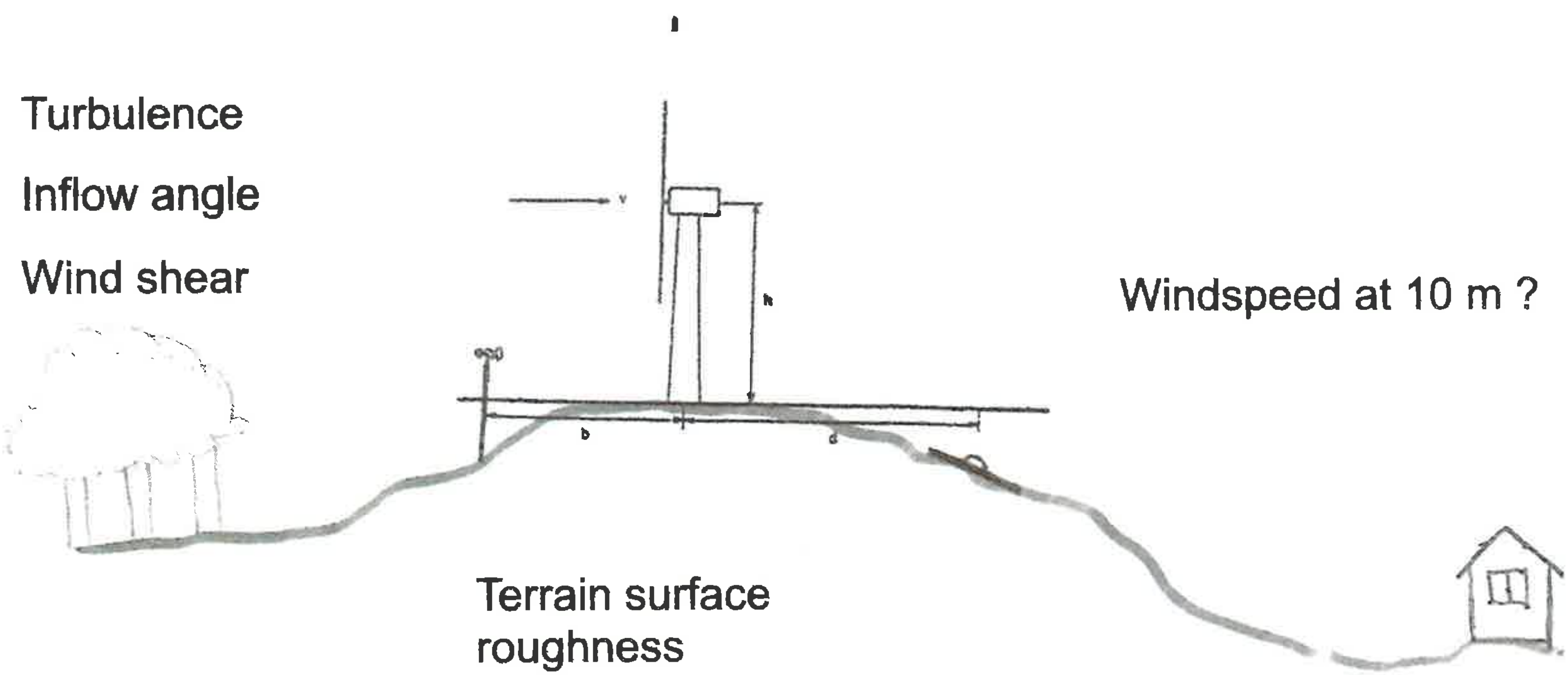
For noise control measurements

For noise level calculations

Turbulence

Inflow angle

Wind shear



Windspeed at 10 m ?

Terrain surface roughness

Conclusion on measurement results

- The differences in site conditions creates differences in emitted sound power level.
- The differences could be both increased and decreased emitted sound power levels in real life applications
- The differences will transfer directly to the imitted sound power levels, and may thereby create increased annoyances in real life

- Therefore – site specific sound power levels should be used unless a good safety margin is present using standardized emission levels.

Uncertainty

- According to IEC 61400-11:2002 the standard deviation of a measurement results is app. 0.9 – 1.5 for an ideal site
- If the measurements are made at a site with considerable turbulence intensity or wind shear the standard deviation can be app. 2.0 dB
- The result is that when used for calculating the noise from a wind farm at an imission point, some WTG will be higher than the expected level and some will be lower.
- To correct for this, the measured inaccuracy cannot be placed upon the total calculated level, but must be included in the calculations.
- The result is that the higher the number of WTG's in the project is, the smaller the resulting inaccuracy.
- If the results are used for calculating the noise from a wind farm the standard deviation should be calculated as the weighted standard deviation

$$\sigma_{res} = \sigma_{method} + \sigma_{source} = \sigma_{method} + \frac{\sqrt{\sum (\sigma_i \cdot 10^{L_i/10})^2}}{\sum 10^{L_i/10}}$$

Solution to the outlined problems

- Accept that different sound power levels should be used in predictions and warranties.
- Avoid using sound power levels that include inaccuracy in predictions unless there is a good safety margin.
- The inaccuracy should be included in the calculation – the higher the number of WTG's the less the probability that all are in the high end of the uncertainty interval
- Use sound power levels that at least are corrected for: hub height, wind shear, air density, turbulence, inflow angle
- Be careful to make sure that the background noise measurements and wind conditions at the turbine positions uses the same reference position.

Noise level calculation models

- There are lots of different noise level calculation models:
  - ISO 9613-2 which is the model that we see the most
  - VDI 2714
  - Concawe
  - BS 5228
  - General Prediction Method (Danish)
  - Danish EPA Guidelines
  - Netherlands Guidelines 1999
  - Swedish method (land/sea)
  - .....

- Most of the methods are developed for noise from Industry, wind speeds below 5 m/s and standard meteorological conditions and must be suspected to give poor results at larger distances.
- ISO 9613-2 is known sometimes to overestimate the terrain effects if soft ground is used
- Manufacturers, developers, consultants and authorities have an interest in a noise level calculation model developed specifically for wind turbine noise

Noise calculation models

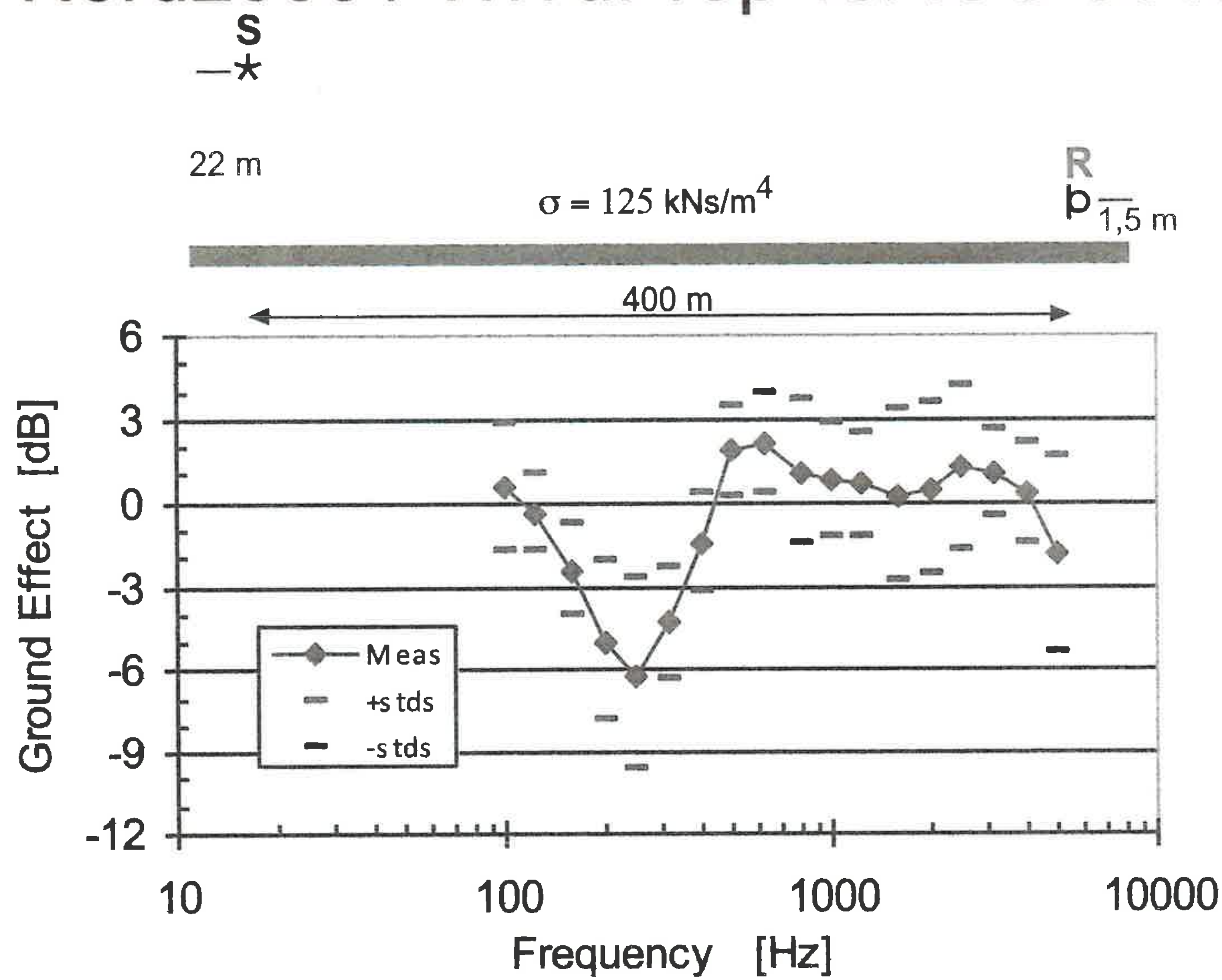
- In an EU project JOR3-CT95-0065 a model for wind turbine noise propagation (WiTuProp) was developed giving good results

- The WiTuProp model takes into account
  - meteorological conditions:
    - Wind speed / terrrain surface roughness and direction
    - Air temperature and air temperature gradient
    - Relative air humidity
  - The ground type
    - Flow resistivity for grassland and harder surfaces
  - Screening (by terain or screens / barriers)

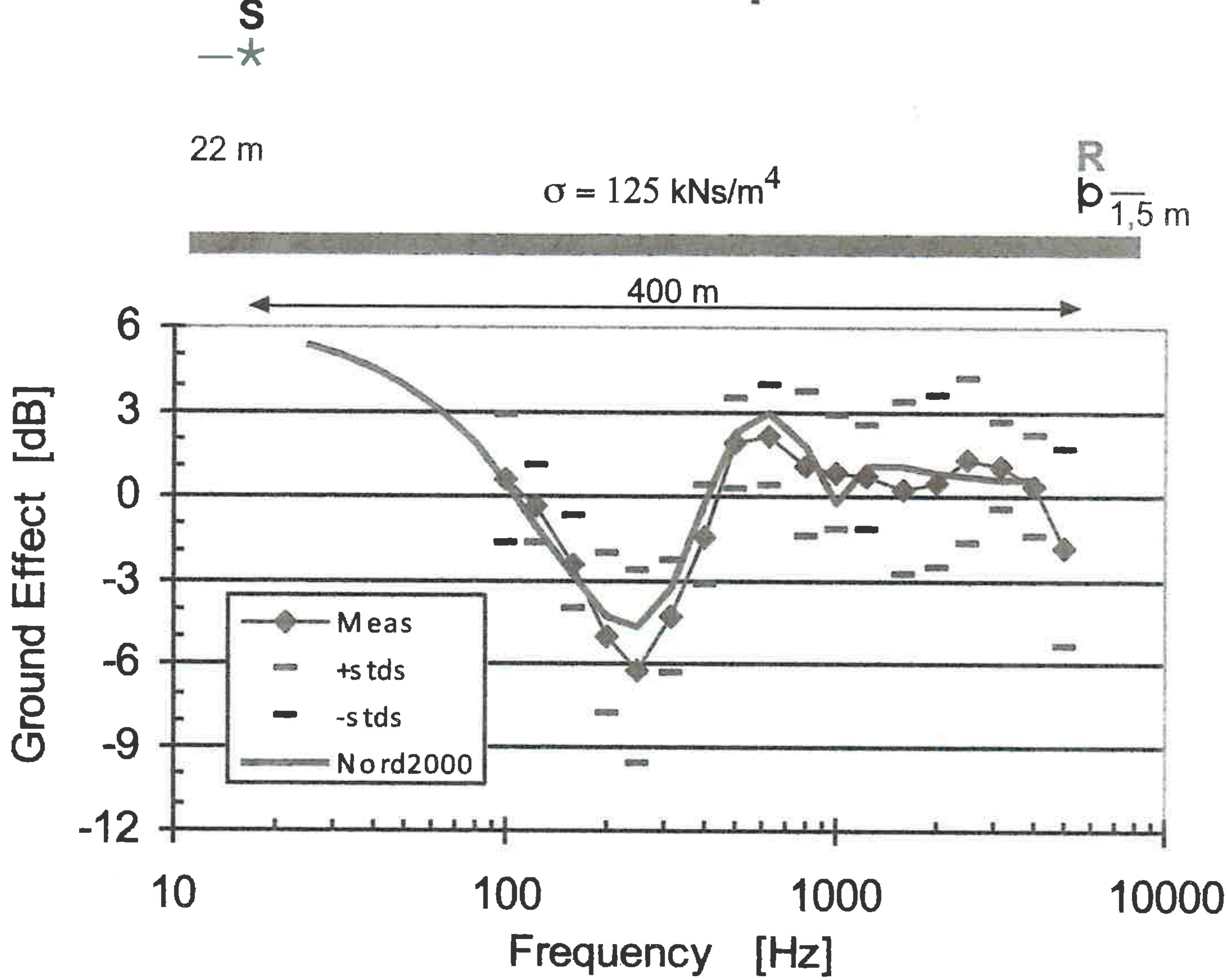
- WiTuProp is a special case of a more comprehensive model developed later: *NORD2000*

485

Nord2000 / WiTuProp vs. ISO 9613-2

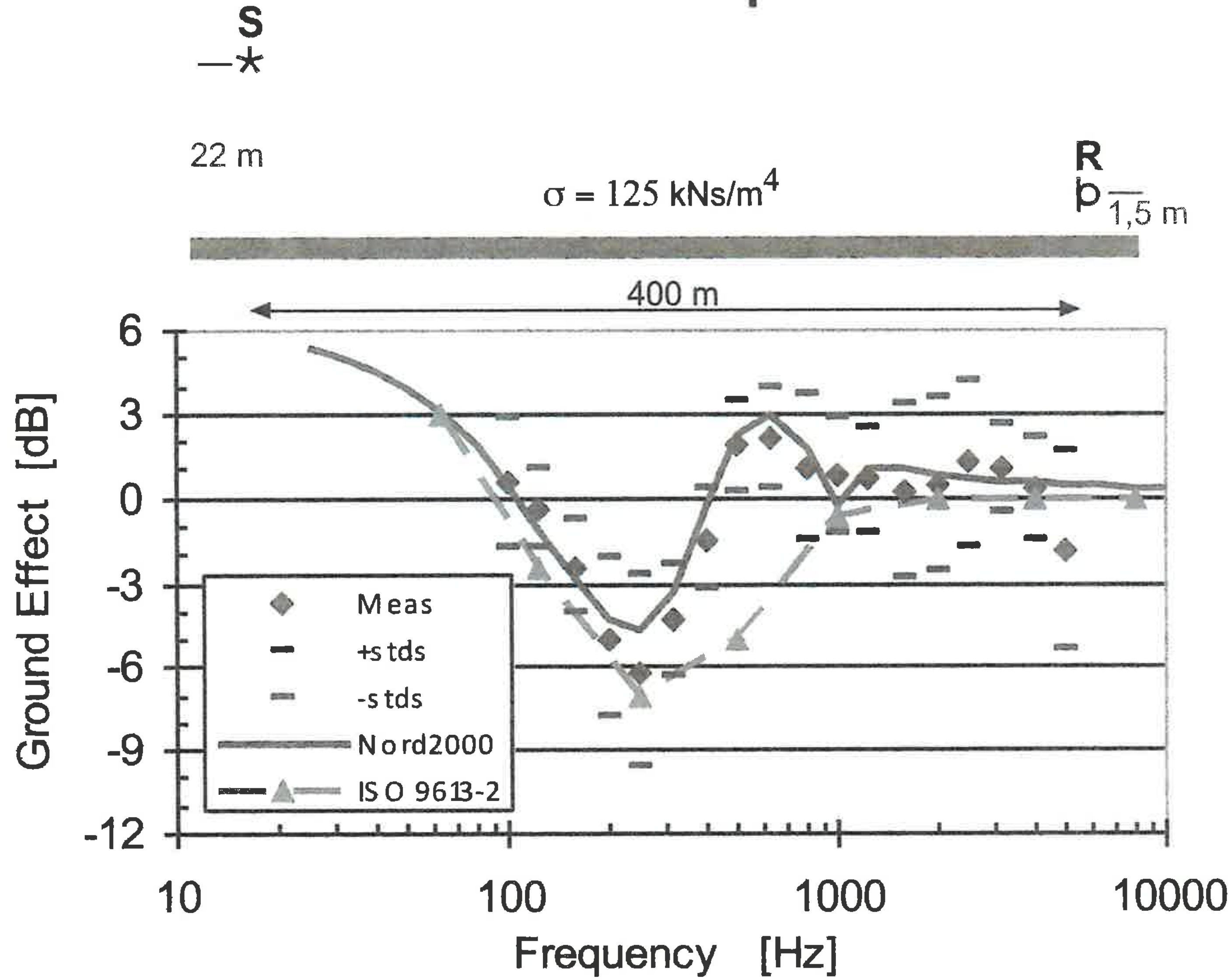


Nord2000 / WiTuProp vs. ISO 9613-2



486

Nord2000 / WiTuProp vs. ISO 9613-2



Nord2000 model

- Meteorological conditions are better covered
- Complex terrain profiles (hill/valley)
- Mixed ground
- Terrain roughness
- Improved screen modelling
- 1/3 octave-band results
- Physical model – NOT empirical

Recommendation if the advanced model is not used:

- Use ISO 9613-2
- Make sure that hard terrain is used
- Be careful when defining screening effects from terrain - specially edge effects can be difficult to model

Noise Assessment

- The noise level at the imission points are normally given as an A-weighted noise level at different wind speeds.
- A tonality evaluation is normally included for the receiving points.

What do we know of the annoyance of the noise:

- We know that noise from wind turbines sometimes annoys people even if the noise is below the noise limits.
- Often people complaints on low frequency noise which many investigations often show in not present
- The noise limits are usually adapted from industrial noise limits and are based upon the principle that a given percentage of the population will feel annoyed when the limit is exactly fulfilled.
- Evaluation of tonality in the turbine noise is more based on the reproducibility of the results than on pure knowledge on what is actually annoying

Noise assessment

- Other descriptors need to be investigated to understand the annoyance caused by wind turbines
  - Low frequency noise and Infrasound – we cannot see it in our measurements
  - Modulation – may be the parameter that is heard as low frequency noise
  - Masking – which noise can mask noise from wind turbines
  - Other characteristics
  - ..
- This mean that tape recordings should me made on all sites in order to enable later analysis of up till now unrecognized parameters.
- In order to enable listener tests, artificial head investigations should be made
- We as a producer cannot cover this alone, since the local rules always need to be followed

491

Our recommended research program

- Artificial head measurements on real turbines of different sizes
- Background noise measurements on real sites
- Listener tests on obtained results
- These measurements are being made on a test basis during our Danish measurements

- General Research that is needed in this area includes
  - Psychoacoustic experiments
  - Listener test
  - Measurements at low frequencies
  - Analysis for other characteristics
  - ..

Document #2

Neglect of Wind Shear in Assessing Long Range Propagation of Wind Turbine Noise

M W Toft

About the author:

- BSc in Physics (University of Bristol); PhD on turbulence and vorticity in superfluid flow (University of St Andrews)
- Over 20 years' experience with CEGB and successor companies in acoustics-related field of ultrasonic non-destructive testing (NDT), as applied to safety of UK nuclear reactors; in particular the validation of theoretical models of propagation of acoustic and elastic waves; programme manager for Generic NDT Development at BNFL-Magnox Generation; provision of expert advice and documentation to the Nuclear Installations Inspectorate, on capability of ultrasonic inspection to guarantee structural integrity of UK nuclear reactors
- Former Member of the British Institute of Non-Destructive Testing (BINDT) - recipient in 2007 of the Institute's premier award, the Roy Sharpe Prize, for contributions to research and development over 20 years
- Member of Peer Review College of the Engineering and Physical Sciences Research Council, 2000 - 2003
- On retiring from the nuclear industry in 2005, made Visiting Fellow at the Department of Physics, University of Bristol, although not active in the latter role
- Expert Witness on noise to Save Berkeley Vale in Public Inquiry APP/C/1625/A/11/2155923/NWF, Jan-Sep 2012, opposing the proposed wind farm development at Standle Farm, Stinchcombe, Dursley Glos

Document #5

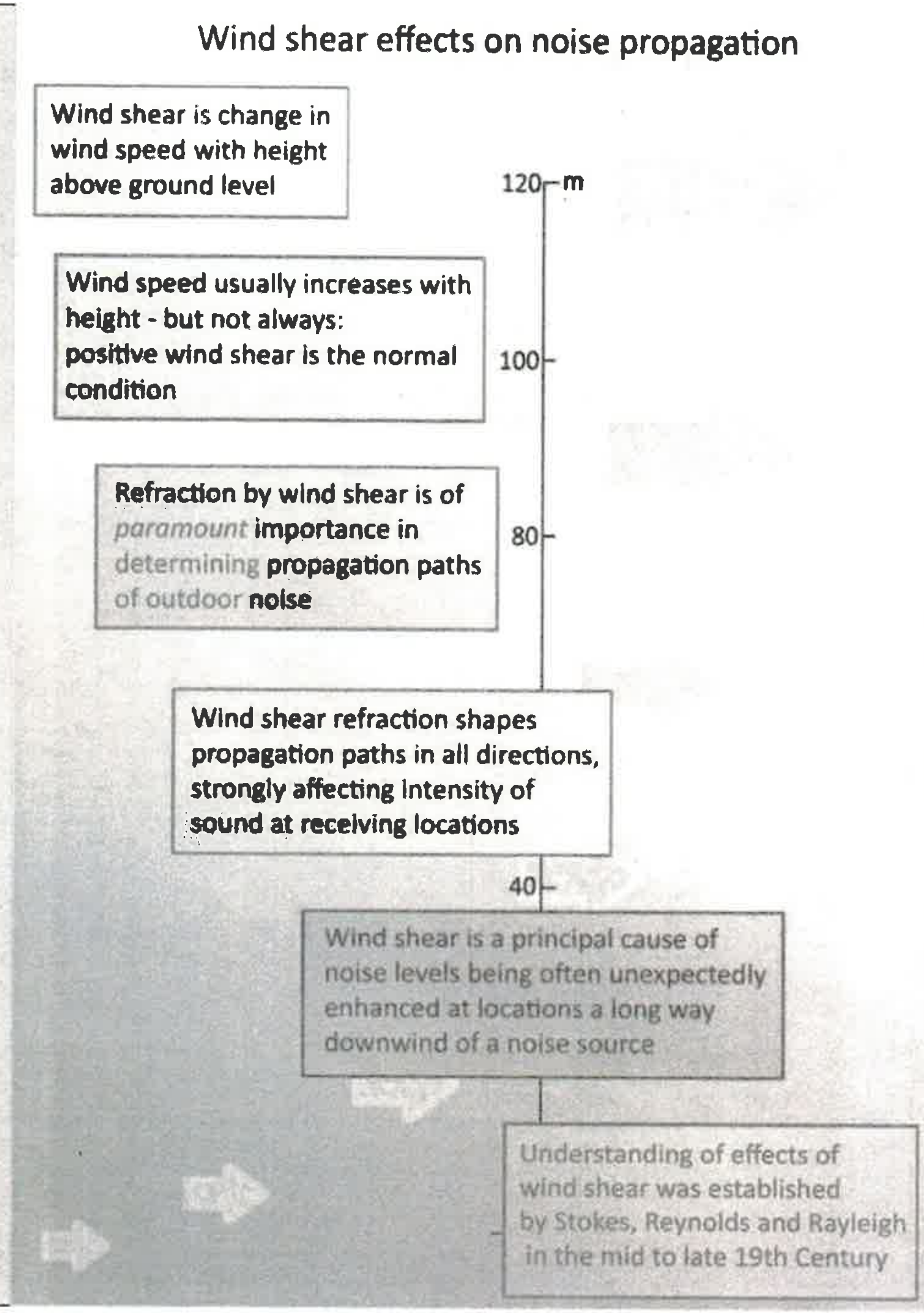
Contents

4947

495

Section 1

Wind Shear - Introduction


Wind shear effects on noise propagation
Wind shear is change in wind speed with height above ground level
Wind speed usually increases with height - but not always: positive wind shear is the normal condition
Refraction by wind shear is of paramount importance in determining propagation paths of outdoor noise
Wind shear refraction shapes propagation paths in all directions, strongly affecting intensity of sound at receiving locations
Wind shear is a principal cause of noise levels being often unexpectedly enhanced at locations a long way downwind of a noise source
Understanding of effects of wind shear was established by Stokes, Reynolds and Rayleigh in the mid to late 19th Century
120 m
100
80
40

Section 2

Motorway Noise Example

497

Wind shear effects on noise propagation

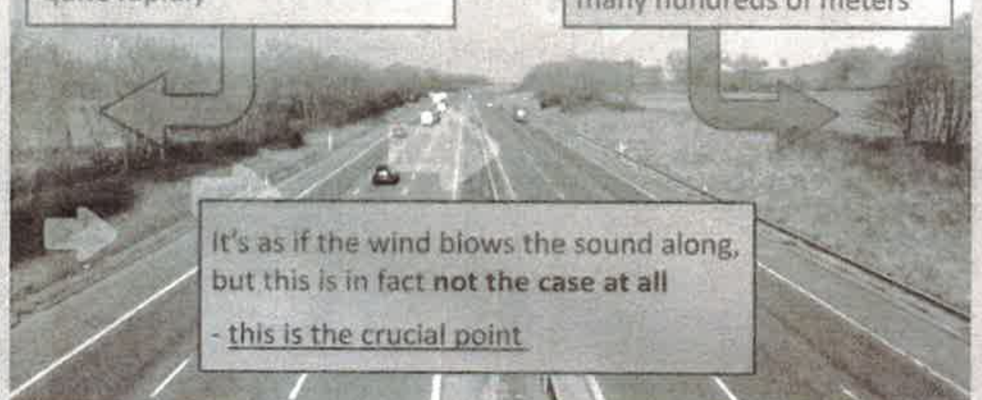
Motorway noise provides an everyday example:

If you stand <u>immediately</u> next to a motorway when the wind is blowing <u>across</u> it, it doesn't matter which side you stand on, upwind or downwind, *noise levels will be essentially the same*

If you walk away from the motorway on the upwind side, ie walking **into the wind,** noise levels **will drop off** quite rapidly

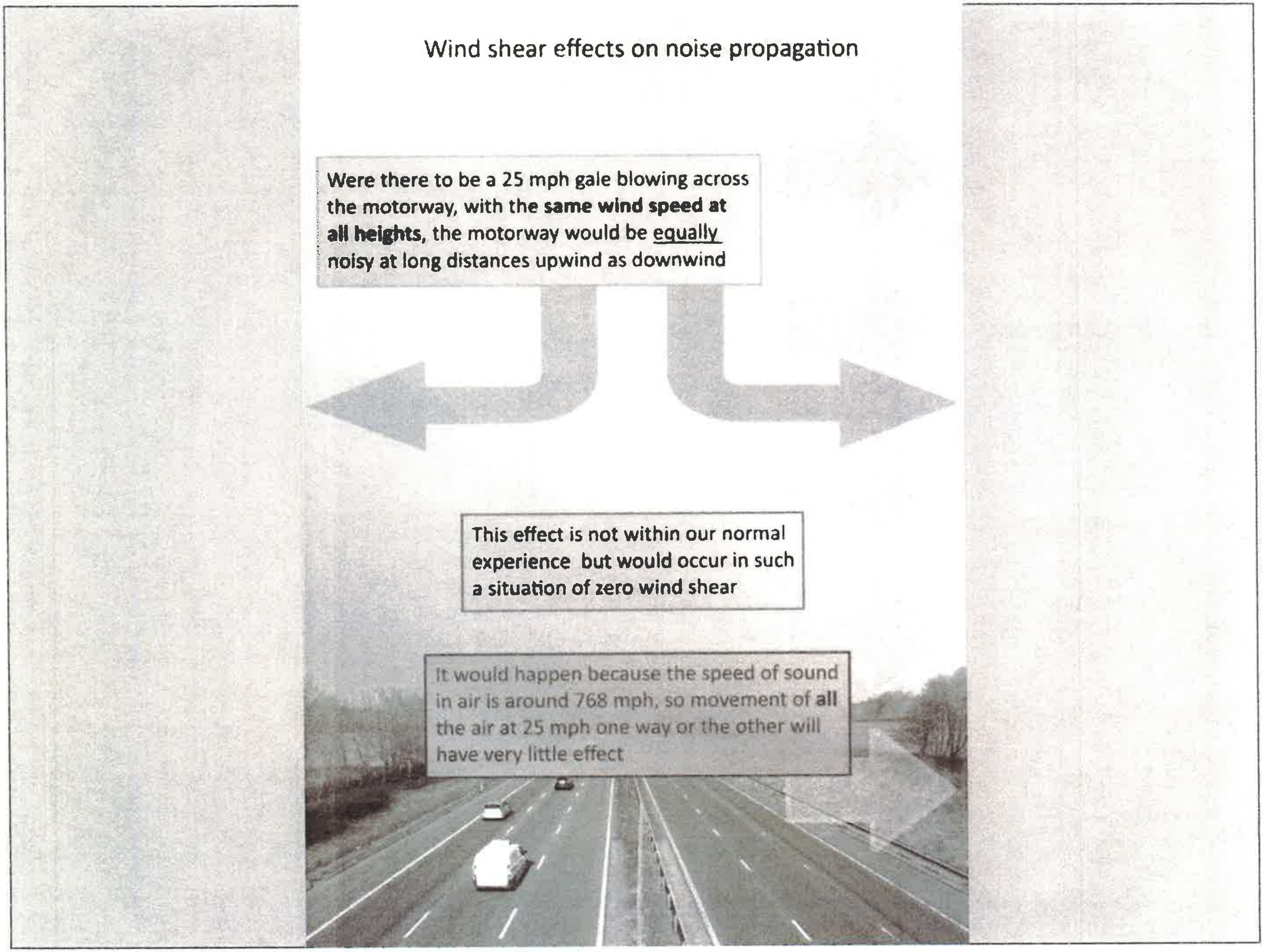
This is **not true of walking** away **on the downwind side:**

noise will persist **at** significant levels for many hundreds of meters



It's as if the wind blows the sound along, but this is in fact **not the case at all**

- <u>this is the crucial point</u>


Wind shear effects on noise propagation
Were there to be a 25 mph gale blowing across the motorway, with the **same wind speed at all heights**, the motorway would be equally noisy at long distances upwind as downwind
This effect is not within our normal experience but would occur in such a situation of zero wind shear
It would happen because the speed of sound in air is around 768 mph, so movement of **all** the air at 25 mph one way or the other will have very little effect

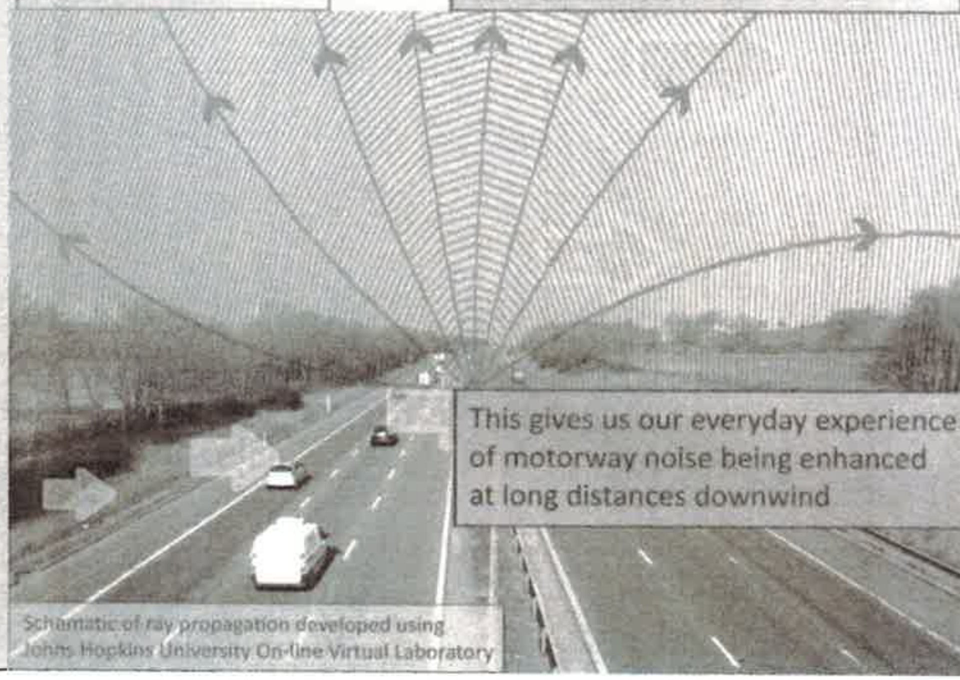
Wind shear effects on noise propagation

But in practice the wind is generally stronger at greater heights, which progressively changes the speed of sound with height

This in turn changes the curvature of the wavefronts and hence the direction of their propagation

The opposite happens on the upwind side

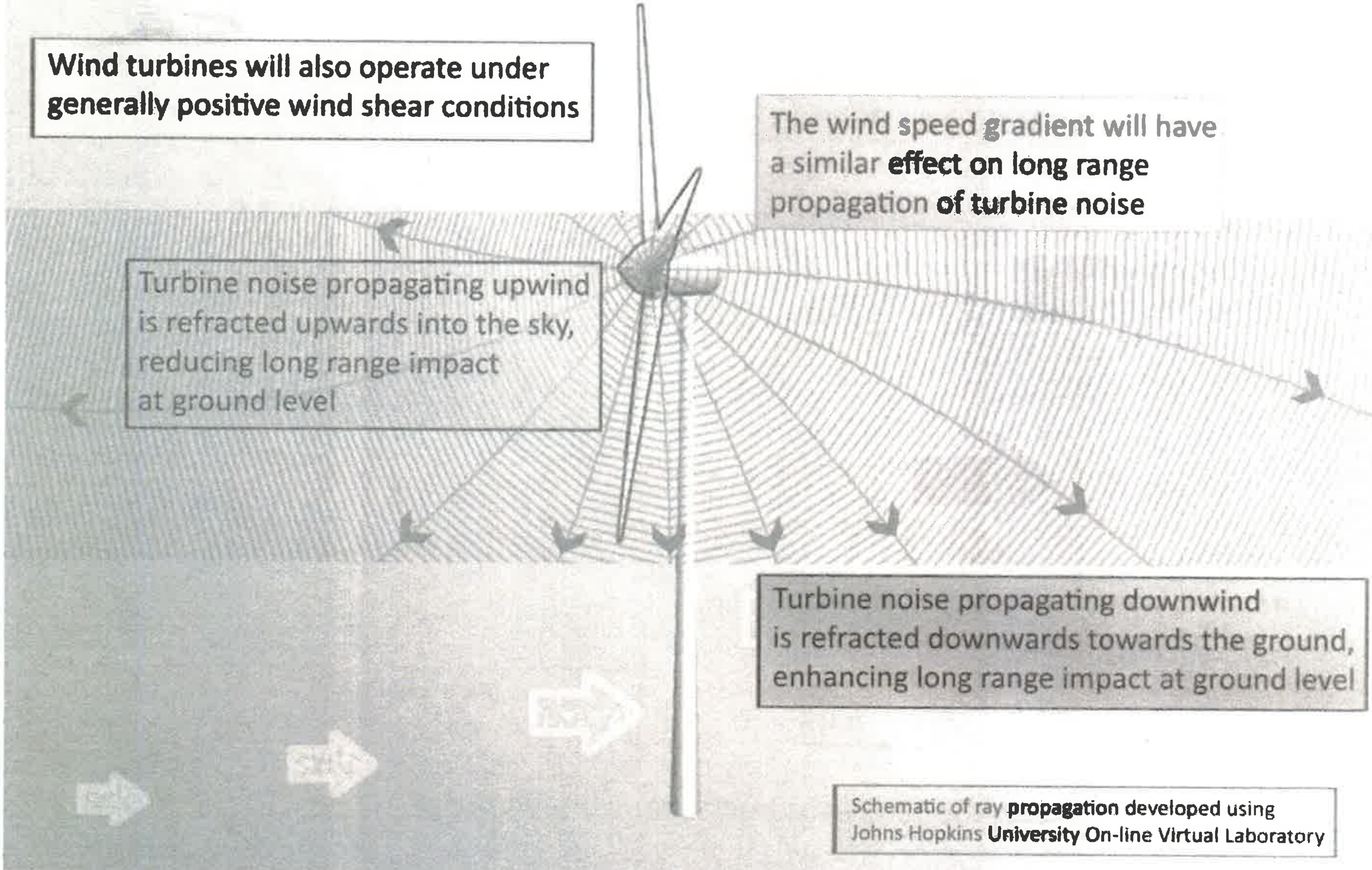
Soundwaves consequently bend back down to earth on the downwind side at longer distances from the source



Section 3

Application to Wind Turbine Noise

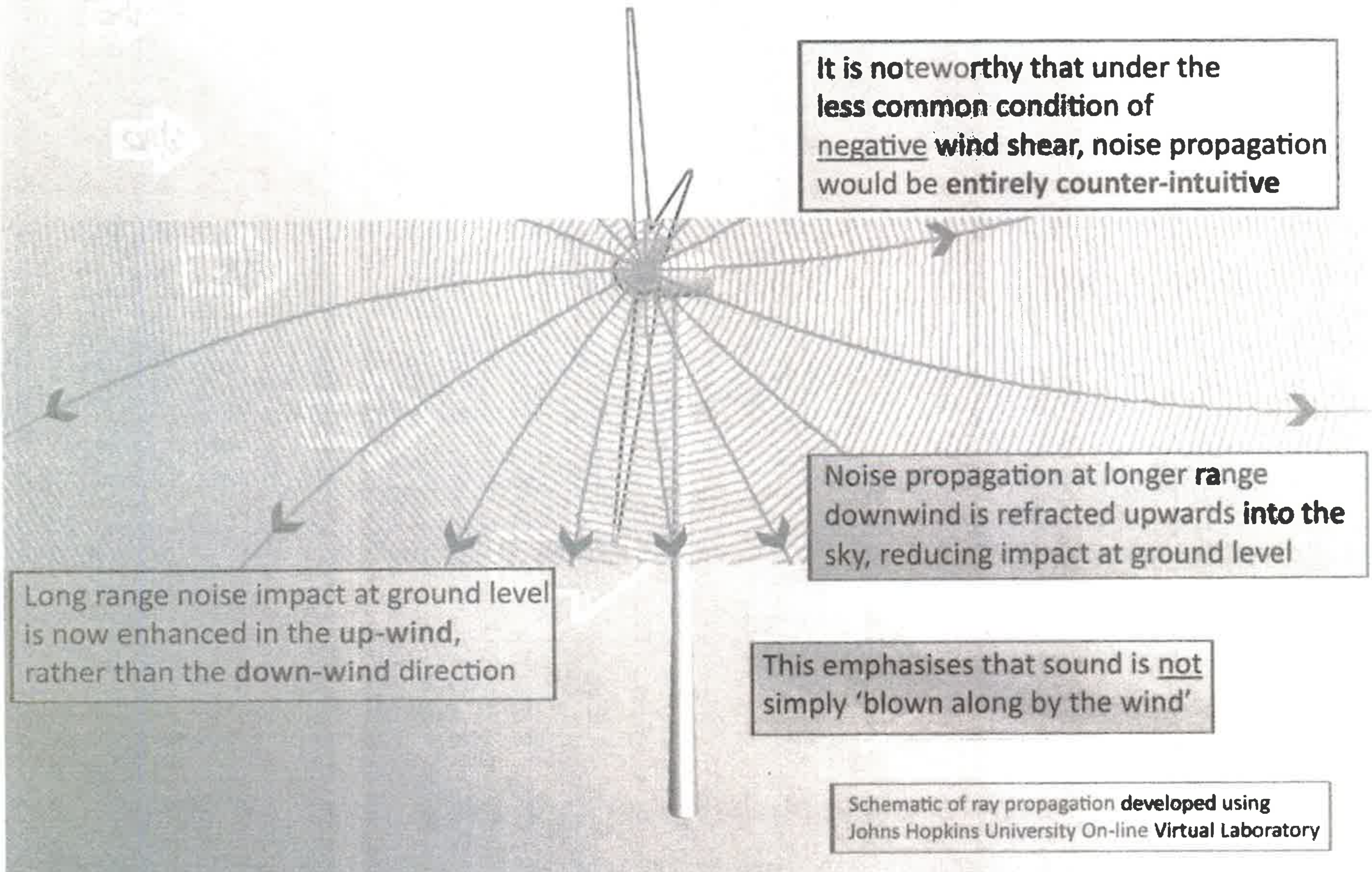
Wind shear effects on noise propagation



502

503

Wind shear effects on noise propagation



Section 4

Implications for Low Altitude Winds

505

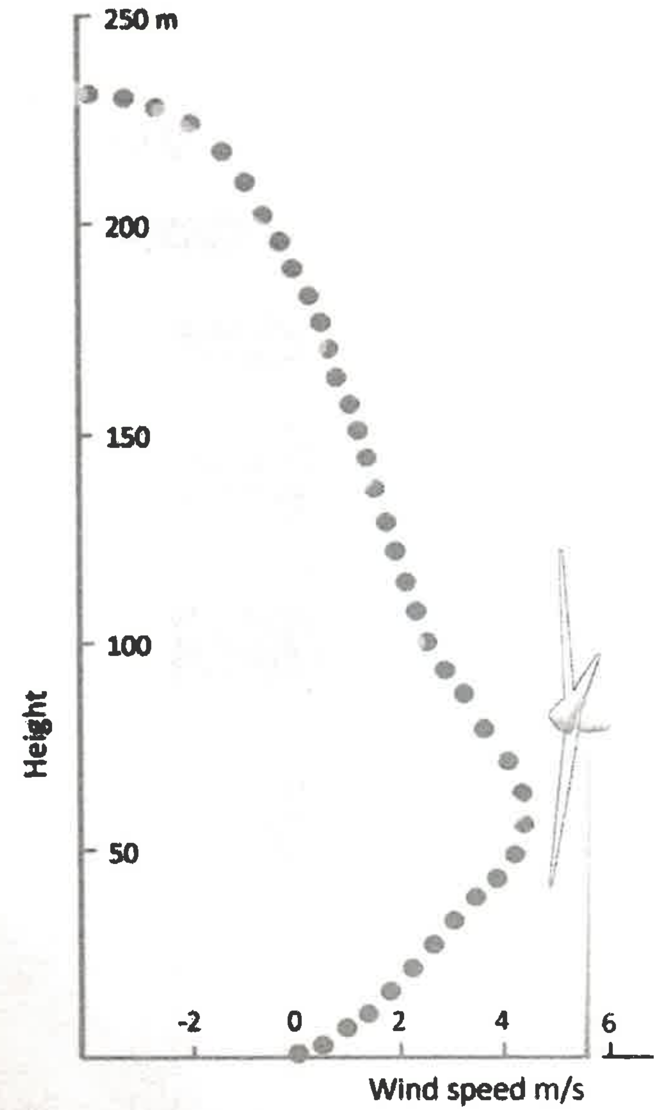
Wind shear effects on noise propagation

One recognised meteorological condition involving a region of negative wind shear is that of a low altitude wind, or 'low-level jet'

A plausible wind speed profile is shown here in relation to the height of a modern wind turbine, illustrating a low level jet with negative wind shear above a height of 50 m

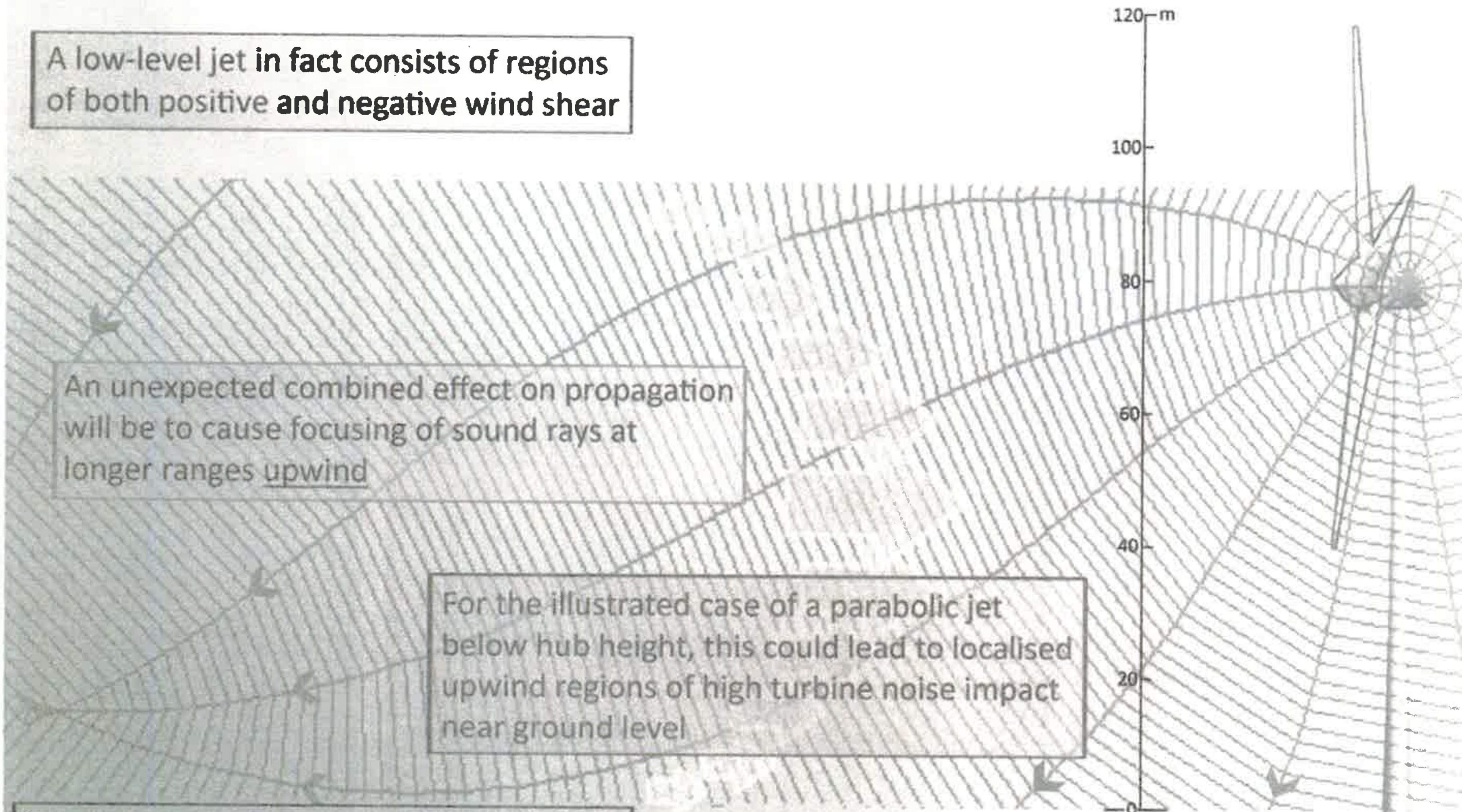
This profile is consistent with measurements presented in a study of road traffic noise propagation in the USA

See Ovenden, Shaffer and Fernando: 'Impact of meteorological conditions on noise propagation from freeway corridors' Journal of the Acoustical Society of America, 126 (1), July 2009



Wind shear effects on noise propagation

A low-level jet in fact consists of regions of both positive and negative wind shear



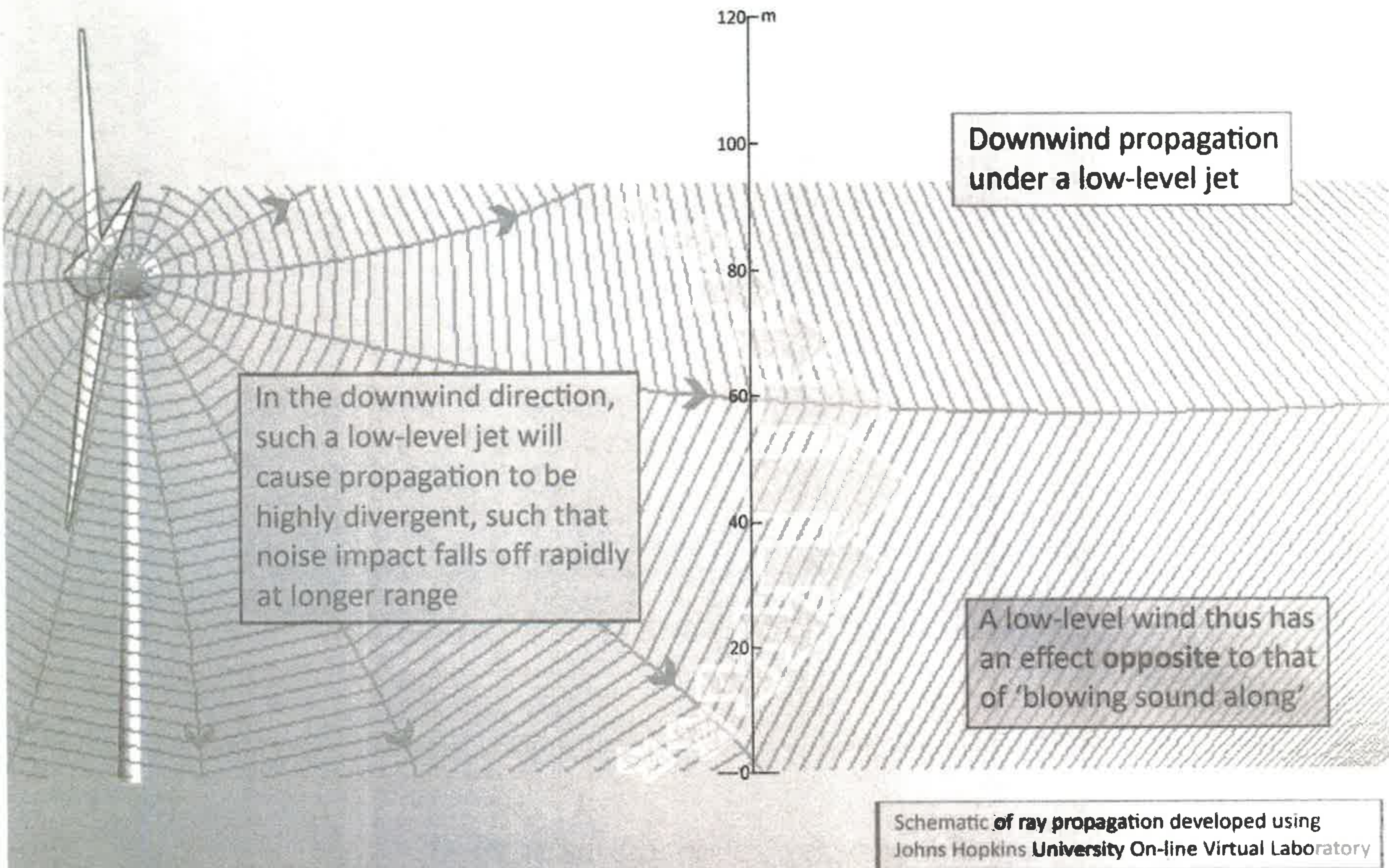
An unexpected combined effect on propagation will be to cause focusing of sound rays at longer ranges upwind

For the illustrated case of a parabolic jet below hub height, this could lead to localised upwind regions of high turbine noise impact near ground level

Wind shear can thus produce seemingly anomolous behaviour under certain well-recognised meteorological conditions

Schematic of ray propagation developed using Johns Hopkins University On-line Virtual Laboratory

Wind shear effects on noise propagation



Section 5

Wind Shear in Practice

509

Wind shear in practice

Wind shear varies significantly and systematically over the course of 24 hours, according to the meteorological condition of the atmosphere

Whilst positive wind shear is the normal condition, zero or negative wind shear can occur in practice, as made clear in the 'Acoustic Bulletin Agreement' of April 2009:

...."On some sites and in some wind conditions the situation may arise that the wind speed U_1 (at the greater height H_1) is equal to or lower than the wind speed U_2 at the lower height H_2."

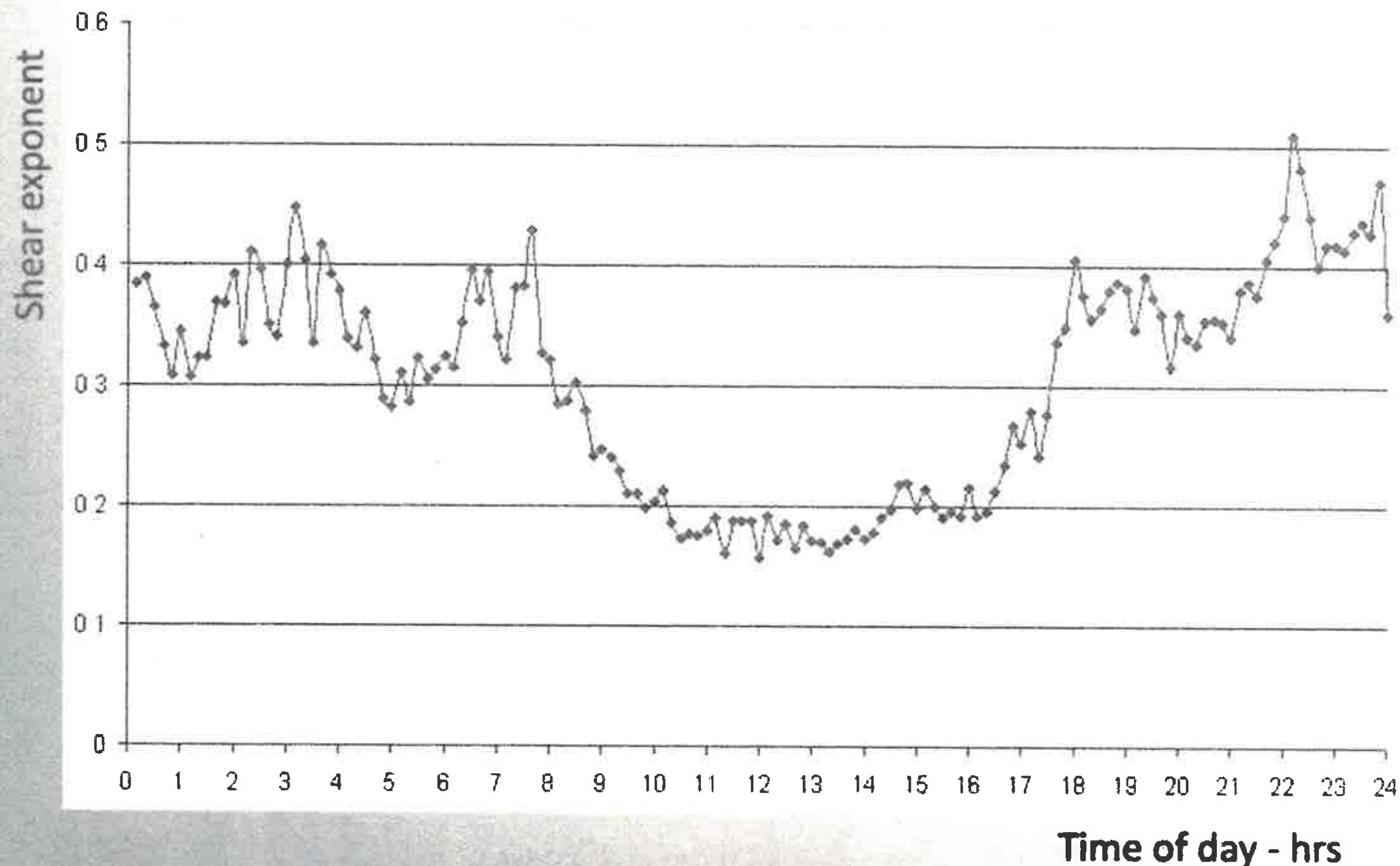
The following illustrations pertain to a proposed wind farm site in Gloucestershire, and show measured diurnal variation in positive wind shear at 60 to 70 m height, spanning 3 seasons of the year - each figure represents the average for a different season, taken over a period of at least 6 weeks

The figures are based on developer's tall mast measurements of wind speeds, recorded every 10 minutes at heights of 60 and 71 m, and were accepted as evidence at Public Inquiry

Wind shear in practice

Daily variation in wind shear averaged over 7 weeks in spring

- Berkeley Vale 2010

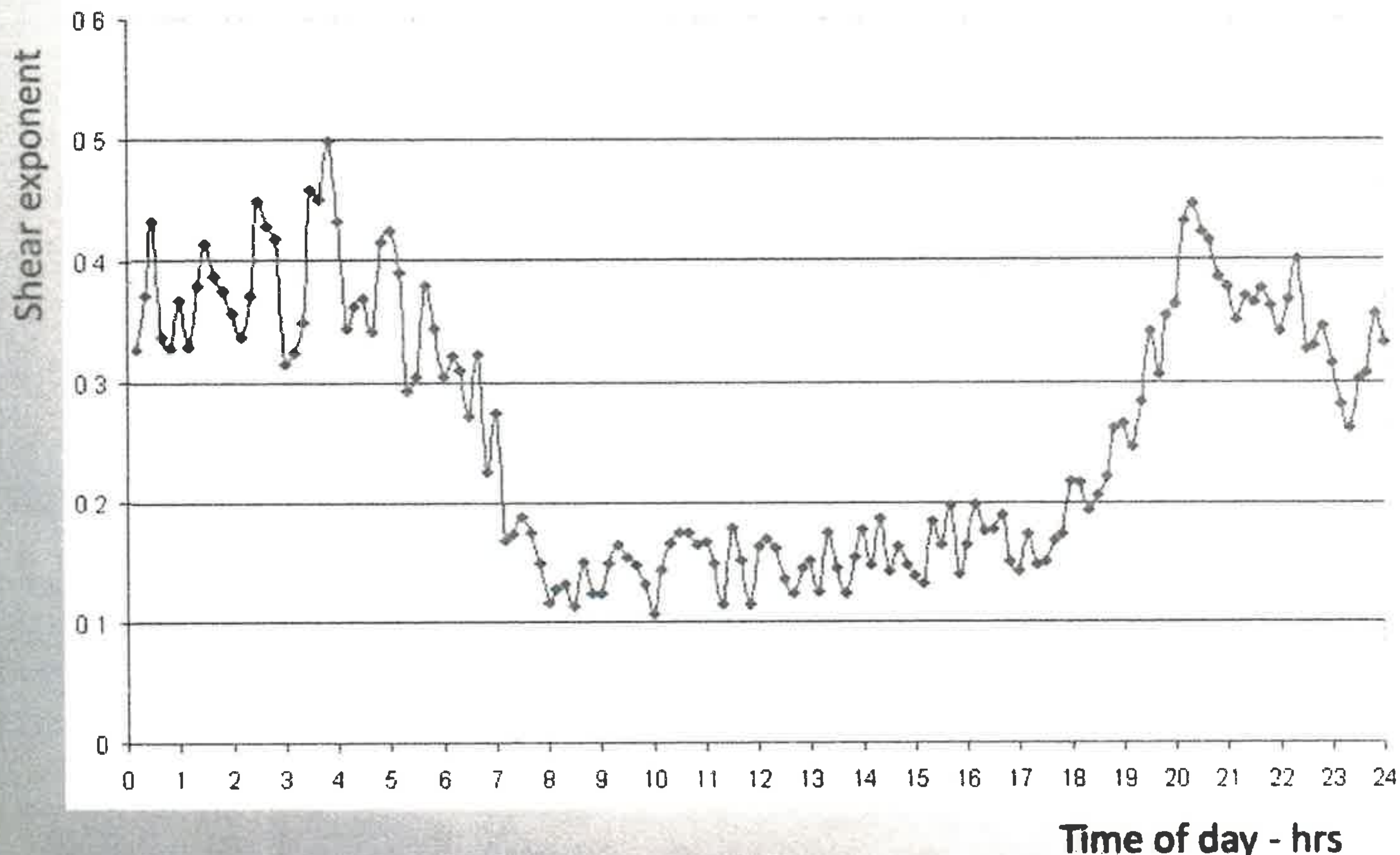


511

Wind shear in practice

Daily variation in wind shear averaged over 6 weeks in early summer

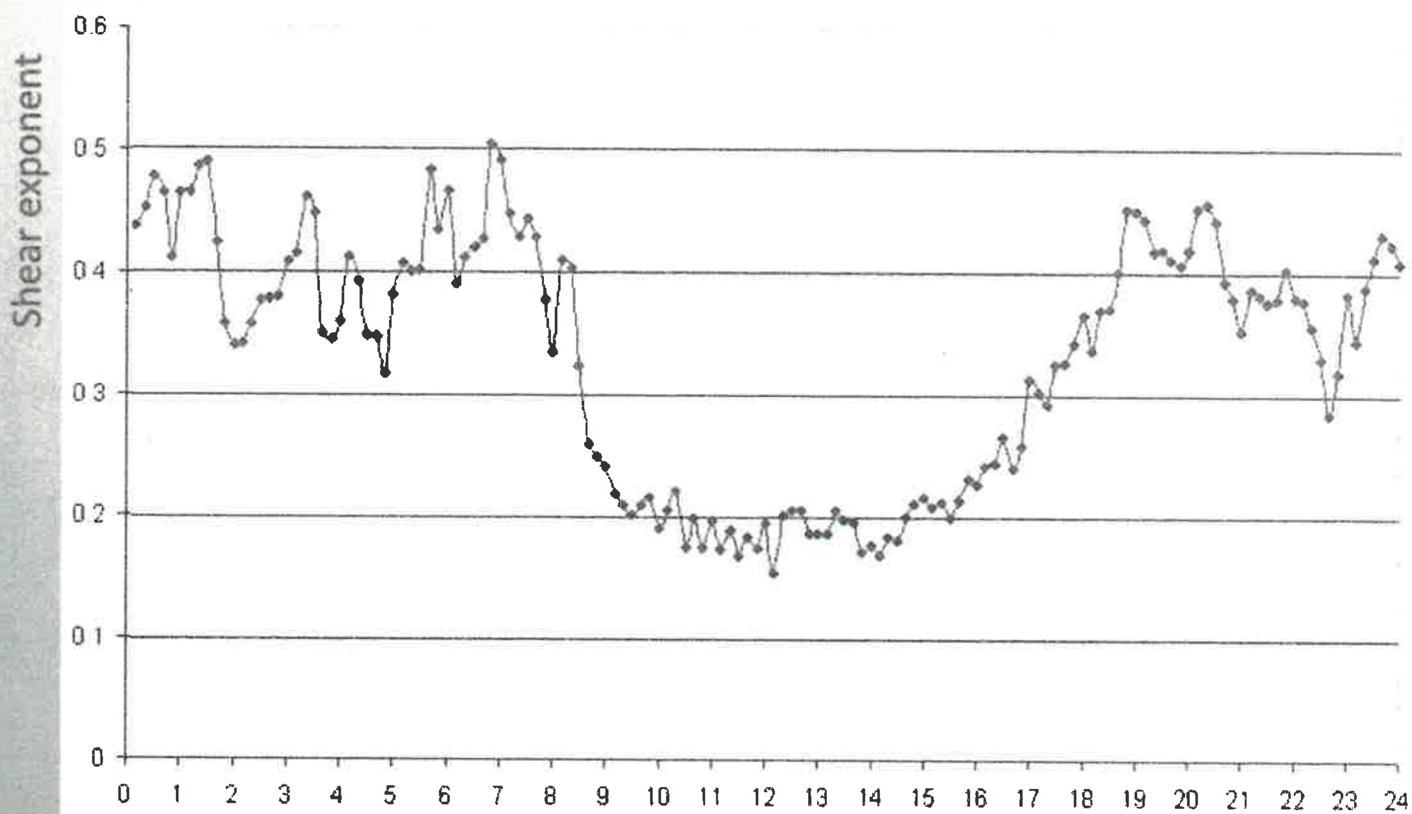
- Berkeley Vale 2010



Wind shear in practice

Daily variation in wind shear averaged over 7 weeks in early autumn

- Berkeley Vale 2010



Time of day - hrs

Wind shear in practice

The above analysis shows systematic daily patterns of very significant wind shear variation at this proposed UK wind farm site

Diurnal variation in wind shear exponent α is strikingly similar across the seasons
- strongest variation is observed in early summer

These results are more extreme than similar observations in a wide-ranging US Department of Energy study, of wind shear in the US Central Plains at heights relevant to modern turbines

See:
Wind shear characteristics at Central Plains tall towers
M. Schwartz and D. Elliott
American Wind Energy Association WindPower 2006 Conference
Pittsburgh, Pennsylvania, June 4–7, 2006

The UK observations of consistently high night-time shears, $\alpha = 0.4$ to 0.5, recorded over 3 different seasons at a single location, were not encountered in the US study covering the entire length of America

Section 6

Implications of Wind Shear Variation

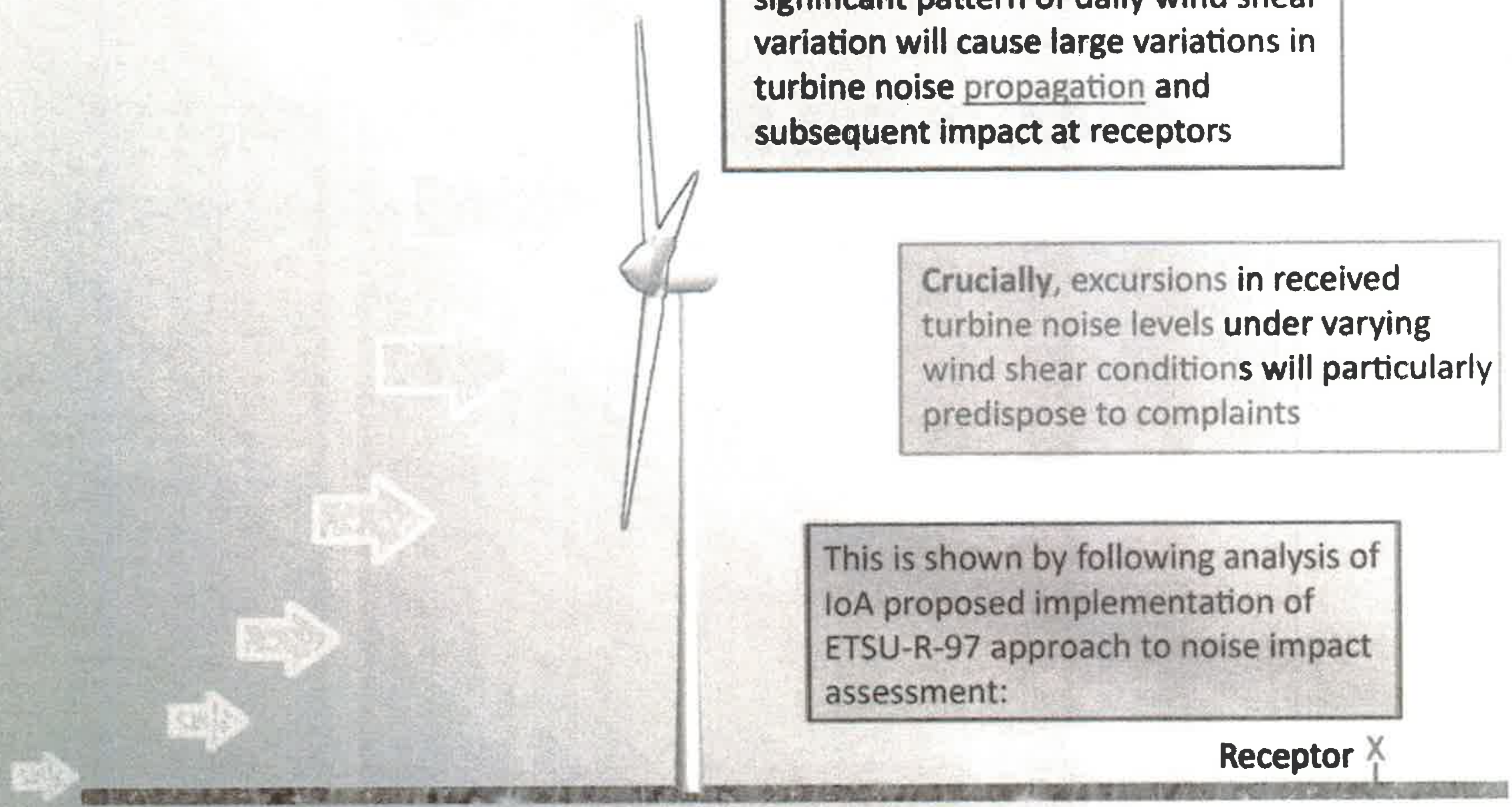
(i) Overview

Implications of wind shear variation

Owing to the effects of refraction, this significant pattern of daily wind shear variation will cause large variations in turbine noise propagation and subsequent impact at receptors

Crucially, excursions in received turbine noise levels under varying wind shear conditions will particularly predispose to complaints

This is shown by following analysis of IoA proposed implementation of ETSU-R-97 approach to noise impact assessment:

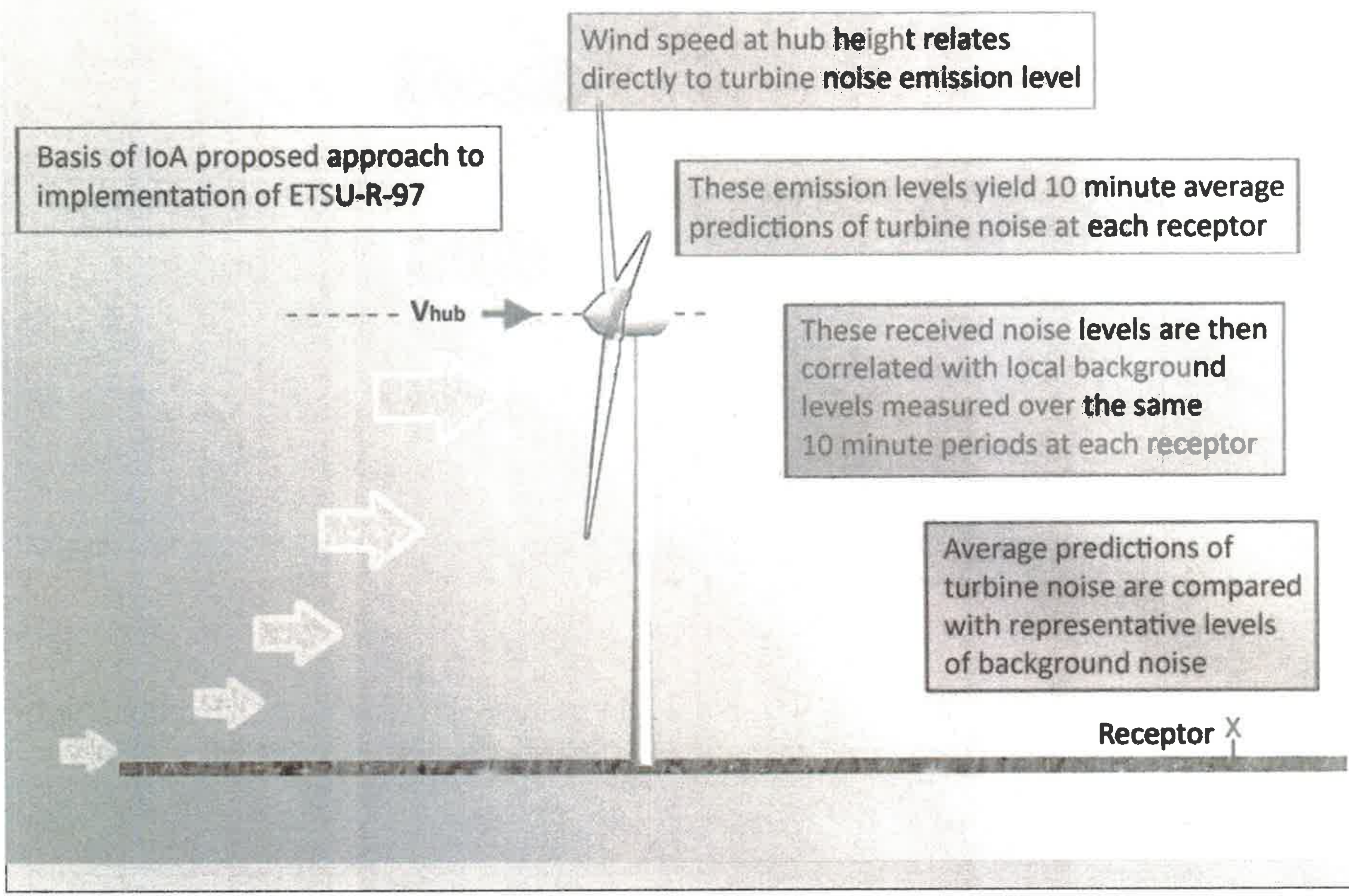


Section 6

Implications of Wind Shear Variation

(ii) IoA proposed approach
to implementation of ETSU-R-97

Implications of wind shear variation



Section 6

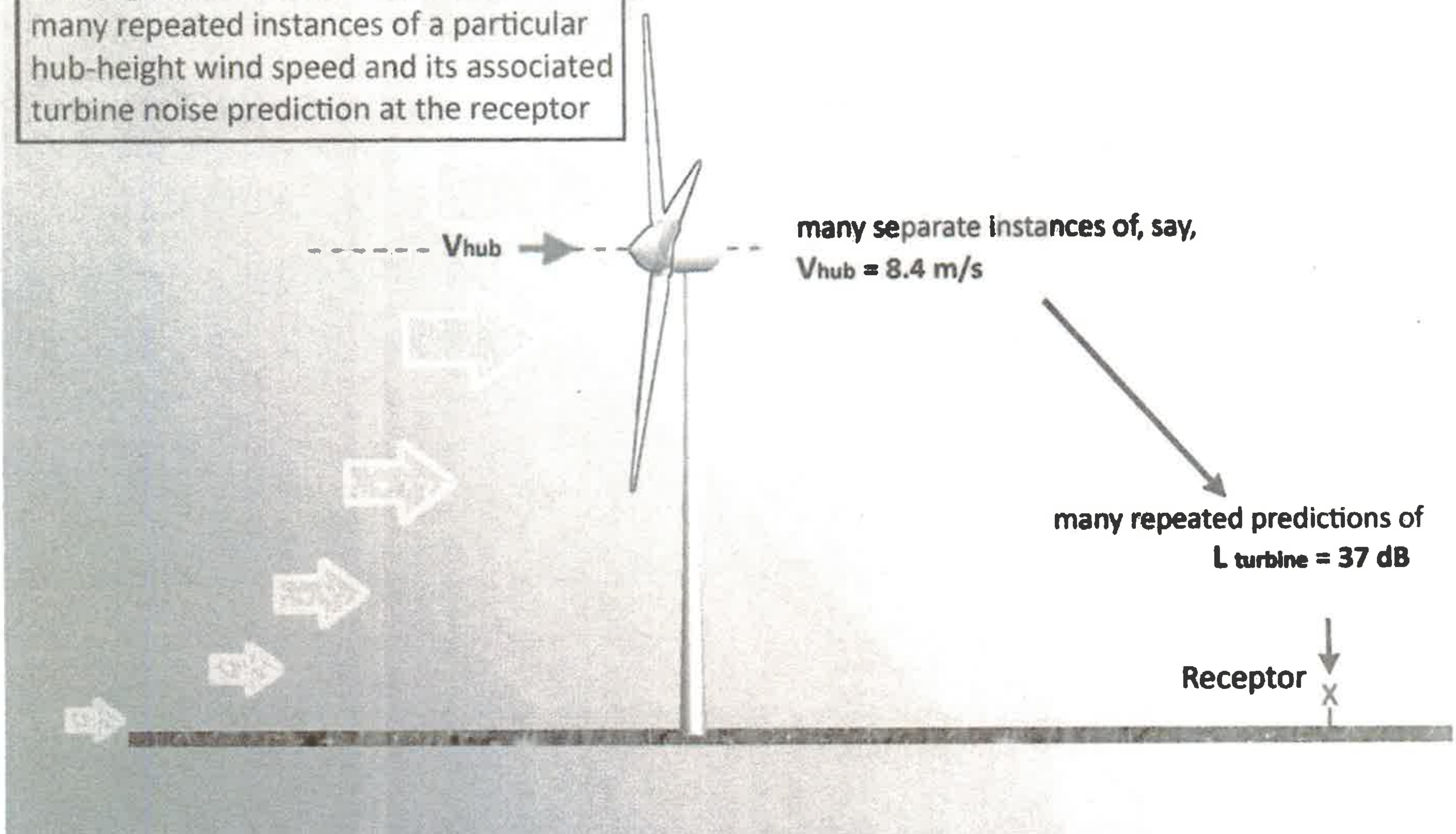
Implications of Wind Shear Variation

(iii) Analysis - A

519

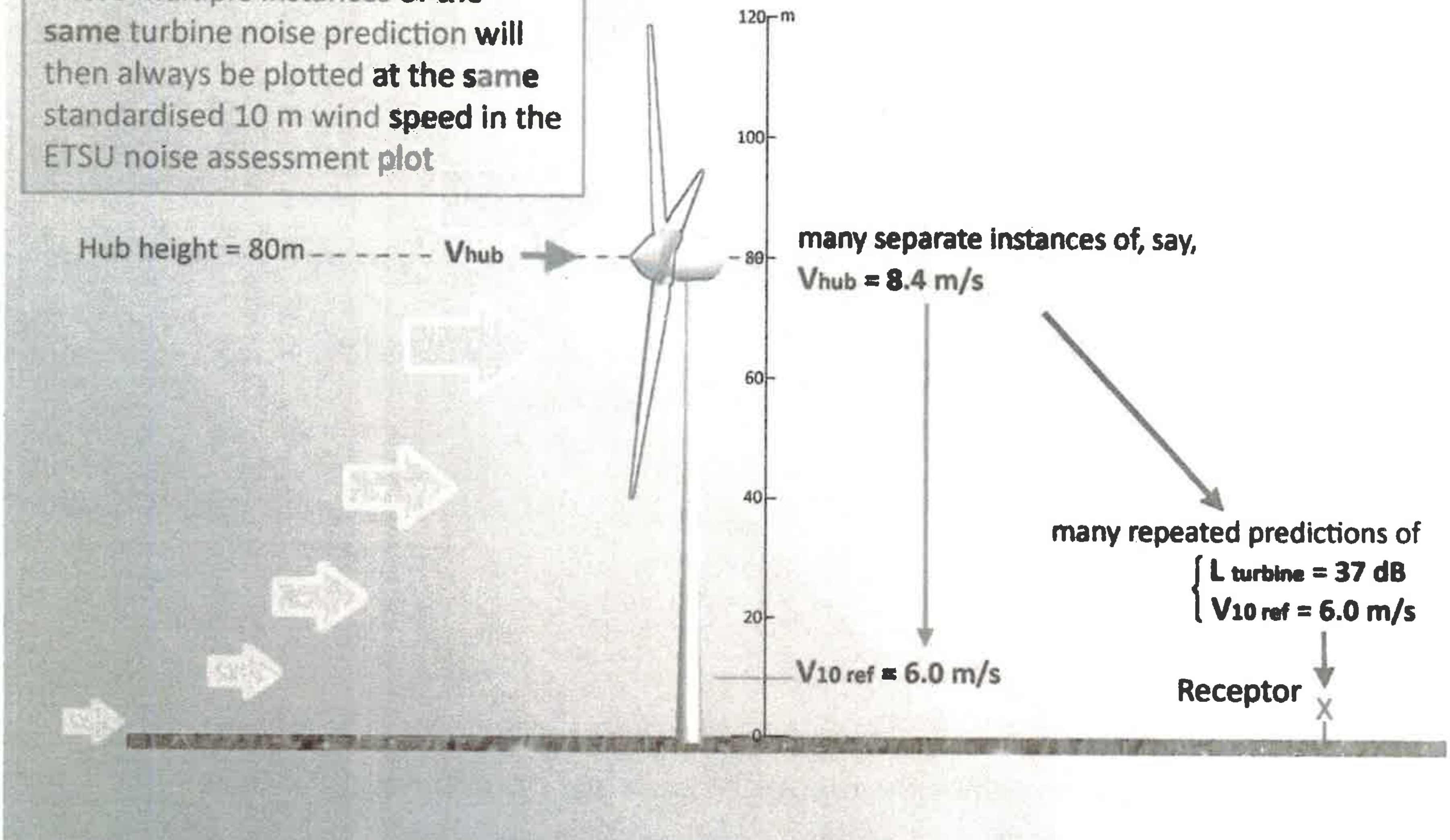
Implications of wind shear variation for noise impact assessment

A background noise survey could record many repeated instances of a particular hub-height wind speed and its associated turbine noise prediction at the receptor



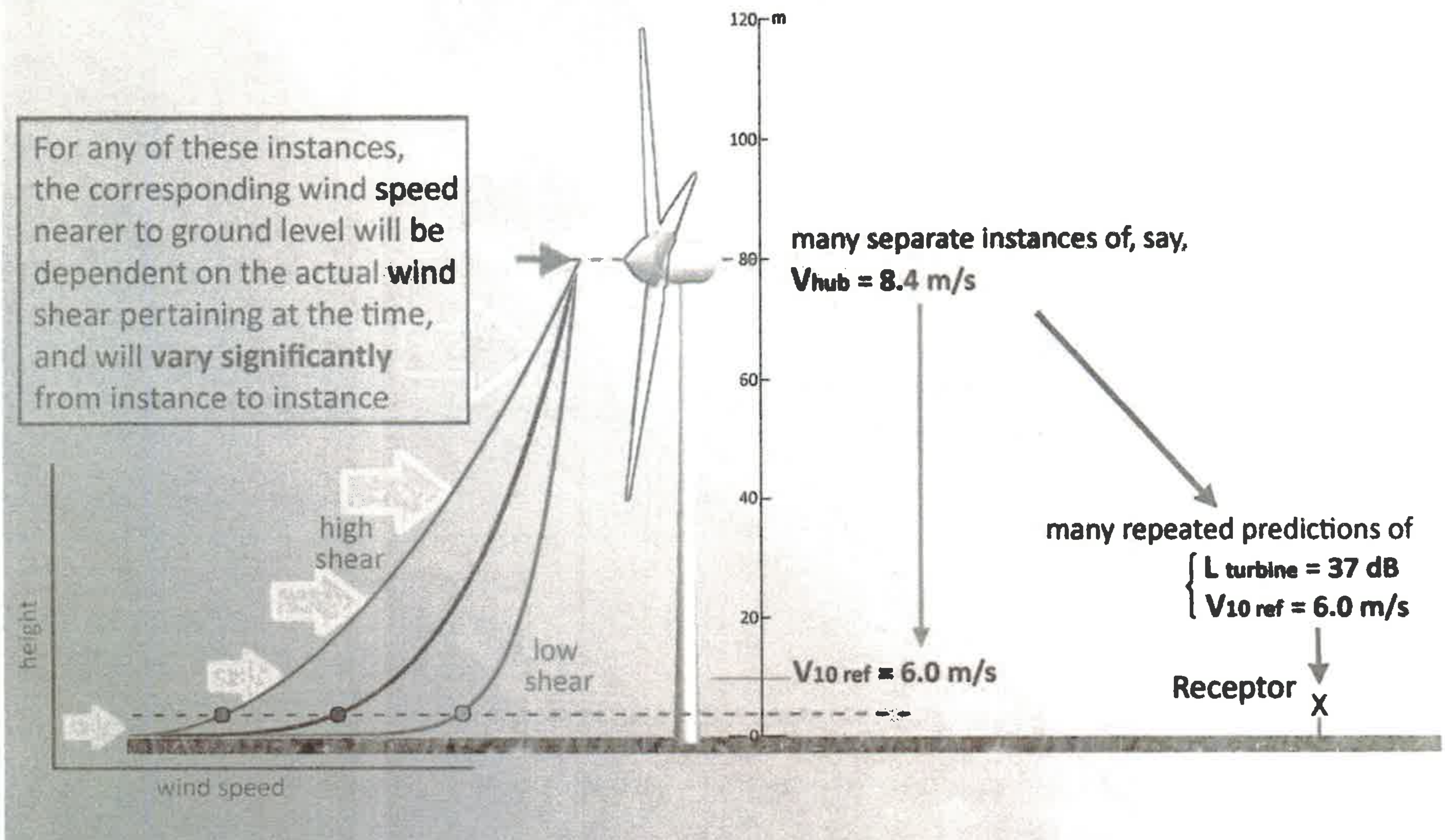
Implications of wind shear variation for noise impact assessment

These multiple instances **of the same** turbine noise prediction **will** then always be plotted **at the same** standardised 10 m wind **speed in the** ETSU noise assessment plot

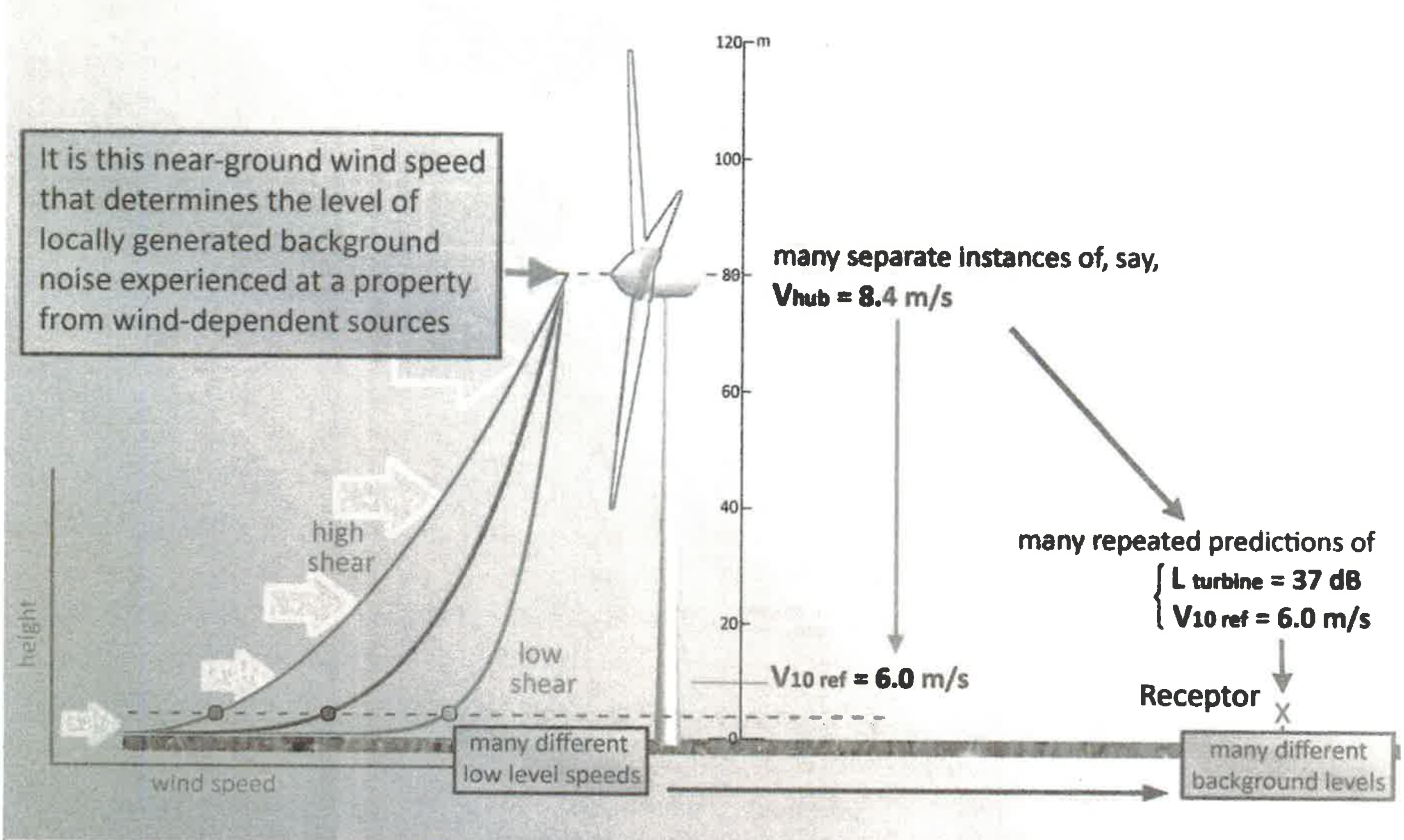


521

Implications of wind shear variation for noise impact assessment

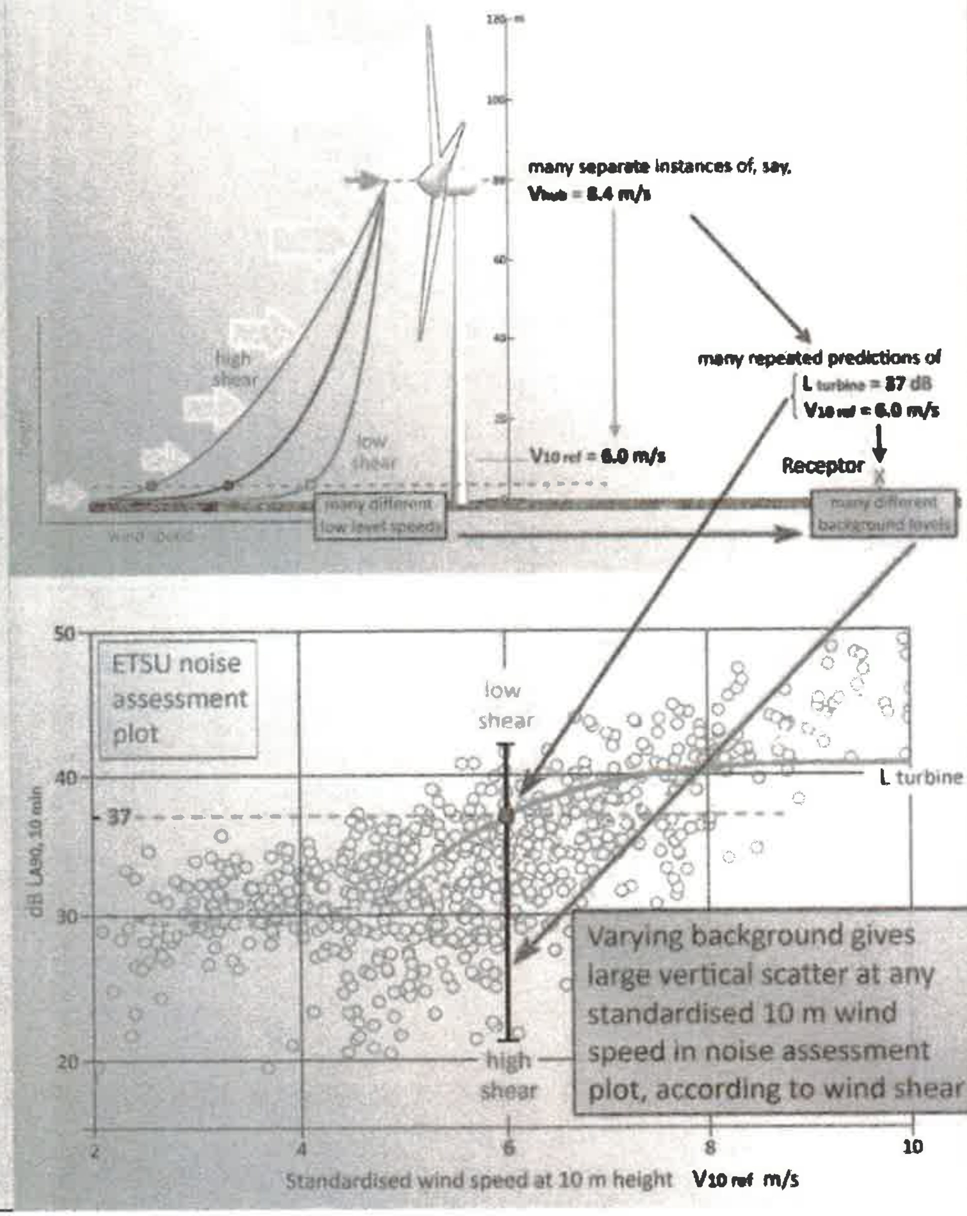


Implications of wind shear variation for noise impact assessment

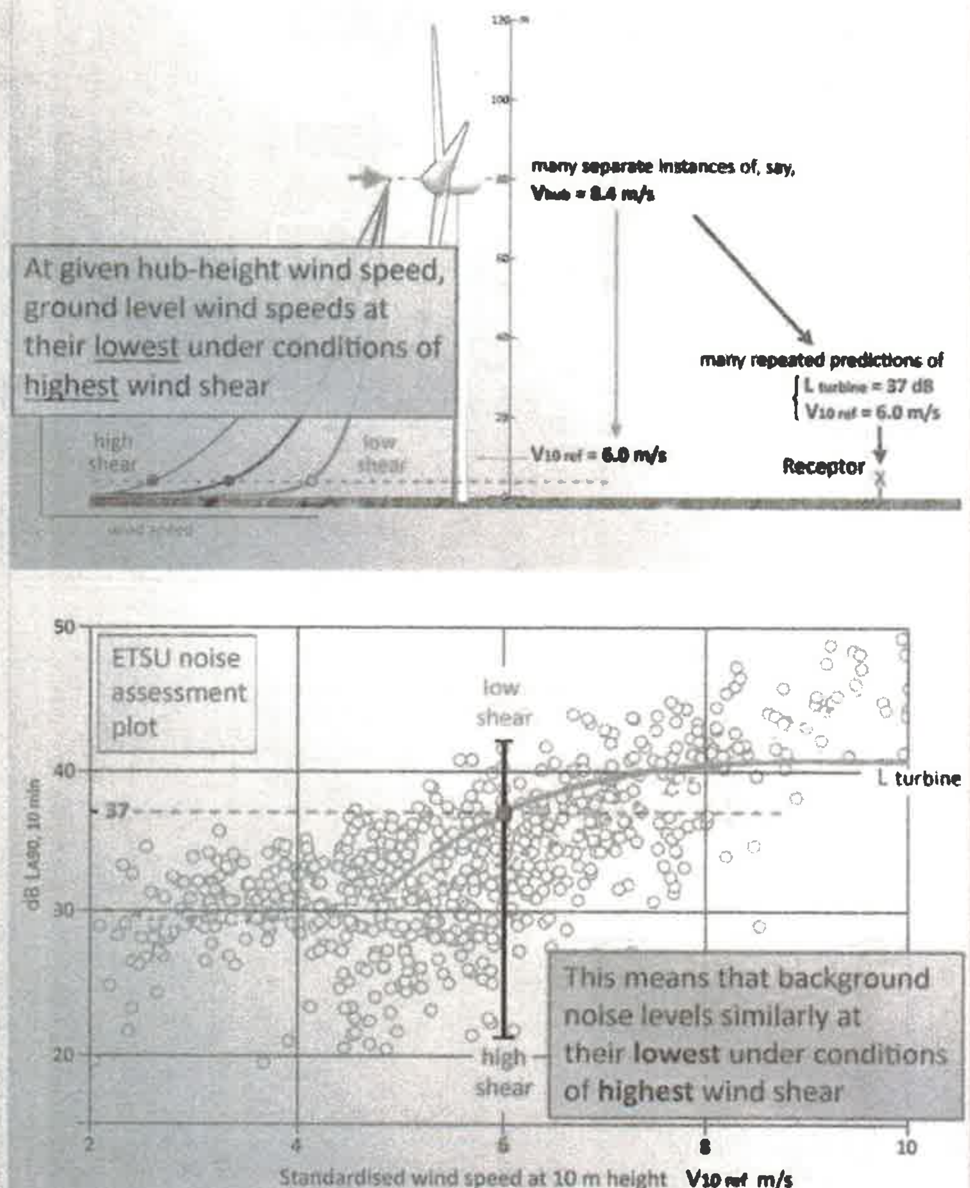


523

Implications of wind shear variation for noise impact assessment



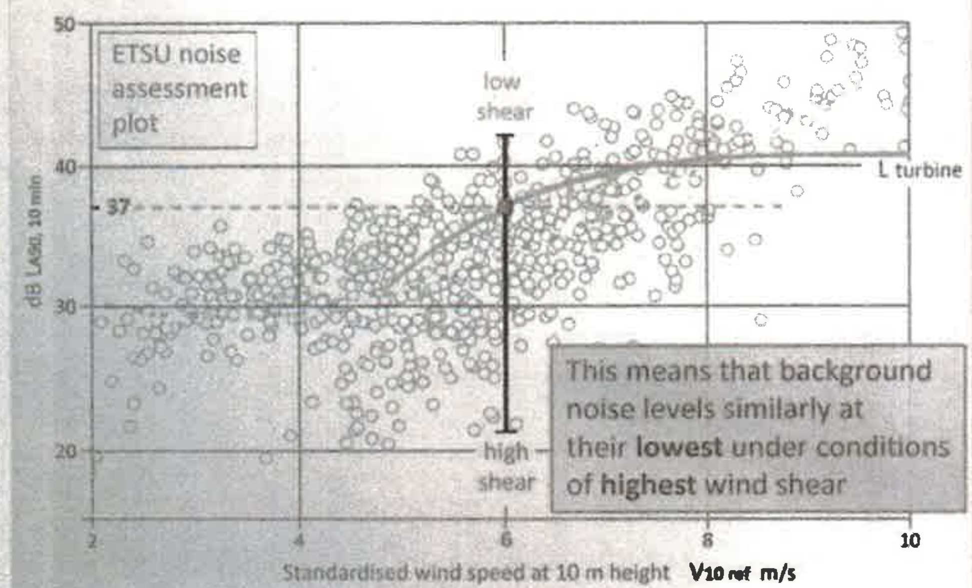
Implications of wind shear variation for noise impact assessment



525

Implications of wind shear variation for noise impact assessment

Focusing attention **on the** ETSU noise assessment plot **below:**



This means that background noise levels similarly at their **lowest** under conditions of **highest** wind shear

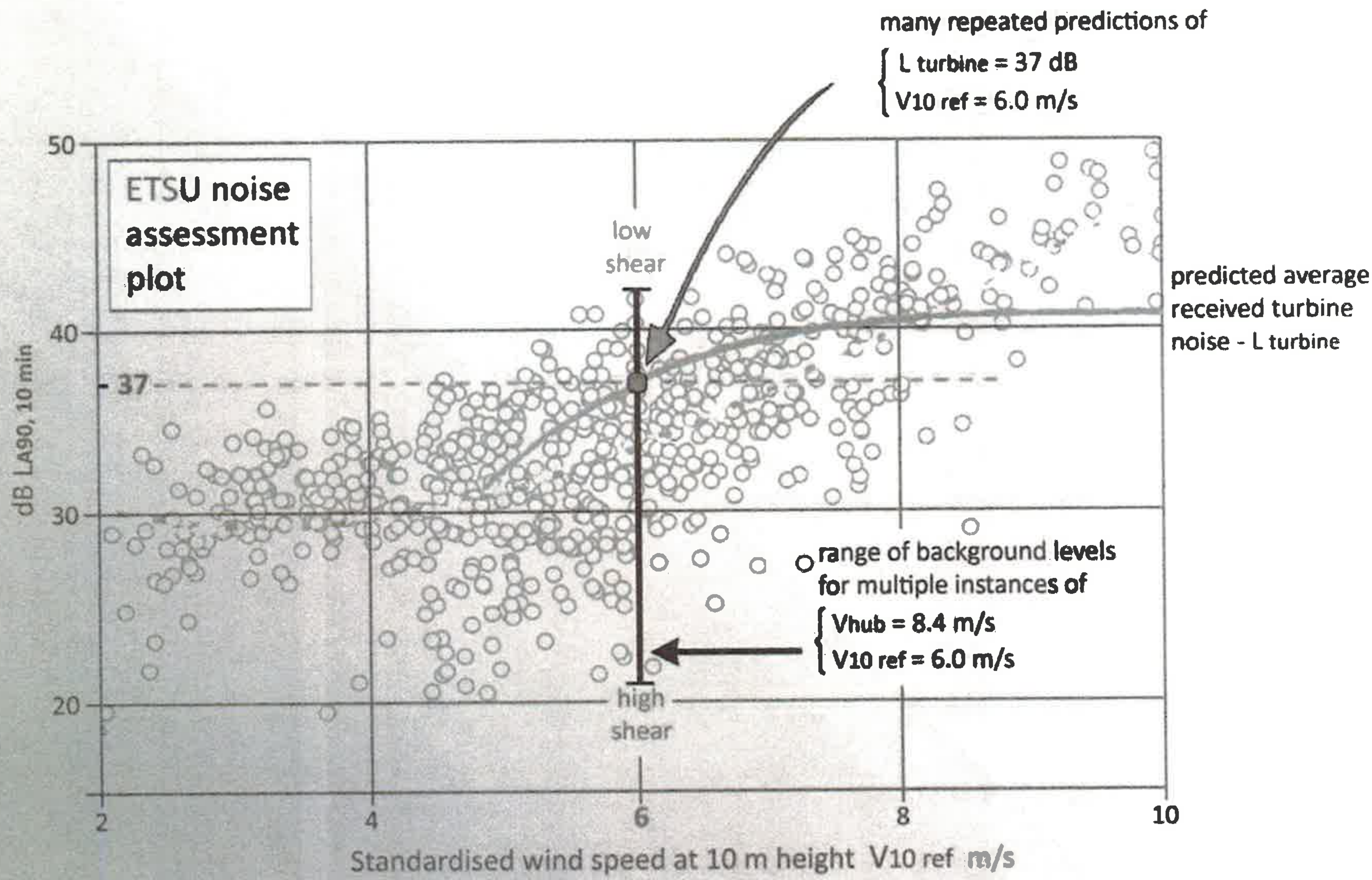
Section 6

Implications of Wind Shear Variation

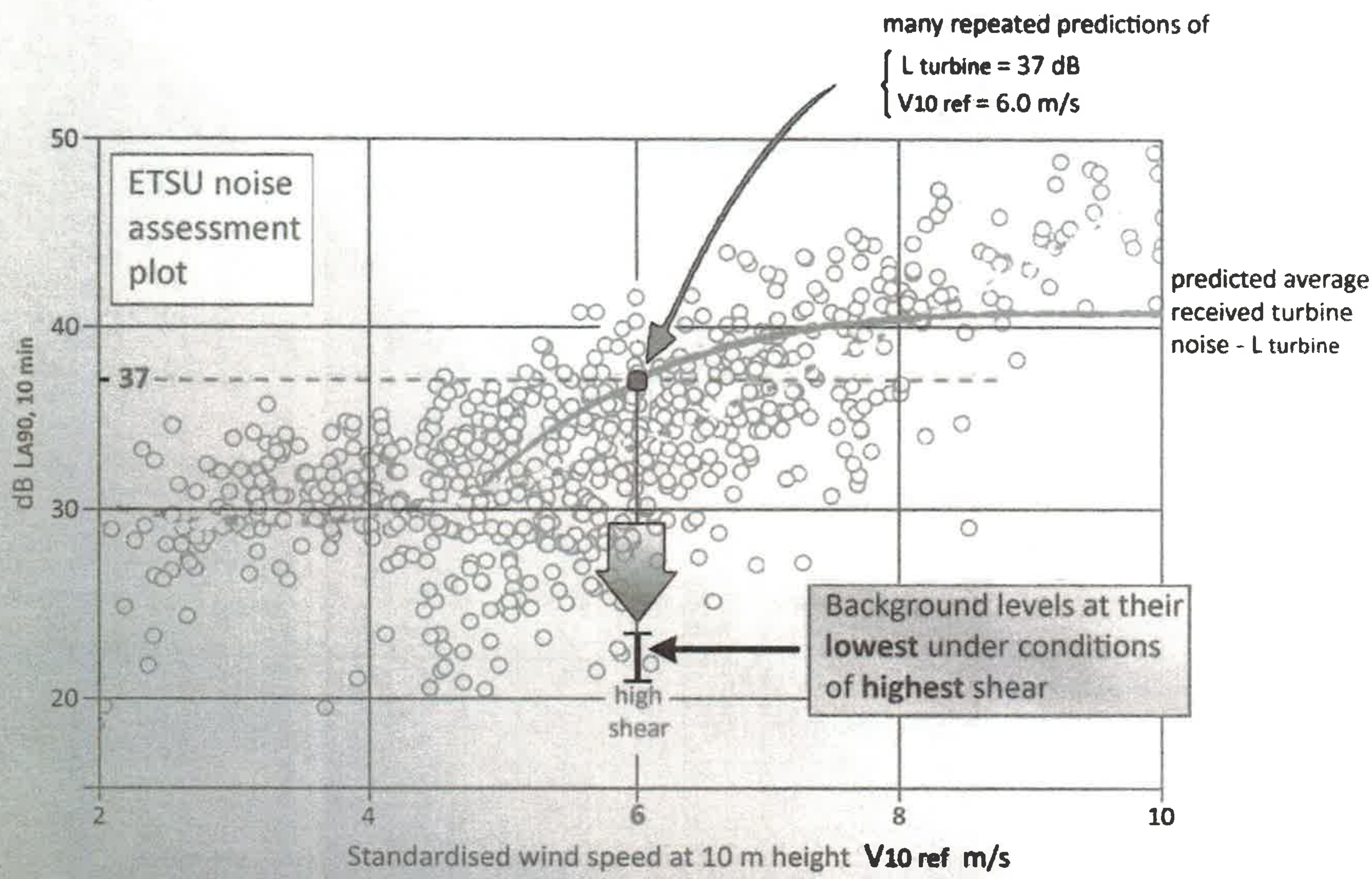
(iv) Analysis - B

527

Implications of wind shear variation for noise impact assessment



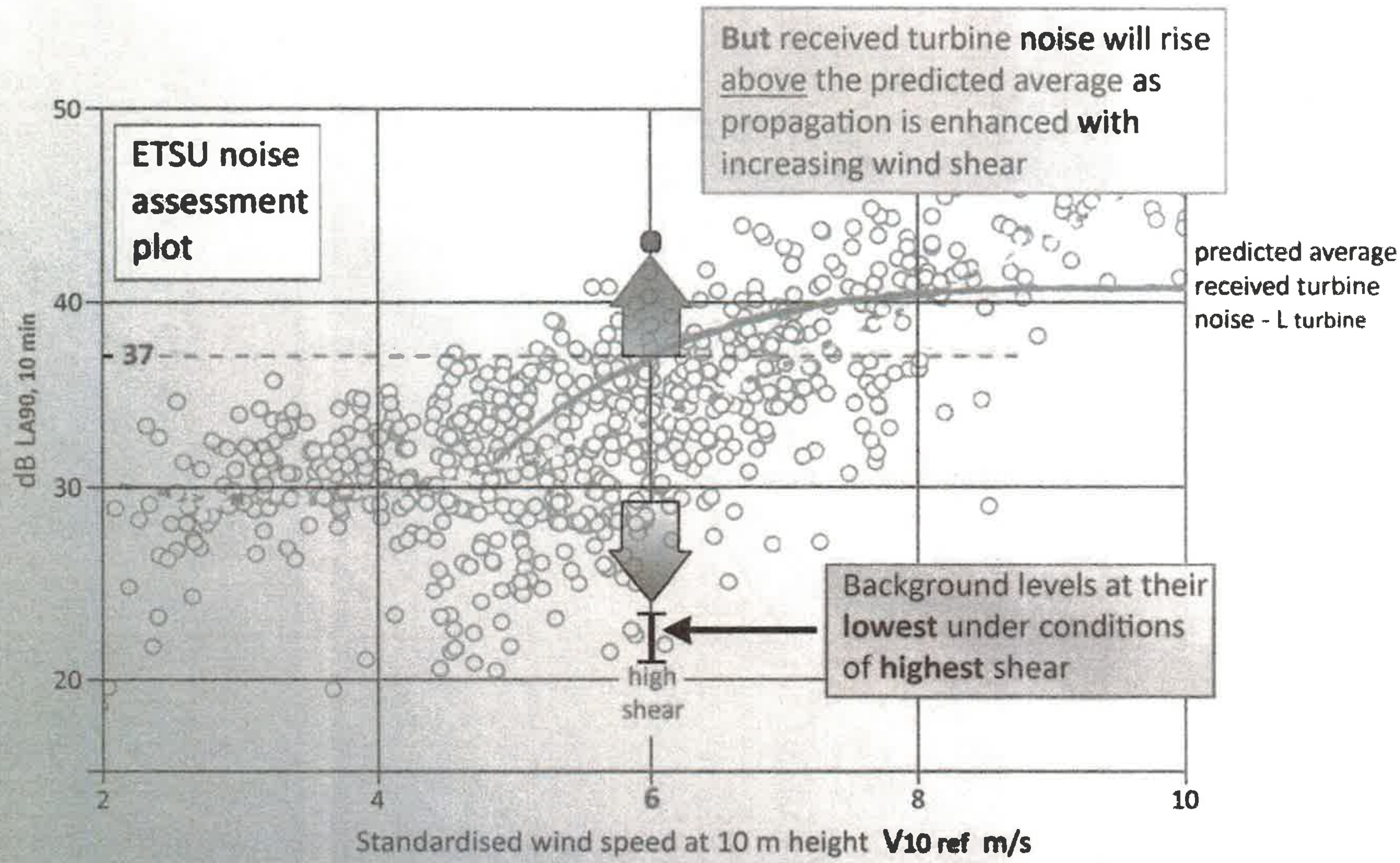
Implications of wind shear variation for noise impact assessment



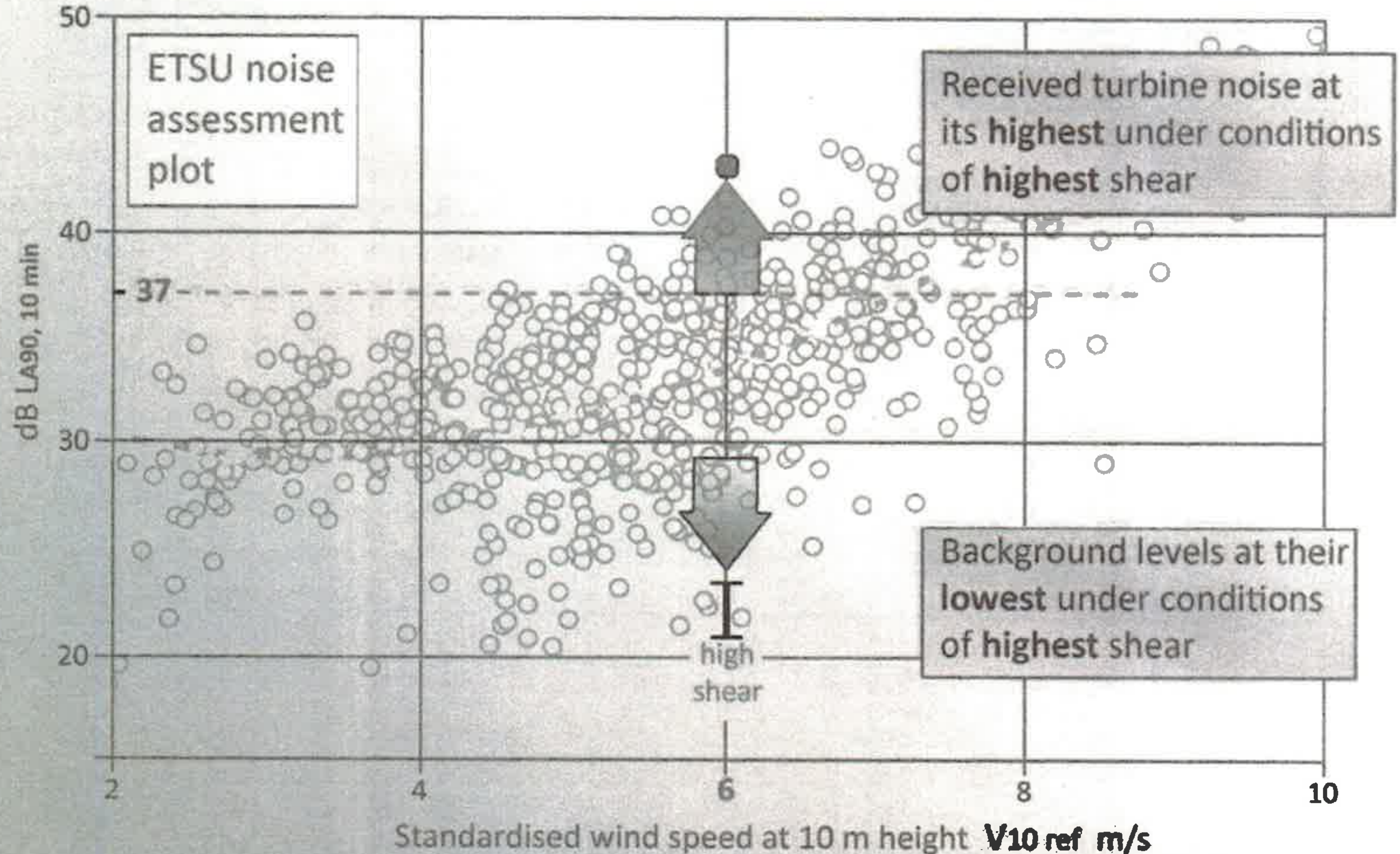
528

529

Implications of wind shear variation for noise impact assessment

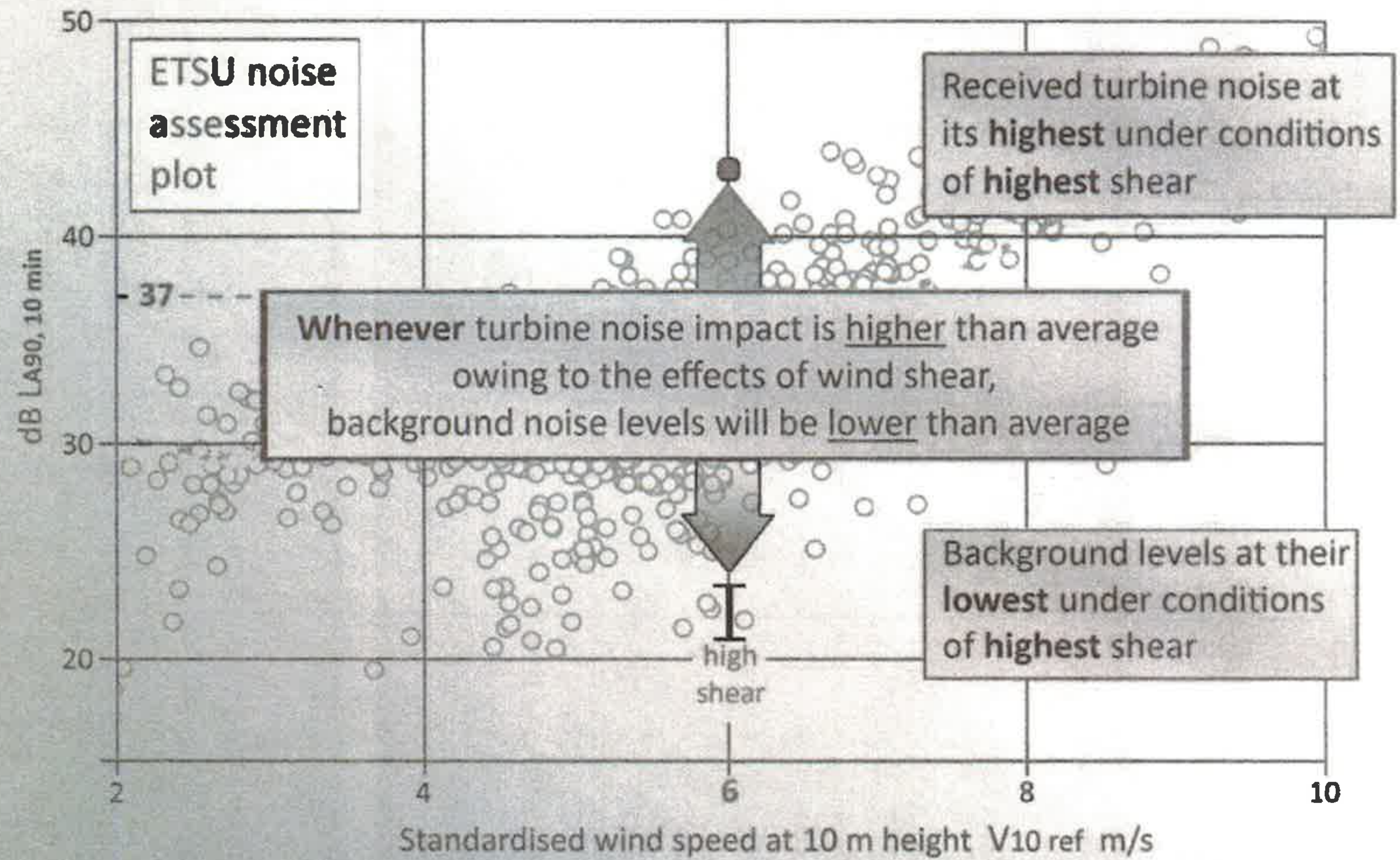


Implications of wind shear variation for noise impact assessment

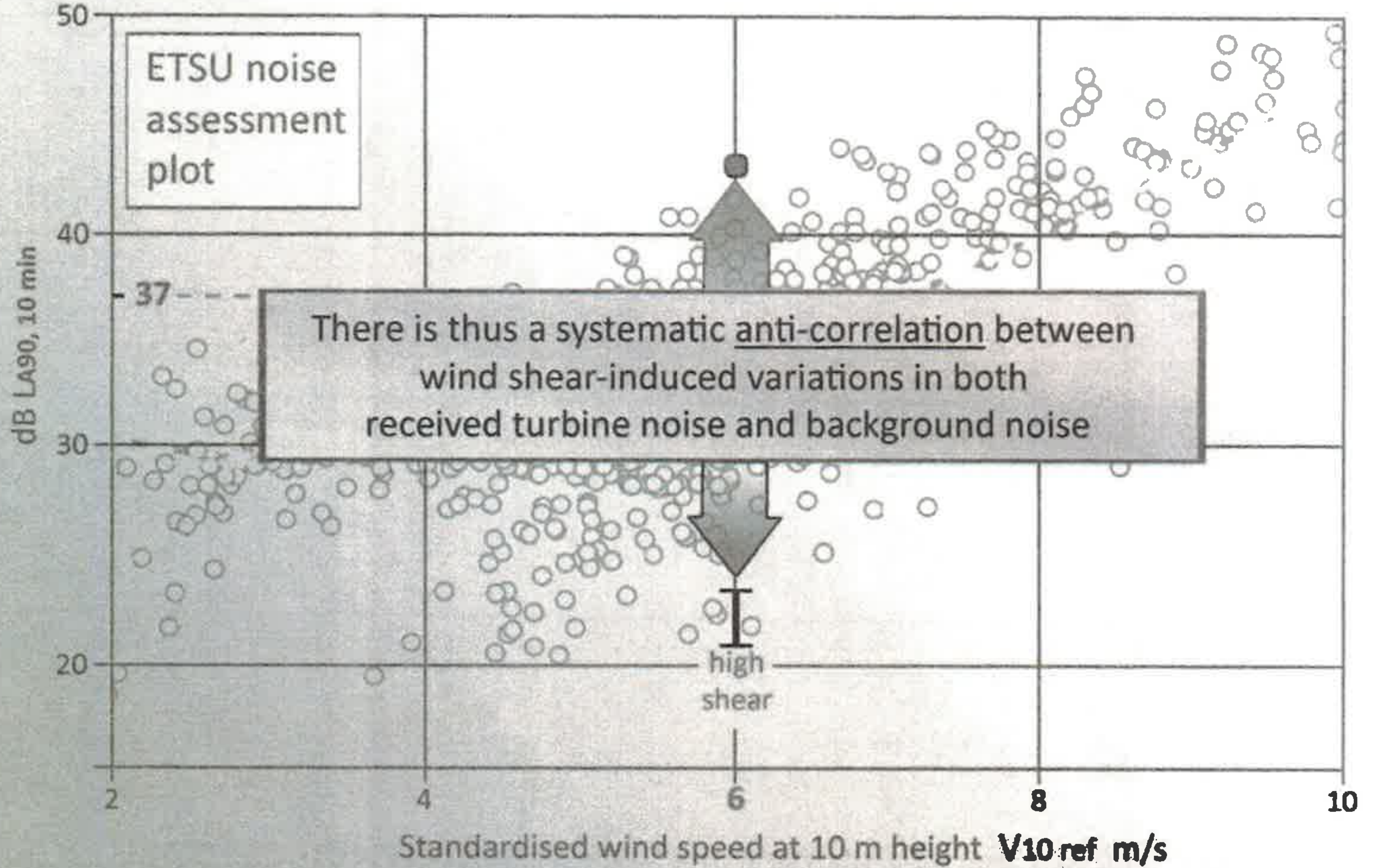


531

Implications of wind shear variation for noise impact assessment

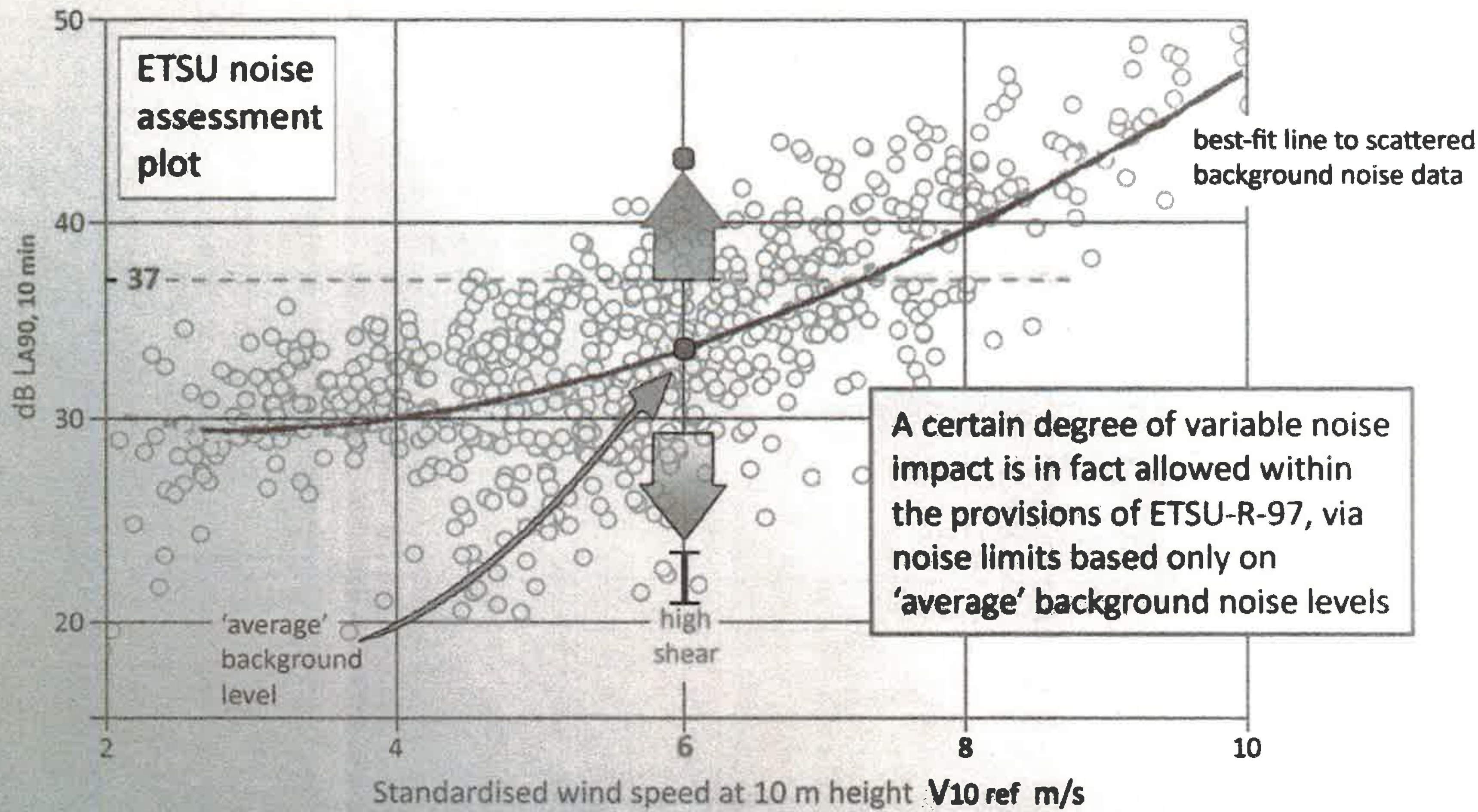


Implications of wind shear variation for noise impact assessment

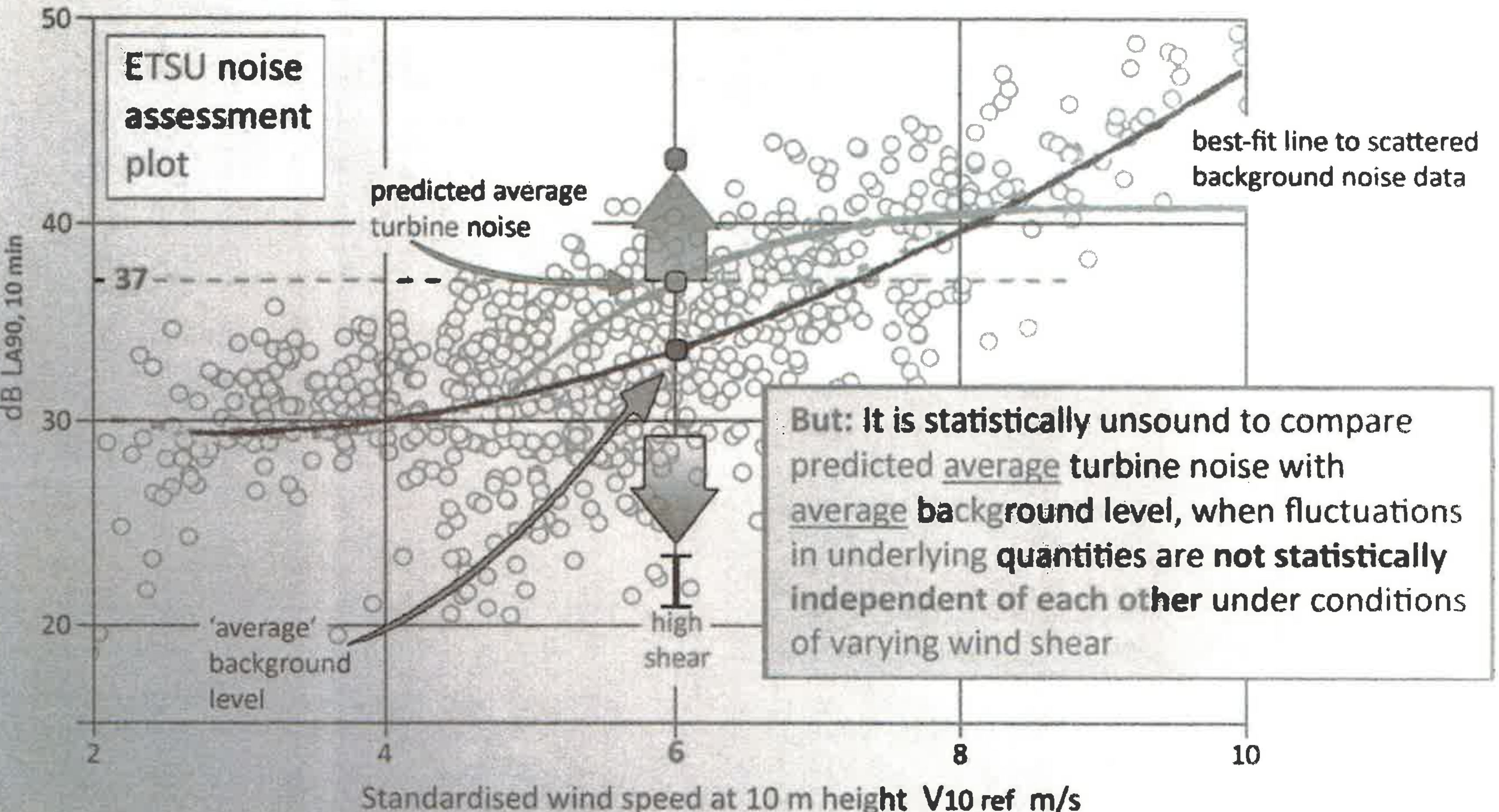


533

Implications of wind shear variation for noise impact assessment



Implications of wind shear variation for noise impact assessment



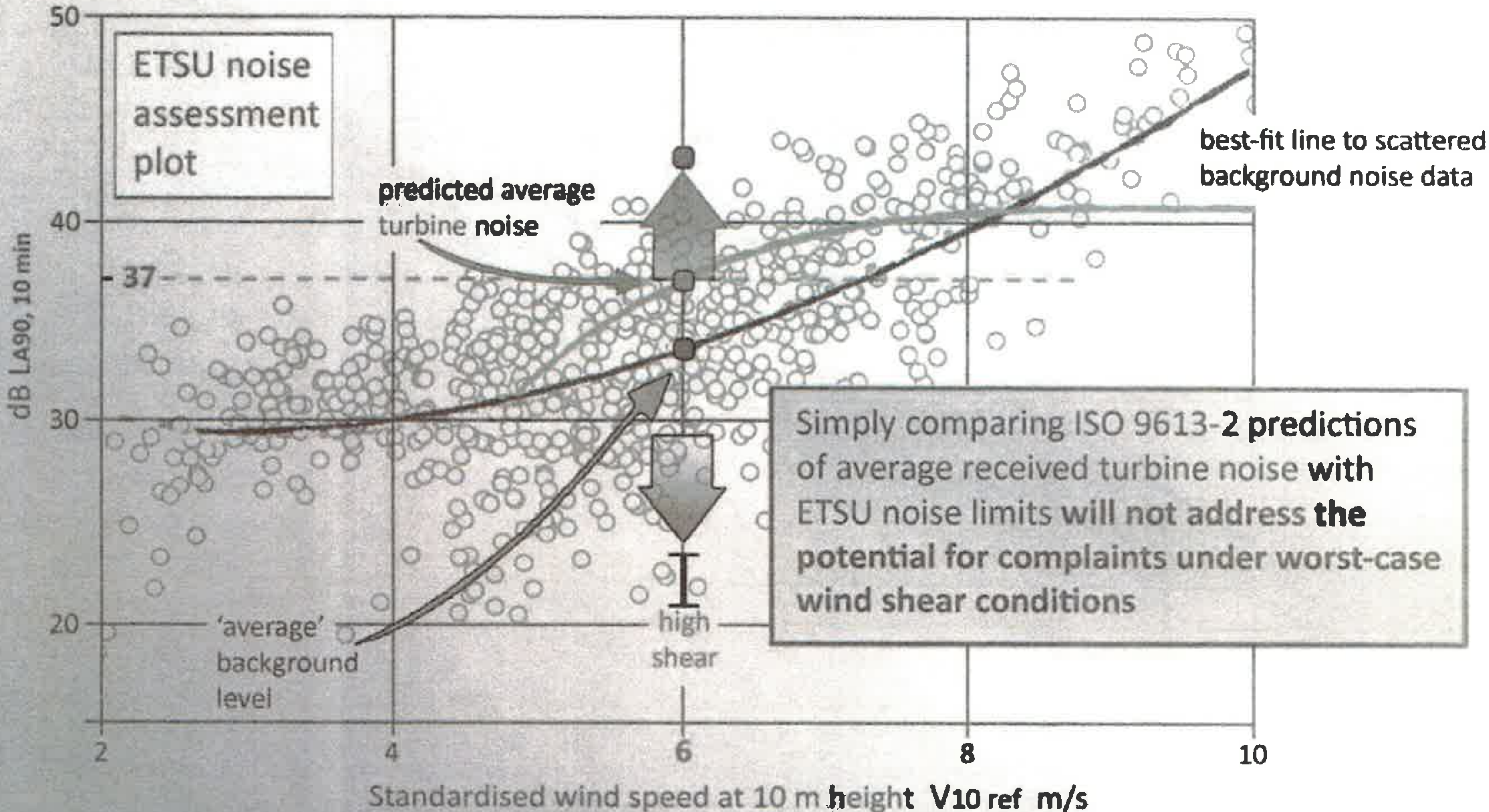
535

Section 6

Implications of Wind Shear Variation

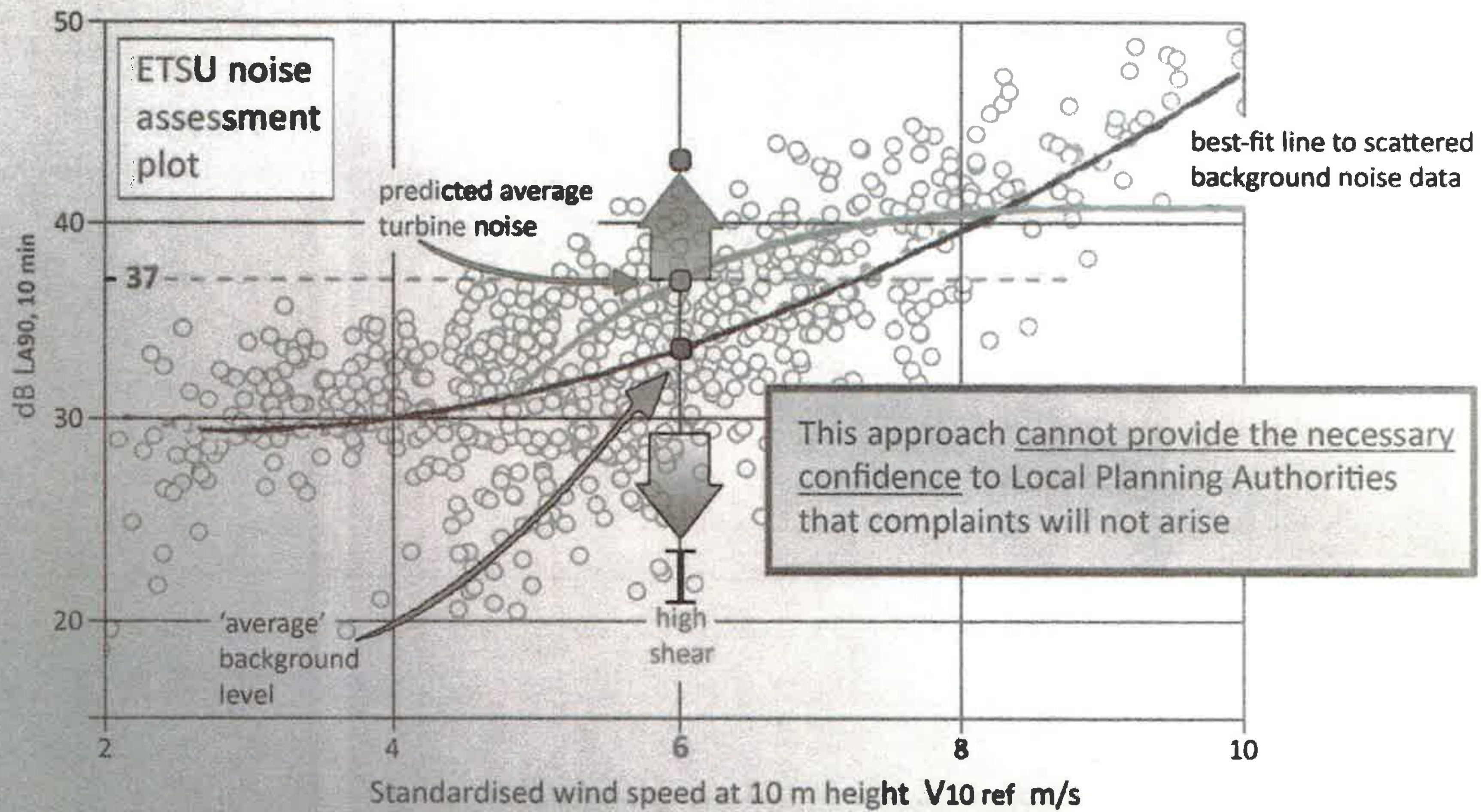
(v) Analysis - conclusions

Implications of wind shear variation for noise impact assessment



537

Implications of wind shear variation for noise impact assessment



Section 7

Neglect of Wind Shear in Noise Impact Assessment

539

Neglect of wind shear in noise impact assessment

The major role of wind shear in outdoor noise propagation is not given **explicit** consideration in wind farm noise assessments

Discussion is usually confined **to quite separate** implications of wind shear for generation of turbine noise at hub height **and background** noise at ground level

Attention is restricted to differences **between** wind speed at different heights

Developers **assume all** propagation effects are covered implicitly **by their use of** International Standard ISO 9613-2 noise prediction methodology

This assumption is unjustified:

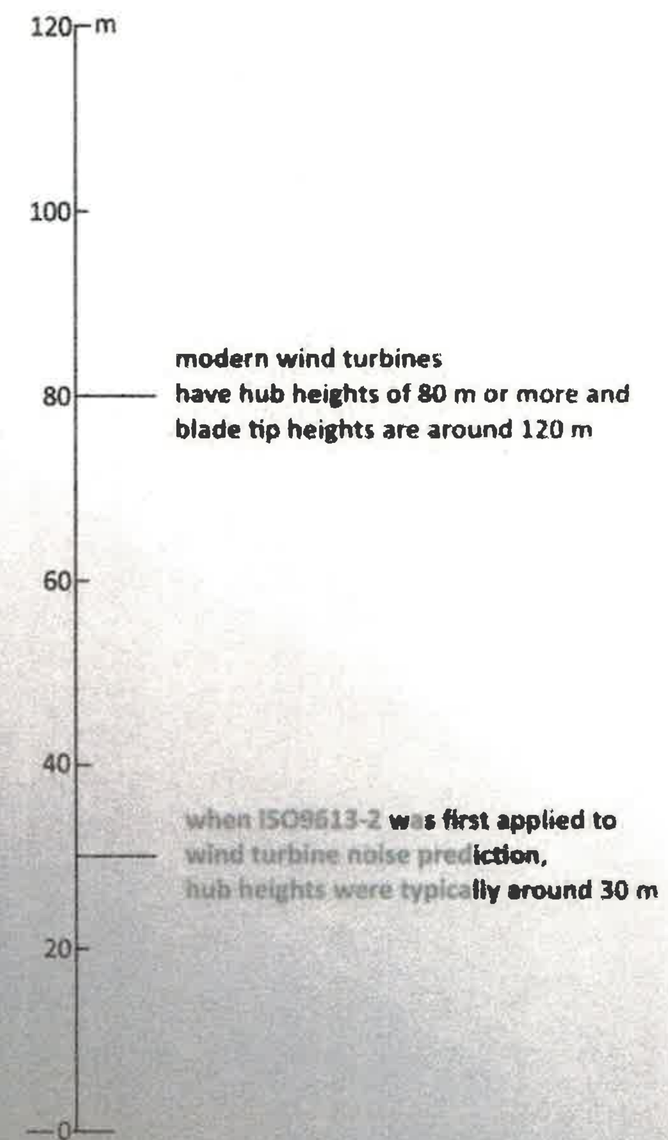
- ISO 9613-2 takes **only limited account** of wind shear effects on **propagation**, and only from *low height*, *non-wind-dependent*, *stationary* noise sources
- the **degree** of wind shear represented within the standard is not specified

Wider concerns regarding developers' choice and validation of ISO 9613-2, for application to modern, tall wind turbines are detailed below

Section 8

ISO 9613-2 – Disparities of Wind Turbine Applications with Original Design Constraints

Present applications of ISO 9613-2 show startling disparities with original design constraints



Present applications of ISO 9613-2 show startling disparities with original design constraints

ISO 9613-2 is a 15 year-old **empirical** scheme

based on:

average noise measurements
from static, near-ground industrial plant

'moderate' downwind conditions

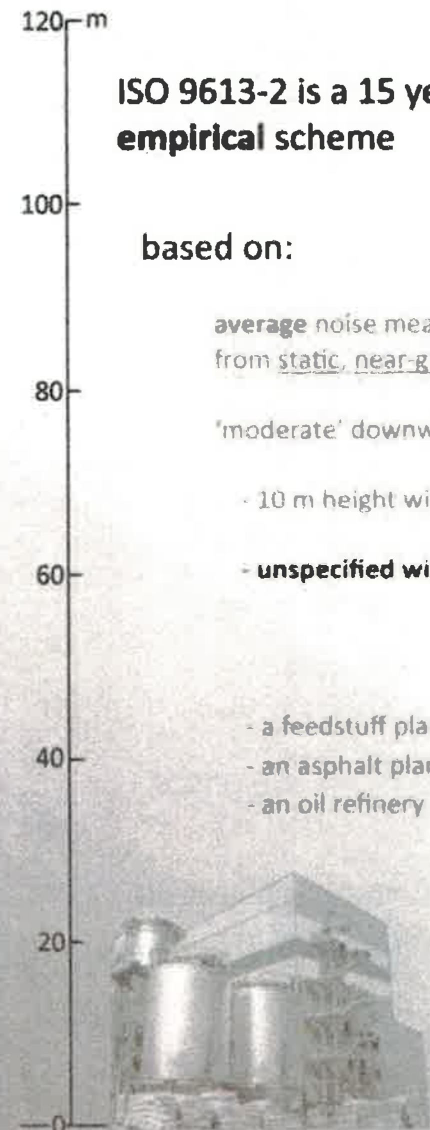
- 10 m height wind speeds up to 5 m/s
- **unspecified wind shear**

validated on:

- a feedstuff plant
- an asphalt plant
- an oil refinery

5/3

Present applications of ISO 9613-2 show startling disparities with original design constraints



ISO 9613-2 is a 15 year-old empirical scheme

based on:

average noise measurements
from static, near-ground industrial plant

'moderate' downwind conditions

- 10 m height wind speeds up to 5 m/s

- **unspecified wind shear**

- a feedstuff plant
- an asphalt plant
- an oil refinery

Food processing plant

- height around 25 m (84 ft)

Present applications of ISO 9613-2 show startling disparities with original design constraints

ISO 9613-2 is a 15 year-old **empirical** scheme

based on:

average noise measurements
from static, near-ground industrial plant

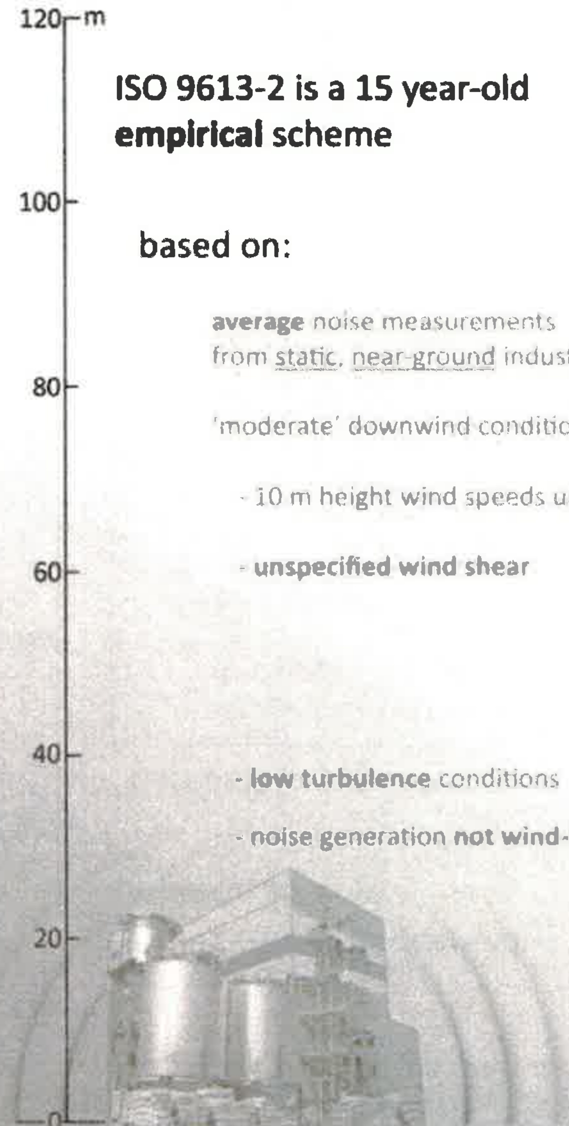
'moderate' downwind conditions

- 10 m height wind speeds up to 5 m/s

- **unspecified wind shear**

- **low turbulence** conditions

- noise generation **not wind-related**



543

Present applications of ISO 9613-2 show startling disparities with original design constraints

ISO 9613-2 is a 15 year-old **empirical** scheme

based on:

average noise measurements
from static, near-ground industrial plant

'moderate' downwind conditions

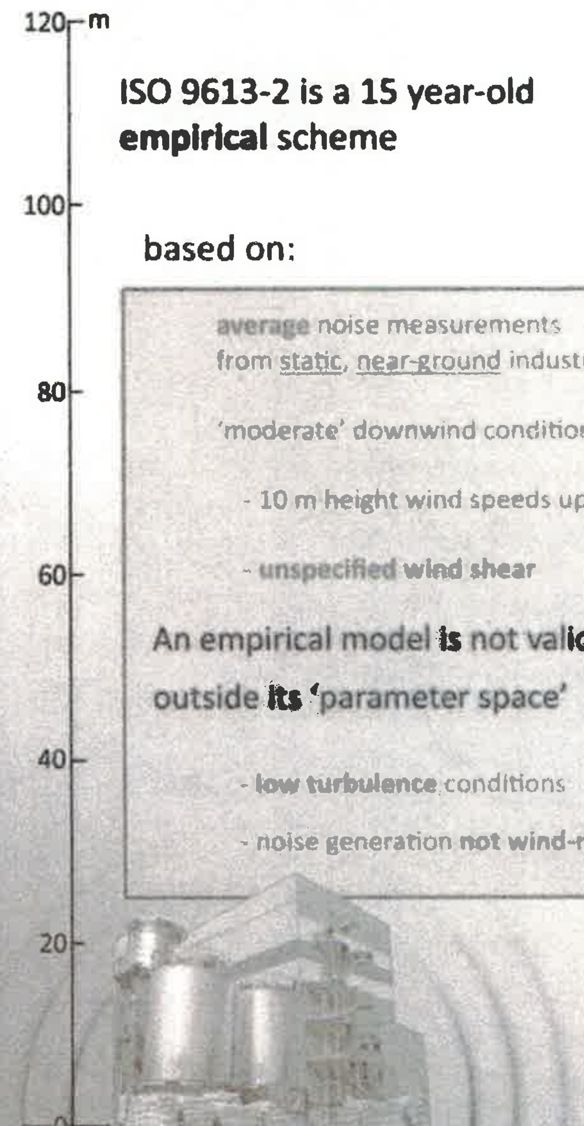
- 10 m height wind speeds up to 5 m/s

- **unspecified wind shear**

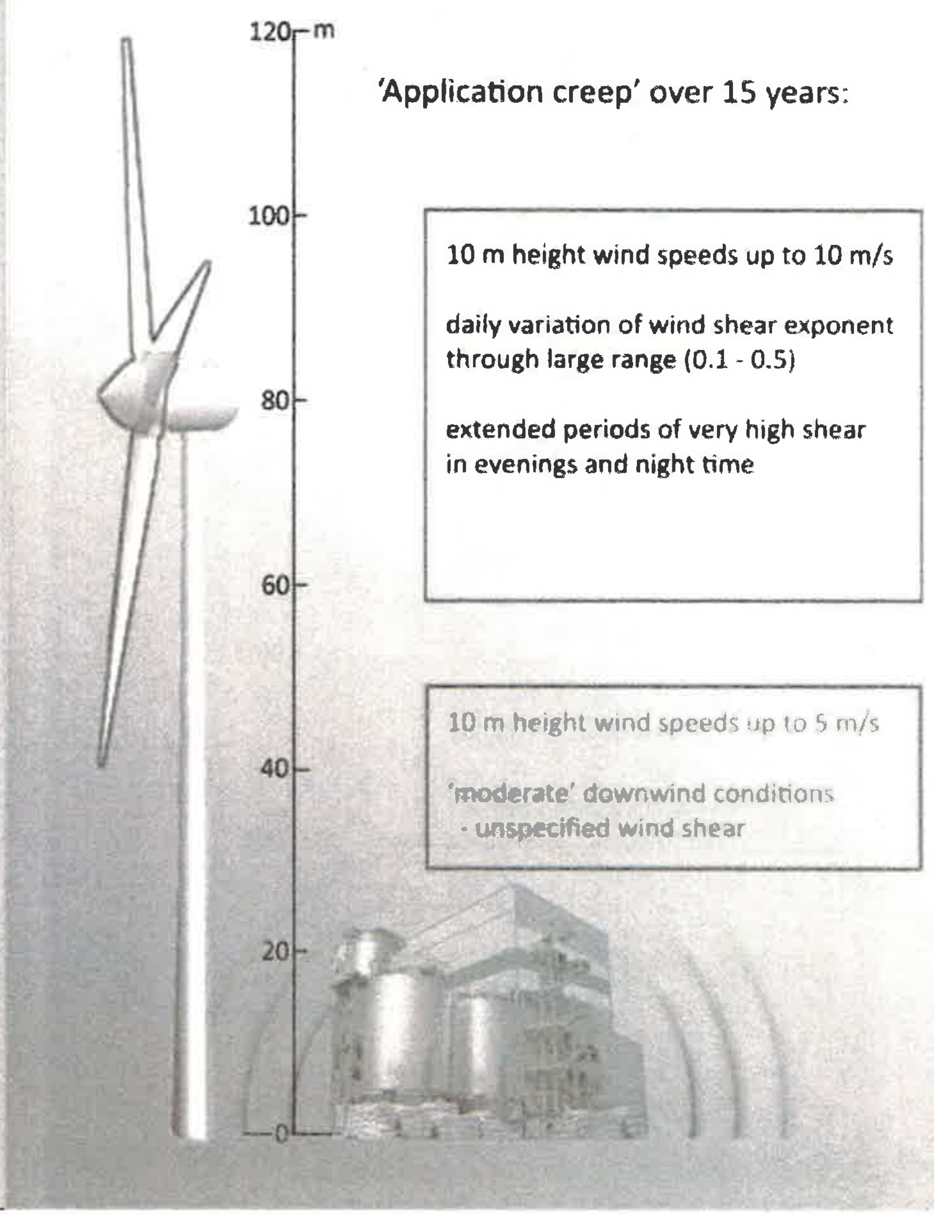
An empirical model **is** not valid outside **its** 'parameter space'

- **low turbulence** conditions

- noise generation **not wind-related**

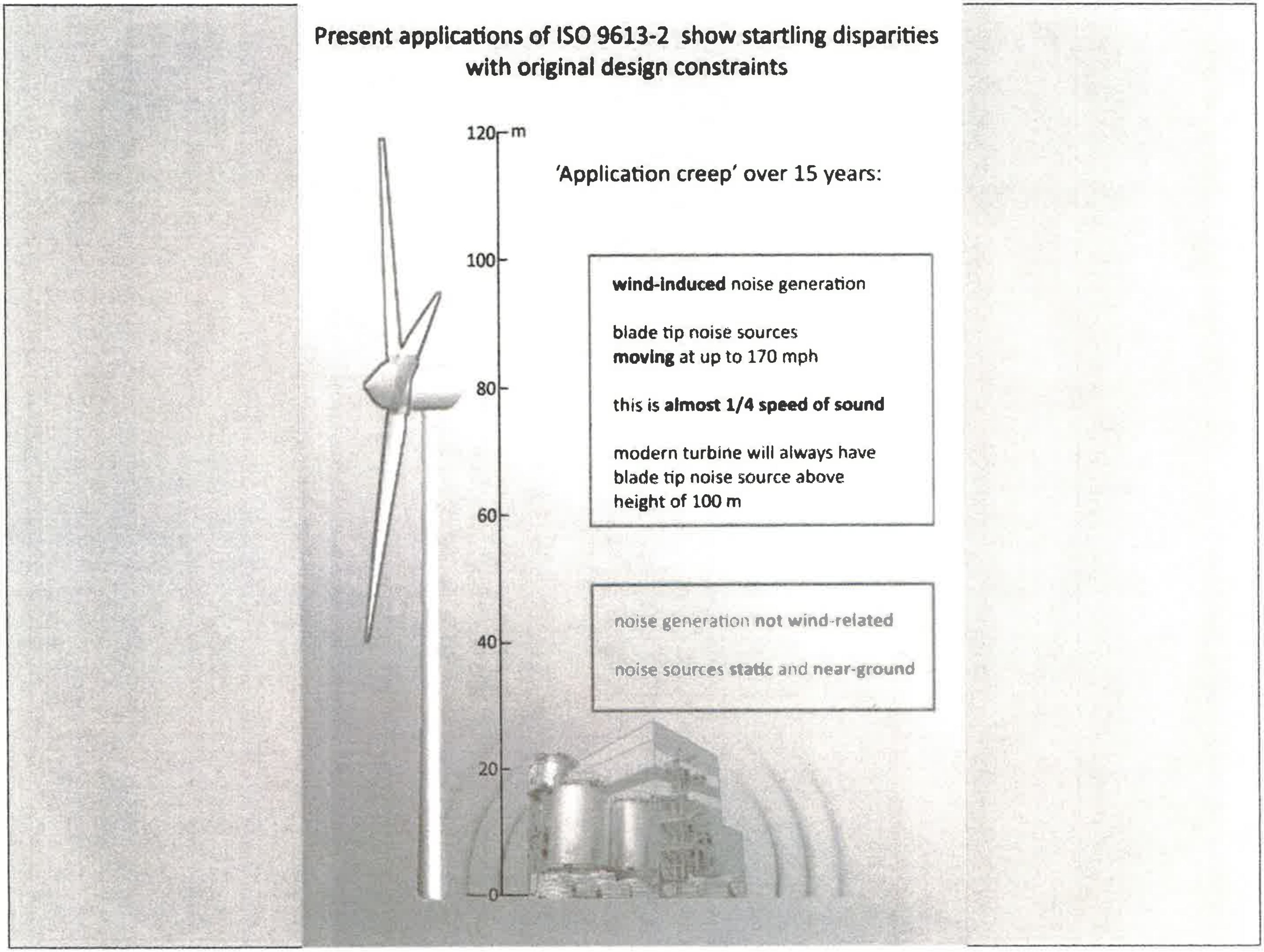


Present applications of ISO 9613-2 show startling disparities with original design constraints

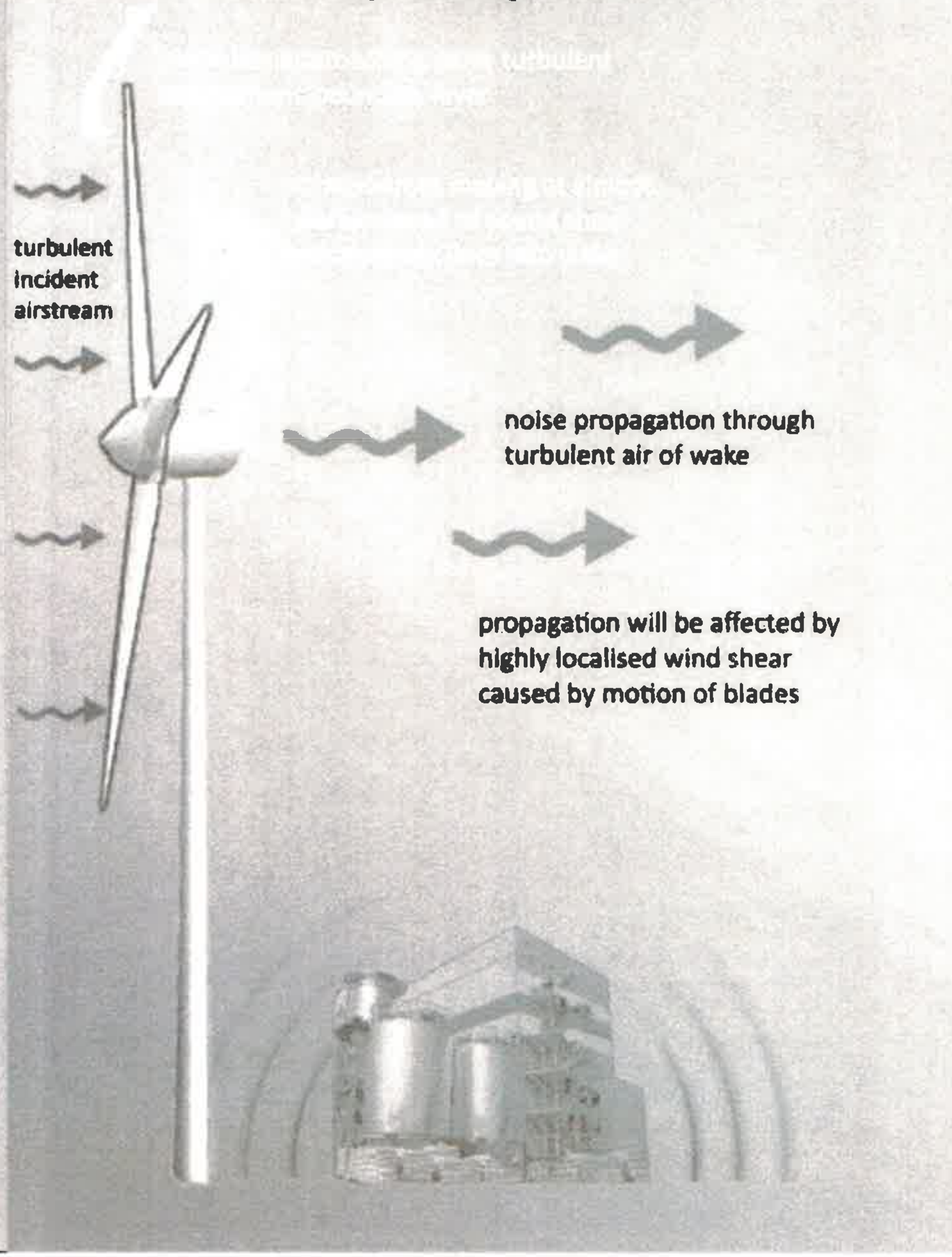


544

545


Present applications of ISO 9613-2 show startling disparities with original design constraints
120 m
100
80
60
40
20
0
'Application creep' over 15 years:
wind-induced noise generation
blade tip noise sources **moving** at up to 170 mph
this is **almost 1/4 speed of sound**
modern turbine will always have blade tip noise source above height of 100 m
noise generation **not wind-related**
noise sources **static** and **near-ground**

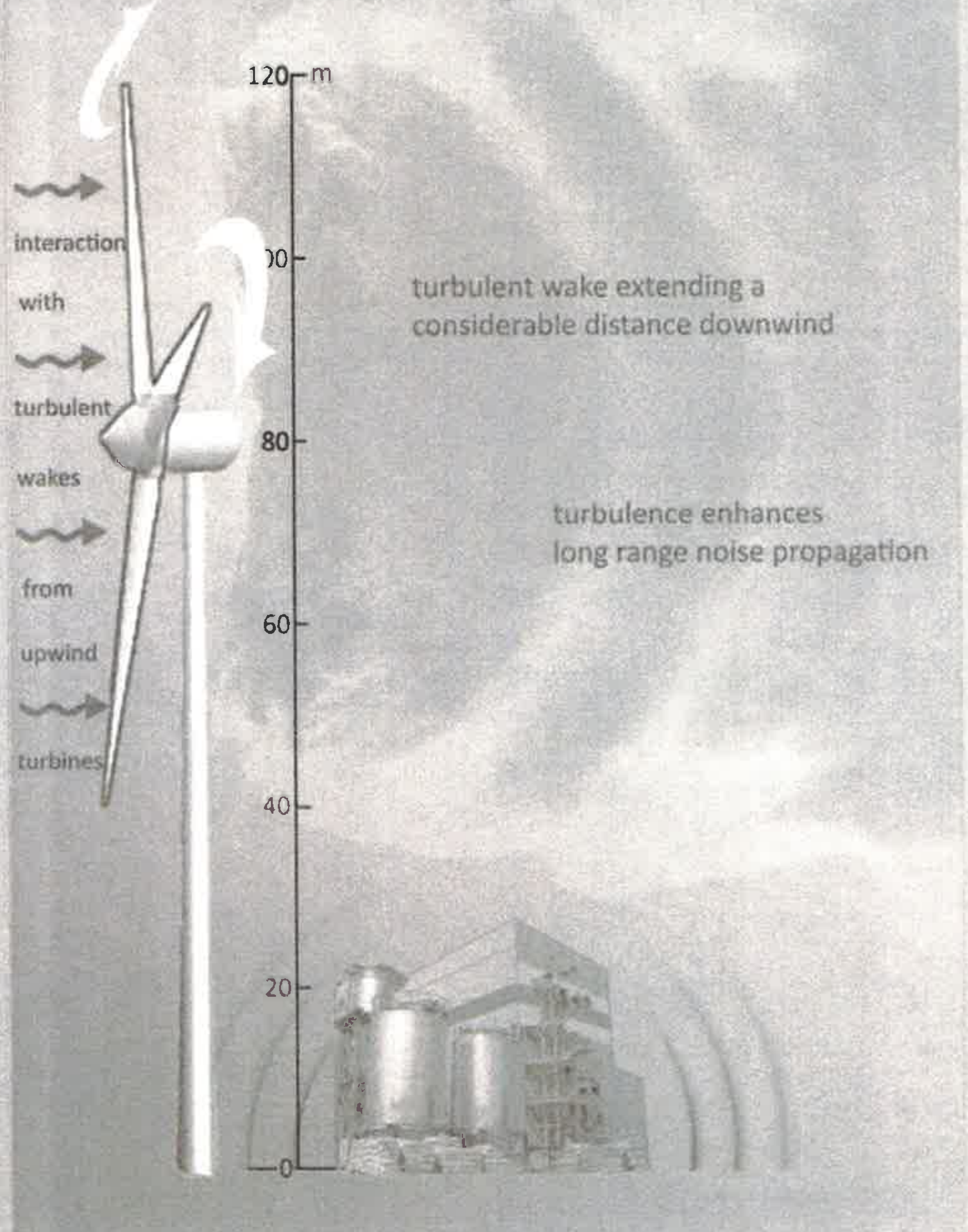
Present applications of ISO 9613-2 show startling disparities with original design constraints



5/16

547

Present applications of ISO 9613-2 show startling disparities with original design constraints



Photograph from Risø, Danish National Laboratory for Sustainable Energy, showing turbine wakes in the Horns Rev off-shore wind farm

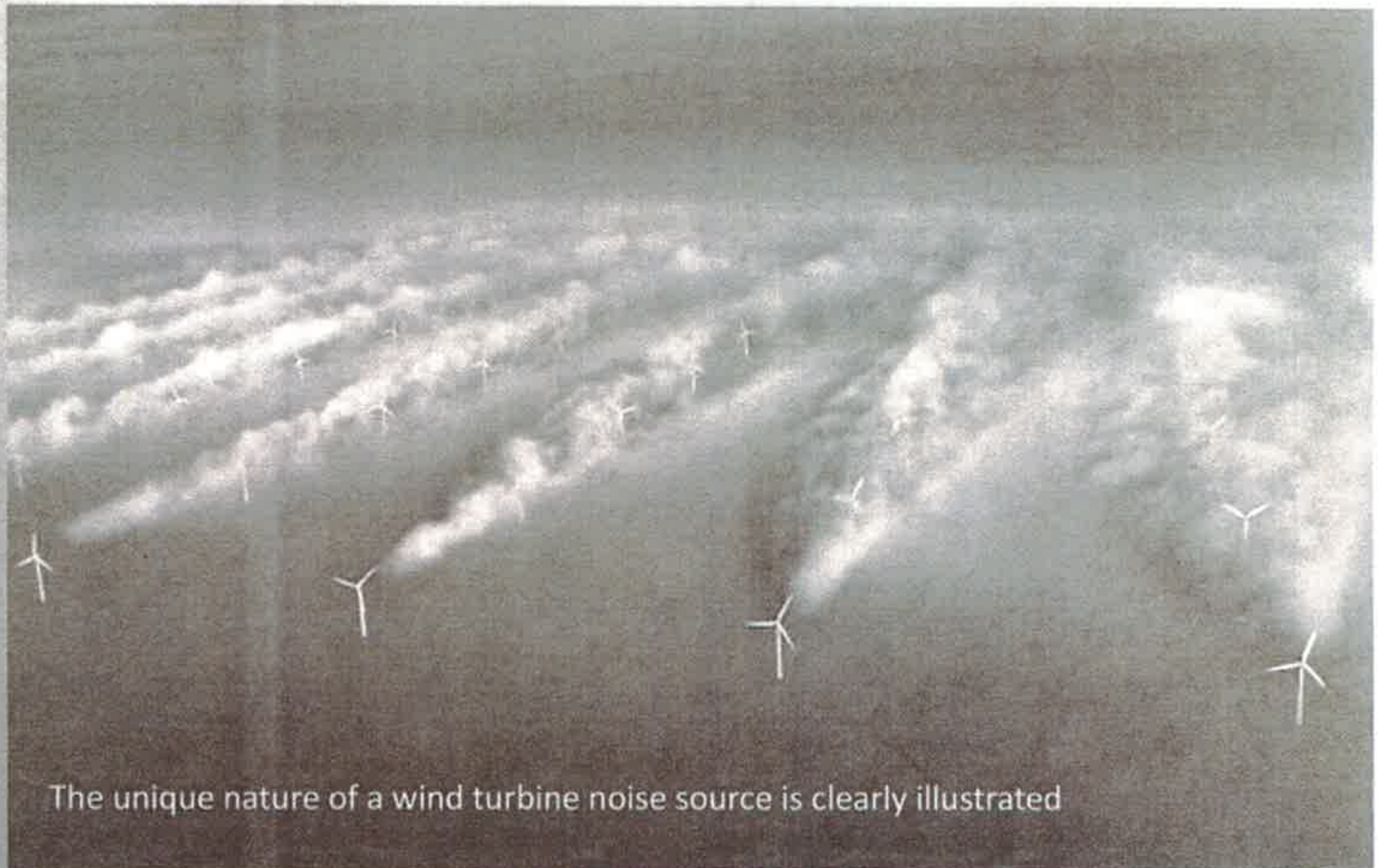
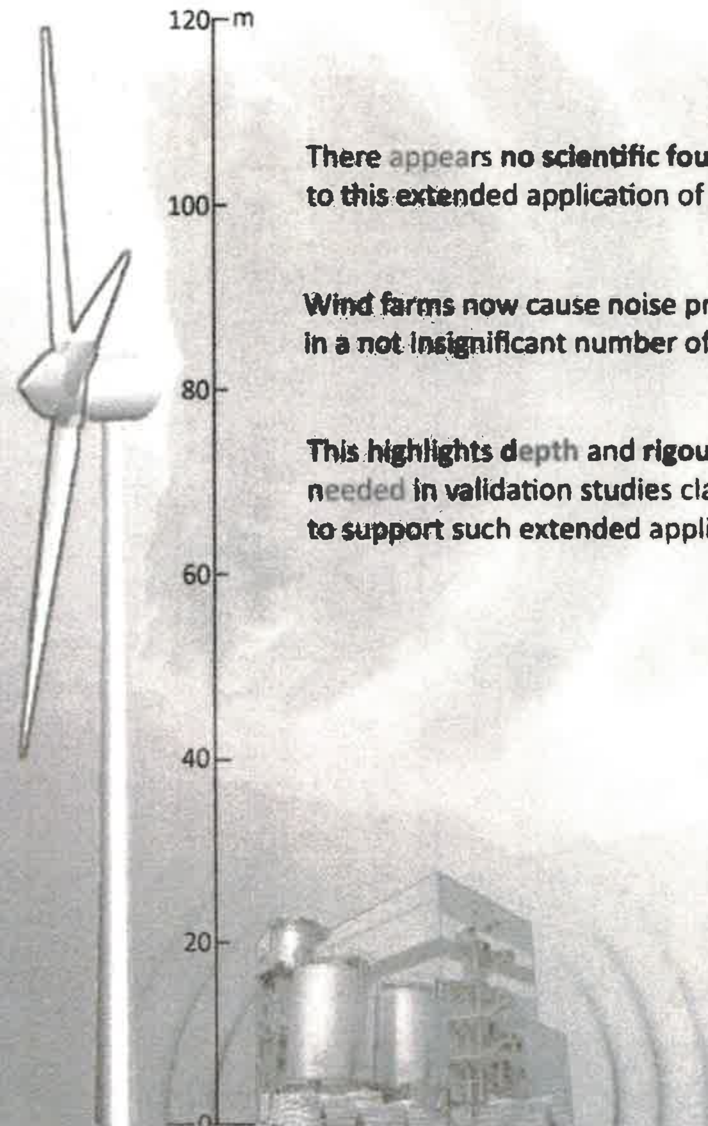


Image presumably obtained under atmospheric conditions rendering turbine wakes visible via formation of water droplets in response to pressure changes

549

Present applications of ISO 9613-2 show startling disparities with original design constraints



There appears no scientific foundation to this extended application of ISO 9613

Wind farms now cause noise problems in a not insignificant number of cases

This highlights depth and rigour needed in validation studies claiming to support such extended application

Section 9

ISO 9613-2 – Validation Studies on Extended Application to Wind Turbine Noise Prediction

- Study 1

551

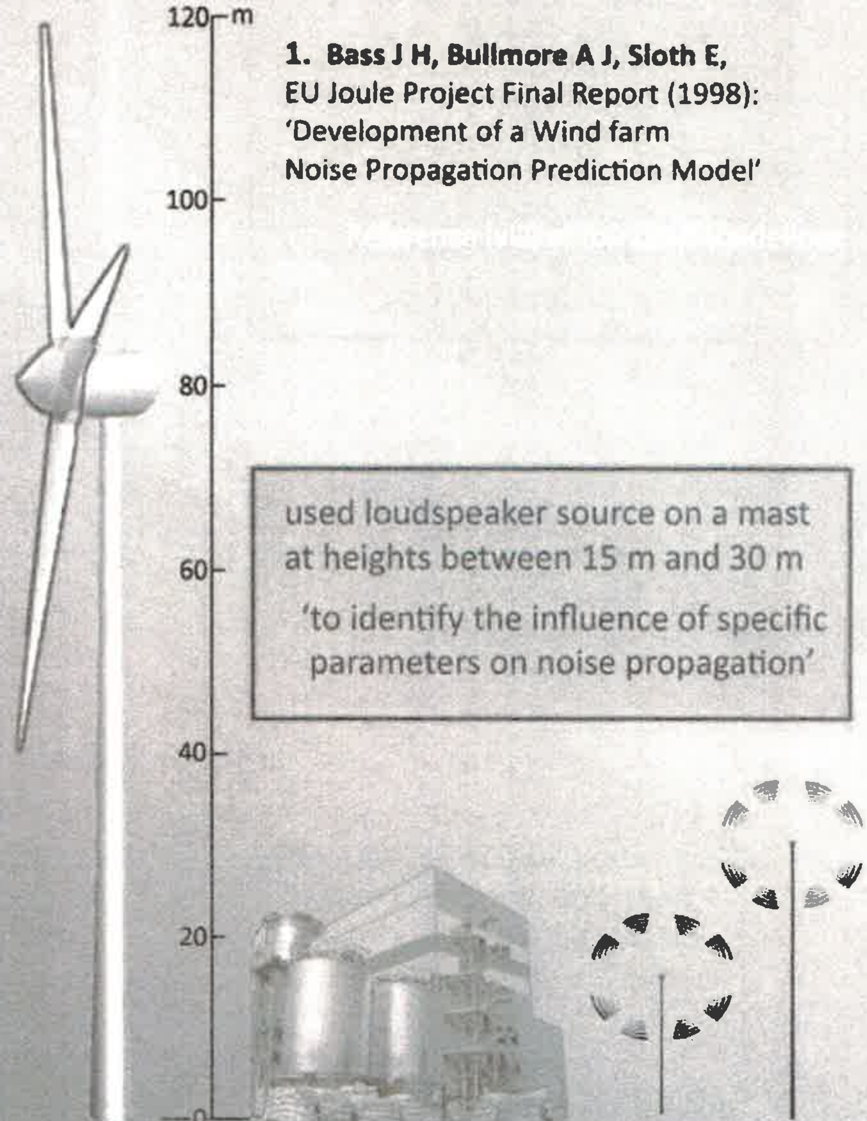
Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

report fails to present any data whatsoever in graphical or tabular form

75

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction



1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

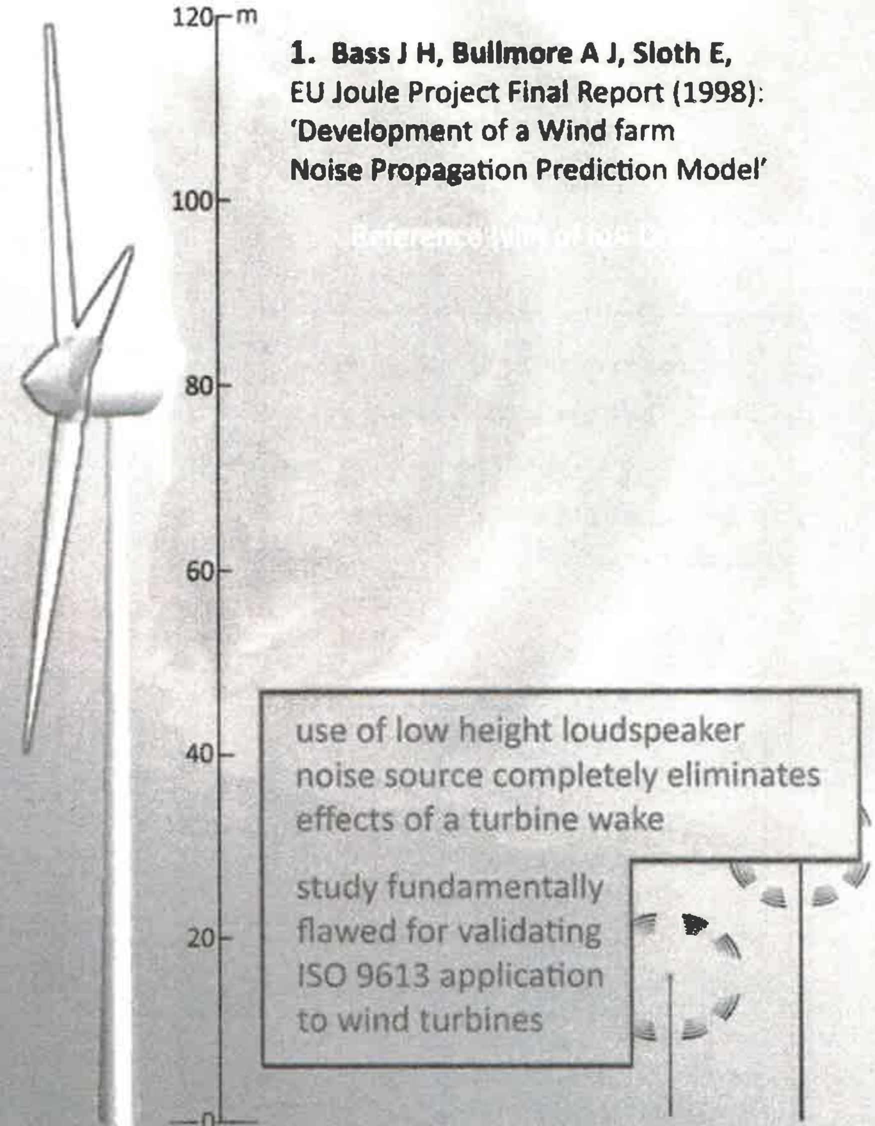
used loudspeaker source on a mast at heights between 15 m and 30 m

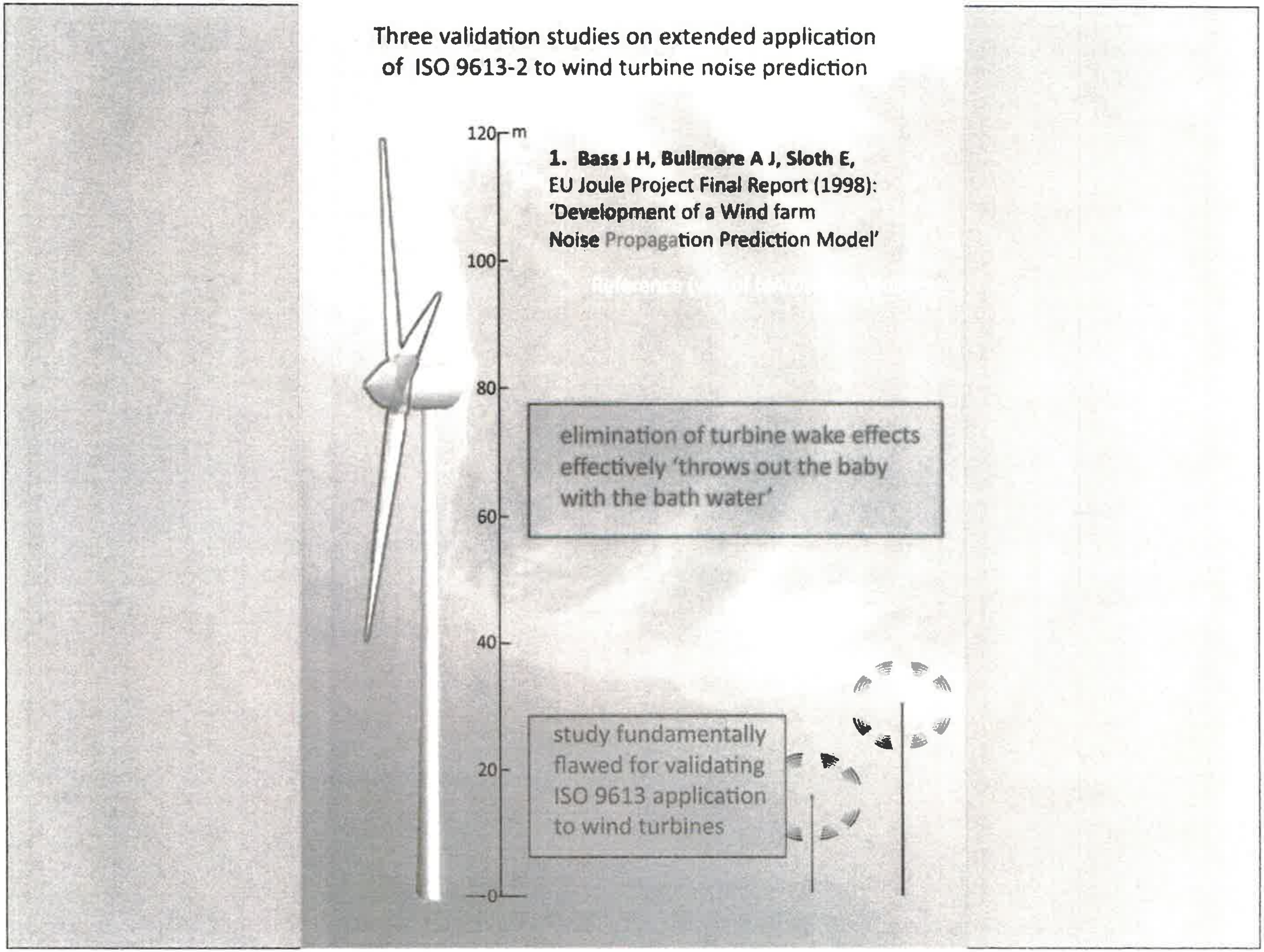
'to identify the influence of specific parameters on noise propagation'

553

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

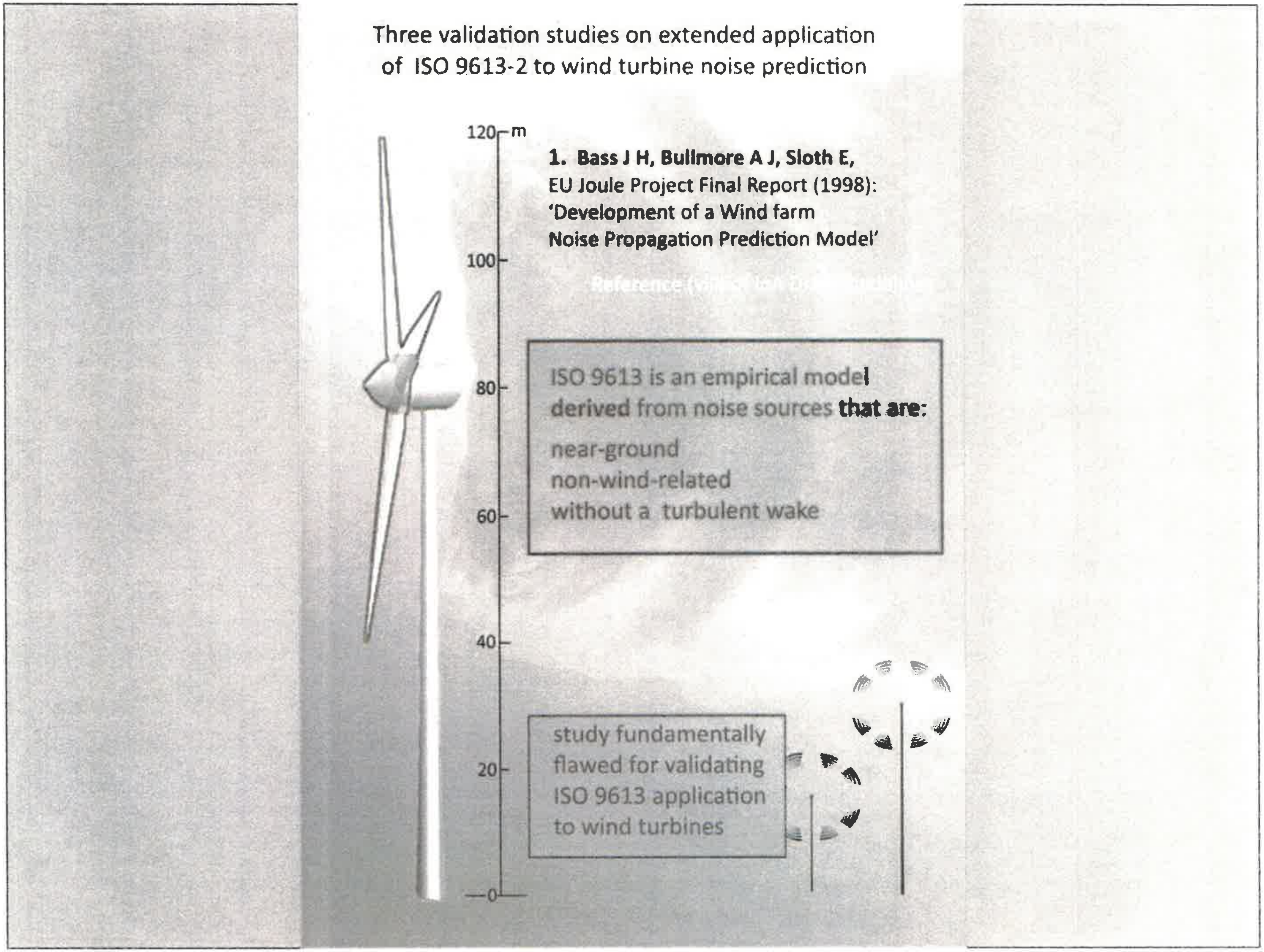
1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm Noise Propagation Prediction Model'

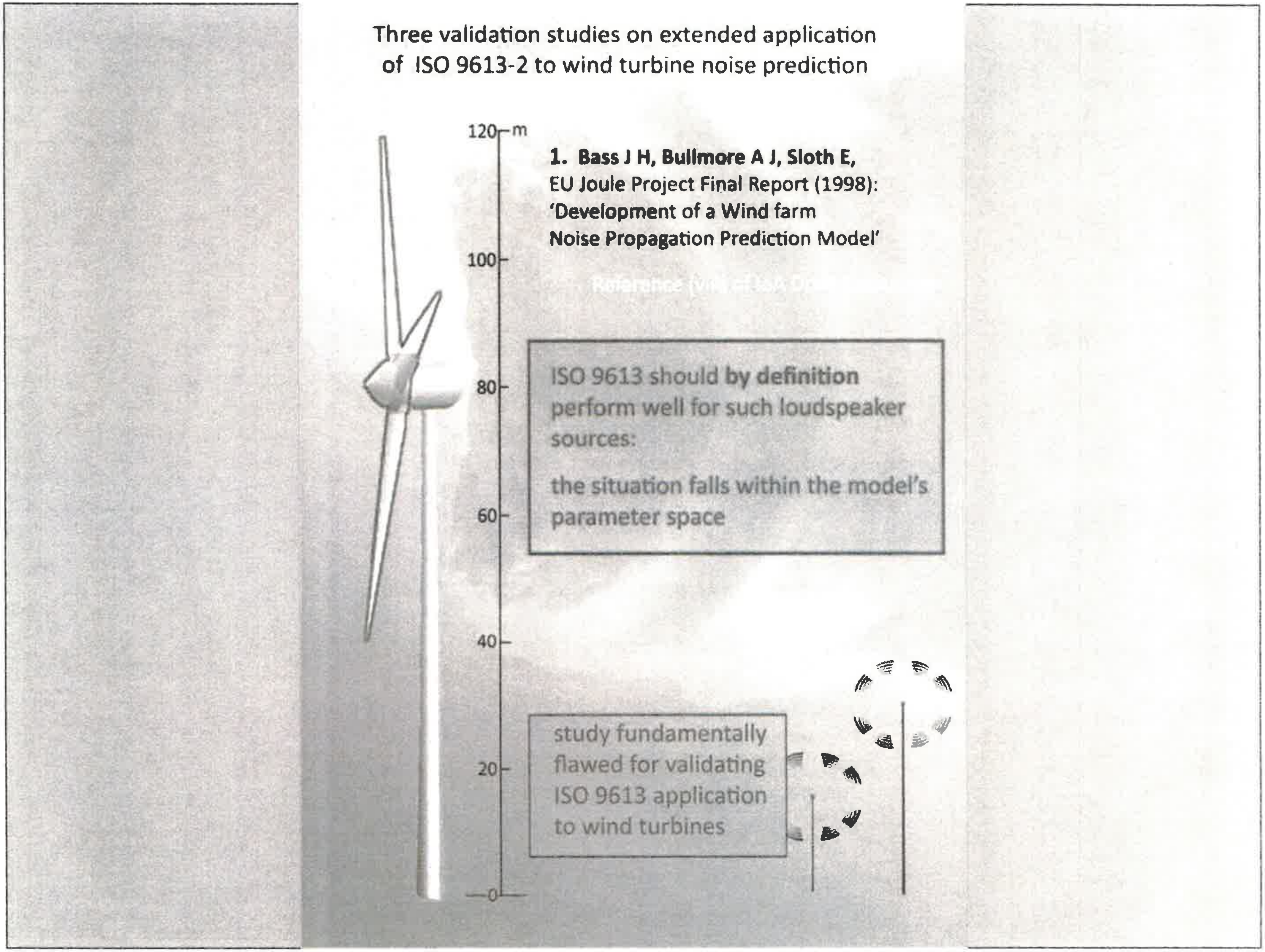



Three validation studies on extended application
of ISO 9613-2 to wind turbine noise prediction
1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'
120 m
100
80
60
40
20
0
elimination of turbine wake effects
effectively 'throws out the baby
with the bath water'
study fundamentally
flawed for validating
ISO 9613 application
to wind turbines

554

555


Three validation studies on extended application
of ISO 9613-2 to wind turbine noise prediction
120 m
100
80
60
40
20
0
1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'
ISO 9613 is an empirical model
derived from noise sources that are:
near-ground
non-wind-related
without a turbulent wake
study fundamentally
flawed for validating
ISO 9613 application
to wind turbines


Three validation studies on extended application
of ISO 9613-2 to wind turbine noise prediction
120 m
100
80
60
40
20
0
1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'
ISO 9613 should by definition perform well for such loudspeaker sources:
the situation falls within the model's parameter space
study fundamentally flawed for validating ISO 9613 application to wind turbines

557

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

Further to ill-conceived scope, report appears inconsistent with established physics

from p1.....'The major objectives of this project are thus: - to establish by measurement the important parameters controlling the propagation of wind farm noise to the far field.....'

However:

the report appears to give no discussion whatsoever of the effects of wind shear

neither does any wind shear data appear to have been measured or provided

it would appear that wind shear was not considered as an important parameter influencing downwind noise propagation

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. **Bass J H, Bullmore A J, Sloth E,**
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

The report then appears totally mistaken in its conclusion that:

'The primary cause for the observed variation in **noise levels** is the systematic dependence of the sound **pressure level** on the component of vector **wind speed** from the source to the receiver'

(*p9 - unscreened* ***propagation over all terrain types***)

this assertion of a **ca**usal relationsh**ip between** sound pressure level and wind speed **is quite wrong** - the two are essentially unrelated

It appears not to have been realised that wi**nd** **shear** must have been simultaneously varying with wind speed, and was causing the observed effects

559

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. **Bass J H, Bullmore A J, Sloth E,**
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

See in contrast a recent authoritative publication on the problem of sound propagation in a wind:

G. W. Gibbons & C. M. Warnick "Traffic noise and the hyperbolic plane", Annals of Physics 325 (2010)

One of the **authors is Prof Gary W Gibbons FRS,**
Professor of Theoretical **Physics at DAMTP,**
the Department **of Applied Mathematics and**
Theoretical Physics, **University of Cambridge**

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998): 'Development of a Wind farm Noise Propagation Prediction Model'

See in contrast a recent authoritative publication on the problem of sound propagation in a wind:

The paper includes a historical perspective on understanding of enhanced noise propagation at long distances downwind:

'This apparent **paradox, and its resolution, have** been known since **at least the time of Stokes [1857].**'

'The explanation **given by Stokes is that this effect** is produced by *wind shear*, **the variability in the** wind speed as a function of height.'

'This gives rise to refraction, causing **sound rays to** bend away from the ground in the upwind **direction** and towards the ground in the downwind **direction.**'

561

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. **Bass J H, Bullmore A J, Sloth E,**
EU Joule Project Final Report (1998): 'Development of a Wind farm Noise Propagation Prediction Model'

Gibbons & Warnick include the following historical references:

[1] G. G. Stokes, "On the Effect of Wind on the Intensity of Sound," Report of the British Association, Dublin, 1857

[2] O. Reynolds, **"On the Refraction of Sound by the Atmosphere," Proc. Roy. Soc. 22 (1874)**

[3] J. W. S. Rayleigh, "The **Theory of Sound"**, Macmillan (1986) §289, Vol 2.

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. **Bass J H, Bullmore A J, Sloth E,**
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

The 3 authors cited by Gibbons and Warnick were leading 19th century scientists:

Sir George Stokes was Professor of Mathematics at Cambridge and the future President of the Royal Society

Osborne **Reynolds** was another future member of **the Royal Society**

Lord Rayleigh **was** another future President of the Royal Society and **Nobel** prize winner; *he put the effect of wind shear* ***on a more quantitative basis*** *in 1894, in his founding* ***work in the development of*** *acoustics,* 'The Theory of Sound'; this book was reprinted as recently as 1986 and **is specifically** recognised today as a 'landmark text' **by the** Institute of Acoustics, via the citation **to their** premier award for outstanding contributions to acoustics, the Rayleigh Medal

562

563

Section 9

ISO 9613-2 – Validation Studies on Extended Application to Wind Turbine Noise Prediction

- Study 2

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

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

This subsequent study was published 11 years after ref (viii) above.

It makes explicit reference to the earlier study and its conclusions, with no critical comment whatsoever

This later study again:

fails to specifically identify **wind shear**
as a key variable **in the** mechanism **of long** range **noise**
propagation

contains no measurements of
wind shear or discussion of its crucial role **in this respect**

The study makes only one specific reference to **wind shear,**
but only regarding differences in wind speed between
hub height and standard reference height (p3, para3)

564

565

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

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

This subsequent study was published 11 years after ref (viii) above.

It is crucial to record vertical atmospheric wind shear conditions during noise measurements, in order to judge applicability to other situations

- daily variation in wind shear might, or might not, have been substantial

This information **is not available** - only horizontal variations in hub-height **wind speed are stated between** individual turbines within a **wind farm**

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

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

This subsequent study was published 11 years after ref (viii) above.

The study provides no specific validation evidence to support extended **application of ISO 9613 to wind turbines** with **a turbulent incident airstream**

meteorological **conditions, or wake effects from other** turbines, could create **such turbulent airstreams**

there is no reason why **ISO 9613-2 predictions should** be at all accurate in these cases

51de

567

Section 9

ISO 9613-2 – Validation Studies on Extended Application to Wind Turbine Noise Prediction

- Study 3

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

3. Evans T and Cooper J,
Proc. Acoustics 2011 Conference, Gold Coast Australia November 2011, 'Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms'

This most recent study was published 13 years after **ref** (viii) above.

It identifies the studies of references (v) and (viii) above as 'key investigations', **and gives a totally non-critical** summary **of their conclusions**

This most recent **study** again:

fails to identify the crucial role **of** wind shear **in** determining the propagation path and **intensity** of outdoor sound

fails to report any measurements of atmospheric wind shear pertaining at the time of the downwind noise measurements

569

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

3. Evans T and Cooper J,
Proc. Acoustics 2011 Conference, Gold Coast Australia November 2011, 'Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms'

This most recent study was published 13 years after **ref** (viii) above.

Again, the **study provides no specific validation evidence** to support extended **application of ISO 9613 to wind turbines** with **a** turbulent **incident airstream**

meteorological conditions, **or** wake **effects** from other turbines, could create **such turbulent airstreams**

there is no reason why ISO 9613-2 predictions **should** be at all accurate in these cases

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

3. Evans T and Cooper J,
Proc. Acoustics 2011 Conference, Gold Coast Australia November 2011, 'Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms'

The results of this study could mislead if simply taken at face value:

ISO 9613-2 predictions employ the LAeq noise metric

Measured noise levels employ the LA90, 10 min metric

comparisons are presented between them, in which one appears **to** have **been** directly subtracted **from** the other

In order to compare **'like with like' a correction** has to be applied to the data:

ETSU-R-97 recommends subtraction **of between** 1.5 and 2.5 dB from LAeq values to yield a reasonable estimate of LA90,10 min levels for wind farm noise

571

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

3. Evans T and Cooper J,
Proc. Acoustics 2011 Conference, Gold Coast Australia November 2011, 'Comparison of predicted and measured wind farm noise levels and implications for assessments of new wind farms'

The results of this study could mislead
If simply taken at face value:

Applying the ETSU-recommended correction:

In 8 out of the 10 cases considered in this study,
ISO 9613-2 underpredicts wind turbine LA90 noise levels

any concavity **in the ground profile** renders this underprediction **significantly more severe**

(the above assumes the standard ISO **input parameter** of G = 0.5 for propagation over mixed ground)

Three validation studies on extended application of ISO 9613-2 to wind turbine noise prediction

1. Bass J H, Bullmore A J, Sloth E,
EU Joule Project Final Report (1998):
'Development of a Wind farm
Noise Propagation Prediction Model'

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

3. Evans T and Cooper J,
Proc. Acoustics 2011 Conference, Gold Coast Australia
November 2011, 'Comparison of predicted and
measured wind farm noise levels and implications
for assessments **of new wind farms'**

Referen**ces (v), (vii) and (viii) of IoA Draft Guidelines**

All 3 of these studies appear scientifically unsound **and none of** them have been published in a peer-reviewed journal

They do not appear appropriate as **fundamental references** for DECC and IoA-endorsed National UK Guidelines on the application of ETSU R 97

512

Section 9

ISO 9613-2 – Validation Studies on Extended Application to Wind Turbine Noise Prediction

- Conclusions

Document #3

11

SERI/TP-217-3261
UC Category: 60
DE88001113

A Proposed Metric for Assessing the Potential of Community Annoyance from Wind Turbine Low-Frequency Noise Emissions

N.D. Kelley

November 1987

Presented at the Windpower '87
Conference and Exposition
October 5-8, 1987
San Francisco, California

Prepared under Task No. WE721201
Program No. 8

Solar Energy Research Institute
A Division of Midwest Research Institute

1617 Cole Boulevard
Golden, Colorado 80401-3393

Prepared for the
U.S. Department of Energy
Contract No. DE-AC02-83CH10093

574

Printed in the United States of America
Available from:
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Price: Microfiche A01
Printed Copy A02

Codes are used for pricing all publications. The code is determined by the number of pages in the publication. Information pertaining to the pricing codes can be found in the current issue of the following publications, which are generally available in most libraries: *Energy Research Abstracts, (ERA); Government Reports Announcements* and Index (*GRA* and I); *Scientific and Technical Abstract Reports (STAR);* and publication, NTIS-PR-360 available from NTIS at the above address.

575

A PROPOSED METRIC FOR ASSESSING THE POTENTIAL OF COMMUNITY ANNOYANCE FROM WIND TURBINE LOW-FREQUENCY NOISE EMISSIONS

N.D. Kelley
Solar Energy Research Institute
Golden, Colorado 80401

ABSTRACT

Given our initial experience with the low-frequency, impulsive noise emissions from the MOD-1 wind turbine and their impact on the surrounding community, the ability to assess the potential of interior low-frequency annoyance in homes located near wind turbine installations may be important. Since there are currently no universally accepted metrics or descriptors for low-frequency community annoyance, we performed a limited program using volunteers to see if we could identify a method suitable for wind turbine noise applications. We electronically simulated three interior environments resulting from low-frequency acoustical loads radiated from both individual turbines and groups of upwind and downwind turbines. The written comments of the volunteers exposed to these interior stimuli were correlated with a number of descriptors which have been proposed for predicting low-frequency annoyance. The results are presented in this paper. We discuss our modifications of the highest correlated predictor to include the internal dynamic pressure effects associated with the response of residential structures to low-frequency acoustic loads. Finally, we outline a proposed procedure for establishing both a low-frequency "figure of merit" for a particular wind turbine design and, using actual measurements, estimate the potential for annoyance to nearby communities.

INTRODUCTION

Experience with wind turbines has shown that it is possible, under the right circumstances, for low-frequency (LF) acoustic noise radiated from the turbine rotor to interact with residential structures of nearby communities and annoy the occupants. Currently there are no universally accepted metrics or descriptors for community annoyance from low levels of LF noise. It is important from both a design and an operational perspective that the potential for such annoyance from wind turbines be quantified as much as possible. This is not a straightforward task, given the highly subjective nature of human response to noise in this frequency range. Given the lack of guidance in this area, we performed a limited experiment in which several volunteers were asked to describe their impressions of three electronically simulated, interior, LF noise environments related to the operation of wind turbines. We correlated the volunteers' responses with a series of currently available LF noise descriptors and identified two that we believe to be the most efficient. The spectral definitions of these descriptors were then modified to include the influence of an intervening residential structure and the levels adjusted for a reference propagation distance.

BACKGROUND

The modern wind turbine radiates its *peak* sound power (energy) in the very low frequency (VLF) range, typically between 1 and 10 Hz. This is a direct consequence of its small rotor solidity and relatively low rotational (shaft) speed (17.5-300 rpm). Other common rotating machinery employing lifting blades (such as the large fans and blowers associated with forced-draft cooling towers and ventilation systems) generally radiate their peak sound powers at frequencies greater than 60 Hz. This higher frequency is due to a combination of high rotor solidity and much faster shaft speeds.

Our experience with the low-frequency noise emissions from a single, 2-MW MOD-1 wind turbine demonstrated that, under the right circumstances, it was possible to cause annoyance within homes in the surrounding community with relatively low levels of LF-range acoustic noise. An extensive investigation of the MOD-1 situation [1,2] revealed that this annoyance was the result of a coupling of the turbine's impulsive LF acoustic energy into the structures of some of the surrounding homes. This often created an annoyance environment that was frequently confined to *within the home itself*.

LOADING OF RESIDENTIAL STRUCTURES BY LOW-FREQUENCY ACOUSTIC EMISSIONS

Impulsive Loading

A significant amount of scientific investigation has gone into documenting the response of residential structures (and resulting community annoyance) to high-energy noise events such as aircraft flyovers and short-duration, impulsive events such as sonic booms and quarrying and mining explosions [3,4]. We found that the periodic loading by the MOD-1 impulses excited a range of structural resonances within the homes measured. Figure 1 schematically illustrates the radiated acoustic frequency spectrum associated with the various types of wind turbine emission characteristics. If there was no small-scale turbulence in the turbine inflow, the acoustic spectrum would resemble the monotonic falloff in the blade passage harmonics indicated by the "steady and long-period loading curve." The curve then rises again as the processes

576

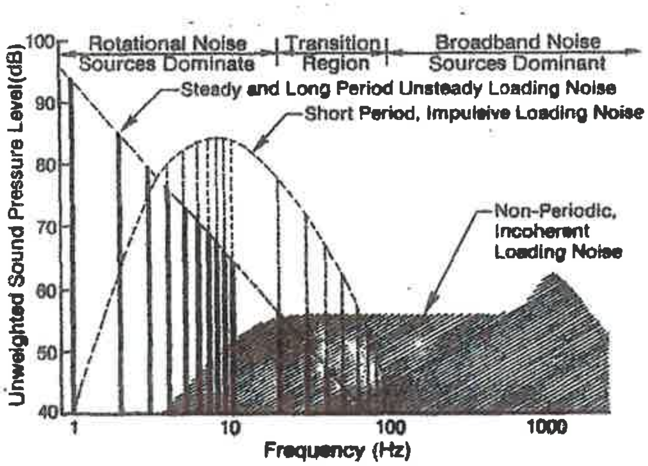


Figure 1. SCHEMATIC REPRESENTATION OF AN AVERAGED RADIATED SOUND PRESSURE SPECTRUM FROM A WIND TURBINE

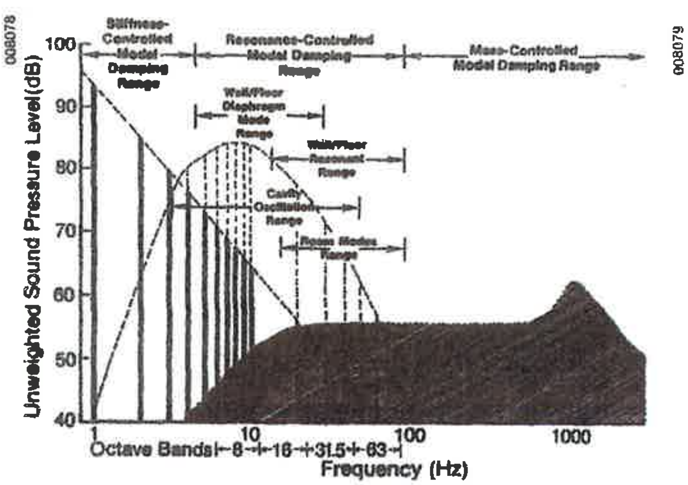


Figure 2. SCHEMATIC SOUND SPECTRUM OF FIGURE 1, WITH RESIDENTIAL VIBRATION AND ACOUSTIC MODES ADDED

responsible for the nonperiodic, incoherent, or broadband (high-frequency) radiation become dominant above 100 Hz. However, there are always some short-period aerodynamic load fluctuations as a result of the rotor encountering atmospheric turbulence, indicated by the dashed region of Figure 1. This region can expand to higher frequencies and contain considerable energy if impulses are present. A blade passing through the downstream wake of the support tower or intersecting its own wake can result in repetitive, transient aerodynamic loads that can produce LF impulsive radiation that is *periodic at the blade passage frequency* (BPF).

The acoustic-mechanical response of a residential structure to acoustic loads is schematically diagramed in Figure 2. The ranges of the various structural and acoustic resonances and the typical wind turbine acoustic spectrum have been superimposed. The dashed region, corresponding to the short-period and impulsive radiation range, overlaps with the structural resonances almost perfectly. Figure 2, therefore, illustrates the coupling mechanisms between the structure and the LF noise excitation. The temporal dynamics of this coupling are shown in Figure 3. The upper curve traces the outdoor acoustic pressure field and the lower one the internal one, as we see in the 31.5-Hz octave frequency band. The pair of turbine-generated impulses, about 8 ms in duration each, produce a strongly resonant pressure field in the house oscillating at the room fundamental of 14 Hz, lasting about 1.8 s. Thus, the action of the house has been to stretch the initial impulse duration over 100 times. The auditory time constant has been estimated to be on the order of 70-100 ms, thus, at least in theory, raising the possibility of audible detection inside the home but not necessarily outside. Hubbard and Shepherd [5] have isolated the Helmholtz response and measured enhancements up to 5 dB. They also found significant sound pressure level variations up to 20 dB when acoustic interactions were present. We have determined a typical indoor/outdoor LF acoustic transfer function using measurements from two homes near the MOD-1 turbine. The impulsive-source curve of Figure 4 illustrates this empirically derived function.

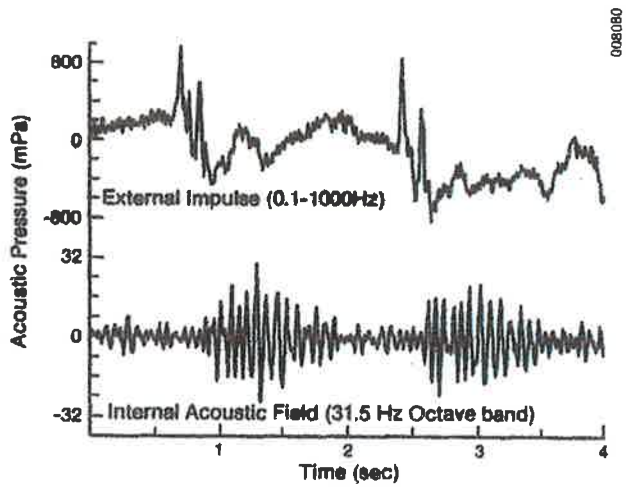


Figure 3. TRANSIENT RESPONSE OF AN INTERNAL PRESSURE FIELD TO EXTERNAL IMPULSIVE EXCITATION

Nonimpulsive Acoustic Loads

Even when an impulsive-type emission characteristic is not present (the MOD-1 did not always generate impulses), a varying level of LF acoustic energy is emitted (see the dashed region of Figure 1) as a result of the turbulent inflow. Because of the low damping present in residential structural modes in the 5-100 Hz range of Figure 1, we needed to find a well-documented source of nonimpulsive, LF acoustic excitation and indoor response for comparison. We were fortunate to obtain a series of measurements made simultaneously inside and outside five homes within a few kilometers of a gas turbine peaking generator [6]. The homes were acoustically excited by broadband LF emissions from a resonating exhaust stack. The nonimpulsive curve of Figure 4 traces the mean of the measured indoor/outdoor response for several rooms of the homes. The two curves of Figure 4 indicate that internal overpressures up to 10 dB can be expected in the 3-10 Hz

577

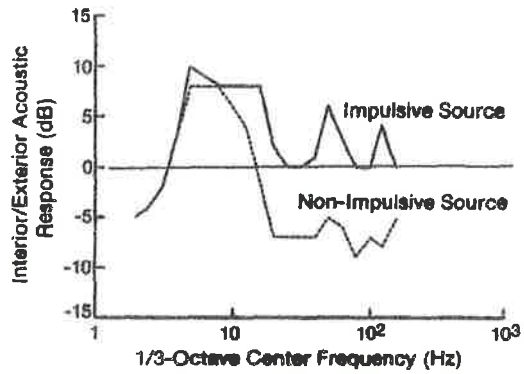


Figure 4. A TYPICAL INDOOR/OUTDOOR ACOUSTIC TRANSFER FUNCTION MAGNITUDE FOR IMPULSIVE AND NONIMPULSIVE LF ACOUSTIC LOADS

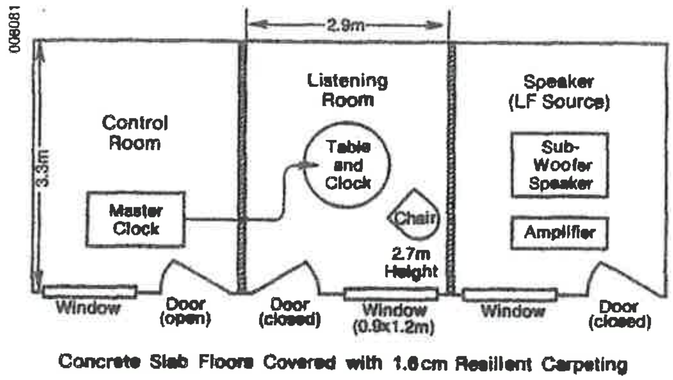


Figure 5. PLAN VIEW SCHEMATIC OF PHYSICAL ARRANGEMENT OF TESTING FACILITIES

range for both impulsive and nonimpulsive acoustic loads. Above 10 Hz, significant overpressures occur in the 40-63 Hz and 80-125 Hz 1/3-octave bands under impulsive loads. Typically, 5-7 dB of attenuation occurs in the 10-160 Hz band range for a nonimpulsive source excitation.

EXPERIMENTAL PROCEDURE

Our objective in the limited experiment reported on here was to simulate a series of LF noise environments that would be likely to exist within a small room of a home (a small bedroom, for example) as a result of the LF acoustic loading caused by wind turbine emissions. Our experience has shown that interior LF annoyance is more likely to occur and be more severe in rooms with small dimensions and at least one outside wall facing the wind turbine. This was also true of the annoyance related to the gas turbine peaking generator; i.e., the most serious annoyance occurred near the sides of the houses facing the LF source. We synthesized three interior LF noise environments that would be expected as a result of the acoustic loading of a residential structure from the following kinds of emissions:

- A single, large, multimegawatt turbine or an array of smaller turbines that *are not* producing periodic impulses *(a periodic random source)*;
- A nearby single turbine operating at a shaft speed of 30 rpm and producing impulses at the blade passage frequency *(a periodic impulsive source)*;
- An upwind *array* of turbines that are individually producing unsynchronized impulses at their blade passage frequencies *(a random impulsive source)*.

In addition to these three basic environments or *stimuli classes*, the periodic random source was repeated but with a "pink" noise masking level of 40 dBA.

Physical Setup

The physical layout of the testing environment is diagramed in Figure 5. A very low frequency or subwoofer speaker system and its high-powered amplifier were placed in a room adjoining the listening area. The subwoofer had a minimum frequency cutoff of about 5 Hz. This arrangement allowed only the dominant LF noise to be transmitted to the listening-room environment via the walls. It also filtered out the higher frequency sounds associated with the nonlinear response of the speaker cone (a "whooshing" sound), which was particularly evident during large excursions. The electronic equipment responsible for developing the subwoofer's "drive" signals was located in the control room. A master time code generator was also located here, and a repeater or slave unit was placed on the table in the listening room for the evaluator to time-index his or her comments. Table I lists the physical and acoustic properties of the listening room. The concrete slab floor minimized tactile (feeling) transmission of LF vibration to the evaluator. Since we were trying to simulate the quiet environment typical of a family home, we did not ask the staff on the other side of the partition to refrain from talking during the evaluation process. As a result, the evaluators occasionally noted hearing conversations from the offices adjacent to the rear wall of the listening room. The background noise was dominated by the sound of air moving through the ventilation system which produced an average background noise level of 35 dBA, typical of a quiet home.

Table I. PHYSICAL AND ACOUSTIC PROPERTIES OF LISTENING-ROOM ENVIRONMENT

Dimensions	2.9 x 3.3 x 2.7 m (25.8 m^3 or 254 ft^3)
Walls	Movable partitions, composition material, nominally supported
Floor	Concrete slab covered with 1.6 cm of resilient carpet
Background Noise Level	35 dBA dominated by ventilation system noise; no attempt to reduce or mask voices generated on other side of rear wall

Evaluation Procedure

A series of sequences was developed for each type of LF noise environment in which the levels and intensities were

578

systematically varied. We found that the corresponding, unweighted acoustic 1/3-octave band pressure levels over the range of 2-160 Hz could be repeated to better than 0.3 dB for each test level. The three simulated characteristic wind-turbine-emission environments are *schematically* diagramed in Figure 6. The averaged 1/3-octave band pressure level spectra for each of the source characteristics, and the incremental level changes are shown in Figures 7, 8, and 9. The room background spectra are indicated with dashed lines.

Seven volunteer evaluators took part in the experiment. The group consisted of three women and four men who ranged in age from the early twenties to the early sixties. All claimed to have an adequate hearing acuity. In this choice of a very limited number of participants, we attempted to obtain what we believed to be a small, random sample of the general population.

During the evaluation, the evaluator sat at the table indicated in Figure 5 on which a record log was furnished. The evaluators were asked to write down their impressions of what they were currently experiencing along with the time indicated on the clock. The evaluation sequence began with the periodic random simulation,

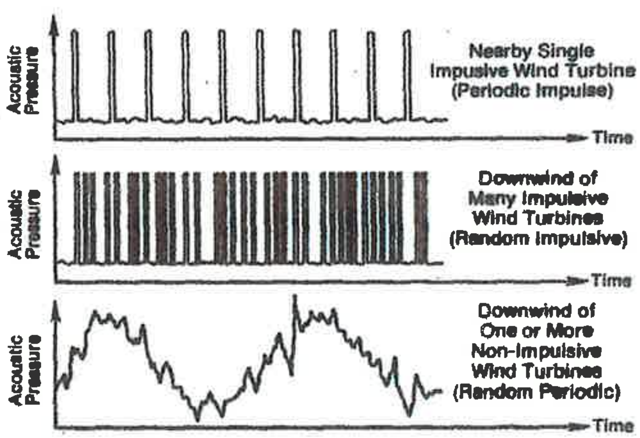


Figure 6. SIMULATED ACOUSTIC EMISSION CHARACTERISTICS OF WIND TURBINES

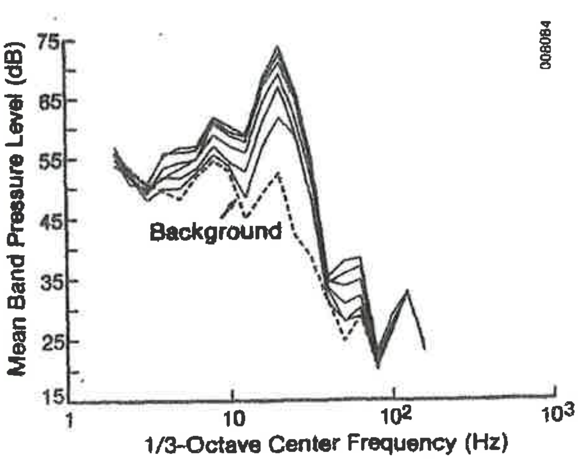


Figure 7. PERIODIC RANDOM STIMULI SPECTRA

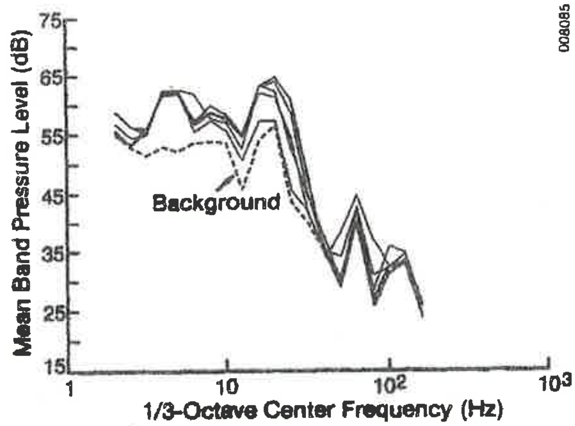


Figure 8. PERIODIC IMPULSE STIMULI SPECTRA

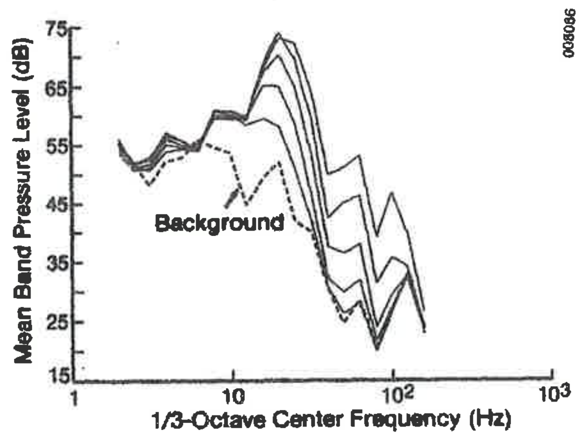


Figure 9. RANDOM IMPULSIVE STIMULI SPECTRA

stepped up through the six intermediate levels, and then back down again to the background level. No indication was given to the evaluators of the stimuli classes or their incremental steps. The initiation and completion times of each incremental step in a simulation were logged for later comparison with the evaluator's opinions. The dwell or integration time at each incremental stimuli step was held at 2 minutes plus or minus a 20% *random* variation to prevent the evaluator from anticipating changes in the testing sequence. The five levels of the periodic impulsive simulation were then sequenced, and this was followed by the five levels of the random impulsive stimuli. Finally, 2 minutes after the conclusion of the random impulsive simulation, the 40 dBA pink noise masking was activated from two speakers in the room's ceiling and the random periodic stimuli sequence was repeated. The entire four-pass process required about 45 minutes to complete.

Data Reduction

The evaluators' responses were quantified by means of a six-level ranking in terms of the following four annoyance categories:

(1) Loudness or noise level

579

(2) Overall degree of annoyance and displeasure

(3) Any sensations of vibration or pressure

(4) The sensing of any pulsations.

Table 2 lists the subjective ranking criteria. The ranked responses were then correlated by linear regression with a series of low-frequency noise descriptors or metrics. These particular metrics or spectral weighting factors have been suggested as measures of LF annoyance by a number of investigators, and they include the following:

- The ISO (International Organization for Standardization) proposed G_1 weighting [7]
- The ISO proposed G_2 weighting [7]
- The LSPL or low-frequency sound pressure level weighting [8]
- The LSL or low-frequency sound level weighting [8]
- The ISO/ANSI (American National Standards Institute) C-weighting [9]
- The ISO/ANSI A weighting [9].

Figure 10 plots these weighting windows over a frequency range of 2-100 Hz. The ISO G_1 and G_2 curves have been proposed for assessing subjective human responses to acoustic noise in the infrasonic range (less than 20 Hz). The ISO/ANSI A- and (usually) C-weighting curves are standard on sound level measuring equipment. As Figure 10 shows, the C-weighting passes much lower frequencies than does the most common noise description,

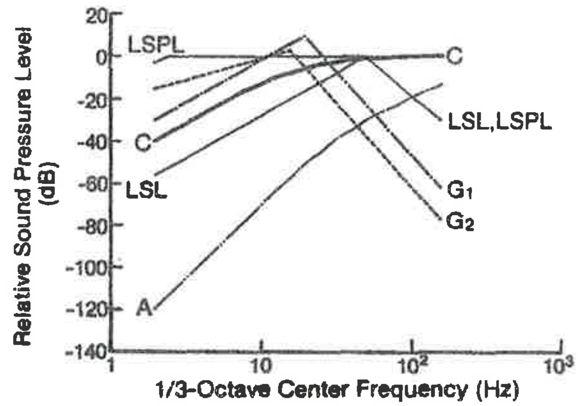


Figure 10. LOW-FREQUENCY NOISE METRICS SPECTRAL WEIGHTINGS

the A-weighting scale. The LSL and LSPL metrics have been proposed by Tokita et al. [8] for assessing residential interior environments. The LSL metric "reflects three low-frequency noise influences: structural, physiological, and psychological complaint stimuli" [8]. The LSL metric has been proposed as an appropriate descriptor for evaluating residential interior environments that contain both infra- and low-frequency audible acoustic components.

RESULTS

The ranked responses to the four annoyance categories were correlated with the four stimuli sequences by regression and are summarized in Table 3. Immediately

Table 2. SUBJECTIVE RANKING CRITERIA FOR LOW-FREQUENCY (LF) NOISE ENVIRONMENTS

Rank	Stimuli Response Rating: 0	1	2	3	4	5
	Perception					
Noise level (loudness)	Can't hear	Barely can here	Weak, but definitely audible	Moderate loudness	High noise level, loud	Very high noise level, very loud
Annoyance/ displeasure	None	Barely aware of presence	Definitely aware of presence	Moderate distraction/ some irritation	Very annoying, irritating	Extremely annoying, uncomfortable
Vibration/ pressure	None	Feel presence	Definitely feel vibration/ pressure	Moderate vibration/ pressure feeling	Very noticeable	Severe vibration
Pulsations	None	Barely feel pulses	Definite pulses or bumping	Moderate booming or thumping	Heavy booming or thumps	Very heavy pulses, booms, thumps
	Acceptable		???????		Clearly unacceptable	

580

Table 3. CORRELATION COEFFICIENTS OF EVALUATOR ANNOYANCE RATINGS OF LF NOISE STIMULI VERSUS SIX NOISE METRICS

Metric	Noise Level	Annoyance/ Displeasure	Vibration/ Pressure	Pulsations	Mean
G_1	0.898 (*0.033*)	0.933 (*0.018*)	0.709 (*0.170*)	0.819 (*0.115*)	0.840 (*0.084*)
G_2	0.873 (*0.071*)	0.879 (*0.053*)	0.701 (*0.157*)	0.769 (*0.148*)	0.806 (*0.107*)
LSPL	0.898 (*0.035*)	0.924 (*0.034*)	0.711 (*0.155*)	0.831 (*0.107*)	0.841 (*0.083*)
LSL	0.935 (*0.021*)	0.958 (*0.014*)	0.732 (*0.174*)	0.860 (*0.097*)	0.871 (*0.077*)
C	0.940 (*0.030*)	0.947 (*0.008*)	0.725 (*0.167*)	0.841 (*0.098*)	0.863 (*0.076*)
A	0.384 (*0.464*)	0.269 (*0.413*)	0.413 (*0.137*)	-0.077 (*0.719*)	0.247 (*0.433*)

obvious is the superiority of the five metrics that pass significant low frequencies in comparison with the A-weighted scale. These results, limited as they are, seem to confirm that (1) people do indeed react to a low-frequency noise environment and (2) A-weighted measurements are not an adequate indicator of annoyance when *low frequencies are dominant*. Table 4 ranks the efficiency of each metric for the stimuli population in terms of the correlation coefficient and stimuli-to-stimuli class standard deviation. These rankings, with the exception of the last two, contain two of the six metrics. We simply do not have a sufficient number of statistical degrees of freedom to differentiate further. Actually, the only statistically significant difference is between the five LF metrics and the A-weighted scale. This experiment would have to be repeated with a much larger number of evaluators (population) to confirm Tables 3 and 4 in terms of their individual matrix elements.

ESTABLISHING AN INTERIOR ANNOYANCE SCALE

The rankings of the evaluators' comments were summarized for each of the four stimuli, and three annoyance-level classes were determined for each. The perception-threshold level is defined as the corresponding LSL- and C-weighted band levels for an evaluation ranking of 1. The annoyance-threshold level classification was arbitrarily assigned a ranking of 2.5, and the unacceptable-annoyance level classification was given a value of 4 or greater. The LSL- and C-weighted metrics corresponding to the annoyance classification rankings are listed in Table 5 for the four stimuli evaluated. As the table shows, three of the four stimuli have similar threshold-perception LSL- and C-weighted values. It is interesting to note that, even though many individual impulsive sources are present, the net effect of a *random summing* of these contributions invokes a response similar to that from a periodic random source. It is also evident that the threshold is considerably lower for a single or a few distinct impulsive sources. This is reflected by the general source characteristics listed at the bottom of Table 5. For all practical purposes, the annoyance level criteria for the C-weighted scale are 10 dB higher than those for the LSL-weighted band pressure level (BPL).

PREDICTING AN INTERIOR LSL OR C LEVEL

To assess the potential of interior LF noise annoyance in nearby communities, we must estimate the LSL or C metric levels from available acoustic measurements of the turbine design. Generally, this will be an averaged, unweighted (linear) 1/3-octave band spectrum over a 5-100 Hz range and, when adjusted for propagation losses, it can be considered representative of the external acoustic load present at the home being evaluated. We noted earlier that the structural dynamic response of houses alters both the temporal and spectral characteristics of the external acoustic excitation and that the alteration characteristics depend on whether the source is impulsive or not. To predict an interior LSL- or C-level (PLSL or PC), we must *spectrally* apply the appropriate

Table 4. APPROXIMATE EFFICIENCY RANKING OF THE SIX METRICS AS DESCRIPTORS OF INTERIOR, LF NOISE ANNOYANCE

Rank	Metric	r[a]	Stimuli Class Variance Coefficient
1	LSL	0.871	8.8%
1	C	0.863	8.8%
2	LSPL	0.841	9.8%
2	G_1	0.840	10.0%
3	G_2	0.806	13.3%
4	A	0.247	175%

[a]Correlation coefficient.

581

indoor/outdoor acoustic transfer function magnitudes plotted in Figure 4 to the measured 1/3-octave band spectrum. Using these functions, we have replotted the original frequency weighting characteristics of the LSL and C metrics in Figure 11 for both impulsive and non-impulsive sources. Table 6 lists the corresponding weighting factors for the transfer function magnitudes of Figure 4.

A limited verification of this procedure is shown in Figure 12. The predicted or PLSL values are plotted against the measured value for a bedroom excited by the MOD-1 impulses. The remaining rooms were in various homes excited by the gas turbine for which annoyance was reported. Figure 13 plots the observed interior LSL values in relation to the LSL annoyance criteria thresholds. While complaints were received from the residents of all four homes in which these rooms were located, we do not have sufficient information to completely verify the vertical stratification other than that it was above the perception level.

ESTABLISHING A REFERENCE EXTERNAL ACOUSTIC LOADING

The method of estimating a representative internal PLSL or PC value requires a suitable measure of the external acoustic loading spectrum. Since most homes are located

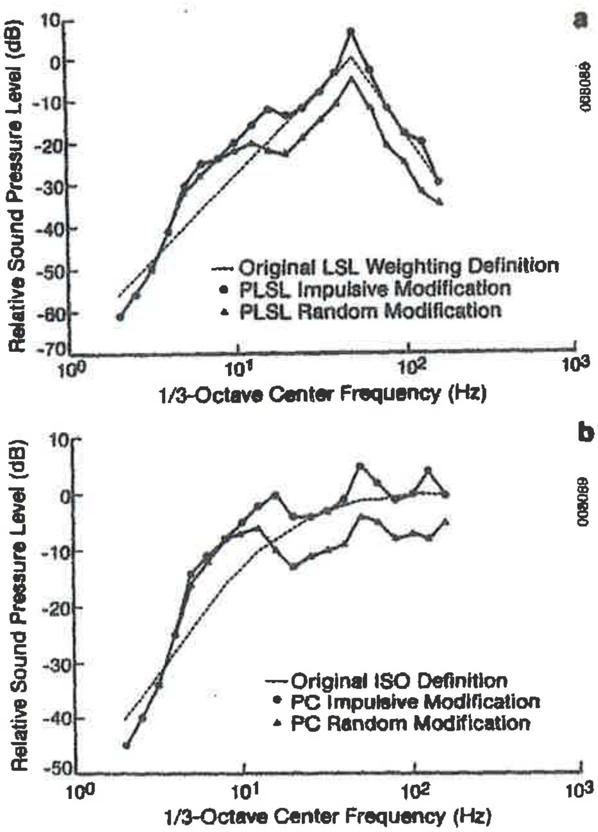


Figure 11. (a) PLSL SPECTRAL WEIGHTING; (b) ISO AND MODIFIED C SPECTRAL WEIGHTING

Table 5. INTERIOR LF ANNOYANCE-LEVEL CRITERIA EMPLOYING THE LSL AND C METRICS

	Threshold Perception		Annoyance Threshold		Unacceptable Annoyance	
Stimuli Class	LSL (dB)	C (dB)	LSL (dB)	C (dB)	LSL (dB)	C (dB)
Nonimpulsive, periodic random	58	68	65	75	68	77
Periodic impulsive source	53	63	57	67	60	68
Random periodic source	59	67	68	76	70	78
Periodic random w/40 dBA mask	59	68	65	75	67	79
Considering Only General Source Characteristics						
Nonimpulsive source	58	68	65	75	68	78
Impulsive source	53	63	57	67	60	68

Table 6. INDOOR/OUTDOOR TRANSFER FUNCTION WEIGHTING FACTORS

1/3-Octave Band Center Frequency (Hz)	Impulsive Transfer Function Magnitude LSL (dB)	Impulsive Transfer Function Magnitude C (dB)	Nonimpulsive Transfer Function Magnitude LSL (dB)	Nonimpulsive Transfer Function Magnitude C (dB)
2.0	-61	-45	-61	-45
2.5	-56	-40	-56	-40
3.15	-50	-34	-50	-34
4.0	-41	-25	-41	-25 [a]
5.0	-30	-14	-32	-16
6.3	-25	-11	-28	-12
8.0	-24	- 8	-24	- 8
10.0	-20	- 5	-22	- 7
12.5	-16	- 2	-20	- 6
16.0	-12	0	-22	-10
20.0	-14	- 4	-23	-13
25.0	-12	- 4	-19	-11
31.5	- 8	- 3	-15	-10
40.0	- 3	- 1	-11	- 9
50.0	+ 6	+ 5	- 5	- 4
63.0	- 3	+ 2	-12	- 5
80.0	-12	- 1	-21	- 8
100	-18	0	-25	- 7
125	-20	+ 4	-32	- 8
160	-30	0	-35	- 5

[a] Recommended minimum 1/3-octave spectral range.

582

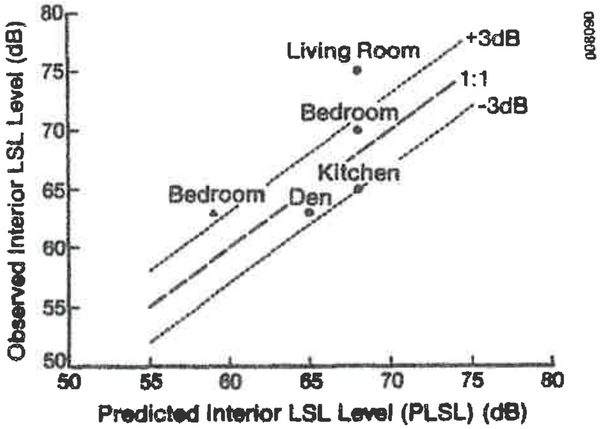


Figure 12. PREDICTED VS. OBSERVED INTERIOR LSL LEVEL COMPARISON

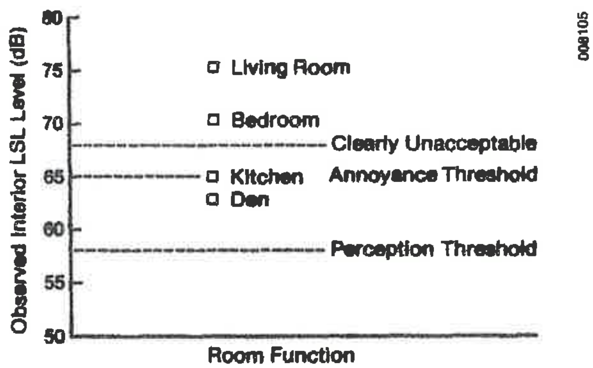


Figure 13. OBSERVED INTERIOR LSL VALUES FOR NONIMPULSIVE SOURCE

some distance from the nearest wind turbine(s), a method must be devised to provide a reference spectrum that takes into account situations in which atmospheric refraction and terrain reflection increase the acoustic levels above those expected from spherical divergence alone. We recommend using a reference distance of 1 km (0.6 mile) for calculating a "figure of merit" PLSL or PC level for a given wind turbine installation. To account for worst-case terrain/atmospheric focusing, we also recommend that 15 dB be added to the PLSL or PC values calculated at the 1 km distance. As an example, Table 7 lists the predicted or PLSL values for a home located 1 km from the MOD-1 and MOD-2 wind turbines [10].

SUGGESTED PROCEDURE FOR ESTIMATING THE INTERIOR LF ANNOYANCE POTENTIAL OF A GIVEN TURBINE DESIGN

The results of this paper are summarized below as a recommended procedure for establishing a low-frequency figure of merit for a given wind turbine design.

(1) Obtain a series of representative, unweighted, averaged 1/3-octave band pressure spectra over a range of 5-100 Hz for a range of operating conditions. Make the measurements at a distance from the turbine where a sufficient signal-to-noise ratio for this frequency range can be reasonably obtained. Use recording periods of at least 2 minutes but not more than 10 minutes.

(2) Establish whether the turbine exhibits impulsive radiation characteristics.

(3) Determine the equivalent near-field PLSL- or PC-weighted level by using the contents of Table 6 for impulsive or nonimpulsive sources to weight the linear 1/3-octave band spectra.

(4) Calculate the equivalent PLSL or PC levels at the reference distance of 1 km by assuming spherical divergence (-6 dB per doubling of distance).

(5) Add 15 dB to the results of step (4). This result is the figure of merit for the worst-case, low-frequency-range acoustic emissions associated with the wind turbine design. This level or these levels can now be compared with Table 5 to assess the interior annoyance potential.

Table 7. PREDICTED INTERIOR LSL (PLSL) VALUES AT 1 km FROM THE MOD-1 AND MOD-2 WIND TURBINES

Turbine	PLSL (dB)	PLSL+15 (dB)
MOD-1 Turbine (Severe impulsive characteristic)		
35 rpm operation	65	80
23 rpm operation	54	69
MOD-2 Turbine (Nonimpulsive characteristic)		
17.5 rpm operation	41	56

ACKNOWLEDGEMENTS

This work has been supported by the U.S. Department of Energy under contract no. DE-AC02-83CH10093. The author wishes to thank the seven SERI staff members who took the time to serve as evaluators for this project. Acknowledgment is also given for the excellent technical support rendered by Ed McKenna, David Jager, James Pruett, and Richard Garrelts. Engineering Dynamics, Inc., was responsible for the design and construction of the very low frequency (subwoofer) speaker system.

REFERENCES

1. Kelley, N.D., H.E. McKenna, and R.R. Hemphill, "A Methodology for Assessment of Wind Turbine Noise Generation," *J. Solar Engineering*, Vol. 21 (1981), pp. 341-356.

2. Kelley, N.D., H.E. McKenna, R.R. Hemphill, C.L. Etter, R.L. Garrelts, and N.C. Linn, *Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact, and Control*, SERI/TR-635-1156, Golden, CO: Solar Energy Research Institute (February 1985), 262 pp.

583

3. Carden, H.D., and W.H. Mayes, *Measured Vibration Response Characteristics of Four Residential Structures Excited by Mechanical and Acoustical Loadings*, NASA/TN-D-5776, Hampton, VA: NASA Langley Research Center (1970), 59 pp.

4. National Research Council, Comm. on Hearing, Bioacoustics, and Biomechanics Assembly of Behavioral and Social Sciences, CHABA Working Group 84, *Assessment of Community Response to High-Energy Impulsive Sounds*, Washington, D.C.: National Academy Press (1981), 31 pp.

5. Hubbard, H.H., and K.P. Shepherd, *The Helmholtz Resonance Behavior of Single and Multiple Rooms*, NASA/CR-178173, Hampton, VA: NASA Langley Research Center (September 1986), 26 pp.

6. Robin Towne, Assoc., Environmental Study of Low-Frequency Noise and Vibration, A Report to the Portland General Electric Co., Portland, OR: Robin Towne, Assoc. (1974), 144 pp.

7. International Organization for Standardization (ISO), Draft Proposal for "Acoustics Methods for Describing Infrasound," ISO/DIS 7196, Geneva, Switzerland: ISO.

8. Tokita, Y., A. Oda, and K. Shimizu, "On the Frequency Weighting Characteristics for Evaluation of Infra and Low-Frequency Noise," *Proc. 1984 Conf. on Noise Control Engineering*, G.C. Maling, Jr., ed., Poughkeepsie, NY: Inst. of Noise Control Engineering (1984), pp. 917-920.

9. American National Standards Institute (ANSI), "American National Standard Specification for Sound Level Meters," ANSI S1.4-1983, New York, NY: ANSI (1983).

10. Kelley, N.D., H.E. McKenna, E.W. Jacobs, R.R. Hemphill, and N.J. Birkenheuer, *The MOD-2 Wind Turbine: Aeroacoustical Noise Sources, Emissions, and Potential Impact*, SERI/TR-217-3036, Golden, CO: Solar Energy Research Institute (to be published).

584

Document #4

12

BEFORE THE ENERGY FACILITY SITING COUNCIL

OF THE STATE OF OREGON

In the Matter of the Application for Site Certificate for the	)))	
BRUSH CANYON WIND POWER FACILITY	))	**HEARING OFFICER REPORT**

PROCEDURAL HISTORY

The Energy Facility Siting Council ("Council") received an application for a site certificate for the Brush Canyon Wind Power Facility (BRC) on March 21, 2013. The proposed facility is a wind powered electric generating facility with a nominal generating capacity up to 535 megawatts located in Wasco and Sherman Counties, Oregon. The applicant is EC&R Development, LLC (Applicant), a wholly owned subsidiary of E.ON Climate & Renewables North America Inc. (E.ON) (Chicago, Illinois), which in turn is a subsidiary of E.ON AG, a publicly traded company headquartered in Dusseldorf, Germany.

On October 21, 2011, Applicant submitted to the Oregon Department of Energy ("ODOE") a Notice of Intent to Submit an Application for Site Certificate for the Brush Canyon Wind Power Facility. ODOE issued the project order on January 5, 2012. The applicant submitted the preliminary application on May 3, 2012 and a revised Final Application on March 21, 2013. ODOE completed its review of the Final Application for Site Certificate and deemed the application complete on March 29, 2013.

On March 15, 2013, Council appointed the undersigned J. Kevin Shuba as the Hearing Officer to conduct a public hearing on the Draft Proposed Order ("DPO") and conduct the contested case in the matter. ODOE issued the DPO on November 18, 2013, recommending that that Council issue a site certificate for the Brush Canyon Wind Facility subject to conditions included and detailed in the DPO. The DPO was issued in the manner provided for in ORS 469.370(4) and OAR 345-013-0210. ODOE also issued its Public Hearing Notice on November

18, 2013, setting the public hearing for December 9, 2013 and announcing the comment period would close at 5:00 p.m. on that day. ODOE subsequently amended the Notice of Public Hearing to postpone the hearing until January 7, 2014 because of inclement weather. The amended notice provided that comment on the DPO would close at the end of the hearing on January 7, 2014. On January 7, 2014, the Hearing Officer convened the hearing at 6:00 p.m. at the Antelope Community Center.[1] ORS 469.370(2) and OAR 345-013-0220 require at least one public hearing on the DPO in the vicinity of the site of the proposed facility. Approximately 70 people attended the public hearing.[2] The testimony at the public hearing becomes a part of the record for decision on the application. ORS 469.370(2) and OAR 345-013-0230(2) direct ODOE to consider the testimony at the public hearing and any timely written comments and agency consultation, as well as comments from the Council on the DPO, when preparing the Proposed Order and in determining whether to recommend granting or denying the Site Certificate.

ODOE provided to the Hearing Officer the DPO and the written comments submitted during the public comment period from November 18, 2013 through the close of the public hearing on January 7, 2014, as well as a summary of the comments. A recording of the hearing conducted by the Hearing Officer was also made and is included in the record. This Hearing Officer Report is provided to the Council to assist both Council and ODOE in reviewing the DPO consistent with the written comments received before the deadline and oral comments received at the public hearing. This Hearing Officer Report summarizes issues highlighted in the oral comments received during the public hearing phase of the siting process. However, this report does not discuss in detail written comments and the exhibits supplied by commenters.

///

///

[1] The recording of the public hearing is included in the record as BRC-0183.

[2] Sue Oliver and Shilo Ray, of ODOE's Hermiston office, also attended the public hearing.

GENERAL CONCERNS

Many of the comments raised multiple issues without citing to a particular standard or proposed condition or stating how the particular standard is not met. To the extent practical, I have noted in my summary those comments that do not appear to relate to a standard and note here that this is a standards-based process that relies on the ODOE staff's analysis of the material submitted to the record, including comments, to determine whether the applicable standards have been met.[3] As examples, many of the written and oral comments that address the visual impacts, impacts of construction traffic on the city of Antelope and wildlife impacts of the facility do not reference a specific standard or applicable state law or give an explanation of why the standard is not met. As a result, these comments may not meet the specificity requirement of ORS 469.370(3) to support inclusion of the issue in the contested case. *See also* OAR 345-015-0220(3)(h) and (i) and OAR 345-015-0220(5). I have organized this Hearing Officer Report by subject matter of the comments discussed and issues raised, roughly in the order that they appear in the DPO.[4] :

1. COMMENTS RECOMMENDING DPO CONDITIONS -

DPO Section IV.A – General standard of Review (OAR 345-022-0000)[5]

A.1 (Construction Deadline): Although written comments were submitted to the record by the Applicant regarding this issue, no person raised this issue at the oral hearing. Applicant seeks to extend the deadline to begin construction from 3 years to 5 years from issuance of the certificate.

///

---

[3] The participants in any contested case will have an opportunity to provide additional sworn evidence to the record for the final decision by the Council.

[4] I have cross-referenced the sections in this Report to the appropriate page numbers in the DPO, BRC-0111. The DPO sets out the text of each standard in full as part of the analysis, and I have not repeated that information here.

[5] BRC-0111, pp. 20-28.

DPO Section IV.B – Organizational Expertise (OAR 345-022-0010)[6]

Construction Rights for Facility Components

EOM, in written comments, raised issues regarding rights of subsurface mineral rights owners, including a claim that subsurface mineral rights owner received inadequate notice of the proceeding.[7] EOM also commented at the Public Hearing, highlighting their concerns. The Applicant responded to the written comments. EOM's comments may raise legal issues, including a procedural issue relating to a claimed right to and lack of notice of the facility. The fact that EOM was able to submit both written comment and appear at the DPO hearing means that it received actual notice of the project but the issue of whether EOM was entitled to another form of notice or whether the application is tainted because EOM was not contacted is an issue for another time.

DPO Section IV.C. – Structural Standard (OAR 345-022-0020)[8]

No Issues regarding the Structural Standard were raised by commenters.

DPO Section IV.D – Soil Standard (OAR 345-022-0022)[9]

No Issues regarding the Soil Standard were raised by commenters.

DPO Section IV.E – Land Use (OAR 345-022-0030)[10]

Consideration of city land use planning in the cities of Antelope and Shaniko: Written comments regarding the Land Use Standard focused on whether the Applicant and staff had adequately defined the scope of the land use analysis, including whether the City land use ordinance of the City of Antelope and Shaniko should have been included. One commenter asserted that the land use requirements of Wheeler County should have been analyzed because of the proximity to the John Day National Scenic Area.[11] No oral comments specifically addressed

---

[6] *Id.*, pp. 29-35.
[7] *See* BRC-0
[8] *Id.*, pp. 36-41.
[9] *Id.*, pp. 42-51.
[10] *Id.*, pp. 52-190.
[11] *See* BRC-0171.

these issues. In addition, some written comments expressed concern that the bases for finding land use compliance relied heavily on findings under the Council's own standards. These commenters questioned whether the Council standard reviewed the same criteria that the local land use provisions would use to determine compliance.

DPO Section IV.F – Protected Areas Standard (OAR 345-022-0040)[12]

The Protected Areas Standard is one of the Council standards addressing the visual impacts of the facility. Although there were many written and oral comments regarding visual impacts, no commenter at the oral hearing specifically coupled their comments with compliance with the Protected Areas Standard.

DPO Section IV.G – Retirement and Financial Assurance (OAR 345-022-0050)[13]

While commenters raised issues regarding taxpayer subsidies and inadequate provision for "clean-up" if the projects are abandoned, which I understand to refer to decommissioning of the facility, the comments were general and did not directly address the standard or any particular condition.

DPO Section IV.H Fish and Wildlife Habitat (OAR 345-022-0060)[14]

Substantial written comments were submitted relating to the Habitat Standards. The comments addressed the adequacy of the habitat categorization, as well as facility impacts on golden eagles, adequacy of monitoring requirements and cost recovery. Commenters also raised issues relating to the proposed habitat mitigation plans as they relate to displacement of deer and protection of protected species. Written comments and oral comments by Central Oregon Land Watch also raised legal issues regarding potential liability for the Council under the Bald and Golden Eagle Protection Act for granting a permit to a facility that results in a "take" under the BGEPA. This commenter pointed out a problem which may have arisen in other EFSC

[12] *Id.*, pp. 192-203.
[13] *Id.*, pp. 204-13.
[14] *Id.*, pp. 214-37.

applications, but for which I know of no resolution. This is a legal question for ODOE to consider as it moves forward towards a Proposed Order.[15] Another commenter questioned whether loss of avian habitat included any measurement of the area impacted by the turbines in the vertical plane (*i.e.* where the blades travel). Finally, one commenter questioned whether the applicant had adequately consulted with the appropriate Tribes, although these comments were written only.

DPO Section IV.I – Threatened and Endangered Species (OAR 345-022-0070)[16]

Commenters combined comments concerning threatened and endangered species under the Fish and Wildlife Habitat Standard.

DPO Section IV.J – Scenic Resources (OAR 345-022-0080)[17]

The Scenic Resources Standard assesses visual impacts of the facility in determining whether the site certificate should be issued. There were a number of written comments regarding Scenic Resources standard for several of the named resources, but no oral commenter specifically identified this standard for analysis. Issues included under this topic were:

- Visual Resource Analysis (BLM)
- "Journey Through Time" Scenic Byway
- Lawrence Memorial Grassland Preserve;
- Shaniko view-shed (specific suggestions for tower relocation, camouflage color and shielding);
- Radar-activated lights on towers

DPO Section IV.K – Historic Cultural and Archaeological Resources (OAR 345-0090)[18]

Commenters mentioned this standard when discussing traffic impacts on historic buildings in Antelope and Shaniko and in discussing visual impacts on historic resources. No comments directly addressed compliance with the standard.

---

[15] Sources indicate that this issue may have come up in the now-withdrawn Antelope Ridge facility
[16] *Id*, pp. 238-46.
[17] *Id.*, pp. 248-58.
[18] *Id.*, pp. 260-66.

DPO Section IV.L - Recreation (OAR 345-022-0100)[19]

Written comments discussed the impact of the facility on private land used for tourism and recreation, (hunting and fishing), but did not address compliance with the standard.

DPO Section IV.M – Public Services

- Bypass route around Antelope (new road constructed by Applicant). Many comments identified this issue. The City of Antelope requests that an alternative route be found for construction and project maintenance traffic that bypasses Antelope. It suggests a possible alternate route would be from the Bennett Road quarry through Johns Canyon that connects to the project access road at the top of the ridge as a more direct route to save time and fuel and not disrupt either city residents or tourists.
- Watershed and Water Supply: Comments indicated that the Applicant responsible to repair damages if construction vehicles caused any. This appears to be covered in the DPO conditions.
- Wildfire/Fire Suppression: (Annexations to South Sherman Fire Protection; funding) At least two comments identified fire suppression as an issue related to the project; Fire Chief MacNab and Mr. Silvertooth-Stewart. Their points were similar -- that neither the City of Shaniko nor the South Sherman Rural Fire Protection District can alone deal with the additional services that the proposed project will likely impose. To deal with this issue, the following were suggested: (1) That the applicant/operator fund for South Sherman RFPD professional services to facilitate annexations to the district and completion of any intergovernmental cooperation agreements. (2) That the applicant/operator use best efforts to ensure that all of the project area is annexed into the district (including any lands later added to the project). (3) That the applicant/operator contribute to the operation of the district through the life of the project. (4) That the applicant/operator assist the district through the life of the project to

---

[19] *Id.*, pp 267-73.

secure other financing such as grants, donations or other funding. OAR 345-022-0110 requires a finding "that the construction and operation of the facility, taking into account mitigation, are not likely to result in significant adverse impact to the ability of public and private providers within the analysis area described in the project order to provide...fire protection." I recommend reevaluation of this issue in the Proposed Order.

- Including a rural addressing system for internal project roads for emergency responders.

Public Services – Condition Specific Comments

- Condition M.5 - Impacts on local roads from construction must be repaired. The DPO appears to already require this of the Applicant. Some comments identified that vibration from heavy equipment near buildings may damage them as many do not have a continuous foundation. The Proposed Order could include some more specific language here.

DPO Section IV.N – Waste Minimization (OAR 345-022-0120)[20]

No issues were raised regarding the Waste Minimization standard by commenters.

DPO Section IV.O – Public Health/Safety for Wind Facilities (OAR 345-024-0010)[21]

While there were many comments that raised the issue of public health and safety generally, no comments specifically related concerns to this standard. The general comments about public health and safety included concerns about turbine setbacks for health and safety, "shadow flicker," and "Windmill Blight."

DPO Section IV.P – Cumulative Effects Standards for Wind Energy Facilities (OAR 345-024-0015)[22]

No comments raised issues specifically related to the Cumulative Effects Standard.

---

[20] *Id.*, pp. 297-300.
[21] *Id.*, p. 301-04.
[22] *Id.*, pp. 305-10

DPO Section IV.Q – Siting Standards for Transmission Lines (OAR 345-024-0090)[23]

The Applicant requested a change to proposed Condition Q.2 in written comments. That standard addresses how the facility can deal with setbacks from occupied structures.

DPO Section IV.R – Noise Control Regulations (OAR 340-035-0035)[24]

One commenter submitted written comments, which were read into the record at the Public Hearing challenging the noise modeling for the facility. Ms. Severe[25] commented that the Applicant's modeling incorporated standards that are inapplicable to the noise generated by a turbine. Her points were that the modeling incorporated assumptions not true of turbines. Two stand-out aspects of her comments were that turbine noise is low frequency and generated at point elevated above the ground. She claims these facts invalidate the noise-related representations of the Applicant because low frequency waves are longer wavelength, higher energy and travel further. Also the height at which they are generated contribute to the distance at which the noise can be detected. According to Ms. Severe, the modeling used by the Applicant incorporates standard testing that is based on noise generated at ground-level. Another commenter at the DPO hearing argued that the Council should not grant an exception to the noise rules under OAR 340-035-0035(6)(a). This issue may raise legal as well as factual issues regarding the noise modeling calculated and provided by the Applicant as part of the application. I recommend further evaluation of Ms. Severe's comments[26] and review of the Applicant's representations and possible revision of the Proposed Order related to noise.

---

[23] *Id.*, pp. 311-16.
[24] *Id.*, pp. 317-26.
[25] Ms. Severe was emotional during her testimony and demonstrated that by banging down her written submissions at the table used by the Hearing Officer and the Siting Officer following her oral testimony.
[26] Ms. Severe's solution may be consistent with DEQ rules on this subject.

DPO Section IV.S – Removal-Fill Law[27]

The Department of State Lands provided a written comment requesting a change to a condition to clarify the timing of the payment in lieu. No oral comments were received on this issue. This issue should be considered and resolved in the language of the Proposed Order.

DPO Section IV.T – Ground Water Act[28]

Although written comments addressed impacts to the City watershed and water supply, no person addressed this issue in oral comments with specificity.

2. COMMENTS THAT MAY OR MAY NOT BE UNDER THE COUNCIL'S JURISDICTION:

- Impacts to National Security (Irene Gilbert)[29]
- Impacts on military training routes for low level training flights (the Department of the Navy). According to the Navy, the proposed Brush Canyon Wind Project is within the confines of four military training routes (IR-342; IR-344; IR-346; VR-1353) that were established following implementation of the Federal Aviation Act of 1958. Specifically, in the Brush Canyon Project area, all of the above military training routes have route widths of eight nautical miles (four nautical miles on each side of centerline) and minimum altitudes down to 500 feet above ground level for the IRs and down to 200 feet for VR-1353. The Navy believes that 29 of the proposed turbines may lie under established military training routes.
- Interference with mineral rights and development; proposed condition to require certificate holder to enter into an agreement with the mineral estate owner (property rights) (EOM). This issue was covered by both EOM and the Applicant in written comments and highlighted by EOM's attorney in oral comments. I do not know of a council standard governing these

---

[27] *Id.*, pp 327-36.
[28] *Id.*, pp. 337-39.
[29] The commenter also stated there is no opportunity for the public to review numerous plans required by the site certificate; that the draft proposed order failed to require compliance with a court decision related to a "legal limit on vegetation control methods;" that proposed setbacks are inadequate to protect the public; that legal property ownership must be determined; and that there is "inaccurate and misleading information" in the application for site certificate." *See* BRC-0171.

property rights issues, but the DPO contains a condition requiring control of the property before beginning construction. In written comments, Applicant states willingness to deal with this as a property issue now that it has been identified and the Proposed Order could include that as a condition.

- Property Value (various commenters commented that the project would adversely impact value of their property without specific information quantifying those impacts other than general observations about views being impacted by windmill or turbine blight.
- Size of interconnect with BPA: this comment concerned the upgrade to the substation with concerns about whether that upgrade was coordinated with the energy output (in megawatts) that are proposed to be generated by this project. Since this is a BPA proposed and engineered upgrade it is unlikely that the applicant could do anything other informing BPA of this project's capability (communication that likely has already occurred).

PROCEDURAL COMMENTS

Location of Hearing: In comments provided for the originally scheduled Public Hearing on December 7, 2103, no commenters asserted that the public hearing should be scheduled nearer to the proposed facility. This issue was rendered moot by the change in date and location of the hearing to Antelope, Oregon.

Notice of this application (EOM): EOM submitted written comments before the first scheduled public hearing claiming that notice of the proceeding was inadequate because subsurface mineral rights holders were not notified of the facility. The attorney for EOM highlighted this procedural issue in oral comments at the public hearing. This is a legal issue for the Department of Energy (with the assistance of the Department of Justice) to address.

"Fast-Tracking" of the Siting Process, Bias of Siting Staff: This was a general comment and included a complaint that Council should have attended the DPO hearing in person. The fast-tracking aspect of the comment was not explained nor was the alleged bias of the staff.

Some of the attendees of the DPO hearing were emotional when providing their comments and obviously feel very strongly about that the project should not be permitted as proposed.

GENERAL COMMENTS

Several commenters, including the City of Antelope, submitted written comments in support of issues mentioned above without specific reference to a standard or suggestions for changes to the DPO/PO, which were highlighted by oral comments at the public hearing. These include concerns about impacts to City of Antelope from construction traffic on the main road through Antelope, requesting that the Council require the applicant to bypass Antelope during construction; impact and damage to historic structures in the City from construction traffic and the impact of construction and the facility on tourism in the area and impacts on livability caused by the existence of a wind facility. Comments also addressed the impact of the facility on the watershed and water supply for the City of Antelope and livability.

CONCLUSION

The Hearing Officer conducted the hearing on January 7, 2014 and reviewed the written comments submitted during the comment period.

RESPECTFULLY SUBMITTED this 11th day of March 2014.

J. Kevin Shuba, Hearing Officer
Brush Canyon Wind Power Facility