ABSTRACTS

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Theoretical analysis of wind turbine used to power a stand-alone solar desalination unit in selected coastal areas of Egypt

Zeinab Sayed Abdel-Rehim

Mechanical Engineering Department, National Research Center ,

Dokki, Giza , Egypt

e-mail: zabdelrehim@yahoo.com

Theoretical analysis of wind turbine used to power a stand-alone solar desalination unit in selected coastal areas of Egypt is presented in this work. The selected coastal areas are; Mersa Matruh and Sidi-Barrani on the Mediterranean Sea coast and Hurghada and Abu Rudies on the Red Sea coast. In these areas, the fresh water shortage is significant problem and the wind energy is usually high that used in renewable energy applications. The available wind data of the selected areas are collected from meteorological station along these coastal areas of Egypt . The wind data are analyzed in a form useful for wind turbine characteristics and wind energy computation. The annual mean wind speeds are 5.3, 5.0, 6.3 and 4.8 m/s for Mersa Matruh, Sidi-Barrani, Hurghada, and Abu Rudies, respectively. The proposed solar desalination system is considered as conventional solar still and simple system of breaking the boundary layer of the basin water surface to enhance the performance of the solar desalination system. This simple system is helical shaft that installed near to the basin water surface. The helical shaft is running with slow speed by using small motor. This motor powered by the considered wind energy. This study aimed at evaluating of the mean wind speed for the selected areas to determine the characteristics of the suitable wind turbine and compute the amount of captured wind energy to power the proposed solar desalination system. Analytical assessment is presented to determine the power available from the wind stream. The analytical assessment reveals that the coastal areas of Egypt offer sufficient wind energy for economic utilization of requirement of energy in these communities. The results show that Mersa Matruh and Hurghada have the highest amount of wind energy, power and distillate water productivity due to the climatic district.

Long range sound transmission over the sea with application to wind turbine noise

Mats Åbom and Mathieu Boué

The Marcus Wallenberg Laboratory (MWL)

KTH, SE-100 44 Stockholm, SWEDEN

matsabom@kth.se

The classical theory of spherical wave spreading is not valid at large distances from a sound source due to atmospheric refraction caused by wind and temperature gradients. For large distances (> 1 km) in the down wind direction a cylindrical type of wave spreading can be expected. Over areas with soft ground conditions, e.g., grass land, the ground damping will restore a behavior close to a free field spherical spreading. This is also the approximation used in most national recommendations for estimating noise emission from wind turbines. However in Sweden there is a special recommendation for sea based wind turbines, which use cylindrical wave spreading for distances larger than 200 m. This model is based on a few old measurements and in order to better validate the model new and better data is needed. This paper presents a measurement procedure for long-range (5-15 km) outdoor sound propagation over the sea. Using the procedure measurements have been performed during the summers of 2005 and 2006 in the Kalmar strait, Sweden, located between the mainland and Öland (~ 10 km). Two different directive sound sources placed on a lighthouse in the middle of the strait produced low frequency tones between 80-400Hz. At the reception point, an array of 8 microphones was used to create an acoustical antenna directed towards the sound sources. Moreover, in order to increase the signal-to-noise ratio different signal enhancement methods were implemented. The sound measurements were compared to atmospheric wind and temperature data to correlate low damping values with meteorological phenomena such as "low level jets". The results expressed as a transmission loss between the source and the receiver, compensated for the atmospheric damping, have been expressed as statistical distributions. The results are discussed and compared with some simulations based on ray-tracing.

In-Home Wind Turbine Noise Is Conducive to Vibroacoustic Disease

Mariana Alves-Pereira

ERISA-Lusofona University, Lisbon, Portugal

Nuno A. A. Castelo Branco

Center for Human Performance, Alverca, Portugal

(vibroacoustic.disease@gmail.com**)**

Introduction. This team has been systematically studying the effects of infrasound and low frequency noise (ILFN, <500 Hz) in both human and animal models since 1980. Recently, yet another source of ILFN has appeared: wind turbines (WT). Like many other ILFN-generating devices, WT can greatly benefit humankind if, *and only if*, responsible and intelligent measures are taken for their implementation. Vibroacoustic disease (VAD) is the pathology that is acquired with repeated exposures to ILFN environments (occupational, residential *or* recreational). This can be considered a scientific fact because there are 27 years of valid and robust scientific data supporting this assertion.

Goal. To evaluate if ILFN levels obtained in a home near WT are conducive to VAD.

Methodology. Case 1: documented in 2004, in-home ILFN levels generated by a port grain terminal, 2 adults and a 10-year-old child diagnosed with VAD. Case 2: isolated farm in agricultural area, four 2MW WT that began operation in Nov 2006, located between 300 m and 700 m from the residential building, 3 adults and 2 children (8 and 12-years-old). ILFN levels of Case 2 were compared to those in Case 1. In both, ILFN was assessed in 1/3 octave bands, without A-weighting, (i.e. in dB Linear). In Case 1, the lower limiting frequency was 6.3 Hz, while in Case 2, it was 1 Hz.

Results. ILFN levels in the home of Case 2 were higher than those obtained in the home of Case 1.

Discussion. ILFN levels contaminating the home of Case 2 are amply sufficient to cause VAD. This family has already received standard diagnostic tests to monitor clinical evolution of VAD. Safe distances from residences have not yet been scientifically established, despite statements by other authors claiming to possess this knowledge. Acceptance, as fact, of statements or assertions not supported by any type of valid scientific data, defeats all principles on which true scientific endeavor is founded. Thus, widespread statements claiming no harm is caused by in-home ILFN produced by WT are fallacies that cannot, in good conscience, continue to be perpetuated. In-home ILFN generated by WT can lead to severe health problems, specifically, VAD. Therefore, real and efficient zoning for WT must be *scientifically* determined, and quickly adopted, in order to competently and responsibly protect Public Health.

Masking of wind turbine sound by sea waves

Paul Appelqvist ÅF-Ingemansson, Martin Almgren ÅF-Ingemansson, Karl Bolin Royal Institute of Technology, Mats Åbom Royal Institute of Technology

Several countries use immission guidelines which relate the wind turbine sound to the background sound assuming a masking effect from wind induced sound. Despite a thorough literature search no studies have been found that investigate the masking potential of wind turbine sound by sea waves. This effect on wind turbine sound could permit optimal energy output without risking complaints by nearby residents especially for off-shore wind farms. Field measurements of sea wave sound are reported from a number of sites along the coast of Sweden. This together with a prestudy concerning the masking potential of sea wave sound on wind turbine sound show that sound from breaking waves has a good masking potential considering an immission value of 40 dB(A) at the shoreline. The shoreline can be regarded as a line source leading to a transmission loss of 3 dB per distance doubling which is verified for distances up to 70 m. Based on the measurements a prediction model for 1/3-octave band spectra is developed as well as a regression model for A- and C-weighted sound pressure level showing a high correlation with the significant wave height. Sea bottom inclination is found to be a determining factor for the characteristics of the sea wave sound and thus the masking potential which is frequency dependent.

Taking into account of atmospheric conditions for a spatio-time localization of the aerodynamic sources on a moving blade by the method of acoustic imagery

Dominique VINCENT, Vincent BENOIT

ACB Engineering - Acoustics Consulting & Sales Company

11E rue Lavoisier 95220 Herblay France

Phone: 0033 1 39 31 46 03 - Fax: 0033 1 39 31 46 17

www.acb-engineering.fr

The rapidly increasing capabilities of computer hardware and electronic components allow to apply the acoustic imaging technique to today's large wind turbines. It is possible to separate and analyse the noise behaviour of the three major zones of noise radiation, which are the tower, the rotor hub and the blades. Locating accurately the origin of the main aeroacoustic radiations on a moving blade drives the beamforming technique to its limits. Advanced methods are required for the space-time localization of the blade and to operate the measurement devices. The blade localization with the beamforming technique can be improved by taking into account the influence of the atmospheric parameters (wind field, hygrometry, temperature). This publication presents our effort to quantify the effects of the latter. The first part is devoted to the analytical presentation of the problem. The second part shows theoretical and experimental results illustrating the differences in localizing aeroacoustic noise sources with or without correction to account for the influence of atmospheric parameters.

Wind Farms Noise Predictions and the Risks of Conservatism

Andrew Bullmore (andrewbullmore@acoustics.hoarelea.com)

Justin Adcock (justinadcock@acoustics.hoarelea.com)

Mark Jiggins (mark.jiggins@btinternet.com)

Matthew Cand (matthewcand@acoustics.hoarelea.com)

Hoare Lea Acoustics, Level 3, Glen House, 200 – 208 Tottenham Court Road

London W1T 7PL

Conservative approaches to the prediction of noise immissions from wind farms reduce the risk of compliance failure. However, overly conservative approaches introduce the risk of not capturing the true energy generating capacity of a given wind farm site. Unlike other forms of development, conservative planning of wind farms cannot be offset by increased mitigation without incurring such lost energy generating potential. The large scale of modern wind farms means that seemingly small conservatisms in the prediction of noise immission levels can translate to substantial lost development opportunities.

A worst case assessment methodology assumes that a receiver is located downwind of every turbine, all turbines experience the same wind conditions as the first upwind turbine, the ground acts as a hard reflective surface, and all turbines are emitting sound power greater than test levels. Whilst this scenario is possible, it is unlikely that all these factors will transpire simultaneously in practice. To gauge the pessimism of this approach, long term measurements were carried out near operational wind farms and

compared to noise levels predicted using several techniques. This paper presents an analysis of these measurements and discusses the opportunities for more realistic prediction techniques. The paper then continues to discuss the potential impact that the use of more realistic prediction techniques may have on increasing the potential generating capacity of wind farm sites.

A Variety of Wind Turbine Noise Regulations in the United States – 2007

James D. Barnes

Acentech Incorporated

33 Moulton Street

Cambridge, MA 02138

USA

617-499-8000

Similar to other new large-scale projects, proposed wind turbine projects can produce varying reactions among community residents, including potential concerns about noise. Both state and local governments within the United States have developed a variety of noise regulations that specifically address wind turbine installations. These regulations have sought a balance of allowing for wind turbine development with protection of the public from excessive noise. A presentation at the 2005 Wind Turbine Noise Conference focused on regulation of wind turbine noise in the Western United States. Since that time, new regulations have been adopted in areas throughout the United States. This paper will identify several types of regulations and discuss their characteristics and impact on wind turbine projects and their associated communities.

Investigating the audibility of wind turbines in the presence of vegetation noises.

Karl Bolin

The Marcus Wallenberg Laboratory, KTH, SE-100 44 Stockholm, SWEDEN

kbolin@kth.se

Relative ratios of wind turbine (WT) noise levels are used in several countries among others Britain and France. To determine the background noise level extensive measurements are performed conducted at dwellings or other locations near the proposed WT site. This paper present a method to avoid these measurements in woodland areas, it also include a pre-study concerning the audibility of WT noise mixed with vegetation noise.

A prediction model for noise from vegetation including the deleafed state is described. This has been coupled to wind turbulence and therefore percentile values such as $L_{A,90}$ and $L_{A,10}$ can be predicted. Furthermore the paper present results from psycho acoustic tests with 6 subjects. These are compared to a loudness model to examine if this is applicable to the concerned sounds. Two different WT sounds have been used as stimuli. The first sound is recorded from a single WT with distinctive amplitude modulations. The second sound is from a WT park.

The results indicate how different WT noises are audible in the presence of natural background noises and could be used as a tool to optimize the power generated from WT as well as avoiding disturbance among nearby residents.

What is the real background noise?

Dick Bowdler New Acoustics UK

The measurement of background noise related to wind speed at noise sensitive properties is required to make a proper assessment of the impact of a wind farm. For example ETSU-R-97 says at least a week is likely to be needed. But the result you get depends on which week you choose. What the distribution of wind speeds was. How much rain there was. What time of year it was. What equipment was used and even who did the measurements.

The background noise graph contains two elements. A wind related curve and a non wind related that includes road traffic, farm noise and so on. The ideal curve is discussed together with the influences that change it.

The paper looks at what wind/noise graphs ought to look like, how to spot that your graph is not right, and to analyse what is wrong. Examples are given of the influence of road traffic, the dawn chorus and other common non-wind noises as well as examples of how noise levels can vary with wind direction.

Living with aerodynamic modulation, low frequency vibration and sleep deprivation - how wind turbines inappropriately placed can act collectively and destroy rural quietitude

Julian.T.Davis BSc (Agric) MBPR Jane Davis MA

We seek to support the scientific work carried out by learned colleagues, by describing the real effects on previously normal family life and adding the human touch to research across industry and government as they work to identify why some geographical terrains are simply not suitable for wind energy.

The paper discusses the significant and measurable effects that the phenomenon of aerodynamic or amplitude modulation, where turbines are inappropriately placed, combined with low frequency sound waves can have.

It informs the casual observer of wind turbines who may have heard the swish as a whisper in the wind, barely audible above rustling trees that aerodynamic modulation can be equivalent to a motorcycle revving outside your bedroom window at 4am.

The effects of the low frequency sound waves, apart from having no moles for two decades, create an annoying hum that is impossible to escape from, especially with a wooden bed on wooden floors.

It seeks to remind developers that excess noise is directly linked to lower productivity and less profit, and encourages scientists to find ways of predicting and correcting these anomalies so that wind power can be correctly and appropriately sited where it will genuinely benefit all mankind without destroying the lives of the few.

Review of post-construction compliance assessment conditions in various wind farm planning permits from New Zealand and Victoria (Australia)

Christophe Delaire Marshal Day Acoustics Australia

The New Zealand Standard 6808:1998 *Acoustics – The assessment and measurement of sound from wind turbine generators* (NZS6808:1998) is currently used in New Zealand and Victoria (Australia) to assess noise emissions from wind farms. Section 5 of NZS6808:1998, related to the post-construction compliance assessment, only details the methodology to determine compliance with the limits.

In Victoria, the planning permit conditions for the proposed wind farm are determined by an independent panel appointed by the Minister for Planning, if the project's power output exceeds 30MW, or the local council for smaller projects. In New Zealand, the planning permit conditions are determined by the local council. In case of appeal, the Environment Court will issue the final permit conditions.

These planning permit conditions usually outline the post-construction compliance assessment requirements and can be more or less stringent for different wind farm projects.

This paper presents a general review of permit conditions for a number of wind farms approved in New Zealand and Victoria. This paper highlights various permit conditions regarding noise compliance assessment of wind farms and discusses history, relevance, practicability and limitations

Applicability of TLM to Wind Turbine Noise Prediction

Guillaume Dutilleux

Acoustics Group

CETE de l'est – Laboratoire Régional des Ponts et Chaussées de Strasbourg

11, rue Jean Mentelin, BP 9, 67035 Strasbourg CEDEX 2, France

guillaume.dutilleux@equipement.gouv.fr

Wind turbine noise propagation takes place in an anisotropic sound speed gradient due to the presence of wind. In the general case of propagation, it is desirable to be able to address upwind configurations. Modelling upwind propagation implies to introduce atmospheric turbulence. Such refinements are not so easy to take into account in current methods like ray tracing or parabolic equation. The present paper shows that the Transmission Line Matrix method (TLM) might be a tool of choice when dealing with an inhomogeneous atmosphere. A novel intensity-based procedure for propagation in an anisotropic gradient is derived. The possibility of introducing turbulence be it thermal or dynamic is investigated on the basis of effective sound speed and sound intensity.

Recommendations for an improved quality of the acoustics of wind farm projects.

Pierre Dutilleux, Joachim Gabriel
DEWI GmbH – Deutsches Windenergie-Institut
Ebertstrasse 96, D-26382 Wilhelmshaven
p.dutilleux@dewi.de**, j.gabriel@dewi.de**

From the consideration of the various acoustic issues that are raised by wind farm projects, the similarities and differences of approaches and methods used in France and in Germany are reviewed. At each step of this review, advantages and drawbacks of each method are underlined. Recommendations to the acousticians, to the wind turbine manufacturers, to the developers and to the operators are derived with the objective of improving the acoustic quality of wind farm projects and their acceptance by the population.

Low Frequency Noise from Wind Turbines

Malcolm Hayes. Hayes McKenzie Partnership Ltd, Lodge Park, Tre'r-ddol
Machynlleth. POWYS, Wales

The completion of the study sponsored by the Department of Trade and Industry into the measurement of low frequency noise at three wind farms in the UK has provided physical evidence of the levels of low frequency and infrasound experienced at dwellings neighbouring wind farms in the UK. The three wind farms were identified on the basis of low frequency noise complaints. The levels of infrasound and low frequency noise were found to fall below the DEFRA Night-time Low Frequency Noise Criteria and were typically at or below the median threshold of audibility in quiet. Additional measurements at another wind farm in the UK confirm that the levels found at the three original wind farms are typical of the levels associated with modern wind farms in the UK. However, residual noise, at frequencies associated with the trailing edge noise of the wind turbines, was audible within the dwellings. Consideration is also given to the potential effects of the measured infrasound and low frequency sound levels with regard to the alleged potential occurrence of Vibro-acoustic disease.

Assessment of Sound and Infrasound at the Pubnico Point Wind Farm, Nova Scotia

Brian Howe, MEng, MBA, Peng, Nick McCabe, PEng

HGC Engineering

2000 Argentia Road, Plaza 1, Suite 203, Mississauga, ON, Canada L5N 1P7

The Pubnico Point Wind Farm began operating seventeen Vestas 1.8 MW wind turbine generators in 2005. The closest residential neighbour to the wind farm had expressed concerns regarding the sound impacting his property, which is adjacent to the wind farm and about 330 metres north of the closest wind turbine generator. His concerns related to the audibility of the sound produced by the wind turbine generators, particularly when the wind is from the south, and suggested an increased

impact during periods of fog. The resident was concerned about the potential for adverse health effects of infrasound due to the operation of the wind turbine generators. Howe Gastmeier Chapnik Limited (HGC Engineering) was retained by Natural Resources Canada to assess the environmental noise impact. This paper is based on the findings of that assessment, and the original report is available on line.

http://www.noise-vibration-acoustics.com/2006/11/hgc_engineering.html

Towards a review of NZ Standard NZS6808:1998 Acoustics - Assessment & Measurement of Sound From Wind Turbine Generators

Malcolm Hunt

Malcolm Hunt Associates

P O Box 11-294, Wellington. New Zealand

Since its introduction in 1998 New Zealand Standard NZS6808:1998 has been widely adopted with Australia and New Zealand as a guideline for the measurement and assessment of wind farm noise. This paper outlines the results of an investigation of technical acoustic matters covered by the Standard, based on stakeholder feedback in relation to the use and experience with New Zealand Standard of NZS6808 *Acoustics - Assessment and Measurement Of Sound From Wind Turbine Generators.*

While any official announcement of a review NZS6808:1998 is yet to be made, this report draws on the experience of the author and colleagues in identifying salient technical matters that need to be covered by such a Standard, including the results of a survey of users and industry stakeholders on experience with NZS6808:1998 to date.

Technical topic areas identified are listed as follows:

1) Noise Propagation Modelling
2) Noise Measurements
3) Low frequency + vibration
4) Wind Farm Noise Limits
5) Reference to related acoustic Standards
6) Tests for Special Audible Characteristics
7) Uncertainty
8) Cumulative Wind Farm Noise Effects

The paper outlines each issue, describes how NZS6808:1998 currently deals with the issue, provides an assessment of the adequacy of the current approach, and puts forward broad recommendations for improvements in approach, with the aim of providing a focus for discussions on how NZS6808:1998 could be revised in the future within the formal Standards review process.

Passive and Active Dynamic Vibration Absorbers for Gear Box Noise Reduction in Wind Turbines

Illgen, A.; Drossel, W.- G.; Wittstock, V.; Neugebauer, R. (Fraunhofer Institute for Machine Tools and Forming Technology IWU, Dresden, Germany)

Mitsch, F.; Hanus, K.- H. (ESM GmbH, Rimbach, Germany)

Lorenz Wiedemann, (SCHIRMER GMBH · BERATENDE INGENIEURE, Dresden, Germany)

In wind turbines the drive train, especially the gear box, is a significant source of noise. Significant contributions come from the gear mesh and from resonances of the structure like the main frame or the torque arm. The structure-borne noise from these sources is transferred either to the rotor or to the tower and radiated to the environment. The contributions to the noise spectrum from these sources are single tones in the frequency range from about 100 Hz to about 600 Hz. Especially tones with high levels are annoying and must be reduced.

Several measures are possible to reduce these tones. One cost-effective and rapidly applicable method is to use passive vibration absorbers. The vibration absorbers for reduction of structure-borne noise developed by ESM are tuneable to nearly every frequency and mass required by the system. For special applications vibration dampers tuneable in all three co-ordinates are available.

Modern wind turbines are running with variable speed. Therefore passive vibration absorbers which work only in a small frequency range come to their limit. For these challenging applications an active system based on piezo stack actuators shall be developed. This Active Vibration Absorber (AVA) works with two commercial piezo stack actuators in phase opposition.

Noise prediction of a new 34 MW wind farm

Antonio Iannotti, Fabio Serpilli

Dipartimento di Energetica – Università Politecnica delle Marche, Ancona

Actually is under environmental assessment study a new wind farm of 34 MW. The analysis needs also an acoustic evaluation of noise impact to the neighbour. In particular the nearest houses are at 300m from wind turbine. Italian laws do not have a specific legislation for wind turbine noise. The study is carried out using common environmental Italian laws. The results show that there isn't an acoustic impact in the frequency range contemplated by Italian laws. The most relevant problems are for low frequency noise.

An Approach to RANS Based Prediction of Airfoil Trailing Edge Far-Field Noise

M. Kamruzzaman, Th. Lutz and E. Krämer, Institute of Aerodynamics & Gas Dynamics(IAG), Universität Stuttgart, Pfaffenwaldring 21, D-70550 Stuttgart, Germany.

This paper describes a prediction scheme for the airfoil Turbulent Boundary Layer Trailing-Edge Interaction (TBL-TE) far-field noise used for the combined aerodynamic and aeroacoustic airfoil design process. The model presented here follows the

spectral solution of the Poisson equation for the surface pressure fluctuations underneath a turbulent boundary layer, and evaluation of the noise emission from the trailing edge due to this fluctuating pressures by solving the diffraction problem. The final form of the model is expressed as an integral of the turbulence sources over the boundary layer thickness and another integral in the wave number direction. In previous investigations [1, 2, 3, 4], several semi empirical methods in combination with the XFOIL airfoil analysis code [5] and Finite Difference code EDDYBL are applied successfully to model the turbulent acoustics sources for the prediction scheme. Presently, a RANS based flow solver together with an appropriate turbulence model is coupled with the noise prediction scheme to avoid a semi-empirical determination of source input parameters, and to improve the accuracy and consistency. The main advantages of the present RANS based approach is the direct derivation of the required turbulence properties by means of different two equation and full Reynolds Stress models. As a result the anisotropic behavior of the turbulence noise source parameters can be analyzed elaborately. Moreover, in detailed investigations and comparison study are carried out on the calculated noise source parameters (i.e. turbulent boundary layer parameters, vertical fluctuation velocity and integral length scale) and total noise spectra based on the experimental results of the Laminar Wind Tunnel (LWT) at the IAG. Encouraging results are obtained. The prediction scheme will be applied further in the design process of low noise airfoils.

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Aerodynamic noise from micro wind turbines: Current situation and future perspectives

Damien Leclercq, Con Doolan School of Mechanical Engineering The University of Adelaide Adelaide, SA 5005, Australia

Micro wind turbines are set to play a role in the future mix of energy generation if the concept of embedded power generation keeps gathering support from governing authorities. Apart from the obvious benefit of additional energy generation at or near the point of use, micro-wind power has an important role to play in terms of public education, which will promote the conservation of energy as well as an increased understanding and a better acceptance of wind power. Unfortunately, noise emissions from small wind turbines constitute one of the main obstacles to widespread use in populated zones, and a great deal of work is needed in this area if domestic wind power is to achieve a success comparable to that of domestic photovoltaic power generation or solar water heating. This paper presents a brief survey of the work published to date on the aerodynamic noise generated by horizontal axis micro-wind turbines. The noise generation mechanisms are reviewed and sorted by order of importance, thus identifying the most pressing issues in terms of noise generation. As an example, the effect of a proposed noise control device is assessed using a recently developed micro-wind turbine experimental research facility. This application is used to outline the scope for future work, and how this work can benefit the development of domestic wind turbines.

Auralization and assessments of annoyance from wind turbines

Søren V. Legarth Delta Acoustics Denmark

Noise from wind turbines is of great concern for the neighbouring residents. Differences in the sound profiles of the wind turbine noise influence the annoyance. By applying a model for sound propagation, it is possible to auralize the sound from the wind turbine at the neighbouring residents. This approach potentially gives a more realistic presentation of the actual wind turbine noise as input to the decision-making process. In the present work, five different wind turbines were recorded and auralized at two distances using the Nord2000 propagation model. 20 subjects rated the processed recordings on overall annoyance with additional natural background noise being switched on and off. Relevant sound attributes like loudness, pace, tonality and swishing sound were also rated by the subjects and compared with physical metrics. As a result, a metric for swishing sound is proposed. Finally, a proposal is presented for a prediction model on annoyance of sound from wind turbines.

Advanced methods for online vibration monitoring of wind turbines

Patrick Labeyrie

CMS Division Technical Manager

AREVA expert in Conditional Maintenance

Frédéric Champavier

Diagnostic specialist of rotating machines

Environmental and technological characteristics of wind turbines, along with the importance of risks incurred in case of serious damage to one of the rotating elements, justify the use of online vibration monitoring, along with adequate diagnosis techniques for these machines.

Due to the complexity of the dynamics of a wind turbine and its operating mode, standard monitoring methods are not suitable. In particular trending requires perfectly stable and repetitive operating conditions which are not the case regarding wind turbine operation.

01dB-Metravib as developed an innovating monitoring technique based on pulse phenomenon to detect bearing wear and tooth cracking. This technique, which has already been implemented successfully on mechanical elements with similar characteristics, is particularly suited for rotating machines operating at very low speed.

Evaluating the potential health impacts of wind turbine noise for environmental assessments

Dr. D.S. Michaud, Dr. S.E. Keith

Consumer and Clinical Radiation Protection Bureau, Health Canada, Ottawa, Ontario, K1A1C1

Email: dmichaud@hc-sc.gc.ca

skeith@hc-sc.gc.ca

The *Canadian Environmental Assessment Act* (CEAA) requires certain projects with federal government triggers to undergo an environmental assessment (EA) before receiving federal government approval. The intent is to ensure that actions are taken to promote sustainable development and to ensure that projects do not cause significant adverse environmental effects. Environmental effects may include health effects from project related noise. To help the responsible authorities for an EA make this determination, they may request specialist information and knowledge from Health Canada or other specialists, as prescribed under CEAA. For wind turbine projects, Health Canada provides advice based on the evaluated project-related changes in high annoyance, per ISO 1996-1 and considers a 6.5% increase in high annoyance to correspond to a severe noise impact. The severity assessment is based on US Federal Transit Administration noise impact criteria. In quiet rural settings, a severe noise impact for wind turbines can correspond to sound levels as low as 45 dBA. This accounts for the finding that in quiet rural areas there may be a greater expectation for and value placed on “peace and quiet” equivalent to up to 10 dB. A constant sound level less than 45dBA measured outdoors also corresponds to the WHO threshold level for sleep disturbance when windows are partially opened. Furthermore, if sound levels at the receptor are kept below 45dBA, the ANSI S12.2 rattle criterion will not be exceeded in the 63 Hz octave band. Turbine noise is evaluated at the wind speed that produces the highest noise from the turbine, and background noise is evaluated in calm winds. This allows for sheltering by obstructions or wind speed gradients related to stable atmospheric conditions. Wind turbine construction noise is assessed in terms of whether widespread complaints may be expected from its normalized day-night sound level, based on the EPA “Levels” document.

Residual loudness of wind turbine sound in the presence of ambient sound

David A. Nelson, INCE Bd. Cert. Nelson Acoustics PO Box 879 Elgin TX 78621

david@nelsonacoustical.com

Human responses to wind turbine sound are difficult to predict. Many non-acoustical factors influence the likelihood of annoyance due to wind turbine sound. Even acoustical factors, such as $L_{A,EQ}$, are often not sufficient to fully describe the range of responses, especially at lower levels. Similar difficulties are encountered in applications as diverse as personal computers, environmental sound emitted from industrial sources, and sound transmitted through partitions. In each case, it has been found that the auditory masking effect of the local ambient environment plays a significant role. It turns out that the "quietest" environment may not be a silent one, but rather one in which the local ambient sound is perceived by the subject as neutral and/or appropriate in quality and which masks intrusive sounds of lesser perceived quality. In the case of wind turbines, annoyance is most often reported out of doors, where the local ambient is affected to a highly variable degree by vehicular traffic and by wind conditions. In the ideal result, the intruding sound is fully masked and becomes inaudible. Zwicker developed a method of "partially masked loudness" to estimate the residual loudness of a sound in the presence of ambient sound. The method will be extended to address the time-varying nature of wind turbine sound. The method will be applied to wind turbine sounds juxtaposed against ambient sounds due to wind in nearby trees. This method will have its primary usefulness at greater distances from the turbine where levels approach ambient and where, because a larger area is swept out, a larger pool of potentially annoyed subjects may reside.

PREDICTION OF WIND TURBINE NOISE AND COMPARISON TO EXPERIMENT

Stefan Oerlemans* and Gerard Schepers¶

*National Aerospace Laboratory NLR, The Netherlands

¶ Energy research Centre of the Netherlands ECN

The accurate prediction of wind turbine noise is important for the design of quiet wind turbines and for the planning of wind farms. The present paper describes the application of a semi-empirical prediction method for trailing edge noise to calculate the noise from two different wind turbines. The availability of detailed acoustic array measurements on the same turbines[1] enables an assessment of the predictions

not only in terms of overall sound levels, but also in terms of other source characteristics.

The source strength is calculated by applying a semi-empirical prediction code for 2D trailing edge noise[2] to radial segments of the wind turbine blade. The main input to this code is the turbulent boundary layer thickness at the trailing edge of the blade, which is obtained from aerodynamic calculations. Next, the effects of Doppler amplification and trailing edge noise directivity are taken into account. Finally, in order to enable direct comparison to the measured results, the simulated sources are

input to the same acoustic array processing code as in the experiments. A good agreement between the measured and simulated source maps was found (Figure 1). In the paper the prediction method will be quantitatively assessed for both turbines in terms of overall source spectra and other source characteristics, such as source radius and azimuth as a function of frequency, and directivity.

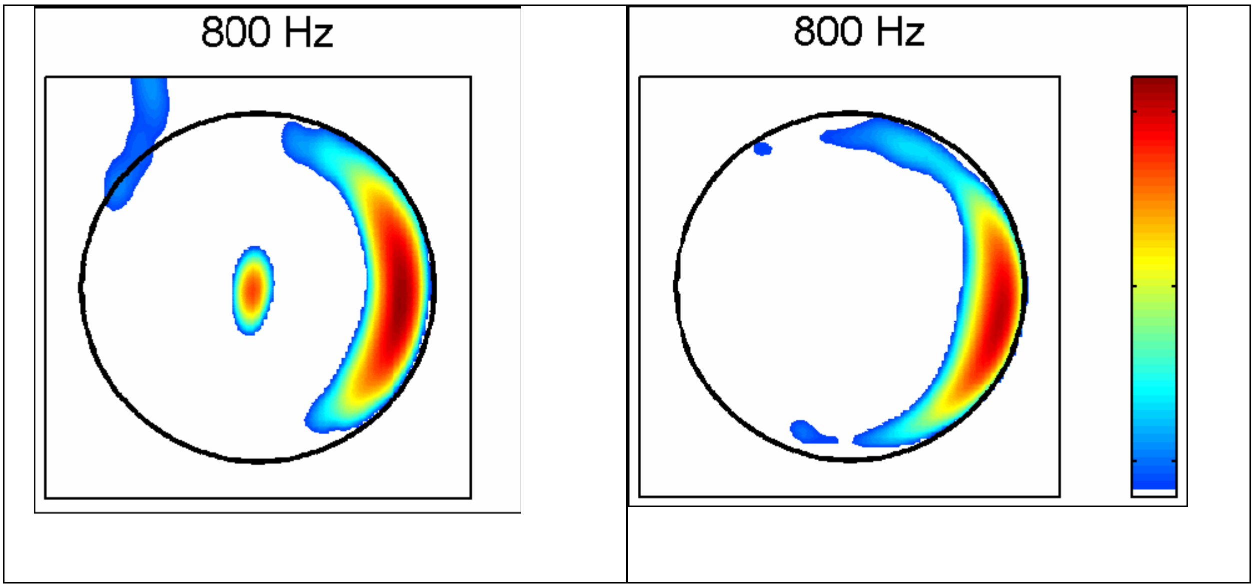

Figure 1: Measured (left) and calculated (right) source maps. The color scale is the same for both maps (range is 12 dB)

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A NEW MECHANISM IN VAWT

Prof.R.V.Sharma, Ravi Kumar Singh[1] ,Nitin Kumar[2]

Assistant Professor, Department of Mechanical Engineering,NIT,Jamshedpur-831014,

[1]2nd Year(B.Tech.), Department of Mechanical Engineering,NIT,Jamshedpur-831014,

[2]3rd Year(B.Tech.), Department of Mechanical Engineering,NIT,Jamshedpur-831014.

e-mail-ramvinoysharma@yahoo.co.in(091-9431347509),

[1] getup.neo@gmail.com,

[2] nitin.science@gmail.com,nitin_nitin_nit_nit@yahoo.co.in

"A kite always flies at height" because there's always wind. The question that is whether we can harness this ever present wind efficiently or not.

Wind Energy is the costliest alternative energy option now a days. And, with the advent of HAWTs, they are dominating the wind farms(whether upwind or downwind).

Here, we are proposing a Self Start Mechanism for Darrieus turbine, an omni-directional VAWT that can be used as a reliable starting option, instead of using induction motor.

Fig. A self Start mechanism for 4-blade Darrieus Wind Turbine, a VAWT

Here, we are proposing a Self Start mechanism for 4-blade Darrieus Wind Turbine, a VAWT. As per the above drawing, the starting set up will be H-Shaped or like a Gyromill, with (twisted)blades such that the machine can generate sufficient drag to produce the necessary starting torque.

Once the turbine starts rotating, the blades rotate about their own axis to revert back to closed position, minimising drag & making the turbine primarily lift based.

As the turbine starts rotating, the weight at the bottom starts falling down, pulling the ropes at the end of all the 4 blades, thereby, reducing the shape of the structure to that of a "troposkein" or egg, thereby concentrating all the gyroscopic forces along the vertical axis.

The 4-blade design does compromise solidarity a bit, but, that helps the turbine stay in the wind more & that further enhances up the efficiency of its power extraction from wind.

The only major problem in this idea is regarding the blades. Though, fibreglass can be used after some improvisation (very thin at centre & long best suited for the job)

Uncloaking the Nature of Wind Turbines – Using the Science of Meteorology

William K. G. Palmer B.A.Sc. P. Eng.

TRI-LEA-EM RR 5

Paisley, ON N0G 2N0 Canada

trileaem@bmts.com

One fact everyone agrees about wind turbines – you either love them or you hate them. The larger proportion of the general population who live far from them think wind turbines are great – while the smaller proportion representing people with homes near where wind turbines were subsequently erected have concerns, particularly about noise. On a popular vote basis, as seen by elected officials, the choice is clear, but on a justice basis, who looks out for the impacted few?

Applying the tenet that widely expressed concerns usually have some basis, this paper applies the unemotional standard of science to determine the truth. A clue was given in the dissertation of Dr. G.P. van den Berg, titled “The sounds of high winds – the effect of atmospheric stability on wind turbine sound and microphone noise” published in 2006. Dr. van den Berg identified that as the atmospheric profile changes from unstable in the sunlit hours to stable after sunset could have a significant impact on the noise perceived by residents around wind farms.

In the year 2006, Ontario installed it’s first large scale commercial wind farms rated at 40, 68, 99, and 186 MW capacity. The 1.5 to 1.8 MW turbines were installed with minimum setbacks to homes ranging from 350 to 450 metres for non-participating neighbours. The electrical output of Ontario wind farms is individually tracked and made available to the public on the internet on an hourly basis, and from this and the power curve of the installed wind turbines the hub wind speed can be accurately estimated. Simultaneously, the Environment Canada meteorological services weatheroffice makes available on the internet hourly wind speed at 10 metres for weather stations near the wind farms. The data has been correlated since the wind farms came into service.

Similar to the noise guidelines used in some other nations, the Ontario Ministry of the Environment "Interpretation document" for wind turbines, permits turbine noise output to be increased at higher wind speeds on the hypothesis that the effect of the increased noise from the turbines will be masked by the ground winds. The limit is based on a logarithmic relation between the wind speed at the hub, and the 10 metre reference level, for a constant value of wind shear, typical of a neutral atmosphere, as identified in the IEC standard 61400-11.

The starting hypothesis of this study was that in the summer time, there would be a large impact on increases of noise at night due to changes in wind shear as the ground heating and cooling was more pronounced than in the wintertime due to the longer periods of sunlight, and more absorbtion on dark coloured ground than during shorter days and snow covered landscape in the winter. In the summer, shortly after sunset on clear nights as the earth cooled, the electrical output of the wind turbines increased – demonstrating an increased wind velocity over the wind turbine blades, while the Environment Canada measured wind speed at 10 metres decreased. However, while there was an appreciable change in the wind shear, the electrical output of the turbines did not increase too dramatically, as the wind turbine output was generally not very high. In the winter time, there was a significant increase in the turbine output, even though the 10 metre reference wind speed did not increase sufficiently to mask the produced noise, and the work found the winter effect was more pronounced than the summer effect.

In summary, the results for one wind farm, the Kingsbridge wind farm near Goderich Ontario, which has the closest distance between the wind turbines and the Environment Canada weather office monitoring station, show that about 31% of the hours of the year show an unmasked noise output above the Ontario Standard, and for nearly 10% of the hours of the year, the noise is significantly above the provincial standard (over 3 dBA), in many cases about 10 dBA above the background level produced by the wind at the receptor. In the 6 months from October 2006 to March 2007, on 64% of the days, there were hours of unmasked noise. This demonstrated the problem to be chronic and significant in nature.

For another Ontario wind farm, the results in the summer period between May 1st and August 31st, 2006 showed 59% of the days demonstrated the problem, with it occurring 48% of the nights, and 33% of the nights showing the condition sustained for 3 or more hours.

On a secondary level, a further issue with the Ontario Ministry of the Environment interpretation document is that it permits wind developers to ignore the effect of any wind turbines at distances greater than 1000 metres from homes in their calculations. While this might be appropriate for widely spaced turbines, in the close arrays as installed in Ontario, the effect of this omission is a under calculation of the noise at homes by from 0.5 to 4.5 dBA for one proposed wind farm. It can be shown that in the extreme, this omission could allow 12 typical 1.65 MW wind turbines equally spaced around a home to result in a noise immersion value of greater than 46 dBA , without even being considered in submissions.

The presentation will go through the results in detail. They will show that the current Ontario interpretation by the Ministry of the Environment is not adequate to protect the public from excessive annoyance. Since many national or provincial standards seem to be based on the IEC 61400-11 standard, it is hoped that the data presented, and the methodology shown to enable anyone to calculate the effect from readily available information will be of interest to the standard developers.

WIND FARM PERCEPTION – A STUDY ON ACOUSTIC AND VISUAL IMPACT OF WIND TURBINES ON RECIDENTS IN THE NETHERLANDS

Eja Pedersen (1), Jelte Bouma (2), Roel Bakker (3)

Frits van den Berg (4)

(1) Occupational and Environmental Medicine, Göteborg University; Sweden; email: eja.pedersen@set.hh.se

(2) Science Shop for Medicine and Public Health, University Medical Centre Groningen, the Netherlands; email: J.Bouma@med.umcg.nl

(3) Northern Centre for Healthcare Research, University Medical Centre Groningen, the Netherlands; email: R.H.Bakker@med.umcg.nl

(4) Science Shop for Physics, University of Groningen, the Netherlands; email: g.p.van.den.berg@rug.nl

A growing concern for the impact of wind farms on residents in the Netherlands has led to resistance against further development of onshore wind power. The concern is partly based on scattered reports of annoyance with wind turbine noise among people living near operating wind farms. Previous studies have shown that wind turbine noise could be annoying at sound pressure levels lower than those known to be annoying for other community noise sources, such as road traffic. This could be due to the special characteristics of wind turbine noise (amplitude modulation) that make the sound easily perceptible. It could furthermore be due to atmospheric situations influencing large modern wind turbines more than older ones, leading to higher sound exposure than accounted for in the planning process. A Swedish study found the prevalence of annoyance in relation to A-weighted sound pressure levels to be higher in rural areas than in suburban areas. In addition to differences in background sound, people's expectation of their living environment varied. The prevalence of annoyance from wind turbine noise in the Netherlands could consequently not be derived without additional knowledge. The objectives for the study WINDFARMperception were to assess the prevalence of annoyance from noise and visual exposure in relation to sound immission levels outside the dwellings of people living in the vicinity of wind farms in the Netherlands, to identify factors interacting with annoyance and to explore possible health effects. Three types of study areas were selected: rural with no main roads, rural with a busy road, and built up areas. The study areas comprised at least two wind turbines larger than 500 kW at a mutual distance of 500 m or less. The study sample (n = 1948) was randomly selected among people living at different immission sound levels (preliminary calculated) within 2.5 km of a wind farm. Responses to environmental stressors in the living environment, including wind turbines and road

traffic, were assessed in a postal questionnaire sent out in April 2007. The questionnaire also comprised questions measuring self-reported health and well-being (GHQ-12). Measures for aural and visual exposure from the nearest wind farm were calculated for each respondent. Preliminary results will be presented at the conference.

SIROCCO: Silent Rotors by Acoustic Optimisation

G. Schepers, T. Curvers[1] S. rlemans[2] K. Braun, T. Lutz, A. Herrig, W. Wuerz[3] A. Matesanz, A. Gonzalez [4]

[1]Energy Research Centre of the Netherlands, ECN, The Netherlands

[2]National Aerospace Laboratory NLR, The Netherlands

[3]University of Stuttgart, Germany

[4]Gamesa Eólica, Spain

In this paper the main results from the European 5th Framework aero-acoustic project 'SIROCCO' are summarized. The project period is from January 1st 2003 until August 31st, 2007.

The main aim of the Sirocco-project is to achieve a significant noise reduction of wind turbines while maintaining the aerodynamic performance. Thereto new acoustically/aerodynamically optimised airfoils have been designed for the outer part of the blade on two baseline turbines.

The project is performed in a number of phases.

Phase 1: Acoustic field measurements are carried out by NLR to characterise the noise sources on the baseline turbines, where the main aim is to verify whether trailing edge noise is the dominant noise source, since this is the noise source which is reduced by the new design methodology from phase 2. Thereto a new measurement technique, the acoustic array measurement technique, has been extended to enable location and quantification of stationary and rotating noise sources.

Phase 2: The University of Stuttgart developed, improved and utilised a combined acoustic/aerodynamic design methodology. The resulting tool was used to design acoustically optimised airfoils, taking into account several (constructive and aerodynamic) constraints, which are needed to implement the new airfoils into an existing blade.

Phase 3: The blades of the baseline turbines have been redesigned using the acoustic airfoils from phase 2 at the outer blade part.

Phase 4: The acoustic and aerodynamic performance of the optimised blades is verified with respect to the baseline blades in detailed field measurements for varying conditions. The acoustic array technique is used to quantify the noise reduction, while the aerodynamic performance is assessed through extensive weather, power and blade root bending measurements. The measurements are performed on a so-called hybrid rotor, i.e. a rotor with one acoustically optimised blade and two reference blades, which assures (almost) identical conditions on the blades.

In the paper results from all four phases will be presented.

Calculate noise of wind-farms

Sénat, Claude; Garrigues, Sébastien; Gamba, René

Gamba Acoustique & Associés, buro parc2, BP 163, 31676 Labege cedex, France; claude.senat@acoustique-gamba.fr

During the conference Windturbinenoise 2005 in berlin, we (Gamba, Garrigues, Sénat) described a model which had been developed and used for noise mapping adapted for wind-farms. This model takes into account the influence of the meteorological characteristics upon the sound propagation. Moreover It differs from the conventional models of specular reflection in that it is based on the assumption that the sound waves are diffused when reflecting back from it**.** The meteorological characteristics are defined by temperature and wind speed changes at height. This model assumes that this changes are homogeneous on the area which is investigated. This current paper describes the evolution of the model with the view to taking into account the non-homogeneity of the changes of wind and temperature on the area.

Low frequency Noise from Large Wind Turbines

Bo Søndergard Delta Denmark

Preliminary results from an ongoing project will be presented.
The project aims to give tools for objective assessment of noise at low frequencies through

Sound Power measurements techniques and noise data
Noise propagation models
Noise insulation measurement techniques and data
Evaluation on the development of noise at low frequencies from small to large wind turbines
Listening tests

The project is scheduled to end late in 2007 and some results may be available at the time of the conference.
The project partners are DELTA, Aalborg University, Risø and DONG Energy

Wind Farm Noise and Regulations in the Eastern United States

Hilkat Soysal, Oguz Soysal

Frostburg State University

Department of Physics and Engineering

Frostburg MD 21532

Email: renewable@frostburg.edu

Recent advancements in the wind turbine technology combined with available federal and state incentives have greatly enhanced the development of wind powered electric generation facilities in the Eastern United States. Particularly ridges of the Allegany Mountains in New York, Pennsylvania, Maryland, West Virginia, and Virginia have become attractive sites for commercial wind farm developers. The fast development of commercial wind farms is currently an important issue in these regions due to environmental impacts.

The paper will describe the demographic structure of the Allegany Mountains and present an assessment of the audible noise at residences near actual wind turbines. EPAUSA noise level recommendations and local noise ordinances that apply to wind turbines will be compared with the acceptable noise levels in various countries. The current status and trend of the wind power development in the Eastern USA, the expected benefits, and public concerns will be discussed.

Wind profiles over complex terrain

Frits van den Berg,
University of Groningen, Groningen,
The Netherlands
g.p.van.den.berg@rug.nl

Over an area with a complex topography the neutral wind profile is more difficult to predict then it is over flat terrain. Theoretical approaches have been given for relatively simple situations (such as an isolated hill or ground plane with parallel ridges) and verified by measurements. As it does over flat land, atmospheric stability also influences the wind profile over complex terrain. As a consequence the ratio between higher (hub height) and lower (near ground) altitude winds depends on topography and atmospheric stability. Some general insights into this topic will be given and results of some measurements.

Domestic Wind Turbines

Gwyn Mapp
Bureau Veritas, 30 Great Guildford Street, London, SE1 0ES.

In 1997 the United Kingdom Government committed to reducing the production of CO_2 from all sources, by 12.5% of the levels generated in 1990, before 2010. In order to achieve this, the government has set a target of increasing the proportion of electricity generated by renewable sources, including Wind Farms, from 4% in 2005 to 10% in 2010, with an aspirational target of 20% by 2020.

The noise emissions from wind farms are well known, and are commonly cited as an objection to the construction of wind farms by neighbours at the planning stage. Despite this, a recent innovation has emerged and captured the imagination of the public: namely micro wind turbines.

Micro wind turbines are currently defined as wind turbines that have an electricity generating capacity of <100KW, and are intended to be installed either on a pole in a garden, or by way of a bracket, upon a gable wall or roof of a building. Some are being marketed as being suitable for residential and urban applications.

This study carried out a thorough literature review of the potential noise and vibration issues that could surround the application of micro wind turbines in a residential/urban setting. This study also carried out an investigation of a micro wind turbine that was installed in an urban setting.

The principle conclusions of this study were:

i) The vibration experienced at the contact point between the support structure of the micro wind turbine and the building exceeded 1mms^{-1} (PPV in the vertical plane) under certain wind conditions;
ii) There is potential for the observed vibration to cause structure borne noise;
iii) The airborne noise issues from the installed micro wind turbine was below background noise levels at the study site;
iv) There is an absence of any standards that may allow the prediction of the effects of micro wind turbines, i.e. standards that allow the determination of the sound power level;
v) The use of the ETSU – R – 97 noise criteria for a single turbine could be considered unacceptable for approximately 80% of the dwellings of the United Kingdom. The situation could be worse if more than one micro wind turbine were installed at any location;
vi) Control of the potential adverse effects from an installation of a micro wind turbine should be controlled by the correct application of planning conditions that specifically control:
   a. The airborne noise upon neighbouring residential premises,
   b. The airborne noise upon the property to which the micro wind turbine is serving,
   c. The airborne noise upon the amenity of the garden of the neighbouring residential premises,

d. The vibration upon neighbouring attached dwellings,
e. The vibration upon the dwelling which the micro wind turbine is serving,
f. The structure borne noise upon neighbouring attached dwellings, and
g. The structure borne noise upon the dwelling which the micro wind turbine is serving; and

vii) The installation of micro wind turbines in urban environments may not prove to be a cost effective method of generating renewable energy.