Lawrence Technological University's

Delphi Inquiries into Wind Turbine Siting Issues

Final Report

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Project Summary

The Energy Office of Michigan and members of the Michigan Wind Working Group asked Lawrence Technological University to conduct a Delphi Inquiry into wind turbine siting issues. A Delphi Inquiry is an iterative series of open dialogs and surveys that leads to a consensus of informed opinions. Our goal was to provide a structured forum to help State and local policy makers collect, understand and analyze the technical data that they need to consider in developing wind turbine siting guidelines.

Our project examined three issues related to implementation of wind turbines:

- turbine noise
- wildlife impacts
- turbine shadow flicker

Lawrence Technological University (LTU) initiated each Delphi Inquiry with a teleconference presentation that introduced our participants to the subject and a survey to assess their understanding. All survey results were posted on the internet and we continued the dialog through an email discussion list. We asked that everyone conduct additional research and bring what they learned to the group through the email discussion list.

Participation was open to the public. Participants included county commissioners, zoning board members, concerned citizens, environmental conservationists, and utility representatives from several areas of the state including: SE MI, the thumb area, northern Lower Peninsula, Western Lower Peninsula, and the Upper Peninsula.

Project Description

Background

In 1999, the US Secretary of Energy, Bill Richardson, launched the Wind Powering America (WPA) initiative. WPA is a regionally-based effort designed to increase the use of wind energy in the United States. The WPA's goals include:

- meeting 5% of the nation's energy needs with wind energy by 2020,
- doubling the number of states that have more than 20 megawatts (MW) of installed wind capacity by 2005, and
- tripling the number of states with installed capacity, and raising the goal for installed capacity to 24 MW by 2010.

The National Renewable Energy Lab (NREL) estimates that Michigan can potentially develop 16,500 megawatts (average annual generation) of wind energy. Developing this potential means Michigan could produce significantly less air pollution than if all new generating capacity were based on coal or natural gas.

Michigan is proceeding to develop renewable energy policies. The Energy Office of Michigan, in their 2004 Annual Report to the Michigan Public Service Commission on Michigan's Renewable Energy Program, is recommending that the State of Michigan adopt the following policies:

- Set a goal of installing 800 MW of wind power by the year 2010.
- Adopt statewide policies to encourage the development of wind energy in Michigan.
- Adopt a Renewable Portfolio Standard (RPS) that requires 1.0% of all energy sold within the state of Michigan be generated from renewable sources (including wind) by December 2006.
- Increase the RPS requirement by 0.5 % each year to reach a total of 10% by 2015.

While the Energy Office has been developing these recommendations, developers have begun evaluating potential locations for utility scale wind farms, and many local stakeholders have voiced concerns over how wind energy will be implemented. Local stakeholders cite conflicts with existing wind developments in different parts of the US as reason for concern. In Altamont Pass, CA wind turbines kill approximately 1,000 birds each year. In Nantucket Sound, MA residents are fighting development because they are concerned about damage to the viewshed. In Mackinaw City, MI, turbine noise and shadow flicker are disturbing residents.

NREL based their estimate on the availability of wind resources and necessity of excluding certain areas from development. Their estimate also includes an assumption about the size of setbacks, i.e., buffer areas between wind turbines and neighboring properties. However, many local stakeholders cite the

above-mentioned conflicts as reasons for needing larger setbacks to mitigate the turbines' impact on rural residents and wildlife.

From the developers' point of view, increasing the setbacks would reduce the amount of wind energy that could potentially be developed. This would also increase the cost of development. So the size of the buffer areas is subject to heated debate.

In July 2004, presented with complex economic, environmental impact and technical data, and many different viewpoints on how to proceed, the Energy Office of Michigan asked LTU to conduct a Delphi Inquiry.

The Delphi Method

A Delphi Inquiry is an iterative series of open dialogs and surveys that lead to a consensus of informed opinions. According to Dalkey and Helmer (1963), researchers at the RAND Corporation developed the original Delphi method in the early 1960s. Linstone and Turoff (2002) describe several variations and applications of the method. In 1967, researchers developed the Policy Delphi; a variation of the Delphi for analyzing policy issues. The Policy Delphi is based on the premise that decision makers want a group of informed professionals to present all the options and supporting evidence for consideration. Rayens and Hahn (2000) demonstrated the Policy Delphi's effectiveness for building consensus on policy issues.

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.

With these goals in mind, we modified the process. LTU initiated each Delphi Inquiry with a teleconferenced presentation that introduced our participants to the issues being addressed. At the presentation, we conducted an initial survey to assess their experience and understanding. We posted the survey results on the Internet and discussed them through an email discussion list. During the discussion, we asked that participants conduct additional research and bring what they learn to the group.

After discussing the survey results and any additional information that participants present to the group, we again surveyed the participants and analyzed the convergence of opinions. Surveys were distributed and returned through regular mail. The electronic dialog was available to provide continuous learning through all iterations of the survey. We expected survey results to show a consensus of opinions

after three to four iterations. However, project funding only permitted two iterations for the noise and wildlife inquiries and only one iteration for turbine shadow flicker.

Research and Support Personnel

Daniel J. Alberts served as project leader and lead researcher. Mr. Alberts is a full-time graduate student pursuing a Master of Science in Technical and Professional Communication at Lawrence Technological University. He brings to the project a BS in Engineering from the University of Michigan and fourteen years experience in technical communication.

Advising faculty include Dr. Robert Fletcher, Associate Professor of Mechanical Engineering and Director of LTU's Alternative Energy Program, and Dr. Brian Pedell, Director of the Technical Communication and Professional Communication Program. Dr. Fletcher brings twenty-four years of industrial research and over ten years' experience in public policy to the project; Dr. Pedell brings ten years' experience in communication research.

The Veraldi Instructional Technology Resource Center (VITRC) and LTU's Office of Public Affairs provided support staff. Dr. Alex DePetro, LTU's E-Learning Specialist, helped coordinate the teleconferences and made the presentations available online as streaming video. Dr. Alex DePetro has been an e-Learning Specialist in the VITRC at LTU for two years. During that time he has played a significant role in the implementation of video conferencing, streaming video and live webcasting. Karen Sanborn, Managing Editor of LTU's News Bureau, assisted with promotion and public awareness.

Two undergraduate students, Tim Bedra and Kevin Pawlowski, donated their time to help research the subject matter.

Collaborative Partners

LTU is working closely with several stakeholder and community education groups throughout the state of Michigan.

- DTE provided office facilities, printing and mailing services, and technical expertise. DTE's Environmental Initiatives Group also helped recruit wildlife conservation professionals to participate.
- The Michigan Wind Working Group (MWWG) helped research and review the presentation materials.
- Copper Country Intermediate School District provided teleconferencing facilities.
- Traverse Bay Area Career Technical Center provided teleconferencing facilities.
- Huron County Technical Center provided teleconferencing facilities.

Project Promotion and Public Awareness

Since participation was open to the public, we promoted the project in the following ways:

- LTU's Public Relations Dept. issues press releases to newspapers and radio stations throughout the state. Only the Great Lakes IT Report published the story.
- Mr. Alberts announced the project at the Great Lakes Renewable Energy Conference and one of the Michigan Renewable Energy Policy forums.
- Mr. Alberts gave interviews to reporters from Michigan Public Radio and WLW radio in Bad Axe.
- The Michigan Wind Working Group and the Michigan Township Association mailed invitations to their membership.
- LTU developed a web site and submitted its URL (http://www.ltu.edu/engineering/mechanical/delphi_wind.asp) to the major search engines.
- Mr. Alberts directly called or emailed zoning board members and county commissioners in Emmet and Huron Counties, Michigan State University Extension Office in Huron and the GEM Center for Science and Environmental Outreach in Houghton County.
- DTE's Environmental Initiatives group emailed announcements to their network of wildlife conservation professionals.

Participants

At the Michigan Wind Working Group's recommendation, participation was open to the public. However, we made a special effort to include county commissioners, local zoning board members and land owners from Huron County (Michigan's thumb area), the Grand Traverse Bay area, and the Keweenaw Peninsula. (According to NREL, these areas have the best wind resources, and are most likely to be targeted for wind energy development.) For the inquiry on wildlife impacts, we also made a special effort to include wildlife conservation professionals.

References

Arditi, David. (2002) The Delphi Method. Retrieved July 24, 2005. Web site: http://www.iit.edu/~it/delphi.html

Dalkey, N., & Helmer, O. (1963). An experimental application of the Delphi method to the use of experts. Management Science, 9, 458-467.

Linstone, H. and Turoff, Murray (2002) The Delphi Method Techniques and Applications. http://www.is.njit.edu/pubs/delphibook/index.html#toc

Rayens Mary and Hahn, E. (2000) Building Consensus Using the Policy Delphi Method. Policy, Politics, & Nursing Practice. Vol. 1 No. 4, November 2000, 308-315

Turbine Noise Impact

Presentation

Mr. Alberts gave the presentation on the “Impact of Wind Turbine Noise” on December 3, 2004. Participants were given a handout that contained miniatures of the slides, a list of URLs that contained additional information and a 4-page survey. The Noise Impact presentation covered the following topics:

- The Delphi Process
- Basic characteristics of sound and noise
- Noise measurement and propagation
- Community Noise Assessment
- Wind Turbine Noise

Due to the need to ship the handouts to the teleconferencing centers a week prior to the presentation, three slides were added to the presentation after the handouts were printed and shipped.

Participants

People attended the presentation at all four locations and via the web cast. Table 1 lists the number of participants who attended at each site and through the Internet.

Table 1. Participants by Site

Site	Number of Participants
LTU	4
Huron Area	3
Grand Traverse Bay	11
Copper Country	13
Internet webcast	2
Total	**33**

It should be noted that additional people may have attempted to participate through the Internet. However, the instructions for accessing the webcast contained an error that could have prevented some people from connecting.

The entire teleconference was videotaped and made available as streaming video from LTU’s web site. One person reported watching this video after the presentation.

Of the 33 participants, 27 (84%) completed surveys. Participants were asked to identify themselves with a stakeholder group, and characterize their prior knowledge of wind farms and noise assessment. Table 2 lists the number of participants who identified their stakeholder affiliation. Table 3 shows how the participants characterized their prior knowledge of wind energy. Five participants (19%) indicated they had previously visited a wind farm. Table 4 shows how the participants characterized their prior knowledge of community noise assessment.

Table 2. Participant Affiliations

Stakeholder Affiliation	**Number**[1]	**Percent**
Local zoning board member	4	14.8%
Farm or land owner	7	26%
Renewable Energy Organization	4	14.8%
Environmental Activist	7	26%
University Educator	2	7.4%
University Student	8	29.6%
Other[1]	5	18.5%
No response	2	7.4%
Planning commission	6	22.2%
Retired	2	7.4%

[1]Participants were permitted to identify with multiple groups. Includes people who identified with other groups but indicated they were retired.

Table 3. 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	1	3.7%
College degree	1	3.7%
Extensive Self Education	7	26%
Read a few articles	18	67%
No experience	0	0%

Table 4. Prior Knowledge of Noise Assessment

Experience Level	Number	Percent
Professional with more than 5 years experience	1	3.8%
Professional with less than 5 years experience	0	0%
College degree	1	3.8%
Extensive Self Education	4	15.3%
Read a few articles	12	46%
No experience	7	27%
No Answer	1	3.8%

First Survey

The survey asked 16 multiple choice and 3 open questions about how wind turbine noise should be addressed in siting guidelines. Table 5 lists the participants' responses and the percentage of responses for each answer.

Table 5. First Noise Survey Results

	Question	Selection	# Resp	%
1	The siting guidelines should specify that the loudness of frequencies between 20 Hz – 20kHz (normal hearing) be measured on which scale?	A	7	27%
		B	0	0%
		C	13	48%
		D	0	0%
		G	0	0%
		N/A	7	26%
2	Should low frequency noise (20-250 Hz) requirements be specified separately?	Yes	17	63%
		No	5	18.5%
		N/A	5	18.5%
3	If you answered yes to question 2, on which scale low-frequency requirements be measured?	A	2	7.4%
		B	0	0%
		C	14	52%
		D	0	0%
		G	1	3.7%
		N/A	10	37%

Table 5. First Noise Survey Results (Continued)

	Question	Selection	# Resp	%
4	Should infranoise (< 20 Hz) requirements be specified separately?	Yes	18	67%
		No	3	11%
		N/A	6	22%
5	If you answered yes to question 4, on which scale infrasound requirements be measured?	A	0	0%
		B	0	0%
		C	3	11%
		D	0	0%
		G	14	52%
		N/A	10	37%
6	If turbines are placed on a farm where someone resides, where should the noise impact be measured?	Outside dwelling on same property	18	67%
		Inside dwelling on same property	9	33%
		Property line	15	55%
	Notes: Intended to protect farm resident from noise impact. Answers were non-exclusive.	Outside neighboring dwelling	5	18.5%
		Inside neighboring dwelling	5	18.5%
6a	If turbines are placed on a property adjacent to a residence, where should the noise impact be measured?	Outside dwelling on same property	7	26%
		Inside dwelling on same property	4	14.8%
		Property line	19	70%
	Note: The participants added this question to protect people living near (but not on) a wind farm. Answers were non-exclusive.	Outside neighboring dwelling	5	18.5%
		Inside neighboring dwelling	6	22.2%
7	Siting guidelines should specify the following maximum dB during the day for frequencies between 20 Hz and 20 kHz:	30 dB*	1	4%
		40 dB	5	18.5%
		45 dB	2	7.4%
		50 dB	10	37%
		55 dB	1	4%
		60 dB	3	11%
		N/A	5	18.5%

Table 5. First Noise Survey Results (Continued)

	Question	Selection	# Resp	%
8	If ambient noise (such as noise from the wind) during the day becomes higher than the specified limits, the limits should be adjusted by:	None	8	30%
		3 dB	2	7.4%
		5 dB	8	30%
		6 dB	0	0%
		10 dB	3	11%
		N/A	6	22.2%
9	Should the maximum turbine noise allowed during the day be based on any of the following indices?			
	L_{max} (Maximum volume)	Yes	11	41%
	L_{10} (annoyance)	Yes	16	60%
	L_{eq} (average sound energy)	Yes	10	37%
	L_{90} (background noise	Yes	12	46%
	L_{dn} (day-night average)	Yes	6	22%
	Speech Interference Level (SIL)	Yes	8	29%
10	If you answered 'yes' to specifying a Speech Interference Level, on what distance should this be based?	1/2 ft	0	0%
		1 ft	0	0%
		3 ft	1	4%
	Note: Percentages are based on the number of people who answered Yes to an SIL in Question 9.	6 ft	2	7%
		10 ft	4	15%
		N/A	20	74%
11	Should sound levels at night be specified as adjustments to day values or absolute values?	Adjustments	9	33%
		Abslolute	14	52%
		N/A	4	15%
12	If you selected absolute values for the previous question, what should the siting guidelines specify as the maximum dB during the night for frequencies between 20 Hz and 20 kHz?	30 dB*	2	7%
		40 dB	5	18%
		45 dB	2	7%
		50 dB	1	4%
	Note: Percentages are based on the number of people who answered Absolute Values in Question 11.	55 dB	1	4%
		60 dB	0	0%
		N/A	0	0%

Table 5. First Noise Survey Results (Continued)

	Question	Selection	# Resp	%
13	Should wind turbine siting guidelines specify a maximum number of starts and stops during the night?	Yes	12	44%
		No	10	37%
		N/A	5	18.5%
14	Siting Guidelines should specify penalties when noise exceeds the limit for more than:	5 min	7	26%
		20 min	2	7.4%
		30 min	4	14.8%
		45 min	0	
		1 hr	4**	14.8%
		3 hrs	1	4%
		No penalty	2	7.4%
		N/A	8	30%
15	Do you have first-hand experience with the following?			
	ASTM E 1240 "Standard Test Method for Performance Testing of Wind Energy Conversion Systems"	Yes	1	4%
	ICE 614000-11 Wind Energy Standards: Acoustic Emission Measurement Techniques	Yes	1	4%
	ISO 1996 "Description and Measurement of Environmental Noise"	Yes	1	4%
	EPA Model Noise Ordinance	Yes	0	0%
	SERI/TP-217-3261 "A Proposed Metric for assessing the Potential of Community Annoyance for Wind Turbine Low Frequency Noise Emissions"	Yes	0	0%
16	If you checked one or more the standards in the previous question Would you recommend that wind turbine siting guidelines specify using these standards?			
	ICE 614000-11 Wind Energy Standards: Acoustic Emission Measurement Techniques	Yes	1	100%

*Participants wrote in this answer.

** One participant suggested that there be penalties be assessed differently for day and night: after 5 min for nighttime, but after 1 hour during the day.

Participants' Comments

The survey asked three open-ended questions about how this presentation and the Delphi process helped them. Participants were asked if this presentation helped them better understand the noise impact of wind turbines, and to provide some general comments on the presentation and the Delphi process. Some their comments follow:

- I had no prior knowledge that turbine noise was an issue. Now I've got some basic knowledge and access to more reading material.
- The program was excellent. For the first time since I've been participating in the wind working group, I felt the discussions were not all one sided.
- Good General understanding.
- You did a great job of synthesizing lots of info in your video presentation. Do you know if it would be possible to copy the video onto a CD(s) for distribution? I believe this information would be very helpful to others, and I would like to share it with folks that may not have access to high-speed Internet.
- Survey questions are generally too complex for undereducated people to answer with confidence.
- Very useful to get people thinking about issues, but not enough information to answer survey questions.
- Discussion [after the presentation] was difficult over videoconference.
- Why only focus on large turbines, won't small turbines be more of a problem if placed on a smaller lot?
- You presented a lot of technical information on an arcane subject then you expect us to be able to evaluate this information correctly and make decisions. I don't think we received enough information or covered the various aspects of sound to be able to make such decisions. I don't think the data you'll receive from this exercise will be valid. But thanks for allowing us to participate.
- I found this to be a very disorganized conference to many distractions by the people putting on the conference. It really did not seem like you were going to get a lot of input from the right people

It should be noted that during the teleconference, the participants voted to allow multiple answers for question 6 (the researcher had previously asked that they circle only one response); and to add question 6a to the survey. This showed both a strong interest in the topic and a willingness to participate. Overall, people seemed pleased with the unbiased presentation, but remained skeptical of the process for acquiring consensus or useful data.

First Survey Conclusions

After the first iteration of the survey we can draw only a few definite conclusions:

- At least 30 percent of participants felt uncomfortable or unprepared to answer questions 1, 3 and 5 about dB weighting scales.
- A clear majority believe that siting guidelines should include specific requirements for low-frequency noise and infra noise.
- The question about noise indices (L10, L90, Lmax, etc.) was not worded well. It will have to be reworded before the responses can be useful.
- Not enough participants had experience with industrial standards to evaluate or recommend adopting them.
- For question 6, a clear majority responded that noise should be measured outside the dwelling.
- For question 6a, a clear majority responded that noise should be measured at the property line.

Post-presentation Discussion

On the day of the teleconference, the 27 participants engaged in a lively discussion to clarify and modify the survey questions. However, Only 15 of the 27 participants joined our electronic discussion list. Over the next two months, five people (including the researcher and one non-participant) posted a total of 13 messages on the topic.

Second Survey

Responses from the first survey indicated that additional educational material was needed for the participants to understand the technical aspects of noise measurement and community noise assessment. Participants' responses also suggested significant changes to Questions 9 through 13.

On March 1, 2005, we distributed an information packet containing some additional educational material, links to some additional references on the Internet, and the second survey. The second survey contained 21 multiple-choice questions. Table 6 lists the participants' responses. Eleven of the twenty seven participants returned the second survey.

Table 6. Second Noise Survey Results

	Question	Selection	# Resp	%
1	The siting guidelines should specify that the loudness of frequencies between 20 Hz – 20kHz (normal hearing) be measured on which scale?	A	6	55%
		C	4	36%
		G	1	9%
2	Should low frequency noise (20-250 Hz) requirements be specified separately?	Yes	10	91%
		No	1	9%
3	If you answered yes to question 2, on which scale low-frequency requirements be measured?	A	2	18%
		C	6	55%
		G	1	9%
		N/A	2	18%
4	Should infranoise (< 20 Hz) requirements be specified separately?	Yes	10	91%
		No	1	9%
5	If you answered yes to question 4, on which scale infrasound requirements be measured?	C	2	18%
		G	8	73%
		N/A	1	9%
6	If turbines are placed on a farm where someone resides, where should the noise impact be measured?	outside dwelling on same property	6	55%
		Inside dwelling on same property	5	45%
	Notes: Intended to protect farm resident from noise impact. Answers were non-exclusive.			
6a	If turbines are placed on a property adjacent to a residence, where should the noise impact be measured?	Property line	7	63%
		Outside neighboring dwelling	1	9%
		Inside neighboring dwelling	3	27%
7	Siting guidelines should specify the following maximum dB during the day for frequencies between 20 Hz and 20 kHz:	30 dB*	2	18%
		40 dB	1	9%
		45 dB	3	27%
		50 dB	1	9%
		55 dB	1	9%
		60 dB	1	9%
		N/A	2	18%

Table 6. Second Noise Survey Results (Continued)

	Question	Selection	# Resp	%
8	If ambient noise (such as noise from the wind) during the day becomes higher than the specified limits, the limits should be adjusted by:	None	8	72%
		10 dB	2	18%
		N/A	1	9%
9	Should Michigan's wind turbine siting guidelines specify that a wind turbine not increase prior existing statistical noise levels by a specified amount? (The levels would be measured at the location you specified in Question 6 and Question 6a.)			
	L_{10} (annoyance)	Yes	6	55%
	L_{eq} (average sound energy)	Yes	3	27%
	L_{90} (background noise	Yes	5	45%
	L_{dn} (day-night average)	Yes	2	18%
9a	If you answered yes for L_{10}, L_{50} or L_{90}, over what time period should the Michigan Wind Turbine Siting guidelines specify these values be measured?	1 hour	3	27%
		12 hours	2	18%
		24 hours	2	18%
		N/A	4	36%
9b	If you answered yes for any statistical value in Question 9, what should Michigan's Wind Turbine Siting Guidelines specify as the maximum increase in these levels caused by wind turbine operation?	None	1	9%
		3 dB	4	36%
		6 dB	2	18%
		10 dB	1	9%
		N/A	3	27%
10	Should the maximum turbine noise allowed during the day be based on the following indices?			
	Speech Interference Level	Yes	6	55%
		No	5	45%
10a	If you answered 'yes' to specifying a Speech Interference Level, on what distance should this be based?	3 ft	1	9%
		6 ft	1	9%
		10 ft	4	36%
		N/A	4	36%
11	Should sound levels at night be specified as adjustments to day values or absolute values?	Adjustments	1	9%
		Absolute	10	91%
11a	If you selected absolute values for the previous question, what should the siting guidelines should specify as the maximum dB during the night for frequencies between 20 Hz and 20 kHz?	30 dB*	7	64%
		40 dB	2	18%
		45 dB	1	9%

Table 6. Second Noise Survey Results (Continued)

	Question	Selection	# Resp	%
12	Should wind turbine siting guidelines specify a maximum number of starts and stops during the night?	Yes	10	91%
		No	1	9%
13	Siting Guidelines should specify penalties when noise exceeds the limit during the day (7 a.m. - 7 p.m.) and evening (7 p.m. - 11 p.m.) for more than:	5 min	4	36%
		30 min	1	9%
		20 min	3	27%
		1 hr	2	18%
13a	Should wind turbine siting guidelines specify a different penalty for violating noise limits at night?	Yes	6	55%
		No	5	45%
13b	If you answered Yes to Question 13a, after how much time should a penalty be imposed when noise exceeds the specified limits at night (11 p.m. –7 am):	5 min	3	27%
		20 min	2	18%
		30 min	1	9%
		No Answer	5	45%
13c	Should Michigan's Wind Turbine Siting Guidelines recommend specific penalties for noise violations? Note: These would not be legally binding. It would be up to local communities to enact legally binding penalties.	Yes	9	81%
		No	2	91%

Since only one person indicated they had first-hand experience with any of the industrial standards, we omitted questions about the standards from the second survey.

Second Survey Conclusions

The participants' lack of experience with noise measurement made it difficult for them to answer the more technical questions. The participants' need to conduct further (independent) research on the topic most likely contributed to the extremely low return rate for the second survey.

Nine surveys are insufficient to provide a statistical analysis. However, those who did return the second survey demonstrated significant agreement (9 out of 11) on several important points:

- Michigan's Wind Turbine Siting Guidelines should specify separate limits for noise for each of the three frequency ranges: normal hearing (20 Hz - 20 kHz), low frequency (20-250 Hz), and infrasound (0-20 Hz).
- Noise limits at night should be specified with absolute values, not adjustments to daytime limits.
- Michigan's Wind Turbine Siting Guidelines should specify a maximum number of starts and stops at night.
- Michigan Wind Turbine Siting Guidelines should recommend penalties for non-compliance with noise ordinances.

A majority (≥6) of the second survey respondents also agreed that:

- Noise exposure should be measured at property lines.
- Noise limits in the normal hearing range (20 Hz - 20 kHz) should be specified on the A scale.
- Limits for low-frequency noise (20-250 Hz) should be specified on the C scale.
- Limits for infranoise (< 20 Hz) should be specified on the G scale.
- Noise limits for wind turbines should not be adjusted if ambient noise from other sources exceed the specified limits.
- Michigan's Wind Turbine Siting Guidelines should recommend penalties for noise violations.
- The guidelines should specify a maximum increase to L_{10} (background noise) caused by wind turbines.
- The maximum allowable noise should be based on the Speech Interference Level.
- The guidelines should recommend different penalties for day and night time noise violations.

However, there was no agreement on what would be considered acceptable noise exposure. Also, since the number of second survey respondents is approximately 1/3 the total number of participants, the results must be considered skeptically. For example, six respondents representing a majority in Question 8 was less than the minority opinion in the first survey.

Also, one important precept of the Delphi process is that while answering a second survey, participants would consider the results of the first survey and discussion. Since several surveys were returned without names, it is not possible to determine if respondents changed their answers from the first iteration to the second.

Recommendations for Turbine Noise

This results of this inquiry support only a few recommendations. Michigan's Wind Turbine Siting Guidelines should:

- Specify separate limits for noise for each of the three frequency ranges: normal hearing (20 Hz - 20 kHz), low frequency (20-250 Hz), and infrasound (0-20 Hz).
- Specify noise levels for frequencies in the range of normal hearing and low frequencies on the A scale, and noise levels for infra sound on the G scale.
- Specify noise levels be measured at property lines.
- Noise limits at night should be specified with absolute values, not adjustments to daytime limits. (This follows the World Health Organization's recommendation.)

However, since there was insufficient agreement on what would be acceptable noise exposure limits, this inquiry cannot support recommending specific limits. Nor can this inquiry support adopting limits recommended by the World Health Organization.

The State of Michigan should consult a professional in community noise assessment to resolve the details of these limits. When specific nighttime limits are set, Michigan's Wind Turbine Siting Guidelines should also specify a maximum number of starts and stops according to the World Health Organization's recommendations.

Environment and Wildlife Impacts

Presentation

Representatives from several organizations helped develop the presentation materials, including:

- Southeastern Michigan Raptor Research
- Bat Conservation International
- The Organization for Bat Conservation
- DTE's Environmental Initiatives Group, and
- Michigan's Department of Environmental Quality

Mr. Alberts gave the presentation on the "Wind Turbines' Impact on the Environment and Wildlife" on February 14, 2005. Participants were given a handout that contained miniatures of the slides, a list of URLs that contained additional information and a 2-page survey. This presentation covered the following topics:

- the Delphi process
- pollution from conventional power generation and predicted health effects,
- impact of turbines on raptors and passerines in several parts of the USA,
- recent research on wind turbine impacts on bat species,
- recommendations from the American Bird Conservancy, Bat Conservation International and the Us Dept Of Interior for mitigating impacts,
- theoretical local climate changes from wind farms, and
- the impact of Michigan's Public Act 451 on wind turbine permitting process.

Participation

More than 40 people called or emailed indicating their intent to attend the presentation. However, due to a severe ice storm, two of the conference sites were closed, and attendance was considerably less than expected. Table 7 lists the number of participants at each site. Of the 15 people who attended the presentation, 5 returned surveys.

Table 7. Participants by Site

Site	Number of Participants
LTU	4
Huron Area	Closed due to ice storm
Grand Traverse Bay	Closed due to ice storm
Copper Country	3
Internet webcast (mostly from Marquette, MI)	8
Total	**15**

LTU videotaped the presentation and distributed copies on CD and through the Internet. For two weeks following the presentation, Mr. Alberts aggressively called and emailed interested people to increase participation. DTE's Environmental Initiatives group helped to promote the program by emailing their contacts in environmental conservation. This resulted in a total of 16 surveys returned.

Participants were asked to identify themselves with a stakeholder group, and characterize their prior knowledge of wind farms and wildlife conservation issues. Table 8 lists the number of participants who identified their stakeholder affiliation. Table 9 shows how the participants characterized their prior knowledge of wind energy. Table 10 shows how the participants characterized their prior knowledge of wildlife conservation issues. Among the professionals were representatives from Southeastern Michigan Raptor Research and the Organization for Bat Conservation. Eight participants (50%) indicated they had previously visited a wind farm.

Table 8. Participant Affiliations

Stakeholder Affiliation	Number[1]	Percent
State of Michigan employees	1	6%
Local zoning board member	1	6%
Farm or land owner	4	25%
Renewable Energy Organization	2	12%
Wildlife Conservation Professional or Environmental Activist	5	31%
Consumer's Organization	3	19%
University Educator	4	25%
University Student	3	19%
Not identified	1	6%
Planning commission	3	19%

[1]Participants were permitted to identify multiple affiliations.

Table 9. 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	1	6%
College degree	0	0%
Extensive Self Education	11	69%
Read a few articles	3	19%
No experience	1	6%

Table 10. Prior Knowledge of Wildlife Conservation Issues

Experience Level	Number	Percent
Professional with more than 5 years exp.	3	19%
Professional with less than 5 years exp.	0	0%
College degree	6	38%
Extensive Self Education	0	0%
Read a few articles	7	44%
No experience	0	0%

First Survey

The participation of several wildlife conservation professionals made it appropriate to ask participants to help identify which questions should be asked. Participants were enthusiastic about this approach and provided many helpful suggestions.

Participants' Comments

Ten of the respondents provided comments or questions that helped develop the survey questions. Suggestions included:

- A wildlife impact study needs to be conducted on the 3 existing wind turbines in Michigan.
- A committee should be created (consisting of wildlife professionals) to monitor wind turbines in Michigan
- Wildlife research should be conducted for at least 1 year prior to erecting a wind turbine to determine wildlife use of the site.
- Who will fund wildlife impact research?
- Can we protect migrating birds and bats by prohibiting wind turbine towers within 5 miles of flyways?
- Should we prohibit turbines along Michigan's shorelines?
- Should we prohibit building new towers within 5 miles of the Mackinaw straits?
- Can wind turbines be shut down during peak migration periods? If so, how much notice needs to be given?
- Should lattice towers be banned?
- Can the State of Michigan adopt and enforce the US Fish & Wildlife Service's Interim Guidelines?
- How much land needs to be cleared for a wind farm?
- Can we map the migratory paths and overlay them on the wind resource maps?
- Can and should turbine blades be painted to make them more visible to birds?

Post-Presentation Discussion

Six of the fifteen respondents joined the email discussion list. Over the next two months, five people posted 24 messages. Subjects included tower lighting, tower design, the US Fish and Wildlife Service's (USFWS) Interim Guidelines, and the USFWS's model Potential Impact Index (PII). In addition, several people emailed Mr. Alberts privately with questions or comments; to which he responded as best he could.

Second Survey

On April 1, 2005, we distributed the second survey through regular mail. Nine of the fifteen original participants returned the second survey, including all of the wildlife conservation professionals.

Additional Participation

Because the first survey was designed to identify questions, we considered it acceptable to invite additional participation. Seven employees of the US Fish and Wildlife Service watched the presentation; three collaborated and submitted a single survey.

Survey Responses

The survey asked 24 multiple choice questions about possible ways to address wind turbines' impact on wildlife. Table 11 lists the survey results.

Table 11. Second Wildlife Survey Results

	Question	Selection	# Resp	%
1	Should the Michigan Wind Turbine Siting Guidelines specify that developers must provide a PII prior to constructing a wind farm?	Yes	10	100%
		No	0	0%
2	The PII requires a comparison to a reference or baseline site. Should comparisons be made to a reference or baseline site within:	the local county	1	10%
		a region of the state of Michigan	4	40%
		the State of Michigan		
		the USA	5	50%
3	Should the Michigan Siting Guidelines specify a reference or a baseline site for PII comparisons?	Yes	8	80%
		No	2	20%

Table 11. Second Wildlife Survey Results (Continued)

	Question	Selection	# Resp	%
4	The procedure for developing the PII (as stated in the US FWS Interim Guidelines) is a model that needs to be modified for different sites. Who should develop the final version?	Michigan Energy Office	0	0%
		Michigan Dept of Natural Resources	1	10%
		Michigan Dept of Environmental Quality	3	30%
		An independent board of environmental consultants appointed by the State of Michigan	3	30%
		Local communities	2	20%
		No Answer	1	10%
5	The USFW recommends that towers be lighted with only white lights. Red lights should be avoided. Should the Michigan Wind Turbine Siting Guidelines include this recommendation?	Yes	8	80%
		No	2	20%
6	The American Bird Conservancy recommends that Any lighting should be with strobe lights, either white or red. The pulse rate should be kept to 20 pulses per minute, if possible, and the pulses should be synchronized. Should the Michigan Wind Turbine Siting Guidelines include this recommendation?	Yes	5	50%
		No	5	50%
7	Should the Michigan Siting Guidelines recommend that turbine blades be painted to make them more visible to birds?	Yes	4	40%
		No	6	60%
8	American Bird Conservancy recommends that wind turbine power lines be underground; power lines should at a minimum comply with Avian Power Line Interaction Committee (APLIC) Standards to Prevent Avian Electrocutions. Should the Michigan Wind Turbine Siting Guidelines include this recommendation?	Yes	9	90%
		No	0	0%
9	Should wind turbines be shut down during the peak migrations of certain endangered species like the Kirkland Warbler?	Yes	9	90%
		No	1	10%
10	If wind turbines can be shutdown during peak migration periods, how much notice needs to be given?	one day	3	30%
		three days	2	20%
		one week	3	30%
		one month	0	0%
		No Answer	2	20%

Table 11. Second Wildlife Survey Results (Continued)

	Question	Selection	# Resp	%
11	If you answer yes to Question 9, should the Michigan Wind Turbine Siting Guidelines specify a penalty for non-compliance?	Yes	7	70%
		No	2	20%
		No Answer	1	10%
12	The USFW recommend a minimum of three years of monitoring wildlife. Some researchers have suggested that for agricultural areas a single season of monitoring is sufficient. Should the Michigan Siting Guidelines recommend a minimum period of wild life monitoring **prior** to wind turbine construction?	Yes	10	100%
		No	0	0%
13	If you answered yes, what should that minimum period be?	one season	0	0%
		two seasons	0	0%
		one year	0	0%
		two years	6	60%
		three years	4	40%
14	Should the Michigan Siting Guidelines recommend a minimum period of wild life monitoring **after** wind turbine construction?	Yes	10	100%
		No	0	0%
15	If you answered yes, what should that minimum period be?	one season	0	0%
		two seasons	0	0%
		one year	1	10%
		two years	4	40%
		3 years	5	50%
16	Who should conduct the wildlife monitoring?	The wind energy developers	0	0%
		The State of Michigan	0	0%
		Local municipalities	2	20%
		An independent board of wildlife professionals	7	70%
		No Answer	1	10%
17	Should wind energy developers be required to pay for the wildlife monitoring regardless of who conducts the studies?	Yes	9	90%
		No	1	10%

Table 11. Second Wildlife Survey Results (Continued)

	Question	Selection	# Resp	%
18	Should all wildlife monitoring data be made public?	Yes	10	100%
		No	0	0%
19	Should the State of Michigan appoint a committee to collect and distribute all wildlife data relating to wind farms in the State of Michigan?	Yes	8	80%
		No	2	20%
20	Bat Conservation International has recommends that no turbines be built on wooded ridge tops. Should Michigan's guidelines include this recommendation?	Yes	9	90%
		No	1	10%
21	Many birds follow Michigan's coastline while migrating. Should wind turbines be prohibited within a certain distance (onshore) of Michigan's coastline?	Yes	8	80%
		No	2	20%
22	If you answered 'yes', what should that minimum distance be?	1/4 mile	1	10%
		1/2 mile	0	0%
		1 Mile	4	40%
		5 miles	2	20%
		7-8 Miles	1	10%
		No answer	2	20%
23	Should the Michigan Siting Guidelines recommend a minimum distance from caves where bats are known to hibernate?	Yes	10	10%
		No	0	0%
24	Should the Michigan Siting Guidelines recommend a minimum distance from bird sanctuaries?	Yes	10	10%
		No	0	0%

Second Survey Conclusions

Participants demonstrated either unanimous or significant (8 out of 10) agreement on 14 of the 24 questions. The wildlife conservation professionals and the laypersons who participated in this study agreed that the Michigan Wind Turbine Siting Guidelines should:

- Require wind energy developers to provide a Potential Impact Index (PII) for each potential site.
- Recommend at least one site whose PII can be used as a baseline for evaluating new sites
- Include the USFW recommendation that towers be lighted with only white lights,
- Include Bat Conservation International's recommendation that no turbines be built on wooded ridge tops.
- Recommend that wind turbine power lines be underground; power lines should at a minimum comply with Avian Power Line Interaction Committee (APLIC) Standards
- Recommend that turbines be shut down during peak migrations of certain endangered species

- Recommend a penalty for non-compliance with shutdowns for peak migration periods
- Recommend minimum time periods for wildlife studies before and after installing wind turbines.
- Recommend that wind turbines be prohibited within certain distances from bird sanctuaries, bat hibernacula, and Michigan's shore.
- The participants also agreed that:
- The State of Michigan should create an independent panel of wildlife professionals to collect and distribute all data related to wind turbines' impact on wildlife in Michigan.
- All data from wildlife studies should be made public.

A number of questions remain unanswered. The USFWS procedure for determining a Project Impact Index (PII) is a model. This model may need to be refined to address Michigan's unique wildlife needs. Furthermore, the PII requires a baseline site for reference. An appropriate site (or sites) need to be determined.

Electronic Discussion

We asked two follow up questions through our email discussion list:

1. At this time, do you have enough information to determine what should be the minimum distance between a wind turbine and either a bird sanctuary or a bat hibernaculum?
2. Do you believe a third Delphi survey on this subject could demonstrate significant agreement (8 out of 10) on what those distances should be?

Two people responded, a representative from the Organization for Bat Conservation and a representative of the US Fish and Wildlife Service. Both agreed that at this time, no one has sufficient information to make these determinations. Further studies need to be conducted.

Recommendations

Additional research is needed to determine how to best mitigate wind turbines' impact on wildlife in Michigan. At this time, we recommend that Michigan's Wind Turbine Siting Guidelines include recommendations to:

- Require a PII according to the USFWS Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines.
- Light turbine towers with only white lights in accordance with the USFWS Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines
- Follow the American Bird Conservancy's Avian Power Line Interaction Committee (APLIC) Standards to Prevent Avian Electrocutions
- Follow Bat Conservation International's recommendation to avoid building turbines on wooded ridge tops.

- Recommend wildlife studies be conducted for 2-3 years prior to erecting wind turbines, and 2-3 years after construction is completed.

Further, the State of Michigan should form a panel (or commission) of wildlife conservation professionals to further study Michigan's needs further and refine these recommendations. This panel should:

- Examine the USFWS' model PII, and adapt it to Michigan's specific needs.
- Determine appropriate reference sites to be used for comparing new wind turbine locations.
- Determine (as well as possible) minimum distances wind turbines should be prohibited from bird sanctuaries, bat hibernacula, and Michigan's shoreline.
- Oversee all wildlife impact studies, including establishing standard protocols, verifying that these protocols are followed, and disseminating the results to local permitting agencies and the general public.
- Recommend annual or biannual updates of Michigan's Wind Turbine Siting Guidelines to minimize wind turbines negative impacts on wildlife.

Shadow Flicker

Presentation

Mr. Alberts gave a presentation on turbine shadow flicker on April 22, 2005. Participants were given a handout that contained miniatures of the slides, a list of URLs that contained additional information and a 3-page survey. This presentation covered the following topics:

- the Delphi Method
- definition of flicker and its health effects
- a video of a home affected by turbine shadow flicker
- examples of turbine shadow maps

Participants

Ten people attended the presentation. Three people reported watching the presentation over the Internet. Table 12 lists the number of participants at each site. Of the thirteen people who saw the presentation, eight returned surveys.

Table 12. Participants by Site

Site	Number of Participants
LTU	1
Huron Area	3
Grand Traverse Bay	3
Copper Country	3
Internet webcast	3
Total	**13**

Participants were asked to identify themselves with a stakeholder group, and characterize their prior knowledge of wind farms and shadow flicker. Table 13 lists the number of participants who identified their stakeholder affiliation. Table 14 shows how the participants characterized their prior knowledge of wind energy. Table 15 shows how the participants characterized their prior knowledge of flicker issues. Three participants indicated they had visited the wind turbines in Mackinaw City, and one participant had visited a wind farm.

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%

The Survey

Survey Responses

The survey asked five multiple-choice questions, and the participants added a sixth question during the post presentation discussion. Table 16 lists the survey results.

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?	O 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%

Participants' Comments

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.

Recommendations

Michigan's Wind Turbine Siting Guidelines should recommend that permitting agencies require wind developers to provide a map of turbine shadows throughout the year. Such a map should specify all areas that will be affected by turbine shadow and the amount of time that each area will be affected. Permitting agencies should make this map available to residents and potential homebuyers that may be affected by turbine shadows.

Post-Project Analysis

Given the history of the Delphi Method, we expected to achieve better results. However, our project incorporated several experimental aspects:

- participants who had no prior knowledge of the subject
- introductory educational materials
- electronic discussion list

Participation and Commitment

The Delphi Method was designed to facilitate information exchange leading to a consensus of informed opinions. For the method to work, each participant must bring to the group enough knowledge or experience to participate in a meaningful dialog. Each participant must also be willing to share their knowledge and willing to learn from others.

Of our three Delphi Inquiries, the inquiry into wildlife impacts was the most successful. The participation of subject matter experts seems to be the key factor in this inquiry's comparative success. Thirty percent of the noise inquiry's participants indicated they did not have enough experience to make informed choices. The noise inquiry achieved consensus on only 12% of the questions; but the wildlife inquiry achieved consensus on 58% of the questions.

Committed participation seems to be more important than the number of participants. Only 33% percent returned a second survey. This low return rate may be attributed to participants' inability to devote enough time to learn the subject. By comparison, 60% of the participants in the wildlife survey (including all of the professionals) returned a second survey.

The earlier participants became involved in the Delphi process, the more invested they became in the project. Members of Michigan's Wind Working Group who became involved in the early planning stages were more invested in the process than any other participants. The wildlife professionals who helped research the February 14th presentation and develop the survey also became more invested in the process than most participants. Most of the participants who joined at one of the presentations neglected to complete a second survey.

For future Delphi Inquires, especially into highly technical subjects, we recommend recruiting subject matter experts rather than trying to include the general public.

Recruiting Participants

The best way to recruit participants for a Delphi inquiry seems to be through professional networking. LTU distributed news releases to all the major newspapers and television stations in Michigan, but these releases were ignored. LTU placed event notices in a few local papers and provided interviews to one local radio station. Unfortunately, the people who responded to these notices only wished to become familiar with subject; they were not prepared to commit to the Delphi process. Some educators invited their students to attend, but only a few students completed surveys.

The best participation came from professional networking. The wildlife professionals who were invited to participate by other wildlife professionals committed themselves to the process.

Email Discussion List

For our email discussion list, we used a publicly service, www.topica.com. To prevent miss use, Topica.com maintains a strict “opt-in only” policy. This restriction prohibits a list administrator from adding people directly to the list. The administrator must send an email that invites people to join the list, and participants must respond to this email to actually join the list. In this case, the restriction seems to have deterred participation. Approximately half the participants failed to join the list.

There are several possible reasons for this low participation in the email list. Many attendees may have only wished to learn about the subject and not participate in the surveys. Many people may have been unfamiliar with the technology of email discussion lists and were uncomfortable using them. At least one participant reported that his spam blocking software prevented him from receiving the invitation.

Among those who did join the email discussion list, participation was considerably less than hoped. A few participants posted messages to the list that contained links to reference material. However, those messages generated no responses. Discussion only occurred when the project facilitator requested answers to specific questions.

To improve participation in the electronic list, we recommend:

- Use a listserv that permits the project facilitator to directly add participants.
- Assign someone to facilitate the discussion. Do not wait for the participants to initiate the discussion.
- Post questions at least once per week.
- Ask questions that are within the experience of the participants.

Appendices

Lawrence Technological University's Delphi Inquiry into Wind Turbine Noise

2nd Iteration

March 1, 2005

Project Summary

The Energy Office of Michigan and the Michigan Wind Working Group asked Lawrence Technological University (LTU) to conduct a Delphi Inquiry into wind turbine siting issues. A Delphi Inquiry is an iterative series of open dialogs and surveys that leads to a consensus of informed opinions. Our goal is to provide a structured forum that helps state and local policy makers collect, understand and analyze the technical data that they need to consider to develop wind turbine siting guidelines.

LTU initiated our inquiry into wind turbine noise with a teleconference presentation on December 3, 2004. This introduced our participants to the basics of noise measurement community noise assessment and wind turbine noise. On that day we also conducted an initial survey to assess participants' level of understanding of the noise issue.

Participants in this process include county commissioners, zoning board members, concerned citizens, wind energy developers, university students and instructors, and utility representatives. Participants represented five regions of the state: SE MI, the thumb area, northern Lower Peninsula, Western Lower Peninsula, and the Upper Peninsula. For more information about the participants, you can download the project's Draft Report from http://www.ltu.edu/engineering/mechanical/delphi_wind.asp.

This packet is for the second survey of the noise inquiry. It presents the results of the first survey with some Further Discussion that we hope will help participants better understand the concepts and issues being considered. This packet also contains the second the survey on noise.

Survey 2

Please note that in this second survey the instructions are a little different. For each question, you are given the original question and the responses from the first survey. Where possible we provide some additional background material to help with your understanding. Thanks to your feedback, we have modified some of the questions for this second survey. Please consider all the information provided, including the results of the first survey, when responding to this second survey and answer the questions as best you can.

Remember that our goal is to reach a consensus of informed opinions.

Participant Name: _____

Question 1

1st Survey

Original Question	Selection	# Resp	%
The siting guidelines should specify that the loudness of frequencies between 20 Hz – 20kHz (normal hearing) be measured on which scale?	A	7	27%
	B	0	0%
	C	13	48%
	D	0	0%
	G	0	0%
	No Answer	7	26%

Further Discussion

More than 30 percent of the participants indicated that they felt unqualified to answer Questions 1, 3 and 5. So we have provided additional information here and some additional references.

Noise scales are like to temperature scales. A thermometer measures the amount of heat in the air. The heat measurement is then compared to a reference scale Fahrenheit or Celsius. When we measure noise, we are actually measuring the amount of pressure that sound makes on the receiver. We then compare that pressure to one of five reference scales. Each scale is designed for specific uses. The table and paragraphs below gives more information on the scales.

Scale	Purpose
A	Designed to approximate the subjective human response to different frequencies. In different frequency ranges, a sound pressure will be given different dB levels to approximate human subjective response.
B	Designed to measure the annoyance of traffic. Sound pressures are adjusted less than on the A scale.
C	Designed to measure actual sound pressure. Sound pressures are only adjusted in the extreme frequencies ranges outside the range of human hearing.
D	Designed to determine the annoyance of airplane engines. This scale attributes more significance to sounds between 1000 and 10,000 Hz.
G	Designed to measure infrasound (below 20 Hz).

The Handbook for Sound Engineers recommends using the A scale for sounds between 20 and 55 dB; the B scale for sounds between 55 and 85 dB; and the C scale for sounds above 85 dB. However , many other sources,

including the Transportation Noise Reference Book, state that in most circumstances the B and C scales offer little advantage over the A scale. The Transportation Noise Reference Book describes the B scale as obsolete and the C scale as having no correlation to human perception of loudness.

Beranek[1] reports that the A scale is used to estimate the probability of hearing damage from noise exposure and Magrab[2] reports that the US Department of Labor based their noise exposure standards on the A scale. Magrab also reports that the A scale should only be used for broadband sound, never for narrow band (less than 1/3 octave) or sound with discernable tones.

Additional information can also be found at:

http://www.lowertheboom.org/trice/decibelmeters.htm

http://www.acoustics-noise.com/dBA-B-C-D-U-G-U-AU-tables.shtml

http://www.lowertheboom.org/trice/BoomCarNoise.pdf

http://www.dataphysics.com/support/library/downloads/articles/DP-Aweight.pdf

2nd Survey

On what scale do you believe wind turbine noise should for frequencies between 20 Hz – 20kHz (normal hearing) be measured? (Please circle only one answer.)

A B C D G

Question 2

1st Survey

Original Question	Selection	# Resp	%
Should low frequency noise (20-250 Hz) requirements be specified separately?	Yes	17	63%
	No	5	19%
	No Answer	5	19%

2nd Survey

Should wind turbine siting guidelines specify a maximum loudness for low frequency noise (20-250 Hz) at the locations you select in Question 6 and Question 6?

Yes No

[1] Noise and Vibration Control by Leo Beranek
[2] Environmental Noise Control by Edward Magrab

Question 3

1st Survey

Original Question	Selection	# Resp	%
If you answered yes to question 2, on which scale low-frequency requirements be measured?	A	2	7%
	B	0	0%
	C	14	52%
	D	0	0%
	G	1	4%
	No Answer	10	37%

2nd Survey

If you answered yes to Question 2, on which scale low-frequency requirements be measured? (Please circle only one answer.)

A B C D G

Question 4

1st Survey

Original Question	Selection	# Resp	%
Should infranoise (< 20 Hz) requirements be specified separately?	Yes	18	67%
	No	3	11%
	No Answer	6	22%

Further Discussion

One participant stated that it was very important that infranoise not be heard or felt past the property line of the least land of the project. For a good description of infranoise and its impacts, please read http://www.lowertheboom.org/trice/BoomCarNoise.pdf pages 14-19

2nd Survey

Should wind turbine siting guidelines specify a maximum loudness for infranoise (< 20 Hz) at the locations you specify in Question 6 and Question 6a?

Yes No

Question 5

1st Survey

Original Question	Selection	# Resp	%
If you answered yes to Question 4 on which scale infrasound requirements be measured?	A	0	0%
	B	0	0%
	C	3	11%
	D	0	0%
	G	14	51%
	No Answer	10	37%

2nd Survey

If you answered yes to Question 4, on which scale infrasound requirements be measured? (Please circle only one answer.)

A B C D G

Question 6

1st Survey

Original Question	Selection	# Resp	%
If turbines are placed on a farm where someone resides, where should the noise impact be measured?	outside dwelling on same property	18	67%
	Inside dwelling on same property	9	33%
	Property line	15	56%
	Outside neighboring dwelling	5	19%
	Inside neighboring dwelling	5	19%

Further Discussion

Since the participants voted to add Question 6a, the last two options are more appropriately covered in that question. So for the second survey, they are omitted from Question 6.

The participants voted to allow multiple answers to this question.

2nd Survey

If turbines are placed **on a the same property** where someone resides, where should the noise impact be measured?

outside dwelling on same property | Inside dwelling on same property

Question 6a

1st Survey

Original Question	Selection	# Resp	%
If turbines are placed on a property adjacent to a residence, where should the noise impact be measured?	outside dwelling on same property	7	26%
	Inside dwelling on same property	4	15%
	Property line	19	70%
	Outside neighboring dwelling	5	19%
	Inside neighboring dwelling	6	22%

Further Discussion

The participants voted to add this question to the first survey to protect people living near (but not on) a wind farm. Since this question was patterned after Question 6, the same answers were possible. However, since the first two options are covered in Question 6a, we omit them from the second Survey.

The participants also voted to allow multiple answers.

One comment made during the discussion was that requiring noise measurements inside of a neighboring dwelling might be practical. He said zoning boards could not mandate that a wind farm developer have access to neighboring homes to conduct measurements inside. If a zoning ordinance required noise measurement inside of a neighboring home, and the homeowner refused to allow the developer inside, it would cause conflicts

2nd Survey

If turbines are placed **adjacent** to a residence, where should the noise impact be measured?

Property line | Outside neighboring dwelling | Inside neighboring dwelling

Question 7

1st Survey

Original Question	Selection	# Resp	%
Siting guidelines should specify the following maximum dB during the day for frequencies between 20 Hz and 20 kHz:	30 dB	1	4%
	40 dB	5	19%
	45 dB	2	7%
	50 dB	10	37%
	55 dB	1	4%
	60 dB	3	11%
	No Answer	5	19%

Further Discussion

One participant wrote in 30 dB. A few participants stated they were uncertain where this noise was measured. Our intention was that it be measured at the location you indicated in Question 6 and Question 6a. To make this clearer we rephrased the question.

2nd Survey

Assuming the noise is measured at the location you specified in Question 6 and Question 6a, what should wind turbine siting guidelines specify as the maximum allowable noise during the day (7 a.m. - 7 p.m.)?

30 dB | 40 dB | 45 dB | 50 dB | 55 dB | 60 dB

Question 8

1st Survey

Original Question	Selection	# Resp	%
If ambient noise (such as noise from the wind) during the day becomes higher than the specified limits, the limits should be adjusted by:	None	8	30%
	3 dB	2	7%
	5 dB	8	30%

Original Question	Selection	# Resp	%
	6 dB	0	0%
	10 dB	3	11%
	No Answer	6	22%

2nd Survey

If ambient noise during the **day** (7 a.m. - 7 p.m.) from sources other than the wind turbines becomes higher than the specified limits, the limits should be adjusted by:

None 3 dB 5 dB 6 dB 10 dB

Question 9

1st Survey

Original Question	Selection	# Resp	%
Should the maximum turbine noise allowed during the day be based on any of the following indices?			
L_{max} (Maximum volume)	Yes	11	40%
L_{10} (annoyance)	Yes	16	60%
L_{eq} (average sound energy)	Yes	10	37%
L_{90} (background noise	Yes	12	44%
L_{dn} (day-night average)	Yes	6	22%
Speech Interference Level (SIL)	Yes	8	30%

Further Discussion

Two participants indicated that this question was confusing. When we reviewed the surveys, we discovered that the question was poorly worded and the responses don't provide useful information.

In many areas, noise levels change several times per day. So a noise source that might seem loud at some times might be barely noticeable at other times. To account for these differences, some acoustic engineers recommend specifying statistical limits.

For example, the Oregon Noise Control Regulation requires the operator of noise producing equipment determine the L_{10} and L_{50} of a community **prior** to installing the equipment. Once the equipment is operating, it must not raise the statistical levels L_{10} or L_{50} by more than 10 dB in any one hour. (Remember that L_{10} refers to a noise level exceeded 10% of the time.) You can read more about Oregon's Noise Control Regulation at http://www.energy.state.or.us/siting/noise.htm. This web site also discusses some of the difficulty of measuring statistical noise levels for wind turbines.

With all of this in mind, we now ask somewhat different questions.

2nd Survey

Should Michigan's wind turbine siting guidelines specify that a wind turbine not increase prior existing statistical noise levels by a specified amount? (The levels would be measured at the location you specified in Question 6 and Question 6a.)

L_{10} (annoyance)	Yes	No
L_{eq} (average sound energy)	Yes	No
L_{90} (background noise)	Yes	No
L_{dn} (day-night average)	Yes	No

Question 9a

1st Survey

This question was not included in the first survey.

2nd Survey

If you answered yes for L_{10}, L_{50} or L_{90} in Question 9, over what time period should the Michigan Wind Turbine Siting guidelines specify these values be measured.

1 hour 3 hours 6 hours 12 hours Other:_____

Note: L_{dn} is a 24-hour average.

Question 9b

1st Survey

This question was not included in the first survey.

2nd Survey

If you answered yes for any statistical value in Question 9, what should the Michigan's Wind Turbine Siting guidelines specify as the maximum increase in these levels caused by wind turbine operation?

3 dB 5 dB 6 dB 10 dB 15 dB

Question 10

1st Survey

Original Question	Selection	# Resp	%
Should the maximum turbine noise allowed during the day be based on any of the following indices?			
Speech Interference Level (SIL)	Yes	8	30%

Further Discussion

This question was originally part of Question 9. However, the SIL is not a statistical measure, and should not be grouped with those measures. The SIL is a maximum noise level that will not interfere with speech recognition between individuals a set distance apart.

2nd Survey

Should Michigan's Wind Turbine Siting Guidelines specify a maximum noise level for speech interference?

Yes No

Question 10a

1st Survey

Original Question	Selection	# Resp	%
If you answered 'yes' to specifying a Speech Interference Level, on what distance should this be based?	1/2 ft	0	0%
	1 ft	0	0%
	3 ft	1	12%
	6 ft	2	25%
	10 ft	4	50%
	No Answer	1	12%

Further Discussion

The percentages for this question are based on the number (8) of people who answered Yes to Question 10. One respondent mentioned that 10 ft is the distance of most rooms. For more information, refer to the presentation handout page 11.

2nd Survey

If you answered Yes to specifying a Speech Interference Level, on what distance should this be based? (Please circle only one)

1/2 ft 1 ft 3 ft 6 ft 10 ft

Question 11

1st Survey

Original Question	Selection	# Resp	%
Should sound levels at night be specified as adjustments to day values or absolute values?	Adjusted	9	33%
	Absolute values	14	52%
	No Answer	4	15%

2nd Survey

Should sound levels at **night** be specified as adjustments to day values or absolute values? (Please circle only one)

Adjustments Absolute values

Question 11a

1st Survey

Original Question	Selection	# Resp	%
If you selected absolute values for the previous question, what should the siting guidelines should specify as the maximum dB during the night for frequencies between 20 Hz and 20 kHz?	30 dB*	2	14%
	40 dB	5	36%
	45 dB	2	14%
	50 dB	1	7%
	55 dB	1	7%
	60 dB	0	0%
	No Answer	3	21%

Further Discussion

The percentages for this question are based on the number (14) of people who answered yes to Question 11.

One respondent mentioned wrote in 30 dB and no one selected 60 dB. So we have changed the possible responses to this question. See the presentation handout page 12 for statistics on sleep interference.

2nd Survey

If you selected absolute values for Question 11, what should the siting guidelines should specify as the maximum dB during the **night** for frequencies between 20 Hz and 20 kHz? (Please circle only one)

30 dB 40 dB 45 dB 50 dB 55 dB

Question 12

1st Survey

Original Question	Selection	# Resp	%
Should wind turbine siting guidelines specify a maximum number of starts and stops during the night?	Yes	12	44%
	No	10	37%
	No Answer	5	19%

Further Discussion

See the presentation handout page 12 for statistics on sleep interference.

2nd Survey

Should wind turbine siting guidelines specify a maximum number of starts and stops during the **night**?

Yes No

Question 13

1st Survey

Original Question	Selection	# Resp	%
Siting Guidelines should specify penalties when noise exceeds the limit for more than:	5 min	7	26%
	20 min	2	7%
	30 min	4	15%
	45 min	0	0%
	1 hr	4**	15%
	3 hrs	1	4%
	No penalty	2	7%
	No Answer	8	30%

Further discussion

One participant suggested that penalties be assessed differently for day and night: after 5 min for night time, but after 1 hour during the day. Another participant suggested that the guidelines specify specific penalties. To see if other participants agree, we modified this question slightly and added Question 13a, Question 13b and Question 13c to the survey.

Note: Some communities may specify noise restrictions starting at 10 p.m. However, for consistency with our previous documentation, we continue to define day as 7 am - 7 p.m., evening as 7 p.m. - 11 p.m., and night 11 p.m. - 7 a.m.

2nd Survey

Siting Guidelines should specify penalties when noise exceeds the limit **during the day** (7 a.m - 7 p.m.) **and evening (**7 p.m. - 11 p.m.) for more than: (Please circle only one)

5 min 20 min 30 min 45 min 1 hr No penalty

Question 13a

1st Survey

This question was not included with the first survey, but participant responses suggested that we add it.

2nd Survey

Should wind turbine siting guidelines specify a different penalty for violating noise limits at night?

Yes No

Question 13b

1st Survey

This question was not included with the first survey, but participant responses suggested that we add it.

2nd Survey

If you answered Yes to Question 13a, after how much time should a penalty be imposed when noise exceeds the specified limits at night (11 pm –7 am): (Please circle only one)

5 min 20 min 30 min 45 min 1 hr

Question 13c

1st Survey

This question was not included with the first survey, but participant responses suggested that we add it.

2nd Survey

Should Michigan's Wind Turbine Siting Guidelines recommend specific penalties for noise violations. Note: These would not be legally binding. It would be up to local communities to enact legally binding penalties.

Yes No

Question 14

1st Survey

Original Question	Selection	# Resp	%
Do you have first-hand experience with the following?			
ASTM E 1240 "Standard Test Method for Performance Testing of Wind Energy Conversion Systems"	Yes	1	4%
ICE 614000-11 Wind Energy Standards: Acoustic Emission Measurement Techniques	Yes	1	4%
ISO 1996 "Description and Measurement of Environmental Noise"	Yes	1	4%
EPA Model Noise Ordinance	Yes	0	0%
SERI/TP-217-3261 "A Proposed Metric for assessing the Potential of Community Annoyance for Wind Turbine Low Frequency Noise Emissions"	Yes	0	0%

Further Discussion

Only one person had experience with any of the standards. Since most of these standards must be purchased and are not readily accessible, we will omit this question from further rounds of the survey.

However the EPA model noise ordinance can be downloaded free from http://www.nonoise.org/epa.htm and may be worth examining.

Question 15

1st Survey

Original Question	Selection	# Resp	%
If you checked one or more the standards in the previous question Would you recommend that wind turbine siting guidelines specify using these standards?			
ICE 614000-11 Wind Energy Standards: Acoustic Emission Measurement Techniques	Yes	1	100%

Further Discussion

Since only one person had experience with any of the standards, we omit this question from further rounds of the survey.

A Delphi Inquiry into

Wind Turbines' Impact on Wildlife and the Environment

February 14, 2005

Hosted by

LAWRENCE TECHNOLOGICAL UNIVERSITY®

Wind Turbines' Impact on the Environment and Wildlife

A Delphi Inquiry

Hosted by

Lawrence Technological University

Today's Agenda

- Presentation
- Open Dialog
- Survey Development

Today's Presentation

- Introduction
  - Who we are
  - Why we are here
- Delphi Inquiry
- Impact on Air Quality
- Wildlife Impacts
  - Birds
  - Bats
- Other Environmental Issues
  - Local climate change
  - MI Public Act 451

Who We Are

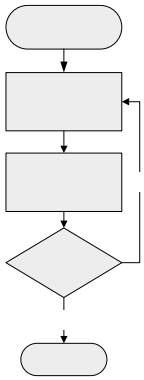
- Lawrence Technological University
  - Lead researcher: Daniel J. Alberts
  - Faculty advisors: Dr. Robert Fletcher, Dr. Brian Pedell
  - Research assistants: Kevin Pawlowski, Tim Bedra
- Collaborative Partners
  - State of Michigan Energy Office
  - Michigan Wind Working Group
  - DTE Energy
  - Copper 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 the wildlife impact issues
- Open the dialog
- Determine what questions need to be asked



Delphi Process

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

- Goal: develop a consensus of INFORMED opinions

Dialog vs Discussion

Discussion: views are presented and defended

Dialog: openly discuss ideas and views to help develop a new understanding

ntation

alog

Survey No

Air Pollution

From Power Generation

ensus?

es

End

Chemicals

- Carbon Dioxide CO_2
- Sulfur Dioxide SO_2
- Nitrogen Oxides NO_x
- Nuclear Waste
- Mercury

- Source: www.elpc.org/polCalc/

Impact of $S0_2$

- Causes breathing difficulty for people with asthma
  - Longer-term exposure can aggravate existing heart disease
- Acid Rain damages forests and crops
  - changes the makeup of soil
  - makes lakes and streams unsuitable for fish
- Accelerates the decay of buildings, monuments, and statues

Impacts of NO_x

- Ground-level Ozone
  - Causes damage to lung tissue and reduced lung function
- Water Quality Deterioration
  - nitrogen loading in water bodies upsets the balance of nutrients used by aquatic plants and animals
  - leads to oxygen depletion and reduces fish populations
- Damages vegetation and reduces crop yields

Health Effect Incidence
(U.S. cases per year)

Mortality	23,600
Hospital Admissions	21,850
Emergency Room Visits for Asthma	26,000
Heart Attacks	38,200
Chronic Bronchitis	16,200
Asthma Attacks	554,000
Lost Work Days	3,186,000

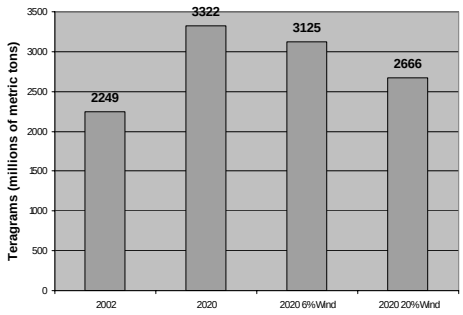
Source: http://www.cleartheair.org/dirtypower/

Sensitive Populations

County	Total Pop	Adult Asthma	Chronic Bronchitis	Emphysema	Cardiovascular Disease
GRAND TRAVERSE	81,263	5,412	2,769	995	18,385
HURON	35,422	2,396	1,266	541	9,473
MASON	28,879	1,941	1,015	403	7,225
MUSKEGON	171,765	11,000	5,597	1,990	36,819
OAKLAND	1,202,721	79,254	40,370	13,831	260,286
SAGINAW	210,087	13,629	7,004	2,581	47,253
WASHTENAW	334,351	22,720	11,092	3,186	62,646
TOTAL:	**7,743,502**	**502,222**	**254,099**	**87,372**	**1,634,360**

Source: http://lungactionhttp://lungaction.org/reports/SOTA04_statesensitive.html?geo_area_id=26

Projected CO_2 Emissions



Source: National Renewable Energy Laboratory 2003 Research Review

Wildlife Impacts

How Wind Turbines Can Affect Birds

Avian Deaths at Altamont Pass

March 1998-Feb 1999

	Deaths*	Sightings
Red-Tailed Hawk	74	1,240
Rock Dove	45	120
Western Meadowlark	29	41
American Kestrel	13	255
Golden Eagle	5	348
Turkey Vulture	0	722
Total	259	4,500

*685 Turbines studied out of 5,400 total turbines
Source: Proceeds of the National Avian-Wind Power Planning Meeting IV

Causes of Death

April 98- Feb 2000

Collisions with Turbines*	87%
Predation	4%
Suspected Electrocutions	2%
Collisions with Wires	1%
Cause not known	6%

* Varies by Species. Only 40% of Golden Eagle deaths attributed to blade strikes

Site Comparison

Site	Raptors	Water Fowl	Protected Passerines
Altamont Pass, CA	47.6%	1%	18%
Buffalo Ridge, MN	1.8%	9.1%	72%
Foote Creek, WY	4.2%	0%	90%
MG&E and WPSC, WI	0%	9.5%	66%

Deaths per Rotor Swept Area

Site	Rotor Diameter	Deaths per RSA
Foote Creek, WY	44 m	3 per 100,000 m^2
Altamont Pass, CA	18 m	9-22 per 100,000 m^2

Altamont Pass

Site Characteristics

- 5,400 turbines
- Most turbines are:
  - Kenetech 100 kW
  - Rotor diameter 18 m
  - 18 m high lattice structures
  - Down wind blades
  - Open nacelles
  - Rotor tip speed >180 mph
- High prey density

US Dept of Interior Recommendations for Site Selection

Avoid:

- documented locations of species protected by Federal Endangered Species Act
- bird migration paths
- daily movement flyways
- riparian areas along streams and landfills
- areas with frequent fog, mist, low cloud ceilings and low visibility
- cliff edges, dips or passes in a ridge
- fragmenting large tracts of wildlife habitat

US Dept of Interior Recommendations for Turbine Design and Operation

- Use tubular towers, not lattice
- Avoid guy wires
- Above 199 ft, minimum FAA minimum lighting requirements
  - White lights only – Avoid Red lights
  - Minimum intensity
  - Minimum flashes
- Turn off turbines during bird peak usage times
- Orient turbine rows parallel to bird movements
- Monitor wildlife impact for 3 years

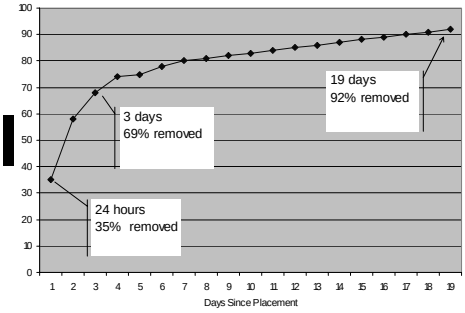
Wildlife Impacts

How Wind Turbines Can Affect Bats

Assumptions in Question

- Assumptions prior to 2003:
  - Methods for studying bird fatalities were valid for bats
  - Turbines did not endanger resident bats only migrating bats
- Speculation:
  - Migrating bats turned off their echolocation

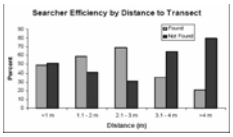
Scavengers Remove Carcasses

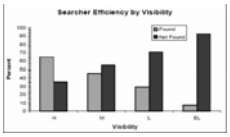


Source: Patterns from Daily Mortality Searches at Backbone Mountain, WV by Jessica Kerns

Searcher Efficiency

- Varies with:
  - Habitat
  - Type of detection
  - Distance from turbine
  - Use of canine searchers



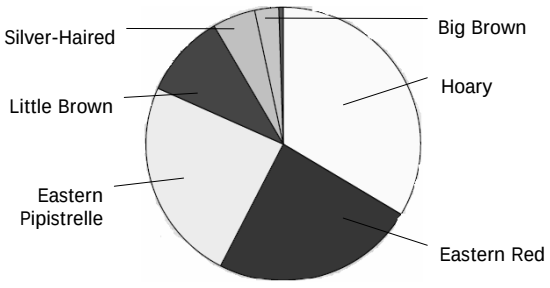


Source: Patterns from Daily Mortality Searches at Backbone Mountain, WV by Jessica Kerns

New Findings

- Meyersdale, PA
- 20 1.5 MW Neg Micon turbines
- July 30th – Aug 1st, 2004
- 290 fatalities
- estimating 29,000 bats could be killed annually at the two sites studied: Mountaineer, WV and Meyersdale, PA.

Bat Species Impacted



Source: Patterns from Daily Mortality Searches at Backbone Mountain, WV by Jessica Kerns

New Research

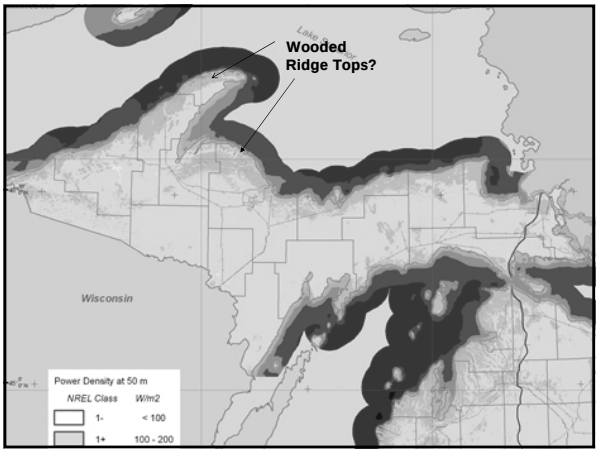
- Sponsors:
  - Bat Conservation International
  - U.S. Fish and Wildlife Service
  - American Wind Energy Association
- Began 3-year study in 2004
  - Identify causes of bat deaths in 2004
  - Test possible solutions in 2005

Photo by Kim Williams, Organization For Bat Conservation

Bat Conservation International Recommendations

- Issued statement in Jan 2005
- Cautions against permitting turbines on wooded ridge tops

BAT CONSERVATION INTERNATIONAL
www.batcon.org



Local Climate Change

The RAMS Simulation

Is the Research Applicable?

- Assumptions
  - 10,000 Turbines at one location
  - Tower height =100 m
  - Rotor diameter = 50 m
  - Assumed weather conditions in Oklahoma's drought of 2000
- Michigan's reality
  - 300 – 500 turbines
  - Tower heights = 60 m
  - Rotor diameters = 80 – 90 m
  - Annual Precipitation 26 - 40 inches

Michigan's Public Act 451

Natural Resource and Environmental Protection Act

Michigan Public Act 451

- Existing Law that impacts Wind Farm Siting and Construction
  - Part 91: Wind Farms will be required to submit a Soil Erosion and Sedimentation Control Plan if more than 1 acre of land is disturbed, or if disturbance is within 500 ft of lake or stream.
  - Part 301: Inland Lakes and Streams
  - Part 303: Wetlands
  - Part 31: Water Resources Protection, i.e., filling flood plains and storm water
  - Part 323: Shore land Protection and Management, i.e., specifies high risk areas that must be avoided
  - Part 353: Dunes Protection

Summary

- Wind Turbines have positive and negative impacts
- MPSC recommending MI install 800 MW of Wind Power by year 2020
- Your input will help develop better siting guidelines and zoning ordinances to mitigate negative impacts

Further Reading

Delphi Method

Building Consensus using Policy Delphi	http://www2.mc.uky.edu/TobaccoPolicy/Article%202.pdf
Collaborative Delphi	http://sustainablerangelands.cnr.colostate.edu/symposium%20proceedings/rowe.pdf
The Delphi Method: Techniques and Applications	http://www.is.njit.edu/pubs/delphibook

Air Pollution

EPA Six Most Common Pollutants	http://www.epa.gov/air/urbanair/6poll.html
ELPC Pollution Calculator	http://www.elpc.org/polCalc/
envirohealth	http://www.envirohealthaction.org/pollution/
MedlinePlus	http://www.nim.nih.gov/medlineplus/airpollution.html
American Lung Association	http://lungaction.org/reports/stateoftheair2004.html
Clear the Air	http://www.cleartheair.org/dirtypower/

Avian Research

National Wind Coordinating Committee	http://www.nationalwind.org/publications/default.htm
	http://www.nationalwind.org//events/past.htm
Curry and Kerlinger	http://www.currykerlinger.com/studies.htm

Local Climate Change

Baidya, Roy and Pacala, S. (Oct 2004) Journal of Geophysical Research, Vol 109, doi:10.1029/2004JD004763, 2004

MI Act 451: Natural Resource and Environmental Protection Act

Michigan Department of Environmental Quality	http://www.michigan.gov/deq/0,1607,7-135-3311_4113-8844--,00.html
	http://www.michigan.gov/deq/0,1607,7-135-3311_4113---,00.html

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: _____

Address: _____ County: _____

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 wildlife research and/or conservation: (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 on wildlife?

_____

_____

_____

On what aspects of wind turbines' impact on wildlife 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?_____

In which additional wind energy Delphi Inquiries would you be willing to participate?

- □ Interference with electronic tower transmission
- □ Land requirements for service roads and power stations
- □ Impact on viewsheds
- □ Decommissioning Issues

Wildlife Impact Questions

Please tell us what questions you believe we need to address in our Delphi Inquiry, the state siting guidelines and local zoning ordinances. If possible, when recommending a multiple choice question, please include at least three potential answers.

Please Return Surveys to:

Att: Wind Energy Delphi
Mechanical Engineering Department
Lawrence Technological University
21000 W. Ten Mile Rd.
Southfield, MI 48075

To all Participants:

Thank you again for participating in Lawrence Technological University's Delphi Inquiry into Wind Turbine's Wildlife Impact issues. As I explained during the presentation, a Delphi Inquiry is an iterative series of discussions and surveys.

Although the ice storm reduced our attendance, we have received enthusiastic participation from several wildlife conservation professionals. This has helped the process considerably. They have helped us identify several important questions regarding wind turbines and wildlife. To all of you, thank you.

Now it is time to proceed with the second survey. Here we address the questions raised in the first part of the inquiry. For this reason, I've put together this information packet.

This packet contains:

a) the second wildlife survey

b) links to additional reference material online

If you have any questions on the material, please post them to our discussion list at mwwg@topica.com. Or contact me at my email address dja1701@nethere.com. Those of you who haven't joined the list may still do so at http://lists.topica.com/lists/mwwg.

Please take the time to consider this information, fill out the second survey and return the surveys to the address below by May 15, 2005.

Thank you.

Daniel Alberts
Wind Energy Delphi
Lawrence Technological University
Mechanical Engineering Dept
21000 W. Ten Mile Rd.
Southfield, MI 48075

www.ltu.edu/engineering/mechanical/delphi_wind.asp
dja1701@nethere.com

A Delphi Inquiry into

Wind Turbines' Impact on Wildlife and the Environment

2nd Iteration April 11, 2005

Participant Name: _____

LAWRENCE TECHNOLOGICAL UNIVERSITY®

Project Summary

The Energy Office of Michigan and the Michigan Wind Working Group asked Lawrence Technological University (LTU) to conduct a Delphi Inquiry into wind turbine siting issues. A Delphi Inquiry is an iterative series of open dialogs and surveys that leads to a consensus of informed opinions. Our goal is to provide a structured forum that helps state and local policy makers collect, understand and analyze the technical data that they need to consider to develop wind turbine siting guidelines.

LTU initiated our inquiry into wind turbine noise with a teleconferenced presentation on December 3, 2005. We followed up with two surveys. The results of the first survey on noise issues is available from our web site. We are still collecting the second noise survey.

LTU initiated our inquiry into wind turbine's impact on wildlife with a teleconference presentation on February 14, 2005. This introduced our participants to some of the research that has been conducted in other states and to many recommendations for minimizing impact. At this presentation, we asked participants to help us develop questions that need to be addressed for the Michigan siting Guidelines. The surveys that were return identified a number of good questions. In this second round we ask many, but not all, of those questions. Two reasons why we chose to omit some of the questions are:

a) Our electronic discussion or some research resolved the issue.

b) The question seemed to be beyond the expertise of participants.

Now it is time to proceed with the second survey; where we will address the questions raised in the first part of the inquiry. For this reason, I've put together this information packet.

Survey 2

Please note that in this second survey the instructions are a little different. For the first wildlife survey, we asked you to help us develop questions that needed to be asked. In this survey, we ask many of those questions. Where possible we provide some additional background material to help with your understanding. Please circle only one answer for each question.

Remember that our goal is to collect and analyze issues related that need to be addressed in developing Michigan's Wind Turbine Siting Guidelines.

Instructions

1. Write your name on the title page.
2. Please circle only one answer for each question.
3. Return the survey in the enclosed self-addressed-stamped envelope.

Project Impact Index (PII)

The US Fish and Wildlife (USFW) Interim Guidelines recommend that wind energy developers compare potential sites by developing a Project Impact Index (PII). However, these guidelines are voluntary.

For more information on the PII, visit http://www.fws.gov/r9dhcbfa/windenergy.htm

1. Should the Michigan Wind Turbine Siting Guidelines specify that developers must provide a PII prior to constructing a wind farm?

   Yes No

2. The PII requires a comparison to a reference or baseline site. Should comparisons be made to a reference or baseline site within:
   a) the local county
   b) a region of the state of Michigan
   c) the State of Michigan
   d) the USA
3. Should the Michigan Siting Guidelines specify a reference or a baseline site for PII comparisons?

   Yes No

4. The procedure for developing the PII (as stated in the US FWS Interim Guidelines) is a model that needs to be modified for different sites. Who should develop the final version?
   a) Michigan Energy Office
   b) Michigan Dept of Natural Resources
   c) Michigan Dept of Environmental Quality
   d) An independent board of environmental consultants appointed by the State of Michigan
   e) Local communities

Tower Design and Construction

5. The USFW recommends that towers be lighted with only white lights. Red lights should be avoided. Should the Michigan Wind Turbine Siting Guidelines include this recommendation?

Yes No

6. The American Bird Conservancy recommends that Any lighting should be with strobe lights, either white or red. The pulse rate should be kept to 20 pulses per minute, if possible, and the pulses should be synchronized. Should the Michigan Wind Turbine Siting Guidelines include this recommendation?

Yes No

7. Should the Michigan Siting Guidelines recommend that turbine blades be painted to make them more visible to birds?

Yes No

8. American Bird Conservancy recommends that wind turbine power lines be underground; power lines should at a minimum comply with Avian Power Line Interaction Committee (APLIC) Standards to Prevent Avian Electrocutions. Should the Michigan Wind Turbine Siting Guidelines include this recommendation?

Yes No

For more information on APLIC, visit http://www.aplic.org/resources.htm

Tower Operation

9. Should wind turbines be shut down during the peak migrations of certain endangered species like the Kirkland Warbler?

Yes No

For more information on the Kirkland Warbler, visit http://www.michigan-sportsman.com/non-game/kirkland_warbler.htm or http://www.avianweb.com/warblers.htm

10. If wind turbines can be shutdown during peak migration periods, how much notice needs to be given?

    a) one day
    b) three days
    c) one week
    d) one month

11. If you answer yes to Question 9, should the Michigan Wind Turbine Siting Guidelines specify a penalty for non-compliance?

Yes No

Wildlife Monitoring

12. The USFW recommend a minimum of three years of monitoring wildlife. Some researchers have suggested that for agricultural areas a single season of monitoring is sufficient.
13. Should the Michigan Siting Guidelines recommend a minimum period of wild life monitoring **prior** to wind turbine construction?

Yes No

14. If you answered yes, what should that minimum period be?
    e) one season
    f) two seasons
    g) one year
    h) two years
    i) other _____

15. Should the Michigan Siting Guidelines recommend a minimum period of wild life monitoring **after** wind turbine construction?

Yes No

16. If you answered yes, what should that minimum period be?
    a) one season
    b) two seasons
    c) one year
    d) two years
    e) other _____

17. Who should conduct the wildlife monitoring?
    a) The wind energy developers
    b) The State of Michigan
    c) Local municipalities
    d) An independent board of wildlife professionals

18. Should wind energy developers be required to pay for the wildlife monitoring regardless of who conducts the studies?

    Yes No

19. Should all wildlife monitoring data be made public?

    Yes No

20. Should the State of Michigan appoint a committee to collect and distribute all wildlife data relating to wind farms in the State of Michigan?

    Yes No

Geographic Restrictions

21. Bat Conservation International has recommends that no turbines be built on wooded ridge tops. Should Michigan's guidelines include this recommendation?

    Yes No

22. Many birds follow Michigan's coastline while migrating. Should wind turbines be prohibited within a certain distance (onshore) of Michigan's coastline?

    Yes No

23. If you answered 'yes', what should that minimum distance be?
    a) 1/4 mile
    b) 1/2 mile
    c) 1 Mile
    d) 5 miles

24. Should the Michigan Siting Guidelines recommend a minimum distance from caves where bats are known to hibernate?

Yes No

25. Should the Michigan Siting Guidelines recommend a minimum distance from bird sanctuaries?

Yes No

Do you have additional questions that you feel still need to be addressed?

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

A Delphi Inquiry into

The Importance of Wind Turbine Shadow Flicker

April 22, 2005

Hosted by

LAWRENCE TECHNOLOGICAL UNIVERSITY®

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

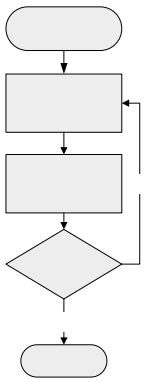
- Lawrence Technological University
  - Lead researcher: Daniel J. Alberts
  - Faculty advisors: Dr. Robert Fletcher
  - Research assistants: Kevin Pawlowski
- Collaborative Partners
  - State of Michigan Energy Office
  - Michigan Wind Working Group
  - DTE Energy
  - Copper Country Intermediate School 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

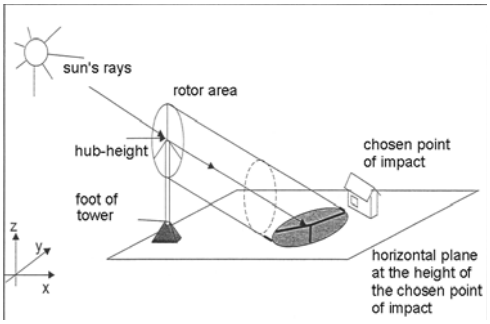
Dialog vs Discussion

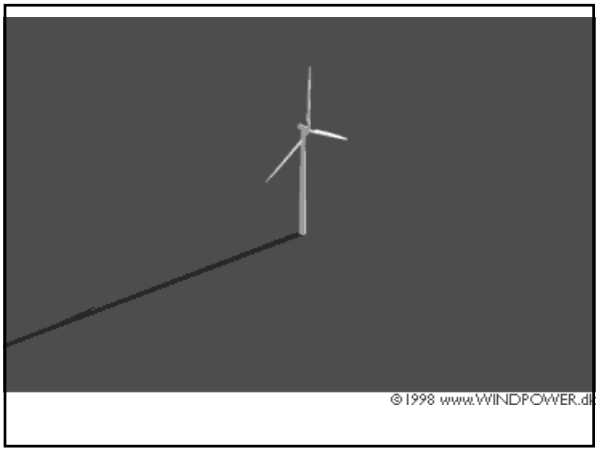
Discussion:	views are presented and defended
Dialog:	openly discuss ideas and views to help develop a new understanding

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

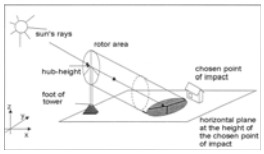
- Epilepsy affects more than 2.5 million Americans.
- Flashing lights can trigger seizures in approximately 5 percent (100,000)
- Flicker between 5 to 30 Hz are most likely to trigger seizures.

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

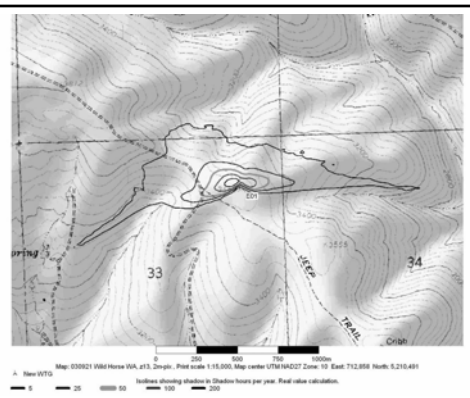
Show video

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:

Att: Wind Energy Delphi
Mechanical Engineering Department
Lawrence Technological University
21000 W. Ten Mile Rd.
Southfield, MI 48075