AWEA/CanWEA Expert Sound Panel and Wind Turbine Sound Regulations

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Why Establish a Sound Panel?

- Respond to health concerns increasingly raised by wind energy opponents:
  - Infrasound and Low Frequency Sound
  - Vibroacoustic Disease
  - Wind Turbine Syndrome
- No governmental or independent agency was able to review this in a timely manner
- Industry and permitting authorities needed to understand potential issues and address fears

International Multidisciplinary Sound Advisory Panel

- **David Colby**
  - Chatham-Kent Medical Officer of Health (Acting)
  - Associate Professor, Schulich School of Medicine & Dentistry, University of Western Ontario
- **Robert Dobie, MD**
  - Clinical Professor, University of Texas, San Antonio
  - Clinical Professor, University of California, Davis
- **Geoff Leventhall**
  - Consultant in Noise Vibration and Acoustics, UK
- **Dave Lipscomb**
  - Forensic Audiologist. President, Correct Service
- **Robert J. McCunney, MD**
  - Research Scientist, MIT Dept of Biological Engineering
  - Staff Physician, Mass General Hospital Pulmonary Division
- **Mike Seilo**
  - Professor of Audiology, Western Washington University
- **Bo Søndergaard**
  - Senior Consultant, Danish Electronics Light and Acoustics (DELTA)

- Technical Consultant:
  - **Mark Bastasch**
    - Acoustical Engineer, CH2M HILL
- AWEA/CanWEA Project Manager:
  - **Jen Banks**
    - AWEA Offshore Wind and Siting Specialist

Adverse Effects of Sound

- Noise Induced Hearing Loss > 80-85 dBA
- Task Interference > 70 dBA
- Speech Interference
  - Above 80 dBA shouting often required
  - Above 50 to 55 dBA, voices begin to raise
- Sleep Disturbance – guidance varies and is often based on transportation sources
- Annoyance

Infrasound and Low Frequency Sound

- Infrasound from wind turbines is not perceptible and does not exceed levels produced by natural sources.
- Low frequency sounds from wind turbines are not distinguishable from background sounds for frequencies less than 40 Hz.
  - Perceptible levels of low frequency sound may be produced under certain conditions
- The audible swooshing sound is typically in the 500-1,000 Hz range; it is neither infrasound nor low frequency sound.

Vibroacoustic Disease (VAD)

- VAD is noted to result in thickening of cardiovascular structures as observed in airplane technicians and military pilots
  - Extremely high occupational exposure over a period of 10+ years
  - Others found evidence of VAD after 13 weeks of continuous exposure to 100 dB of low frequency sound
- These sound levels are 50 to 60 dB louder than those from wind turbines.
  - “Wind turbines produce low levels of infrasound and low frequency sound, yet there is no credible scientific evidence that these levels are harmful…attribution of dangerous properties to low levels of infrasound continues unproven, as it has been for the past 40 years.” (expert panel)

Wind Turbine Syndrome (WTS)

- Dr. Nina Pierpont conducted telephone interviews with 10 families, who reported:
  - Sleep disturbance
  - Headache
  - Internal quivering, vibration, or pulsation
  - Concentration and memory
  - Irritability and anger
  - Fatigue and motivation
- Hypothesis:
  - Low levels of airborne infrasound affect the vestibular system or cause vibrations in internal organs (Visceral Vibratory Vestibular Disturbance – VVVD)

WTS?

- The proposed pathophysiological pathway is not plausible:
  - Low levels of sound from outside the body are not sufficient to exceed levels within the body
  - Vestibular organs respond to head position and movement, not airborne sounds emitted by wind turbines
- “There are no unique symptoms or combinations of symptoms that would lead to a specific pattern of this hypothesized disorder” (expert panel).

Annoyance

- WTS symptoms are similar to those of noise annoyance that are exhibited by a small proportion of sensitive persons to low level sounds.
- Potential for annoyance is not unique to wind turbines and depends on various acoustic and non-acoustic factors .

Expert Panel Conclusions

Unanimously endorsed:

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

Ontario Health Dept - May 2010

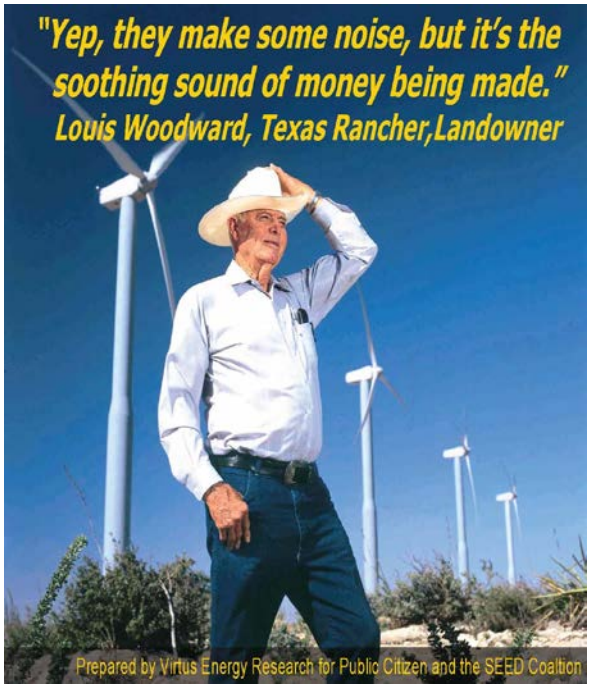
- The scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects.
- Low frequency sound and infrasound from current generation upwind model turbines are well below the pressure sound levels at which known health effects occur.
- Community engagement at the outset of planning for wind turbines is important and may alleviate health concerns about wind farms.
- Concerns about fairness and equity may also influence attitudes towards wind farms and allegations about effects on health. These factors deserve greater attention in future developments.

Wind Turbine Sound and Permitting

- If not handled properly, concerns over sound may complicate both permitting and operations.
  - When does a sound become a noise and an issue?
  - What are the issues?
  - What types of studies are necessary?
  - What additional research would be helpful?
  - How is noise regulated?

" Soothing Sound of Money Being Made?"

- Noise is "unwanted sound"
- Perception of noise is subjective
- Not likely an issue for INFORMED "project participants"
- Some may always be annoyed
- Annoyance increases as noise level increases
- Annoyance ≠ Impact
- Compliance ≠ No Annoyance



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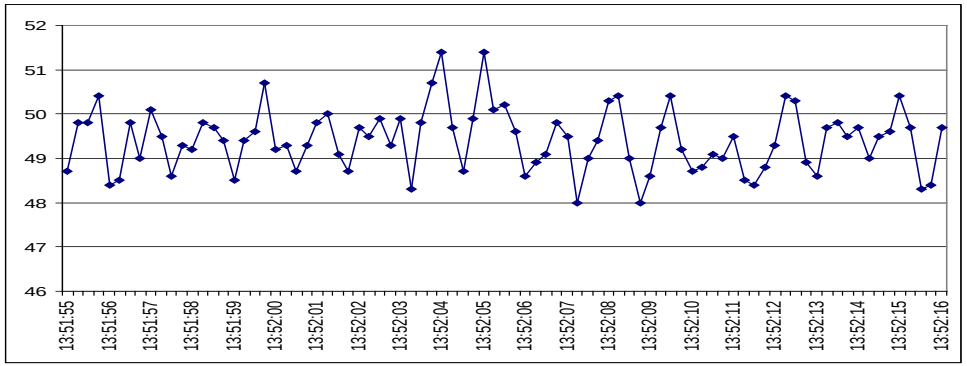
Characteristics That May Increase Annoyance

- Tonal Noise
- “Impulsive” or excessively amplitude modulated
  - Confusion between Infrasound, Low Frequency, and Amplitude Modulated noise (swish, swish)
  - “A time varying sound is more annoying than a steady sound of the same average level” – Dr. Geoff Leventhall
  - Amplitude modulation is area of research in the U.K.



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When is Noise a Potential Issue?

- Proximity to homes, schools, hospitals or other noise sensitive areas
- High wind shear (fast winds at hub height, calmer winds below)
- Homes in sheltered valleys
- Stall regulated turbines (older technology)
- Condition of homes (insulation, windows)
- Opposition to overall project

What Types of Studies Are Required?

- When is modeling required?
  - Does permitting process require noise be assessed?
  - Are there noise limits?
  - How close are the compliance points?
  - How close are the receptors? How many turbines?
- What type of modeling is required?
  - Most are based on ISO9613-2
  - Based on vendor sound power level data
    - Near cut-in, when background levels are typically low
    - Maximum sound power level
- When is Monitoring Required?
  - Pre-project, mandatory compliance monitoring or only in response to complaint?

Relative Importance of Noise and Drivers for Noise Control

- Noise is increasingly recognized as an important factor in the development and deployment of Wind Turbines
- Increasingly competitive marketplace
  - IEC 61400-11 allows for comparison between manufacturers
- Compliance with regulatory limits
  - Every dB increase in turbine sound results in greater setback distance
  - Reduced project size for louder turbines

Potential Sound Research

- Wind farm sound measurements at residences:
  - Development of “certified” equipment or standardization of windscreens
  - Development of wind farm-specific measurement protocol
- Develop more effective comparisons or demonstration tools (simulations) to educate the public and decision makers?

Potential Sound Research

- Address concerns regarding potential short-term increases in sound level for less-than-optimum flow conditions
  - Dirty blades, ice, excessive turbulence or wake effects
- Amplitude Modulation (AM): Swishing sound characterized by rise and fall in sound level
  - Limited instances of substantial AM have been documented.
  - AM is a concern and is being further evaluated in the U.K.
    - What is a reasonable level of AM?
    - How should it be quantified and what can be done to predict or mitigate?

Potential Sound Research

- Increase number of credible, scientifically and rigorously peer reviewed or government publications
- Address the health and annoyance concern
  - Consider typical limits (40 to 50 dBA)
  - Consider sleep disturbance and annoyance from wind farms, as well as other sources of noise
  - Expand on Swedish/Dutch studies (WindfarmPERCEPTION) with emphasis on improved determination of acoustic levels and improved dose/response relationship

Wind Farm Sound Planning

- Non-acoustic factors may be as important as acoustic factors
  - Visibility and attitude toward source
  - Good public relations and outreach imperative
  - Understanding need and importance of the source
  - Field trips to operating facilities are helpful
  - Silence is not a reasonable goal **nor should it be implied**
  - Ensure local community and landowners understand benefits

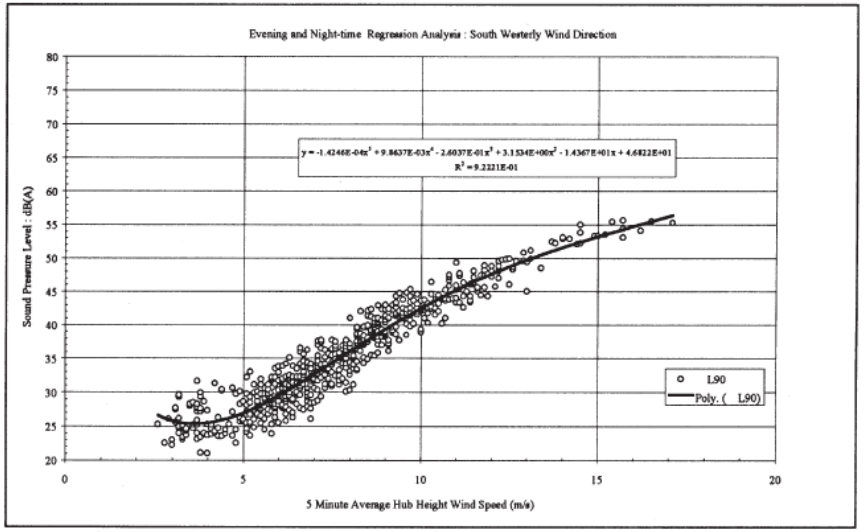
Community Acceptance

- In quiet rural areas, wind turbines can and will be heard for a considerable distance.
  - Audibility has not been the basis for determining significant impact
- What level of noise is reasonable to balance “residential amenity”?

U.S. State Regulations – All Noise Sources

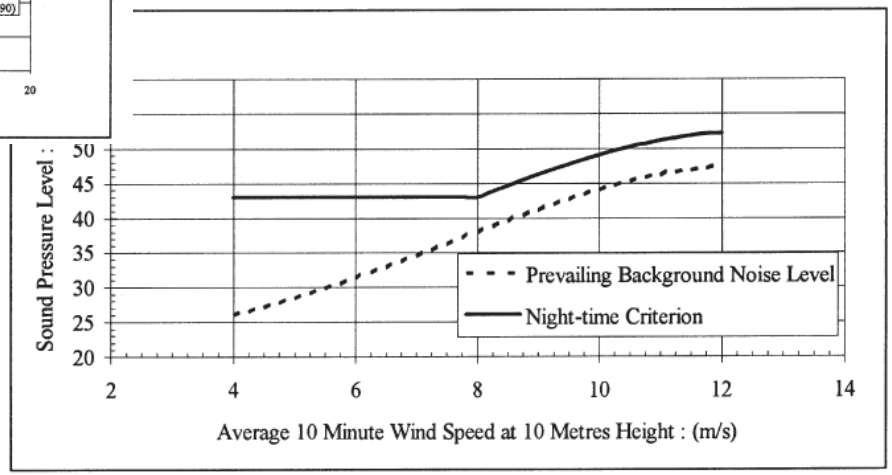
- According to a 1990s survey of states:
  - Only 13 had state regulations – for any sources, not just wind turbines
  - 5 of those 13 had them “on the books” but did not enforce
  - Even though it is “not enforced,” state permitting process may require compliance
- Some states do not have regulations, but have guidance or model ordinances (New York and California)
- Poorly worded and ambiguous regulations
- Primarily rely on median (L_{50}) or equivalent (L_{eq}) average dBA
- Concerns over Wind Turbines are causing many communities to evaluate their noise regulations.

Relative and Absolute Criteria



Increase over what? Need to define existing level.

(scatter has proved to be more significant than depicted here)



Is 15-dB increase OK, when result is less than 45 dBA? What is maximum level acceptable?

Is wind to be treated differently than other sources?

Example of night-time noise criterion

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Wind Turbine Sound Regulatory Approaches

- Limit:
  - Absolute maximum sound level
  - Relative increase or change in sound level
  - Combination of both approaches
- Oregon, USA
  - 10 dBA L_{50} increase or 36 dBA unless neighbors agree to higher level (noise easement)
  - Maximum allowable level of 50 dBA

Wind Turbine Sound Regulatory Approaches

- New Zealand (NZS 6808, 2010)
  - **Greater of** 40 dB $L_{A90(10min)}$ or the existing background ($L_{A90(10min)}$) by more than 5 dB at noise sensitive locations
    - Additional restrictions for special "high amenity areas" during the evening and nighttime hours, but these limits should not be less than 35 dB $L_{A90(10min)}$.
  - Penalties for "Special Audible Characteristics": tones and excessive amplitude modulation
  - Restrictions addressing infrasound, low frequency noise or ground-borne vibrations *are not justified*.

Wind Turbine Sound Regulatory Approaches

- The Netherlands
  - Importance of Renewable Energy was acknowledged
  - National goals could not be met with more restrictive limits
  - "Health Based Guidelines": Based on evaluation of Dutch and Swedish studies including WindfarmPERCEPTION study.
  - Wind Turbines Sound Calculated Annual Average Levels:
    - L_{den} (47 dBA) (day-evening-night level, European Union metric)
    - L_{night} (41 dBA) - nighttime level to limit sleep disturbance

Wind Turbine Sound Regulatory Approaches

- The Netherlands (continued)
  - 8% potentially highly annoyed indoors from wind turbines
    - Similar % to other sources (planes, trains, automobiles)
  - No sound level measurements are required.
    - Modeling is similar to ISO 9613-2
    - Annual average calculation considers variability in wind speed and wind direction
    - 41 dBA L_{night} considered World Health Organization guidelines

Wind Turbine Sound Regulatory Approaches

- The Netherlands (continued)
  - Regulation is based on dose-response relationship developed specifically from studies of wind turbines in the Netherlands
  - No need to specifically address “special audible characteristics” (tonality, amplitude modulation, low frequency noise)
    - WindfarmPERCEPTION and other studies already considered these potential concerns


Thank you.
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