ENVIRONMENTAL IMPACT ASSESSMENT
THE BARBADOS LIGHT & POWER COMPANY LIMITED
LAMBERTS EAST WIND FARM
GENERATING STATION

ADDENDUM TO FINAL REPORT

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EXECUTIVE SUMMARY

Project Proposal

The Barbados Light and Power Company Limited (BLPC) is applying to the Town and Country Development Planning Office (TCDPO) for planning permission to construct a 10 MW wind farm comprised of 11 wind turbines, associated control building, and access tracks on land at Lambert's East in the parish of St. Lucy, Barbados. Each turbine will have a tubular tower of approximately 55 m height, and three rotor blades with a rotor diameter of approximately 56 m. A new transmission line will connect the site to a new substation to be developed at Trents.

Project Schedule

Barbados Light and Power Company Limited originally planned to commence development of the project during 2007 with completion early in 2009. However the schedule has since been delayed. Additional site studies such as geotechnical testing will also be required to complete the design. It is estimated that the construction period will take approximately 6 months from the final design to commissioning.

Approach

The proposed Terms of Reference (TOR) for the Environmental Impact Assessment were provided in an Outline Planning Application to TCDPO dated June 11, 2004. These TOR were subsequently approved with comments on October 3, 2005.

In April 2007, AMEC completed the report *"Environmental Impact Assessment – Lamberts East Windfarm"* to meet the requirements of the Terms of Reference.

Following public and regulatory review, a series of comments were provided to BLPC for further clarification and response. This addendum report responds to the additional information requested.

Assessment of Environmental Effects

The April 2007 report provided an assessment of the environmental effects of the construction phase and the operational phase including potential effects from accidents and malfunctions. The report recommended mitigation methods and considered the significance of the environmental effects from construction and operations for the following:

Aesthetics

Photomontages were prepared to simulate the windfarm on the landscape from key vantage points at Risk Road, Pie Corner and the existing wind turbine. In addition, a map of the zone of

visual influence indicated areas from which the windfarm would be visible. The nature of the landscape of this part of Barbados is such that there are few viewpoints from which the whole of the wind farm would be seen. This partial visibility of the turbines allows the structures to blend in with the scenery. From these simulations, it was concluded that the project will not impose a significant visual impairment of the scenery of the area.

Ecological Effects

There are no environmentally sensitive areas in the proximity to the site and hence the study focussed on the effects on birds and bats.

It is known that birds breed in and migrate close to, or through the project area as Barbados is a temporary stop en-route to South America. The preferred habitats for these species are coastal beaches and mudflats, as well as freshwater and saltwater marshes. In the Lamberts study area, there is no preferred habitat for these shorebirds in proximity to the site. As a result, migratory shorebirds and waders do not utilize the study area. Therefore, collisions are not likely and significant adverse effects on shore birds are not expected.

Similar to the transitory migratory species, overwintering species rely on habitats that provide foraging and refuge. The Lamberts study area does not provide the appropriate habitat for these over wintering residents.

Based on studies done on similar wind farms and the data collected on migratory and resident birds at the proposed wind farm site, the significance of effects on avian populations due to operation of the windfarm is considered to be minor.

There are no maintained records of bat distribution in Barbados. AMEC's biologist consulted with Mr. Wayne Burke of the Graeme Hall National Park regarding bird and bat populations. Field surveys of the study area, both during the day and during the evening hours did not record any sightings of bats. The proposed location of the turbines is not in proximity to any significant stands of trees that would provide roosting areas. The gully areas near the study area were surveyed and no bats or significant areas for bat hibernacula were observed. As a result, it is unlikely that the area supports a large resident population of bats. Based on previous studies done on similar wind farms and lack of observed usage of the site by bat species, the significance of effects on bat populations due to operation of the wind farm is considered to be minor.

Air Quality

During construction the potential impacts on air quality are predominantly dust emissions from excavations. These will be localized short duration and can be mitigated by a dust control program and by good housekeeping. The Environmental Management Plan for construction provides mitigation measures for dust control. The impacts from construction on air quality are therefore considered minimal. There will be no air emissions from the windfarm during

operations. The facility will have a beneficial effect on air quality as it will reduce BLPC's overall emissions by displacing the use of fossil fuelled generation.

Noise

Noise levels during construction will be localized, of short duration and restricted to working hours, and the impacts are considered to be minor.

Sound contours were developed for the wind farm operating at different wind speeds using a software noise model. Based on maximum power output at a wind speed of 8m/s, the predicted noise level at the Lambert's Plantation house which is the closest receptor is 45 dBA. This sound level is consistent with the recommended outdoor noise standards of the World Health Organization and the World Bank for sleeping. At higher wind speeds the background sound levels increase at a greater rate than the turbine noise.

Residents to the east of the site have expressed concerns over low frequency sound, based on published experience at some European facilities. Several studies have been done in other jurisdictions in response to community concerns over low frequency sound which was problematic of early wind turbines from the 1980s. Advances in turbine design have addressed the problems of low frequency sound. Research conducted on modern wind turbines has shown that the levels of low frequency noise have been below accepted thresholds, and are no longer a problem. Wind turbines have an amplitude modulation at low frequency producing the characteristic "swoosh", which should not be confused with low frequency sound or infrasound.

Traffic

Moving the turbine blades and towers from the port to the site will result in abnormal loads travelling along country lanes. The main section of each turbine blade is approximately 25 m long and weighs about 4 tonnes. The tower is a tapered steel tube with a maximum diameter of 3.5 m which is supplied in 2 or 3 sections of length and has a total weight of about 60 tonnes. The weight of the nacelle is 20 to 25 tonnes. An assessment will be done of the routing for major equipment transfers from the port in advance, to identify any constraints. It is recommended that the Ministry of Public Works and Transport be provided with the schedule and routing for equipment transport, to coordinate the overnight transport of oversize loads. In addition, the public will be provided with advance information on temporary road closures through announcements in the newspapers and through radio and television.

There will be no significant effect on traffic during the operations phase as the site will be unmanned except for maintenance checks.

Groundwater

The site is located in a Zone 4 water zone which is not a sensitive area for groundwater protection. The operation of wind generators produces no discharges and, other than lubricants

contained within the nacelle, uses no liquid products. The Environmental Management Plan describes measures to be taken to protect groundwater. Consequently, no effects/impacts to groundwater are expected from the construction or operation of the windfarm.

Electromagnetic Interference

Contact was made with the telecommunications companies, the CBC and the airport to determine the probability of effects of the turbines on transmissions. It was determined that the wind farm will not affect cellular telephone, communications transmissions, satellite television receptions or airport radar.

The effect of the wind farm on households using a conventional antenna is difficult to predict due to the directional nature of the transmissions, and the type of individual antenna being used. A study completed by the BBC recommends that wind turbines be at least 500 m from any viewer to avoid interference. Very few residences are within this separation distance and hence the potential for interference will be limited. Indications from the public open house were that the area to the east of the proposed wind farm has a poor reception using conventional antennae due to the higher ground along the ridge blocking direct line of sight to the transmitter. It is recommended that BLPC take preliminary measurements of signal strength in the area close to the site, to allow confirmation of effects on signal quality following development of the project.

Corrective measures can be used after the construction of the wind turbines to minimize the impact of any resulting degradation to the TV signal. These measures include providing improved antennae or repeaters. No significant adverse environmental effects related to electromagnetic interference are likely with implementation of the recommended mitigation measures.

Shadow Flicker

A wind turbine, like other tall structures, can cast a shadow on the neighbouring area when the sun is low in the sky. The movement of the rotor blades can chop the sunlight, causing a flickering (blinking) effect referred to as “shadow flicker”.

The potential flicker was modeled and the results plotted on maps which show the maximum number of hours per year of shadow flicker on a 1 m x 1 m (vertical) house window situated 2 m above the ground and facing north, east, south or west. For those dwellings closest to the wind farm the theoretical maximum amount of shadow flicker could be as much as 80 hours per year, an average of less than 15 minutes per day. The effects diminish with distance. The modeling is very conservative and assumes full sunshine throughout the year (ie no cloudy periods). It does not take into account the following:

- Periods when the sun is obscured by cloud – no shadow;

- Wind direction – shadow flicker is not an issue when the rotor is pointing in a direction perpendicular to the direction of the sun from the window;

- Turbine operating hours – there is no shadow flicker when a wind turbine is shutdown, as would be the case for low or very high wind, maintenance or repair;

- Shading due to terrain, vegetation, or buildings – these will block the shadow; and,

- Hours when the property is actually used by people (who are awake) and they are situated at a spot where flicker could be an irritant – at other times there is no one to be annoyed by the flicker.

Taking into account all of the factors will reduce the period that shadow flicker might be an irritant to at most a few minutes per day. Should shadow flicker be an issue, it can be mitigated by planting trees in specified locations or by pre-programming the turbine to shut down at times when shadow flicker would cause a nuisance.

The effects of shadow flicker are considered to be minor and no significant environmental effects are anticipated.

Waste Disposal

There are few sources of waste from a wind farm, these are incidental to the generation of power and related to maintenance activities. Typical wastes generated would include failed equipment, packaging materials, and other materials associated with maintenance of equipment such as spent lubricating oils. The Environmental Management Plan recommends procedures for the management of these wastes. It is concluded that there will be no significant effects/impacts from waste disposal during the operational phase of the proposed wind farm.

Accidents and Malfunctions

The wind industry has an excellent safety record. With more than 70,000 turbines in service across the world, and over 25 years of operation, the industry has recorded only one accidental death of a member of public (a German skydiver).

Although information provided by local residents suggested higher levels of incidents causing death, these were predominantly industrial accidents involving workers which are preventable and road accidents during delivery of equipment. Examples which were provided of accidents involving the public included a low flying aircraft, a parachutist, an injury from falling ice and a fall from a tower. Comments were sought from the Civil Aviation Office during the completion of the EIA to cover air traffic; falling ice was not considered applicable for Barbados and falls from towers can be prevented by excluding public entry. The summary of accidents provided does not change the conclusions of the environmental assessment report that “The wind industry has an excellent safety record”.

To prevent fires, the wind turbine generators have built-in thermal sensors to shut them down if an overheating condition arises. The wind farm will not store bulk oils or chemicals or have any activities that have the potential for a serious spill. The Environmental Management Plan includes contingency measures to address potential accidents or malfunctions.

With the implementation of mitigation measures, significant adverse residual effects due to accidents and/or malfunctions are unlikely to occur.

Conclusions

With input from the general public and regulatory agencies, and following detailed analysis by the Project Team, the environmental effects (both biophysical and socio-economic) associated with the construction and operation of the proposed wind farm Project have been assessed. This assessment has concluded that the Project is not likely to cause significant adverse environmental effects given implementation of the recommended mitigation measures.

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1.0 INTRODUCTION

1.1 Background

The Barbados Light & Power Company (BLPC) is proposing to construct a 10 MW wind farm on land at Lambert's Plantation in the parish of St. Lucy to help meet the Nation's needs for additional power. This new generation site will be a source of renewable energy displacing the country's dependence on imported fuel and will increase overall system reliability.

To address environmental concerns relating to the expansion, BLPC retained AMEC Earth and Environmental (AMEC) to conduct an Environmental Impact Assessment (EIA) which identified the potential impacts of the wind farm development and determined what measures can be taken to mitigate against any negative impacts. The project team prepared the following detailed report for public and regulatory review:

> *Environmental Impact Assessment - The Barbados Light & Power Company Limited - Lamberts East Wind Farm Generating Station- April 2007.*

The completed report was submitted to the Town and Country Development Planning Office (TCDPO) for review. As part of that process, the Chief Town Planner circulated the report to key agency personnel to assist with the review.

This addendum report responds to the questions and comments raised by the TCDPO and the Josey Hill Residents Association, which were the only two stakeholders that requested further information. The report is organized with each comment provided in bold followed by the project team's response in regular font. Excerpts of report text or amendments to report text are italicized.

The complete information requests and detailed responses provided are appended as follows:

Appendix A: Letter from TCDPO, July 19, 2007 and response from BLPC August 29, 2007;

Appendix B: Letter from TCDPO, July 24, 2008 and response from BLPC October 13, 2008;

Appendix C: Letter from TCDPO, May 29, 2009 and response from AMEC July 3, 2009; and,

Appendix D: Evaluation of Environmental Noise Analysis for "Lamberts East Wind Farm" - documentation provided by Josey Hill residents.

2.0 TOWN AND COUNTRY DEVELOPMENT PLANNING OFFICE

2.1 Responses to Letter dated July 24, 2008

Methodology of noise monitoring/sampling – this should include, but not limited to:

- **Information on the type of sound level meter used to take measurements;**
- **Information on the specific locations of the receptor/sampling points from proposed project site;**
- **Activities/conditions that might have affected noise levels at sampling locations (e.g., construction work in the area); and,**
- **Meteorological conditions at sampling sites.**

    - The sound measurements were performed using a Quest Technologies M-27 noise logging dosimeter. Prior to and after use, a calibration check was performed using a sound level calibrator.

    - All of the locations were selected to represent the closest residences to the windfarm around the perimeter of the site. Specific locations where the noise measurements were taken are described in Section 5.2.1 and shown on Figure 5.2 of the report. The noise levels provided background information on the existing environment. The noise assessment of the windfarm, however, used the WHO guideline of 45dBA as a reference for acceptable overnight noise levels at the closest residences.

    - The only location where noise levels would be influenced by construction would be L2 at Date Tree where construction of a house was occurring and could have influenced the daytime noise levels. However, when determining the existing ambient noise levels it is the night-time levels that are the lowest levels which need to be considered. At that location the lowest noise level (L_{EQ}) attained at night was in the 55dBA range which is higher than the predicted noise levels from the wind farm at that location.

    - The following table presents the meteorological conditions during the noise monitoring.

Location : Caribbean Institute for Meteorology & Hydrology, Husbands, St. James									
Defined Test Periods (Section 5.2.1 EIA BLPC Lamberts East Wind Farm)	Year	Month	Day	Hour	Temp (°C)	RH (%)	Wndspd (knots)	Wnddir (°)	Rnfl (mm)
	2006	5	18	8	28.6	75	11.0	9	0.0
	2006	5	18	11	31.0	64	14.0	13	0.0
	2006	5	18	14	31.0	64	15.0	15	0.0
Lamberts Plantation - 14:00 May 18 to 13:15 May 19	2006	5	19	8	28.6	72	12.0	13	0.0
	2006	5	19	11	31.5	51	15.0	14	0.0
	2006	5	19	14	31.6	54	15.0	15	0.0
	2006	5	20	8	29.0	71	12.0	12	0.0
	2006	5	21	8	29.0	68	12.0	8	0.0
Date Tree Hill - 14:15 May 21 to 12:40 May 22	2006	5	22	8	28.5	73	11.0	12	0.0
	2006	5	22	11	31.2	57	16.0	12	0.0
	2006	5	22	14	31.2	60	14.0	13	0.0
	2006	5	23	8	28.0	74	13.0	11	0.0
	2006	5	23	11	31.1	54	15.0	15	0.0
	2006	5	23	14	31.0	57	16.0	10	0.0
SDA Church, Cave Hill - 14:45 May 23 to 13:00 May 24	2006	5	24	8	28.6	67	12.0	10	0.0
	2006	5	24	11	31.1	57	12.0	12	0.0
	2006	5	24	14	31.0	52	12.0	12	0.0
	2006	5	25	8	28.5	71	12.0	12	-
	2006	5	25	11	30.5	62	12.0	14	-
Josey Hill - 13:00 May 25 to 09:40 May 26	2006	5	25	14	31.0	57	12.0	13	-
	2006	5	26	8	26.0	88	8.0	4	-
	2006	5	26	11	29.0	71	9.0	6	-
	2006	5	26	14	29.0	66	10.0	12	-

Temp = Temperature, RH = Relative Humidity, Wndspd = windspeed, Wnddir = wind direction, Rnfl = rainfall

Methodology/rationale for the 350 m separation distance and the additional 50 m from roads and footpaths. From what point is the 350 m measured?

The 350 m separation distance from the closest residence was one of the guidelines used during the site screening stage to select acceptable sites. This is an industry guideline based on seven rotor diameters, which is normally adequate to mitigate noise effects and reduce shadow flicker. The actual effects are then predicted based on the turbine specifications and computer modelling over a range of wind velocities, and refinements are made if necessary. The separation is measured from the base of the tower. The 50 m separation from roads and footpaths is a reasonable setback around the tower to allow for maintenance access and equipment laydown.

What constitutes daytime hours during which construction is proposed to take place?

Construction will occur within the hours of 7 am to 7 pm. As in any construction project, there may be a need to extend the working hours during special circumstances such as major concrete pours.

Details and specifications of the turbines proposed to be used.

- **Is the 45 dBA turbine noise quoted in the ES applicable to one turbine or is it the cumulative found generated by the proposed 11 turbines?**

The specific turbines to be used have not been purchased as selection will follow a competitive tendering process once the project has been approved. The Environmental Impact Assessment report was based on the installation of Vestas V52-850kW turbines. The Vestas V52-850kW turbine is typical of the size and type of wind turbine that will be installed. Appendix D provides information on the Vestas V52-850kW turbine

The noise assessment was based on all 11 turbines operating simultaneously.

Further details on the modelling used to predict Shadow Flicker (European standards quote maximum 30 hours per year or 30 minutes per day).

The software used to calculate shadow flicker results was "WindFarm". Information on WindFarm can be found at www.ReSoft.co.uk. As recommended in the Environmental Impact Assessment Report, the effects of shadow flicker can be mitigated by selectively preprogramming the turbines to shut down during the brief periods when the sun is low on the horizon and has the potential to cause shadow flicker.

Dust control measures should be included in mitigation of impacts for construction equipment operation.

Dust control measures are covered in Section 7.1.3 of the Environmental Impact Assessment Report and also in more detail in the Environmental Management Plan for Construction as contained in Appendix C. The contractor will be required to adhere to the mitigation methods as specified in the Environmental Management Plan for Construction.

The methodology for the surveys of bat populations should be described and further information on if the field survey was designed to take into account resident knowledge and experience. A post-construction Environmental Management Plan should be submitted.

AMEC's biologist consulted with Mr. Wayne Burke of the Graeme Hall National Park regarding bird and bat populations. Significant published information was available regarding the local bird populations for the Lamberts area, but there was no source of information on resident bat

populations other than anecdotal. In the absence of records for bat populations the AMEC biologist completed field surveys during daytime hours of potential habitat for bats in the area of the Lamberts site. As the wind farm site has little in the way of stands of trees which would provide habitat, the survey extended to gullies in the area. There were no significant areas for bat hibernacula found. In addition to the habitat survey, field visits were conducted during evening hours to determine if there were any sightings of bats. No bats were observed during the daytime or evening field visits suggesting that there was no large resident population.

A post-construction Environmental Management Plan should be submitted.

An Environmental Management Plan for the operations phase has been included with the environmental report in Appendix E.

Submission of a Geotechnical survey to establish the stability of the area for the proposed development.

It is not usual to complete geotechnical studies as part of the environmental assessment. The geotechnical study will be completed during the site engineering design, as the testing should be done at the precise location of each turbine. The design loads will be specific to the model of turbine selected and will be specified by the turbine manufacturer. If there are issues of instability, these will be addressed either via the footing design or by moving the individual turbines on the site.

2.2 Responses to Letter dated May 29, 2009

Methodology of noise monitoring:

- **Noise dosimeters are ideal for measuring personal exposure to occupational noise but are not appropriate for the purposes of a field noise survey. An Integrating Sound Level Meter is recommended as a more accurate method of determining the Leq and is particularly useful if the noise is highly variable.**

- **Detailed descriptions of the monitoring sites and noise generating activities that were occurring at the time of monitoring should be provided.**

    - We agree that an Integrating Sound Level Meter is the most accurate instrument for a detailed noise survey where one is measuring the environmental impact from installed noise sources. On this occasion, background sound measurements were performed using a Quest Technologies M-27 noise logging dosimeter which has a logging capability. Measurements of the A-weighted sound pressure level were taken at 1-minute intervals over a 24-hour period at each of four receptor locations. This data set was then evaluated in terms of the hourly equivalent sound level (L_{eq}). While this data provides guidance on the noise background, the

noise assessment of the windfarm used the International Finance Corporation[1] (World Bank) guideline of 45 dBA as a reference for acceptable overnight noise levels at the closest residences.

- The locations were selected to represent the closest residences to the windfarm around the perimeter of the site. Measurements were taken at a height of approximately 1.5 m above the ground and the location was chosen both to be representative of conditions at the measurement location and to avoid any reflective impacts associated with structures on the measurement site. Information on meteorological conditions was presented in our letter of October 9, 2008.

- In our letter of October 9, 2008 it was also noted that the only location where noise levels would be influenced by construction would be L2 at Date Tree, where construction of a house was occurring and could have influenced the daytime noise levels. However, when determining the existing ambient noise levels it is the night-time levels that are the lowest levels which need to be considered. At that location the lowest noise level (L_{EQ}) attained at night was in the 55dBA range which is higher than the predicted noise levels from the wind farm at that location.

Methodology/rationale for the 350 m separation distance.

- **The industry guideline used to calculate the 350 m setback should be referenced. The EPD remains concerned that 350 m from the base of the tower to the nearest resident is not adequate to reduce potential impacts.**

- **It is also not clear if the land within the 350 m is to be acquired by the developer or if the owner may wish to develop it at a later date.**

  - The 350 m separation distance from the closest residence was only one of the guidelines used during the feasibility study to pre-screen generally acceptable sites. This is an industry guideline based on seven rotor diameters (50 m rotor), which is normally adequate to mitigate noise effects and reduce shadow flicker. The guideline was used in the report by Renewable Energy Systems: “Feasibility Study for a Wind Farm on Barbados – March 2004”.

  - The primary standard used was the World Bank 45 dBA night-time criterion for noise, applied at wind speeds of 8 m/s or less[2].

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1 International Finance Corporation (IFC) Environmental Health and Safety Guidelines, April 2007

2 Ibid

Hours of construction.

- **Use of heavy equipment should be limited to daytime.**
    - We agree with this recommendation.

Section 7.2.4 Specifications of Turbines

- **Since the type of turbine to be used has not been finalised, a range of noise data from different types of turbines being considered should have been provided to represent alternatives available.**

- **Little information has been provided as to what levels of low frequency noise are considered "problematic" and/or "significant" as well as no indication given as to established accepted thresholds for such noise.**
    - As noted, the specific turbines to be used have not been purchased as selection will follow a competitive tendering process once the project has been approved. The Environmental Impact Assessment report was based on the installation of Vestas V52-850 kW turbines as being typical of the size and type of wind turbine that will be installed in terms of power, hub-height and potential noise level. The noise assessment was based on all 11 turbines operating simultaneously.
    - When the final turbine design parameters and geotechnical data are available, the layout will be re-optimised using the Windfarm program. At that time the potential noise impact at each receptor will be re-evaluated using CADNA\A, an ISO96 13-compliant noise assessment software, and a report submitted.
    - There has been considerable debate in recent years over the potential impact from low-frequency sound from wind turbines and there is no consensus as to a specific limit criterion for low frequency or infrasound. Typically if there is a tonal quality present in the turbine mechanical or aerodynamic noise spectrum then a 5 to 10 dB penalty is added to the calculated receptor noise level.
    - It is generally agreed that low frequency sound level was worse with older model turbines where the blades passed through the tower shadow (downwind rotors or large vertical axis machines). Modern machines are much less susceptible to low frequency infrasound[3]. There has been confusion over low frequency modulation of sound and the presence of infrasound and while there is a great deal of discussion about infrasound in connection with wind turbines in the media, there is no verifiable evidence for infrasound production by modern wind turbines[4].

[3] HGC Engineering Wind Turbines and Sound: Review and Best Practice Guidelines. Report to Canadian Wind Energy Association, February 2007

[4] Ibid

- The post-commissioning noise monitoring plan will, however, quantify any production of low frequency and infrasound from wind turbines on the site.

Dust Control Measures

- **Although dust control measures are covered in Section 7.1.3 of the Environmental Impact report and in more detail in the Environmental Management Plan for Construction, neither one makes specific mention of releases of particulates e.g., dust from vehicles entering or leaving the site. Examples of controls not mentioned may include wheel washing and enforceable speed limits.**

  - The temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process[5].

  - Best Management Practices for dust control will be used during construction as detailed in the report. In particular, vehicles traveling on unpaved areas of the site will be limited to 15 kph. Since dust emissions from paved road surfaces are up to 90% less than for unpaved surfaces, project efforts were aimed at reduction of particulate emission at source.

  - However, track-out of silt, especially post wet suppression, remains a potential concern. Dust levels at the site will be monitored regularly using a hand held dust monitor. The area of paved road within 50m of the site exit will be inspected regularly for silt track-out and will be cleaned as necessary. This is felt to be a more effective process than wheel washing.

Section 7.2.4 Post Commissioning Noise Monitoring.

- **The appended Environmental Management Plan indicated post commissioning noise monitoring at one location only. There should be a more comprehensive monitoring plan with multiple locations along with a schedule indicating the times and frequency of the monitoring.**

Wind turbine noise typically includes both mechanical and aerodynamic effects. To ensure that all effects are measured, the proposed monitoring plan will include:

[5] EPA AP42 Chapter 13 section 2-3

- Measurements of A-weighted sound pressure level (dBA) taken at a minimum of five locations around the wind farm. These locations will be chosen once the final farm design has been approved and will be representative of the nearest residential receptor as well as offsite receptors in the cardinal directions as well as both upwind and down wind locations. Approximate locations could include:

  - Josey Hill
  - Cave Hill / graveyard
  - Lamberts plantation (closest receptor)
  - Alexandra
  - Collins / the risk

- Measurements will be taken over a minimum period of 48 hours using Type I or Type II integrating sound level meters at a height of 1.5 m above the ground using wind shielded microphones which will be site calibrated daily before and after each set of measurements. Monitors will be no closer than 3m from any reflecting surface (wall) and specific high noise events (onsite or offsite) will be logged.

- Measurements will include both hourly sound pressure level (Leq) as well as 1/3 octave band data to assess the tonal quality of any noise impact. This will be compared to the applicable criteria as well as to the results of the noise modelling.

- Measurements will be taken over three 24-hour periods with the wind farm fully operational to allow for collection of noise data over a range of wind speed and wind direction conditions.

- The monitoring program will be repeated at the time of each plant expansion.

3.0 JOSEY HILL RESIDENTS ASSOCIATION

3.1 Responses to comments – July 19, 2007

The members of the Josey Hill Residents Association submitted various documents covering a variety of issues related to the effects of wind farms to the TCDPO. The following summarizes AMEC's response to the submission provided by the Josey Hill Residents Association: *"A critique of Environmental Impact Assessment for The Barbados Light & Power Company Limited Lamberts East Wind Farm Generating Station*[6]*".* In our response we have extracted the main objections raised namely*:*

- Accidents and Malfunctions;
- Wind Farm Sound Limits and Regulatory Criteria;
- Background Noise Levels;
- Appropriate Noise Impact Assessment Methodology; and,
- Shadow Flicker.

3.1.1 Accidents and Malfunctions

Information was provided on a range of accidents related to windpower projects. The fatalities and injuries reported were largely of project personnel in industrial accidents which are preventable.

Accidents cited which involved the public were mainly traffic accidents due to distracted drivers or road accidents during equipment delivery. None of these are unique to the operation of windfarms. The AMEC report made recommendations for equipment delivery overnight including road closures.

Examples of accidents involving the public include a low flying aircraft, a parachutist, an injury from falling ice and a fall from a tower. Comments were sought from the Civil Aviation Office during the completion of the EIA to cover air traffic; falling ice was not considered applicable for Barbados and falls from towers can be prevented by excluding public entry.

The summary of accidents provided does not change the conclusions of the environmental assessment report that "The wind industry has an excellent safety record".

3.1.2 Wind Farms Sound Limits and Regulatory Criteria

Wind farm sound is typically experienced at relatively low levels over wide areas and has the potential to affect nearby noise sensitive activities. Establishing appropriate noise limits and setback distances for wind turbines has been a concern of many who are interested in wind energy. However, an individual's reactions to wind farm sound depend on more factors than

6 *Evaluation of Environmental Noise Analysis – Lamberts East Wind Farm*. R.H. Bolton, February 22, 2007 Rev. 1, Environmental Compliance Alliance of Rochester, NY.

simply sound level. Audibility is not an appropriate basis for setting noise limits as it is difficult to define and could unreasonably restrict any activity that generates sound (Standards New Zealand 2009[7]). The authors of this standard also note that limits for wind farm noise are required to provide protection against sleep disturbance and maintain reasonable residential amenity. Since noise levels within a building are difficult to predict, it is considered more appropriate to predict free field noise levels outside of the structure and make a conservative assumption on the attenuation properties of the building envelope. Studies on noise levels (referenced in BWEA 1996[8]) associated with sleep disturbance range from 30 to 40 dBA measured at the interior sleeper location with varying levels (10 to 15 dB) of sound attenuation assigned to the building itself (or an equivalent 40 to 55 dB external noise level).

The draft New Zealand standard[7] notes that wind farm noise should not exceed the background sound level by more than 5 dB, or a value of 40 dB, whichever is the higher. This limit is recommended for protection of sleep and is also appropriate for protecting the health of residents and maintaining reasonable amenity for most noise sensitive locations.

The World Bank in its Environmental Health and Safety Guidelines[9] (2007) references environmental noise limits determined by the World Health Organization in their Guidelines for Community Noise[10] and recommends noise impact L_{eq} limits of 55 dBA (daytime) and 45 dBA (night-time) or an increase of 3 dBA over background.

A medical Expert Panel Report (AWEA/CANWEA 2009[11]) notes that *"there are several approaches to regulating noise, from any source, including wind turbines. They can generally be classified as absolute or relative standards or a combination of absolute and relative standards. Absolute standards establish a fixed limit irrespective of existing noise levels. For wind turbines, a single absolute limit may be established regardless of wind speed (i.e., 50 dBA) or different limits may be established for various wind speeds (i.e., 40 dBA at 5 m per second [m/s] and 45 dBA at 8 m/s).*"

In their report, the BWEA Working Group on Wind Turbine Noise (BWEA 1996) reviewed information available in the UK, Denmark, Holland and Germany. They were of the opinion that limits should not be imposed for wind speeds in excess of 12 m/s as measured at the meteorological standard height of 10 m due to the impact of wind noise on the sound data so produced. In addition it should be noted that the L_{90} description would be approximately 1.5 to 2.5 dBA less than the L_{eq} measured over the same period. The Working Group recommended the application of a 45 dBA limit for both day or night or 5dB above measured background.

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7 A*coustics – Wind Farm Noise*, Draft Standard DZ6808 V2.5, Standards New Zealand, 2009

8 *The Assessment and Rating of Noise from Wind Farms*, Report of the British Wind Energy Association Working Group on Noise from Wind Turbines, Final Report September 1996

9 *Environmental Health and Safety (EHS) Guidelines – General Guidelines*, International Finance Corporation – Word bank, April 2007.

10 *Guidelines for Community Noise* (edited by B. Berglund, T. Lindvall, D. Schwela, K-T. Goh). The World Health Organization, 1999 Geneva, Switzerland. ISBN: 9971: 9971-88-770-3,

11 *Wind Turbine Sound and Health Effects – an Expert Panel Review*, David Colby MD et al, American Wind Energy Association and Canadian Wind Energy Association, December 2009

The Ontario Ministry of the Environment[12] has chosen an approach to sound level criteria which includes the effects of wind speed. The wind farm noise criteria applied are shown in Table 3-1 below.

TABLE 3-1
ONTARIO SOUND LEVEL LIMITS (ONTARIO MOE 2008)

Wind Speed (m/s) at 10 m height	4	5	6	7	8	9	10
Wind turbine sound level limits Rural Areas (dBA)	40	40	40	43	45	49	51
Wind turbine sound level limits Urban Areas (dBA)	45	45	45	45	45	49	51

AMEC therefore concludes that our use of a setback limit equivalent to a 45 dBA wind turbine noise contour is appropriate.

3.1.3 Background Noise Levels

Background noise is made up of a variety of components including noise associated with human activity (voices, traffic, electronic equipment) and the natural environment (wind noise, waves, insects, birds and so on). It is a generally accepted fact that background noise increases with wind speed; however, the rate of increase is site specific and depends on the acoustic environment of the site and the degree of sheltering of winds from specific directions as well as degree of the building and vegetative cover which may impact the associated wind noise environment. Typically if a wind farm meets noise limits at speeds below 12 m/s (measured at 10 m above grade) it is most unlikely (BWEA 1996[13]) to cause any greater loss of amenity at higher wind speeds.

The AMEC Environmental Assessment Report noted that background noise measurements ranged from 35 to 50 dBA but did not provide details. In fact noise measurements were taken at four (4) receptor locations over consecutive 24-hour periods. Table 3-2 shows maximum and minimum 1-minute sound levels in dBA. If the observed minima are taken as being representative of the quietest periods in each neighbourhood, then Bolton's assertion that - *Perhaps parts of the site are even quieter (than the EPA "farm in valley" location at 35 dBA) at certain times like the Grand Canyon (North Rim) location showing a mean at 20 dB* – may be completely discarded (Bolton Section 4.1 and Figure 7).

12 *Noise Guidelines for Wind Farms*, Ontario Ministry of the Environment, PIBS 4709e, 2008

13 *The Assessment and Rating of Noise from Wind Farms*, Report of the British Wind Energy Association Working Group on Noise from Wind Turbines, Final Report September 1996

TABLE 3-2
OBSERVED 1-MINUTE MAXIMUM AND MINIMUM AMBIENT NOISE LEVELS – LAMBERTS

	Receptor 1	Receptor 2	Receptor 3	Receptor 4
Location	Lamberts Pltn	Date Tree Hill	Cave Hill	Josey Hill
Date	May 18th - 19th	May 21st - 22nd	May 23rd - 24th	May 25th - 26th
7am - 7pm	40 - 61	48 - 73	40 - 70	39 - 61
7pm - 11pm	39 - 68	44 - 66	41 - 76	35 - 59
11pp – 7 am	35 - 67	45 - 70	35 - 56	34 - 55

Bolton also notes in Section 3.1 that, contrary to a statement by AMEC, wind noise would not mask the noise from the wind turbines. While we agree that noises generally only mask where the spectra are similar, the wind turbine noise curves provided to AMEC do not show strong tonal characteristics, nor can wind noise be classified as purely “white noise”, as anyone who has listened to wind around vegetation and structures on an otherwise quite night can attest. Since the wind noise effects are between wind turbine noise at receptor height and wind noise at receptor height his comment regarding an apparent difference here can also be discarded (Bolton Section 3.1 Paragraph 3).

3.1.4 Appropriate Noise Impact Assessment Methodology

Prediction and measurement of sound levels from wind farms involve values of a range of parameters which can be known or predicted only within a certain tolerance. The Ontario MOE[14] specifies that *predictions of the total sound level at a point of reception must be carried out according to the method described in the standard ISO9613-2 subject to the inclusion of specific parameters*. Kaliski and Duncan 2008[15] note that ISO 9613-2[16] methodology is appropriate for propagation modeling of wind turbines, but modeling parameters should be adjusted appropriately to account for this source's unique characteristics. Standards New Zealand also observes that *this method provides a good balance between accuracy and completeness on one hand, and the effort of obtaining data to enter into the model on the other*[17].

The ReSoft WindFarm noise module used to assess wind turbine noise impact in the AMEC report is based on the Danish Noise Model[18] and includes propagation characteristics of ISO9613 and potential tonal impacts as indicated in source octave band sound spectra. This methodology provides a good screening method prior to final turbine selection and final layout. It

14 *Noise Guidelines for Wind Farms*, Ontario Ministry of the Environment, PIBS 4709e, 2008
15 *Propagation Modelling Parameters for Wind Power Projects*. Kenneth Kaliski and Eddie Duncan, Sound and Vibration, December 2008
16 *ISO 9613-2 Acoustics – Attenuation of Sound During Propagation Outdoors, Part 2 General Method of Calculation*, International Organization for Standardization 1996.
17 A*coustics – Wind Farm Noise*, Draft Standard DZ6808 V2.5, Standards New Zealand, 2009
18 *Description of Noise Propagation Model Specified by Danish Statutory order on Noise from Windmills*, Nr 304, May 1991, ReSoft WindFarm V4 Manual.

should be noted that should this project proceed, AMEC would recommend that more detailed noise modelling using the CADNA\A environmental noise model be carried out using the meteorological and other model characteristics recommended for wind farm work. Since wind turbine designs are continually improving in the direction of better aerodynamics, as well as more efficient and quieter turbines, this will allow a more refined analysis based on the selected turbines.

3.1.5 Shadow Flicker

"Shadow Flicker" is the effect of the moving shadow from the rotor, when the rotor is between the receptor, such as a residence, and the sun. It is more prevalent when the sun is low on the horizon such as early morning and dusk. This is not a new phenomenon, as vehicles passing across a bridge can produce the same effect on nearby residences. AMEC used the WindFarm model to predict the extent and duration of shadow flicker and concluded that the maximum effects on the closest residences could be up to 80 hours per year or less than 15 minutes per day. As the effects are limited to short periods of time, the AMEC report recommended preprogramming the turbines to shut down when the conditions that cause shadow flicker exist.

3.2 Concerns Related to Low Frequency Sound

Some area residents have expressed concerns over the output of low frequency sound from wind turbines. These concerns are based on information available over the internet where neighbours of wind farms had complained about noise and the potential for low frequency sound (less than 200 Hz) and infrasound (less than 20 Hz). Although wind turbines may produce some sound at (ultrasound and infrasound) frequencies considered to be outside the normal range of human hearing, these components will be well below the threshold of human perception[19] (Standards New Zealand 2009). Leventhal[20] noted in a 2003 study that at low frequencies, a sound must be at a much higher decibel level to be audible. In particular at the infrasound range of 4 to 20 Hz the average hearing threshold was 107 to 79 dB. Studies conducted have shown that typical wind turbine sound levels in this frequency range do not exceed the threshold of hearing.

Claims have been made that low frequency noise and vibration from wind turbines have caused illness and other adverse physiological effects among very few people worldwide living near wind farms. The paucity of evidence does not justify at this stage any attempt to set a precautionary limit more stringent than those referenced above. The American and Canadian wind energy associations, AWEA and CanWEA, assembled a distinguished panel of independent experts to address concerns that the sounds emitted from wind turbines cause adverse health consequences. The panel concluded that there is no evidence of harmful effects

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19 A*coustics – Wind Farm Noise*, Draft Standard DZ6808 V2.5, Standards New Zealand, 2009

20 A *Review of Published Research on Low Frequency Noise and its Effects*. Leventhall, H. G., S. Benton, and P. Pelmear. 2003. *http://www.defra.gov.uk/environment/noise/research/lowfrequency/pdf/lowfreqnoise.pdf.*

from the low levels of sound from wind turbines, as experienced by people in their homes. In fact studies have shown that peoples' attitudes toward wind turbines may affect the level of annoyance that they report[21].

Dr. Nina Pierpoint, a US physician, has posted numerous articles[22] linking low frequency sound from wind farms with health concerns, in opposition to a proposed wind energy development in close proximity to her community. She has recently published a book describing health effects collectively referred to as "wind turbine syndrome". In reviewing the study, the British National Health Service[23] states: The study provides the comments: *"This study provides no conclusive evidence that wind turbines have an effect on health or are causing the set of symptoms described here as "wind turbine syndrome". The study design was weak, the study was small and there was no comparison group".*

The AWEA/CANWEA Expert Panel noted that while "*Some reports have suggested a link between low frequency sound from wind turbines and certain adverse health effects. A careful review of these reports, however, leads a critical reviewer to question the validity of the claims for a number of reasons, most notably (1) the level of sound exposure associated with the putative health effects, (2) the lack of diagnostic specificity associated with the health effects reported, and (3) the lack of a control group in the analysis."*

One study[24], for example, has claimed that wind turbines in residential areas produce acoustical environments that can lead to the development of Vibroaccoustic Disease (VAD) in nearby home-dwellers. The panel, which included medical practitioners, observed that this type of study is known as a case series and is *"of limited, if any, value in evaluating causal connections between an environmental exposure (in this case, sound) and a designated health effect (so called "wind turbine syndrome"). This particular case series is substantially limited by selection bias, in which people who already think that they have been affected by wind turbines "self select" to participate in the case series. This approach introduces a significant bias in the results, especially in the absence of a control group who do not live in proximity of a wind turbine".*

A study conducted by HGC Engineering for the Government of Canada[25] (NRCan, 2006) addressed sound, including low frequency (infrasonic) sound, at the Pubnico Point Wind Farm in Nova Scotia. The wind farm consists of 17 Vestas 1.8 MW turbines with hub heights of 80 m (the turbines proposed for Lamberts East are in 1 MW range with hub height of approximately 50 m). Acoustic measurements were taken within the wind farm and at two homes nearest to

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21 *Wind Turbine Sound and Health Effects An Expert Panel Review*, David Colby MD et al, AWEA and CANWEA December 2009

22 *Wind Turbine Syndrome: a report on a natural experiment*. http://www.windturbinesyndrome.com/wp-content/uploads/2009/03/ms-ready-for-posting-on-wtscom-3-7-09.pdf. N. Pierpoint, 2009 unpublished draft

23 ttp://www.nhs.uk/news/2009/08August/Pages/Arewindfarmsahealthrisk.aspx

24 *Alves-Pereira, M., and N.A.A. Castelo Branco*. 2007b. In-Home Wind Turbine Noise is Conducive to Vibroacoustic Disease. Proceedings of the Second International Meeting on Wind Turbine Noise. Lyon, France: September 20-21, 2007. INCE/Europe.

25 Environmental Noise Assesment Pubnico Point Wind Farm, Nova Scotia, HGC Engineering, Natural Resources Canada Contract NRCAN-06-00046, August 2006.

the site, the nearest (the d'Entremont residence) being 330 m from the closest turbine. The study concluded that: *"Sound at infrasonic frequencies is not present at perceptible levels near the wind turbine generators nor at the d'Entremont residence and it is concluded that infrasound is not an issue".*

Surveys completed independently in the UK by Dr. Amanda Harry and by Dr. Bridget Osborne documented a range of symptoms among residents in the vicinity of large wind farms, attributable to low frequency sound. In response to concerns over low frequency sound and infrasound from three wind farms cited in the survey by Dr. Amanda Harry, the Department of Trade & Industry of the UK conducted a study at dwellings where there had been complaints (DIT 2006). The study concluded that:

- *"Infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour;*

- *Low frequency noise is measurable on a few occasions, but below the existing permitted Night Time Criterion. Wind turbine noise may result in internal noise levels within a dwelling that is just above the threshold of audibility, however at all sites it was lower than that of local road traffic noise; and,*

- *That the common cause of complaint was not associated with the low frequency noise, but the occasional audible modulation of aerodynamic noise especially at night. Data collected showed that the internal noise levels were insufficient to wake up residents at these three sites. However once awoken, this noise can result in difficulties in returning to sleep."*

The British Wind Energy Association commissioned a study (BWEA 2005) of low frequency sound from turbines. The study concluded that the early wind turbines from the 1980s were designed with the blades located downwind of the turbine tower such that the wind had to travel past the tower before it struck the blades. This caused the sound output from this type of turbine to generate a strong low frequency pulse. Advances in turbine design have the blades on modern turbines located upwind of the tower. The stand-off distance between the blades and the tower has also increased in order to minimise the possibility that the blades may interact with disturbed air flow upwind of the tower. The consequence of these developments has been to dramatically reduce tower interaction effects, and the generation of high levels of low frequency noise by wind turbines. Research conducted in low frequency noise on modern wind turbines has shown that the levels of low frequency noise have been below accepted thresholds, and is therefore not considered to be a problem. In the UK, a 2007 study of 133 wind farms by researchers from the University of Salford[26] concluded that *"despite press articles to the contrary the incidence of wind farm noise and amplitude modulation (AM) in the UK is low.*

[26] *Research into Aerodynamic Modulation of Wind Turbine Noise Final Report*, Moorhouse A. et al., University of Salford Contract NANR233, July 2007

In summary therefore, low frequency sound is prevalent in the environment from many natural (wind, waves) and anthropogenic sources (traffic, appliances). Although there have been suggestions that low frequency sound from wind turbines is problematic, scientific studies have found that modern turbines do not produce significant levels. Recent design improvements resulting in upwind turbines, slower rotor speeds and an increased distance between tower and rotor have been incorporated to dramatically reduce the low frequency sound associated with earlier downwind turbines.

Following review, analysis, and discussion, the AWEA/CANWEA Expert Panel reached agreement on three key points:

- There is nothing unique about the sounds and vibrations emitted by wind turbines;
- The body of accumulated knowledge about sound and health is substantial; and,
- The body of accumulated knowledge provides no evidence that the audible or subaudible sounds emitted by wind turbines have any direct adverse physiological effects.

In conclusion, the Expert Panel found that:

- Sound from wind turbines does not pose a risk of hearing loss or any other adverse health effect in humans.
- Subaudible, low frequency sound and infrasound from wind turbines do not present a risk to human health.
- Some people may be annoyed at the presence of sound from wind turbines. Annoyance is not a pathological entity.
- A major cause of concern about wind turbine sound is its fluctuating nature. Some may find this sound annoying, a reaction that depends primarily on personal characteristics as opposed to the intensity of the sound level.

The Panel authors go on to note "*Wind turbines produce low levels of infrasound and low frequency sound, yet there is no credible scientific evidence that these levels are harmful. If the human body is affected by low, sub-threshold sound levels, a unique and not yet discovered receptor mechanism of extraordinary sensitivity to sound is necessary—a mechanism which can distinguish between the normal, relatively high-level "sound" inherent in the human body and excitation by external, low-level sound. Essential epidemiological studies of the potential effects of exposure at low sound levels at low frequencies have not been conducted. Until the fuzziness is clarified, and a receptor mechanism revealed, no reliance can be placed on the case reports that the low levels of infrasound and low frequency sound are a cause of vibroacoustic disease*".

4.0 CLOSURE

This report has been prepared for the exclusive use of the Barbados Light & Power Company Limited for specific application to the project. The work was performed using generally accepted practices.

AMEC Earth & Environmental,
a division of AMEC Americas Limited

Prepared by:

Signature _____ Date: 26 January 2010

Peter Rostern, P.Eng.
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Signature _____ Date: 26 January 2010

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Fred Meth, M.Sc.
Senior Consultant
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APPENDIX A

Letter from TCDPO , July 19, 2007 and response from BLPC August 29, 2007

Town and Country Development Planning Office
Block C, Garrison, St. Michael. BB14038. Barbados.
Tel. No. (246) 467-3000
Fax No. (246) 430-9392
E-mail: contact@townplanning.gov.bb

Ref. No.: 3262/11/04C *Date:* 2007-07-19

Managing Director
The Barbados Light & Power Co. Ltd
P.O. Box 142
Garrison Hill
ST. MICHAEL

Dear Sir,

Re: Application No. 3262/11/04C
Construction of a Wind Driven Generating Station to operate for 24 years and consisting of eleven (11) turbines and associated equipment at Lamberts Plantation, St. Lucy

The following documents submitted by the Josey Hill Residents Association are submitted for your review and response prior to the public hearing.

The Chief Town Planner will advise of the details for the advertising of the public meeting by later correspondence.

Your attention to the foregoing will oblige.

Yours sincerely,

Mark Cummins
CHIEF TOWN PLANNER

Attachments

MC/tf

Caithness Windfarm Information Forum

Summary of Wind Turbine Accident data to November 1st 2006.

The attached table includes all documented cases of wind turbine accidents which could be found and confirmed through press reports or official information releases up to November 1st 2006. The wind industry is extremely reluctant to make such data available, and because of this, data has been extremely difficult to obtain. Several Consultants from the UK and US wind industry have confirmed difficulty in obtaining such data, and CWIF believe that this compendium of accident information may be the most comprehensive put together to date.

Data in the detailed table attached is by no means comprehensive – it has little data from Denmark and Holland – two of the biggest wind turbine operators in the world. CWIF believe that what is attached may only be the "tip of the iceberg" in terms of numbers of accidents and their frequency. However, the data gives an excellent cross-section of the types of accidents which can and do occur, and their consequences.

It is noticeable that since about 1999/2000 data has been easier to find – presumably since the wide distribution of media via the internet. Numbers of accidents in the data reflect this, with an average of **31.6** accidents found per year from 1999 to 2005 inclusive, and only an average of **5.1** accidents found per year in the previous nine years (1990-1998 inclusive). With few exceptions, before about 1997, only data on fatal accidents has been found. Hopefully, future legislation will require operators to report all fatal and near miss accidents on an annual basis, as with other industries.

Data attached is presented chronologically. It can be broken down as follows:

Number of accidents

Total number of accidents: 301

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.	1	8	2	1	3	3	3	3	9	16	7	33	27	11	52	33	33	36	20

**2006 above includes to 1 Nov 2006 only*

Fatal accidents

Number of fatal accidents: 37

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.	1	8	2	1	1	1	1		2	4		1	3		1	3	2	3	3

**2006 above includes to 1 Nov 2006 only*

Fatal accidents include 5 transport/driver distraction accidents and 2 unconfirmed accidents from 1996.

These resulted in 38 fatalities:

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- 31 were wind industry workers (maintenance/engineers, etc). Most common cause - falls from turbines. Included is one apparent suicide.
- 7 were public fatalities, of which three were from road accidents attributed to "driver distraction of turbines" by police, one was from a road accident in which a driver was killed in collision with a turbine transporter, one was in a transport accident in which the road collapsed and the driver drowned, one was from an aircraft accident which hit a new and unmarked anemometer, and the remaining accident was the collision of a parachutist with a turbine.

Human injury

A further eleven accidents regarding human injury are documented. Seven accidents involved wind industry workers, and a further four involved members of the public. One lost a leg in a transport accident, one was hit by thrown ice, one fell from 100m metre tower during an accompanied visit, and one flew his aircraft into a windfarm site.

Blade failure

By far the biggest number of incidents found were due to blade failure. "Blade failure" can arise from a number of possible sources, and results in either whole blades or pieces of blade being thrown from the turbine. A total of 98 separate incidences were found:

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.					1	1	1	3	3	6	1	18	3	5	15	11	14	9	7

**2006 above includes to 1 Nov 2006 only*

Nine incidents were reported in 2005, and seven in 2006 to date. This data makes nonsense of the operator's statement regarding "a one off event" for the incident at Crystal Rig, Berwickshire, Scotland.

Pieces of blade are documented as travelling over 400m, typically from much smaller turbines than those proposed for use today. In Germany, blade pieces have gone through the roofs and walls of nearby buildings. **This** is why **CWIF believe that there should be a minimum distance of at least 1km between turbines and occupied housing** – and preferably about 5km to address other problems such as noise.

Fire

Fire is the **second most** common **accident** cause in incidents found. Fire can arise from a number of sources – and some turbine types seem more prone to fire than others. A total of 44 fire incidents were found in the data:

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.										1	1	2	3	1	16	6	3	6	5

**2006 above includes to 1 Nov 2006 only*

The biggest problem with turbine fires is that, because of the turbine height, the fire brigade can do little but watch it burn itself out. While this may be acceptable in reasonably still conditions, in a storm it means burning debris being scattered over a wide area, with obvious consequences. In dry weather there is obviously a wider-area fire-risk, especially for those constructed in or close to forest areas and/or close to housing.

Structural failure

From the data obtained, this is the third most common accident cause, with 37 instances found. "Structural failure" is assumed to be major component failure under conditions which components should be designed to withstand. This mainly concerns storm damage to turbines and tower collapse. However, poor quality control and component failure can also be responsible – the collapse in May 2005 of a brand-new 300 foot turbine in Oklahoma during light winds are a good example of this.

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.						1					3	6	9	2	8	3	2	3	

**2006 above includes to 1 Nov 2006 only*

While structural failure is far more damaging (and more expensive) than blade failure, the accident consequences and risks to human health are most likely lower, as risks are confined to within a relatively short distance from the turbine.

Ice throw

21 incidences of ice throw were found (one of which has been classed as "human injury" above, in italics below):

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.									4	3		3	*1*		2		4	3	1

**2006 above includes to 1 Nov 2006 only*

Ice throw has been reported to 140m.

These are indeed only a very small fraction of actual incidences – a report* published in 2003 reported 880 icing events between 1990 and 2003 in Germany alone. 33% of these were in the lowlands and on the coastline.

**("A Statistical Evaluation of Icing Failures in Germany's '250 MW Wind' Programme – Update 2003, M Durstwitz, BOREAS VI 9-11 April 2003 Pyhätunturi, Finland.)*

Transport (non-fatal)

Eleven reported accidents – including a 45m turbine section ramming through a house while being transported. One man lost his leg in 2006 following a transport accident off the Scottish coast. Most involve turbine sections falling from transporters, though turbine sections have also been lost at sea.

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.													1		3		2	3	2

**2006 above includes to 1 Nov 2006 only*

The "2000" incident refers to a newspaper report which reports 73 accidents over 4 years along a 4km piece of road, and attributes them to driver distraction by turbines and thrown ice and blade pieces landing on and over the road.

Environmental damage

Very few cases of environmental damage have been reported – the majority in the past four years. This is perhaps due to a change in legislation or new reporting requirement. All involved damage to the site itself, or reported damage to or death of wildlife. Three instances include deaths of protected species of bird.

By year:

Year	70s	80s	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06*
No.					1									1		5	1	4	1

**2006 above includes to 1 Nov 2006 only*

Other

Other types of accident are also present in the data. Component failure has been reported under "other" if there has been no consequential structural damage. Lightning strikes have been included under "other" only when a strike has not resulted in blade damage or fire. A separate 1996 report** quotes 393 reports of lightning strikes from 1992 to 1995 in Germany alone, 124 of those direct to the turbine, the rest are to electrical distribution network.

***(Data from WMEP database: taken from report "External Conditions for Wind Turbine Operation – Results from the German '250 MW Wind' Programme", M Durstewitz, et al, European Union Wind Energy Conference, Goeteborg, May 20-24, 1996)*

David Craig
Caithness Windfarm Information Forum
1 November 2006

(76)

Industrial Wind Turbines, Infrasound and Vibro-Acoustic Disease (VAD)

PRESS RELEASE

May 31, 2007

Issued by

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School of Health Sciences (ERISA)
Lusofona University
Portugal
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Department of Environmental Sciences & Engineering
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Portugal

Nuno Castelo Branco, MD
Surgical Pathologist
President, Scientific Board
Center for Human Performance (CPH)

The **Center for Human Performance** is a civilian, non-profit organization dedicated to research in vibro-acoustic disease. CPH was founded in 1992 and has been the organization which coordinates all the different teams that work on vibro-acoustic disease research, and that include (in Portugal) the cardiology and pulmonary departments of the Cascais Hospital, the neurophysiology department of the National Institute of Cancer, the department of human genetics of the National Institute of Public Health, the department of speech pathology of the School of Health Sciences of the Polytechnical Institute of Setúbal, among several others over the past 25 years.

Contact: Professor Alves-Pereira, *vibroacoustic.disease@gmail.com*

Excessive exposure to infrasound and low frequency noise (ILFN, defined as all acoustical phenomena occurring at or below the frequency bands of 500 Hz) can cause vibro-acoustic disease (VAD).[1]

Research into VAD has been ongoing since 1980, conducted by a multidisciplinary team of scientists led by pathologist Nuno Castelo Branco, MD.

In March 2007, for the first time, the Portuguese *National Center for Occupational Diseases* gave 100% professional disability to a 40-year-old flight attendant who had been diagnosed with VAD since 2001. Two other VAD patients also have been given a similar disability status.

Initially, only ILFN-rich occupational environments were investigated. However, over the past several years, many individuals and their families have approached our team because of the ILFN contaminant in their homes. The sources of residential ILFN vary from industrial complexes, to large volume highways, to public transportation systems, etc.

In a case study published in *Proceedings of Internoise 2004* (an annual scientific meeting dedicated to all aspects of acoustics), one of the first documented cases of environmental VAD was reported in a family of four, exposed to the ILFN produced by a nearby port grain terminal.[2]

Over the past three years, several families have contacted this team complaining of noise caused by the proximity of industrial wind turbines (windmills). However, only within this past month (April 2007) has this team obtained detailed acoustical measurements within a home surrounded by four recently installed industrial windmills.

This acoustical data was essential in order to compare in-home, windmill-produced acoustical environments with the residential, ILFN-rich environments that are known to be conducive to VAD.

The levels of ILFN inside the windmill-surrounded home are larger than those obtained in the home contaminated by the port grain terminal.

The scientific report on this will be formally presented at *Internoise 2007*, to be held on 28-31 August in Istanbul, Turkey.[3]

These results irrefutably demonstrate that wind turbines in the proximity of residential areas produce acoustical environments that can lead to the development of VAD in nearby home-dwellers.

In order to protect Public Health, ILFN-producing devices must not be placed in locations that will contaminate residential areas with this agent of disease.

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[1] Castelo Branco NAA, Alves-Pereira M. (2004) Vibroacoustic disease. *Noise & Health* 2004; 6(23): 3-20.

[2] Castelo Branco NAA, Araujo A., Joanaz de Melo J, Alves-Pereira M. (2004) Vibroacoustic disease in a 10-year-old male. *Proc. Internoise 2004*, Prague, Czech Republic, August 22-25, 2004: No. 634 (7 pages).

[3] www.internoise2007.org.tr

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A CRITIQUE ANALYSIS OF ENVIRONMENTAL IMPACT ASSESSMENT FOR THE BARBADOS LIGHT & POWER COMPANY LIMITED LAMBERTS EAST WIND FARM GENERATING STATION.

APRIL, 2007.

PRESENTED BY THE JOSEY HILL RESIDENTS ASSOCIATION.

The Residents set out to critique this Assessment, mainly to highlight the areas of the report which do not reflect the true picture.

The Residents approached this EIA document in the order as it is presented.

EXECUTIVE SUMMARY.

NOISE:

Page 3: '*Sound contours were developed for the wind farm operating at different wind speeds using a software noise model. Based on maximum power output at a wind speed of mm/s, the predicted noise level at the Lambert's Plantation house which is the closest receptor is 45dBA. This sound level is consistent with the recommended outdoor noise standards of the World Health Organization and the World Bank for sleeping. At higher wind speeds the background sound levels increase at a greater rate than the turbine noise'.*

The WHO recommends that 45dBA should be the limit for night time noise.

'Residents to the east of the site have expressed concerns over low frequency sound, based on published experience at some European facilities. Several studies have been done in other jurisdictions in response to community concerns over low frequency sound

which was problematic of early wind turbines from the 1980s .Advanced turbines have addressed the problems of low frequency sound.. Research conducted on modern turbines has shown that the levels of low frequency noise have been below accepted thresholds, and are no longer a problem'.

This statement is untrue. All over the world people have been complaining of noise problems, mainly low frequency noise. Research has found that modern wind turbines are still problematic and are giving cause for more people to speak out against these structures. Research on modern wind turbines, published, February 2007 provides evidence to the contrary. --- Please see enclosed report by Barbara J Frey, MA and Peter J Hadden, BSc, FRICS. (February, 2007, and the latest 'Press Release', May, 30, 2007).

"Industrial wind turbines produce an intermittent flow of electricity but in the process also produce undesirable noise emissions when installed too close to people's homes, causing environmental noise pollution.--- Wind turbines located at a sensible distance from dwellings are unlikely to cause environmental noise pollution and health problems".

ACCIDENTS and MALFUNCTIONS;

"The wind industry has an excellent safety record. With more than 70.000 turbines in service across the world, and over 25 years of operation, the industry has recorded only one accidental death of a member of public" (German skydiver).

The above statement is untrue and sought to mislead. See: www.wind-works.org/articles/BreathLifehtml. You will find over 300 accidents some fatal

PROJECT PROPOSAL.

Page 2, "The wind farm will feed approximately 28 million kWh into the grid system, producing 2% of the island's electricity..... This figure has now been revised downwards. The cost of installing 11 wind turbines was given as over 20 million dollars. We were informed that Light & Power approached the European Investment Bank to borrow US.D 16.7million. We have read in a British newspaper just recently that the larger wind companies are buying up the smaller companies and the price per wind turbine has gone up 40%.and a waiting list of 18 months. How much more will they cost then?

2.2 SELECTED PROJECT STANDARDS and GUIDELINES

"For wind farms, turbine noise increases with speed but wind-induced background noise also increases..."

This implies that the noise created by the vegetation will somehow mask some of the noise created by the wind turbines.

The land on which the wind turbines are to be located has little or no vegetation, with the exception of a few casuarinas trees. The height of the wind turbines will dwarf any surrounding vegetation. .... (See "Noise Report")

LOW FREQUENCY SOUND;

"Some area residents have expressed concerns over output of low frequency sound from turbines. These concerns are based on information available over the internet.....Surveys completed independently in the U.K. BY Dr. Amanda Harry and Dr. Bridget Osborne....'Dr Nina Pierpont, a USA physician, has posted numerous articles linking low frequency sound from wind farms with health concerns....."

In addition to the above doctors mentioned, Doctors in Australia, Germany, Denmark, Portugal, Spain, France, New Zealand have concluded that a phenomenon which they termed Vibro-Acoustic- Disease,(V.A.D.) or wind turbine syndrome is caused by the low frequency noise produce by wind turbines being placed too close to dwellings. Those doctors have stated, "No one has complained of V.A.D, living more than 1.5 miles away from any wind farm". (See enclosed literature). Also, just been released on May, 30, 2007 in Portugal; research material by Professor Mariana Alves-Pereria, Lusofona University, Portugal. (Enclosed is a press release)

Sites can be viewed at: http://www.ninapierpont.com/pdf/Branco_&_Alves-Pereira_Vibroacoustic Disease.pdf

http://www.ninapierpont.com/pdf/Alves-Pereira_grain_elevator_VAD.pdf

"The EIA, top of page 76: Specific monitoring options will be discussed with regulatory agencies and could involve monitoring at the closest residences following installation of the turbines.

Above statement is not acceptable. Research has shown that once the wind turbines are erected, residents have no recourse. The only recourse left is for the residents to move away.

SHADOW FLICKER:

Has not been addressed. Please see "Shadow Flicker Report".

Many fires connected to wind turbines are as the result of Lightning strikes.

During stormy weather, lightning is known to have struck houses in the area. Last year a neighbor's house was struck and all her appliances were lost. Three coconut trees were scorched and died; another telephone and electrical sockets were blown out of the wall. Another neighbor's coconut tree was struck by lightning. The close proximity of turbines to dwellings will increase the likelihood of lightning strikes and subsequent fires.

HURICANES:

Barbados is in a hurricane zone. Every year there is the potential that the Island could be struck by a hurricane. Wind turbine blades are known to have been dislodged and landed 1/3 of a mile from the tower. Why place innocent people's lives at risk? If wind turbines are a safe distance away, there is less chance some one can be injured or killed by the blades being torn off.

350 meters setback is inadequate. Doctors all over the world have stated their preference for setback of wind turbines. This was after extensive research which shows that complaints are minimal if wind turbines are erected 1.5 miles from the nearest resident.

GEOLOGY:

References to caves in the area were mentioned, so as to bring attention to the fact that because of the terrain, noise seems to travel great distances. People in Josey Hill can hear quite clearly the sound of traffic traveling from Pie Corner up towards Date Tree Hill. The wind farm siting is approximately half the distance from the residents in Josey Hill, if the sound of vehicles can be heard so far away are we to believe that wind turbines are only as noisy as a bedroom fan?

HEALTH: 'Wind energy projects are being promoted world-wide". No one disputes this fact. Wind energy is fashionable and is being subsidized by governments at the expense of the tax-payers. Wind is being promoted by the manufacturers of the industries who are mostly owned by the same companies and who did the greatest damage that created global warming, (Literature included). Not all countries are ideal for wind energy. In small Islands they may need to be put out at sea.

Europe and parts of USA can not depend on sunshine. The Government of Mauritius have stated they intend to have all buildings equipped with Photovoltaic cells so as to provide electricity for homes and industries.

It is important to note that Denmark and Germany are saturated with wind turbines, yet they are unable to meet their needs or reduce the cost of fossil fuel imports. Europe has signed an agreement to build a new generation of nuclear power plants to provide the energy required .Brittan is proposing to use clean coal for energy use. A few months ago, India signed an agreement with Russia to build 4 nuclear power stations. If L& P is serious about providing clean energy and cares about the health of the people alternatives would be sought to provide that energy.

Most of the fuel import is for vehicular usage.

It is important to note that the wind does not blow all the time. The switch from incandescent bulbs to energy saving can reduce energy bills by one third. There are new buildings being built by some of the largest firms here in Barbados and they are installing electric water heaters to provide for hot water. What a disgrace when solar panels could be used.

The residents have concluded that this area is wholly unsuited for the construction of a wind farm. AMEC's EIA fails to appreciate the hazard to the community that this project would cause if allowed to go ahead. AMEC fails to adequately address the following which are our concern.

(1) Health issues
(2) Noise and flicker.
(3) Close proximity of turbines to dwellings.

Section 2.0 INTRODUCTION

1 Industrial wind turbines produce an intermittent flow of electricity but in the process also produce undesirable noise emissions when installed too close to people's homes, causing environmental noise pollution. (See Section 6.5 of this paper.)

2 Wind turbines located at a sensible distance from dwellings are unlikely to cause environmental noise pollution and health problems. When the State allows priority to commercial interests, the reasonable needs of families and their human rights are extinguished. There are questions of human rights and of industrial and governmental ethics when developers construct wind turbines too close to dwellings, especially when Government decision makers are fully aware that there is a high probability that families may lose the right of respect for their home and private life. In such instances, both the commercial groups and the State are party to the violation.

3 This Review seeks to bring together research evidence in the professional literature that addresses the substantive nature of the problem, both from the acoustical and biomedical perspectives. However, the Review would be incomplete without Section 3, Overview of the Problems – Personal Perspectives, which includes the observations and reflections by those living near wind turbines, as well as reports in the media. The Review also considers the possible infringement of human rights when developers build wind turbines in close proximity to dwellings.

4 Precision in predicting noise levels in homes neighbouring wind turbines has so far eluded the wind industry. As early as 1987, Glegg, Baxter, and Glendinning reported on the problems with predicting noise accurately:

> *'This paper describes a broadband noise prediction scheme for wind turbines. The source mechanisms included in the method are unsteady lift noise, unsteady thickness noise, trailing edge noise and the noise from separated flow ... [In] spite of these detailed predictions of the atmospheric boundary layer the noise predictions are 10dB below the measured levels ... [The upwind] support tower cannot be ignored, since significant acoustic scattering occurs when the rotor blade is close to the tower. This can be very important subjectively and so a theoretical model has been developed which allows for the increase in radiation due to this effect.'* [Glegg SAL, Baxter SM, and Glendinning AG. The prediction of broadband noise from wind turbines. Journal of sound and vibration 1987; 118(2): 217-39, pp 217-218]

5 In a recent (2006) Report the Dti found further studies of wind turbine noise were necessary:

> *'However, the presence of aerodynamic modulation which is greater than that originally foreseen by the authors of ETSU-R-97, particularly during the night hours, can result in internal wind farm noise levels which are audible and which may provoke an adverse reaction from a listener ... To take account of periods when aerodynamic modulation is a clearly audible feature within the incident noise, it is recommended that a means to assess and apply a correction the incident noise is developed.'* [Dti Executive

Summary of the Measurement of Low Frequency Noise at Three UK Wind Farms, contract number W/45/00656/00/00, URN number 06/1412, Contractor: Hayes McKenzie Partnership Ltd, 2006.]

The report states that *'... it may be appropriate to re-visit the issue of aerodynamic modulation and a means by which it should be assessed.'* [p 65]

6 The wind energy industry and its consultants – acoustical engineers – claim that the audible and inaudible noise effects have minimal consequence on humans and that infrasound (0Hz – 20Hz, part of the low frequency noise spectrum), is inaudible and weak and therefore not a human health risk. This review has not found any epidemiological evidence to support these suppositions.

7 As more wind turbines are installed near homes, more communities are affected by these complex sounds. Noise is the human face of the science of sound, and physicians are seeing the results. More people living close to wind turbines – within 1.5km – complain of sleep deprivation, headaches, dizziness, unsteadiness, nausea, exhaustion, mood problems, and inability to concentrate.

Physicians and researchers in the UK, Portugal, Germany, the USA, Australia, and New Zealand, among others, have observed a similar constellation of symptoms.

8 Although acousticians and engineers working for the wind energy industry conclude that audible noise and low frequency noise from wind turbines are unlikely to cause health effects, experts in biomedical research have drawn different conclusions.

9 Indeed, in 2006, the French National Academy of Medicine issued a report that concludes:

'The harmful effects of sound related wind turbines are insufficiently assessed ... People living near the towers, the heights of which vary from 10 to 100 meters, sometimes complain of functional disturbances similar to those observed in syndromes of chronic sound trauma ... The sounds emitted by the blades being low frequency, which therefore travel easily and vary according to the wind, ... constitute a permanent risk for the people exposed to them ... An investigation conducted by the Ddass [Direction Departementale des Affaires Sanitaires et Sociales] in Saint-Crepin (Charent-Maritime) revealed that sound levels 1 km from an installation occasionally exceeded allowable limits.'

The report continues:

'While waiting for precise studies of the risks connected with these installations, the Academy recommend halting wind turbine construction closer than 1.5 km from residences.'
[Chouard C-H. Le retentissement du fonctionnement des eoliennes sur la sante de l'homme (Repercussions of wind turbine operations on human health). Panorama du Medecin, 20 March 2006]

10 Warning signs of future problems with new technologies have been overlooked or ignored in the past, much to the detriment of the public's health. One has only to look at the history of asbestos and mesothelioma; tobacco and lung cancer and chronic pulmonary diseases; thalidomide and birth defects; mercury and neurotoxicity; x-rays and fluoroscopes and cancer; lead-based paint and childhood poisoning; and coal miners and black lung, to name but a few. The pattern of medical problems took time to emerge before a pattern of health complaints were observed, followed by epidemiologic studies and public health policy.

11 Human health effects may take years to emerge as a pattern, when the detrimental effects are past correction. As the numbers of wind turbine installations close to people's homes increase, reports of health effects have escalated, from sites across the globe. These problems do not appear to be present where wind turbines are located at a safe distance from homes.

12 This paper brings together research evidence on the characteristics of noise radiated by wind turbines and how that noise affects human health. As this is a public health issue, this paper also presents the advice and policy recommendations of medical and epidemiological experts.

This paper also considers whether as a result of reported health problems, the noise emission components of wind turbines should be regarded as an environmental noise pollution, which is a violation of basic Human Rights.

Section 3.0 OVERVIEW OF THE PROBLEMS: Personal Perspectives

'Britain should be considerably quieter than it is ... unless something is done the situation will soon become intolerable.' **[The *Times*, London, 3 July 1963]**

1 This section of the paper, perhaps more than any other, illustrates that noise is the human face of the science of acoustics. This section presents that essential – but often ignored – side of the equation: the voices of those directly affected by the construction of wind turbines near their homes.

2 In 1966, Dr Alan Bell observed that noise is much more than an occupational hazard:

> *'Noise is a sensory input, devoid of information, that nevertheless demands attention ... it is a public nuisance and a danger to mental and physical health ... The degree of annoyance is not necessarily directly related to the intensity of the sound ... The factors influencing community responses included lack of sleep ... The results of past lack of forethought are aggravated by situations still developing that will certainly create noise problems in years to come ... Even rural peace is often shattered.'* [Bell, A. Noise: an occupational hazard and public nuisance. Geneva: World Health Organization, 1966.]

3 Both the European and British Wind Energy Associations, in their Best Practice Guidelines, state that:

> ***'Wind turbines should not be located so close to domestic dwellings that they unreasonably affect the amenity of such properties through noise, shadow flicker, visual dominance or reflected light.'***

4 But these are only industry guidelines. Planning Policy Statement 22, section 22, says that:

> *'Renewable technologies may generate small increases in noise levels (whether from machinery such as aerodynamic noise from wind turbines, or from associated sources – for example, traffic).*
>
> ***Local planning authorities should ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels.***
>
> *Plans may include criteria that set out the minimum separation distances between different types of renewable energy projects and existing developments. The 1997 report by ETSU* [ETSU-R-97, The assessment and rating of noise from wind farms] *for the Dti should be used to assess and rate noise from wind energy development.'*

5 This guidance is scrupulously followed by wind turbine developers and Planning decision makers. Section 4.0 of this paper, Acoustics, addresses the limitations of ETSU-R-97; yet it is interesting to note here that the standards in ETSU-R-97 appear to provide less protection to people than the standards of the World Health Organisation *Guidelines for Community Noise 1999*.

6 ETSU-R-97 and subsequent policies based on that document fail to protect families living near wind turbines, as the following illustrates:

For a fortnight beginning 12 January 2004, complainants and witnesses gave evidence about their experiences living near the Askam, Cumbria, UK, wind turbines. These wind turbines are rather modest compared to the larger turbines of today: seven wind turbines, each 62.5m high.

Prior to the construction, the developers had assured the community that wind turbines near their homes would not create noise or visual disturbances. Background noise prior to the wind farm was as low as 16.5 dB, with a nighttime average of about 19 dB. The readings are now regularly in the middle to high 40's dB.

> *'Eventually the developers admitted everything that we had claimed – but still nothing has been done to resolve these problems to the satisfaction of those people who matter.'* [Brierley D., *Public Presentation,* Askam, Cumbria, 2006]

7 On seeking assistance from the local Council, the Askam residents were then informed that *'because of the court case of **Gillingham v Medway Council**, the classification of the area had changed with the passing of the planning permission'*. That is, the area where the wind turbines were built had been reclassified as a mixed rural/industrial area; local residents were unaware of this reclassification.

Consequently, their expectations of noise levels were considered *'unrealistically high'* for an industrialised area, according to the local authority. [Brierley, 2006]

8 Indeed, when the Askam residents brought a case against the developer PowerGen (E.oN), the judge eventually ruled against the residents, saying that ***"audibility and annoyance are not to be equated with nuisance."*** [Brierley D., *Public Presentation,* Askam, Cumbria, 2006]

9 The following are excerpts of statements of only a few who have lived near wind turbine installations. Some of these families have consequently moved home because they felt it impossible to enjoy a normal family life by remaining.

It is important to remember that some of these statements were written or presented several years after living with the daily, or nearly daily, intrusions of noise and/or shadow flicker / strobing caused by wind turbines.

Please note: In respect for the residents' confidentiality, the authors are identifying the families by number rather than by name.

10 *'Everything changed ... when the wind turbines arrived ...approximately 700 metres away from our property ... At this point we had no idea how this development (windfarm) was to effect [sic] our quality of life and cause so much pain and suffering. Within days of the windfarm coming into operation we began to hear a terrible noise, but didn't know, at first, where it was coming from. As it continued we eventually realised the noise originated from the windfarm. We were horrified. Were we the only ones suffering this noise?*

Would this continue for the proposed length of time the windfarm would be there i.e. for the next 20 years? The noise drove us mad. Gave us headaches. Kept us awake at night. Prevented us from having windows and doors open in hot weather, and was extremely disturbing.'
Member of Family 01

Some time after the wind turbines began operation, this resident learned that other people were experiencing the same problems; they attempted to voice their concerns and their distress:

'From that day, until the present, despite telephone calls, letters to, (and liaison meetings with), the owner, the operators, representatives of the Parish Council, the District Council, the local Planning Committee, the Environmental Health Department and our member of Parliament ... nothing has been resolved.'

11 On one occasion, several of the wind turbines were switched off on the morning of one bank holiday, to give this family some relief (this is 4 years on ...), but by evening, the turbines were operational, and the noise returned. This resident's statement continues with an anecdote: one of the wind turbine operators who lived several kilometres from the site said

'... quite openly, that he walked his dog on the foreshore ... and had identified noise from the wind turbines ...over 4 kilometres away from the site.'

Occasionally the family would request that one or more turbines could be switched off so that they could spend time in their garden, but:

'I found it beyond belief that after almost 4 years we still had to ask for time to work in our own garden and even then to be restricted to 4-5 hours.'
Member of Family 01

12 Other witnesses said that even without a view of the turbines, there is an audible impact:

'I cannot come to terms with the thought of this situation continuing for another 15 years. From our property we cannot see any of the turbines, but we can certainly hear them.' **Member of Family 02**

'They were noisy immediately, blades "whooshing" around ... if the wind is from the East, or the South, the noise is horrendous. You can't get away from the noise, where can you go? It's all around outside and you get it inside the house as well. It's worst during the night, I have to "bed hop" to get any sleep ... but it doesn't work ... This noise is like a washing machine that's gone wrong. It's whooshing, drumming, constant drumming, noise. It is agitating. It is frustrating. It is annoying. It wears you down. You can't sleep at night and you can't concentrate during the day ... It just goes on and on ... It's torture ... [4 years later] *You just don't get a full night's sleep and when you drop off it is always disturbed and only like "cat napping". You then get up, tired, agitated and depressed and it makes you short-tempered ... Our lives are hell.'* **Member of Family 03**

13 One resident near the wind farm, a mechanical engineer and his family, accepted the developer's assurance that the turbines would not be a noise nuisance. However, when the wind turbines became operational, they began to experience problems with noise. Following this, they then discovered that other families had similar problems. The developer denied that any problem existed:

> *'The wind farm was described as "inaudible", which clearly wasn't true. They also denied the existence of upwind noise, a fact they later retracted and admitted did exist ... at one of these meetings Mr —, of —, said ... that his company was not prepared to take any action to reduce or eliminate'* the phenomenon of shadow flicker. *'Throughout the negotiations with the developer's side, it has been disappointing to encounter the amount of "stonewalling" and intimidation, which culminated in the threat of legal action against us, when our sole intention was to remedy the problems inflicted on us by the presence of the wind farm, which caused the various nuisances.'* **Member of Family 04**

14 Another family living near the wind turbines, who had also been reassured by the developer prior to the installation that noise would not be a nuisance, did indeed experience a 'noise nuisance' when the turbines became operational. At a meeting, a representative of the developer, when asked about the problems with noise, especially after assurances that noise would not be a problem at this site, responded:

> *'... no wind farm was "inaudible". I suggested that any further correspondence publicising wind farms in general should, in future, be correctly worded and not mislead the general public in this way ... everything we were complaining about was being aggressively fought against by the developers ... My personal feeling is that the residents have been let down by all the parties involved, but specifically by the Environmental Health Department's apparent inability to resolve what is a genuine and distressing sequence of noise nuisances that have gone on now for over 4 years.'* **Member of Family 05**

15 Yet another resident living near the wind turbines, although not visible from his home, found the noise from the turbines disturbing, especially when the wind prevails from the East, which is frequent:

> *'It was like the Chinese water torture, it was constant pulsating noise. I also had to move bedrooms on occasions in an attempt to escape the noise. It's a feeling as much as a noise ... It's an irritating and tiring noise, especially when you have not had any sleep because of it.'* **Member of Family 06**

16 The litany continues: One resident, with many years work experience of oil and gas exploration, development, and production, including work as a consultant internationally, questioned the wisdom of installing wind turbines near homes. It was not the technology to which he objected. However, he felt reassured by the developer that the wind turbines would not create a nuisance, and that the developer would safeguard their 'continuing quality of life':

> *'It is not necessarily the noise level per se, but the nature of this noise. It may not be constant. It has lasted some 10 – 12 days without respite, with varying intensity such that even when not present you are waiting for it to re-occur.*

The most apt description is that it is an audio version of the Chinese Water Torture. The noise is such that the noise is felt as much as heard ... Developers have been informed ... that this noise is making people ill, although I have no experience of this. This, I believe, may be attributable to the low frequency element of noise created by the wind farm. This phenomenon is documented in a report published by DEFRA, where wind farms are confirmed as a source of low frequency noise.'
Member of Family 07

This particular resident was 'appalled' when the signatory of the developer's letter assuring the community that the wind turbines, when operational, would not create a noise nuisance, later admitted to him privately, that:

'There is noise with all wind farms. It is to be expected and you have to live with it.'

'This confirmed my worst fears that the residents had been misled ...'

17 Apparently, the developer eventually provided attempts at noise mitigation:

'This, I believe, is an admission that noise problems exist ... the developers want to dictate the times of day, duration and location of the residencies [sic] that will and will not be affected by noise emanating from their wind farm. This is entirely contrary to the [developer's] letter and the BWEA and EWEA guidelines ... It is also contrary to the EHO's mission statement as publicly depicted on their web site.' **Member of Family 07**

18 And from a farming family:

'The noise is a big "Whooshing" noise ... I hear it inside my home ... If I sit in the garden it's there, not always as it depends really on the wind direction and if the wind is from the west side of my property it is worse ... I am not against wind energy, but these are definitely in the wrong place. If only someone had come and looked at it or even if they came today, they would realise what I am trying to say.' **Member of Family 08**

19 One family has since moved away; their home was 680m from the nearest wind turbine.

Another family that has since moved away lived 700m from the nearest wind turbine.

Another family is moving away; they live 800m from the nearest turbine.

Of the other witnesses, distances from the nearest turbines range from 600m to 1000m. One resident, who lives 390 m away, sleeps with the radio on, but this person declined to testify.

20 In a paper known as "The Darmstadt Manifesto", published in September 1998 by the German Academic Initiative Group, and endorsed by more than 100 university professors in Germany, the German experience with wind turbines is described in graphic terms:

'More and more people are describing their lives as unbearable when they are directly exposed to the acoustic and optical effects of wind farms. There are reports of people being signed off sick and unfit for work, there is a growing number of complaints about symptoms such as pulse irregularities and states of anxiety, which are known to be from the effects of infrasound [sound frequencies below the normal audible limit].'

21 In Bradworthy, North Devon, UK, noise complaints lodged to the local environmental health officer after three wind turbines – each 85m high – became operational in 2005, are still unresolved. One resident, who lives as near as 533m to these three turbines, endures

'strobe or shadow flicker entering my Kitchen, Conservatory and Sitting room, all on the East side, when the sun rises in the east, in Autumn and Winter behind the wind turbines. This will last for three months and is NOT ACCEPTABLE ... The prolonged flicker causes a headache, affects my eyes and causes disorientation.'

This resident has observed and described the noise at various times of day, in all weather conditions, and rarely is there a lull in the noise, which is characterised, depending upon the strength and direction of the wind, as swooshing, swishing, whining, a constant aeroplane drone, a police siren, and like a spin dryer.

'That shadow flicker would cause problems was denied 3 times in the planning appeal book.' [MH, Bradworthy]

Yet, the developer's Planning Appeal stated:

'Shadow Flicker. As previously stated, this is not considered an issue due to the distance and orientation of the turbines to the nearest dwelling.'

Instead, this property owner explains that the shadow flicker *'actually reaches past my property and over a public highway ... 500 metres away is too close.'* [MH, Bradworthy]

22 In a letter to the *Western Morning News,* 16 October 2001, Patrick and Phoebe Lockett, of Wadebridge, Cornwall, UK, wrote:

'We live near the Bears Down windfarm in North Cornwall, where there are 16 turbines between 750 and 1400 metres from our home, and we are subjected to intrusive noise. When the wind direction is south to south-westerly, there is a rhythmic thumping sound which disturbs us and our neighbours, in our homes and gardens, day and night.

We are writing to residents in the areas of North Devon where there are proposed wind farm developments, advising them not to take reassurances from developers at face value.

I quote from a letter we received in October 1998 from National Wind Power's head of operations and technology, John Warren:

"We are 100 per cent confident that there will be no noise problem at any nearby residence."

NWP say that they do not know why the turbines are making this noise. They are monitoring it and tell us they will try some experimental adjustments to the turbine blades. Our only hope is that NWP's investigations will provide a solution to the distressing situation in which we and our neighbours find ourselves.'

23 Two years later, in a letter to the Western Morning News on 15 November 2003, Phoebe Lockett wrote:

'We are still experiencing noise problems with the turbines on Bears Down.'

24 *The Courier-Mail* (Queensland, Australia) reported on 4 October 2005, that a Queensland government-owned wind farm, which began operating in 2000, was creating sleep disturbances and noise problems at nearby properties. Jim and Dot Newman said:

'... the throbbing, thumping noise from the generators could be heard at all hours of the day. It was very frustrating in the beginning and makes us extremely upset, but there is nothing we can do about it.'

After a year, the couple decided to move, but could not find a buyer for their property. The newspaper reported that:

'A number of Victorian residents know exactly how the Newmans feel and are equally angry at Stanwell Corporation.'

Stanwell had assured residents that they would not be disturbed by the turbines.

With two 60m towers standing 750m and 810m from their homes, Keith and Terry Hurst said:

'It was terrible, we had real trouble sleeping and the worst part was we decided to move and it took 18 months to sell the place.' In a 'booming' property market, they lost money selling their house. One real estate agent said that 'it was nearly impossible to sell a property within one kilometre of a wind turbine or a proposed wind turbine.'

25 Stanwell's spokesperson said that:

'... independent experts and noise level monitoring had verified the Toora Wind Farm [as] fully compliant with its operating permit conditions.' (Gregg N. Wind energy not resident-friendly. The Courier-Mail, Queensland, Australia, 4 October 2005.)

26 A common thread runs through these observations by those who live near wind turbines: It is not necessarily only the loudness of the noise; it is also the character of the noise that is disturbing. The wind turbine noise is periodic; intermittent; 'whooshing' or 'swishing'; it interferes with outdoor activities at one's home and with sleep or studying, i.e., it severely disrupts normal family life.

As one of those living near the wind farm in Askam observed:

> ***'You think "Oh it's stopped" – then it starts up again.'***
> (Member of Family 09)

27 In New Zealand, a man may be forced from his home because noise from wind turbines will make his house 'uninhabitable'. After 20 years, it is understandable he is reluctant to leave. However, the nearest of the planned twelve turbines is only 500m from his boundary, and the decibel levels will exceed those allowable, according to the state-owned power company's representatives.

28 In 2005, a family living near the Te Apiti wind farm in New Zealand, had to move house because noise and vibration *'made it impossible for them to stay'*. [http://stuff.co.nz : *Turitea man fears he'll have to go.* 10 November 2006]

Indeed, those living near the Te Apiti wind turbines have first-hand experience with those problems:

> *'... in an easterly there is an intrusive rumble for days on end. They say the windmills emitted a low frequency noise for three days on end, making their lives a living hell.'*

At another time,

> *"... the rumbling was so bad it sounded like one of those street cleaning machines was driving up and down near the house. In fact it sounded like it was going to come through the house,"* said Wendy Brock.

29 According to Meridian, the developer:

> ***'... it's a small number of people making a big noise about nothing.'***

And another Meridian spokesperson, Alan Seay, said that:

> ***'... the monitoring has shown quite clearly they were well within the guidelines.'***
> [Flurry of complaints after wind change. TV1 News, New Zealand, 25 July 2005, http://tvnz.co.nz/view/page/411749/599657]

30 In Nova Scotia, Canada, one family and one wind farm developer have drawn different conclusions from similar noise readings at the family's home. Although the family insists that the noise from the 17 wind turbines – the closest is 400m from their home – has affected their well-being, the developer does not acknowledge any deleterious effects on the family. [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. Canadian Press, 13 November 2006, http://thestar.com]

The d'Entremont family complained of noise and low frequency vibrations in their house after the wind turbines began operation in May 2005. The inaudible noise deprived his family of sleep, gave his children and wife headaches, and *'made it impossible for them to concentrate'*. They now live nearby; if they return to their home, the symptoms return.

31 *'But a study released this month by the federal natural resources department, which oversees funding for wind farm projects, found no problems with low-frequency noise, also known as infrasound.'*

The government report concludes that the measurements:

'indicate sound at infrasonic frequencies below typical thresholds of perception; infrasound is not an issue'.

The developer says he was not surprised by the report's findings:

'It essentially says that there's no issue whatsoever with infrasound.'

32 D'Etremont hired his own consultant to record the noise levels at his home:

'Gordon Whitehead, a retired audiologist with twenty years of experience at Dalhousie University in Halifax conducted tests.'

Whitehead's data was similar to that of the government's report. However, as a health professional, Whitehead reaches a different conclusion:

'They're viewing it from the standpoint of an engineer; I'm viewing it from the standpoint of an audiologist who works with ears ... The report should read that (the sound) is well below the auditory threshold for perception. ***In other words, it's quiet enough that people would not be able to hear it. But that doesn't mean that people would not be able to perceive it.'***

Whitehead explains that

'... low-frequency noise can affect the balance system of the ear, leading to a range of symptoms including nausea, dizziness and vision problems. It's not perceptible to the ear but it is perceptible. It's perceptible to people with very sensitive balance mechanisms and that's generally people who get very easily seasick.'

33 The developer has acknowledged that some questions remain:

'From our perspective, I think it's really up to the scientific community to really address and research such issues (as low-frequency noise) ... I know there is research that points to different directions.' [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. Canadian Press, 13 November 2006, http://thestar.com]

34 In a newspaper article describing the d'Etremonts' situation and the wind power company's position, Michael Sharpe, a Dalhousie University audiologist, said that:

'Even if someone isn't affected directly by low-frequency noise, the constant swoosh of the blades, even at allowable levels, can have psychological effects.

"If the sound is audible and it annoys you, then it can seem louder," says Sharpe who compares it to a dripping tap that can keep someone awake at night.

"As your stress level increases, your awareness of the annoying sound increases as well. As we know, elevated stress levels for a prolonged period of time can have a negative health effect." [Keller J. Turbines stir up debate. *The Chronicle Herald*, Halifax, Nova Scotia 21 May 2006.]

35 The d'Etremonts are unable to sell their home because of the wind farm. [Keller J. Nova Scotians flee home, blame vibrations from 17 turbines for loss of sleep, headaches. *Canadian Press*, 13 November 2006 http://thestar.com]

36 Dr Robert Larivee, a Professor of Chemistry who lives 3000m east of twenty wind turbines – commissioned in 2003 – in Meyersdale, Somerset County, Pennsylvania, USA, wrote to his County Commissioners (2005) after an acoustician measured noise at his property that rose to 75 dB.

'These levels are much higher than those predicted by the company. There are a number of reasons that may contribute to this. Probably the most significant factor is the topology of the area. Our area has many mountains and valleys ... '

Dr Larivee quotes the US Environmental Protection Agency, which says that

'noise levels above 45 dB(A) disturbs sleep and most people cannot sleep above the noise level of 70 dB(A). Emotional upset, irritability and other tensions, may also arise. Noise contributes to ailments like indigestion, ulcers, heartburn and gastrointestinal malfunction in the body.' [Letter from Dr Robert Larivee, Meyersdale, Pennsylvania, USA, to the County Commissioners http://www.pbase.com/wp/image/39285457]

37 Another resident of Meyersdale, who lives less than one mile from the twenty wind turbines, wrote a lengthy letter on 7 March 2006 to 'Interested Parties'. Karen Ervin felt she had to *'share the realities and impacts'* of living near a wind turbine facility. She calls her situation the **"Human Experimental Factor"**, as the community deals with *'the multiple nuisances and issues'* affecting her family, her neighbours, and local adjacent property owners during the two years the wind turbines have been operating:

'Prior to the building of the facility, our neighbors and we were never made aware of the nuisances that occur with a wind turbine facility. The noises emitted from the turbines have definitely changed our style of living. The noises produced from the blades turning on the turbines create a 'threshing' sound within and around our home as well as the adjacent properties ... '

'At times it is difficult to fall asleep with the "pounding" of the turbines. One is often awakened by the 'droning' noise of the turbines, finding it most difficult to fall back asleep. The noise becomes so disruptive; one can concentrate on nothing else but the constant droning. During the winter months, the noise is quite unbearable at times, sounding like drums beating constantly in the background. During the summer months, we cannot have our windows open ... '

'Advocates for these facilities will often compare this "threshing" noise to the "peaceful" sound of waves beating against the rocks at the seashore; but I

have been to the seashore and it certainly is in no way comparable to the "calming sound" of waves.'

Noise is not the only problem: flicker and 'strobing' are also nuisances. Ms Ervin concludes her letter with this observation:

> *'This industry without stringent regulations can be truly labelled a "Pandora's Box". Be careful for what is opened, and be prepared for the negative impacts that have occurred and continue to occur with this industry.'* [Letter, Karen Ervin, Meyersdale, Pennsylvania, USA, 7 March 2006, www.pbase.com/wp/image/39285457]

38 Yet another resident living near the Meyersdale wind turbine facility, Mr Rodger Hutzell, Jr, and his family experienced

> *'... noise nuisance issues, specifically when trying to go to sleep at night. The noises are greater during the winter months. The noise appears to correlate to a continual droning sound. When awakened at night, there are times that is impossible [sic] to get back to sleep due to the threshing sounds produced by the wind turbines.'* [Letter, Rodger A Hutzell, Jr, Meyersdale, Pennsylvania USA, 13 February 2005, www.pbase.com/wp/image/39285457]

39 In Mackinaw City, Michigan, USA, wind turbines rise 325 feet high, visible from nearby homes. Kelly Alexander's home is ¼ mile away from the nearest turbine. Initially Mr Alexander was in favour of the turbines, especially after the developer's assurances that the wind turbines would not be noisy. Flicker is also a problem, but this was never mentioned by the developer to Mr Alexander or the community.

Once the turbines became operational, Alexander heard

> *'a constant humming sound inside his home when the turbines are running, whether the windows are open or not. He said the situation was unliveable and all he wants is for things to be the way they were ...'*

40 **The wind energy company representative said that it *'has lived up to ordinance requirements.'***

Alexander's response was:

> *'Stop lying about these turbines. Tell people the truth.'* [Holland *Sentinel*, 31 December 2002]

41 In September 2002, the Mackinaw *Journal* reported on these turbines. Danny Dann and Kelly Alexander said that the turbines *'were exceeding a 60-decibel noise limit'*, and that ten other immediate neighbours were also concerned about the noise. The Mackinaw City Community Development Director said that they had sought legal advice because they did not have *'anything in our lease agreement to terminate the contract.'*

42 The owner, Bay Windpower, planned to erect at least two more wind turbines in the same area. [McManus S. Turbines still causing a problem, neighbors say. Mackinaw *Journal*, August 29 – September 26, 2002, p 3]

43 In 2004, Dr James LeFanu wrote that *'there have been some interesting comments on the substantial health problems – headaches, anxiety, sleep disturbances'* experienced by those living near wind farms:

> *'The cause seems to be the low-frequency noise generated by the incessant throb of their turbines ("like a concrete mixer in the sky"). "I like to think I know a bit about sound," writes Basil Tate, a recording engineer from Cornwall, "but it always amazes me how my wife can feel low-frequency sounds that are a long way away and be extremely distressed by them." Little wonder that some of those living close to wind farms have been forced to flee their homes.'* [LeFanu J, Dr. In sickness and in health. *Daily Telegraph* 14 March 2004]

44 Unhappily, this is not an exaggeration. Gwen Burkhardt was surprised when Dewi Jones, director of Winjen, which runs Blaen Bowi wind farm in Wales, UK, said:

> ***'There are a lot of wind farms operating in the UK and we haven't come across the complaint before.'*** ['Did turbines make you sick? Journal 18 May 2005, www.thisissouthwales.co.uk]

In her letter to the Journal [1 June 2005], Ms Burkhardt wrote that:

> *'I spoke to you and two of your employees on March 10 this year ... I explained to you in great detail about my own illness which was also brought on by the low frequency sound emitting from the very same turbines.*
>
> *It has caused me and my family a great deal of distress and has resulted in us having to move away from the area where I was born and where we have farmed for the last 27 years. Have you just forgotten our conversation? Do you simply not care? ... I do remember you sympathising with me and also telling me that you would not like to live near the turbines yourself.'* [Burkhardt G. Complaints are not new. *Journal*, 1 June 2005, www.thisissouthwales.co.uk]

45 In July 2005, Mr Murray Barber wrote to inform Energiekontor AG about the noise problems at the Forestmoor wind farm near Bradworthy, Devon, UK. His family's home, located 650m from the nearest of three turbines, is affected especially during calm days when the noise is very audible.

> *'The noise nuisance caused is irritating, distracting, stressful ... We do not understand why it is necessary for all three turbines to be driven at a high speed of rotation in absolute still air.'* [Letter from M Barber to Energiekontor AG, 12 July 2005]

In response, Energiekontor AG informed Mr Barber that:

> ***'The threshold of hearing is considerably lower than these levels, so noise from the turbines will be audible, however, at a level which is considered by the guidelines not to unduly affect amenity.'*** [Letter to M Barber from Energiekontor AG 19 July 2005]

46 in Fenner, New York, USA, when the trees are bare, Wayne Danley's wife 'flees' the living room of their house because of the flicker created by the turbine's rotating blades. Mr Danley lives 900 feet from the nearest wind turbine:

> *'It sounds like a train going through, except the train never comes through ... It's too close.'* [Neighbors complain of wind farm nuisances, The Albuquerque *Tribune*, 28 April 2006]

In response, Marion Trieste, publicist for the Alliance for Clean Energy New York, said:

> ***'There's a lot of misinformation, and a lot of inflamed discussion about negative encroachment.'*** (Neighbors complain of wind farm nuisances, The Albuquerque *Tribune* 28 April 2006)

And according to Laurie Jodziewicz, a policy specialist for the Alliance, **there are complaints about the *'strobe-light effects, but those occur only during certain months of the year and depend on the sun's angle to the turbine blades.'*** (Neighbors complain of wind farm nuisances, The Albuquerque *Tribune* 28 April 2006)

47 Given the sophistication of engineering design computer modelling, one might presume that these effects could be calculated prior to the construction of the wind turbines. However, Mr Danley had it right: the wind turbine was too close. With appropriate planning and distances between homes and wind turbines, these problems would not only be attenuated, they would cease to exist.

> *"It's not there all the time, but you're always waiting for it ... [It's] totally infuriating.'*

The thump-thump-thump 'reverberates up to 22 times a minute,' said Les Nichols, who lives beside a wind farm in Furness, UK. When seeking permission for the seven turbines, the developers *'guaranteed there would be no noise nuisance.'* (Garrett A. Ugly side of wind power. The Observer, Sunday, March 2, 2003)

48 Yet Bruce Allen, a director of Wind Prospect, the management company for the owner, PowerGen Renewables, said that:

> ***'The wind farm "had not breached its planning requirements. It's a subjective thing – like living beside a busy road." '*** (Garrett A. Ugly side of wind power. The Observer, Sunday, March 2, 2003)

Garrett's article continues:

> Giant wind turbines *'planted on your doorstep ... can transform a tranquil neighbourhood overnight into a menacing industrial site ... there are no rules about how close they can be to homes.'*
>
> *'The Welsh Affairs Select Committee recommended they shouldn't be less than 1.5 kilometres (0.93 miles) from any house, but developers generally go as close as between 500 metres (1,640 ft) and 600 metres (1,968 ft) ... '* (Garrett A. Ugly side of wind power. *The Observer*, Sunday, March 2, 2003)

49 As Phoebe Lockett, who lives near the Bears' Down wind farm in Cornwall, UK, wrote in a personal communication:

> *'There seems to be little known of what noise there may be from wind turbines and very few people who have genuine expertise in this area. The planning guidelines and studies carried out beforehand are, in my opinion, of little use.'*
>
> *'Please let me know if I can be of further assistance, as I do not like to think of others having to go through the same distress.'* [Letter, personal communication, 15 November 2003]

50 Eleven wind turbines, 121m high, have been operating in Taurbeg, Cork, Ireland, since February 2006, where residents *'are anything but happy ...'* The noise from the turbines are causing sleepless nights; one resident said the noise was like a *'plane which consistently hovers but never lands.'*

Another resident told the newspaper that *'The thought of another six going up within 500 metres of my front door is just a nightmare ... The noise from the windmills kept everybody in the area awake.'*

There were a number of complaints about the inaccuracies of the photomontages produced by the developer during the application process. Residents also suffer flicker, and one person labelled the result *'visual chaos'*.
[Herlihy M. Windmills 'are a nightmare'. The Corkman, 6 April 2006]

51 In the summer of 2006, eight wind turbines with an installed capacity of 16MW became operational at Deeping St Nicholas, Lincolnshire, UK. The noise from these turbines transformed the lives and the livelihood of the Davis family, living in a farmhouse only 907m from the nearest turbine. Jane and Julian Davis, who farm at Deeping St Nicholas and who learned of the development while reading their local newspaper, did not object to the development. They support wind energy and believe that renewable energy sources are essential to preserving the environment.

Although the Davis family cannot see the wind turbines from their home, the noise – both inside and outside their home, and which also caused vibrations within the structure of their home – has had a deleterious impact on their health and sense of well-being. Prior to the wind farm, they had no problems sleeping through the night. Now, when the wind blows from the southeast or the southwest, the noise from the acoustic radiation seriously disturbs their sleep.

> *'They have spent more than 60 nights in the last six months sleeping at friends' houses', and when home, they 'are existing on less than four hours sleep a night and sometimes a lot less.'* [Couple driven out of home by wind farm. Spalding Today (UK) 21 December 2006]

After taking its own acoustic readings, the local Council confirmed the noise problem, and it is investigating the matter further. [Davis J. Personal communication, 19 January 2007]

Local land agents have told them that their property is 'unsaleable'. Although consultants for the developer are evaluating the issue, and the Dti are investigating wind farm noise, that does not alleviate the impact on the family. [Tasker J. 'Wind farm noise is driving us out of our house.' Farmers Weekly 12 January 2007]

As the noise established itself as an ongoing problem, the Davis family learned that developers had used only predicted levels for their home without taking actual baseline measurements. Indeed, background noise most often measured below 20 dB at night (and usually in the range of 14 dB); now noise in the range of 40 dB occurs when the wind shifts to the southeast or the southwest, and on occasion, the noise has measured over 60 dB. [Personal Communication, 19 January 2007]

Quite generously under these circumstances, the Davis family continue to support wind energy but believe that wind turbines must be sited further from homes because the noise level and the impact of the noise cannot be accurately predicted. Jane Davis says that:

> *'More needs to be done if wind power is to become a viable alternative source of energy. It is a national issue and the Government ought to be doing more about this if we need lots more wind power.'* [Spalding Today (UK) 21 December 2006]

The Environmental Statement that accompanied the developer's application said that there would be no noise. [Davis J. Personal communication, 19 January 2007]

Meanwhile, Jane Davis says that she and her family are literally ***'fighting for our lives.'*** [Personal communication, 19 January 2007]

52 These are the voices and concerns of people who are despairing. However, with civic spirit, they speak out to alert others to the realities of living near wind turbines. As Bell noted in his 1966 report on noise for the World Health Organization:

> *'Anti-noise campaigns serve a useful purpose in focusing public attention on the matter; they provoke discussion and are often a stimulus to positive control measures.'*

53 According to Dr Dilys Davies, consultant clinical psychologist:

> *'Noise problems can lead to ill health'*, leaving the person *'more easily disturbed by noise in the future ... There is pressure on the heart, your breathing and whole arousal system. Your muscles tense as you wait for the noise, and if you are not careful you get used to being in that state constantly ...'* [Aitch, I. Keep It Down. Telegraph, 2 December 2006]

54 Many of those affected by wind turbine noise believe that the developers and decision-makers of the State have misled them. One explanation might be that the methodology for calculating the disturbance levels created by wind turbines at nearby homes is woefully inadequate, concentrating almost entirely on audible sound levels while dismissing other noise characters with a 'penalty in the

condition' [Planning Approval], which has produced unreliable information. The consequent release of noise pollution on people's homes produces sleep deprivation and other health injury, and the adverse effects are entirely avoidable.

There appears to be a total 'disconnect' between the experiences of those living near wind turbines and those who have a commercial interest.

55 The natural commercial instinct of developers is to maximise development potential from land, thereby leaving the minimum distance between turbines and homes. This presumes reliability and certainty in determining the physical impacts on families. However, such reliability and precision in calculating the effects does not exist, as the wind energy industry itself notes in its professional literature. (See Section 4.0, Acoustics, of this paper.)

56 It is too easy to dismiss the reports of noise disturbances and flicker effects by people living near turbines. Yet these problems emanate from many people in many countries, living in varied topographies, with one thing in common: they all live in close proximity to wind turbines.

57 It is somewhat hypocritical of public officials to decry the despoiling of the environment on a global basis, while ignoring the despoiling of the environment – including noise pollution – on a local level. At what point will officials and government agencies respond to these issues that involve the genuine – and avoidable – suffering of those living near wind farms? **At the least, further investigation into the health effects is warranted, with a minimum buffer zone of 2km between the nearest wind turbine and any dwelling.**

Evaluation of Environmental Shadow Flicker for

"Lambert's East Wind Farm"

R.H. Bolton
March 5, 2007
Rev. 3

Table of Contents

1.0 Introduction

Barbados Light and Power Company Limited proposes to construct a 10 MW wind farm using 11 wind turbines each with a 900 KW rating. The project will be located at Lambert's East in the parish of St. Lucy, Barbados. Each turbine will have a tubular tower of up to 55m height, and three rotor blades with a maximum rotor diameter of 56 m.

Large scale shadow flicker is a new phenomenon, not experienced by people on an "industrial scale", with very large sized shadows moving across their home or through their local views. As a new source of environmental pollution extra care is needed when evaluating the long term consequences.

There are many modern tools to evaluate and predict the effects of shadow sources, well known to the scientific and engineering communities. But these tools must be used correctly and carefully in order to avoid the "garbage in garbage out" syndrome and erroneous conclusions.

2.0 Lambert's East Wind Farm Project

AMEC Earth and Environmental has submitted a comprehensive draft Environmental Impact Statement (EIS) for the wind farm (Ref. 1). AMEC Earth and Environmental is a division of AMEC which also owns AMEC Wind, a developer of wind farms. Immediately, an extra measure of caution is demanded to ensure proper due-diligence analyzing the AMEC EIS report when a probable conflict of interest is involved.

Barbados' Environmental Protection Division of the Ministry of Housing, Lands and Environment does not have legislated standards for shadow flicker, which is a new environmental pollutant.

2.1 Synopsis of Barbados

Barbados is the easternmost and one of the southernmost Caribbean island nations, just 275 miles northeast of Venezuela. It is a small island of 21 x 14 miles yet has a population of 267,00 which gives it one of the highest population densities on earth.

Although an independent democracy it, like Canada and India, remains one of the United Kingdom's Commonwealth countries. Its citizens are noted for friendliness and a high quality of life, ranking third on the UN Development Index, ahead of Italy, Spain and Ireland.

Barbados is subtropical and Atlantic trade winds are normally from the north east.

> Today the Barbados economy is becoming less reliant on sugar and more so on services, particular tourism.

> The combined effect of these factors has led to extensive pressure on the few remaining areas of natural biological diversity. The more recent sources of pressure on the island's biological diversity include the need for housing and the use of land for housing sub-divisions and tourism developments such as hotels, marina and golf courses.
>
> (Ref. 2)

The south is most populated while the north has plantations sprinkled with residential communities.

> The project site is located on agricultural land, at Lamberts East in the northern parish of St. Lucy. The site occupies a ridge at the periphery of an area of relatively flat land, which forms part of the Castle Plantation. Vegetation on the site consists mainly of coarse grass. Sugar cane is grown to the west of the site on the Castle plantation. The seaward (eastward) slope of the site is covered by grass and scrub.
>
> (5.6.1, Ref. 1, *ob sit*)

3. Shadow Flicker Definition

There is no dictionary definition for the shadow flicker phenomenon but it is easy to describe. When the sun, or moon, rises or sets behind an operating wind turbine a shadow of the moving blades will be cast. This shadow may be quite large in extent due to the size of industrial scale turbines and their height, often accentuated by placement on hill tops. Stop to ponder this phenomenon, which is infrequently related in everyday experience. One that comes to mind is a car traveling along a highway near a defoliated forest when the sun is at a low angle. The tree shadows will very quickly pass shadows on the car as it moves by. This is a high frequency shadow flicker, but of a linear type, not corresponding to wind turbine flicker.

3.1 AMEC on Shadow Flicker

There are three primary environmental pollutants associated with large wind turbine farms: aesthetics, noise and shadow flicker. AMEC writes the following:

> Shadow Flicker
> A wind turbine, like other tall structures, can cast a shadow on the neighbouring area when the sun is low in the sky. The movement of the rotor blades can chop the sunlight, causing a flickering (blinking) effect referred to as "shadow flicker".
> The potential flicker was modeled and the results plotted on maps which show the maximum number of hours per year of shadow flicker on a 1 m x 1 m (vertical) house window situated 2 m above the ground and facing north, east, south or west. For those dwellings closest to the wind farm the theoretical maximum amount of shadow flicker could be as much as 80 hours per year, an average of less than 15 minutes per day. The effects diminish with distance. The modeling is very conservative and assumes full sunshine throughout the year (ie no cloudy periods). It does not take into account the following:
> - Periods when the sun is obscured by cloud – no shadow
> - Wind direction – shadow flicker is not an issue when the rotor is pointing in a direction perpendicular to the direction of the sun from the window
> - Turbine operating hours – there is no shadow flicker when a wind turbine is shutdown, as would be the case for low or very high wind, maintenance or repair
> - Shading due to terrain, vegetation, or buildings – these will block the shadow

- Hours when the property is actually used by people (who are awake) and they are situated at a spot where flicker could be an irritant – at other times there is no one to be annoyed by the flicker

Taking into account all of the factors will reduce the period that shadow flicker might be an irritant to at most a few minutes per day. Should shadow flicker be an issue, it can be mitigated by planting trees in specified locations or by pre-programming the turbine to shut down at times when shadow flicker would cause a nuisance.

The effects of shadow flicker are considered to be minor and no significant environmental effects are anticipated.

Although this is a seemingly reasonable definition and description of the effects it falls well short. The shadow impact will be much larger than stated. In rural settings homes are often located on larger parcels and in the fair-weather seasons home owners will frequently use their property outdoors for recreation and work – law mowing, car washing, picnics, relaxing etc. So in these conditions, which are also the sunniest in Barbados, the presence of blade flicker anywhere within a reasonable viewshed of a residence must be considered an environmental nuisance and must be mitigated. Wind turbine blade shadows are not a mere shadow being cast because they will often be moving and creating a highly objectionable nuisance. Also 83 m. high turbines on elevated hill ridges will cast distinct shadows for thousands of feet, well above any vegetative screening. AMEC only predicts shadows for a 1 x 1 meter zone for a dwelling, completely ignoring the shadowing of other areas of the home, outdoor areas and more distant viewsheds.

Furthermore the AMEC discussion fails to include all flicker effects such as night-time flicker conditions as with moon shine. Rural residents experience very dark skies and on moon lit nights the night-scape can be very dramatic and enjoyable to the residents. Blade flicker nuisance from a rising or setting moon will be an environmental detriment and must be evaluated along with sun-shine effects.

Other flicker annoyance may be present as well such as with a picturesque sunset that expands well along the horizon. Brighltly lit from behind, though not casting shadows, the flickering blade movement of turbines on the horizon will likely cause visual disturbance to the viewscape and must be evaluated, particularly when linear strings of turbines are sited causing wide-angle disruptions.

3.2 Benchmarking Shadow Flicker

Manual geometrical computations of shadow effects are straightforward but tedious, so one of the several software analysis tools are used. AMEC doesn't disclose the model it used but it was apparently Wind Pro (Ref. 3). Though biased toward wind farms it seems to allow appropriate input parameters and perform reasonably accurate predictions. However any seasoned engineer quickly learns that modeling software must be very carefully used and verified to engender confidence and error sensitivity. At a minimum some crude benchmark calculations have to be done by conventional means, which will now do.

To calculate blade flicker the propagation distances can easily be checked. The sun is a very distant object and always has the same angular subtense of about 11 mrad (milliradians) to an observer. When looking through turbine blades toward the sun, the size of the visual impact depends on distance between the observer and the turbine. Thus if the observer is very close to the turbine blades the blades will be large in comparison with the sun, as illustrated in Fig. 1 below. As the observer-to-blade distance increases the proportion of the blades covering the sun decreases as shown in Fig.2.

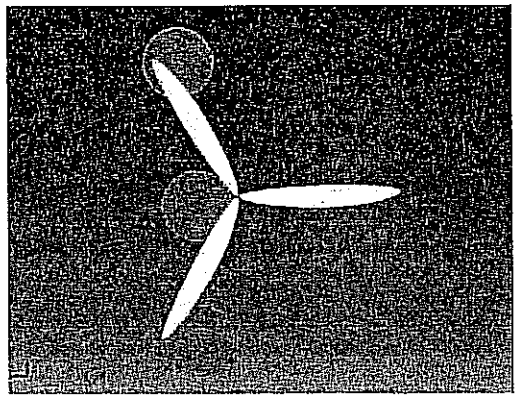


Fig. 1: Observer Close to Blades

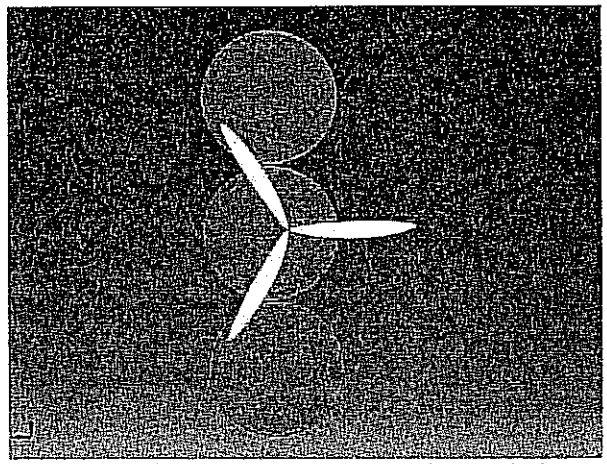


Fig. 2: Observer More Distant from Blades

Using this information some simple distance calculations can be made. For example when the blades just cover the sun they will occupy and angle of 11 mrad. AMEC says it will use turbines the same as, or nearly identical to the Vestas V-52 850kW unit used throughout their EIS analysis. This unit has a 55 m hub height and 56 m rotor diameter.

Using simple geometry the distance the observer would be for the sun to just cover a rotor diameter (56 m) is 56/11 mrad = 5 km. This very long distance can only occur though when the sun is at a low angle over the horizon. Turbines on elevated ridges or plateaus however will cast very long shadows into the adjacent lower lands because of the sun's higher angle. The Lambert's Wind Farm is proposed for a site with elevation of

about 100 m.[1] The east coast is about 1 km away and at sea level. A simple geometric calculation shows the turbine shadow will cast 2 km, well into the sea beyond the coast, with the sun at a 5 degree sun angle[2]. A graphic of the calculation is illustrated in Fig. 3 below.

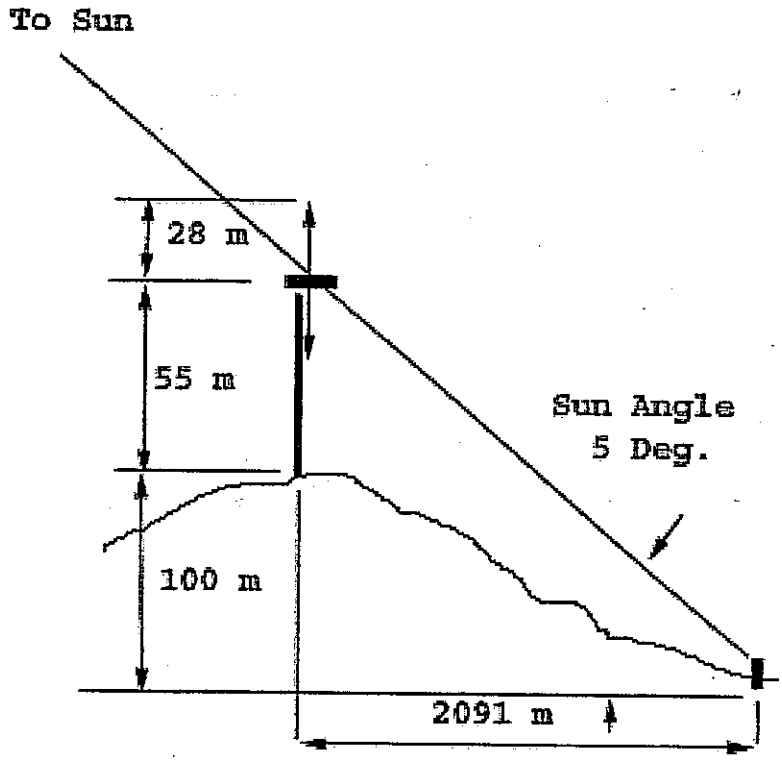


Fig. 3: Shadow Geometry

The 11 flickering turbine shadows will be seen along the cliffs in the evening sunset or moon set. As the sun sets or rises the shadow distance decreases. A table of values as the sun rises is shown in Fig 4 below.

Sun Angle (Deg. Above Horiz)	Shadow Distance m
3 (min)	3492
5	2091
10	1037
15	683
20	503

Fig. 4: Table of Shadow Distances

[1] Source: Google Earth
[2] Generally a 3 degree sun angle is chosen as a minimum starting angle.

The sun moves through the sky at about 15 degrees/hr depending on time of year and latitude. From the table its clear that the shadow impact for this example extends at least 500 m. for over an hour a day. Thus nearby residents and visitors walking, driving or picnicking near the cliffs during the evening will often be impacted, and annoyed by the moving shadows. The relationship of the wind farm to the coast is shown in Fig. 5 below. Note the large number of homes in proximity to the wind farm lying just to the east.

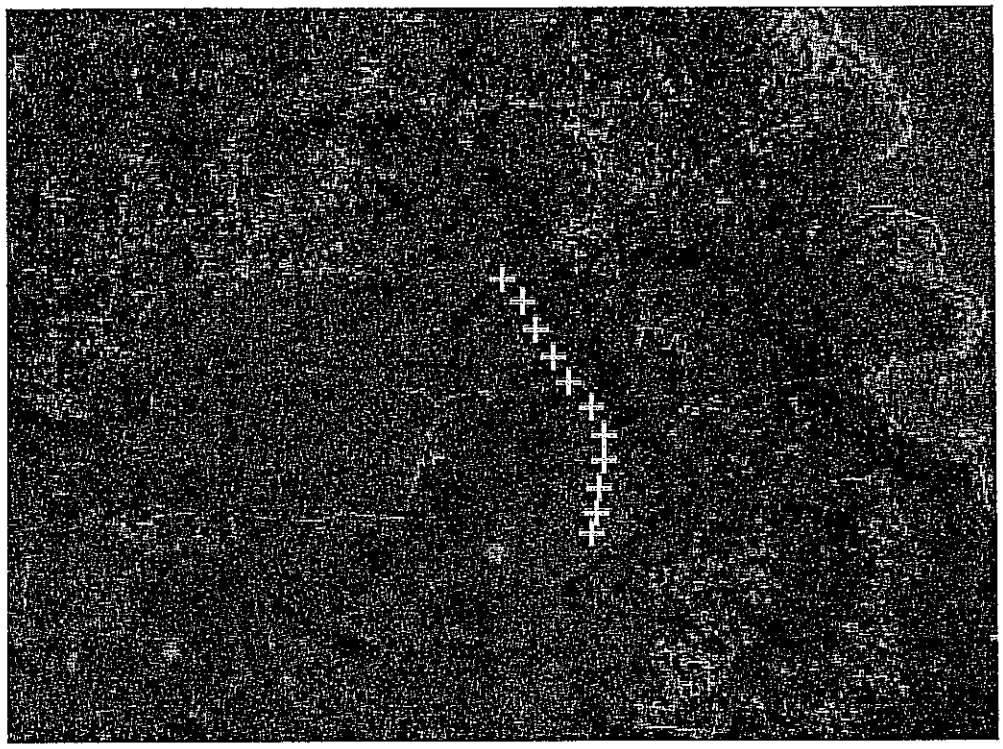


Fig. 5: Lambert's East Wind Farm Relationship to Surrounding Dwellings[3]

3.3 Visual Impact

Receptors – human or animal directly within the shadow flicker cast by a bright sun will be highly affected by the rapid shadow dimming and brightening. This has not been experienced by most people, or animals before and will be a completely new phenomenon.

Residents and passersby (highway traffic) not immediately within the shadow will nevertheless readily observe the shadow flicker because of the unavoidable human attraction to motion and the large area covered. A 56 m diameter shadow is large and will be visible from long distances not in the direct path of the shadow. Human acuity is about 0.3 mrad and a shadow at this limit would be barely visible. But at angles larger than say an outstretched hand (~ 120 mrad) one would expect the shadows on the landscape to be easily distinct. This corresponds by simple geometry to a viewshed distance around the

[3] Source: Google Earth Map and turbine locations from 7.2-1 of Ref 1.

observer of 56/120 mrad = 467 m. Thus a resident, tourist, or motorist would be exposed to shadow flicker up to ~ ½ km in each compass direction from his view. And thus the wind farm will, at times, strongly impact the entire Parish. The shadows are multiplied by 11, since the turbines are aligned north to south, the worst direction for shadow impact in this setting.

A visualization can be constructed using the view assessment photos provided in the DEIS. For example a photo simulation of the turbines is shown in the DEIS Fig. 7-4 with the view taken at location 2 (Ref. 1, Fig 7.2). The distance to the closes turbine from this location is about 800 m., see Fig. 6 below.

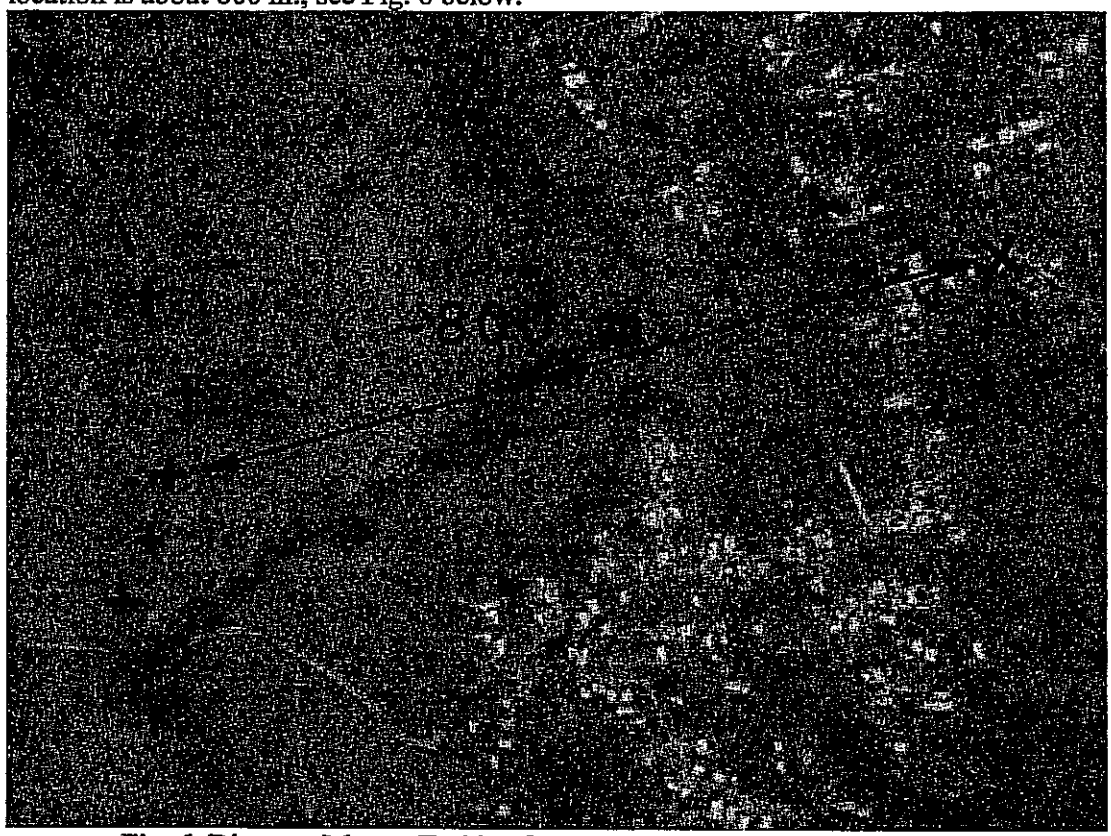


Fig. 6: Distance Map to Turbine from Location 2 (Google Earth photo)

The setting sun can be added to the photo simulation to give a new simulation showing the sun in several positions as it sets near the turbine blades, see Fig. 7 below. The shadow actually covering an observer at location 2 lasts about 15 minutes, but the view of the shadow on the surrounding terrain lasts much longer. Every day of the year the sun moves north or south in its path across the sky and shadowing will frequently occur for periods from adjacent turbines. A similar simulation for Pie Corner, Location 1, is shown in Fig. 8 with the same impact.

Hence the actual impact of this shadowing is far larger than implied in the AMEC analysis and shadow iso-maps. AMEC provides shadow contour maps (Fig's 7-10 to 7-13) that delineate shadow occurrence only on a 1x1 m window area of a residence facing

north, south, east and west. This is an utterly preposterous simplification and not at all representative of the impact of large moving shadows on the landscape or home.

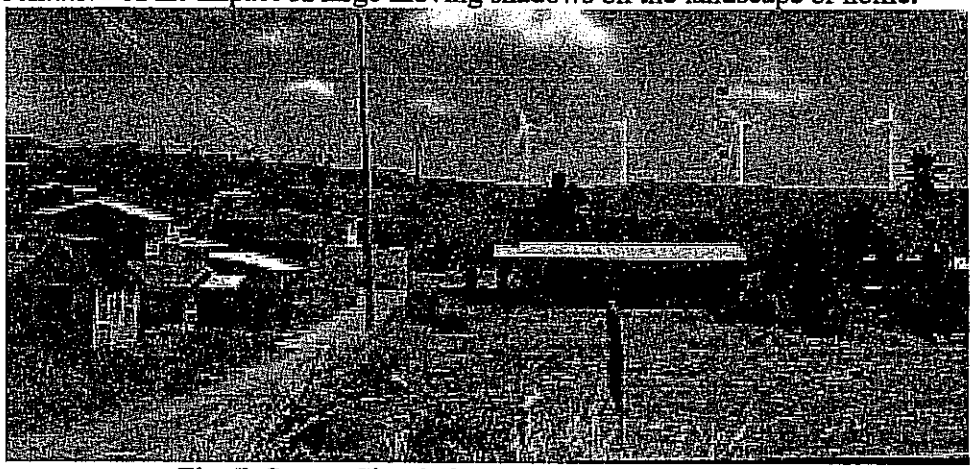


Fig. 7: Sunset Simulation at Location 2, Risk Road

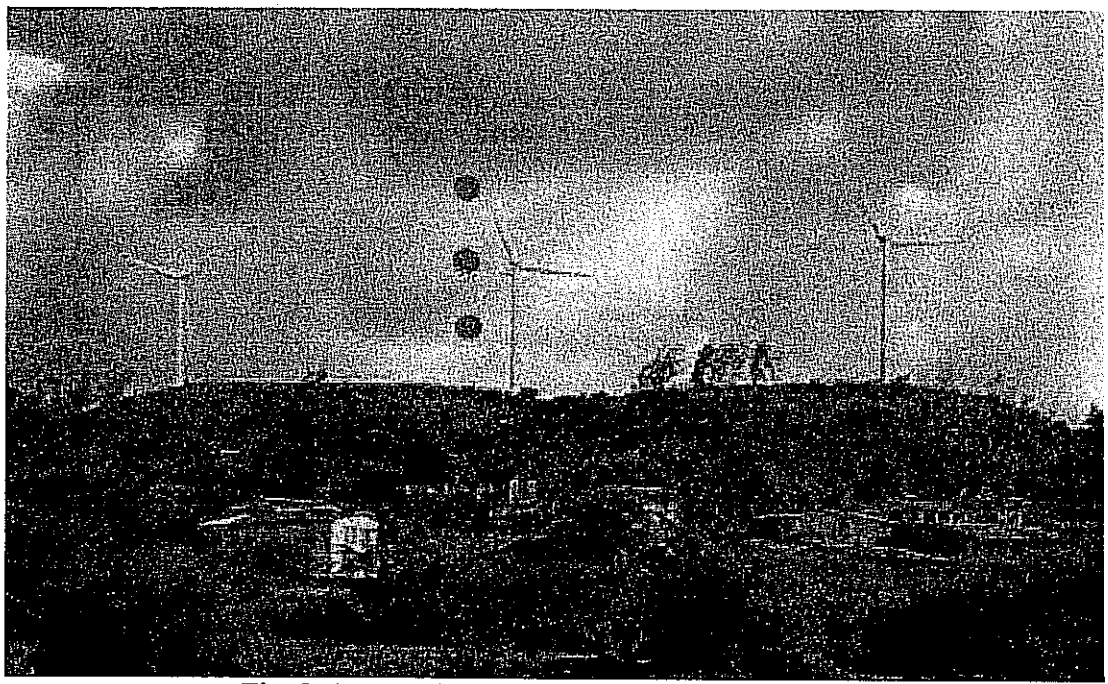


Fig. 8: Sunset Simulation at Location 1, Pie Corner

4.0 Shadow Flicker Assessment Comparisons

Flicker annoyance standards and requirements are not set by any agency throughout the world, apparently because the effect is new and not yet studied. There is however a rule of thumb, derived apparently from a Meridian Energy study based on their experiences with shadow flicker (Ref 4) that says the nearest affected receptors should be no closer than 10 turbine rotor diameters. This reference is sometimes cited by other agencies when

evaluating shadow flicker, see Ref. 4 for example and section 5.4 below. Using this criteria, which is suspicious, the turbine setbacks for the Lambert's Wind Farm would be 10 x 56 = 560 m. As shown above, and discussed below, however this setback would seem to be too generous.

4.1 Michigan, Delphi Inquiry

Some indication of the potential adverse impacts and community resistance comes from a Delphi method study conducted in Michigan (Ref. 6).

A Delphi inquiry is a methodological technique to inform participants in a panel study about issues which they may have had little, or a lot of experience. From the Report:

> Traditionally, a Delphi Inquiry involves a panel of experts. However, our goals included:
> - providing a formal instrument to gather and analyze concerns about wind turbine siting issues from as many stakeholders as possible statewide,
> - analyzing and building consensus among stakeholders, public policy makers, and concerned citizens on how to best address wind turbine siting issues, and
> - supplementing the pending state guidelines and providing local government policy makers with information to help develop zoning ordinances.

The Process follows this outline:

> Delphi Process:
> Present basic information
> Open dialog
> Develop survey questions
> Answer survey questions
> Analyze results
> Repeat
> Goal: develop a consensus of
> INFORMED opinions

The panelists in this portion of the study and expertise are listed below. After the presentation and survey these results are posted:

> Participants' provided a few comments on this issue.
> - Comparison of flicker rates was informative.
> - The video was the best example of the experience of shadow flicker.
> - I don't see flicker as a problem.
> - I wouldn't want to live with the nuisance anymore than I enjoy driving when the low sunlight shining through the trees on the roadside causes a similar flicker on the side windows. It is unpleasant and distracting.
> - Even though you dismiss the potential for seizures, the potential for flicker to invade a person's living space could cause stress and headaches.
>
> Survey Conclusions
> Participants demonstrated significant agreement that Michigan's Wind Turbine Siting Guideline address the issue of shadow flicker. However, there is no significant agreement on how to address this issue. The closest participants came to agreeing was recommending that permitting agencies require wind developers to provide a map of projected shadows, and to make this map available to the public.

Table 13. Participant Affiliations

Stakeholder Affiliation	Number[1]	Percent
Local zoning board member	2	25%
Planning Commissioner	2	25%
Farm or land owner	6	75%
Not identified	1	12%

[1]Participants were permitted to identify multiple affiliations.

Table 14. Prior Knowledge of Wind Energy

Experience Level	Number	Percent
Professional with more than 5 years experience	0	0%
Professional with less than 5 years experience	0	0%
College degree	0	0%
Extensive Self Education	5	63%
Read a few articles	2	25%
No experience	1	12%

Table 15. Prior Knowledge of Flicker Issues

Experience Level	Number[1]	Percent
Professional with more than 5 years exp.	1	12%
Professional with less than 5 years exp.	0	0%
College degree	0	0%
Extensive Self Education	3	38%
Read a few articles	2	25%
No experience	2	25%

Table 16. First Flicker Survey Results

	Question	Selection	# Resp	%
1	Should Michigan's Wind Turbine Siting Guidelines address the issue of shadow flicker?	Yes	7	88%
		No	1	12%
2	Should turbines be constructed ONLY where they can cast NO shadow on a residence, or should turbine owners be allowed the option of constructing turbines where they might need to be turned off to prevent shadow flicker from negatively affecting a neighboring residence?	No Shadow Only	2	25%
		Option of turning off turbine	4	50%
		No Answer	2	25%
3	What is the maximum amount of time per day that flicker should be allowed to affect a residence?	0 min	3	38%
		15 min	1	12%
		No Answer	4	50%
4	What is the maximum number of consecutive days that flicker should be allowed to affect a residence?	1 day	1	12%
		No Answer	7	88%
5	What is the maximum number of days per year that flicker should be allowed to affect a residence?	2 days	1	12%
		No Answer	7	88%
6	Should permitting agencies require a map (or model) of all potential turbine shadows as part of the permitting process?	Yes	5	63%
		No Answer	3	37%

It is evident from the Delphi study that caution and concern should be exercised. Half the participants had little or no flicker knowledge with ¾ being landowners. Though allowable flicker was not determinable, fully 75% believed that flicker was a great enough nuisance to require no flicker exposure, either due to siting requirements or shutting down of the turbine in flicker conditions.

4.2 Massachusetts

Some guidance comes from the U.S. state of Massachusetts

Model Amendment to a Zoning Ordinance or By-law: Allowing Wind Facilities by Special Permit, Massachusetts Division of Energy Resources , Massachusetts Executive Office of Environmental Affairs:

> 6.2 Shadow/Flicker
> Wind facilities shall be **sited in a manner that minimizes shadowing or flicker impacts.** The applicant has the burden of proving that this effect does not have significant adverse impact on neighboring or adjacent uses through either siting or mitigation.
>
> (emphasis added)

4.3 Sweden

A comprehensive Swedish study (Ref. 7) undertook a detailed public reaction to wind farms there, which were generally favorably received by the community.

> Abstract
> The aim of this project has been to **get more knowledge about the impact of noise, shadows and on the view of the landscape from wind turbines.** Further to be able to increase the reliability and relevance of the methods used to calculate and evaluate nuisances from wind turbines in applications for windpower development. We have also tried to find other factors that can play a role for the evaluation of wind turbines, if they will be considered as a nuisance or not. The research has focused on a critical review of the methods and regulations that are used in Sweden and other countries, and case studies to find out how people living neighbors with wind turbines will be affected by noise, rotating shadows, visual intrusion and other factors. This report includes the case studies of wind turbine areas at Gotland.
>
> Shadows.
> Although none of the respondents in Klintehamn according to calculations of shadows on the facade, in the worst case, has more than 30 hours/year and a maximum of 30 minutes/day **24 % are rather or much annoyed by shadows.** On Näsudden 17 % of the respondents had according to calculations more than 30 hours/year (facade, worst case) but only 4 % are rather or much annoyed by shadows. In När nobody was annoyed by shadows.
>
> **One possible explanation that so many in Klintehamn are annoyed by shadows, could be that most of the respondents live east south east of the turbines, and will get shadow flicker in the evenings during the period April to September (90 % of the respondents), that is when the shadows are most intensive and most people are at home.** On Näsudden half of the respondents get shadows in the evening, while the rest get shadows in the morning or in the middle of the day. Respondents that are not annoyed by shadows although they have a large shadow impact, these appear in the morning or during winter. Respondents that are annoyed although the shadow impact is small, the shadows appear in the evening. In När no

respondent gets shadows during summer evenings. **The conclusion from this is that it is more important at what time of the day and the year shadows have an impact, than the total calculated time in hours a year of shadow impact.**

On Näsudden there is no connection between calculated duration of shadow impact and annoyance. There is however a moderate-strong connection between the distance to the closest turbine and annoyance from shadows. This could indicate that the geometrical model for shadow impact calculation is not accurate when there are several turbines at large distances from a building, since the shadow impact from distant turbines are included, although the shadows, according to a recent study, have a maximum extension of approximately 1 km (Freund 2002).

Since a new rule about calculation of shadow impact, which states that the calculation should be made for the building lot (garden), instead of window, has been introduced by the Swedish building authority (Boverket), the time for shadow impact in Klintehamn has been calculated for both lot and façade. There is a statistically significant *moderate* connection between shadow *minutes/day on facade* and annoyance.

(emphasis added)

4.4 United Kingdom

From a "Planning for Renewable Energy" guide (Ref. 8):

76. Shadow flicker can be mitigated by siting wind turbines at sufficient distance from residences likely to be affected. **Flicker effects have been proven to occur only within ten rotor diameters of a turbine. Therefore if the turbine has 80m diameter blades, the potential shadow flicker effect could be felt up to 800m from a turbine.**

5. 0 Conclusion

AMEC claims "The effects of shadow flicker are considered to be minor and no significant environmental effects are anticipated." This is simply not shown by any credible evidence. It is well documented that shadow flicker is a serious environmental pollutant that can be extremely annoying. There is limited guidance about appropriate setbacks that should be required so prudence suggests a conservative setback criteria be instituted to prevent undue impact. Once the turbines are sited the only recourse is to actually turn-off the turbines during flicker events. AMEC's suggestion that vegetation can be erected to mask shadows is completely ludicrous. In sunny climates the flicker annoyance extends well beyond a window in a home and can blight the entire viewshed for over an hour a day, every day.

The AMEC study is extremely naive and though an apparently sophisticated analysis was performed it was clearly without a competent or objective understanding of the problem and use of the modeling software. An objective and competent evaluation by a third party not associated with AMEC or wind industry should be contracted for this evaluation to be unbiased and fair.

When combined with the noise pollution and visual degradation that many residents will experience, it is clear that wind farm turbine siting setbacks should probably be increased to a minimum of 1 km from any residence. See the discussion in section 4.4 of

"Evaluation of Environmental Noise Analysis for 'Lambert's East Wind Farm' " (Ref. 9). Failure may have adverse effects on future community development and prospects for increased or even contemporary tourism. Certainly the current residents will be impacted and will probably be very unhappy.

###

Richard H. Bolton , CV in Appendix 1

References

1. *Environmental Impact Assessment, The Barbados Light & Power Company, Ltd, Lamberts East Wind Farm Generating Station, Draft,* AMEC Earth & Environmental, TV 61036, Februrary 2007

2. *Barbados Second National Report on the Implementation of the Convention on Biological Diversity*, March 2002

3. *WindPRO* , EMD International Co. Denmark, version 2.4.0.67

4. *Project West Wind: Shadow flicker assessment report*, Meridian Energy, June 22, 2005

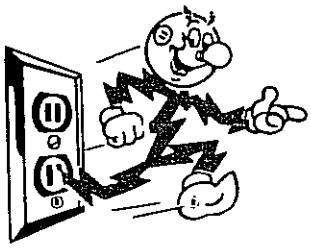
5. *Report for Decision on Scout Moor wind facility*, Rochdale Metropolitan Council , G. Dickman,Regulatory Committee 16th December 2003

6. *Delphi Inquiries into Wind Turbine Siting Issues*, Daniel J. Alberts, Final Report Lawrence Technological University, June 13, 2005

7. *Wind Power Environmental Impact of Wind Power Station Siting,* (VINDKRAFTENS MILJÖPÅVERKAN FALLSTUDIE AV VINDKRAFTVERK I BOENDEMILJÖ), A. Widing *et al*, Centrum för Vindkraftsinformation Institutionen för naturvetenskap och teknik, Gotland University, Sweden, 2004

8. *Planning for Renewable Energy, A Companion Guide to PPS22*, Office of Deputy Prime Minsiter, Queen's Printer and Controller of Her Majesty's Stationery Office, 2004

9. *Evaluation of Environmental Noise Analysis for "Lambert's East Wind Farm"*, R. Bolton, Environmental Compliance Alliance, Feb 16, 2007



THE BARBADOS
LIGHT & POWER
COMPANY LIMITED

P.O. BOX 142
GARRISON HILL, ST. MICHAEL, BARBADOS, W.I.

PHONE: (246) 436 - 1800
FAX: NO: (246) 429 - 6000

29 August 2007

Mr Mark Cummins
Chief Town Planner
Town and Country Development Planning Office
Block C
Garrison
ST. MICHAEL BB 14038

Dear Mr. Cummins

Re: Application 3262/11/04C – Construction of a Wind Driven Electrical Generating Station at Lamberts East, Lamberts Plantation, St. Lucy

Please find enclosed a response prepared by our environmental consultants, AMEC Earth & Environmental, to your letter dated 19 July 2007.

Yours faithfully,
THE BARBADOS LIGHT & POWER COMPANY LIMITED

Hallam Edwards
Senior Manager Generation

RB:mk

Enc.

August 17, 2007

TV61036

The Barbados Light and Power Company Limited
Garrison Hill,
St Michael
Barbados

Attention: Mr. Roger Blackman

Dear Mr. Blackman,

RE: Comments on: Lamberts Windfarm - Letter from TCDPO

I am pleased to provide you with our response to the submission provided by the Josey Hill Residents Association: *"A critique of Environmental Impact Assessment for The Barbados Light & Power Company Limited Lamberts East Wind Farm Generating Station".*

We have reviewed concerns of the residents to determine if the information presented by residents changes the conclusions of the environmental assessment study. The following is our review of the comments in the order presented:

Noise

AMEC agrees with the statement that *"The WHO recommends that 45dBA should be the limit for night time noise"* and chose that as the basis for evaluating acceptable noise levels.

Comments are made on the potential health effects of noise from wind turbines. This was addressed in the environmental assessment report. The environmental assessment compared predicted sound levels with levels set by WHO which considers health effects in its establishment of acceptable standards.

Accidents and Malfunctions

Information is provided on a range of accidents. The fatalities and injuries reported were largely of project personnel in industrial accidents which are preventable.

Accidents involving the public were mainly traffic accidents due to distracted drivers or road accidents during equipment delivery. None of these are unique to the operation of windfarms. The AMEC report made recommendations for equipment delivery overnight including road closures.

Additional examples of accidents involving the public include a low flying aircraft, a parachutist, an injury from falling ice and a fall from a tower. Comments were sought from the Civil Aviation Office during the completion of the EIA to cover air traffic; falling ice was not considered applicable for Barbados and falls from towers can be prevented by excluding public entry.

AMEC Earth & Environmental,
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Fax (905) 568-1686

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The summary of accidents does not change the conclusions of the environmental assessment report that "The wind industry has an excellent safety record".

Project Proposal

Comments are made on the estimated output and costs stated in the EIA. The information provided in the EIA was based on the engineering studies completed and it is not material to the conclusion of the environmental effects of the project.

Selected Project Standards and Guidelines

The submission does not agree with the statement in the EIA report that higher wind speeds increase background noise. The submission assumes that the EIA statement refers to induced noise from vegetation.

Figure 2-1 of the EIA report includes a graph showing the increase in background noise with increased wind speed. The graph has been prepared by the Government of Ontario and is included in the document *"Interpretation for Applying MOE NPC Technical Publications to Wind Turbine Generators"*. That reference document is provided in its entirety in (Appendix B) of the EIA and is used as the basis of issuing environmental approvals for noise emissions from wind turbines.

Low Frequency Sound

The submission refers to reports on low frequency sound by: Dr. Amanda Harry, Dr. Bridget Osborne and Dr. Nina Pierpoint. The EIA already considered these reports.

An additional article has been supplied (authors AlvesPeriera and Branco) that suggests infrasound occurs from a wide range of sources, but no data has been provided to put it into context.

The submission takes exception to the suggestion in the EIA report that noise monitoring can be completed following installation. Monitoring is almost always a requirement of regulatory agencies as a means verifying that the environmental performance as predicted in the EIA and approved by the regulatory agency has been met.

Shadow Flicker

Shadow flicker was covered in the EIA report and comments have been provided on behalf of the Josey Hill residents by R. Bolton. AMEC provides a review of Mr. Bolton's comments as follows:

- The Table of Contents does not match the content of the paper.
- The author, Mr. R. Bolton, states on p.3 "Large scale shadow flicker is a new phenomenon, not experienced by people on an "industrial scale", with very large sized shadows moving across their home or through their local views." This is not correct.

Vehicles passing across a bridge can produce the same (actually larger) scale of shadows passing in front of, say, the window of a house aligned with the vehicles and the sun (or moon). There are many bridges with nearby communities in the world.

- Mr. Bolton perhaps suggests on p.3 that the AMEC analysis of shadow flicker suffers from the "garbage in, garbage out syndrome". He does not prove this.

- Mr. Bolton states on p.3 that "...shadow flicker...is a new environmental pollutant." The reviewer would be pleased to receive proof of this.

- Mr. Bolton states on p.5 "AMEC doesn't disclose the model it used but it was apparently Wind Pro (Ref. 3)." The software used to calculate shadow flicker results was "WindFarm". Information on WindFarm can be found at www.ReSoft.co.uk

- Mr. Bolton states on p.5 "Also 83 m high turbines on elevated hill ridges will cast distinct shadows for thousands of feet, well above any vegetative screening", and later in the Conclusions on p.14) "AMEC's suggestion that vegetation can be erected to mask shadows is completely ludicrous". These statements refer to a statement in the AMEC Report on p.5 that proposes to mitigate shadow flicker effects "by planting trees in specified locations". It appears that Mr. Bolton believes that the mitigation proposed by AMEC is to plant sufficient vegetation to prevent any shadows at all from the wind turbines. This is not the case; AMEC proposes to plant vegetation (trees, shrubs) in strategic locations (generally in close proximity to the sensitive locations) in order to prevent shadows where they might be a nuisance.

- Mr. Bolton states on p.5 "Furthermore the AMEC discussion fails to include all flicker effects such as night-time flicker conditions as with moon shine". Moon shine, which, of course, is sunlight reflected from the moon's surface is much less intense than direct sunlight. As a consequence, moonlight shadows are quite limited in intensity and would not be expected to have the same impact as shadows cast by the sun.

- Mr. Bolton states on p.5 "Though biased toward wind farms it [the software] seems to allow appropriate input parameters and perform reasonably accurate predictions". It is not clear to the reviewer how a model that produces accurate predictions can be biased.

- On p.6 Mr. Bolton states "... the size of the visual impact depends on distance between the observer and the turbine". This statement is correct in some sense because Mr. Bolton does not define the "size of the visual impact". However it appears to be inconsistent in the context of the discussion in the paper that he provides on shadow flicker. For all practical purposes, on the surface of the earth sunlight is a collimated beam. The amount of solar energy intercepted by an obstacle and prevented from reaching the observer's eye is independent of the distance to the obstacle. (Note though, that there are mitigating effects such as refraction of the light around the obstacle (turbine blade in this case), and the contribution of diffuse light which will scatter into the path between the blade and the observer.) In addition, a discussion of what distance the observer should be at in order to see the turbine blades occluding the sun's disk is given as a precursor to calculating the shadow length. These two subjects are unrelated. The

shadow length has nothing to do with the spherical angle within which the observer sees the sun.

- Mr. Bolton states on p.7 "A simple geometric calculation shows the turbine shadow will cast 2 km, ..." His calculations show the distance from the obstacle to the projection of the line that comes from the sun to the tip of the obstacle and eventually to the earth's surface - this is not necessarily the length of the shadow. The shadow is the region in the field of the sunlight with a lower radiant intensity than surroundings. The human eye detects this difference and perceives the less radiant region as shadow. There is a threshold difference that can be sensed by the human eye. It is believed (as stated in the research article cited by Mr. Bolton) that shadows generated in sunlight can be detected no more than 1 km from the obstacle. Therefore, it is very unlikely that there will be shadows "well into the sea beyond the coast" (p.7) and consequently "over one hour impact" of flickering shadows on the coastal region, as stated by Mr. Bolton.

- Mr. Bolton states on p.8 "A 56 m diameter shadow is large ...", "... human acuity is about 0.3 mrad ...but at larger angles ... (~120 mrad) ... one would expect the shadows on the landscape to be easily distinct. This corresponds to ... 56/120 mrad = 467 m". The author seems to state that the obstacle causing the shadow is the full 56 m diameter of the rotor disk. This is clearly not the case. If the full 56 m diameter disk were to occlude the sun, there would be no flicker. It is the individual turbine blades that generate the flicker. Using a typical blade chord dimension (2 m) for the size of turbine under consideration, Mr. Bolton's calculation results in 2/120 mrad = 17 m, not 467 m.

- Mr. Bolton states on p.14 "The AMEC study is extremely naive and though an apparently sophisticated analysis was performed it was clearly without a competent or objective understanding of the problem and use of the modeling software. An objective and competent evaluation by a third party not associated with AMEC or wind industry should be contracted for this evaluation to be unbiased and fair". Given Mr. Bolton's treatment of the subject in this paper, it is not clear whether he is competent with regard to the determination of AMEC's competency. The reviewer invites Mr. Bolton to provide convincing proof of this lack of competency.

Lightning

Lightning strikes were covered in the EIA report.

Hurricanes

Wind turbines will lock out at high wind speeds to prevent damage.

Geology

Comments are made on the presence of caves and infer that these cause increased noise as traffic travels from Pie Corner to Date Tree Hill. This may be due to the added engine noise from vehicles as they climb the steep gradient, and would therefore not be relevant for wind turbines.

Health

The comments refer to other forms of clean energy including photovoltaic cells and nuclear plants that are being considered elsewhere and that BLPC should consider other alternatives.

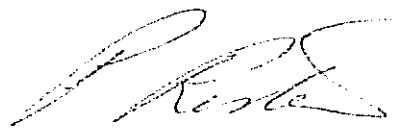
Technology selection for power generation projects is based on detailed engineering studies that consider such factors as reliability, affordability and practicality. This is not a part of the scope of the EIA.

Closure

The comments provided by the residents of Josey Hill have been reviewed and do not change the conclusions of the AMEC report.

If you have any questions on the commentary provided, please call.

Yours truly,
AMEC Earth & Environmental Limited,
a division of AMEC Americas Limited



Peter Rostern, M.B.A., P.Eng.
Principal Environmental Engineer

c.c. Mr. Ian Shepanik

APPENDIX B

LETTER FROM TCDPO , JULY 24, 2008 AND RESPONSE FROM BLPC OCTOBER 13, 2008

Town and Country Development Planning Office
Block C, Garrison, St. Michael. BB14038. Barbados.
Tel. No. (246) 467-3000
Fax No. (246) 430-9392
E-mail: contact@townplanning.gov.bb

Our Ref.: 3262/11/04C **Date: July 24, 2008**

The Barbados Light & Power Co. Ltd
P.O. Box 142
Garrison Hill
ST. MICHAEL

Attn.: Mr. Hallam Edwards

Dear Sir,

Application No. 3262/11/04C –
Construction of a Wind Driven Electrical Station at
Lamberts, East, Lamberts Plantation, St. Lucy

Reference is made to your letter dated June 12, 2008 regarding the above captioned.

The Environmental Statement (ES) submitted in support of this application has been reviewed and found to be deficient in the following areas: -

1. Methodology of noise monitoring/sampling – this should include, but not limited to:
   - information on the type of sound level meter used to take measurements;
   - information on the specific locations of the receptor/sampling points from proposed project site;
   - activities/conditions that might have affected noise levels at sampling locations (e.g. construction work in the area);
   - meteorological conditions at sampling sites.
2. Methodology/rationale for the 350m separation distance and the additional 50m from roads and footpaths. From what point is the 350m measured?
3. What constitutes daytime house during which construction is proposed to take place?
4. Details and specifications of the turbines proposed to be used.
   - Is the 45d BA turbine noise quoted in the ES applicable to one turbine or is it the cumulative found generated by the proposed 11 turbines?
5. Further details on the modelling used to predict Shadow Flicker. (European standards quote maximum 30 hours per year or 30 minutes per day).

6. Dust control measures should be included in mitigation of impacts for construction equipment operation.

7. The methodology for the surveys of bat populations should be described and further information on if the field survey was designed to take into account resident knowledge and experience.

8. A post-construction Environmental Management Plan should be submitted.

9. Submission of a Geo-technical survey to establish the stability of the area for the proposed development.

The information requested above should be submitted as an addendum to the ES at your earliest convenience.

On completion of the review of the addendum, if satisfactory, you will be advised of the details for advertising of the public meeting.

Your attention to the foregoing will oblige.

Yours sincerely,

P. SMITH
For Chief Town Planner

PS/mjf

THE BARBADOS
LIGHT & POWER
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13 October 2008

Mr. Mark Cummins
Chief Town Planner
Town and Country Development Planning Office
Block C
Garrison
ST. MICHAEL BB 14038

Dear Mr. Cummins

Re: Application 3262/11/04C – Construction of a Wind Driven Electrical Generating Station at Lamberts East, Lamberts Plantation, St. Lucy

Further to your letter dated July 24, 2008, Ref.: 3262/11/04C, please find enclosed a revised response prepared by our environmental consultants, AMEC Earth & Environmental.

Yours faithfully,
THE BARBADOS LIGHT & POWER COMPANY LIMITED

Arthur Lewis
Senior Manager Generation (Ag.)

RB:mk

Enc.

cc: Managing Director
Chief Operating Officer
Senior Planning Engineer – R Blackman
Trainee Generation Engineer – C Gill

October 9, 2008

TV 61036

The Barbados Light & Power Co. Ltd.
P.O. Box 142
Garrison Hill
St. Michael

Attention: Mr. Hallam Edwards

Dear Mr. Edwards:

Re: Application No. 3262/11/04C
Construction of a Wind Driven Electrical Station at Lamberts, East, Lamberts Plantation, St. Lucy

Thank you for forwarding comments requesting additional clarification on our environmental assessment report for the above site. I have repeated the comments and provide responses in italicised fonts below.

1. Methodology of noise monitoring/sampling – this should include, but not limited to:

   - Information on the type of sound level meter used to take measurements;
   - Information on the specific locations of the receptor/sampling points from proposed project site;
   - Activities/conditions that might have affected noise levels at sampling locations (e.g. construction work in the area);
   - Meteorological conditions at sampling sites.

Response:

   - *The sound measurements were performed using a Quest Technologies M-27 noise logging dosimeter. Prior to and after use, a calibration check was performed using a sound level calibrator.*

   - *All of the locations were selected to represent the closest residences to the windfarm around the perimeter of the site. Specific locations where the noise measurements were taken are described in Section 5.2.1 and shown on Figure 5.2 of the report. The noise levels provided background information on the existing environment. The noise assessment of the windfarm however used the WHO guideline of 45dBA as a reference for acceptable overnight noise levels at the closest residences.*

AMEC Earth & Environmental,
a division of AMEC Americas Limited
160 Traders Blvd. East, Suite 110
Mississauga, Ontario
Canada L4Z 3K7
Tel (905) 568-2929
Fax (905) 568-1686

www.amec.com

- *The only location where noise levels would be influenced by construction would be L2 at Date Tree where construction of a house was occurring and could have influenced the daytime noise levels. However, when determining the existing ambient noise levels it is the night-time levels that are the lowest levels which need to be considered. At that location the lowest noise level (L_{EQ}) attained at night was in the 55dBA range which is higher than the predicted noise levels from the wind farm at that location.*

- *The following table presents the meteorological conditions during the noise monitoring.*

Location : Caribbean Institute for Meteorology & Hydrology, Husbands, St. James

Defined Test Periods (Section 5.2.1 EIA BLPC Lamberts East Wind Farm)	Year	Month	Day	Hour	Temp (°C)	RH (%)	Wndspd (knots)	Wnddir (°)	Rnfl (mm)
	2006	5	18	8	28.6	75	11.0	9	0.0
	2006	5	18	11	31.0	64	14.0	13	0.0
	2006	5	18	14	31.0	64	15.0	15	0.0
Lamberts Plantation -	2006	5	19	8	28.6	72	12.0	13	0.0
14:00 May 18 to 13:15 May 19	2006	5	19	11	31.5	51	15.0	14	0.0
	2006	5	19	14	31.6	54	15.0	15	0.0
	2006	5	20	8	29.0	71	12.0	12	0.0
	2006	5	21	8	29.0	68	12.0	8	0.0
Date Tree Hill -	2006	5	22	8	28.5	73	11.0	12	0.0
14:15 May 21 to 12:40 May 22	2006	5	22	11	31.2	57	16.0	12	0.0
	2006	5	22	14	31.2	60	14.0	13	0.0
	2006	5	23	8	28.0	74	13.0	11	0.0
	2006	5	23	11	31.1	54	15.0	15	0.0
	2006	5	23	14	31.0	57	16.0	10	0.0
SDA Church, Cave Hill -	2006	5	24	8	28.6	67	12.0	10	0.0
14:45 May 23 to 13:00 May 24	2006	5	24	11	31.1	57	12.0	12	0.0
	2006	5	24	14	31.0	52	12.0	12	0.0
	2006	5	25	8	28.5	71	12.0	12	-
	2006	5	25	11	30.5	62	12.0	14	-
	2006	5	25	14	31.0	57	12.0	13	-
Josey Hill -	2006	5	26	8	26.0	88	8.0	4	-
13:00 May 25 to 09:40 May 26	2006	5	26	11	29.0	71	9.0	6	-
	2006	5	26	14	29.0	66	10.0	12	-

2. Methodology/rationale for the 350m separation distance and the additional 50m from roads and footpaths. From what point is the 350m measured?

Response:

The 350 metres separation distance from the closest residence was one of the guidelines used during the site screening stage to select acceptable sites. This is an industry guideline based on seven rotor diameters, which is normally adequate to mitigate noise effects and reduce shadow flicker. The actual effects are then predicted based on the turbine specifications and computer modelling over a range of wind velocities and refinements are made if necessary. The separation is measured from the base of the tower. The 50 metre separation from roads and footpaths is a reasonable setback around the tower to allow for maintenance access and equipment laydown.

3. What constitutes daytime hours during which construction is proposed to take place?

Response:

Construction will occur within the hours of 7 am to 7pm. As in any construction project, there may be a need to extend the working hours during special circumstances such as major concrete pours.

4. Details and specifications of the turbines proposed to be used.

   - Is the 45d BA turbine noise quoted in the ES applicable to one turbine or is it the cumulative found generated by the proposed 11 turbines?

Response:

The specific turbines to be used have not been purchased as selection will follow a competitive tendering process once the project has been approved. The Environmental Impact Assessment report was based on the installation of Vestas V52-850kW turbines. The Vestas V52-850kW turbine is typical of the size and type of wind turbine that will be installed. Appendix D provides information on the Vestas V52-850kW turbine

The noise assessment was based on all 11 turbines operating simultaneously.

5. Further details on the modelling used to predict Shadow Flicker. (European standards quote maximum 30 hours per year or 30 minutes per day).

Response:

The software used to calculate shadow flicker results was "WindFarm". Information on WindFarm can be found at www.ReSoft.co.uk. As recommended in the Environmental Impact Assessment Report, the effects of shadow flicker can be mitigated by selectively

preprogramming the turbines to shut down during the brief periods when the sun is low on the horizon and has the potential to cause shadow flicker.

6. Dust control measures should be included in mitigation of impacts for construction equipment operation.

Response:

Dust control measures are covered in Section 7.1.3 of the Environmental Impact Report and also in more detail in the Environmental Management Plan for Construction as contained in Appendix C. The contractor will be required to adhere to the mitigation methods as specified in the Environmental Management Plan for Construction.

7. The methodology for the surveys of bat populations should be described and further information on if the field survey was designed to take into account resident knowledge and experience. A post-construction Environmental Management Plan should be submitted.

Response:

AMEC's biologist consulted with Mr. Wayne Burke of the Graeme Hall National Park regarding bird and bat populations. Significant published information was available regarding the local bird populations for the Lamberts area, but there was no source of information on resident bat populations other than anecdotal. In the absence of records for bat populations the AMEC biologist completed field surveys during daytime hours of potential habitat for bats in the area of the Lamberts site. As the wind farm site has little in the way of stands of trees which would provide habitat, the survey extended to gullies in the area. There were no significant areas for bat hibernacula found. In addition to the habitat survey, field visits were conducted during evening hours to determine if there were any sightings of bats. No bats were observed during the daytime or evening field visits suggesting that there was no large resident population. .

8. A post-construction Environmental Management Plan should be submitted.

Response:

An Environmental Management Plan for the operations phase has been included with the environmental report in Appendix E.

9. Submission of a Geo-technical survey to establish the stability of the area for the proposed development.

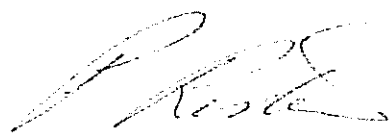
Response:

It is not usual to complete geotechnical studies as part of the environmental assessment. The geotechnical study will be completed during the site engineering design, as the testing should

be done at the precise location of each turbine. The design loads will be specific to the model of turbine selected and will be specified by the turbine manufacturer. If there are issues of instability, these will be addressed either via the footing design or by moving the individual turbines on the site.

I trust that this responds to the information request. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,
AMEC Earth & Environmental,
a division of AMEC Americas Limited



Peter Rostern, P.Eng.
Principal Environmental Engineer

APPENDIX C

LETTER FROM TCDPO , MAY 29, 2009 AND RESPONSE FROM AMEC JULY 3, 2009

Town & Country Development Planning Office
BLOCK C, GARRISON
ST. MICHAEL
BARBADOS

Tel. No. (246) 467-3000
Fax No. (246) 430-9392
E-mail: contact.townplanning@gov.bb

Ref. No:

Date: 2009-0

FACSIMILE TRANSMISSION FORM

TO: Roger Blackmoore

ADDRESS: B h a Towers

FAX NO. OF RECIPIENT: 425-9255.

SUBJECT: Application 3260/1 for - Continued Proposed Demolish of Bake at Lauriston

FROM: Margaine Stuart Chief Town Planner

NO. OF PAGES (including cover) 2

MESSAGE:

TIME:

Public Sector Reform
Making Barbados Work Better

MEMORANDUM

FROM: **DIRECTOR**
ENVIRONMENTAL PROTECTION DEPARTMENT

TO: **Chief Town Planner**
Town and Country Development Planning Office

Attention: Marjorie Stuart-Griffith

REF#: **20/T23** **DATE: 29 May 2009**

Subject: **Re: Application No. 3262/11/04C – Construction of Wind Driven Generating Station at Lambert's Plantation, St. Lucy**

1. The Environmental Protection Department (EPD) has reviewed the response from Barbados Light & Power Co. Ltd (BL&P) regarding clarification of the EIA report. It should be noted that some of the comments forwarded to BL&P by the Town and Country Development Planning Office (Ref: 3262/11/04C dated July 24, 2008) differed to the comments submitted by the EPD (Ref: 20/T23 dated May 27, 2008). As a result some of the responses were insufficient and require further clarification.

2. The following areas require further attention:

i. **Methodology of Noise Monitoring**
   - Noise dosimeters are ideal for measuring personal exposure to occupational noise but are not appropriate for the purposes of a field noise survey. An Integrating Sound Level Meter is recommended as a more accurate method of determining the L_{eq} and is particularly useful if the noise is highly variable.
   - Detailed descriptions of the monitoring sites and noise generating activities that were occurring at the time of monitoring should be provided.

Environmental Protection Department
Ministry of the Environment, Water Resources and Drainage
NUPW Complex, Dalkeith, St. Michael.
Phone: 1-246-310-3600, Fax: 1-246-228-7103; e-mail: enveng@caribsurf.com

ii. Methodology/Rationale for the 350m separation distance

- The industry guideline used to calculate the 350m set back should be referenced. The EPD remains concerned that 350m from the base of the tower to the nearest resident is not adequate to reduce potential impacts.
- It is also not clear if the land within the 350m is to be acquired by the developer or if the owner may wish to develop it at a later date.

iii. Hours of Construction

- Use of heavy equipment should be limited to daytime.

iv. Section 7.2.4 Specifications of Turbines

- Since the type of turbine to be used has not been finalised, a range of noise data from different types of turbines being considered should have been provided to represent alternatives available.
- Little information has been provided as to what levels of low frequency noise are considered "problematic " and /or "significant" as well as no indication given as to established accepted thresholds for such noise.

v. Dust Control Measures

- Although dust control measures are covered in Section 7.1.3 of the Environmental Impact Report and in more detail in the Environmental Management Plan for Construction, neither one make specific reference to the minimisation of releases of particulates e.g. dust from vehicles entering and leaving the site. Examples of controls not mentioned may include wheel washing and enforceable speed limits.

vi. Section 7.2.4- Post Commissioning Noise Monitoring

- The appended Environmental Management Plan indicated post commissioning noise monitoring at one location only. There should be a more comprehensive monitoring plan with multiple locations included along with a schedule indicating the times and frequency of the monitoring.

3. Sincere apologies for the tardiness of this submission.

Ingrid Lavine
For DIRECTOR

July 3rd 2009

TV 61036

The Barbados Light & Power Co. Ltd.
P.O. Box 142
Garrison Hill
St. Michael

Attention: Mr. Roger Blackman

Dear Mr. Blackman:

Re: Application No. 3262/11/04C
Construction of a Wind Driven Electrical Station at Lamberts, East,
Lamberts Plantation, St. Lucy

Thank you for forwarding comments requesting additional clarification on our environmental assessment report for the above site. I have repeated the comments and provide responses in italicised fonts below.

1. **Methodology of noise monitoring**:

- Noise dosimeters are ideal for measuring personal exposure to occupational noise but are not appropriate for the purposes of a field noise survey. An Integrating Sound Level Meter is recommended as a more accurate method of determining the Leq and is particularly useful if the noise is highly variable.
- Detailed descriptions of the monitoring sites and noise generating activities that were occurring at the time of monitoring should be provided.

Response:

- *We agree that an Integrating Sound Level Meter is the most appropriate instrument for any noise survey where one is measuring the environmental impact from designated noise sources. On this occasion, the sound measurements were performed using a Quest Technologies M-27 noise logging dosimeter which while most often used for personal exposure, also has a logging capability. Measurements of the sound pressure level were taken at 1-minute intervals over a 24-hour period and this data set was then evaluated in terms of the hourly equivalent sound level (Leq). While this data is representative of the background, the noise assessment of the windfarm used the International Finance Corporation[1] (World Bank) guideline of 45dBA as a reference for acceptable overnight noise levels at the closest residences.*

[1] International Finance Corporation (IFC) Environmental Health and Safety Guidelines, April 2007

- *The locations were selected to represent the closest residences to the windfarm around the perimeter of the site. Measurements were taken at a height of approximately 1.5 metres above the ground and the location was chosen both to be representative of conditions at the measurement location and to avoid any reflective impacts associated with structures on the measurement site. Information on meteorological conditions was presented in our letter of October 09, 2008.*

- *In our letter of October 09, 2008 it was also noted that the only location where noise levels would be influenced by construction would be L2 at Date Tree where construction of a house was occurring and could have influenced the daytime noise levels. However, when determining the existing ambient noise levels it is the night-time levels that are the lowest levels which need to be considered. At that location the lowest noise level (L_{EQ}) attained at night was in the 55dBA range which is higher than the predicted noise levels from the wind farm at that location.*

2. **Methodology/rationale for the 350m separation distance**.

- The industry guideline used to calculate the 350m setback should be referenced. The EPD remains concerned that 350m from the base of the tower to the nearest resident is not adequate to reduce potential impacts.
- It is also not clear if the land within the 350m is to be acquired by the developer or if the owner may wish to develop it at a later date.

Response:

- *The 350 metres separation distance from the closest residence was only one of the guidelines used during the feasibility study to pre-screen generally acceptable sites. This is an industry guideline based on seven rotor diameters (50m rotor), which is normally adequate to mitigate noise effects and reduce shadow flicker. The primary standard was the World Bank 45 dBA impact criterion for wind speeds of 8 m/s or less[2].*
- *The guideline was used in the report by Renewable Energy Systems: "Feasibility Study for a Wind Farm on Barbados – March 2004"*

3. **Hours of construction**

- Use of heavy equipment should be limited to daytime.

Response:

We agree to limit the use of heavy equipment to daytime hours.

[2] Ibid.

4. **Section 7.2.4 Specifications of Turbines**

- Since the type of turbine to be used has not been finalised, a range of noise data from different types of turbines being considered should have been provided to represent alternatives available.
- Little information has been provided as to what levels of low frequency noise are considered "problematic" and/or "significant" as well as no indication given as to established accepted thresholds for such noise.

Response:

- *As noted, the specific turbines to be used have not been purchased as selection will follow a competitive tendering process once the project has been approved. The Environmental Impact Assessment report was based on the installation of Vestas V52-850kW turbines as being typical of the size and type of wind turbine that will be installed in terms of power, hub-height and potential noise level. The noise assessment was based on all 11 turbines operating simultaneously.*
- *When the final turbine design parameters and geotechnical data are available, the layout will be re-optimised using the Windfarm program. At that time the potential noise impact at each receptor will be re-evaluated using Windfarm or some other ISO9613-compliant noise assessment software and a report submitted.*
- *There has been considerable debate in recent years over the potential impact from low-frequency sound from wind turbines and there is no consensus as to a specific limit criterion for low frequency or infrasound. Typically if there is a tonal quality present in the turbine mechanical or aerodynamic noise spectrum then a 5-10 dB penalty is added to the calculated receptor noise level.*
- *It is generally agreed that low frequency impact was worse with older model turbines where the blades passed through the tower shadow (downwind rotors or large vertical axis machines). Modern machines are much less susceptible to low frequency infrasound[3]. There has frequently been confusion over low frequency modulation of sound and the presence of infrasound and while there is a great deal of discussion about infrasound in connection with wind turbines in the media, there is no verifiable evidence for infrasound production by modern wind turbines[4].*
- *The post-commissioning noise monitoring plan will however quantify any production of low frequency and infrasound from wind turbines on the site.*

5. **Dust Control Measures**

- Although dust control measures are covered in Section 7.1.3 of the Environmental Impact report and in more detail in the Environmental Management Plan for Construction, neither one makes specific mention of releases of particulates e.g. dust from vehicles entering or leaving the site. Examples of controls not mentioned may include wheel washing and enforceable speed limits.

---

[3] HGC Engineering *Wind Turbines and Sound: Review and Best Practice Guidelines*. Report to Canadian Wind Energy Association, February 2007

[4] Ibid.

Response:

- The *temporary nature of construction differentiates it from other fugitive dust sources as to estimation and control of emissions. Construction consists of a series of different operations, each with its own duration and potential for dust generation. In other words, emissions from any single construction site can be expected (1) to have a definable beginning and an end and (2) to vary substantially over different phases of the construction process*[5].
- *Best Management Practices for dust control will be used during construction as detailed in the report. In particular vehicles traveling on unpaved areas of the site will be limited to 15 kph. Since dust emissions from paved road surfaces are up to 90% less than for unpaved surfaces, project efforts were aimed at reduction of particulate emission at source.*
- *However track-out of silt especially post wet suppression remains a potential concern. Dust levels at the site will be monitored regularly using a hand held dust monitor. The area of paved road within 50m of the site exit will be inspected regularly for silt track-out and will be cleaned as necessary. This is felt to be a more effective process than wheel washing.*

6. **Section 7.2.4 Post Commissioning Noise Monitoring**.

- The appended Environmental Management Plan indicated post commissioning noise monitoring at one location only. There should be a more comprehensive monitoring plan with multiple locations along with a schedule indicating the times and frequency of the monitoring.

Response:

Wind turbine noise typically includes both mechanical and aerodynamic effects. To ensure that all effects are measured, the proposed monitoring plan will include:

- *Measurements of A-weighted sound pressure level (dBA) taken at a minimum of five locations around the wind farm. These locations will be chosen once the final farm design has been approved and will be representative of the nearest residential receptor as well as offsite receptors in the cardinal directions as well as both upwind and down wind locations. Approximate locations could include:*
  - *Josey Hill*
  - *Cave Hill / Graveyard*
  - *Lamberts plantation (closest receptor)*
  - *Alexandra*
  - *Collins / the Risk*
- *Measurements will be taken over a minimum period of 48 hours using Type I or Type II integrating sound level meters at a height of 1.5 metres above the ground using wind shielded microphones and which will be site calibrated daily before and after each set of measurements. Monitors will be no closer than 3m from any reflecting surface (wall) and specific high noise events (onsite or offsite) will be logged.*

[5] EPA AP42 Chapter 13 section 2-3

- *Measurements will include both hourly sound pressure level (Leq) as well as 1/3 octave band data to assess the tonal quality of any noise impact. This will be compared to the applicable criteria as well as to the results of the noise modelling.*
- *Measurements will be taken over three (3) 24-hour periods with the wind farm fully operational to allow for collection of noise data over a range of wind speed and wind direction conditions.*
- *The monitoring program will be repeated at the time of each plant expansion.*

I trust that this responds to the information request. If you have any questions, please do not hesitate to contact the undersigned.

Sincerely,
AMEC Earth & Environmental,
a division of AMEC Americas Limited

Peter Rostern, P.Eng.
Principal Environmental Engineer

Steve Lamming Ph,D., CCEP
Sr. Associate Air Quality/Noise

APPENDIX D

EVALUATION OF ENVIRONMENTAL NOISE ANALYSIS FOR "LAMBERTS EAST WIND FARM" - DOCUMENTATION PROVIDED BY JOSEY HILL RESIDENTS

Evaluation of Environmental Noise Analysis

for "Lambert's East Wind Farm"

R.H. Bolton
February 22, 2007
Rev. 1

Table of Contents

1.0 Introduction

Barbados Light and Power Company Limited propose to construct a 10 MW wind farm using 11 wind turbines each with a 900 KW rating. The project will be located at Lambert's East in the parish of St. Lucy, Barbados. Each turbine will have a tubular tower of up to 55m height, and three rotor blades with a maximum rotor diameter of 56m.

Large turbines create strong noise levels from wind through the blades and by the turbine mechanisms themselves. To capture the wind these turbines are to be installed linearly on a north-south ridgeline and thus have significant potential to create a noise nuisance to residents downwind of the farm. Wind turbine noise added to the prevailing ambient background sound is an important environmental consideration when siting wind turbines since they are a permanent installation and may significantly annoy residents or even personal health. Also, relevant consideration of noise impacts is required by the Barbados Ministry of Environment.

The purpose of this report is to evaluate, not to repeat the noise study associated with this project, which was the province of the project sponsor, Barbados Light & Power Company Limited and their consultant, AMEC Earth and Environmental.

There are many modern tools to evaluate and predict the effects of noise sources, well known to the scientific and engineering communities. Sounds, as a form of wave propagation have been thoroughly and meticulously studied and measured. There are therefore a host of instrumentation and analysis tools available. But these tools must be used correctly and carefully in order to avoid the "garbage in garbage out" syndrome and erroneous conclusions.

2.0 Lambert's East Wind Farm Project

AMEC Earth and Environmental has submitted a comprehensive draft Environmental Impact Statement for the wind farm, which includes an operational noise assessment in section 7.2.2 (Ref. 1) AMEC Earth and Environmental is a division of AMEC which also owns AMEC Wind, a developer of wind farms. Immediately, an extra measure of caution is demanded to ensure proper due-diligence by the AMEC noise report when a probable conflict of interest is involved.

Barbados' Environmental Protection Division of the Ministry of Housing, Lands and Environment does not have legislated standards for noise levels but does include conditions for noise abatement in new projects. It also investigates noise complaints.

2.1 Synopsis of Barbados

Barbados is the easternmost and one of the southernmost Caribbean island nations, just 275 miles northeast of Venezuela. It is a small island of 21 x 14 miles yet has a population of 267,00 which gives it one of the highest population densities on earth.

Although an independent democracy it, like Canada and India, remains one of the United Kingdom's Commonwealth countries. Its citizens are noted for friendliness and a high quality of life, ranking third on the UN Development Index, ahead of Italy, Spain and Ireland.

Barbados is subtropical and Atlantic trade winds are normally from the north east.

> Today the Barbados economy is becoming less reliant on sugar and more so on services, particular tourism.
> In 1997, the population of Barbados was recorded as 266 990, making it one of the ten most densely population countries in the world.
> The combined effect of these factors has led to extensive pressure on the few remaining areas of natural biological diversity. The more recent sources of pressure on the island's biological diversity include the need for housing and the use of land for housing sub-divisions and tourism developments such as hotels, marina and golf courses.
>
> (Ref. 2)

The south is most populated while the north has plantations sprinkled with residential communities.

> The project site is located on agricultural land, at Lamberts East in the northern parish of St. Lucy. The site occupies a ridge at the periphery of an area of relatively flat land, which forms part of the Castle Plantation. Vegetation on the site consists mainly of coarse grass. Sugar cane is grown to the west of the site on the Castle plantation. The seaward (eastward) slope of the site is covered by grass and scrub.
>
> (5.6.1, Ref. 1, *ob sit*)

3.0 AMEC Noise Analysis

AMEC's noise analysis consists of three parts:

- Discussion of wind turbine noise in relation to ambient noises.
- Identification of a reference "standard".
- Computer modeling to predict wind farm noise in comparison to the standard.

It will be clearly shown however that all three claims are not adequately addressed and greatly understate the likely impact of the proposed wind farm.

3.1 Ambient and Wind Turbine Noise

AMEC claims that the wind turbines only operate when the prevailing winds are generating noises to mask the turbine noise.

> 7.2.4 Noise
> Mechanical and electrical noise from a wind turbine can be contained in the main by the wind turbine nacelle structure. However, the noise created by the rotor cannot be confined and is broadcast to the surroundings. It is however somewhat akin to the noise of the wind through trees etc, and so blends into the background without causing significant annoyance a short distance from the turbines. In very low wind speeds, the turbines do not operate and no noise is created. **As wind speeds increase, so too does the background noise, such that at the higher**

wind speeds the wind turbine noise is completely masked.

(emphasis added)

However turbine noises are not completely masked by ambient noises because they contain significant and easily detectable modulation components.

Their claim has two errors. It is only true that noises will mask each other if they are of essentially the same type. AMEC assumes that since the turbines noises are essentially "white"[1] that they will statistically combine with the prevailing ambient under windy conditions and that the ambient is also a "white" noise. This is only partially true and an oversimplification. If the white noises have periodic components, such as modulation or tonal components then the noises will not mask each other, which will be discussed further in Section 4.4.

Also for masking to work the assumption must be made that the wind at the turbine height is the same as the wind at the receptor/resident. Generally wind increases with elevation so in most wind situations the turbines will experience higher winds than the terrain below, exposing residents to noises because at ground level the wind will be low or calm, and wind induced ambient is greatly diminished.

3.2 Noise Criteria

Barbados, like many countries does not have strong noise control standards. AMEC uses only Canadian standards and these should be compared with results and standards of other countries. Wind turbines are a new source of industrial noise pollution in Canada and elsewhere and should be carefully studied. Once turbines are erected and operational little can be done, or will be done to correct any noise study failures.

AMEC also tries to state that 45dBA is a recommended limit by the WHO for night time but this is a limit to protect actual physical health. Annoyance and distress can occur at lower levels, which will be discussed further in section 4.4 below.

> As the Government of Barbados does not have specific noise levels standards for wind farm developments, the suggested criteria is based on the guidelines used in Ontario Canada. Under those guidelines, the maximum noise levels at the closest residence would be 45dBA at up to 8m/s wind speed and would be allowed to increase at higher wind speeds due to the wind-induced increased background sound levels. **This also compares with the guidelines for the World Health Organization and World Bank which each recommend 45dBA at sensitive receptors such as houses during the night time.**
>
> (Ref. 1, *ob sit*)

The most common noise assessment technique is to measure the prevailing background noises at distances from the project site. A considerable distance is needed in the case of large wind turbines because their radiated sounds may carry several kilometers. A limit of 3-6 dBA increase is usually imposed as a limit over which noise becomes objectionable.

---

[1] From Wikepedia: White noise is a random signal (or process) with a flat power spectral density. In other words, the signal's power spectral density has equal power in any band, at any centre frequency, having a given bandwidth. White noise is considered analogous to white light which contains all frequencies.

A 3 dBA rise is the most protective, preventing annoyance to sensitive persons. This concept is shown graphically in Fig. 1 below. AMEC does not use this method.

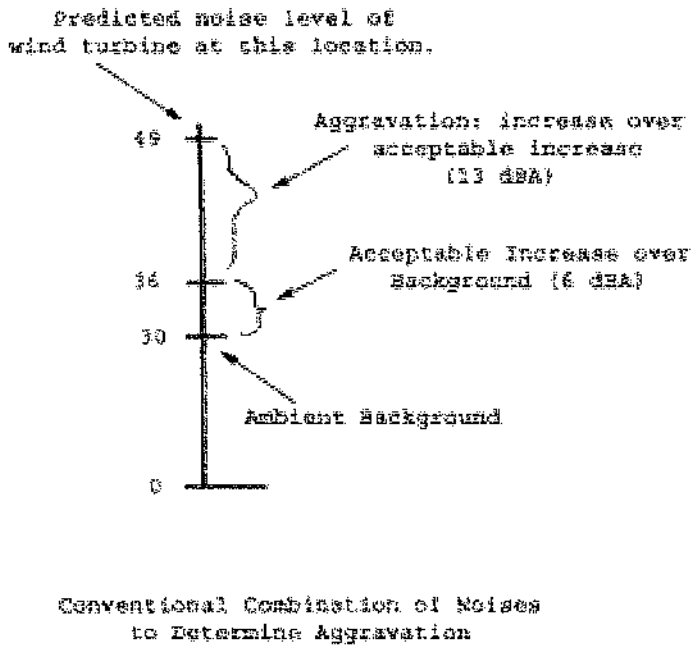


Fig. 1: Noise Aggravation Mathematics

3.3 Noise Predictive Modeling

AMEC uses ReSoft WindFarm computer software modeling to predict the noise propagation due to the wind farm then compares this prediction to their 45 dBA stated limit.

> Sound contours were developed for the wind farm at different wind speeds using the ReSoft WindFarm software noise module. This is based on the "Description of Noise Propagation Model Specified by Danish Statutory Order on Noise from Windmills (Nr. 304, Dated 14 May 1991)" as produced by the Danish Ministry of the Environment National Agency for Environmental Protection. The DSO 304 model attenuation coefficient has been adjusted to match the 40, 43 and 45 dBA noise level predicted by an ISO 9613-2 model as referenced by the Ontario noise guideline. The ISO 9613-2 model was used to check the results from the DSO 304 model with the adjusted attenuation coefficient. Figures 7.2-7 – 7.2-9 show sound level contours in the vicinity of the closest receptors for given wind speeds of 6m/s (40 dBA contour), 7m/s (43 dBA contour) and 8m/s (45 dBA contour), respectively.
>
> (Ref. 1, *ob sit*)

The ReSoft software model does not disclose any basis or confirmation studies of its model. The only reference is:

> Noise Calculation
> WindFarm noise model shows the noise levels at each surrounding house and individual turbine noise at each house.
> Calculate and show noise contours across the wind farm site.
> Calculate and show noise levels at specific locations.
> Select broadband noise spreading or spreading by octaves.

The noise model included in the noise calculation module is based on "Description Of Noise Propagation Model Specified By Danish Statutory Order On Noise From Windmills (Nr. 304, Dated 14 May 1991)" as produced by The Danish Ministry Of The Environment National Agency For Environmental Protection.

(source ReSoft.com website info.)

ReSoft is a general purpose software program that tries to "be everything" for the developer. Here are its major modeling features:

Energy Yield
Optimisation
Wind Flow Across the Terrain
Wind Analysis
Noise Calculation
Zone -of-Visual-Influence
Photomontage and Landscape View

Wind turbine noise propagation is a complex environmental effect and it is highly questionable that ReSoft has incorporated or verified the necessary elements to assure believability in its predictions. It should also be noted that the Danish EPA (DEPA) noise model is a sacrificial compromise, not fully protective of its citizens. The DEPA does however recognize the severity of noise pollution and need for abatement.

13.2 Level of protection
Environmental noise in Denmark is usually so low that it is not likely to cause serious human damage like hearing impairment. However, **environmental noise is annoying and may have adverse effects such as:**

interference with speech communication,
performance and productivity,
disturbance of rest and sleep and
physiological and mental health effects like stress, hypertension, ischemic heart disease

Different kinds of noise have different kinds of effects, as annoyance is subjective. Noise annoyance is highly dependent on different noise sources, frequency spectrum, and relation to the noise source and on personal expectations. Many people living in down town areas in big cities like Copenhagen do not expect tranquility. Even the duration and variation over time of noise is important when transforming sound propagation into annoyance.
Until now focus has been on annoyance, but also sleep disturbance shall be included in future regulation.

13.3.1 Objectives and principles
In the objects clause of the Danish Environmental Act is stated, among other things, that the act shall prevent and abate noise impact on the public.
Sufficient scientific evidence on noise annoyance is still lacking for some types of noise.
No Danish research on dose and effect relationship has been carried out recently. DEPA did carry out investigations in 1985 and 1995 on annoyance due to noise from railway traffic and shooting ranges respectively as part of the development of guidelines on these noise sources.
In mid-1990, a pilot study was carried out on noise from wind turbines as part of a common European Study.

13.6 Evaluation

Present guidelines and criteria values express **a compromise between high quality of life and socio-economic considerations (technical, economical and community aspects), accepting that a minor part of the public (typically the 10% most noise sensitive people) might still feel highly annoyed.**

(emphasis added)
Ref. 3

AMEC refers to the ISO noise standards when verifying the DEPA (DSO 304) conformance:

The ISO 9613-2 model was used to check the results from the DSO 304 model with the adjusted attenuation coefficient.

ISO 9613-2 is a comprehensive noise analysis tool and useful in many situations. A synopsis is given below. But note that elevated sources, wind turbines, are not included in this standard.

Scope:

This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.

These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night. Inversion conditions over water surfaces are not covered and may result in higher sound pressure levels than predicted from this part of ISO 9613.

The method also predicts a long-term average A-weighted sound pressure level as specified in ISO 1996-1 and ISO 1996-2. The long-term average A-weighted sound pressure level encompasses levels for a wide variety of meteorological conditions.

The method specified in this part of ISO 9613 consists specifically of octave-band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originates from a point sound source, or an assembly of point sources. The source (or sources) may be moving or stationary. Specific terms are provided in the algorithms for the following physical effects:

— geometrical divergence;
— atmospheric absorption;
— ground effect;
— reflection from surfaces;
— screening by obstacles.

Additional information concerning propagation through housing, foliage and industrial sites is given in annex A.

This method is applicable in practice to a great variety of noise sources and environments. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, industrial noise sources, construction activities, **and many other ground-based noise sources.** It does not apply to sound from aircraft in flight, or to blast waves from mining, military or similar operations.

(Ref 4) emphasis added

3.2 AMEC Conclusion

AMEC concludes based that the wind farm will cause no undue noise and no mitigation is required. However their conclusion can not be substantiated and is indeed flawed and

doubtful. No background measurements were conducted. The only noise analysis consisted of a limited reference to biased Canadian and Danish standards, an inappropriate ISO standard and operation of a software model where the model characteristics and input parameters are unknown and not verifiable.

> Recommended Mitigation
> Specific mitigative options to reduce noise have been incorporated into the design and structure of the wind turbines and therefore the wind farm will meet the recommended criteria for noise. No additional mitigative measures are required.
>
> Significance of Environmental Effects
> **There will be no significant effects/impacts on nearby residences during the operational phase of the proposed wind farm.**
>
> (Ref. 1, *ob sit*)

The effects outlined in ISO 9716-2 are fundamental to sound propagation, are well developed and known and must be adequately addressed for elevated sources. For example "Mechanical Radiation" (Ref. 5) includes a complete derivation from the governing differential equation for sound propagation in a refractive medium – air and water - which reduces as it should to the familiar Snell's law of optics. Indeed there are strong similarities in all wave propagation mathematics, whether the wave is an electromagnetic transverse wave (i.e. radio and/or light radiation) or a molecular compression wave (sound). Waves can be treated as "rays" and exhibit diffraction, refraction and coherence effects and have been thoroughly studied for 200 years now.

Refraction occurs from the change in sound propagation velocity due to atmospheric variability. One source is wind shear, the progressive increase in wind speed above ground and which occurs frequently. From *Mechanical Radiation* (Ref. 5 *ob cit*):

> Its practical importance in sound propagation in a windy atmosphere is obvious: **elevated sound sources are decidedly advantageous in transmitting to windward.**
>
> (emphasis added)

A graphical depiction is shown below, Fig 7-30 from *Wind Turbine Acoustics,* (NASA, Ref. 6). This example is for wind propagated through a wind farm grid of low power wind turbines (100 KW, 31 generators/row, 5 rows). Note the very long sound propagation distance of about 2,500 m. at 40 dB. The much larger (10 MW total vs. 3.1 MW) Barbados project has a roughly linear clusters which will act together and create a similar propagation field. In downwind conditions it is reasonable to expect that certain regions would experience noise levels far in excess of AMEC's primitive ReSoft predictions.

Another refraction is from temperature effects. Sound speed changes with temperature and there is usually a temperature gradient above earth, sometimes inverted by radiation cooling. The complex interaction of these refractive effects with the wind gradient effect may cause a tunneling or cylindrical "focusing" of the sound at great distances from the turbine. By studying historical meteorological data and through local interviews a predictive model can be constructed to reasonably predict the frequency occurrence and

propagation distances with some statistical confidence. Barbados' subtropical climate may not be contusive to this phenomenon however.

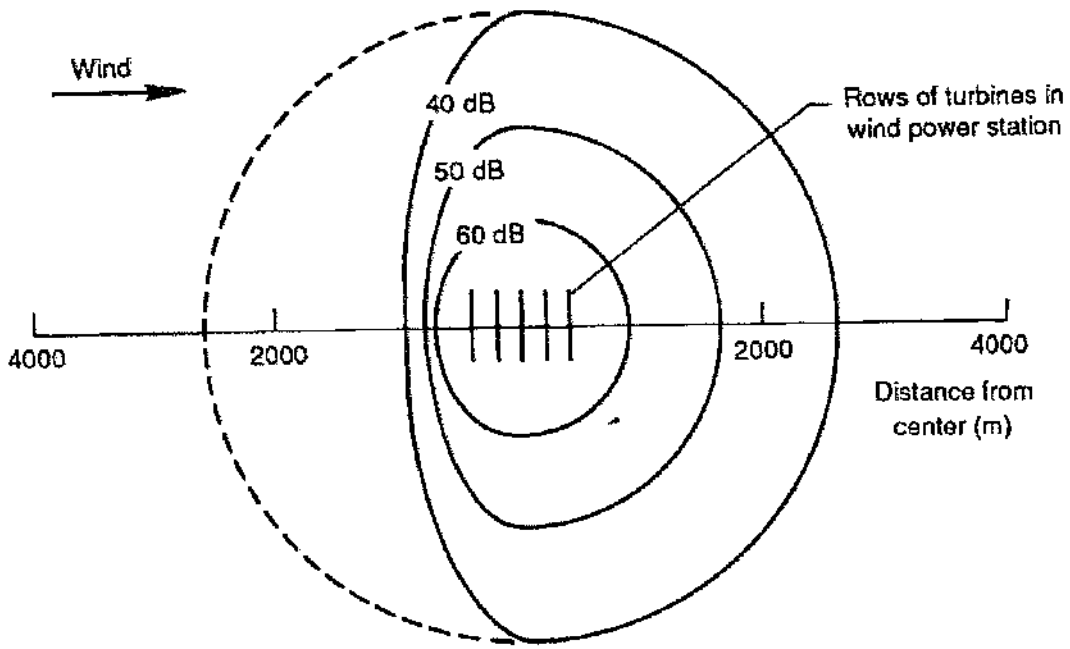


Figure 7-30. Calculated contours of sound pressure level around a five-row example array for the one-third-octave band at 1000 Hz (α = 0.54 dB/100 m) [Shepherd and Hubbard 1986]

A comprehensive theoretical study "Modeling of Noise from Wind Turbines" was done by W. J. Zhu in 2004, (Ref. 7). This study includes some refraction and reflection effects due to hilly terrain. It shows conclusively the danger of not including refractive/reflective effects in models. Zhu uses simple assumptions for sound propagating from a turbine down into a valley under different conditions and finds a 6 dB increase in noise is predicted for many frequencies, see Fig. 2 below.

In at least one study, "Environmental Noise Assessment Pubnico Point Wind Farm" (Ref. 8) software that accounts for wind gradient propagation confirmed this increase. The original Pubnico Point noise prediction was also made using Cadna/A and was predicted to be 49 dBA (using the inappropriate ISO 9613-2 method).

> The results of the assessment, using the predictive mathematics of ISO 9613-2, suggest a sound level of 49 dBA would be expected at the d'Entremont residence based on a sound power level determined at a wind speed of about 9 m/s.

However using a software model (CONCAWE6) that included the prediction of downwind effects the noise prediction increased 6 dBA, or a doubling of perceived sound! This was confirmed in the field measurements:

> ...effects of wind and atmospheric conditions using the methods of the CONCAWE6 noise assessment protocol was thus undertaken. **This protocol allows for predictions under specific wind speeds or**

atmospheric conditions. The predictions indicate that the predicted 49 dBA level could be as high as 54 dBA at the d'Entremont residence when winds (including winds as light as 5 m/s) are from the south, or as low as 42 dBA with winds from the north. This is consistent with the automatic sound level monitor results, and demonstrates that even with an impact that is acceptable under Interpretation, there can be periods and conditions when the sound level impact is higher.

(emphasis added)
Ref. 8, *ob cit*

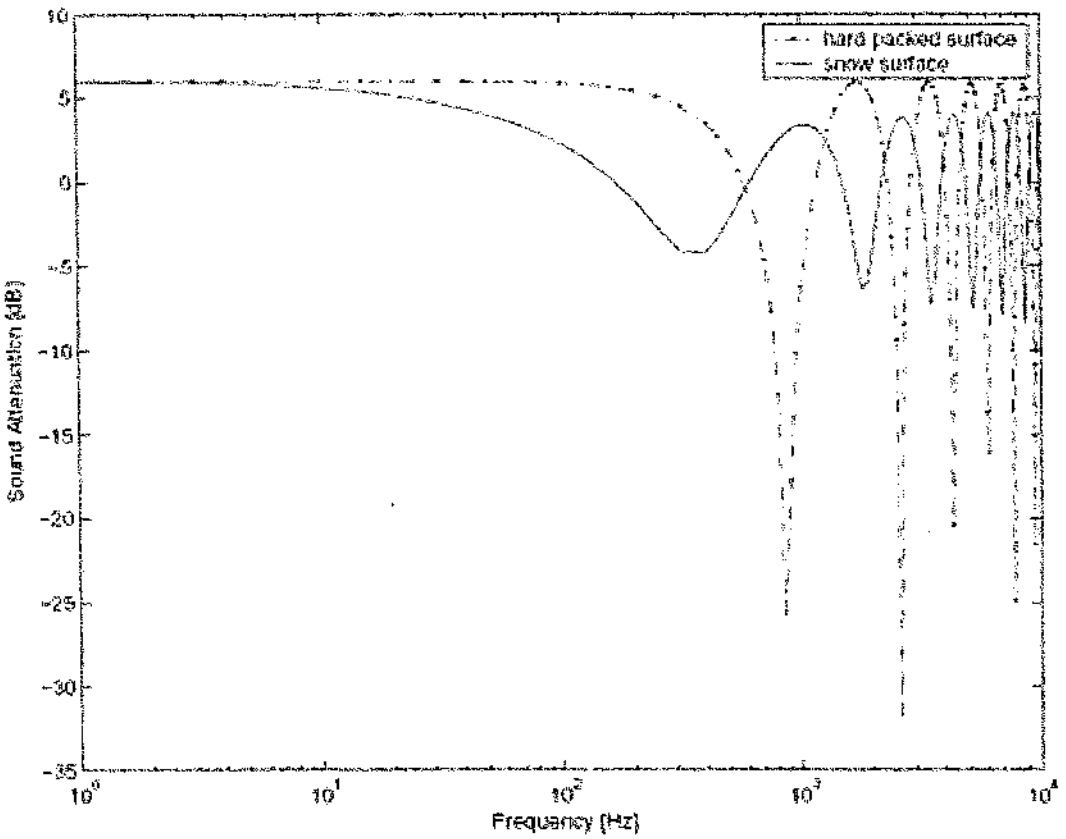


Fig. 2: Predicted Sound Absorption With Refraction and Terrain (Zhu *ob sit*, Ref. 7)

Even for this brief Pubnico study period of 5 days, it was noted that other atmospheric effects can result in a nearly 400% increase in sound perception beyond predictions. These will be discussed further in section 4.4:

However, under certain wind and atmospheric conditions when background sound would be expected to be low, **the measured sound levels were found to exceed the criteria and expected background sound by up to 13 dB.**

(emphasis added)
Ref. 8 *ob sit*

AMEC's ReSoft uses the conventional "-6 dBA/distance doubling" noise attenuation factor for computing propagation distances, adjusting for atmospheric absorption. This is the expected geometrical result due to simple spherical spreading of the sound. It is a similar attenuation result that would be obtained for other sources of spherical radiation such as for a light bulb. However it has been shown that when atmospheric refractive

("focusing") effects are present that the sound attenuation is only about 3 dBA/doubling. See van den Berg (Ref. 9) , and NASA (Ref. 6 *ob cit*). Hence the sound propagates much further before significant attenuation.

4.0 Associated Noise Studies from other Regions and Agencies

In the study of complex phenomena or in the manufacture of electrically operated equipment it is common for analysts and manufacturers to use information, studies and standards developed in other countries as a guide. The beneficial sharing builds the knowledge base, prevents undesirable effects and enhances public comfort and safety.

For example consumer electrical equipment will often bear an Underwriter's Laboratory (UL) label certification of design and manufacturing safety for U.S. products and also a Canadian Standard's Association (CSA) certification for products sold in Canada since the electrical supply is identical, though the safety measurements and standards are slightly different.

Likewise for wind turbine noise, the noise emanations are similar, turbines are manufactured internationally, and noise measurement methods and reporting units are identical. It is therefore useful to assess other analyses to survey their conclusions, rationale and compare these to the AMEC analysis.

Several other reports identify rural, country ambient sounds as about 30 dBA, or frequently quieter, and that quieter noise levels in the 30 dBA range should be used as opposed to urban environments that frequently allow 50 dBA limits. For example, wind turbines in Europe are more widely established and noise studies there indicate that in terrain similar to many areas of the Lambert's East Wind Farm site low noise backgrounds are to be expected. The wind turbines noises are therefore much more objectionable, and that setbacks up to 1.5 km, or more, are needed.

4.1 U.S. Environmental Protection Agency Noise Study

Early in the EPA's founding, circa 1971, it conducted a comprehensive analysis of noise pollution (Ref. 10). Modern urbanization has significantly increased noise pollution in urban areas due to the post-WW II presence of passenger jets and the proliferation of expressways and automobiles. This study includes a variety of sound assessment methods, measurements of noises, receptor acceptance levels and statistical analysis of data. Today the EPA findings are the general underpinning of many noise policies in the U.S.

From the EPA study, pertinent to wind farm siting in Barbados' rural areas:

> 3.1 Variation of Outdoor Noise Environment with Location
>
> The range of daytime outdoor noise levels at the 18 locations is presented in Figure 7. The locations are listed from top to bottom of the figure in descending order of their daytime residual noise levels (Lg0). The noisiest location which is outside of a 3rd floor apartment overlooking an 8-lane freeway is at the top of the list with its daytime residual noise level of 77 dB(A). **The rural farm is next to the bottom of the list with its daytime residual noise level of 33 dB(A).**

This difference of 44 dB in the residual noise levels of these two locations constitutes a large range in noise climate. Its magnitude clearly implies that all citizens do not enjoy the same "quality" in their noise environment. In fact, the owner of the 3rd floor apartment near the freeway has trouble keeping the apartment rented for more than a month to any one tenant. His problem is not surprising since the outdoor noise level is sufficiently high to render normal speech communication difficult indoors even when the windows are closed.

(emphasis added)

From the EPA daytime noise graph below (their Fig. 7) we see clearly that a daytime "farm in valley" noise level is less than 40 dBA, half the time. At night, from the EPA's Fig. 9 graph the "farm in valley" is now quieter than 33 dBA half the night and is only above 36 dBA for 10% of the night. The details of the "farm in valley" location are not explicit and it is unknown how closely this site may mimic the Lambert's East Wind Farm area. Perhaps parts of the siting area are even quieter at certain times, like the "Grand Canyon (North Rim)" location, showing a mean of 20 dBA?

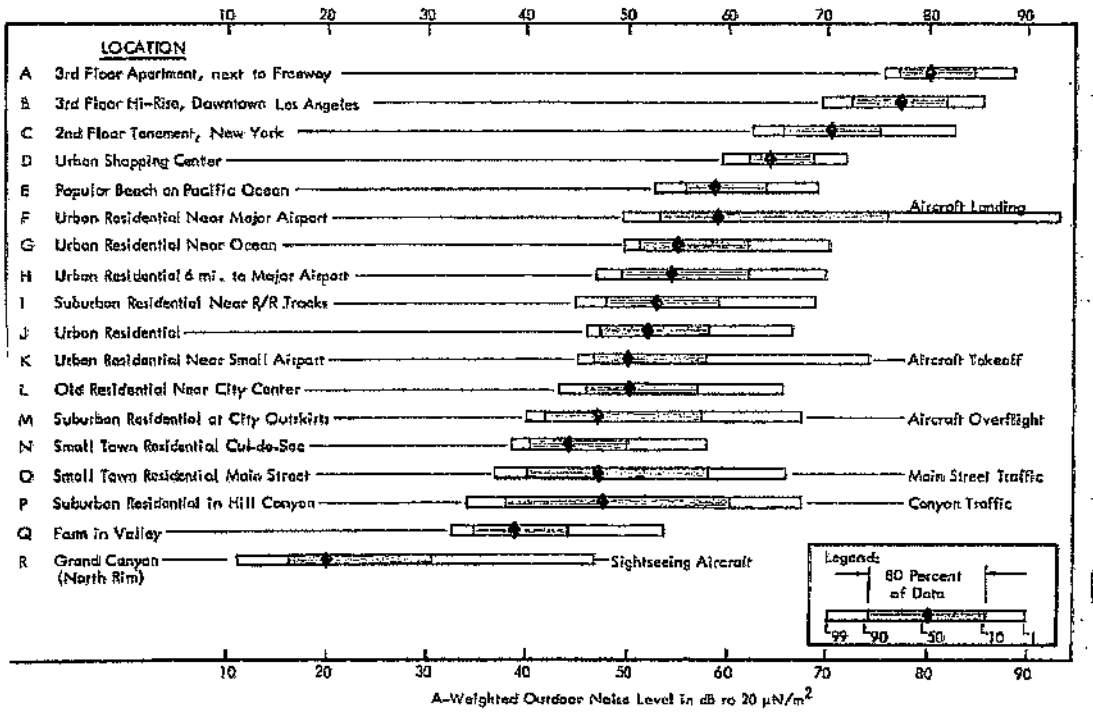


Fig. 7 of EPA Report, Daytime Noise Measurements

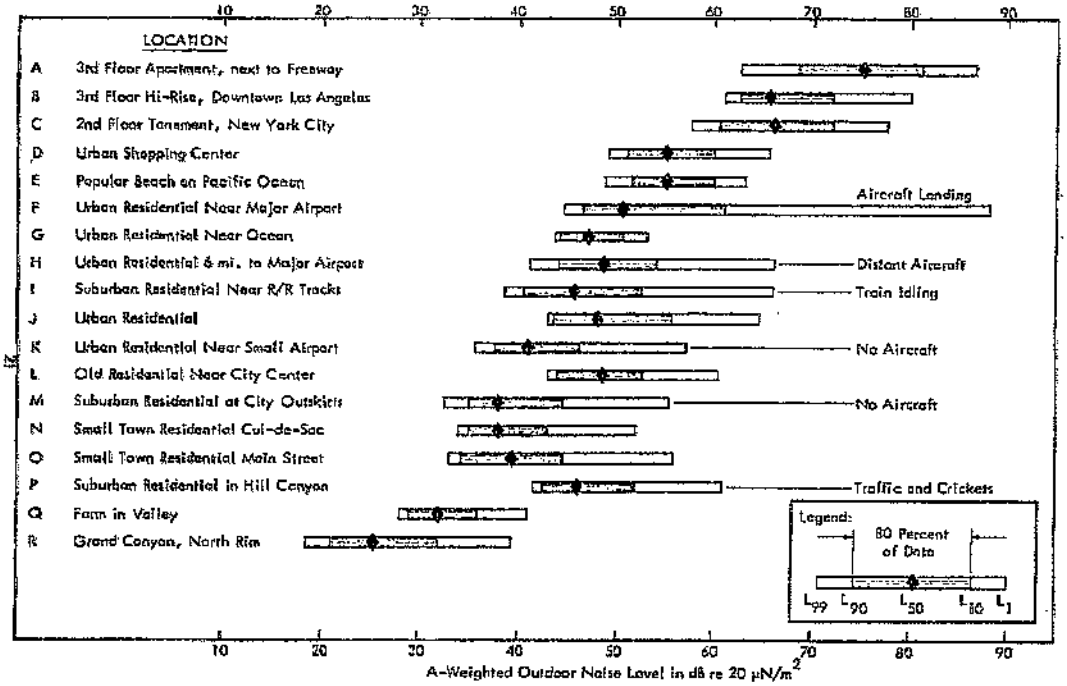


Figure 9. Nighttime Outdoor Noise Levels Found in 18 Locations Ranging Between the Wilderness and the Downtown City, with Significant Intruding Sources Noted. Data are Arithmetic Averages of the 9 Hourly Values in the Nighttime Period (10:00 p.m. - 7:00 a.m.) of the Levels Which are Exceeded 99, 90, 50, 10 and 1 Percent of the Time

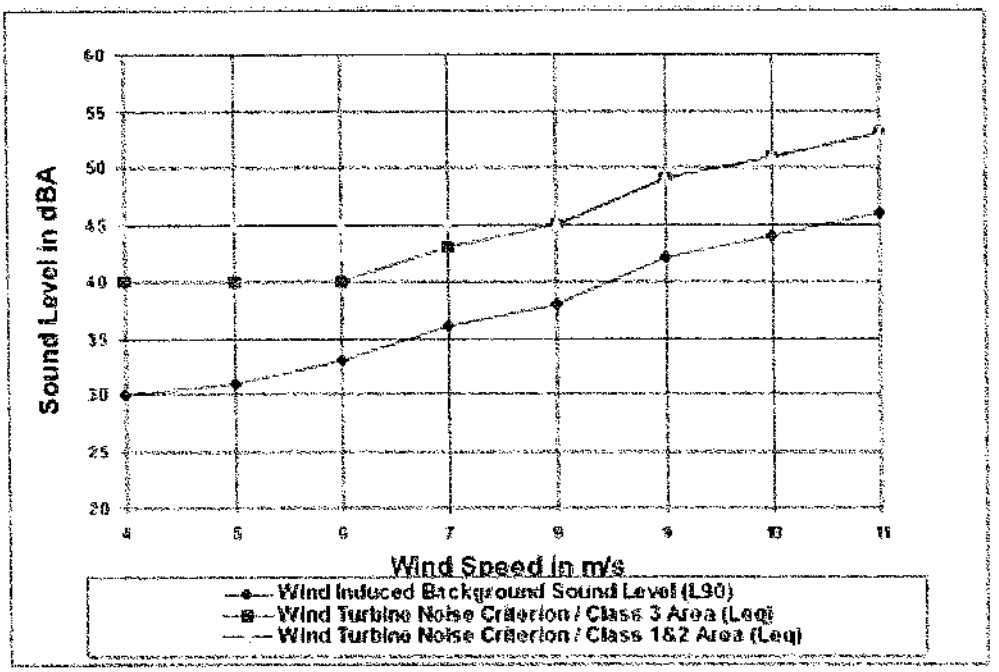
Fig. 9 of EPA Report, Nighttime Noise Measurements

4.2 Canadian Requirements

As AMEC references, the Ontario Canada Ministry of the Environment has evaluated noise requirement for siting of wind turbines in Ontario Canada (Ref. 11). They publish a graph for various environments with a weighted increase for increasing winds. See Fig. 3 below, also cited in the AMEC report.

To assess noise limits the project sponsor identifies predicted noise emissions at a location and compares it with the values in the graph to flag nonconformance. For rural settings the noise limit is 40 dBA across a range of turbine speeds, rising to 52 dBA only in higher winds.
There is no indication of how this standard was derived[2] nor how satisfactory it is in relation to wind turbine noises. Wind turbines are a relatively new source of rural noise pollution and in relation to other assessments the Canadian standards can be considered to be very liberal. By what criteria are the Canadian standards truly applicable to Barbados?

[2] Many standards committees and government guidance's are formulated with input from sponsors who often succeed in securing a sacrificial level of noise pollution, often 10% of affected resident's.



"Class 3 Area" means a rural area with an acoustical environment that is dominated by natural sounds having little or no road traffic, such as the following:

i. a small community with less than 1000 population;

ii. agricultural area;

iii. a rural recreational area such as a cottage or a resort area; or a wilderness area.

Fig. 3: Ontario Canada Turbine Noise Acceptance Chart

4.3 United Kingdom

The UK Noise Association has extensively studied turbine noise issues. From *Location, Location, Location, An investigation into wind farms and noise by the Noise Association,* by John Stewart (Ref. 12):

> Wind Farm Noise – the impact on areas of low background noise:
> Mid Wales -a land of hills and valleys. A place where the wind blows frequently and the population tends to be thinly spread. Ideal for wind farms. And, not surprisingly, many are planned. **The best place very often for the turbines to catch the wind is close to the top of a hill.** It means that the wind turbines can be at their most productive. But it also means that the **noise may cascade down the surrounding valleys.** To makes matters worse, many of the scattered hamlets within the valleys snuggle into corners protected by the hills and the mountains where the background noise level is very low indeed. **You only need to visit these areas to hear the 'swish, swish, swish' of the turbines – particularly downwind – over a mile away from the wind farm.**
>
> (emphasis added)

The description of Mid Wales above somewhat describes the siting area for the Lambert's East End. The prevailing (urban) UK national guidelines for noise limits are (from Stewart):

• Daytime noise levels outside the properties nearest the turbines should not exceed 35-40 dB(A) or 5dB(A) above the prevailing background, whichever is the greater.
• Night noise limits outside the nearest property should not exceed 43 dB(A) or 5dB(A) above the prevailing background, whichever is the greater.

But in areas like Mid Wales, the guidelines are deemed by the UK Noise Association to give noise levels too high. Likewise, a lower noise threshold limit, in the 35 dBA range is to be anticipated for the Lambert's East wind farm project.

Further corroboration pertaining to Scotland siting comes from Dick Bowdler, "a noise and acoustic consultant for more than 30 years and most of my current work is dealing with the assessment of environmental noise as it affects residential properties. I work equally for those potentially creating noise and those affected by it. I have been a supporter of wind energy and other forms of renewable energy for some 35 years." (Ref.. 13) Continuing, he says:

> In practice, in most rural areas, my rule of thumb is that **the nearest turbine needs to be at least 1¼ miles from any house**. However, these are areas where the background noise level can be 20 dBA at night. You suggest that **your background noise level could be 30-32dB. This seems a likely figure if you have 350 houses in the area,** though I suspect it could be a bit lower than this. On this basis, noise from the wind farm should not exceed 35dBA. **If the developers are suggesting that 55 decibels is acceptable, this is quite outrageous.** 55dBA is more than four times as loud as your background noise.
>
> Most of the Scottish wind farms that have recently been approved have no housing closer than about 1 mile, except where the house belongs to the landowner of the wind farm site. There are a few applications with houses as close as about 2000 feet but these have all either been turned down or withdrawn by the developer.
>
> I am not familiar with the GE turbines, but I suspect that they have a sound power level of about 105dBA. In this case, the noise level would be between 45 and 50 dBA at 1400 feet in neutral weather conditions and if the nearest turbines were in full view.
>
> (emphasis added)

The GE turbines Bowdler cites have very similar noise output as the proposed Vestas. Note that Bowdler predicts a 45-50 dBA sound propagation of over 400 m. in neutral weather (ie no sound 'focusing'), already in excess of AMEC's simple analysis.

4.4 Sweden

The Swedish Environmental Protection Agency (SEPA) published a report "Noise Annoyance from Wind Turbines – a review" (Ref. 14). This report "reviews the present knowledge on perception and annoyance of noise from wind turbines in residential areas as well as in recreational areas."

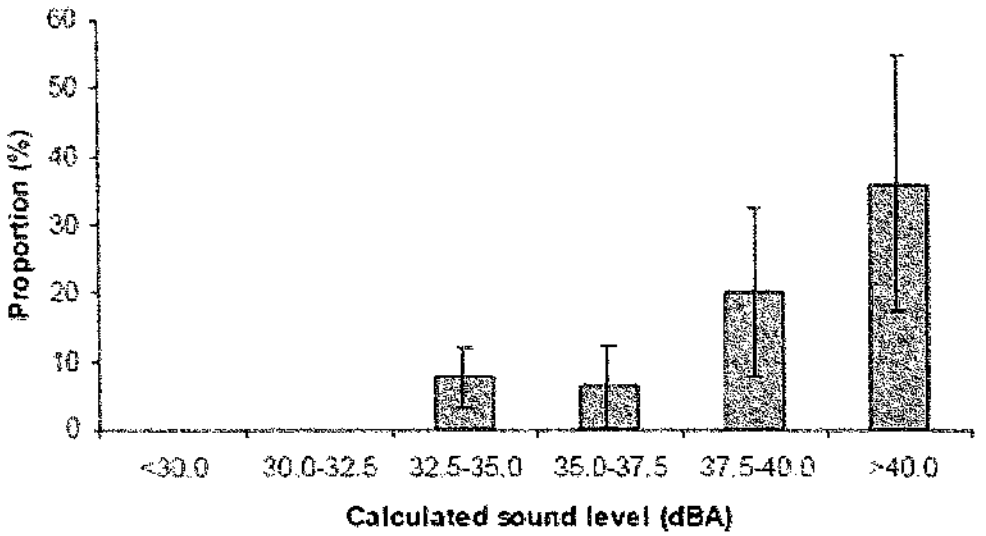
The study relates information useful for two criteria: perception and objection. Each receptor location, turbine location, vegetation and terrain may have a marked impact on turbine noise perception. This is particularly important in geographies having many undulating hills. From the study:

> Topographical conditions at site have importance for the degrees to which the noises from wind turbines are masked by the wind. **Dwellings that are positioned within deep valleys or are sheltered from the wind in other ways may be exposed to low levels of background noise, even though the wind is strong at the position of the wind turbine** [Hayes 1996]. The noise from the turbine may on these conditions be perceived at lower sound pressure levels then expected. Current recommendation state that measures and sound propagation calculations should be based on a wind speed of 8 m/s at 10 meter above the ground, down wind conditions, creating a "worst case" scenario.
>
> (emphasis added)

Also this study categorized the objection to noise by a well composed, statistically valid survey of a variety of residents near a moderate-power (600 KW/unit) wind turbine installation. The study setup parameters are given below, followed by Fig. 4, a "chart of annoyance" from the report summarizing the results.

> The Swedish study was performed in Laholm during May-June 2000. The areas chosen comprised in total 16 wind turbines thereof 14 had a power of 600 kW. The study base comprised one randomly selected subject between the ages of 18 and 75 in each household living within a calculated wind turbine sound pressure level of 25 to 40 dBA (n=518).
> The annoyance was measured using a questionnaire. The purpose of the study was masked and among questions on living conditions in the countryside, questions directly related to wind turbines were included. Annoyance from several outdoor sources was asked for regarding the degree of annoyance both outdoor and indoor. Annoyance was measured with a 5-graded verbal scale ranging from "do not notice" to "very annoyed". The same scale was used for measuring annoyance from wind turbines specifically (noise, shadows, reflections, changed view and psycho-acoustical characters). The respondents' attitude of the impact of wind turbines on the landscape scenery and the attitude to wind power in general were also measured with a 5-graded verbal scale, ranging from "very positive" to "very negative". Questions regarding living conditions, health, sensitivity to noise and employment were also included. A total of 356 respondents answered the questionnaire, which gave a total response-rate of 69%.
> For each respondent calculated A-weighted sound pressure level as well as distance and direction to the nearest wind turbine were obtained. Sound pressure levels (dBA) were calculated at 2.5-decibel intervals for each household. The calculations were done in accordance with [Naturvårdsveket 2001] and reflect downwind conditions. Data of distance between the dwelling of the respondent and the nearest wind turbine, as well as the direction, was obtained from maps.
> The correlation between noise annoyance from wind turbines and sound pressure level was statistically significant (r_s=0.399; n=341; p<0.001). **The annoyance increased with increasing sound pressure level at sound pressure levels exceeding 35 dBA.** No respondent stated them selves very annoyed at sound pressure levels below 32.5 dBA (Fig. 1). **At sound pressure levels in the range of 37.5 to 40.0 dBA, 20% were very annoyed and above 40 dBA 36%.** The confidence intervals were though wide; see Figure 1.
>
> (emphasis added)
> *Noise Annoyance from Wind Turbines – a review* (Ref. 14, *ob cit*)

Note that about 40% of the participants find turbine sounds above 40 dBA "very objectionable". Even 32.5-35 dBA are "very objectionable" to 10 % of respondents. This study should serve as a direct warning that residents will strongly object to the Lambert's East Wind Farm, if sited as planned. After turbine farms are operational, with finality and permanence, resident "receptors" will have no recourse for any mitigation other than to physically move away, if possible.



The proportions very annoyed by noise outdoors from wind turbines (95%CI) at different A-weighted sound pressure levels [Pedersen and Persson Waye 2002].

Fig. 4: Chart of Very Annoyed Respondents

Also of interest from the Swedish EPA study are comments relating to wilderness areas pertaining to some of the Barbados project area:

"3.3 Perception of noise from wind turbines in wilderness recreational areas

The special soundscape of wilderness recreational areas has been described by a number of authors, e.g. [Miller 2001, Dickinson 2002]. **The soundscape differs from site to site and can be very quiet in remote areas, especially when vegetation is sparse** (as in the Swedish bare mountain region). In a comparison between different outdoor settings in USA, it was found that the sound pressure level in a suburban area at nighttime was above 40 dBA, along a river in Grand Canyon 30-40 dBA and at a remote trail in the same park 10-20 dBA [Miller, 2002]. **The effect of intruding sound should be judged in relation to the natural ambient soundscape. The sound pressure level of the intruding sound must be compared to the sound pressure levels of the background noise.** The durability of audibility is another variable of importance for understanding visitors' reactions to noise [Miller 2001].

No studies on noise from wind turbines in wilderness areas have to my knowledge been carried out, but the effect of noise from other sources has been discussed in a few articles. A larger study on noise annoyance from aircraft over-flights on wilderness recreationists was performed in three wilderness areas in USA [Fidell et al 1996].

(emphasis added)

Noise Annoyance from Wind Turbines – a review (Ref. 14, *ob cit*)

There is an additional noise component to wind turbine noise not generally studied but possibly very important, a definite noise modulation effect:

> When listening to a wind turbine, **one may distinguish broadband noise and a beating noise.** Broadband noise is characterized by a continuous distribution of sound pressure. **The beating noise is amplitude modulated, i.e. the sound pressure level rises and falls with time.** This noise is of interest for this review, **as it seems to be more annoying than a non-modulated noise at the same sound pressure level.** Only a few studies have however explicitly compared noises with and without modulations.
>
> ..
>
> Modulated noise from wind turbines has the beat of the rotor blades' pace. The amplitude modulation has in experimental studies found to be most apparent in the 1 and 2 kHz octave band with amplitude of ± 2-3 dB [Dunbabin 1996]. Theories have been put forward regarding the source and extent of the amplitude modulation. One possible mechanism is the interaction of the blade with disturbed airflow around the tower, another the directionality of radiation from the blades as they rotate. Finally it is possible that variation in noise levels occur due to the atmospheric wind profile, which would result in a slight variation in angel of attack as the blade rotates [Dunbabin 1996]. In summery, **the modulation in the noise from wind turbines is not yet fully explained** and will probably not be reduced in the near future **and is therefore a factor of importance when discussing noise annoyance from wind turbines.**
>
> ....
>
> The new turbines erected today often have variable rotor speed. This means that the modulation frequency will be low at low wind speed, typically **0.5 Hz** at 4 m/s and higher at high wind speed, typically **1.0 Hz** at 20 m/s. This is still in the span were **modulations could easily be detected.**
>
> (emphasis added)
>
> *Noise Annoyance from Wind Turbines – a review* (Ref. 14, *ob cit*)

Modulation has been recorded at the Pubnico Point Wind Farm (Ref. 8, *ob cit*). That farm is composed of 17 generators of 1.8 MW capacity (Vestas) arranged in a grid pattern. The generators operate at 16 rpm across their operating range. The three blades therefore give 48 pressure pulses (due to passage by the tower support) or 0.8 Hz, within the human modulation response range. This modulation will propagate long distances and there may be cumulative out-of-phase frequency multiplication across the farm 0.8 Hz x 17 = 13.6 Hz. If some blades operate synchronously the amplitude will give approximately a 4x boost to the sound pressure level. The impulses were detected in the Pubnico study at a strong modulation level of 5 dB (roughly a 2x loudness perception modulation) indicating the possible presence of these coherence effects.

> The three-bladed wind turbines, rotating at about 16 rpm, have a blade pass frequency of about 0.8 Hz. Thus, over 20 seconds, about 16 'swoosh' sounds would be expected, and can be seen in Figure 4a. The influence of the 'swoosh' is clearest at midband frequencies, centered at about 1000 Hz, where the amplitude modulates by about 5 dB.
>
> (Ref. 8, *ob cit*)

The Fig. 4a referred to is a 2-D sound spectrum showing the modulation graphically and is shown below as Fig. 5. Time is on the horizontal axis and sound frequency on the vertical axis. The colors represent the loudness intensity. The "swish" modulation, which is <u>not</u> what is called "infra-sound", is clearly evident in the red colors.

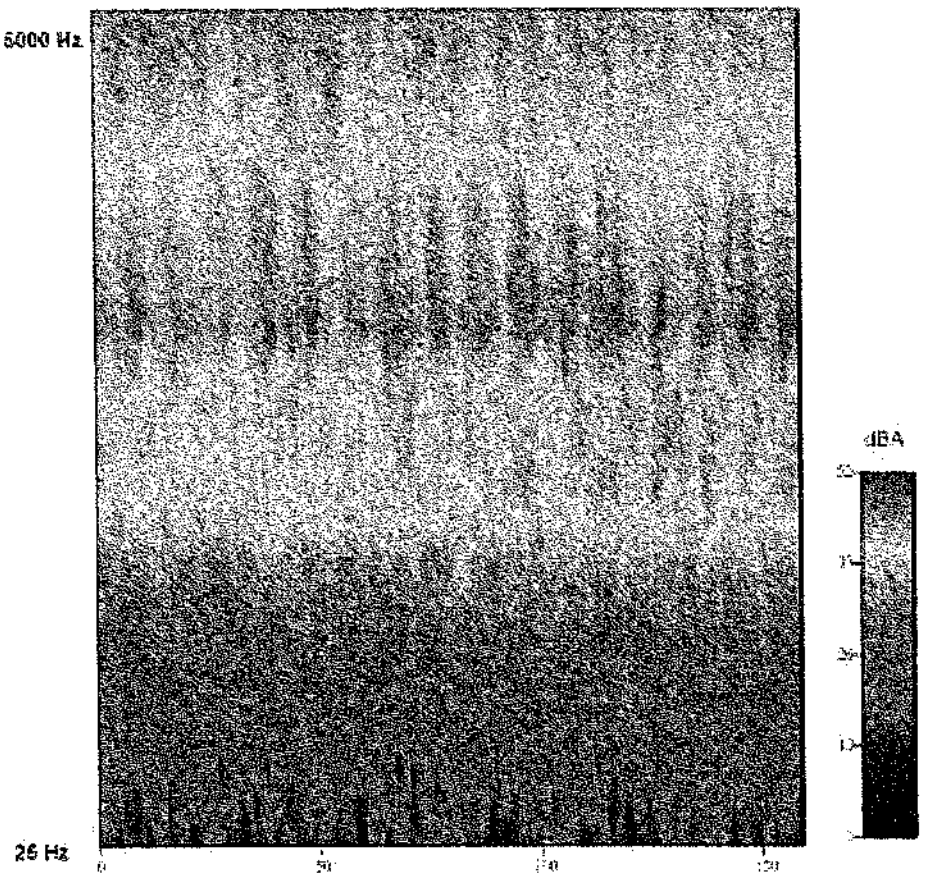


Fig. 5: Sample Spectrum of Noise Modulation (Pubnico Point, *ob cit*)

Strong modulation due to coherence has been noted in at least one other comprehensive study done near a German-Dutch wind farm:

> A second effect that adds to the sound annoyance is that **the sound has an impulsive character**. The primary factor for this is the well known swishing sound caused by the pressure fluctuation when a wing passes the turbine mast. For a single turbine these 1 – 2 dB broad band sound pressure fluctuations would not classify as impulsive. When several turbines operate nearly synchronously the pulses however may occur in phase: two equal pulses give a doubling in pulse height (+3 dB), three a tripling (+5 dB).
>
> (emphasis added)
>
> *Wind turbines at night: acoustical practice and sound research* (Ref. 9, *ob cit*)

A follow-up discussion of the Swedish study is in *Perception and annoyance due to wind turbine noise—a dose–response relationship* by Pedersen and Waye, published in 2004 (Ref. 15):

> Already, turbines are being erected near densely populated areas. Preliminary interviews conducted among 12 respondents living within 800 m of a wind turbine, and a register study of the nature of complaints to local health and environments authorities, indicated that **the main disturbances from wind turbines were due to noise, shadows, reflections from rotor blades, and spoiled views.**

> Furthermore, **noise from wind turbines comprises modulations with a frequency that corresponds to the blade passage frequency** ~Hubbard *et al.*, 1983! **and is usually poorly masked by ambient noise in rural areas** ~Arlinger and Gustafsson, 1988!.
>
> The aims of this study were to evaluate the prevalence of annoyance due to wind turbine noise and to study dose–response relationships. The intention was also to look at interrelationships between noise annoyance and sound characteristics, as well as the influence of subjective variables such as attitude and noise sensitivity.
>
> (emphasis added)

As noted this was a moderate-impact study in comparison to the farm proposed for the Barbados project. The Swedish turbines are a modest 600-660 kw. The study is relevant nevertheless because it focuses specifically on community reaction to wind farms.

> Five areas totaling 22 km² comprising in total 16 wind turbines and 627 households were chosen within a total area of 30 km² (Table I) Subjective responses were obtained through questionnaires delivered at each household and collected a week later in May and June 2000. The response rate was 68.4%. A-weighted SPL's due to wind turbines were calculated for each respondent's dwelling. Comparisons were made of the extent of annoyance between respondents living at different A-weighted SPL's.
>
> Most people live in privately owned detached houses in the countryside or in small villages. The wind turbines are visible from many directions.

The report concludes that there is a much higher annoyance with wind turbines than that associated with other forms of noise such as from aircraft, road traffic or railways (See graph, Fig. 6). The onset of annoyance begins a SPL of 32 dBA sharply increasing to 35% of respondents at 41 dBA. A noise level of 45 dBA as proposed by AMEC would clearly be outrageous to many residents. In trying to explain the differences Pedersen says:

> For wind turbine noise **the main annoyance reaction is formed when spending time outdoors.**
>
> (emphasis added)

As a sub-tropical island most Barbadians spend a lot of time out doors and with their home windows open. They will be particularly subject to turbine noises.

Also:

> Another factor that could be of importance for explaining the seemingly different dose–response relationships is that **the wind turbine study was performed in a rural environment, where a low background level allows perception of noise sources even if the A-weighted SPL are low.** Wind turbine **noise was perceived by about 85% of the respondents even when the calculated A-weighted SPL were as low as 35.0–37.5 dB.** This **could be due to the presence of amplitude modulation in the noise, making it easy to detect and difficult to mask by ambient noise.** This is also confirmed by the fact that the aerodynamic sounds were perceived at a longer distance than machinery noise.
>
> (emphasis added)

There may be a combinatorial effect associated with blade flicker and/or aesthetic degradation:

> Data obtained in this study also suggest that visual and/or aesthetic interference influenced noise annoyance.

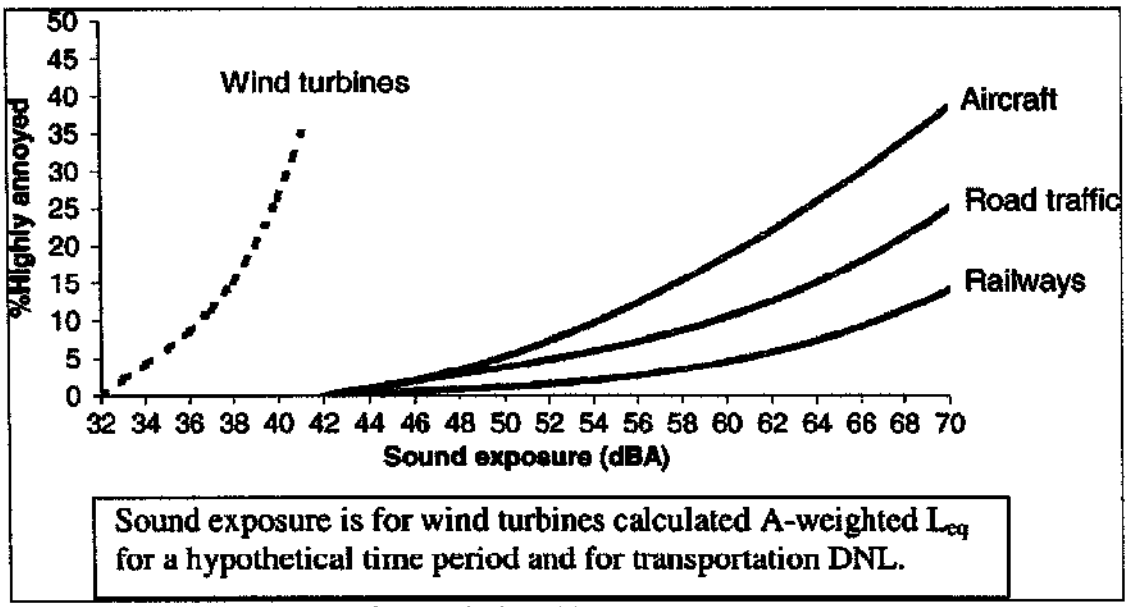


Fig. 6: High Annoyance from Wind Turbines (Pederson 2004, Ref. 20)

Pressure waves created by the blades as they pass by the support tower propagate long distances and are a modulation of sound intensity, not a "noise" *per se* but a loudness variance. This is apparently the main objection to wind turbine "noise":

> The high prevalence of noise annoyance could also be due to the intrusive characteristics of the aerodynamic sound. The verbal descriptors of sound characteristics related to the aerodynamic sounds of swishing, whistling, pulsating/throbbing, and resounding were—in agreement with this hypothesis—**also reported to be most annoying.**
>
> (emphasis added)

4.5 Australia

The Australian findings and requirements mimic those around the world and are much lower than AMEC's conclusions. From *Environmental Noise Guidelines: Wind Farms* (Ref. 21):

> The impact of a given noise is also closely linked to the amount it exceeds the background noise. For example, **the same noise in a quiet rural area will generally have a greater adverse impact than in a busy urban area because of the masking effect of high ambient noise environments.** If the noise generated does not exceed the background noise by more than 5 dB(A) the impact will be marginal and acceptable.

2.2 Noise criteria - new wind farm development
The predicted equivalent noise level (LAeq,10), adjusted for tonality in accordance with these guidelines, **should not exceed 35 dB(A),** or the background noise (LA90,10) by more than 5 dB(A) whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG.

(emphasis added)

4.6 NASA

Noises carry greater distances from elevated noise sources like wind turbines and this has been reported by NASA in a study *Wind Turbine Acoustics* by Hubbard and Shepherd (Ref. 6, *ob cit*) From the Introduction:

> Wind turbine generators... are producing electricity both singly and in wind power stations that encompass hundreds of machines. Many installations are in uninhabited areas far from established residences, and therefore there are no apparent environmental impacts in terms of noise. There is, however, **the potential for situations in which the radiated noise can be heard by residents of adjacent neighborhoods, particularly those neighborhoods with low ambient noise levels.** ...
>
> (emphasis added)

This report contains detailed noise analyses of various wind turbine styles – upwind rotors vs. downwind rotors, blade shape, rotational speed etc. And it includes a detailed sound propagation analysis. Sound "bends" (refracts) in the atmosphere much like light refracts in striking a lens. A graph of the effect, from the report, is shown in Fig. 7 below.

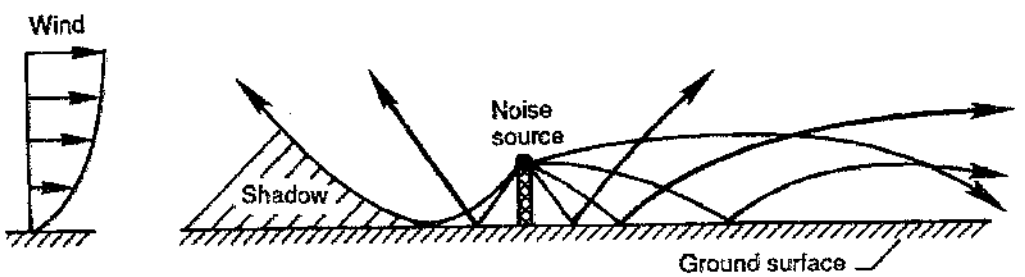


Figure 7-20. Effects of wind-induced refraction on acoustic rays radiating from an elevated point source [Shepherd and Hubbard 1985]

Fig. 7: Sound Refraction Effects (NASA Fig 7-20)

The "Shadow" zone in the figure may explain the observed "quietness" experienced by observers when taken to stand near wind farm. The noises are masked unless the observer is 2-4x the tower height distance. And it underscores the necessity of comprehensive and accurate engineering studies of complex phenomena. Merely relying on anecdotal "I don't hear anything" knee jerk responses to a turbine visit is misleading and hardly equivalent to living year round as a saturated "receptor".

Recall from the Mid Wales description above that turbine sounds carry 1.5 km. The sounds carry further for a "line" of turbines and many wind farms are arranged in linear and row clusters. As mentioned earlier, in this situation sounds diminish at about ½ the normal rate assumed for spherical spreading, or -3 dB/doubling of distance rather than -6 dB/doubling and this is discussed as well in the NASA report.

4.7 W.H.O. Sound Levels for Night Sleeping

The World Health Organization (Ref. 17) has begun conducting comprehensive analysis of the health impairment due to night time noises and disturbance to sleep. Though targeting the effects from aircraft and highway noises the conclusions can be associated with wind turbines since those studies are as yet not started.

The WHO's actual conclusions should serve as a guide and warning, that sleep disturbance is not merely an annoyance and an 'anti-wind turbine' sentiment, but a genuine health hazard.

> Conclusions:
> 8. **There was unanimous agreement that disturbed sleep had serious health** effects – solid evidence existed in sleep medicine, the insomnia model would be used as a proxy and its causes and effects described on the final document.
> 9. The analysis of the evidence suggested **that Lnight outdoor>42 dB(A) induced sleep disturbances.**
> 18. The NOAEL for Myocardial Infarction was Lday = 60–65 dB outdoors **and Lnight outdoors = 50 – 55 dB** for road traffic. [3] (emphasis added)

4.0 Conclusion

An accurate and comprehensive noise analysis is crucial for delineating turbine setbacks to mitigate noise pollution. But clearly the AMEC study is critically flawed. The study must be repeated with far better analysis in terms of a) establishing a reasonable noise criteria that will be protective of the populace. This should include a measurement of ambient background levels using a valid sampling methodology b) reasonable computer

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[3] As the report discusses there is an association between long term noise exposure and heart attack (myocardial infrarction or MI):

> **Sufficient evidence existed for an association between community noise and ischaemic heart diseases;** limited/sufficient evidence existed for an association between community noise and hypertension. Most information came from road traffic noise studies but there was normally little information regarding night noise in particular. But **night time values could be extrapolated from day time results.** **(footnote cont next p)**
> Below 60 dB(A) for Lday there was no noticeable increase in MI risk to be detected. Therefore for the time-being, Lday = 60 dB(A) could be set as the NOAEL ("no observed adverse effect level") for road traffic noise and myocardial infarction (Babisch, 2002). For noise levels greater than 60 dB(A), the MI risk increased continuously, and was greater than 1.2 for noise levels of 70 dB(A).
> *Discussion*
> **Normally CVD effects manifested themselves after 10 years living in a noisy area.**
> (emphasis added)

modeling to show noise contours accounting for likely atmospheric, ground reflection and modulation effects.

Setbacks are reasonably expected to be 1.5 km, minimum, 4x further than the present siting plans. Fig. 8 below is a photo with the wind farm superimposed that shows the closeness of surrounding dwellings within a mere 1 km. Several thousand residents will surely be affected by noise pollution. With the winds predominantly easterly the Josey Hill area will be highest impacted.

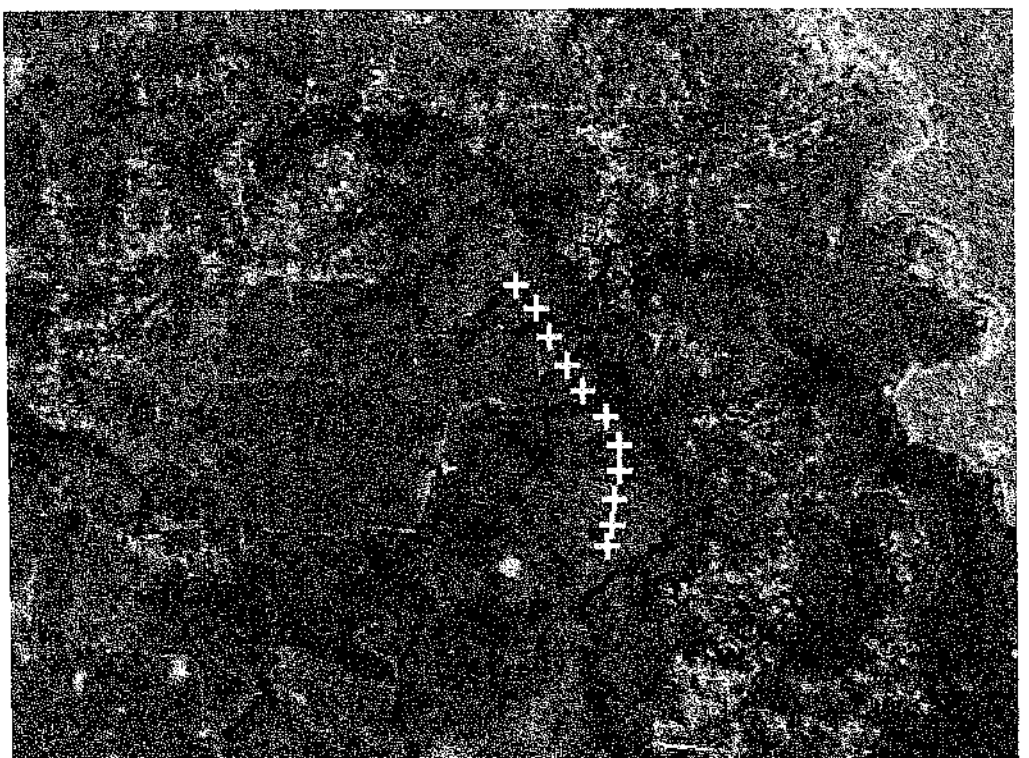

Fig. 8: Lamberts East Wind Farm Relationship to Surrounding Dwellings[4]

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Richard H. Bolton , CV in Appendix 1

[4] Source: Google Earth Map and turbine locations from 7.2-1 of Ref 1.

References

1. *Environmental Impact Assessment, The Barbados Light & Power Company, Ltd, Lamberts East Wind Farm Generating Station, Draft,* AMEC Earth & Environmental, TV 61036, August 2006

2. *Barbados Second National Report on the Implementation of the Convention on Biological Diversity*, March 2002

3. *Environmental Factors and Health (The Danish Experience)*, COWI Consulting Engineers and Planners, Danish Environmental Protection Agency 2001

4. *ISO 9613-2 Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation*, 1996HIS Specs and Standards Service

5. *Mechanical Radiation*, R. Lindsay, Mc. Graw-Hill, 1960

6. *Wind Turbine Acoustics* NASA Technical Paper 3057, H. Hubbard and K.Shepherd ,1990

7. *Modeling Of Noise From Wind Turbines*, Wei Jun Zhu, Technical University of Denmark, Mechanical Department, Feb. 2004

8. *Environmental Noise Assessment Pubnico Point Wind Farm, Nova Scotia,* by Howe Gastmeier Chapnik Ltd. for Natural Resources Canada, Contract NRCAN-06-00046, August 2006

9. *"Wind turbines at night: acoustical practice and sound research"*, F. G.P. van den Berg, presented at Euronoise 2003, Paper ID 160

10. *Community Noise,* US EPA Office of Noise Abatement and Control, by Wyle Laboratories under Contract 68-04-0046, Dec. 31, 1971.

11. *Interpretation for Applying More NPC Technical Publications to Wind Turbine Generators* , Ministry of the Environment, Ontario Canada, Version 1.0, July 6, 2004

12. *Location, Location, Location, An investigation into wind farms and noise by the Noise Association,* by John Stewart, UK Noise Association, London, July 2006.

13. Private communication from Dick Bowdler, New Acoustics Co., Scotland, U.K., to Sue Sliwinski, Oct. 16, 2002, used with permission.

14. *Noise Annoyance from Wind Turbines – a review*, by E. Pedersen and H. Halmstad, Naturvårdsverket, Report 5308, Swedish Environmental Protection Agency, ISBN 91-620-5308-6.pdf, August 2003.

15. *Perception and annoyance due to wind turbine noise—a dose–response relationship,* by E. Pederson and K. Waye, J. Acoust. Soc. Am. 116 (6), December 2004

16. *Environmental Noise Guidelines: Wind Farms*, Australia Environmental Protection Authority, Feb. 2003

17. *Report on the third meeting on night noise guidelines,* WHO European Centre for Environment and Health, Bonn Office Lisbon, Portugal, 26–28 April 2005

Appendix 1

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I graduated from the University of Rochester in 1975 with a B.S. in Physics and subsequently took graduate courses in optics there.

From 1975 to my retirement in 1998 I was a Project Engineer at Eastman Kodak and receive 5 US Patents. Always working in new product research, engineering and development I was often involved in "due diligence" engineering analysis for new product proposals throughout the corporation. This involved considerations of manufacturability, reliability, ergonomics, customer acceptance, and design methodology. My work was cross-disciplinary because of my physics background and my exposure within Kodak to many other scientists and engineers. I often worked in engineering disciplines of optical design, mechanical design, systems design, and product software.

From 1976 to 1986 I had the position of Adjunct Faculty, Rochester Institute of Technology, Physics Laboratory.

From 2005 to present I have been a Technician at Hobart and William Smith Colleges' Physics Department, where I am responsible for laboratory setup, physics equipment parts manufacture, and devising new demonstrations.

I am President of Bare Hill Software Company that develops engineering software for Macintosh and Microsoft personal computers. In that capacity I served as consultant engineer to Eastman Kodak, Corning Glass, and Xerox on various equipment projects.

I am President of the Environmental Compliance Alliance founded to promote public and government agency awareness of New York State and Federal environmental regulations, and promoting agency compliance with those regulations.

In my professional experience I have learned to examine and analyze technical reports, especially with regard to methodological, technical and statistical errors. I recently consulted on a wind turbine project slated for Clinton County in upstate NY. My noise analysis is being used in a proceeding there.

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