A Delphi Inquiry into

The Importance of Wind Turbine Shadow Flicker

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Hosted by

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Wind Turbine Shadow Flicker

Today's Presentation

- Introduction
  - Who we are
  - Why we are here
- Delphi Inquiry
- Shadow Flicker
  - Definition and Characteristics
  - Why it can cause problems
  - When and where it occurs
  - Ways to address Flicker

Who We Are

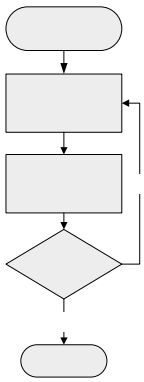
- Lawrence Technological University
  - Lead researcher: Daniel J. Alberts
  - Faculty advisors: Dr. Robert Fletcher
  - Research assistants: Kevin Pawlowski
- Collaborative Partners
  - State of Michigan Energy Office
  - Michigan Wind Working Group
  - DTE Energy
  - Copper Country Intermediate School District, Huron Area Technical Center, Traverse Bay Area Career Technical Center

Why We Are Here

- Help Michigan develop wind energy policy
  - Michigan's estimated wind potential: 16,000 MW
  - Identify and analyze wind turbine siting issues
  - Start building some consensus on issues
  - Help validate and supplement pending state guidelines
- Help municipalities develop local zoning ordinances

Today's Goals

- Introduce the Delphi Process
- Introduce Flicker
- Open dialog
- Conduct the first survey



Delphi Process

- Present basic information
- Open dialog
- Develop survey questions
- Answer survey questions
- Analyze results
- Repeat

- Goal: develop a consensus of INFORMED opinions

Previous Presentations

- Noise and Wildlife Impacts
  - http://www.ltuvitrc.com/rfletcher_eee9998.htm
- Documentation
  - http://www.ltu.edu/engineering/mechanical/delphi_wind_handouts.asp

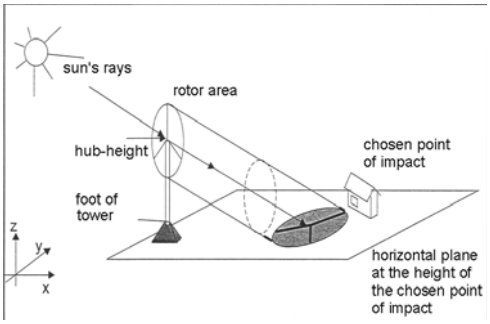
Dialog vs Discussion

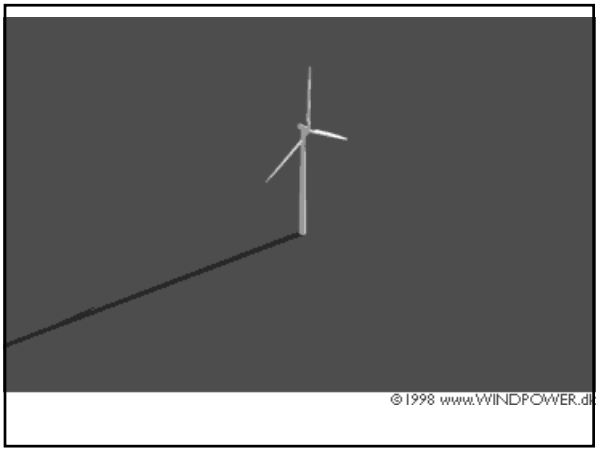
Discussion:	views are presented and defended
Dialog:	openly discuss ideas and views to help develop a new understanding

Definition

Flicker	A repeating cycle of changing light intensity
Turbine Shadow Flicker	occurs when shadows of the rotating blades pass over an object or across a window.

Example





Sources of Flicker

Source	Flicker Rate
Florescent lights	120 Hz
Computer screens	75 Hz (some are adjustable)
Televisions	60 Hz Interlaced
Vehicle turn signals	1-3 Hz
Wind Turbine Shadow	.5 – 1.25 Hz

Flicker Facts

- People will notice flicker up to about 50 Hz. (varies with intensity)
- Above 50 Hz, the brain's response to the flash lasts longer than the flash itself.
- 10-25 Hz cause problems
  - eye strain, headaches, nausea, seizures
- Effects vary with
  - Prominence
  - Distance
  - Color

Source: http://www.ccohs.ca/oshanswers/ergonomics/lighting_flicker.html

Photosensitive Epilepsy

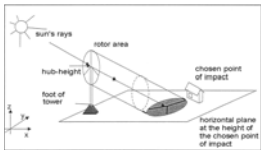
- Epilepsy affects more than 2.5 million Americans.
- Flashing lights can trigger seizures in approximately 5 percent (100,000)
- Flicker between 5 to 30 Hz are most likely to trigger seizures.

Infamous Pokemon Cartoon

- Episode #38 in 1998 triggered seizures in 685 people
  - Most were children
  - Many had NO previous seizures
- Red and Blue flashes at 12 Hz for 5 seconds
- Japanese Response
  - New Guidelines
  - 3 Hz max
  - 2 seconds max duration

Turbine Shadow Flicker

- Occurs when:
  - The turbine is between the sun and the viewer
  - The rotor (blades) are perpendicular to the line between the sun and the viewer.
- No flicker occurs at night or when the sun is obscured.



Is Shadow Flicker a Problem?

- 41% of Lincoln Township, WI residence say 'Yes'.
  - http://www.aweo.org/windlincoln.html
- Prison Officials in UK say 'Yes'.
  - http://www.timesonline.co.uk/article/0,,2-1561250,00.html

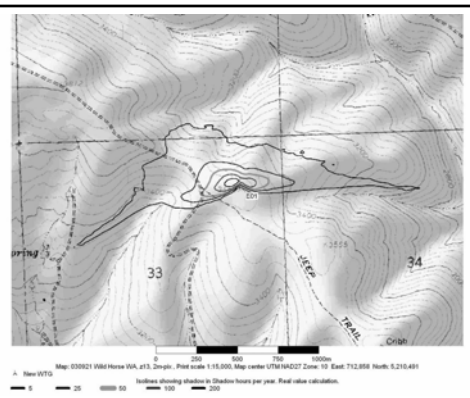
Show video

Predicting Shadows

- Computer inputs
  - Turbine locations
  - Potential receptor locations
  - Sun's movement
  - Hub height
  - Rotor diameter
  - Wind direction frequency distribution
  - Sunshine hours (monthly averages)

Predicting Shadows

- Computer Outputs
  - Areas in shadow
  - Estimated time receptor will be affected by flicker



WindPRO shadow map by Arne Nielsen, Wind Engineers, Inc., www.windEngineers.com

State Siting Guidelines

- Should Michigan's Wind Turbine Siting Guidelines address the issue of shadow flicker?
- How should we address it?

Further Reading

Flicker

http://www.ccohs.ca/oshanswers/ergonomics/lighting_flicker.html

Photosensitive Epilepsy

http://epilepsy.org/visitors/centre/ctf/photosensitive_epilepsy.html
http://www.epilepsyfoundation.org/answerplace/Medical/seizuires/precipitants/photosensitivity/photosensitivity.cfm

Pokemon

http://faculty.washington.edu/chudler/pokemon.html
http://www.sciencedaily.com/releases/1999/06/990601080722.htm

Wind Turbine Flicker

www.aweo.org/windlincoln.html
http://www.timesonline.co.uk/article/0,,2-1561250,00.html
http://www.windpower.org/en/tour/env/shadow/

Participant Profile

To report a demographic analysis of the study, we need some background information on the participants. Please tell use the about yourself.

Name: _____

Mailing Address: _____

Phone number:_____ Email:_____

Professional title: _____

Stakeholder Affiliations (Select all that apply):

- □ State of Michigan employee. Specify Department _____
- □ Local zoning board member
- □ County Commissioner
- □ Planning Commissioner
- □ Wind Energy Developer (including owners, investors, employees)
- □ Utilities, electric cooperatives, transmission company
- □ Farm or land owner
- □ Renewable Energy Organization (i.e. Next Energy, GLREA, ACORE, etc)
- □ Environmental Activist. Specify Organization _____
- □ Consumer's Organization (i.e., Michigan Farm Bureau, etc.)
- □ Educator □ Student (circle one: K-12, University)
- □ Other, Specify: _____

Please characterize your knowledge/experience with wind energy: (circle one)

No experience	Read a few articles	Extensive self education	College degree	Professional less than 5 years	Professional more than 5 years

Please characterize your knowledge/experience with shadow flicker: (circle one)

No experience	Read a few articles	Extensive self education	College degree	Professional less than 5 years	Professional more than 5 years

Have you personally visited a wind farm? Yes No

How did this presentation help you better understand the impact of wind turbine shadow flicker?

_____

_____

_____

On what aspects of wind turbines' impact on flicker do you plan to conduct further research after today?

_____

_____

_____

Will you participate in a continuing email dialog on this topic?

Yes No

If so, how many times per week will you participate in the email dialog?_____

Will you be able to participate in a second round of this survey?

Yes No

Shadow Flicker Questions

1. Should Michigan's Wind Turbine Siting Guidelines address the issue of shadow flicker?

   Yes No

If you answer 'No' to Question 1, you are done. If you answer 'Yes' to Question 1, continue to question 2.

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 Option of turning off turbine

If you answer answered "No Shadow Only", you are done. Otherwise continue to Questions 3 - 5.

3. What is the maximum amount of time per day that flicker should be allowed to affect a residence?

   5 min 10 min 15 min 20 min Other_____

4. What is the maximum number of consecutive days that flicker should be allowed to affect a residence?

   1 day 5 days 7 days 14 days Other_____

5. What is the maximum number of days per year that flicker should be allowed to affect a residence?

   2 day 10 days 14 days 28 days Other_____

6. Should permitting agencies require a map (or model) of all potential turbine shadows as part of the permitting process?

   Yes No

Further Comments and Questions:

Please Return Surveys to:

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