Interim Results: Health and Safety Impacts from Large-Scale Wind Turbines

Prepared for the Municipality of the County of Kings

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Presented at the Special PAC Meeting (1pm, April 23, 2012)

Scope of our work

- **Objectives**
  - Provide independent technical advice on risks to health and safety
  - Be supportive of the ongoing review of the MPS / LUB which looks at costs and benefits overall
  - Align current research with anecdotal reports
  - Present a balanced overview of current understanding
- **Limitations**
  - No review of existing proposals in Kings County
  - Based on current literature and application to local context
  - Focus on health and safety only
  - Short time frame of contract – March 2, 2012 award

Resources

- **Recent work in US (both issued January 2012)**
  - *Wind Turbine Health Impact Study by Independent Expert Panel*. Prepared for Massachusetts Department of Environmental Protection and Department of Public Health.
  - *Strategic Health Impact Assessment on Wind Energy Development*. Prepared by Office of Environmental Public Health, Oregon Health Authority.
- **Bibliography of other resources**
  - Over 130 other sources reviewed: literature (both peer and non-peer reviewed) + government guidance + project specific reports
  - Includes review of submissions by residents to the Municipality

Wind Energy in Kings County

- Projects in early stages of proposal
  - Two ComFIT projects – distribution sized; community owned
  - One larger project – independent power producer; competitive bid
- Council decided to re-review given public concern on potential projects
- Potential risk to health and safety is but one aspect under review

Social consent is a key indicator of reported levels of stress and annoyance by wind farm neighbours

Approvals Processes

- **Municipal**
  - Land use planning and issuing necessary permit
  - Currently, Kings has as-of-right in certain zones with 700m separation distance from dwellings (May 2011)
- **Provincial**
  - Nameplate capacity of 2MW require an environmental assessment (EA); this includes noise
- **Federal**
  - Federal departments, such as Health Canada, will provide expert advice as part of NS EA process, e.g., noise

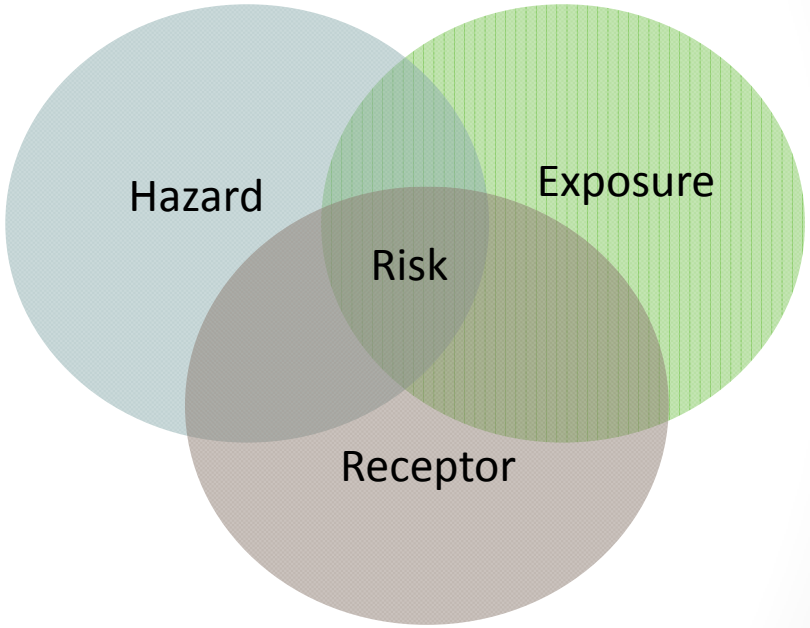
Risk to Human Health and Safety

Three items required to constitute a risk:

Hazard/Dose Response – agent or stressor needed to cause adverse impact

Exposure – sufficient amount or intensity of hazard experienced by a receptor

Receptor – resident



Context of Health Risks

- Function of frequency and intensity of human exposure to hazard
- Acceptable levels of risk determined on hazard-by-hazard basis
- For example, pesticides in drinking water
  - Health Canada has guidelines based on dose-response relationship
  - Science based but have uncertainty – some are unknown
- Never is there “no risk” yet we accept risk where benefit
- Difficult to untangle an association between noise from wind turbines and annoyance independent from visual impacts

Decision makers must weigh benefit and risks of wind turbines

Scoping of H&S Impacts

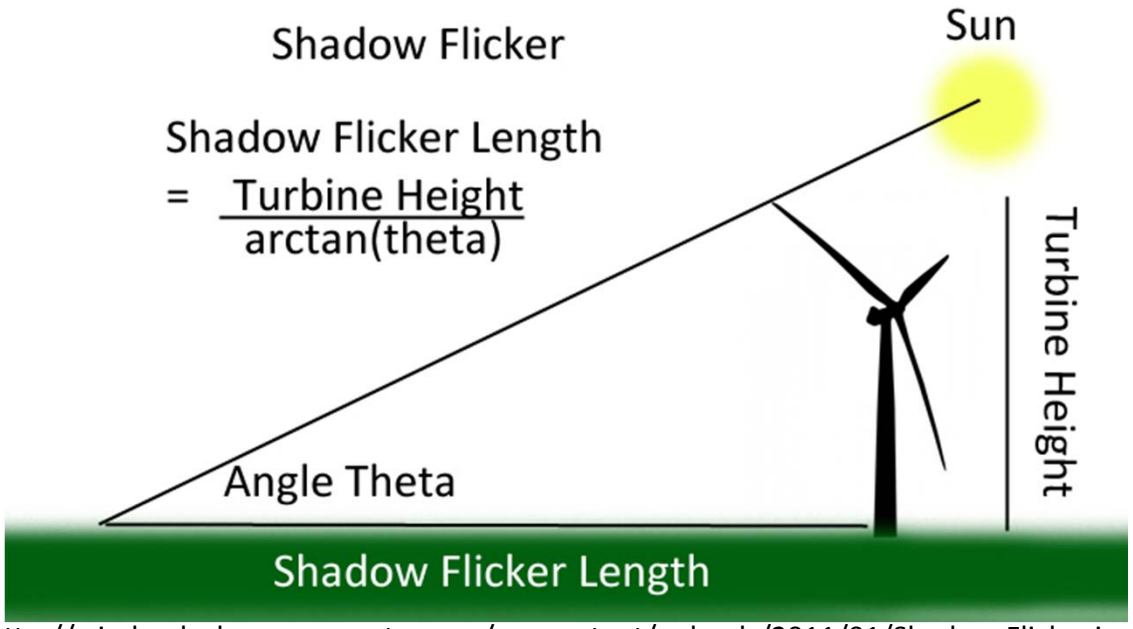
1. Audible noise
2. Electromagnetic Fields
3. Flight Safety
4. Ice Throw
5. Livestock
6. Low Frequency Noise and Vibration
7. Safety during Construction
8. Shadow Flicker
9. Stray Electrical Charge
10. Unplanned Events During Construction
    - fire, lightening, hydrocarbons and structural failure/blade throw

Ice Throw – Impact and Risks

- Ice may form on turbines – like any large structure
- Physical risk if people/structures in area of potential ice throw
- Vibration sensors to turn off turbine when ice build up
- Two scenarios:
  - Ice falling from stationary structure is blown by high wind
    - Likely no more than 100m
  - Ice thrown from operating turbine
    - Likely farther due to speed of rotor, length of blade, etc.
- Formula derived (MA Panel)
  - $x_{max,\ throw} = 1.5\ (2R + H)$

Shadow Flicker: Background

- Effect when operating wind turbine is between sun and receptor – depends on season and time of day
- Frequency is about 0.5 to 1.1 Hz (based on rotational speed)



http://windandsolarenergycenter.com/wp-content/uploads/2011/01/Shadow-Flicker.jpg

Shadow Flicker: Impact & Risks

- Impact will not exceed 1400m; more intense to about 400m
- Not a trigger of epileptic seizures as photosensitivity is typically 16 to 26 Hz, with lowest of 10 Hz
- Prolonger shadow flicker can result in transient health effects, i.e., >30minutes per day
- Direction of impact zone a function of orientation of turbine and sun – minimize impact via siting
- Calculate the estimated flicker distance given the formula:
  - $x_{max,\ flicker} = 2R * 10$
- Accepted maximum duration of 30min /day and 30 hr per year

Audible Noise: Background

- Noise is unwanted sound
- Perceived as both frequency and amplitude
  - Typical human hearing is 20 to 20,000 Hz
  - Sound pressure level as A-weighted decibel (dBA)
  - Wind turbines: ~ 100dBA at hub and decreasing over space

Source: Pembina Institute (http://www.pembina.org/docs/re/web-eng-wind-factsheet.pdf)

Audible Noise: Nature of Impact

- Sound pressure levels decrease with distance from source:
  - Climatic conditions
  - Frequency of sound
  - Terrain and ground characteristics
  - Building materials
- Sound pressure levels vary by turbine technology
- Two components: “swish” and “thump”
- Often noise most noticeable during nighttime conditions with lower wind speeds

Noise can be predicted with models and baseline conditions measured.

Audible Noise: Guidance

- **Health Canada**
  - 45 dBA measured over 24hrs with 10 dBA penalty for nighttime
  - Measured outside of buildings (~15-20 dBA reduction indoors)
  - Uses worst case conditions in predictive models and penalties
  - Consistent with WHO of 30 dBA indoor to protect sleep
- **Nova Scotia**
  - 40 dBA daily average at outside of buildings
- **Other jurisdictions vary**
  - Ontario is based on 40 dBA with matrix of separation distances
  - Massachusetts has maximum increase over background of 10 dBA

Audible Noise – Best Practices

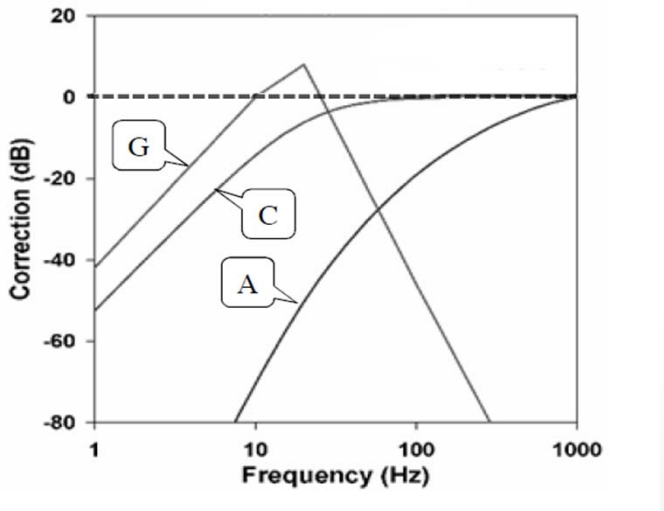
- Recommend sound pressure level approach rather than separation distance
  - Accounts for site specifics, size of project, turbine technology
  - Challenge of staff resources
  - Integrates with NS EA process where > 2 MW
- Where noise receptors within 2km (not involved in the project), require developers to demonstrate:
  - 40 dBA Leq outside of dwelling
  - Maximum increase of 10 dBA at night over baseline
  - Complete modeling by experienced consultants at industry standards
  - Share assumptions and outcomes with stakeholders

Audible Noise – Separation Distance

- Separation distances cannot address specifics of project and site without being too big or too small
- If Council wishes to use separation distances, consider:
  - Under 400m has been shown to cause high levels of annoyance and limited evidence of health impacts
  - Between 400m and 700m may be acceptable in some circumstances, predictive modeling is strongly recommended
  - Between 700m and 1000m is likely protective in most cases, yet predictive modeling is recommended for arrays of wind turbines
  - Between 1000m to 1500m is considered very conservative, yet predictive modeling is recommended for large projects, e.g., >25 turbines

Low Frequency Noise and Vibration

- Under 100Hz is considered low frequency while infrasound is under 20Hz.
- Perception varies for sound with low frequency content; in general, more annoyance reported
- G-weighted measurement is preferred to A-weighted for infrasound
- Wind turbines emit infrasound and low frequency noise
- Limited ability to distinguish from broadband sound, e.g., “thump” noise is not low frequency sound.



Infrasound from Wind Turbines

- Below levels that can be directly heard or felt outdoors; it may couple to structures and be felt indoors
- Insufficient evidence to associate with annoyance or other health effects at levels produced by wind turbines
- Significant uncertainty exists
  - Subjective nature and interaction with humans
  - Limited monitoring and evidence
  - New research focused on coupling via inner ear – but not yet understood
- Best practices for audible noise appear protective for low frequency noise and vibration based on current understanding

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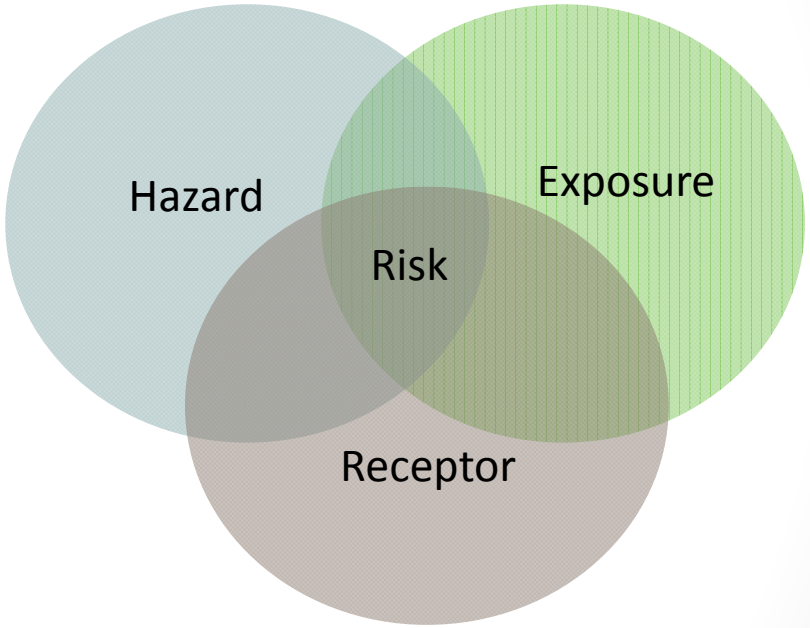
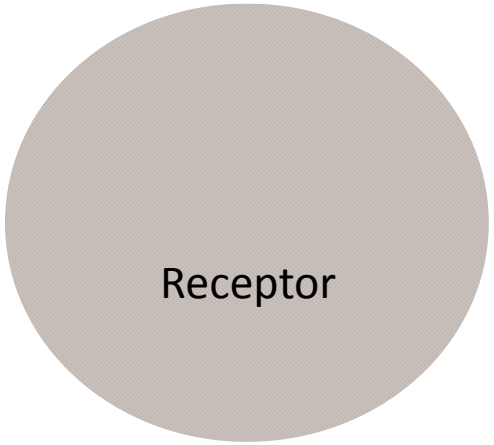
Receptor – resident



Risk to Human Health and Safety

Receptor is the resident



Human Health Hazards

Audible Noise

Inaudible Noise & Vibration

Flicker

Ice Throw

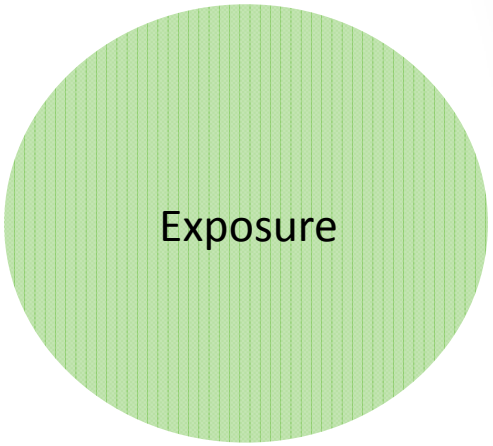
What are the effects caused by the hazard?
How much hazard is needed to cause an effect?

Human Exposure

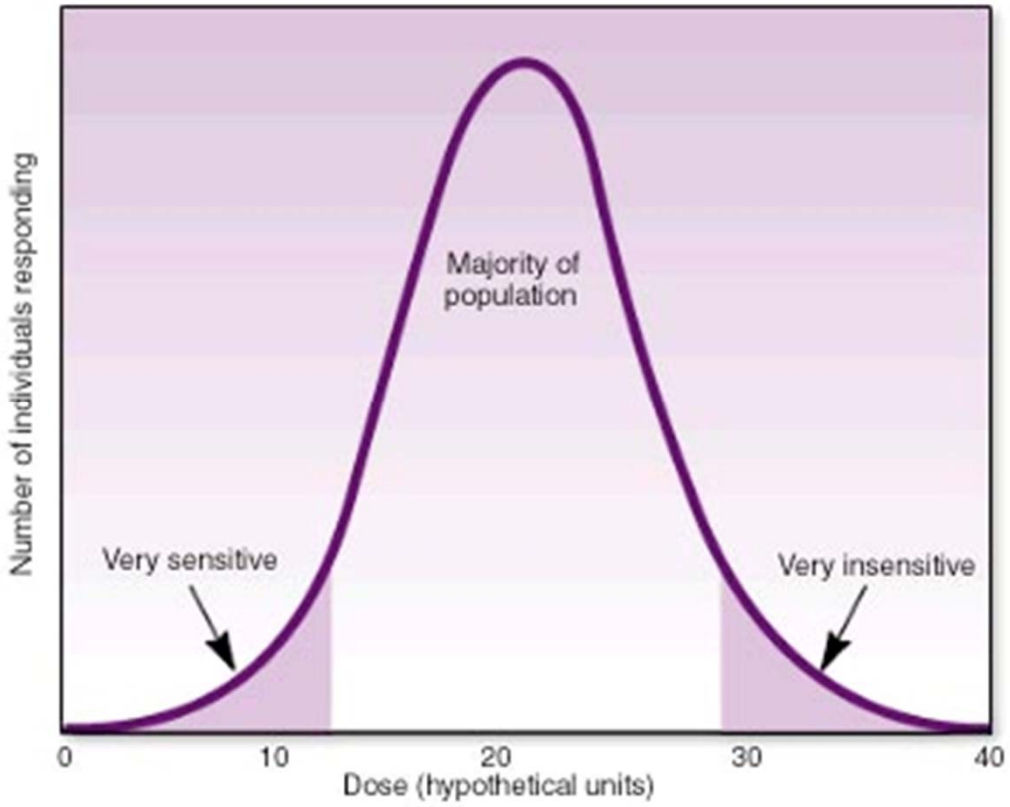
Describes the magnitude & intensity of the hazard experienced by the receptor.

How much noise, vibration, flicker or ice throw each day? Week? Years?

Measured* or *Modeled



Population Response to Hazards

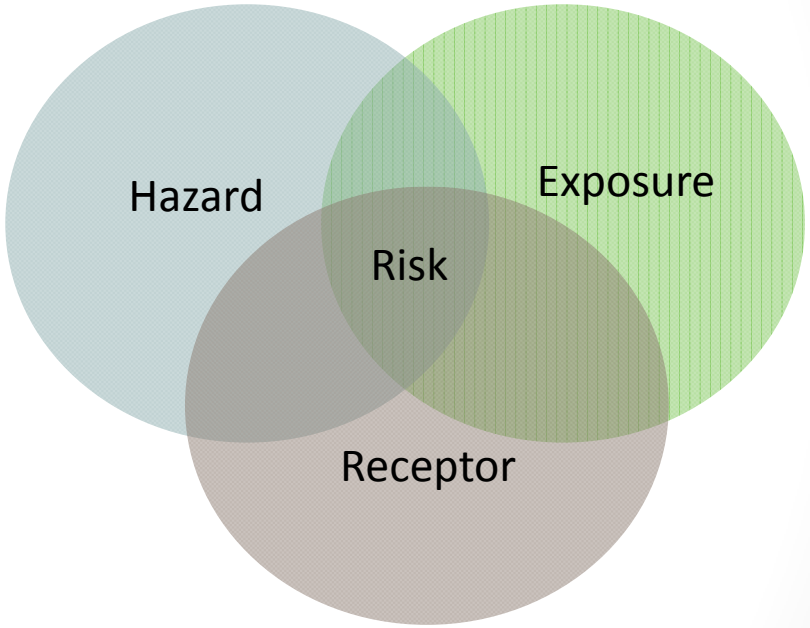


Risks to Human Health and Safety

Associations between exposure and health are based on the evidence.

Evidence (data that support or refute)

Data/Studies (information/results)



Noise and Vibration: Audible Sound and Infrasound

Few *epidemiological* studies of human health effects from exposures to ***turbine noise & vibration*** have been conducted.

Reports of effects have been reported

- Self-reported effects
- Lack of robust sound pressure measurements

Hazard-free status cannot be assumed from the weak studies that showed no strong associations between these exposures and illness.

Health Effects of Noise and Vibration

- Most ***epidemiologic studies*** on human response to ***wind turbines*** relates to self-reported "annoyance" or quality of life
- limited epidemiologic evidence suggesting an association between exposure to wind turbines and annoyance.
- Cannot determine whether there is an association between noise from wind turbines and annoyance independent from the effects of seeing a wind turbine and vice versa.

How much noise and/or vibration results in health effects?
Not Known

Health Risks Associated with Wind Turbines

- Most epidemiologic studies on human response to ***wind turbines*** relates to self-reported "annoyance"

- limited epidemiologic evidence suggests an association between exposure to wind turbines and annoyance.

- Cannot determine whether there is an association between noise from wind turbines and annoyance independent from the effects of seeing a wind turbine and vice versa.

Self-reported "annoyance"

- Limited evidence from epidemiological studies suggesting an association between noise from wind turbines and sleep disruption….
- More evidence from reports

  it is possible that noise from some wind turbines can cause sleep disruption.

- Not enough evidence to provide absolute sound-pressure thresholds at which wind turbines cause sleep disruption
- Whether annoyance from wind turbines leads to sleep issues or stress has not been sufficiently quantified. While not based on evidence of wind turbines, ***there is evidence that sleep disruption can adversely affect mood, cognitive functioning, and overall sense of health and well-being.***

Sleep disruption has been reported

Sleep disruption DOES adversely affect health

- Insufficient evidence that the noise from wind turbines is ***directly (i.e., independent from an effect on annoyance or sleep) causing health problems or disease.***

- Epidemiological data do not suggest association between noise from wind turbines and measures of psychological distress or mental health problems, but one study reports decrease in quality of life;

- Insufficient ***data*** to suggest a **direct** association between noise from wind turbines and pain and stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and headache/migraine.

Not enough data to suggest an association between wind turbine noise and a multitude of health effects, other than sleep disruption

Low Frequency Noise and Vibration

- Evidence from studies and from reports provides limited information about the effects of infrasound-generated turbines;
- Some people are more sensitive to experiencing infrasound;
- Uncertainty exists on effects of indoor levels of ILFN, as well as potential for infrasound to couple into structure.

Health Risks of Wind Turbines

- **Shadow flicker** does not cause epileptic seizures, yet can be disruptive;
- **Ice**, if thrown and hits people, can cause physical harm;
- **Audible noise**, especially at night may disrupt **sensitive** receptors' sleep.
  - May occur directly (if close enough) or indirectly (if annoyed)
  - Sleep disruption can result in headaches, loss of cognition, exhaustion and poor quality of life.
- **Infrasound** may be sensed by **sensitive** individuals, likely not directly from the turbine, but by coupling into homes, may result in disorientation, dizziness, nausea.

Best Practices: Health Canada Risk Guidelines

- Maintaining and improving health is the primary objective
- Involve interested and affected parties
- Make effective use of sound science advice
- Use a “precautionary approach”

Best Practices: Stakeholder Engagement

- **Project planning:** Use expertise available from developers, their consultants, Nova Scotia Environment and Health Canada
- **Project planning:** Require developer to form a Community Liaison Committee early in the project planning stages
- **Operational:** Form a complaints response procedure so residents have clear process if complaints
- **Ongoing:** continue dialogue on all issues – while health is an endpoint, it is tied to other issues

Evidence suggests correlation between perception of large-scale wind turbines and annoyance.

Summation

- Balanced overview of risks to health and safety based on current understanding
- Both uncertainties and certainties exist – there is never "no risk"
- Health and safety is one aspect of a complicated issue

Risks and benefits of large-scale wind turbines in Kings County must be weighed in context of all considerations

View of six large-scale wind turbines from Highway 217 looking northwest on Digby Neck (J.Rod. December2010).

Questions?