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Addressing Wind Farm Noise Concerns

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THE acoustic ecology INSTITUTE
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Variable community responses to wind farm noise

Variable community responses to wind farm noise

Are concerns about turbine noise hurting wind's brand?

Siting controversies can undermine wind energy in the minds of citizens and local decision-makers

Bird and bat mortality have long been a key public concern

As with bats and birds, noise is being raised as an issue nearly everywhere, even though problems arise only in certain types of project areas

Noise concerns have become a primary consideration during planning, permitting, and operation of new wind farms in an increasingly wide range of communities

Wisconsin Minnesota Michigan Massachusetts California Connecticut Maine Vermont New York Oregon Ontario Ohio Illinois Arizona Nebraska *(even Wyoming!)*

Are concerns about turbine noise hurting wind's brand?

Two things to stress:

NOT talking here about health effects claims
Just looking at community acceptance of audible turbine noise as a new presence in local soundscapes

Post-construction noise issues occur in only a small minority of new wind projects
Most wind farms are far from nearly all non-participating homes

Projects in areas with higher population densities – rural bedroom communities or neighborhoods in towns – seem to generate the most reactions

Are concerns about turbine noise hurting wind's brand?

In towns with issues, how many people are *actually* upset?

Broad community acceptance is not the whole story
Commonly find 70-85% wind approval in town or county as a whole

How do those living *close* to the new source of community noise react?
Within a half mile or so, 20-40% of residents can be upset *about the noise*

This is the seedbed for the backlash we're now dealing with

Even the Gold Standard of community annoyance surveys shows this dichotomy:

Pedersen et al: 3 studies, 1700 people
(Scandinavia 2000-2007; **annoyance = 4 or 5**, on 5 point scale)
8-9% noise annoyance among all those surveyed (out to 1 or 1.5mi.)
But: 22% of those who can hear turbines
In rural areas: 30-40% of those who hear 40dB or more

Are concerns about turbine noise hurting wind's brand?

No matter how common or how unusual noise problems may be,
building closer to more homes creates a need to reduce the sound output of turbines

"It's on the top of the minds for all manufacturers. We're all doing things to reduce the amount of noise that's generated."

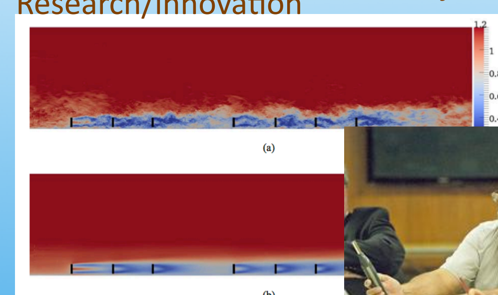
Paul Thompson, Mitsubishi
North American Windpower, July 2011

So: How is the industry addressing concerns about wind turbine noise?

Operational adjustments


Photo: Charlotte Goodhue Courier-Gazette, Rockland, ME

Research/innovation



Graphic: M. Churchfield, 2012 Eddy simulation, Lillgrund wind farm


Photo: The Daily Telegram, Adrian MI

Working with communities

Working with communities: **creating realistic expectations**

"You won't hear it"
Residents 1/2 - 3/4 mile away
(Turbines routinely clearly audible, sometimes intrusive)

Wind in trees equal to or louder than turbines
(yet: masking requires similar frequency spectrum; often less wind noise on ground)

Experience tells us people live even closer with ease
(yet: steadier winds in ranch country, more turbulence and low clouds here; more noise sensitive than turbine hosts)

Working with communities: **creating realistic expectations**

"I don't think you'll hear it most of the time"
Residents 1 to 1 ½ miles away
(Turbines faintly audible on still mornings and winter days, never intrusive)

Takes into account variability/uncertainties
Ridge to valley wind/ambient noise factors
Variability of source levels and propagation

Working with communities: **understanding averages & peaks**

Projects can operate in compliance……
generally based on average sound levels
….yet generate widespread community complaints
triggered by peak sound levels

David Hessler: Best Practices Guidelines, 2011
National Association of Regulatory Utility Commissioners

"Extensive field experience measuring operational projects indicates that sound levels commonly fluctuate by roughly **+/- 5 dBA** about the mean trend line and that short-lived (10 to 20 minute) spikes on the order of **15 to 20 dBA above the mean** are occasionally observed"

*We can expect peaks of **10dB over the mean** will thus occur somewhere between "commonly" and "occasionally"*

Working with communities: **adapting to population density**

Some annoyance appears as turbines become audible (30-35dB)
(in the more noise-sensitive communities)
and becomes more widespread as noise levels approach 45dB

Annoyance rates can reach 20% or more when mean sound levels are 40-45dB
When there are relatively few homes in this range, noise issues are minimal

When 100 – or 200 – homes are in this range, dozens of complaints can ensue
(Hardscrabble, Falmouth)

Hessler thus **recommends an ideal design goal of 40dB** (24-hr mean) **or less at residences in more populated areas, and feels 45dB offers a good balance** "as long as the number of homes within the 40-45 dBA range is relatively small."

(i.e., aiming to assure that relatively few people live in the higher annoyance zone)

David Hessler (2011). Best Practices Guidelines for Assessing Sound Emissions From Proposed Wind Farms and Measuring the Performance of Completed Projects. Prepared for the Minnesota Public Utilities Commission, under the auspices of the National Association of Regulatory Utility Commissioners (NARUC). October 13, 2011.

Operational adjustments

Reducing the sound levels of turbines
in more populated areas

Post-construction noise mitigation
in areas where complaints arise

Pre-construction noise modeling
to facilitate preferred turbine layouts
and to meet lower night-time or populated area noise limits

Operational adjustments
Aerodynamic blade noise


Photo: Charlotte Goodhue, Courier-Gazette, Rockland, ME

Serrated edges

Sandia research suggests 3-8dBA reductions
(Barrone, 2011)

Fox Islands Wind retrofit to reduce sound levels for neighbors

Neighbors report less lower-frequency thumping, perhaps a slight increase in higher-frequency whoosh
This would be consistent with Sandia study, which found serrations reduce lower frequencies and slightly increase >2kHz

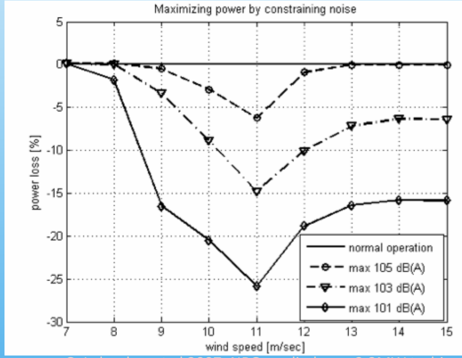
Operational adjustments
Aerodynamic blade noise

NRO: Noise Reduced Operation

Computer controlled adjustment of blade pitch and RPM
Options allow choice of noise reduction, typically from 1-5dBA

Power loss is minimal (<5%) in moderate winds at 1-2dB reduction; power loss increases (up to 25%) with higher winds and more dB reduction

Routine (close siting)
Night (lower noise limits)
Conditional (wind speed/directions that increase noise at receptors)



G. Leloudas, et al 2007; NRO applied on a 2.3MW turbine

Turbulence research:
noise reduction as secondary benefit of innovation

inflow turbulence / turbine wakes / directional wind shear

Primary drivers for turbulence research:
Reducing blade loads (system wear/fatigue; facilitating longer blades)
Minimizing power losses

Many of the most troublesome aspects of turbine noise for neighbors seem to be associated with likely turbulence effects
"Knocking" "Banging" "Sneakers in drier"
Deep rumbling low frequency noise

These more intrusive sounds and harder-to-ignore sound qualities are key drivers of negative attitudes toward turbines, making it more difficult to accept and live with typical gentler turbine sounds

The relative lack of turbulence in open, flat ranch country may contribute to the lower incidence of noise issues (more consistent sound, less intrusive sound qualities)

Turbulence research:
noise reduction as secondary benefit of innovation

Adaptive blade design to reduce transient loads in turbulence
Sandia National Lab / NREL / turbine manufacturers

Passive Load Mitigation

Modern materials
Carbon fiber integrated as targeted component in blade core designs

Innovative blade geometries
"Bend-twist coupling"

Good first step forward from reducing stress primarily by adjusting pitch angle

Active Aerodynamic Load Control (AALC)
Electronic sensors instantly trigger discrete blade flaps

Sandia SMART blades

Other flap and flexible blade tip designs

Blades respond to local load variations along blade length, relieving transient pressures

Turbulence research:
noise reduction as secondary benefit of innovation

Turbine wake research

Sandia SWiFT facility
Lubbock, TX
Being built to study turbine wake interactions; will include acoustic data

NREL wake research
60-70% decrease in power output behind first row of turbines (Churchfield, 2012)

Complex shear research

NREL directional shear studies looking beyond "the narrow definition of shear (change in wind speed with height)... Directional shear can be 20-40 degrees or more…and can impart considerable stress on the turbine infrastructure"

Jeffrey Freedman & Kathleen Moore (2012). Wind Shear and Why it Matters. North American Windpower, Volume 9, Number 5, June 2012, p.48-51.

Turbulence research:
noise reduction as secondary benefit of innovation

<u>2012 DOE report</u>
What we know
What we need to know

Working groups summarize
- current state of knowledge
- complicating factors
- desired next steps

at several scales:
Regional atmospheric
Wind-farm scale
Single-turbine scale
down to mm-scale interactions with blades!

Working with communities:
place identity

"one size fits all" siting becoming more difficult

Wide range of recent local wind farm ordinances
From the **familiar and generally accommodating** (1000-1700 ft)
To the **effectively exclusionary** (2 miles)
With many **attempts at a "happy medium"** (2500-4000 ft)

Why such a variability?

Place Identity

Working landscape	**Tranquil refuge**
Rural areas are places for economic activity and technological development/ experimentation; we like big machines!	Rural areas are places for peace and restoration; we chose to move far from background road or other constant noise!
Turbine sound is relatively insignificant compared to what we're used to, and is easy to live with	**Turbine sound is an intrusion**, often the loudest thing we hear and so randomly variable it just gets under our skin

Working with communities:
adapting to local differences

Developers willing to work with a variety of setback and noise limits will have far more opportunities

Focus on less contentious regions

Most new wind farms are still built far from non-participating homeowners and with <u>hosts who don't mind some noise</u>

Ranchers and working farmers remain willing and eager hosts

Seek sites with few homes close enough to hear

Work with towns to forge a <u>win-win approach for noise sensitive areas</u>

Oregon wind farms built with 36dBA
Record Hill Wind, Roxbury ME

Continue current practices and be prepared to spend time/money addressing noise concerns

Proactive pre-proposal <u>community engagement</u>
Gratiot County Wind (MI), Blue Creek Wind Farm (OH)
<u>Possible heated resistance</u>: appeals/litigation
Cape Vincent (NY), Mars Hill (ME), Kent Breeze (ONT)
Possibility of post-construction mitigation of <u>complaints at margins of noise criteria</u>
Pinnacle (louvers), Hardscrabble (experimental NRO), Fox Islands (serrated blades, NRO)

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The extended paper on this topic in the REW NA proceedings includes much more detail and full references
This presentation and paper are available at the link below

AEI Wind Farm Noise Resources
AcousticEcology.org/wind

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