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Public Service Commission of Wisconsin
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Wisconsin
Wind Siting Council

Wind Turbine Siting-Health Review

and

Wind Siting Policy Update

October 2014

October 31, 2014

Chief Clerk Jeff Renk
Wisconsin State Senate
P.O. Box 7882
Madison, WI 53707

Chief Clerk Patrick E. Fuller
Wisconsin State Assembly
17 West Main Street, Room 401
Madison, WI 53703

Re: Wind Turbine Siting-Health Review and Wind Siting Policy Update Pursuant to Wis. Stat. § 196.378(4g)(e).

Dear Chief Renk and Chief Fuller:

Enclosed for your review is the 2014 Report of the Wind Siting Council. This report is a summary of developments in the scientific literature regarding health effects associated with the operation of wind energy systems, and also includes state and national policy developments regarding wind siting policy. The Wind Siting Council has no recommendations to be considered for legislation at this time. On behalf of the Council, I wish to thank you for the opportunity to provide this report to the legislature.

Sincerely,

Carl W. Kuehne
Wind Siting Council Chairperson

Enclosure

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1.0 EXECUTIVE SUMMARY

The Wind Siting Council offers this report to the Wisconsin State Legislature for its consideration with a copy given to the Public Service Commission of Wisconsin.

2009 Wisconsin Act 40 (Act 40) took effect on October 15, 2009. Act 40 created a policy framework to allow uniform local regulation of wind energy systems in Wisconsin. Wisconsin Statutes § 196.378(4g), created by Act 40, directed the Public Service Commission of Wisconsin (Commission or PSC) to promulgate rules to specify maximum restrictions that a municipality can impose on installation and use of wind energy systems throughout the state of Wisconsin. Act 40 also created Wis. Stat. § 15.797 which directed the Commission to appoint a Wind Siting Council (Council) to provide advice and counsel during the rulemaking process. Furthermore, Wis. Stat. § 196.378(4g)(e) directs the Council to provide a report on pertinent peer-reviewed literature of the effects of wind energy systems on human health to the Commission and the Wisconsin State Legislature, every five years. Wisconsin Stat. § 196.378(4g)(e) also requires the Council to study state and national regulatory developments regarding wind siting. The report may include recommendations for legislation. This report provides this literature review and also describes current policy trends with regards to wind energy system siting. This consensus report also has attached several appendices describing the positions of minority factions within the Council.

As required by Wis. Stat. § 15.797(1)(b), the Commission appoints a Council of 15 members[1] representing stakeholder categories with interests in or related to wind projects. One member is to have expertise on health impacts attributed to wind energy systems and be a member of the UW-system. This seat is currently vacant. The issues surrounding wind siting are complex and involve many competing policy priorities including protecting health and safety, complying with regulatory mandates, protecting the environment, preserving local government control, considering impacts to private property, and providing a reliable and affordable supply of energy. The make-up of the Council reflects these diverse interests. Each member of the seven stakeholder groups represented on the Council has their own unique view about how to balance these priorities.

The Council understands that the diversity of its membership and the volume of research on wind health and siting issues on all sides of the debate presents challenges. The Council agrees that the protection of public health and safety are paramount. Accordingly, the Council agreed prior to its investigation and preparation of this report to review facts and science with the awareness that not all scientific documents are of equivalent rigor or impact. Accordingly, more weight was given to some types of literature over others.[2]

[1] See Appendix A for a description of Council member stakeholder groups and membership.
[2] See Appendix B for a detailed description of literature criteria.

Pertinent literature included empirical research, reviews, and opinion articles that were gleaned from peer-reviewed scientific journals and reports from governmental entities. The scope of literature that was used for the wind-health review was also generally restricted to literature that specifically focused on the effects of wind energy systems on human health or well-being. As part of the Council's work while developing its 2010 wind siting recommendations that led to the creation of the Commission's administrative rules relating to wind energy systems, Wis. Admin. Code ch. PSC 128 (PSC 128), the Council provided an exhaustive and then up-to-date review of pertinent wind-health scientific literature.[3] This report covers new information that has been published in the scientific literature from 2011 to 2014.

To prepare this report, Council members collected literature related to the effects of wind energy systems on human health. Commission staff also conducted a formal literature review. These efforts identified over 40 peer-reviewed publications on wind-health issues and three governmental reports.[4] Although the Council sought to provide the most detailed and complete literature review as possible, certain limitations were encountered. The Council had limited access to some non-publicly available articles and there is a relative paucity of current and diverse research on the effects of wind energy systems on human health and well-being.

The Council's conclusions and recommendations are detailed below.

Summary of Key Findings from Wind-health Literature

- Nine publications based on cross-sectional surveys of individuals living in the proximity[5] of utility-scale wind energy systems have been conducted or analyzed since the Council's 2010 recommendations.
- Some individuals living in the proximity of wind systems may experience annoyance[6] and a small fraction report sleep disturbance[7] due to wind turbine noise during operation.
- Some individuals report increases in stress due to wind turbine operation.
- Stress and sleep disturbance may be related to chronic health conditions.

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[3] The Council's 2010 report contained both general conclusions and siting recommendations as well as a minority, dissenting appendix.

[4] The Council agreed to offer greater weight to peer-reviewed literature on wind-health issues, as mandated by Wis. Stat. § 196.378(4g)(e). As such, the Council's conclusions are based upon the peer-reviewed literature. Appendix C contains discussion of governmental reports identified by the Council. Full citation of all articles included in this survey is provided in Appendix D.

[5] "Proximity" and "near" refer to distances less than 1.5 miles.

[6] "Annoyance" is used throughout this report to mean "a feeling of resentment, displeasure, discomfort, dissatisfaction or offence which occurs when noise interferes with someone's thoughts, feelings or daily activities", as used by the World Health Organization in its publication regarding occupational noise, available at http://www.who.int/quantifying_ehimpacts/publications/en/ebd9.pdf. Although this report relies on this definition, it should be noted that rarely do the empirical reports, reviews, and governmental reports cited herein provide the definition of "annoyance" under which the authors' conclusions were reached. Thus, caution is merited when comparing conclusions regarding "annoyance" throughout the published literature.

[7] Approximately 4 percent of respondents

- There are substantial individual differences in how people report their perception of wind energy systems and a negative perception affects whether an individual reports adverse health effects that they attribute to wind energy systems.
- The majority of individuals living near utility-scale[8] wind systems do not report stress, sleep deprivation, or chronic adverse health effects attributed to wind turbines.

The strength of these conclusions is complicated by two factors. First, although there are nine publications on surveys of individuals living near wind turbines, the conclusions from two studies are of limited scope. For instance, one article by Taylor et al. (2013) surveys individuals living near wind turbines that have a maximum generating capacity of 5 kilowatt (kW) or less. These turbines are thus substantially smaller than a typical utility-scale turbine and the conclusions of that survey may not be applicable to the usual wind-health discussion. A second survey by Krogh et al. (2011) was only conducted near existing wind systems where anecdotal reports of health effects have been reported. Therefore, without a control group and due to the use of biased[9] survey questions, it is difficult to apply that study's conclusions to other wind projects. Indeed the bias introduced in the Krogh et al. (2011) survey results in reports of negative effects (sleep disturbance and headache) attributed to wind turbines by over 70 percent of participants, which is unusually high compared to other studies where negative effects were reported. The limitations of available research confines the Council's survey to only seven pertinent, unbiased, cross-sectional studies, three of which use the same data set.

The limited empirical research on wind-health issues leads to the second complicating factor for the Council's survey. Many of the reviews and opinion articles published since 2011 that were included as part of this literature survey are centered on these seven studies.[10] Thus, each review/opinion article identified is not an independent appraisal of the available science, but rather a summary of the same information repeated multiple times. Consequently, broad statements such as there is "overwhelming evidence"[11] that wind energy systems negatively impact human health rely on a limited amount of actual empirical research and summaries of summaries.

Based on the available literature, what the Council can reasonably conclude is that some individuals residing in close proximity to wind turbines perceive audible noise and find it annoying. A small subset of these individuals report that this noise negatively affects their sleep

[8] Turbines less than 100 kW in size are considered "small wind" under PSC 128 and are not subject to all of the same requirements as larger turbines. A typical utility-scale turbine generates at least 1.5 megawatt (MW) of electricity and 2.3 MW and larger turbines are currently operating in Brown County, Wisconsin and are being proposed for St. Croix County, Wisconsin. These higher capacity turbines are also proposed or are installed in other states and countries.

[9] "Bias" is used throughout this report to mean to have a tendency to show an unjustified prejudice towards an argument.

[10] Katsaprakakis 2012, Nissenbaum et al. 2012, Shepherd et al. 2011, Bakker et al. 2012, Pedersen 2011, Janssen et al. 2011, Mroczek et al. 2012

[11] Phillips 2011

and may result in other negative health effects. However, based on objective surveys near wind energy projects, it appears that this group is in the minority and that most individuals do not experience annoyance, stress, or perceived adverse health effects due to the operation of wind turbines. This conclusion is especially true if wind turbine siting is used to limit high noise exposure.

Summary of Regulatory Developments in Wind Siting

After reviewing the wind siting policies of all fifty states and the District of Columbia, as well as peer-reviewed literature regarding wind siting policy, the Council has concluded that Wisconsin's siting regulations for wind energy systems are consistent with other state and national policy regulatory developments.

No Recommendations for Legislation

Wisconsin's wind siting rule, Wis. Admin. Code ch. PSC 128, is the product of an extensive and transparent review process and has been in effect since March 16, 2012. Absent any specific information arising from a wind project reviewed and approved under PSC 128, and based on the survey of peer−reviewed scientific research regarding the health impacts of wind energy systems, and the study of state and national regulatory developments regarding the siting of wind energy systems, the Council majority finds no reason at this point to recommend legislation regarding the siting of wind energy systems.

2.0 THE COUNCIL AT WORK

Wind Siting Council Membership

Recognizing that there are many complex, diverse, and sometimes controversial issues involved in wind turbine siting, the Legislature prescribed a very diverse and explicit membership to the Council. Wisconsin Stat. § 15.797(1)(b) directs the Commission to appoint a Wind Siting Council of up to 15 members to, among other things, advise the Commission in its rulemaking process, provide pertinent information regarding wind siting policy, and survey the wind-health literature.

Wind-health Report Drafting

The Council first met to discuss the drafting of this wind-health review and policy update in mid-December, 2012. At that meeting, the Council developed a tentative timeline for report drafting. At the next meeting in early March, 2013, the council agreed upon the types of literature that would be considered in its survey and on a date before which to compile a literature list. Council members also agreed to have Commission staff assist them in drafting this report. By the beginning of May, 2013, Council members had submitted the literature they wished to be included in the report and Commission staff had conducted a formalized wind-health literature review. In mid-August, 2013, Council members received a list of all pertinent literature that was identified for this survey to facilitate the drafting process.

Commission staff then prepared a draft report for the Council to review. The Council's review began in February of 2014 and continued through multiple iterations of discussion and revision. In May of 2014, the Council voted to adopt this wind-health report, including the dissenting minority report that is attached as an appendix.

Wind-policy Update Drafting

In September, 2013, the Council was asked to provide to Commission staff any documents they would like to consider for the wind siting policy update. The Council did not identify any information beyond the 2012 National Association of Regulatory Utility Commissioners (NARUC) wind siting best practices.[12] Commission staff further surveyed all American states' policies to evaluate national policy trends.

[12] Stanton 2012

3.0 COUNCIL REVIEW OF WIND TURBINE-HEALTH LITERATURE

Survey of Peer-Reviewed Literature

The first large utility-scale wind turbines in Wisconsin went online in the late 1990's. From the outset of this newly implemented technology, there was considerable debate in different political subdivisions regarding the siting of wind turbines. As wind energy systems increased in size and capacity, some of this debate turned to the possible impacts that turbine operations may have on human health. Concerns about potential adverse health effects led to a formal regulatory framework in 2009 with the passage of Act 40 and creation of Wis. Stat. § 196.378(4g) which requires the Council to, among other things, provide recommendations on wind turbine siting criteria for rulemaking purposes and survey current, peer-reviewed literature on health impacts. As part of its recommendations to the Commission regarding wind siting rules, the Council completed its initial survey of the wind-health literature in 2010. The majority of the members concluded that given appropriate siting measures, including 50/45 dB(A) day/night noise limits, 1,250-foot wind turbine setback, and less than 30 hours of shadow flicker per year for non-participating residences, it is reasonable to conclude that adverse health effects would be unlikely to occur. These conclusions were codified in PSC 128 which describes the wind siting rules that the Commission considers when reviewing wind energy projects and the siting criteria that local governments may not be more restrictive than.

With over 400 utility-scale wind turbines installed throughout Wisconsin, some members of the public have continued to express concerns over potential adverse human health effects attributed to wind turbines. When wind energy systems were initially being proposed, the potential adverse health effect causes that people were concerned with included noise, shadow flicker, electromagnetic fields (EMF), stray-voltage, ice-throw, and physical collapse of the turbine. As wind energy has expanded, the most common issue that is now being studied with regard to impacts on individuals residing in close proximity to wind turbines is noise generated by the moving blades, electric generator, and mechanical yawing mechanisms. The level of public concern and amount of scientific or technical research associated with other potential adverse health causes have diminished.

In this five-year review, the Council surveyed scientific research, analysis, and opinions on the issue of wind energy systems and health that have been published since its 2010 recommendations to the Commission.[13] The Council conducted this survey using the operational definition of health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[14] As noted above, the focus of this survey is generally on the effects of wind turbine-generated noise, as this is the primary area where academic research is being conducted and the only such cause studied in the peer-reviewed publications identified

[13] See minority appendices E and F for further discussion of potential adverse health effects associated with wind energy systems.
[14] World Health Organization definition of health, available at http://www.who.int/about/definition/en/print.html.

by the Council. In addition to surveying literature that was identified by Council members, Commission staff also conducted a formal literature search in March of 2013, using the academic search engine ISI Web of Knowledge. Search terms included wind turbine and health, noise, low-frequency noise, infrasound, or shadow flicker. This search was repeated, using the same search criteria, in December 2013 to identify any articles that were subsequently published. All peer-reviewed publications that were relevant and available were collected. This group of papers was then narrowed to those published in 2011 or later for inclusion in this report. Additional publications were referenced in the Council's report as they became available in 2014, however a formal literature search was not conducted after December 2013.

Empirical Research

One of the most powerful measures to assess potential adverse health effects caused by utility-scale wind turbines are the results from epidemiological studies. The Council identified a number of cross-sectional, survey-based studies. These types of studies are common because they are easy to conduct, inexpensive, and can determine baseline prevalence of impacts across communities. They are, however, limited because they are not experimental and therefore cannot show absolute cause and effect. They are also limited in that they are subject to bias, discussed below, and they are a snapshot and are not able to establish trends. The Council's review of the wind-health literature revealed nine publications on cross-sectional surveys of individuals living near wind farms, related to health.[15] Of these nine publications, four appear to be unbiased with large sample sizes,[16] three have small sample sizes, limiting the reliability of their conclusions, and applicability of the other two is limited due to scope or study design.

Caution may be warranted when reviewing these surveys as they are subject to different, and sometimes overlapping, biases due to study design. These include observation, confirmation, and selection bias. Observational bias results when authors limit the scope of a study to a particular area or issue, in particular an area or issue where results are expected to be found while disregarding other information. This bias makes a positive result more likely than if a randomized sample was surveyed. Confirmation bias encompasses a range of effects that can be described broadly as a tendency to draw conclusions that are in keeping with pre-established beliefs. It can arise through the way data is collected, such as disregarding evidence that would be in conflict with anticipated results. Selection bias has to do primarily with failure to select study subjects that accurately represent the population or by allowing subject self-selection. For instance, performing a survey through an open, online means may select for those individuals motivated to participate rather than a cross section of a population.

[15] Bakker et al. 2012, Pedersen 2011, Nissenbaum et a. 2012, Shepherd et al. 2011, Katsaprakais 2012, Krogh et al. 2011, Taylor et al. 2013, Janssen et al. 2011
[16] Note, however, that these publications use the same source data set.

In addition to these biases in research design, there is also personal bias. As with any contentious field of academic study, some authors of the articles cited in this report may have interests in one area of argument. For instance, some authors reach the conclusion that wind turbines cause adverse health impacts by relying on evidence that other authors deem unreliable. The source of funding for some of the articles cited herein may also be from organizations that support or oppose wind energy. This may or may not influence the authors' perspectives on the wind-health issue. What is clear is that the majority of the articles cited in this report are peer-reviewed and that, regardless of the opinions of the article authors, outside experts have opined that the articles offer some degree of independence and important scientific information.

Surveys with Large Sample Sizes

The largest analysis (1,755 respondents) was conducted by Pedersen (2011) and involved three cross-sectional surveys in the Netherlands and Sweden using similar survey designs to evaluate the effect of environmental noise on health and well-being.[17] Respondents could indicate their level of annoyance from any sort of environmental noise. In all three surveys, most respondents did not report annoyance or adverse health effects associated with environmental noise. For those individuals that did report annoyance, it directly correlated to environmental noise, including noise generated by wind turbines. Surveys from two of the three wind energy systems also indicated that sleep interruption was related to environmental noise, including wind turbine noise. All three surveys also indicated that environmental noise is associated with stress. The study's author suggested that stress from environmental noise may cause a positive feedback loop between stress and sleep disturbance, where stress causes sleep disturbance which in turn causes more stress. Although annoyance, sleep disturbance, and stress were linked to environmental noise, the authors point out that these effects are only attributable to wind turbines when they are generating sound levels over 40 dB(A),[18] a sound level that can be avoided through proper siting[19] and which is greater than some European regulatory limitations.

Bakker et al. (2012) conducted a separate analysis on a subset of the data (725 respondents) gathered in the Netherlands by Pedersen (2011).[20] This analysis again showed that the majority of respondents did not identify environmental noise from wind turbines as annoying. Twenty-three percent of respondents did report annoyance from wind turbine noise to some degree while outdoors and 14 percent reported annoyance from turbines while indoors. This annoyance was directly related to noise level, with approximately 4 percent of annoyed respondents reporting annoyance where sound levels were less than 30 dB(A) and approximately 66 percent where they were above 45 dB(A), a trend that is also supported by experimental evidence by Ruotolo et al. (2012). This analysis also examined sleep disturbance in greater detail. Sleep disturbance was reported by approximately 33 percent of respondents and it increased with greater environmental

[17] Survey participants lived within 1.5 miles of multiple wind turbines with a capacity of at least 0.5 MW.
[18] Wisconsin's wind siting rules limit day noise to 50 dB(A) and night noise to 45 dB(A).
[19] To be discussed in further detail below.
[20] Survey participants lived within 1.5 miles of multiple wind turbines with a capacity of at least 0.5 MW.

noise levels. However, of these individuals, 86 percent attributed their sleep disturbance to people, animals, or traffic/mechanical noise and 14 percent (approximately 4 percent of total respondents) indicated that wind turbine noise interrupted their sleep. The authors' data indicate that most people living near wind energy systems are not annoyed by environmental noise and that there is limited support for wind turbine-caused stress leading to physiological distress, especially in urban areas with other environmental noise.

These same survey data collected by Pedersen (2011) were further analyzed by Janssen et al. (2011) to determine if respondents found wind turbine noise to be qualitatively different than other sources of environmental noise as well as to identify what variables may affect annoyance.[21] The authors found that respondents were more annoyed by wind turbine noise than by road or rail noise when above 40 dB(A) and aircraft noise when above 45 dB(A), [22] possibly due to the characteristics of wind turbine noise which modulates in amplitude and frequency.[23] Those who benefited economically from wind energy systems reported less annoyance by wind turbines than those who did not receive an economic benefit.[24] Those who considered themselves to be more sensitive to noise, individuals who could see a turbine from their residence, and middle-aged individuals reported more annoyance by wind turbines than individuals who did not fall into any of those categories. The former result regarding sensitivity is supported by an experimental study by Ruotolo et al. (2012) from which the authors conclude that noise sensitivity is positively correlated with annoyance. Janssen et al. (2011) also concluded that annoyance from environmental noise increases rapidly as sound levels exceed 35 dB(A) outdoors and 40 dB(A) indoors. The study authors found this to be especially true for wind turbine noise, with a large number of individuals reporting to be both annoyed or highly annoyed by wind turbines producing outdoor (approximately 40 percent of respondents) or indoor (approximately 18 percent of respondents) sound levels over 45 dB(A).[25]

In a separate study, Mroczek et al. (2012) examined the potential for quality of life impacts, including health-related quality of life effects, through a survey of 1,277 randomly-chosen adults residing in areas near wind farms. Study participants were given standard and scientifically accepted quality of life questionnaires assessing physical and mental health. These questionnaires were supplemented with questions about distance between a house and a wind farm, age, gender, education, and professional activity. Contrary to arguments commonly made about the health impacts of wind turbines to near-by residents, statistical analysis of the responses found that quality of life was reported to be the best across all categories by the respondents living the closest to wind farms, while the worst by those living farther than 4,900 feet from a wind farm. In particular statistically significant trends included people living more

[21] Survey participants lived within 1.5 miles of multiple wind turbines with a capacity of at least 0.5 MW.
[22] James 2011
[23] Renterghem et al. 2013, Fiumicelli 2011, van Renterghem et al. 2013
[24] As also found by Bakker et al. 2012
[25] These percentages are calculated from polynomial best fit formulas provided by the study authors. Substantial uncertainty exists for this value because of a low sample size of individuals that experience sound levels over 40 dB(A).

than 4,900 feet from a wind farm assessing their vitality significantly lower than those living in the closest distance to a wind farm. Similarly, mental health and social functioning assessments were lower for those living over 3,280 feet from a wind farm as compared to those living closer. Mroczek et al. (2012) therefore conclude that "close proximity of wind farms does not result in the worsening of the quality of life."

Surveys with Limited Sample Size or Scope

In another study, Katsaprakakis (2012) reviewed the potential environmental and health impacts associated with wind energy systems and conducted a small survey of 100 individuals on their opinions regarding wind turbines. As in the previous surveys, the author found that wind turbines generally do not cause adverse health effects and that the primary concern associated with wind turbines is noise generated during operation (approximately 35 percent of respondents). This survey also found that in general people are supportive of wind energy and the author concludes that, with proper siting,[26] there are no statistically documented adverse health effects associated with wind turbines.

Shepherd et al. (2011) came to somewhat contradictory conclusions using measures of quality of life. In a survey of 39 individuals living within 1.2 miles of 2.3 MW wind turbines (and compared to 158 individuals living further away from the same wind turbines), the authors found that individuals residing in close proximity to turbines reported reductions in sleep quality, energy, and overall quality of life. This survey also indicated that there is great interpersonal variation in opinions on wind projects and concluded that individuals that report greater perceived noise sensitivity are more likely to report annoyance,[27] reduced sleep quality, and lower psychological and social well-being. A separate survey by Nissenbaum et al. (2012) of 38 individuals living within 0.8 miles of 1.5 MW wind turbines (and compared to 41 individuals living further away) in Maine showed similar results. This survey found that when compared to people living further than 0.8 miles from turbines, those individuals living within 0.8 miles reported worse sleep quality, were sleepier during the day,[28] and reported worse mental health scores. The authors also described a dose response curve where adverse health effects are inversely related to distance from a turbine.[29] Although the findings of both of these studies are in agreement, caution is merited as the sample size in both is small, limiting the conclusions and reducing the ability of the surveys to reveal adverse health effects.

Taylor et al. (2013) conducted another relatively small survey (138 respondents, approximately 11 percent return rate) in the United Kingdom of individuals living within 0.62 miles of a wind turbine. The authors concluded that perceived noise rather than actual turbine noise is a

[26] To be discussed in further detail below.
[27] A finding similar to that of Janssen et al. 2011 and Ruotolo et al. 2012
[28] Note that with regards to both sleep quality and daytime sleepiness, although the authors concluded that differences exist between the near and far groups exist, both groups reported values that fall under "poor sleep quality" and "not sleepy" when their scores are indexed against standard classifications.
[29] This trend was only significant after controlling for age, gender, and household clustering.

predictor of negative, non-specific adverse health effects. Furthermore, the authors concluded that individuals who have a negative attitude towards wind turbines are more likely to experience adverse health effects, regardless of actual noise levels. These conclusions suggest that perceived adverse health effects associated with wind turbines are greatly influenced by an individual's perception or acceptance of wind turbines rather than actual, physiological effects. Although these findings are compelling, they have limited applicability to wind energy in Wisconsin. As with Shepherd et al. (2011) and Nissenbaum et al. (2012), this study had a low response rate which can introduce bias due to certain population segments being over or under-represented and the authors also restricted their survey to individuals living near turbines rated at a capacity of 5 kW or less. This is orders of magnitude below the capacity of wind turbines that are generally installed in utility-scale wind systems and below the capacity that is generally the target of public concern in Wisconsin.

In another study with limited applicability, Krogh et al. (2011) used an open, online survey to evaluate wind turbine caused adverse health effects in Canada.[30] The authors found that 94 percent of respondents self-reported altered health or quality of life and specifically that 72 percent of participants reported experiencing stress, depression, and sleep disturbance due to wind turbines. Although these findings are striking, it should be noted that there are several limitations on using the survey results due to the study design. First, this study was not conducted via a random sample and it may be that individuals who have negative opinions about wind energy were more motivated to fill out the survey and are therefore overrepresented. Second, the survey design used biased questions. For instance, Question 8 asks, "Do you feel that your health has in any way been affected since the erection of these turbines?" These types of questions predispose respondents to negative responses and are atypical when compared to the more robust surveys reviewed here.[31] Finally, the authors use a p-value[32] that is less conservative than the established scientific norm to establish significance. These limits severely reduce the applicability of this study when considering potential adverse health effects of wind turbines in the general population.

Other Research on Impacts to Individuals Residing in Close Proximity to Wind Farms

As of the writing of this report, there is also a small but growing body of research related to the health impacts of wind turbines that does not take the form of the surveys discussed above. This includes research on other factors that could impact reported symptoms, as well as broader research modeling and analyzing the population-level health impacts related to wind energy.

[30] Participants lived from 0.2 to 1.5 miles from a wind turbine.
[31] For example Pedersen 2011
[32] In this case, p-value refers to the acceptable probability of finding a significant result where one does not exist. A p-value of 0.05 is used for most scientific study to establish significance, meaning a false-positive chance of 5 percent is acceptable. The authors of this study used p-values up to 0.1 to establish significance, or a 10 percent acceptable false-positive probability.

Using a double-blind design, Crichton et al. (2013a), examined the importance of individuals' differences in perception of wind turbines in predicting perceived adverse health effects. The authors informed half of a group of healthy individuals that infrasound causes adverse health effects (high-expectancy group) and the other half that it does not (low-expectancy group). Individuals were then exposed to infrasound and sham infrasound (told they were exposed when they were not). Individuals from the high-expectancy group reported more adverse health effects than from the low-expectancy group and also reported adverse health effects at the same level during actual and sham exposure. In a follow-up study using a similar experimental design, Crichton et al. (2013b) informed study participants that infrasound either improves health or causes health problems. The study authors report that when actually exposed to infrasound, those participants reported feeling better or worse, in accordance with which expectancy group they were in. Taken together, these studies indicate that individual differences and expectations (psychogenic factors) appear to be more important in predicting perceived infrasound-caused adverse health effects than other factors, including actual exposure. However, these conclusions are limited because both studies were conducted exclusively on college students and had small sample sizes.

In research looking more broadly at importance of psychogenic factors in reported symptoms, Chapman et al. (2013) examined the spatial and temporal distribution of noise or health complaints with regard to wind farms in Australia. Recorded complaints from all 51 Australian wind farms from the period 1993-2012 were compiled, corroborated, and analyzed as part of the study. The authors examined the relations within complaints, and the relation of complaints to other known factors, such as distance to wind turbines and timing with regard to dissemination of health concerns by interest groups. Chapman et al. (2013) found that the majority of wind farms had no history of complaints, and that less than 1% of residents within 1km of wind farms with large (>1MW) turbines complained. It was also found that the timing of complaints with regard to wind turbine operation was "inconsistent with turbines causing acute effects", which supports the conclusion of Taylor et al. (2013) that "it is the perception of noise rather than actual noise that is important in predicting symptoms of ill-health."

Research Conclusions

There is a relative paucity of empirical, epidemiological studies on the effects of wind turbines on human health and well-being.[33] Within the literature that does exist, there are also some apparently contradictory results. Based on the strength of the information that is available, it is reasonable to conclude that the majority of individuals living near wind energy systems do not experience adverse health effects or reduced well-being.

It should be noted that a small minority of individuals living in close proximity to wind turbines are annoyed by wind turbine noise and of these, some experience sleep disturbance and stress.

[33] With this said, the Council recognizes that much important and groundbreaking research is being conducted in the wind-health field.

It is currently not possible, based on available research, to conclude with scientific certainty whether these adverse health effects are caused by wind energy systems. Furthermore, there exists empirical research suggesting that these issues are affected by factors including expectations of health impacts and personal attitudes and opinions with regards to wind energy systems.

Reviews and Opinions

The majority of the articles that the Council identified through its literature search are review and opinion articles. Review articles are useful in that they offer expert summaries of relevant literature, but they are also limited if available research is of modest quantity and quality. Although multiple cross-sectional studies have been administered in areas with wind energy systems, as noted above one of these studies is not applicable to wind energy issues in Wisconsin, another is biased, and several of the analyses conducted on surveys with large sample sizes used the same data set. For these reasons, it is necessary to view the over twenty review and opinion articles that deal directly with wind-health issues with caution. Rather than being reviews of a large body of independent primary literature, they represent syntheses of a handful of studies[34] and some are published by authors working actively for or against the wind energy industry.[35] Furthermore, some of the reviews that have been published misinterpret the results of the empirical research,[36] make claims of a causal link between wind turbines and adverse health effects without providing any evidence or citations,[37] or make erroneous claims about wind-energy policy.[38] With that said, there are several unbiased reviews that accurately interpret the primary literature and reach meaningful and balanced conclusions.[39]

Review and opinion articles on the wind-health issue generally fall into one of two categories, either supporting the claim that wind-generating facilities cause adverse health effects[40] or disputing the claim that actual physiological adverse health effects exist as a result of exposure to wind turbines.[41] What is not under dispute between these two groups is that wind turbines produce environmental noise, that some individuals find that noise annoying, and that environmental noise may cause sleep disruption if the sound levels are high enough. There is, as a result, a consensus that proper wind turbine siting is imperative when designing wind generating systems to reduce the impacts of noise on people.[42]

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[34] See Horner et al. 2011
[35] See Moller and Pedersen 2011
[36] For example Hanning and Evans 2012, Phillips 2011
[37] For example Havas and Colling 2011, Phillips 2011
[38] For example Vanderburg 2011
[39] Roberts and Roberts 2013, Knopper and Ollson 2011, Fiumicelli 2011
[40] Phillips 2011, Havas and Colling 2011, Horner et al. 2011, James 2011, McMurtry 2011, Salt and Kaltenbach 2011, Shain 2011, Rand et al. 2011, Ambrose et al. 2012, Bronzaft 2011, Hanning and Evans 2012, Harrison 2011, Jeffery et al. 2013, Farboud et al. 2013, Arra et al. 2014
[41] Knopper and Ollson 2011, Thorne 2011, Bolin et al. 2011, Crichton et al. 2013(b), Moller and Pedersen 2011, Roberts and Roberts 2013
[42] See Krogh 2011, Shepherd and Billington 2011

The hypothesized route by which adverse health impacts arise among the review and opinion articles that can generally be characterized as against wind energy systems follows two paths. The first, and more compelling, hypothesized argument is that there is an indirect effect by which noise from wind turbines can cause annoyance and stress in individuals, that stress and noise may lead to sleep deprivation, and that these factors can act together or separately to cause adverse health effects.[43] Some of the adverse health effects that are commonly described include tinnitus, difficulty concentrating, hypertension, depression/anxiety, difficulty in diabetes control, and fatigue.[44] While many arguing that wind energy is safe claim that any health effects are secondary and due to individuals' reactions to wind turbines,[45] opponents of this argument assert that adverse health effects are caused by wind turbines, regardless of whether they are by secondary pathways.[46]

The second hypothesized pathway by which adverse health impacts arise is more contentious. Several authors provide case studies describing their experience working near wind energy systems as well as anecdotal reports of adverse health effects experienced by residents living near wind turbines.[47] The mechanism leading to adverse health effects suggested in these case studies is not the annoyance-stress-health effect pathway that has been outlined above, but rather physiological disease caused by inaudible infrasound and low-frequency noise (ILFN).[48] The authors concede ILFN is generally not perceived by humans at the sound pressure levels produced by wind turbines. Rather, they point to a mechanism described by Salt and Kaltenbach (2011) in which ILFN stimulates individuals' outer hair cells in the outer ear, causing a neurological impulse, but one that is not physically perceived by humans. The authors suggest that these unperceived impulses then cause chronic, physiological adverse health effects. They also suggest that effects of ILFN could also be exacerbated by resonance that may occur in rooms that meet the resonant frequency of long-wave ILFN[49] or because of the pulsing nature of turbine noise. This argument has been adopted by other scientists and is supported in both technical review articles[50] and an opinion article published in a medical journal.[51] However, there appears to be a dearth of empirical research on the purported ILFN-adverse health effect link and only one principle investigator is actively pursuing a research program on the effect of ILFN on outer hair cell stimulation.[52]

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[43] Jeffery et al. 2013, Bronzaft 2011, Shain 2011, Horner et al. 2011, Phillips 2011, Arra et al. 2014
[44] See McMurtry 2011 for an exhaustive list of symptoms and a medical case definition.
[45] Knopper and Ollson 2011
[46] Horner et al. 2011, Shepherd et al. 2011, Bakker et al. 2012
[47] Ambrose et al. 2012, Rand et al. 2011
[48] Infrasound is generally considered sounds below 20 hertz (Hz) and low-frequency noise is generally considered sounds between 20 Hz and 200 Hz.
[49] Havas and Colling 2011
[50] Havas and Colling 2011, James 2011, Farboud et al. 2013
[51] Hanning and Evans 2012
[52] Alec N. Salt at Washington University, St. Louis, MO

As noted previously, in no instance in the Council's literature survey did an article make the claim that wind turbines have no effect on individuals living near them. Rather, the view of those authors in the relatively pro-wind category is that they can cause annoyance, may cause sleep disturbance, and may cause some stress due to environmental noise and a loss of control over the environment.[53] Although these effects may be viewed by some as adverse health effects, another group of articles concludes that there is not a direct link between wind turbines and negative effects in human health[54]and that wind turbines do not elicit more complaints of adverse health effects than other types of novel environmental noise.[55] Furthermore, these articles indicate that the primary predictor of whether an individual will report adverse health effects subsequent to a wind energy facility coming online is the individual's perceptions of wind turbines.[56] In other words, these authors argue that an individual's disposition (positive or negative) towards wind turbines is a powerful predictor of whether they will report adverse health effects.

There is also no debate in the literature that wind turbines produce ILFN and that larger wind turbines generally emit more audible noise than smaller turbines. Larger turbines also emit higher levels of low-frequency noise, but not substantially larger amounts of infrasound,[57] and actually produce less infrasound than some other sources of environmental noise.[58] In reviews and opinion articles that are not critical of wind turbines, the conclusion is that ILFN at the level produced by turbines does not lead to adverse health effects[59] and that there is no scientifically accepted physiological pathway that would cause such effects.[60]

The Council's survey also identified reviews and opinion articles that dealt with noise limits and potential health effects. Some concern is presented that wind turbine noise modelling is inaccurate[61] and that noise limits are inadequate.[62] However the former claim is disputed by testing of actual wind energy systems which suggest that noise levels do not differ significantly from those predicted by a common noise modelling software program.[63] The latter will be addressed in the policy update section of this report.

The Council's survey of review and opinion articles identified more articles that were critical of wind energy systems than in support (15-critical, 7-supportive). This does not indicate that the consensus of the scientific community is that wind energy facilities have proven adverse health effects in humans, however. Although the reviews and opinion articles that are not critical of

[53] Knopper and Ollson 2011, Roberts and Roberts 2013, Bolin et al. 2011
[54] Roberts and Roberts 2013
[55] Knopper and Ollson 2011
[56] Knopper and Ollson 2011
[57] Moller and Pedersen
[58] Bolin et al. 2011
[59] Roberts and Roberts 2013, Knopper and Ollson 2011, Bolin et al. 2011
[60] Bolin et al. 2011, Roberts and Roberts 2013
[61] Thorne 2011
[62] Palmer 2013
[63] Kaldellis et al. 2012

wind energy are fewer in number, other factors are also important when evaluating these articles. For instance, many of the critical reviews and opinion articles are published in very low-impact[64] journals, make erroneous claims, and do not follow scientific standards on citing evidence. This point is made not to discount the importance of considering critical reports, but rather to emphasize that multiple factors must be considered when evaluating publications on important public health issues.

Conclusion

Although there are several publications arguing that noise from wind turbines directly causes adverse health effects in humans, based upon the peer-reviewed literature, it appears at this time that there is insufficient data to validate this scientific conclusion. It will be a priority of the Council to continue surveying the peer-reviewed literature to determine if this consensus changes, if a viable mechanism for ILFN-caused adverse health effects is shown, and if the medical community identifies a disease associated with wind turbine-noise exposure. Although important and indeed groundbreaking research is clearly being conducted in the field of wind-health interactions, the Council is unable, at this time, to conclude that wind turbines have a direct and negative effect on human health.

As it stands, the literature available to the Council lacked strength and in some instances, was biased. Many of the authors of the material cited herein point this out and call for more detailed, randomized, long-term studies in the future. The Council is aware of at least one study[65] being conducted by a government panel that is designed to do just that and at least one additional governmental review of the literature.[66] These may shed light on new health issues associated with wind turbines or confirm the Council's finding that there is no direct link between wind turbines and human health. At the very least, ongoing research should clarify the sometimes muddy waters of the wind-health debate.

[64] "Impact factor" is a calculation based on the number of times a journal is cited over the total number of all citations in a given time period and is a proxy of importance. High-impact journals carry more weight, prestige, and influence than low-impact journals.
[65] Government of Canada, Health Canada and Statistics Canada Group
[66] Government of Australia, National Health and Medical Research Council

4.0 WIND SITING POLICY UPDATE

Under Wis. Stat. § 196.378(4g)(e), the Council is charged with reviewing regulatory developments in wind siting policy and providing a report and recommendations to the Legislature. Working towards this end, the Council reviewed the wind siting policies of all fifty states and the District of Columbia.[67] Commission staff also conducted a formal academic search of the peer-reviewed literature regarding wind siting policy. This survey was completed in November 2013 and used the academic search engine ISI Web of Knowledge. Search terms were designed to gather results both on general wind siting policies as well as pertinent developments regarding the specific rules contained in PSC 128.[68] Terms regarding noise and health or shadow flicker were not included as these were used in the formal academic search that was conducted as part of the wind-health section of this report and have been addressed earlier in this report. These searches and a review of news reports identified two non-governmental reports on wind siting policy, three white papers on the effects of wind energy systems on residential home value specifically, and eight peer-reviewed articles.[69,70]

While the Council considered all of these documents, the Council heavily relied upon the comprehensive 2012 report commissioned by the National Association of Regulatory Utility Commissioners (NARUC report).[71] NARUC is a national association representing state public service commissioners and acts as a resource for state utility regulatory agencies. It commissioned a report on wind siting policies under a grant from the United States Department of Energy, and the NARUC report is an extensive policy document regarding wind siting in the United States.

Rules on the siting of wind energy systems in Wisconsin are codified in Wis. Admin. Code ch. PSC 128 and have been in effect since March 16, 2012. These rules apply to local regulation of wind energy systems with a total combined generating capacity of less than 100 MW, and they limit the restrictions that a local jurisdiction may impose on a wind energy development in Wisconsin. Wind energy developments of 100 MW combined generating capacity or greater are subject to Commission review. The Commission is not required to strictly adhere to Wis. Admin. Code ch. PSC 128, however it must consider the requirements in its review of a

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[67] See Appendix G for the results of this review.

[68] Search terms included "Wind siting policy," "Wind siting rule," "Wind turbine setback distance," "Wind turbine noise limit," "Wind turbine property value," "Wind turbine siting," and "Wind turbine decommissioning." In total, these terms elicited 398 hits, of which 8 were in some way relevant to wind turbine siting or health.

[69] This survey also identified three articles regarding noise and health that were published after and one that was not identified by the Commission staff's academic survey. These are included in the wind-health portion of this report.

[70] Two articles identified, Fargione et al. 2012 and Mulvaney et al. 2013, are relevant to wind policy issues, however they do not apply to issues that the Council has addressed here. Fargione et al. 2012 recommends a mapping process to identify wind turbine sites that are optimal in terms of mitigating harm to wildlife. Mulvaney et al. 2013 conducted a survey of individuals living near proposed or actual wind energy systems in Indiana and concluded that most people living near wind energy projects are supportive, primarily for financial and environmental reasons and that those opposed are more vocal in their opposition and are often exurbanites who moved to a rural area for the lifestyle.

[71] Stanton was commissioned by NARUC to prepare the 2012 report and views or opinions reached therein are not necessarily those of NARUC or the US DOE.

proposed wind energy system. Wisconsin wind siting rules are some of the most comprehensive in the nation, covering nearly every aspect of wind siting, and include:

- 50 dB(A) day and 45 dB(A) night noise limits.
- Turbine setback from property lines, roads, and utility rights-of-way of 1.1 times turbine height.
- Turbine setback from non-participating residences of 3.1 times turbine height, up to 1,250 feet.
- A maximum of 30 hours of shadow flicker per year at non-participating residences and mitigation if over 20 hours.
- Mitigation of radio and television interference.
- Testing of stray voltage by the wind energy system owner, if requested.
- Proof of financial responsibility for decommissioning.

Findings Related to Wind Siting Rules under PSC 128

Outlined below is a discussion of major state and federal policies regarding wind siting.

Jurisdiction

The NARUC report's exhaustive review of wind siting policies in all of the United States found that jurisdiction over wind energy developments is held at the state level in 22 cases, the local level in 26 cases, and jointly controlled in two cases. Regardless of state jurisdiction, local governments still have substantial control over siting criteria in 48 states.[72] Over half of states have some sort of wind siting criteria, whether at the state or local level, and 10 states provide local jurisdictions with voluntary guidelines in the form of model wind siting ordinances.[73] Model ordinances are not legally binding; however, portions of them may reflect policy determined at the state level that is mandatory.[74]

Noise[75,76]

States that mandate siting rules or recommend wind siting policies often provide limits on the noise levels from wind turbines that individuals living near wind energy projects may experience. In general, states with wind siting policies require or recommend that non-participating landowners are not subjected to noise levels over 55 dB(A)[77] at an occupied

[72] Environmental Law Institute 2013
[73] Stanton 2012
[74] For instance noise limits or maximum imposed setback distances.
[75] See the "Wind-health Review" section of this report for a discussion of the potential adverse health effects elicited by noise from wind turbines.
[76] PSC 128 imposes a 50/45 dB(A) day/night limit.
[77] Median 55 dB(A), Range 45-60 dB(A).

dwelling. Some states that are more restrictive also have noise limits at property boundaries, separate day and night noise restrictions or differentials to ambient sound levels.

The NARUC report has a few key recommendations on noise restrictions. First, it recommends that noise standards should be based on land use.[78] The report argues that doing so would incorporate background noise when considering siting, as the noise levels that may elicit annoyance may be washed out to some degree by background noise and thus not be as noticeable. Second, it recommends that a clear monitoring, arbitration, and mitigation process be implemented to deal with resident complaints. Finally, it recommends using a 40 dB(A) noise level as an ideal design goal with a 45 dB(A) regulatory limit at non-participating residences. This maximum regulatory limit on noise in Wisconsin is less restrictive than this recommendation, however Wisconsin's limit is more restrictive than limits imposed by some other state and local jurisdictions.[79] Although both King and Mahon (2011) and the NARUC report recommend considering background noise, the majority of states establish absolute limits and do not formally take background noise into account as part of noise standards[80]. There is also evidence that regulations that do consider background noise or predicted noise attenuation caused by the walls of homes may not accurately reflect actual noise propagation, especially for low frequency noise.[81]

Turbine Setbacks[82]

For those states that mandate wind siting rules or recommend siting criteria, the setback distance of wind turbines from property boundaries, occupied dwellings, or public/utility rights-of-way ranges from one to five times turbine height. However, most states with wind siting rules or model ordinances recommend setback distances between one and 1.5 times turbine height, and some setback distances are contingent on turbine capacity or the type of structure or boundary to which the setback is applied.[83] Watson et al. (2012) point out that there is no perfect setback distance because local landscapes vary and there can be competing interests between wind developers and local populations.

The NARUC report takes a somewhat different stance. Rather than regulating for specific setback distances, the report recommends regulating for issues that are often reported near wind energy systems. It recommends having setbacks that would meet noise and shadow flicker

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[78] This recommendation is supported by the conclusions reached by King and Mahon 2011.
[79] For instance Colorado has 55 dB(A) day and 50 dB(A) night noise limits and the median limit imposed at 21 wind energy facilities that are under local jurisdiction throughout Michigan is 55 dB(A), with a range from 40 to 60 dB(A).
[80] Delaware, Massachusetts, Michigan and Oregon have noise restrictions that specify allowances over the ambient noise levels.
[81] Hansen et al. 2012
[82] PSC 128 allows local governments to impose a setback of 1,250 foot or 3.1 times turbine height from nonparticipating residences and occupied community buildings, and 1.1 times turbine height from property lines and public and utility rights-of-way.
[83] See Appendix G for a list of all states' policies.

restrictions, arguing that avoiding actual impacts on residents is of primary importance, rather than imposing what may be an arbitrary distance.

Shadow Flicker[84,85]

Few states offer guidelines or recommendations for shadow flicker limitations. Among those that do, limits up to 30 hours per year are common. Some other states recommend having wind developers describe the mitigation measures that they would implement to reduce the effect of shadow flicker on residences. Technology may be available that can assist in modifying turbine operations to mitigate shadow flicker impacts to residences, although it is in the early stages of deployment.[86] The NARUC report has similar recommendations to those put forward by states, and suggests shadow flicker limits of less than or equal to 30 hours of exposure per year and 30 minutes per day at non-participating residences.[87]

Decommissioning[88]

The NARUC report recommends establishing clear triggers for decommissioning,[89] in addition to requiring wind energy system owners to have an escrow account to cover decommissioning costs. States with decommissioning rules or recommendations generally call for a decommissioning plan to be submitted prior to construction, and some also suggest having proof of financial security from a turbine owner. However, the specific amount of financial security to maintain can be difficult to assess as no major wind energy systems have been decommissioned to date and the estimated cost to decommission a single turbine ranges from $9,791 to $631,875.[90]

Signal Interference[91]

Few states have policies regarding regulation of or recommended mitigation for signal interference caused by wind turbines. Those that do suggest mitigation of interference at cost to

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[84] PSC 128 allows local governments to impose a 30 hour annual limit at non-participating residences.
[85] Under PSC 128, the PSCW has the ability to create measurement, compliance, and testing protocols, including a shadow flicker compliance and mitigation protocol, but to date no shadow flicker protocol has been created. The PSCW has established a noise protocol and a stray voltage protocol.
[86] For example, turbine producer Vestas advertises the Vestas Shadow Detection System (VSDS) as able to pause turbine blades if the unit registers shadow flicker beyond a certain threshold by combining sensors with shadow modeling software.
[87] PSC 128 does not limit per day exposure.
[88] PSC 128 requires decommissioning at the end of a turbine's useful life, creates rebuttable presumptions to establish when the end of the useful life has occurred, and requires a wind energy system owner to maintain proof of financial ability to fund decommissioning.
[89] For example, operational dormancy periods after which a wind turbine owner would be required to decommission it.
[90] Ferrell and DuVuyst 2013
[91] PSC 128 allows local governments to require mitigation of any radio, television or other communications signal interference resulting from wind energy systems by its owner.

the wind energy system owner. This is consistent with the recommendations of the NARUC report. Unlike other states, Michigan's model ordinance does not permit any signal interference.

Other Pertinent Findings

Permitting Process

The NARUC report offers a number of insights on states' role in wind development projects. It recommends establishing a single-stop consultation process between applicants, regulators, and governmental bodies where all aspects of the project and the regulatory process can be discussed.[92] It suggests that states should also develop clear and consistent guidelines for applicants to use which should be readily available to allow for successful project development.[93] Complicated and multi-level review processes should be avoided as they have led to permitting taking over five years in other countries.[94] During this consultation and permitting process, the NARUC report calls for developing a clear, explicit, and transparent complaint review process that explicitly defines protocols for noise monitoring and mitigation.[95, 96] Finally, the NARUC report recommends that states develop maps of preferred wind energy development zones based on wind resources and land use planning and wind energy exclusion zones based on natural and other resources.[97]

Population Density

The recommendations put forward by the NARUC report are influenced by the practices utilized by states where there are fewer perceived conflicts with wind system development. The report recognizes that the "progress in wind energy development can reflect simply an abundance of wide-open spaces where turbines can be placed without affecting many citizens at all[98]", which may indicate that in considering relevant siting policy recommendations, a consideration of comparative population densities may also be useful. Appendix L provides a comparison of county and town population densities for states in the Upper Midwest where there are developed

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[92] PSC 128 requires pre-application consultation meetings, which can provide an opportunity for an applicant and the local government to discuss concerns and clarify expectations.
[93] PSC 128 requires the PSC to establish detailed Application Filing Requirements for projects permitted under PSC 128, and these Requirements are available on the PSC's website.
[94] Iglesias et al. 2011
[95] PSC 128 establishes a complaint process for complaints about projects permitted under PSC 128. The process includes the ability to appeal a decision by the local government to the PSC.
[96] PSC 128 allows local governments to use the Noise Measurement Protocol established and periodically revised by the PSC. The Noise Measurement Protocol is available on the PSC's website.
[97] Some states, including Texas, Colorado, Utah, Michigan, and Nevada provide preferred wind energy zones and others, including Wisconsin, Ohio, and Michigan, provide recommended commercial wind energy exclusion zones. See Appendix I for a map of areas not recommended for wind development established by the Wisconsin Department of Natural Resources.
[98] Stanton 2012

wind energy systems. It shows higher county and township population density in areas where wind energy systems have been developed in Wisconsin than in our neighboring states.

Property Impacts

The question of whether wind turbines impact neighboring property values was discussed by the Council in 2010 and continues to be a topic of interest in the wind siting arena. To date, no state has specifically established a regulation regarding potential property value impacts from wind turbines. However, some jurisdictions are requiring property value guarantees when issuing a permit for a wind energy development (see Appendix H).

Conclusion

Wisconsin's siting regulations for wind energy systems are evidently consistent with other state and national policy regulatory developments. It is clear that in future projects, Wisconsin should continue to provide a transparent regulatory and approval process for wind developers, as well as keep in mind that best practices should be determined by the best available information about the relationship between wind energy systems and siting and zoning.[99]

[99] Stanton 2012

Appendix A

Wind Siting Council Membership

Wisconsin Stat. § 15.797(1)(b) requires the Commission to appoint a Wind Siting Council. Specifically, the Legislature set forth the following representation on the Council:

- Two members representing wind energy system developers (Developer Members).
- One member representing towns (Towns Member) and one member representing counties (County Member).
- Two members representing the energy industry (Energy Members).
- Two members representing environmental groups (Environmental Members).
- Two members representing realtors (Realtor Members).
- Two members who are landowners living adjacent to or in the vicinity of a wind energy system and who have not received compensation by or behalf of owners, operators, or developers of wind energy systems (Landowner Members).
- Two public members (Public Members).
- One member who is a University of Wisconsin System faculty member with expertise regarding the health impacts of wind energy systems (UW Faculty Member).

Consistent with the Legislature's directive, the Commission appointed people of diverse backgrounds and experiences, satisfying the explicit legislative statutory criteria. At the time of this report, the following individuals are members of the Council[100]:

- Bill Rakocy, Emerging Energies of Wisconsin, LLC—Developer Member
- Wes Slaymaker, WES Engineering—Developer Member (Appointed 08/29/14)
- Glen Schwalbach, Town of Rockland—Towns Member
- Scott Godfrey, Iowa County—County Member
- Andy Hesselbach, We Energies—Energy Member
- Deb Erwin, Northern States Power Company Wisconsin—Energy Member
- Michael Vickerman, RENEW Wisconsin—Environmental Member
- Tyson Cook, Clean Wisconsin—Environmental Member
- Tim Roehl—Realtor Member (Appointed 08/29/2014)
- Tom Meyer, Restraino & Associates—Realtor Member
- Jarred Searls—Landowner Member
- James Amstadt—Landowner Member
- Carl Kuehne—Public Member
- Mary Brandt—Public Member (Appointed 08/29/2014)
- Vacant—UW Faculty Member

[100] Three members were appointed at the end of August and after the Health Section of this report had been finalized. They are noted as appointed 08/29/2014.

Appendix B

Peer Review

Peer review is an integral part of the scientific publication process. It both provides review of the hypotheses, techniques, and conclusions of scientific literature as well as support that a publication has met the standards of the scientific and technical community.[101] Peer review typically involves review of a draft manuscript by at least two independent individuals and a journal editor.

Reviewing generally adheres to the following rules:[102]

- Peer reviewers must:
    - Have expertise in the given field.
    - Be independent of the agency/research group under review.
    - Be free of real or perceived conflict of interest.
- Peer reviewers must comment on science and not policy.
- Peer reviewers must offer independent reviews of the material.

Reviewers provide comments on the writing, hypotheses, techniques, results, and validity of the conclusions reached in the manuscript. These comments are typically then reviewed by an editor to determine if the manuscript has relevance and merit for a given scientific or technical journal. If the manuscript requires clarification or reinterpretation, it is returned to the author(s) to make changes which are then evaluated by the editor to determine if the manuscript is suitable for publication.

Although this is the "gold standard" reviewing process used by scientific and technical journals, other types of review also exist that do not provide the same level of scrutiny. For instance, summary abstracts or papers that are presented at scientific or technical conferences may be reviewed by a board of editors. There are several primary differences between this type of review and the former described.

Editors of material for conferences typically:

- Review material for the interest that it will elicit as presented material.
- Are not multiple independent reviewers.
- Do not place the material under the same level of scientific scrutiny as in the journal article review process.
- Do not require a response by the author(s).
- Do not necessarily hold expertise in the field of study.

[101] United States Office of Information and Regulatory Affairs 2004.
[102] American Association for the Advancement of Science 2005.

Although conference abstracts or papers may be published as part of a conference, these articles do not, generally, carry the same degree of scientific influence as those published in traditional scientific and technical journals for these reasons.

It should also be noted that the validity afforded to peer-reviewed literature is only as good as the process that was used for the review. If non-experts are consulted or if experts review materials outside of their field of study, then material has *not* been adequately academically peer-reviewed. Although high-impact[103] journals place a strong emphasis on the review process and are highly selective in materials they publish, low impact journals may not subject their manuscripts to the same level of scrutiny. This may occur for three primary reasons: 1) low-impact journals generally receive fewer manuscripts than high-impact journals, and thus inherently are not able to be as selective in choosing manuscripts to publish, 2) low-impact journals generally receive manuscripts from inexperienced researchers (e.g., a summer study by an undergraduate research assistant) which may be more technically flawed than manuscripts prepared by senior scientists, and 3) expert reviewers are often less inclined to review manuscripts for low-impact journals as the review process is voluntary, reviewers have limited time, and reviewing for a low-impact journal does not add the same level of prestige to the reviewers' career as reviewing manuscripts for a high-impact journal. This is not to say that valid scientific research is not published in low-impact journals, however caution may be warranted when interpreting low-impact publications.

[103] "Impact factor" is a calculation based the number of times a journal is cited over the total number of all citations in a given time period and is a proxy for importance. High-impact journals carry more weight, prestige, and influence than low-impact journals and include journals such as *Science, Nature,* and *The New England Journal of Medicine*.

Scientific Documents

There are several types of scientific and technical publications, all of which carry different levels of scientific purpose, scope, scrutiny, and influence. These are general descriptions and do not represent any and all cases. Footnotes indicate examples of each that are available in the relevant wind-health literature.

Type	Scope	Peer-reviewed?	Influence	Description
Articles	Research[104]	Yes	High	Presents the results of an original study that has been vetted to ensure that it complies with accepted scientific standards, including study design, sampling techniques, and statistical methods.
Articles	Meta-analysis	Yes	High	Presents the summarized, analyzed results of multiple research articles. Both the articles used for the analysis and the meta-analysis itself have been vetted to ensure they comply with accepted scientific standards, including study design, sampling techniques, and statistical methods.
Articles	Review[105]	Yes	High	Presents a summary of multiple research articles and meta-analyses. Both the articles used for the review and the review itself have been vetted to ensure they comply with accepted scientific standards.
Articles	Opinion[106]	Yes	Moderate	Presents the opinions of the author(s) on a scientific topic. The opinion has been vetted as reasonable, informative, and advancing from a scientific or technical viewpoint.

[104] Pawlaczyk-Luszczynska et al. 2005
[105] Bastasch et al. 2006
[106] Bronzaf 2011

Type	Scope	Peer-reviewed?	Influence	Description
Major Governmental or Non-governmental Organization	Research	No	High	Presents the results of an original study that has been conducted by appointed experts. Although these types of studies are not necessarily vetted, the researchers are generally considered to be leaders in their field and therefore conformists with scientific standards. Publications directed by major governmental agencies (e.g., state, federal, or international agency) or non-governmental organizations (e.g., World Health Organization) are generally considered to hold similar validity as top research articles.
Major Governmental or Non-governmental Organization	Review[107]	No	High	Presents a review of research articles and meta-analyses conducted by appointed experts. Although these types of reviews are not necessarily vetted, the researchers are generally considered to be leaders in their fields and therefore conformists with scientific standards. Publications directed by major governmental agencies (e.g., state, federal, or international agency) or non-governmental organizations (e.g., World Health Organization) are generally considered to hold similar validity as top review articles.

[107] Ellenbogen et al. 2012

Type	Scope	Peer-reviewed?	Influence	Description
Major Governmental or Non-governmental Organization	Guidelines[108]	No	High	Presents recommendations on a given subject based on the knowledge and experience of appointed experts. Although guidelines are not necessarily vetted, the writers are generally considered to be leaders in their fields and therefore conformists with scientific standards. Guidelines recommended by major governmental agencies (e.g., state, federal, or international agency) or non-governmental organizations (e.g., World Health Organization) are generally considered as balanced and based on relevant scientific evidence.
Reports	Report[109]	No	Limited	Presents the results of observations, often by a scientific or technical consulting firm. The report procedural design generally complies with accepted sampling techniques, however it generally does not represent a broad sampling, the results of which could be statistically applied over other geographic areas or situations.
Self-published material, Websites, Blogs, etc.	Any	No	Limited	Presents the views of experts or non-experts. These views are of varying degree of validity, review, and may or may not be reliable or attributable.

[108] World Health Organization 2009
[109] Walker et al. 2012

Appendix C

Summary of Governmental Reports

The Council identified three governmental reports reviewing the effect of wind energy facilities on human health and well-being.[110] All of these reports serve a similar function to this report in that they were designed to survey the pertinent wind-health literature and provide policy recommendations. Although these reports are not peer-reviewed, they are generally prepared by panels of experts[111] for governmental bodies and hold similar weight as top peer-reviewed publications.

National Health Service, Shetland, Scotland

The National Health Service, Shetland, Scotland recently released its "Report on the Health Impacts of Wind Farms Shetland 2013" (Shetland report).[112] The author's goal in this report was "to provide a report on the 'health effects (if any) of wind farms'" and the health issues examined included construction, operation, and maintenance safety, shadow flicker, EMF, and noise.

The author of the Shetland report concluded that there is not a significant health risk to individuals living near wind turbines during construction or operation of wind energy systems. However, there is risk to construction workers, on the scale of any other large construction project. Unlike other governmental reviews and the general scientific consensus, the Shetland report concluded that utility-scale wind turbines may pose a seizure risk to photosensitive epileptics due to the shadow flicker that is produced by turbine operation. It was noted, however, that this is only an issue during abnormal operational speeds. EMF was also briefly discussed in this wind-health report. The author concluded that there is no risk to individuals living near wind turbines from EMF.

Similar to many of the findings discussed previously, the Shetland report concluded that wind turbines do produce noise that is annoying to some people. The report indicated that distance to wind turbines is directly related to reports of annoyance and that other factors, such as turbine visibility and economic gain, also influence annoyance. Wind turbines may also interrupt sleep in some individuals living near them. The report concludes that annoyance and sleep deprivation may interact to increase stress and lead to, indirectly, some chronic health conditions. The Shetland report notes that ILFN may be annoying to some people, however the levels produced by wind turbines are generally less than from other industrial noise sources and are likely inaudible to most people. The author states that some caution should be taken in these

[110] Ellenbogen et al. 2012, Joshi et al. 2013, Taylor 2013. The Council identified two additional governmental reports regarding ILFN.
[111] With the exception of Taylor 2013, which was prepared by one expert.
[112] Taylor 2013

conclusions, however, because of the "limited amount of original scientific research" on these topics available at the time.

Oregon Office of Environmental Health

Also in 2013, the Oregon Office of Environmental Health, Public Health Division released the final draft of its "Strategic Health Impact Assessment on Wind Energy Development in Oregon".[113] The objective of this exhaustive review was to provide a document to "assist stakeholders to understand and respond to health-related questions at new wind energy developments […]." Towards this end, the panel reviewed the effects of wind energy facilities on sound, visual impacts, and air pollution, among other things.

Oregon's key findings on the impacts of wind turbine noise on human health are similar to those described in the Shetland report. This assessment found that wind turbines produce noise that may be unwanted and annoying, which may lead to stress. Wind turbine noise may be more annoying relative to other noise sources due to its rhythmic nature. However other effects also influence annoyance such as subjective experience, distance to wind turbines, and whether an individual benefits financially from the turbine. Oregon's assessment also found that wind turbines produce ILFN at levels below human hearing, but that at some locations it approaches levels that may be perceived by humans. It concluded that long term exposure to sound levels of a high enough level may impact peoples' health, however uncertainty on the effects of turbines exists "due to moderate or limited evidence […]."

When considering shadow flicker, Oregon concluded that it is unlikely to cause adverse health effects or trigger seizures in epileptics and that few individuals will be annoyed by it. The Oregon assessment also found benign local effects in air pollution associated with the construction of turbines, with any emissions produced by construction having local and short-term impacts. Overall, the Oregon assessment concludes that adoption of wind energy reduces pollution-caused adverse health effects associated with fossil fuel power generation and will help alleviate future climate change.

Massachusetts Departments of Environmental Protection and Public Health

The Massachusetts Departments of Environmental Protection and Public Health commissioned an expert panel to do an independent review of potential health impacts of wind turbines in 2012.[114] The goal of the expert panel was to "identify any documented or potential health impacts or risks that may be associated with exposure to wind turbines […]." Specifically, the panel was charged with reviewing existing data and literature to evaluate the effects of wind turbine noise, vibration, and shadow flicker on human health, among other things. This review came to similar conclusions as the Shetland and Oregon reviews, and this Council's survey of the literature. It found that there is limited evidence that wind turbines can cause annoyance and

[113] Joshi et al. 2013
[114] Ellenbogen et al. 2012

sleep disruption and concludes that it is very difficult to decouple the effects of interpersonal views on wind turbines from perceived annoyance. The Massachusetts panel also concluded that infrasound produced by wind turbines is below the audible threshold of humans, that the possibility that infrasound from wind turbines is able to stimulate the vestibular systems (outer hair cell pathway) has not been sufficiently scientifically explored, and that the limited epidemiological evidence does not suggest that wind turbines are responsible for chronic adverse health effects. Finally, the panel concluded that shadow flicker does not elicit seizures, but may cause annoyance if individuals are exposed for a sufficient duration.

Appendix D

Works Cited

Author	Title	Journal	Year	Volume	Edition	Pages	Type
Ambrose SE, Rand RW, Krogh CME	Wind turbine acoustic investigation - infrasound and low-frequency noise - a case study	Bulletin of Science, Technology & Society	2012	32	2	128-141	Article, Opinion
American Association for the Advancement of Science	AAAS Policy Brief: OMB Bulletin on Peer Review		2005				Report, Guidelines
Arra I, Lynn H, Barker K, Ogbuneke C, Regalado S	Systematic review 2013: Association between wind turbines and human distress	Cureus	2014			1-15	Article, Review
Bakker RH, Pedersen E, van den Berg GP, Stewart RE, Lok W, Bouma J	Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress	Science of the Total Environment	2012	425	1	42-51	Article, Research
Bastasch M, van Dam J, Sondergaard B, Rogers A	Wind turbine noise – An overview	Canadian Acoustics	2006	34		7-15	Article, Review
Bolin K, Bluhm G, Eriksson G, Nilsson ME	Infrasound and low frequency noise from wind turbines - exposure and health effects	Environmental Research Letters	2011	6	3	1-6	Article, Research
Bronzaft AL	The noise from wind turbines: Potential adverse impacts on children's well-being	Bulletin of Science, Technology & Society	2011	31	4	291-295	Article, Opinion
Chapman S, St. George A, Waller K, Cakic V	Spatio-temporal differences in the history of health and noise complaints about Australian wind farms: Evidence for the psychogenic , “communicated disease” hypothesis	PLos One	2013	8	10	1-11	Article, Research

Author	Title	Journal	Year	Volume	Edition	Pages	Type
Crichton F, Dodd G, Schmid G, Gamble G, Cundy T, Petrie KJ	The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound	Health Psychology	2013b			1-5	Article, Research
Crichton F, Dodd G, Schmid G, Gamble G, Petrie KJ	Can expectations produce symptoms from infrasound associated with wind turbines?	Health Psychology	2013a	32			Article, Research
Ellenbogen JM, Grace S, Heiger-Berays WJ, Manwell JF, Mills DA, Sullivan KA, Weisskopf MG	Wind turbine health impact study: Report of independent expert panel		2012				Report, Review
Environmental Law Institute	Siting wind energy facilities - What do local elected officials need to know?		2013				Report, Guidelines
Farboud A, Crunkhorn R, Trinidade A	"Wind turbine syndrome": Fact or fiction?	The Journal of Laryngology and Otology	2013	127	3	222-226	Article, Review
Fargione J, Kiesecker J, Slaats MJ, Olimb S	Wind and wildlife in the Northern Great Plains: Identifying low-impact areas for wind development	PloS One	2012	7	7	1-14	Article, Research
Ferrell SL, DeVuyst EA	Decommissioning wind energy projects: An economic and political analysis	Energy Policy	2013	53		105-113	Article, Opinion
Fiumicelli D	Wind farm noise dose response: A literature review	Acoustics Bulletin	2011	11/12		26-34	Article, Review
Hanning CD, Evans A	Wind turbine noise: Seems to affect health adversely and an independent review of evidence is needed	British Medical Journal	2012	344	e1527	1-3	Article, Opinion
Hansen K, Henrys N, Hansen C, Doolan C, Moreau D	Wind farm noise – What is a reasonable limit in rural areas?	Proceedings of Acoustics	2012	Nov	21-21	1-8	Article, Research
Harrison JP	Wind turbine noise	Bulletin of Science, Technology & Society	2011	31	4	256-261	Article, Opinion

Author	Title	Journal	Year	Volume	Edition	Pages	Type
Havas M, Colling D	Wind turbines make waves: Why some residents near wind turbines become ill	Bulletin of Science, Technology & Society	2011	31	5	414-426	Article, Opinion
Horner B, Jeffery RD, Krogh CME	Literature reviews on wind turbines and health: Are they enough?	Bulletin of Science, Technology & Society	2011	31	5	399-413	Article, Review
James RR	Wind turbine infra and low-frequency sound: Warnings signs that were not heard	Bulletin of Science, Technology & Society	2011	32	2	108-127	Article, Opinion
Janssen SA, Vos H, Eisses AR, Pedersen E	A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources	Journal of the Acoustical Society of America	2011	130	6	3746-3753	Article, Research
Jeffery RD, Krogh C, Horner B	Adverse health effects of industrial wind turbines	Canadian Family Physician	2013	59	1	473-475	Article, Opinion
Joshi S, Hamberg A, Cain D, Douglas JP, Teshale S, Early-Alberts J	Strategic health impact assessment on wind energy development in Oregon		2013				Report, Review
Kaldellis JK, Garakis K, Kapsali M	Noise impact assessment on the basis of onsite acoustic noise emission measurements for a representative wind farm	Renewable Energy	2012	41	1	306-314	Article, Opinion
Katsaprakakis DA	A review of the environmental and human impacts from wind parks. A case study for the Prefecture of Lasithi, Crete	Renewable and Sustainable Energy Reviews	2012	16	6	2850-2863	Article, Research
King EA, Pilla F, Mahon J	Assessing noise from wind farm developments in Ireland: A consideration of critical wind speeds and turbine choice	Energy Policy	2012	41		548-560	Article, Research
Knopper LD, Ollson CA	Health effects of wind turbines - A review of the literature	Environmental Health	2011	10	78	1-10	Article, Review
Krogh CME	Industrial wind turbine development and loss of social justice?	Bulletin of Science, Technology & Society	2011	31	4	321-333	Article, Review
Krogh CME, Gillis L, Kouwen N, Aramini J	WindVOICE, a self-reporting survey: Adverse health effects, industrial wind turbines, and the need for vigilance monitoring	Bulletin of Science, Technology & Society	2011	31	4	334-345	Article, Research
McMurtry RY	Toward a case definition of adverse health effects in the environs of industrial wind turbines: Facilitating a clinical diagnosis	Bulletin of Science, Technology & Society	2011	31	4	316-320	Article, Opinion

Author	Title	Journal	Year	Volume	Edition	Pages	Type
Moller H, Pedersen CS	Low-frequency noise from large wind turbines	Journal of the Acoustical Society of America	2011	129	6	3727-3744	Article, Research
Mroczek B, Kurpas D, Karakiewicz B	Influence of distances between places of residence and wind farms on the quality of life in nearby areas	Annals of Agricultural and Environmental Medicine	2012	19	4	692-696	Article, Research
Mulvaney KK, Woodson P, Prokopy LS	A tale of three counties: Understanding wind development in rural Midwestern United States	Energy Policy	2013	56		322-330	Article, Research
Nissenbaum MA, Aramini JJ, Hanning CD	Effects of industrial wind turbine noise on sleep and health	Noise & Health	2012	14	60	237-243	Article, Research
Office of Information and Regulatory Affairs	Final Information Quality Bulletin for Peer Review		2004				Report, Guidelines
Palmer W	Wind turbine sound prediction - the consequence of getting it wrong	Proceedings of Meetings on Acoustics	2013	19	1	1-9	Article, Opinion
Pawlaczyk-Luszczynska M, Dudarewicz A, Waszkowska M, Szymczak W, Sliwinska-Kowalska M	The impact of low frequency noise on human mental performance	International Journal of Occupational Medicine and Environmental Health	2005	18		185-198	Article, Research
Pedersen E	Health aspects associated with wind turbine noise - Results from three field studies	Noise Control Engineering Journal	2011	59	1	47-53	Article, Research
Phillips CV	Properly interpreting the epidemiological evidence about the health effects of industrial wind turbines on nearby residents	Bulletin of Science, Technology & Society	2011	31	4	303-315	Article, Opinion
Rand RW, Ambrose SE, Krogh CME	Occupational health and industrial wind turbines: A case study	Bulletin of Science, Technology & Society	2011	31	5	359-362	Article, Research
Roberts JD, Roberts MA	Wind turbines: Is there a human health risk?	Journal of Environmental Health	2013	75	8	8-13	Article, Review

Author	Title	Journal	Year	Volume	Edition	Pages	Type
Ruotolo F, Senese VP, Ruggiero G, Maffei L, Masullo M, Iachini T	Individual reactions to a multisensory immersive virtual environment - The impact of a wind farm on individuals	Cognitive Processing	2012	13	s1	s319-s323	Article, Research
Salt AN, Kaltenbach JA	Infrasound from wind turbines could affect humans	Bulletin of Science, Technology & Society	2011	31	4	296-302	Article, Opinion
Shain M	Public health ethics, legitimacy, and the challenges of industrial wind turbines: The case of Ontario, Canada	Bulletin of Science, Technology & Society	2011	31	4	346-353	Article, Review
Shepherd D, Billington R	Mitigating the acoustic impacts of modern technologies: Acoustic, health, and psychosocial factors informing wind farm placement	Bulletin of Science, Technology & Society	2011	31	5	389-398	Article, Opinion
Shepherd D, McBride D, Welch D, Dirks KN, Hill EM	Evaluating the impact of wind turbine noise on health-related quality of life	Noise & Health	2011	13	54	333-339	Article, Research
Stanton T	Wind energy & wind-park siting and zoning best practices and guidance for states		2012				Report, Guidelines
Taylor J, Eastwick C, Wilson R, Lawrence C	The influence of negative oriented personality traits on the effects of wind turbine noise	Personality and Individual Differences	2013	54	3	338-343	Article, Research
Taylor S	Report on the health impacts of wind farms, Shetland 2013		2013			1-52	Article, Review
Thorne B	The problems with "Noise Numbers" for wind farm noise assessment	Bulletin of Science, Technology & Society	2011	31	4	262-290	Article, Research
van Renterghem T, Bockstael A, de Weirt V, Botteldooren D	Annoyance, detection and recognition of wind turbine noise	Science of the Total Environment	2013	456-457		333-345	Article, Research
Vanderburg WH	Assessing our ability to design and plan Green Energy Technologies	Bulletin of Science, Technology & Society	2011	31	4	251-255	Article, Opinion
Walker B, Hessler GF, Hessler DM, Rand R, Schomer P	A cooperative measurement survey and analysis of low frequency and infrasound at the Shirley Wind Farm in Brown County, Wisconsin		2012			1-51	Report, Research

Author	Title	Journal	Year	Volume	Edition	Pages	Type
Watson I, Betts S, Rapaport E	Determining appropriate wind turbine setback distances: Perspectives from municipal planners in the Canadian provinces of Nova Scotia, Ontario, and Quebec	Energy Policy	2012	41		782-789	Article, Opinion
World Health Organization	Night noise guidelines for Europe		2009				Report, Guidelines

Appendix E

Minority Analysis prepared by Tyson Cook, Bill Rakocy, and Michael Vickerman

Introduction

The Wind Siting Council has an important and valuable role in providing advice and counsel around the development of wind siting regulations in the State of Wisconsin. We acknowledge that there are a large number of stakeholders affected by regulations and any regulatory developments, and consequentially there will be a broad array of opinions on various relevant issues. Appropriately, the Wind Siting Council is comprised of members representing a broad range of stakeholders and opinions.

Despite differences of opinion between stakeholders and Wind Siting Council members, the Council has been able to work effectively together over many months in a collaborative manner, and to come to broad consensus on a number of topics. On other topics where consensus could not be reached, the Council has generally been successful in working to reach agreement between significant majorities of the members. As should be expected however, there are still some topics where opinions are strongly held by a minority of Council members. In order to allow these opinions to be clearly stated, the Council has agreed to permit the attachment of "Minority Reports" to the Wind Siting Council report (hereafter "Report"). This Minority Report addresses the disagreement among Council members regarding the scope of health impacts of wind energy systems to be considered.

Charge of the Wind Siting Council

As noted in the Report, the Wind Siting Council acts under certain statutory obligations. In particular, Wis. Stat. 196.378(4g)(e) requires that:

> "The wind siting council shall survey the peer-reviewed scientific research regarding the health impacts of wind energy systems and study state and national regulatory developments regarding the siting of wind energy systems…"

We find that the Council has done an excellent job, in keeping with these obligations, of reviewing the available peer-reviewed research regarding the potential for direct negative health impacts of large wind energy systems to residents living near those systems. We further believe that the assessment and overall conclusion of the Wind Siting Council based on that review is sound, namely the finding that:

> "Although there are several publications arguing that noise from wind turbines directly causes adverse health effects in humans, based upon the peer-reviewed literature, it appears at this time that there is insufficient data to validate this scientific conclusion."

However, while there is some latitude for interpretation of the charge under Wis. Stat. 196.378(4g)(e), there is no basis for limiting the Report to the examination of potential negative direct health impacts to residents living next to those systems as was decided by the Council during the open meeting of 4/7/2014. Indeed, we believe that the statutory language calling for a survey of peer-reviewed literature creates an obligation to include literature which also addresses positive health impacts on the vast majority of Wisconsin's population that does not live next to wind turbines. This obligation requires the Wind Siting Council to include any peer-reviewed studies regarding health benefits from reduced fossil fuel emissions that result from increased wind energy generation.

The importance of considering these broader public health impacts in the Report is significant. The specific wind siting decisions that are made pursuant to state rules and regulations can have varying levels of health benefits at the regional scale. The nature of electrical system operation is such that generation is dispatched based in part on locational need. The specific location of wind energy systems thereby affects the types of generation displaced and therefore the corresponding levels of health benefits. Additionally, the siting of wind energy systems in locations that reduce transmission congestion can also magnify health benefits by reducing electrical losses in transmission lines. The rules and regulations that govern the siting of wind energy systems also impact the amount of health benefits that may accrue on the statewide level, by affecting the ability for those systems to be installed in the state.

Public Health Impacts of Wind Energy Systems

In neglecting to include the full range of research on "health impacts of wind energy systems," the Report does not represent a complete survey of the relevant peer-reviewed scientific literature the Wind Siting Council is charged with. Instead, the report as drafted could best be described as an examination of writings regarding reported health complaints of individuals living near wind farms. As such, it does not provide the level of understanding on the issue at hand that would be necessary to make informed decisions. Indeed, by excluding recent peer-reviewed research on broader public health impacts - which may be qualitatively at odds with some of the other potential impacts examined - the report exhibits a level of observational bias that may lead to inaccurate conclusions in the minds of readers and fails to fulfill the Wind Siting Council's statutory requirements in Wis. Stat. 196.378(4g)(e).

In addition to the growing body of scientific evidence refuting a direct linkage between wind turbines and negative, localized health impacts through mechanisms such as infrasound and low frequency noise, there is a large and long-standing consensus around other issues relevant to the health impacts of wind energy systems to the public. Most significant of these are the avoided emissions that would result as wind energy systems displace the combustion of fossil fuels to generate electricity. Through the avoidance of these fossil fuel emissions, wind energy systems directly increase our air quality and benefit public health and welfare.

These public health impacts were recently examined by Greene and Morrissey (2013), who studied the accrual of health benefits associated with wind energy production the producing state.

The research focused on sulfur dioxide (SO_2) and nitrous oxide (NO_x) emissions, since the effects of those pollutants are more localized geographically and temporally. The authors found that the displacement of electricity production from fossil fuel sources resulted in significant local health benefits, consistent with other research.[115] In particular, their research estimated that emissions avoided due to wind energy systems in Oklahoma resulted in over 1,000 fewer premature deaths for 2011, along with an additional reduction of over 1,000 non-fatal heart attacks, 2,000 hospital visits, 500 cases of chronic bronchitis, and 90,000 work and school absences due to illness. The authors note that the reductions in SO_2 and NO_X emissions, which were also seen by Madaeni and Sioshansi (2012) in Texas, "clearly illustrate the health benefits brought on by the increased use of wind energy in Oklahoma," and that on an economic basis "these values represent a savings of tens of millions of dollars annually."

In a systematic assessment of renewable energy across the United States, Siler-Evans et al. (2013) also examined the health benefits resulting from emission reductions as a result of wind energy, specifically displaced carbon dioxide (CO_2), SO_2, NOx, and fine particulate matter (PM2.5). The assessment estimated the potential avoidance of emissions and the related health and environmental impacts from a hypothetical wind energy system sited at any one of 33,000 locations across the United States. The avoided impacts were based on analysis of the "marginal electricity production" at each of those locations, which is the electricity generation that would be displaced by the installation of the wind energy system in that particular site. In conducting the assessment, the authors used economic values of health and environmental damages for each hour from 2009 through 2011, quantified using dollar-per-ton damages from over 1,400 fossil-fueled power plants.

The results showed that the displacement of pollutants resulted in varying amounts of avoided cost, depending on location and generation mix. More coal-reliant states were shown to have higher health and environmental benefits associated with wind energy systems than states which utilize more natural gas or renewable energy. For instance it was noted that, "a wind turbine in West Virginia avoids $230 in health and environmental damages per kilowatt per year ($81/MWh) - seven times more than a wind turbine in Oklahoma and 33 times more than a wind turbine in California." It should be noted that the $81/MWh estimated on the high end by Siler-Evans et al. is within or below the range estimated by others for external health costs from emissions of coal-fired power plants. For example, Smith et al. (2013) estimate those costs to be between $32/MWh and $289/MWh, while Machol and Rizk (2012) estimate $140-450/MWh. Both of those studies also reinforce the importance of location and generation mix to the total value of emissions avoided, with coal-reliant states such as Wisconsin seeing the greatest benefit.

Research done by McCubbin and Sovacool (2013) directly compared two wind farms, Altamont (580MW) and Sawtooth (22MW), to electricity production through natural gas. Since natural gas production is the fossil fuel with fewest health impacts related to pollutant emissions, this provides a very conservative estimate for the positive public health impacts associated with wind energy systems. Like Siler-Evans et al. (2013), McCubbin and Sovacool (2013) use models to

[115] See, e.g. Liu et al. (2012) who found "a significant elevation of hospitalization for respiratory diseases among individuals… who lived near a fuel-fired power plant."

evaluate the economic costs of health and environmental impacts such as increased morbidity and mortality from air pollution and incidence of noise and reduced amenity, aesthetics and visibility, which are seen from the respective generation sources. The study featured a particular focus on PM2.5, due to the health issues it creates. The authors used the Co-Benefits Risk Assessment Tool (COBRA) to model how emissions affect ambient PM2.5 levels. They take the avoided emissions and convert them into economic values based on estimated social costs and valuation of public health endpoints, such as hospital admissions and work loss days. The results were that between 2012 – 2031, the Altamont site would result in an estimated $560 million to $4.38 billion in public health and environmental benefits, and the Sawtooth site would result in estimated benefits of $18 million to $104 million. These numbers were again consistent with the estimates of other researchers regarding the value of avoided emissions, such as Smith et al. (2013) and Machol and Rizk (2012). However, a state with a larger portion of coal-powered electricity generation like Wisconsin could be expected to have larger public health benefits than the California electrical generation system considered by McCubbin and Sovacool (2013), which is comprised of less than 1% coal generation.

Based on the $0.20/kWh value from Machol and Rizk (2012), a 580MW project like that considered by McCubbin and Sovacool (2013) could result in approximately $300 million in benefits annually, or $5.4 billion over a similar time period (2012-2031) in the state of Wisconsin.

International research has also examined the link between wind energy systems and public health impacts. For instance, both Partridge and Gamkhar (2011) and Ma et al. (2013) examine the emissions avoided in China by the addition of wind power production. Partridge and Gamkhar (2011) use the measurements from 117 wind projects, as compared to emissions data from a single 1200MW supercritical coal-power plant (similar to the Elm Road Generating Station in Wisconsin). Focusing only on PM2.5, their results show emissions reductions resulting in avoided premature deaths, avoided new cases of chronic bronchitis, and avoided hospital stays resulting from the projects. These results agree with the findings of Liu et al. (2012) who saw increases of 11%, 15%, and 17% respectively in hospitalization due to asthma, acute respiratory infections, and chronic obstructive pulmonary disease in individuals living near fossil-fired power plants in New York compared with those who did not. Similarly, Ma et al. (2013) studied the emissions offset by two 49.5MW wind power projects in relation to a regional data from 2001 to 2010, and found that emissions mitigation from the wind power production resulted in cost savings due to lower health care costs through improved air quality and reduced damage to public health, of over $1.38 billion (USD).

It should be noted that peer-reviewed scientific research summarized in this report represents only that which explicitly and directly links wind energy systems to human health outcomes. There is a much larger body of work that could be drawn upon to independently show both (1) the potential for pollution reductions as a result of wind energy systems, and (2) the potential benefits to human health from such reductions. Despite their relevance to the topic, those articles were not included here for the sake of brevity, due to the sheer volume of such research and because they can be safely anticipated to yield qualitatively similar findings.

The public health benefits of non-polluting renewable energy systems such as wind turbines have been one of many reasons for their installation across the nation. Indeed, even health benefits going beyond the more traditional pollutants (e.g. the fine particulate matter, sulfur dioxide, and nitrogen oxides that were the major focus of the research discussed in this Minority Report) have been well established. A recent demonstration of this is the proposed rules by the U.S. Environmental Protection Agency (EPA) to limit carbon pollution under section 111(d) of the under the federal Clean Air Act. The establishment of these rules was necessitated by a series of rulings by the U.S. Supreme Court, which upheld the finding that greenhouse gases endanger public health and placed a legal obligation on the EPA to limit such gases. In their proposed rules to limit those greenhouse gases, and thereby reduce the endangerment to public health and welfare, the EPA specifically included the use of renewable energy systems such as wind energy as a potential compliance mechanism.

Conclusion

A survey of peer-reviewed research regarding public health impacts related to wind energy systems uniformly indicates health benefits resulting from the operation of those systems. This is in stark contrast to the lack of evidence in the peer-reviewed scientific literature to substantiate the direct adverse health effects that the Council focused on in the Report. As opposed to the potential for negative effects examined by the Council, the public health benefits of reduced air pollution that result from the operation of wind energy systems are well known and widely understood.

The Wind Siting Council has an important advisory role with regard to the development of wind siting regulations in the State of Wisconsin. While the Report developed by the Council is a step toward fulfilling its statutory obligations, it does not fully meet that charge. The inclusion of peer-reviewed scientific research on the topics noted here clearly falls within the framework for the Report established under Wis. Stat. 196.378(4g)(e). Aside from statutory obligations, it is also critical that the Wind Siting Council consider these topics because the potential for health benefits from wind energy systems are directly impacted by, and are therefore directly relevant to discussions of, wind siting rules and regulations in the state.

The research discussed here demonstrates a consensus among the scientific community that there are public health benefits resulting from wind energy systems. The work and findings described by the majority Wind Siting Council report make clear that this consensus is not counter-balanced by similar scientific evidence of potentially negative direct health impacts. The sum of these two facts makes clear the following: from the perspective of scientific peer-reviewed research, wind energy systems substantially benefit human health and welfare.

Works Cited

Greene, J; and Morrissey, M, 2013. Estimated Pollution Reduction from Wind Farms in Oklahoma and Associated Economic and Human Health Benefits. Journal of Renewable Energy.

Liu, X; Lessner, L; and Carpenter, D, 2012. Association between Residential Proximity to Fuel-Fired Power Plants and Hospitalization Rate for Respiratory Diseases. Environmental Health Perspectives, 120(6)807-810

Ma, X; et al., 2013. Co-benefits analysis on climate change and environmental effects of wind-power: A case study from Xinjiang, China. Renewable Energy, 57()35-42

Machol, B and Rizk, S, 2013. Economic Value of U.S. Fossil Fuel Electricity Health Impacts. Environment International, 52(2)75-80

Madaeni, S and Sioshansi, R, 2013. Using Demand Response to Improve the Emission Benefits of Wind. IEEE Transactions on Power Systems, 28(2)1385-1394

McCubbin, D. and Sovacool, B, 2013. Quantifying the health and environmental benefits of wind power to natural gas. Energy Policy, 53()429-441

Partridge, I and Gamkhar, S, 2012. A methodology for estimating health benefits of electricity generation using renewable technologies. Environmental Int'l, 39(1)109-110

Siler-Evans, K; Azevedo, IL; Morgan MG; and Apt, J, 2013. Regional variations in the health, environmental, and climate benefits of wind and solar generation. PNAS, 110(29)11768-11773

Smith, K; Frumkin, H; et al., 2013. Energy and Human Health. Annual Rev. Public Health, 34()159-188

Appendix F

Wisconsin
Wind Siting Council

Minority Response

Prepared by Dr. James Amstadt, Carl Kuehne, Tom Meyer, and Glen Schwalbach. P.E.

Additionally signed onto by Mary Brandt and Tim Roehl

Wind Turbine Siting-Health Review
Wind Turbine Siting-Policy Update
and
Recommendations for Legislation

October 2014

Executive Summary

In 2009, Wisconsin Act 40 directed the Public Service Commission of Wisconsin (Commission or PSC) to appoint a Wind Siting Council (Council or WSC) to provide advice to the PSC during the rule- making process for the siting of wind turbines. Act 40 also requires that Council to submit a report to the Legislature every 5 years to provide updated information about health research and regulatory developments, as well as to provide recommendations for legislation if needed.

Act 40 specifies the makeup of the membership of the Wind Siting Council and it created a bias in the form of a majority made up of several pro-wind energy interests and pro-wind environmentalists versus a minority of others who would focus on safety and health. Because of that built-in pro-wind bias, the Council's minority created this Minority Report to reveal the information that the Council majority omitted from the Wind Siting Council report to the Legislature.

The pro-wind bias, as found on the Wind Siting Council, is found on the PSC staff as well. One reason for the PSC's bias is that it seems they deem that the statute for Renewable Portfolio Standards requires them to "go easy" on safety and health restrictions for wind energy projects. This bias has created wind siting rules in Wisconsin that are not as protective as they should be. Wisconsin's wind siting law and rules (PSC 128) require local units of government to process applications for all but the largest wind projects. These wind projects are extremely complicated and are often unique to the local land features. But local governments are not allowed to consider safety and health protections that are more restrictive than PSC 128. So, they cannot require protections to suit the local circumstances, to adopt the recommendations of their medical or technical experts or engineers, to accommodate the latest science, or to require the latest protective technologies. Wisconsin law and PSC 128 require local government units to approve these wind projects with noise restrictions and setbacks that the Council's current regulatory review would consider to be some of the least protective in the country.

This Minority Report highlights areas in PSC 128 that differ from health standards and best practices found in the documents reviewed by the Council for the Majority Report, differences that were downplayed by the pro-wind Council majority. These health standards and best practices are designed to protect non-participating homeowners' health and property rights. These best practices strike a balance between protecting residents and creating a regulatory environment that the wind industry can use to get approvals that work for both the industry and the communities where they are built.

Because Wisconsin's wind siting law is so dysfunctional, wind turbine development plans are met with great opposition by the communities where they are proposed. The communities that object are aware of the health concerns that are described in the Minority Report. Wind turbine noise is linked to chronic sleep disturbance, which is linked to more serious physical maladies. Wisconsin law does not allow setbacks that adequately prevent harmful noise impacts to homeowners. Officials are not permitted to set wind turbine setbacks any farther than an arbitrary 1250-foot or 3.1 times the total height, whichever is less, from a neighbor's occupied structure.

The Council's regulatory review also found that, because Wisconsin's setback is from a wind turbine to a neighbor's occupied structure, some of that neighbor's land is now inside the "safety setback" distance from the wind turbine. This "safety setback" can overlap as much as 800 feet of that neighbor's property. This is a "taking" of the owner's property right to use their land for intended purposes because it is no longer possible to build with local building setbacks near their property line and stay outside of the "safety setback" due to a turbine being located nearby. In other states there is a trend to create setbacks a safe distance from the neighbor's property line instead of the neighbor's structure.

A significant study done by a member of the Council showed that the towns in which wind projects have been built in Wisconsin have population densities generally much higher than towns or townships in neighboring states where similar projects have been built. Couple this with the fact that the wind resource in Wisconsin is much less than in these neighboring states, and it is like forcing a square peg into a round hole, whereby there is likely to be some severe damage. Wisconsin's existing wind projects have been permitted in our more populated areas, and thus, are more often too close to residences with more resultant negative health impacts than in other states.

This Council minority concludes that Wisconsin's wind siting law needs revision for noise protection and property rights protection. Also, a restructuring of the Wind Siting Council makeup is needed to eliminate bias, as is a restructuring of what information the Council is allowed to review in order to advise the Legislature about wind energy systems. Rewriting the wind siting laws to offer better protections for non-participating residents and correcting the bias of the Wind Sting Council will restore the public trust in the wind-siting laws of Wisconsin, creating a win-win situation for both the wind industry and non-participating residents.

To proceed wisely, the minority, the majority and numerous technical and public policy experts agree that more acoustic and epidemiological studies are needed. Wisconsin wind projects are ripe for such studies before more damage is done, but government funding is needed.

Also, Wisconsin needs a process to compensate those citizens who had to abandon their homes to get relief from negative health effects, who have not moved and suffer negative health effects, or who have taken a financial loss due to a neighboring wind project.

Please read the full Minority Report for the complete details and conclusions.

1.0 Purpose:

The purpose of this report by the Council minority is to challenge the reader to take a second look at all of the available data on the subject of wind turbine health impacts and evaluate this data in a more critical light. To ensure that the economic interests of wind turbine project developers were protected in the recommendations made to the Legislature, the Council majority opinion sided with pro-wind factions to minimize any impediments to the construction of wind turbine projects.

The Council minority consists of six (almost half) of the fourteen participants in the Wind Siting Council, including both Public Members, the Towns member, both Realtor Members, and one Landowner Member.

Ultimately, the Council majority found secondary in their report the importance of the proper siting of wind turbines and the direct impact these turbines have on the health and welfare of citizens. The Council minority opinion takes a more cautious and concerned approach to wind development, placing a priority on the siting rules of wind turbines and the health and welfare of people over the interests of wind energy developers and system operators. This Minority Report will reveal the shortcomings of Wisconsin's current statewide wind siting law under which the rules (PSC 128) were promulgated and recommend areas where the law and, thus, PSC 128 should be improved.

2.0 Applicable Statutes and Limitations:

2009 Wisconsin Act 40 directed the Public Service Commission of Wisconsin (Commission or PSC) under Wis. Stat. §15.797 to appoint a Wind Siting Council (Council or WSC) to provide advice and counsel to the Commission during the rule-making process for the siting of wind turbines. In addition, the Council under Wis. Stat. §196.378(4g)(e) shall report to the Legislature every five years after surveying health research and regulatory developments and shall make recommendations for legislation, if any.

Wis. Stat. §15.797(1)(b) contains statutory guidelines that favors a Council heavily weighted towards wind development. Recognizing that, in the Council's current composition, a bias exists in favor of wind energy interests and that members in the majority of the Council have made great efforts to disqualify and discredit documents linking wind turbines to negative health effects, there exists a justifiable rationale for the necessity of this Minority Report to supplement the Council majority's findings.

Further limiting the WSC's scope on reviewing the health impacts of wind turbine development is the fact that the Council majority interpreted Wis. Stat. § 196.378(4g)(e) as directing the Council to survey *only* peer-reviewed scientific research regarding the health impacts of wind energy systems and to review *only* U.S. state and national regulatory developments regarding the siting of wind energy systems. Consequently, the Council has considered only a microcosm of relevant studies and policies that by themselves do not reveal all of the factors vital to protecting human health and safety.

Although Wis. Stat. § 196.378(4g)(e) does list the type of documents that the Council must consider, we, the Council minority, do not consider that list to be exclusive of other relevant data. We find that the inclusion of other credible research, empirical evidence, and affidavits is in the best interest of the public. Inclusion of such documents will provide the Legislature and the PSC with a more complete and better representation of the effects that wind turbines have on human health.

It is the responsibility of the Legislature to address the experiential realities of citizens affected by wind turbines and it is the Council's responsibility to provide the Legislature with pertinent information that addresses all health concerns that may affect the quality of life as it relates to siting a wind turbine near residences.

3.0 Minority Review of Majority Health Summary

In its summary of *Key Findings from Wind-health Literature*, the Council recognized several trends in its review of the selected literature since the Council's 2010 recommendations. Of primary concern on the matters of health are cross-sectional surveys that show evidence of individuals living in the proximity of wind turbines experiencing elevated levels of annoyance and sleep disturbance due to wind turbine noise while the turbines are in operation. Two studies showing cause for alarm are Janssen et al. (2011) and Bakker et al. (2012) that found a staggering *40 percent and 66 percent (respectively) of individuals* studied reported to be both annoyed or highly annoyed by wind turbines producing outdoor sound levels over 45 dB(A).

It should be noted that stress from annoyance and sleep disturbance may be related to chronic health conditions and that individual perception may increase or decrease the severity of reported conditions. The long-term effects of chronic sleep restrictions and deprivation have been thoroughly studied and have been identified by the American Academy of Sleep Medicine to include symptoms of depression, anxiety, fatigue, high blood pressure, obesity, heart attack and diabetes. Coupled with these medical and mood conditions are performance reductions including attention deficits, longer reaction times, increased errors and distractibility. Severe drowsiness can be a safety hazard, causing traffic crashes and workplace injuries, among other incidents.

In their conclusion of key findings, the Council found that some individuals residing in close proximity to wind turbines perceive audible noise and find it annoying, that these individuals report that this noise negatively affects their sleep, and that these events may result in other negative health effects. The Council minority concurs in this conclusion, illustrating the importance of effective siting laws to protect residents from the negative health effects of wind turbines.

3.1 Minority Reaction to Council Review and Significance of Annoyance

The term "annoyance" is used widely in the literature reviewed by the Council, and thus, is also used in the Council's report. The definition of annoyance selected by the Council majority is that referenced in a World Health Organization's (WHO) publication regarding occupation noise (*not* a peer-reviewed document reviewed by the Council), namely, "a feeling of resentment, displeasure, discomfort, dissatisfaction or offence which occurs when noise interferes with someone's thoughts, feelings or daily activities."

The Council minority does not believe this definition accurately represents the physiological response recognized by numerous studies showing an effect on human health. A paper published by the World Health Organization in 2011 states that WHO's definition of health *implies that noise-induced annoyance may be considered an adverse effect on health. (Miedema, H. et al, Burden of disease from environmental noise, WHO, 2011).*

As explained by Suter, A., (1991) "Annoyance" has been the term used to describe the community's collective feelings about noise ever since the early noise surveys in the 1950s and 1960s, although some have suggested that this term tends to minimize the impact. While "aversion" or "distress" might be more appropriate descriptors, their use would make comparisons to previous research difficult. Suter continues to expound on this thought, noting:

> *It should be clear, however, that "annoyance" can connote more than a slight irritation; it can mean a significant degradation in the quality of life. This represents a degradation of health in accordance with the WHO's definition of health, meaning total physical and mental well-being, as well as the absence of disease. (Suter, A., Noise and Its Effects, Administrative Conference of the United States, Editor. 1991).*

Other reputable studies reviewed by the Council, including Ellenbogen et al. (2012) and Shepherd et al. (2010), define "annoyance" as "a mental state characterized by distress and aversion, which if maintained, can lead to a deterioration of health and well-being", while Taylor, S. (2013) defines "annoyance" as connoted in contemporary medicine as being, "used as a precise technical term describing a mental state characterized by distress and aversion, which if maintained, can lead to deterioration in health and well-being".

Again, erring on the side of caution, the Council minority in its review of definitions of "annoyance", finds that the use of this term should be elevated to recognize its status as a technical term identifying events relating to the physiological definition of a medical condition with the potential to cause long-term chronic conditions.

3.2 Minority Reaction to Council Review on the Survey of Peer-reviewed Literature

The Council completed its initial survey of peer-reviewed wind-health literature and made recommendations to the Commission regarding wind siting rules in 2010. At that time the majority of the members recommended siting measures, including 50/45 dB(A) day/night noise limits, 1.1 times the maximum blade tip height setback and less than 40 hours of shadow flicker per year for non-participating residences. These recommendations were modified by the PSC and codified in *PSC 128, Wind Siting Rules*. A minority of the 2010 Council members strongly disagreed with these conclusions however, and their concerns were presented in Appendix E of the 2010 *Final Recommendations To the Public Service Commission: Wind Siting Rulemaking Pursuant to 2009 Wisconsin Act 40*. (see http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=136311) The current Council minority affirms that position, and further asserts that these siting measures are recurrently inconsistent and outdated with developing research, noting that wind turbines generate sound that has components not even measured by the usual sound level meters when using a scale for normal audible sound, i.e. the dB(A) scale.

In their review of over 400 wind turbines installed throughout Wisconsin, the Council noted that some members of the public who reside near wind turbines have continued to complain about adverse human health impacts attributed to wind turbines. Unfortunately, the Council came to the incorrect and unsubstantiated conclusion that the level of public concern and amount of

scientific or technical research associated with potential negative health impacts have diminished due to lack of interest or formal complaints. After complaining for a number of years and getting inadequate or no resolutions of the problems, residents have abandoned their homes or suffer in frustrated silence. The majority members of the Council did not allow reference to the complaint affidavits and local government resolutions in the Majority Report as requested by the minority members. Additionally, although PSC 128 requires wind project owners to maintain complaint logs and to submit them to the PSC upon request, the PSC has never requested such complaint logs and has not done so for this health review, although requested to do so by the Council Chairman, a minority member. Therefore, while PSC 128 directs all complainants to direct their complaints to the project owner, all such complaints have not been reviewed by the Council.

If proper weight were given to the empirical and anecdotal evidence of adverse effects of wind turbines on human health, we believe that the volume of reports of potential negative health impacts have not in fact diminished, but instead have increased, with any appearance to the contrary being the result of previous reports having either been disregarded or being submitted to the PSC and not acted upon.

When individuals report harmful effects or violations of the existing standards, no measure of accountability exists in Wisconsin law to ensure wind turbine operators are pursuing corrective action processes, thus resulting in an underreporting of noise violations. In order to better represent the true conditions under which adverse health reactions may in fact occur, a more efficient and comprehensive monitoring system of these noise levels, and a more responsive corrective action system, must be established to protect residents from noise violations.

In the study Pedersen (2011), the Council highlighted that although annoyance, sleep disturbance, and stress were linked to environmental noise, these effects are only attributable to wind turbines when they are generating sound levels over 40 dB(A). Yet, Wisconsin's wind siting rules allow daytime noise to be up to 50 dB(A) and nighttime noise to be up to 45 dB(A). Both are above the levels that were attributed to marked reactions in survey participants. As a point of reference, every step increase of 10 dB(A) results in a doubling of sound impact, i.e., 40 dB((A) is perceived as twice as loud as 30 dB(A) while 50 dB(A) is perceived as 4 times as loud as 30 dB(A).

Bakker et al. (2012), a separate analysis on a subset of the data from Pedersen (2011), found 23 percent of respondents reported annoyance from wind turbine noise to some degree while outdoors and 14 percent reported annoyance from turbines while indoors. This annoyance was directly related to noise level, with approximately 4 percent of annoyed respondents reporting annoyance where sound levels were less than 30 dB(A) and approximately 66 percent when they were above 45 dB(A), a trend that is also supported by experimental evidence in Ruotolo et al. (2012).

Sleep disturbance was reported by approximately 33 percent of respondents and it increased with greater environmental noise levels. The authors found that respondents were more annoyed by wind turbine noise than by road or rail noise when above 40 dB(A) and aircraft noise when above 45 dB(A). This occurs because of the unique characteristics of wind turbine-generated noise, which is long in duration (often 24/7) and has an amplitude modulated, or impulsive

cadence. This constantly changing sound increases attention and cognitive appraisal and reappraisal, inhibiting acclimatization to the sound.

Janssen et. al. (2011), also concluded that annoyance from environmental noise increases rapidly as sound levels exceed 35 dB(A) outdoors and 40 dB(A) indoors. The study's authors found this to be especially true for wind turbine noise, with a large number of individuals reporting to be both annoyed or highly annoyed by wind turbines producing noise outdoors (approximately 40 percent of respondents) or indoors (approximately 18 percent of respondents) when sound levels are above 45 dB(A).

Furthermore, in Shepherd et al. (2011), the authors found that individuals residing in close proximity to turbines reported reductions in sleep quality, energy and overall quality of life. Nissenbaum et al. (2012) also showed similar results. Krogh et al. (2011) found that 94 percent of respondents self-reported altered health or quality of life specifically, and that 72 percent of participants reported experiencing stress, depression and sleep disturbance directly due to wind turbines.

Finally, the Council majority report omitted highly relevant facts from several studies that it relied heavily upon for its conclusions, including studies by Taylor, Crichton, Chapman, Katsaprakakis, and Mroczek, some of which also had serious design flaws. For specific examples of such reports, see Footnote 1 at the end of this report. Regrettably, and to the detriment of the reliability of the Majority Report, the Council majority voted to prematurely adopt the Wind-Health Report draft "as-is" prior to any adequate discussion of it in Council meetings. This barred correcting the deficiencies noted above.

It is important to note that it is incredibly difficult to design a control group in which there is no simulated placebo. The Council found that the limitations of available research confined the Council to only seven, unbiased, cross-sectional studies, of which three use the same data set. Again, the Council minority supports and recommends that more studies be commissioned in order to preserve and expand the diversity of data, but recommends, based on the evidence provided from available survey data, a highly cautionary approach to wind siting regulations.

3.3 Minority Reaction to Council Review on the Survey of Regulatory Developments

Besides the interpretation of the Council's majority that state and national regulatory developments shall not include those of foreign states or nations and shall not include results of studies commissioned by state or national government entities, even if in the U.S., the Council's majority also did not allow the Majority Report to include reports on the actions of various Wisconsin county boards, county boards of health, town boards and the Wisconsin Towns Association. These entities have passed resolutions or, otherwise, requested the PSC or the state to conduct additional studies to evaluate the health impact of wind turbines on the public. The PSC has not responded to these local government entities.

Similarly, the Majority Report does not include reference to the numerous complaints, affidavits, and testimonies of Wisconsin citizens regarding their health issues since wind turbines were put in operation near their homes. If the PSC would follow-up on these complaints in the field, as well as review complaint logs of wind project operators as mentioned above, a meaningful

appreciation of the actual negative impacts upon people and an evaluation of the responses of wind project operators would significantly add to the PSC's body of knowledge and perhaps help mitigate the complaints.

The Council reviewed a summary of state regulations for wind turbine siting. Compiling such data is challenging since such regulations are often in a state of flux, state regulations often do not preempt local governments from having their own siting restrictions to suit local situations, and certain wind turbine siting regulations may be preempted by other state regulations regarding safety.

3.4 Majority Survey Conclusions and Minority Response

In their final review, the Council *unanimously* agreed that wind turbines have a physiological effect on some populations when in operation. The Majority Report stated:

> *What is not under dispute between these two groups is that wind turbines produce environmental noise, that some individuals find that noise annoying, and that environmental noise may cause sleep disruption if the sound levels are high enough. There is, as a result, a consensus that proper wind turbine siting is imperative when designing wind generating systems to reduce the impacts of noise on people.*

The Council suggests two pathways by which adverse health impacts may arise, including the stress/annoyance indirect pathway as well as the direct pathway of physiological perceptions and adverse reactions to inaudible infrasound and low-frequency noise (ILFN). Inaudible infrasound is generally considered to be sound below 20 hertz (Hz) while low frequency sound is generally considered to be sound in the range of 20 to 200 Hz. Note that infrasound and low-frequency noise (ILFN), when compared to audible noise, travels much farther, reflects more readily off the atmosphere and terrain, travels easier through walls, and resonates inside of buildings. It is important to observe that the current regulatory guidelines in Wisconsin do not regulate, monitor, or allow limits to infrasound and low frequency noise (ILFN).

Scientific measurements of infrasound and low frequency noise (ILFN) emissions by wind turbines have been thoroughly documented in studies such as the Shirley Wind Study (2012) commissioned by the PSC. Unfortunately, and to the detriment of studies regarding the adverse effects of wind turbines on human health, these acoustic measurements are not included in the WSC report simply because the measurements are only data sets and not considered peer-reviewed research. This acoustic testing in the Shirley Wind project was done by acoustic experts and could be considered more relevant than some peer-reviewed research. Significantly, the joint conclusion of the report states: *"The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry."*

Although studies have shown infrasound and low frequency noise (ILFN) are harmful and have adverse health effects, a majority of those studies are not eligible for inclusion in this report due to the Council majority's interpretation of Wisconsin's statutory limits on scientific research to only include peer-reviewed data. Again, the Council minority disagrees with the Council

majority's conclusion that there are no significant ill or adverse health effects, while such effects *are* indicated in both the literature reviewed by the Council *and* in a greater body of information excluded from review by the Council majority.

From the collections of data sets that are available, we can see infrasound and low frequency noise (ILFN) emissions from wind turbines have been identified, and that these emissions have the potential to cause physical harm in persons who are exposed to said sounds. Collaborative efforts from across many fields of science have discovered causal evidence of symptoms relating to wind turbine developments, thus requiring further analysis and study. Such studies must be carefully designed due to the challenges of structuring an experiment that involves an operating wind energy system in conjunction with human subjects. Wisconsin is an ideal place to conduct such studies due to the level of complaints and its relatively denser populations near wind turbines than in other states.

In their final conclusion, the Council minority and many subject experts disagree with the Council majority and believe there is sufficient data to infer that wind turbines have a direct and negative effect on human health based on their survey of applicable literature.

3.5 Minority Conclusion to the Health Section

The overwhelming empirical evidence from the peer-reviewed literature surveyed by the Council shows that when certain people are near operating wind turbines they become ill, but when the turbines are stopped, their conditions subside. Regardless of the reasons why, the law regulating the siting of turbines must protect the human rights and well-being of those living nearby and provide protection for innocent populations who are harmed by wind turbines sited too close to their homes - even if the mechanism of the harm is not yet fully understood.

The point is, there is enough causal evidence for alarm. We wholeheartedly agree with the Council majority opinion that more studies need to be commissioned to better understand the science surrounding these negative effects on human health. Also, the WSC's methodology for evaluating the litany of surveys and data sets every five years for the Legislature needs to be retooled to include previously excluded research and documented observations of human health impacts.

We must rethink setting maximum limits on regulation of wind turbines when the science has not been fully settled. The Hippocratic Oath, a physician's rite of passage states, "I will prescribe regimens for the good of my patients according to my ability and my judgment and never do harm to anyone". In the case of wind turbine siting, we must take a precautionary stance to preserve the health and well-being of all those who might otherwise suffer undue harm and not put limits or maximums on wind turbine regulations that have not been proven to be adequate.

In conclusion, existing evidence of physical harm caused by infrasound and low frequency noise (ILFN), coupled with the evidence that all wind energy systems emit infrasound and low frequency noise (ILFN) that is measurable at the homes of victims who report symptoms of low frequency noise, creates enough of a relationship that the Legislature and the PSC should act

immediately to mitigate, through curtailment and other mandates, the harmful effects that have already been reported in Wisconsin. Most importantly, the Legislature and the PSC need to commission acoustic and epidemiological studies, conducted by independent experts, near Wisconsin wind turbine installations prior to construction of future systems to ensure that Wisconsin's regulations are not responsible for more harm to the health and safety of people living near wind energy systems. The four independent acoustic experts who conducted the acoustic study in the Shirley Wind project recommended "additional study on an urgent priority basis".

Also, the Legislature and the PSC should act to establish relief for those citizens who have been harmed by existing wind turbines in Wisconsin.

4.0 Minority Reaction to the Wind Siting Policy Update

Under s. 196.378(4g)(e) the Wind Siting Council is charged with reviewing developments in wind siting policy and providing a report with recommendations to the Legislature. Erroneously, the Council majority interpreted this charge to mean only regulatory developments from within the United States, and excluded review of regulatory developments in any other country.

Even within the narrow scope of this review, several key findings showed that Wisconsin's regulatory framework is unusual and does not do enough to protect the health of people living near wind turbines or the property rights of non-participating property owners in Wisconsin.

Wisconsin's regulatory environment is unusual in that regardless of the specific protections that might be appropriate for a proposed wind energy system, Wisconsin's wind siting rules create maximum limits that are more in line with most states' minimum standards and prevent Wisconsin local officials from offering ANY restrictions that would be more protective. In other words, Wisconsin's standards are the maximum protections that officials can impose, which is the opposite of how most regulations are written. Officials can never be more restrictive than these maximum protections for any reason under Wisconsin's wind siting rules.

4.1 Findings from the Regulatory Review

The Council did not acknowledge many regulatory developments in their Majority Report, but did rely heavily upon the 2012 National Association of Regulatory Utility Commissioners (NARUC) report. Several of the NARUC recommendations illustrate areas where Wisconsin's wind turbine siting regulations are inadequate even under the less than cautionary approach of NARUC's consultant who wrote the report.

Wind turbines in Wisconsin are allowed to subject people to audible sound levels that are twice as loud as the 2012 NARUC report recommends. NARUC recommends that 40 dB(A) should be an ideal design goal while Wisconsin law does not allow any restrictions to limit the noise below 50 dB(A) during the daytime. Because the dB(A) scale is a logarithmic scale, a 50 dB(A) sound is perceived as twice as loud as sound that is 40 dB(A) in amplitude.

The NARUC report recommends that noise standards should be based on land use. The report argues that doing so would incorporate background noise when considering siting, as the noise levels that may elicit annoyance may be washed out to some degree by background noise and thus not be as noticeable. However, PSC 128 does not consider background or ambient noise levels as some states do by setting their noise limit at 5 or 10 dB(A) over ambient, even though rural areas in Wisconsin where wind turbines are sited typically have nighttime ambient noise levels near 30dB(A).

The NARUC report also recommends that a clear monitoring, arbitration, and mitigation process be implemented to deal with resident complaints. Wisconsin's regulations are very lacking in this regard. While scores of Wisconsin residential complaints have been reported and logged by the PSC, the follow-up has generally been by phone calls. We are unaware of any official monitoring, in-field measurements, arbitration, or verified mitigation of any of the complaints. The NARUC report elaborates further that it is important for wind project developers and local officials who are approving the projects to have a transparent complaint review process that explicitly defines protocols for noise monitoring and mitigation. Wisconsin's wind siting laws forbid this, as any monitoring or mitigation requirements imposed by local jurisdictions would be stricter than the rigid framework that the current rules allow. PSC 128 does not require any noise monitoring, and consequently, PSC staff has explained that when noise violation complaints are received there is usually nothing they can do because there is no concurrent monitoring data to verify the noise violation. Additionally, PSC 128's complaint review process fails to make clear that unresolved complaints can be appealed to the PSC and how complainants are to make such an appeal. Finally, lacking any penalties for violations, PSC 128 provides no compliance incentive.

Accompanying greater experience with ever-larger wind turbines, the Council minority has observed a regulatory trend to create greater setbacks and lower noise limits as well as basing these limits on *property lines* rather than residence locations, even while Wisconsin continues to maintain 1250 feet or 3.1 times the total height, whichever is less, as the maximum allowable setback from a non-participant's *home*. States are beginning to learn the health impact lessons already learned in European countries and are slowly beginning to make necessary policy changes to protect public health.

Because the setbacks in Wisconsin are set from turbine to occupied structure, some property owners find that their buildable land is now within the 1250-foot setback, and they are no longer able to use their own property the way they wish due to health and safety concerns. This constitutes a "taking" of the non-participating landowners' property, and there is no protection from this scenario in Wisconsin's regulations. Regulations should protect non-participating property owners from being forced to place structures too close to wind turbines on adjacent properties, as the state of Ohio did in 2014 by now measuring their setback from the property line instead of from the residence.

Besides the setback from non-participating residences, PSC 128 limits the setback from participating residences and road right-of-ways of 1.1 times the turbine's total height to protect host or participating property owners from ice or turbine blade failure debris. This setback is

inadequate. A review of actual incident reports of ice and debris throw indicates that a setback of at least 1.5 times should be a minimum. Engineering calculations have shown the possibility of broken turbine blades flying even much farther. The Council minority recommends that this minimum setback be established at 1.5 times the total height, not a maximum of 1.1 times to provide a logical distance and to allow for larger setbacks when circumstances require such.

Both Watson et al. (2012) and the NARUC report emphasize that a "one size fits all" setback standard is inappropriate. Watson et. al. describes competing interests between wind developers and local populations as a reason to vary the setback distances. The NARUC report recommends having setbacks that would meet necessary noise and shadow flicker restrictions, arguing that avoiding actual impacts on residents is of primary importance, rather than imposing what may be an arbitrary distance.

The NARUC report recommends establishing clear triggers for decommissioning, in addition to requiring wind energy system owners to have an escrow account to cover decommissioning costs. PSC 128 does not require an escrow account for decommissioning, but rather allows the wind developer to choose from a variety of less secure financial instruments or an escrow account.

It is very significant that the review revealed that the population density, in general, is higher in Wisconsin towns where wind projects are located than in towns where wind projects are located in all of Wisconsin's neighboring states. This should support the assertion that greater protections be provided to the people who are living near these Wisconsin developments, as more people are being impacted due to the higher population density and the consequent practice of locating wind turbines closer to non-participating residences.

4.2 Conclusion for the Policy Review section

The Wind Siting Council's majority members wrote in their conclusion to the Policy Review section nothing about the above discrepancies between Wisconsin's wind siting laws and the NARUC recommendations, but instead wrote: "…Wisconsin should continue to provide a transparent regulatory and approval process for wind developers…"

The Council minority concludes instead that Wisconsin's wind siting laws fall far short of the best practices that are recommended in the United States and falls even farther short of the best practices that are being implemented in other countries that have broader experience with wind energy than we do.

5.0 Minority Conclusion

The Council minority concludes that Wisconsin's wind siting laws are not written to meet current standards or best practices to protect public health and safety, but instead are biased to favor wind project developers.

This bias is cemented by the statutory structure of the Wind Siting Council, seating several members who are linked either to the wind energy industry or to environmentalist groups that favor the green energy movement, leaving only a few members on the Council who aren't linked to those influences. This construct leaves the Legislature to be poorly advised by a biased Council majority.

This Council minority also asserts that PSC staff seems to also be biased toward the wind industry and PSC staff tended to downplay any dissenting reports that reflected poorly on Wisconsin's current wind siting laws. One reason for this seems to be that the PSC staff feels that the Legislature has given them a mandate to support wind and other renewables because of the statutory requirements for the Renewable Portfolio Standard (RPS) for utilities that are within the PSC's jurisdiction. The existence of the RPS creates a secondary status for health and safety.

It is important, both to the industry and residents, that residents have confidence in the wind siting laws of Wisconsin and that the laws are effective in protecting the health and safety of people who live near existing wind turbines. Effective laws help to reduce opposition to new projects.

6.0 Recommendations for Legislation:

Current Wisconsin law lacks an effective way for people who are suffering harm caused by existing wind turbines sited too close to their homes to seek effective mitigation or recourse. Wisconsin law needs to be changed to lay out a step-by-step complaint protocol with oversight by the PSC so wind turbine operators are held to the standards that are consistent with the standards and best practices highlighted in this Minority Report. PSC oversight is necessary to ensure accountability so complainants can expect resolution when a problem arises related to a nearby wind turbine.

It is important to change the current Wisconsin law that requires local officials to limit their protections for safety and health to the maximum allowed by PSC 128. Perhaps PSC 128 could become a model ordinance. Local officials should be able to meet their statutory obligation to protect the health and safety of the public and exceed limits of PSC 128 when such can be justified by qualified technical experts or licensed engineers. As studies reveal new standards and best practices or technology improves, officials should be able to require such to match the local conditions, such as geology, groundwater sensitivities, and population densities, or accommodate any unique specifications of the wind project to protect their residents.

Wisconsin law needs to change the local approval process for wind energy systems to allow local officials access to the PSC staff at no expense to the local unit of government. It is important to give local officials access to the same knowledge and experience that the PSC commissioners have when a wind siting application is considered. This assumes the legislature will clarify the PSC's role in protecting health and safety.

This Council minority strongly recommends acoustic and epidemiological studies be carried out, especially in Wisconsin where there are existing complaints of sleep disturbance, headaches, nausea, tinnitus, or much worse which appear to be related to existing wind energy systems. These studies should include measuring and analyzing the nature and effects of infrasound and low frequency noise (ILFN). If the studies find that negative health impacts are occurring when the wind turbines are operating within Wisconsin's current operation standards, a development moratorium should be enacted until the relationship between the wind turbine and the negative health impacts is fully understood. Until then, safe wind turbine siting standards are impossible to set. As the policy review highlighted, setbacks that avoid actual impacts on residents is of primary importance, rather than imposing what may be an arbitrary distance.

The legislature should develop a process to establish relief for those citizens who are verified to have been harmed by existing wind turbines in Wisconsin.

Wind turbine setbacks should also be set based on the distance of the turbine to a neighboring property line instead of the distance from the turbine to the structure of the neighbor's home. Wind projects with their multi-story heights and unique sound projections should follow the long-standing convention of measuring setbacks from property lines as with any other kind of structure or land use.

The statutory structure of the Wisconsin Wind Siting Council that creates the pro-wind bias within the Wind Siting Council must be changed through legislation. Also at issue are the statutory limits as to which studies and regulatory developments the Wind Siting Council may review when creating their report to the Legislature. Because of the bias and the limits in the document review to only include "peer-reviewed" studies, and regulatory review that is limited to only regulation changes from the United States, the Legislature gets a myopic view of the issues related to wind turbine siting.

This Council minority hopes this report and recommendations will help legislators create new wind siting laws that will restore confidence in Wisconsin's wind siting process.

Footnote 1 for Page 8

For example, the discussion of the favorable findings in the Katsaprakakis study left out the critical facts that the average distance from the 13 surveyed settlements to the small .5 MW turbines was over 4000' and the average noise level was only 32-36 dB(A). The majority report presents without qualification the obviously implausible findings of the Mroczek study - that respondents living nearest to wind turbines reported the highest quality of life while those living farthest away reported the opposite - but fails to mention the author's numerous qualifications regarding the probability that economic benefits were likely to be the largest factor affecting responses from participants, 48% of which were unemployed. The Taylor survey, which the majority report twice declares to be inapplicable to Wisconsin, considered 12 turbines averaging only **2** kw each (750 times smaller than a typical 1.5 MW Wisconsin turbine), yet included the article's findings in order to make the argument that reported adverse health effects are due primarily to negative attitudes toward wind turbines and not due to *real* health effects. The works by Crichton and Chapman, both advocates of the "it's all in your head hypothesis", are based on

seriously flawed designs. For example, Chapman, whose "study" is very widely criticized as "junk science" by many highly qualified experts, relied almost exclusively on complaint logs from wind project owners to reach his conclusions.

Bibliography for Minority Report

Bakker, R. H., Pedersen, E., van den Berg, G. P., Stewart, R. E., Lok, W., & Bouma, J. (2012). Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. *Science of the Total Environment*, *425*, 42-51.

Ellenbogen, J. M., Grace, S., Heiger-Bernays, W. J., Manwell, J. F., Mills, D. A., Sullivan, K. A., & Weisskopf, M. G. (2012). Wind turbine health impact study: Report of independent expert panel. *Massachusetts: Massachusetts Department of Public Health*.

Janssen, S. A., Vos, H., Eisses, A. R., & Pedersen, E. (2011). A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources. *The Journal of the Acoustical Society of America*, *130*(6), 3746-3753.

Krogh, C. M. (2011). Industrial wind turbine development and loss of social justice?. *Bulletin of Science, Technology & Society*, *31*(4), 321-333.

Nissenbaum, M. A., Aramini, J. J., & Hanning, C. D. (2012). Effects of industrial wind turbine noise on sleep and health. *Noise and Health*, *14*(60), 237.

Pedersen, E. (2011). Health aspects associated with wind turbine noise—Results from three field studies. *Noise Control Engineering Journal*, *59*(1), 47-53.

Ruotolo, F., Senese, V. P., Ruggiero, G., Maffei, L., Masullo, M., & Iachini, T. (2012). Individual reactions to a multisensory immersive virtual environment: the impact of a wind farm on individuals. *Cognitive processing*, *13*(1), 319-323.

Shepherd, D., & Billington, R. (2011). Mitigating the acoustic impacts of modern technologies acoustic, health, and psychosocial factors informing wind farm placement. *Bulletin of Science, Technology & Society*, *31*(5), 389-398.

Suter, A. H. (1991, November). Noise and its effects. In *Washington, DC: Administrative Conference of the United States*.

Taylor, J., Eastwick, C., Wilson, R., & Lawrence, C. (2013). The influence of negative oriented personality traits on the effects of wind turbine noise. *Personality and Individual Differences*, *54*(3), 338-343.

Walker, B., Hessler, G., Hessler, D., Rand, R., & Schomer, P.(2012, December 24). A cooperative measurement survey and analysis of low frequency and infrasound at the Shirley Wind Farm in Brown County, Wisconsin. Retrieved from: http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=178263.

Appendix G

Summary of National Wind Siting Policies of all Fifty States and the District of Columbia

This table was compiled by surveying relevant wind-energy policy sources[1] and should not be considered an authoritative or exhaustive review of all national wind policies. Below is a summary of states' policies relevant to rules that are mandated under Wis. Admin. Code ch. PSC 128 for wind projects with a generating capacity of 100 MW or less.[2]

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Alabama	None, State	None	None	None	None	None	None	None	None
Alaska	None, State	None	None	None	None	None	None	None	None
Arizona	None, Local	None	None	None	None	None	None	None	None
Arkansas	None, Local	None	None	None	None	None	None	None	None
California	Yes, Local	Siting decisions made at county level; State mandatory maximum standards for local regulation of wind	≤ 50 kW	60 dB(A) for small wind or existing maximum (whichever is lesser) at property line	50 kW or less: Maximum setback from property line can be no more than tower height, unless greater setback is needed to comply with applicable fire setback under state Public Resources Code	None	None	None	None

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Colorado	Yes, Local	No state wind law or guidelines; State noise law	None	55 dB(A) day, 50 dB(A) night from property line	None	None	None	None	None
Connecticut	Yes, State	Mandatory; Connecticut Siting Council issues permits	Consumer < 65 MW, Utility > 65 MW	55 dB(A) day, 45 dB(A) night at the property line	2.5 times turbine height for >65 MW projects; 1.5 times turbine height for <65 MW projects or manufacturers recommendation, whichever is greater	None	None	Not more than 30 hours per year	Submit a decommissioning plan
Delaware	Yes, Local	Mandatory	Wind energy systems installed at single-family homes	≤ 5 dB(A) over ambient, up to 60 dB(A) at the property line	1.0 times turbine height	None	None	None	None
Florida	None, State	None	None	None	None	None	None	None	None
Georgia	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting	None	55 dB(A) as measured at property line of non-	1.1 – 1.5 times turbine height, depending on capacity	1.5 – 2.5 times turbine height,	1.1 – 1.5 times turbine height, depending	Less than 30 hours per year	Submit a decommissioning plan

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
		requirements, however the state provides a model ordinance		participating landowner		depending on capacity	on capacity		
Hawaii	None, Local	None	None	Wind projects must comply with Hawaii Dept. of Health Ch. 46 Community Noise Control Rules. Maximum permissible sound levels in dB(A) vary with zoning districts.	None	None	None	None	None
Idaho	None, Local	None	None	None	None	None	None	None	None
Illinois	Yes, Local	Mandatory state limit on small wind setback; other decisions	None	Wind projects are required to comply with	1.1 times turbine height	None	None	None	None

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
		made at county level		Illinois' Pollution Control Board noise standards, approx. 45 dB(A) at property line.					
Indiana	None, Local	None	None	None	None	None	None	None	None
Iowa	Yes,* Both	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	≤ 100 kW	A level that will not elicit nuisance	1.25 times turbine height	None	1.25 times turbine height for public/utility rights-of-way	None	None
Kansas	None, Local	None	None	None	None	None	None	None	None
Kentucky	Yes,* State	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements,	> 20 kW	55 dB(A) limit at occupied buildings of non-	1.5 times turbine height	2.0 times height for turbines > 20 kW and < 100 kW, 2.5 times for	1.5 times turbine height for public rights-of-way	Less than 30 hours per year	Submit a decommissioning plan

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
		however the state provides a model ordinance		participating residences		turbines ≥ 100 kW			
Louisiana	None, Local	None	None	None	None	None	None	None	None
Maine	Yes,* State	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	All capacities, however most recommendations regard ≥ 100 kW	55 dB(A) day/45 dB(A) night limit within 500 feet of a sleeping quarters, 55 dB(A) for protected areas, 75 dB(A) at property lines, 5 dB(A) penalty for repeating sounds	1.5 times turbine height	None	1.5 times turbine height for public/utility rights-of-way	Facility must be designed to "avoid unreasonable adverse" effects	Submit a decommissioning plan
Maryland	Yes, State	Voluntary (siting guidelines for wildlife), PSC regulates projects over 70 MW	None	None	None	None	None	None	None

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Massachusetts	Yes,* State	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	≥ 600 kW	Not more than 10 dB(A) over ambient as measured at the property line of the facility or nearest inhabited buildings	1.5 times turbine height	3 times turbine height	1.5 times turbine height for public/utility rights-of-way	None	None
Michigan	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	None	≤ 55 dB(A) or 5 dB(A) over ambient at property line	1 times turbine height	None	1 times height for public rights-of-way	Describe mitigation	Submit a decommissioning plan
Minnesota	Yes,* State	Mandatory, unless county affirmatively assumes jurisdiction on projects 5 - 25 MW	> 5 MW	55 dB(A) day, 50 dB(A) night, using state noise standard	Wind access buffer requires 3 rotor diameters on secondary wind axis, 5 diameters on primary wind access, from	500 feet from dwelling and sufficiently far to meet	250 feet from road rights-of-way	None	Submit a decommissioning plan

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
					neighboring property, including public lands	noise standards			
Mississippi	None, State	None	None	None	None	None	None	None	None
Missouri	None, Local	None	None	None	None	None	None	None	None
Montana	None, Local	None	None	None	None	None	None	None	None
Nebraska	Yes, State	Mandatory decommissioning standard, all other siting guidelines are subject to local or county jurisdiction	None	None	None	None	None	None	Provide proof of available financial security for decommissio ning costs

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Nevada	Yes, Local	Local jurisdiction over siting requirements; State restricts unacceptable limits on siting unless restrictions are due to noise, setback, health effects, etc.	None	None	None	None	None	None	None
New Hampshire	Yes, State	Mandatory limits not to be exceeded by municipalities	> 100 kW	Maximum 55 dB(A) at property lines	1.5 times turbine height	None	None	None	None
New Jersey	Yes, Both	Mandatory; Utility scale turbines must be installed on contiguous parcels ≥ 20 acres; limits on community scale projects	None	Maximum 55 dB(A) at property lines for community turbines	1.5 times turbine height for community project	None	None	None	None
New Mexico	None, State	None	None	None	None	None	None	None	None

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
New York	Yes,* Local	Voluntary; except mandatory requirements for bat/bird surveys only, State regulation over 25 MW	None	55 dB(A) at property lines	1.5 times turbine height	None	None	None	None
North Carolina	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements	≥ 1 MW of turbine capacity within 0.5 miles between turbines	Maximum 55 dB(A) at occupied buildings	1.5 times turbine height	2.5 times turbine height	1.5 times turbine height to public rights-of-way	None	None
North Dakota	Yes, State	Mandatory for any wind project greater than 0.5 MW, smaller facilities regulated at local level	≥ 0.5 MW	50 dB(A) within 100 feet of inhabited residence or community building	1.1 times turbine height from property line of non-participating landowner, unless variance is granted.	None	1.1 times turbine height from inter/ state highway; same + 75 feet from county or town road centerline	None	None

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Ohio	Yes, State	Mandatory	≥ 5 MW	Model day/night levels and describe mitigation measures	1.1 times turbine height to wind farm property line and at least 1125 feet from tip of the turbine's nearest blade at ninety degrees to the nearest adjacent property line.	At least 1125 feet in horizontal distance from the tip of the turbine's nearest blade at ninety degrees to exterior of habitable, residential structure unless waived.	None	Model exposure and describe mitigation measures	None
Oklahoma	Yes, local	Mandatory decommissioning standard, all other siting guidelines are subject to local or county jurisdiction	None	None	None	None	None	None	After 15 years of operation, proof of financial security

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Oregon	Yes,* State	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	≥ 50 kW	36 dB(A) or 10 dB(A) over ambient	1.5 times turbine height	None	None	None	None
Pennsylvania	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	None	55 dB(A) at occupied buildings	1.1 times turbine height	5 times turbine height	1.1 times turbine height to public road	Owner should make a reasonable effort to minimize shadow flicker at residences	Submit a decommissioning plan and proof of financial security
Rhode Island	Yes,* State	Voluntary (recommendation – currently interim siting factors available)	Guidelines vary depending on size classification. Stated here are for >200	Individual noise study recommended. Recommended conformance with existing	1.5 times turbine height from all non-residential property lines	2 times height of turbine from residential property lines	1.25 to 1.5 times turbine height to rights-of-way	Communities to define amount, range of 3 to 30 hours per year provided.	None

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
			feet height or 100 kW generation	municipality noise ordinances.					
South Carolina	None, State	None	None	None	None	None	None	None	None
South Dakota	Yes,* Local	Voluntary, Counties are responsible for determining zoning/siting requirements, however the state provides a model ordinance	≥ 75 feet tall	≤ 55 dB(A) at occupied building	500 feet or 1.1 times turbine height, whichever is greater, unless easement has been obtained from adjoining property owner.	1,000 feet for non-participant landowner; 500 feet or 1.1 times turbine height for participant landowner, whichever is greater.	500 feet or 1.1 times turbine height to public right-of-way, whichever is greater	None	Submit a decommissioning plan and proof of financial security after 10 years of operation
Tennessee	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	> 20 kW	55 dB(A) limit at occupied buildings of non-participating residences	1.5 times turbine height	2.0 times height for turbines > 20 kW and < 100 kW, 2.5 times for turbines ≥ 100 kW	1.5 times turbine height for public rights-of-way	Less than 30 hours per year	Submit a decommissioning plan

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Texas	None, Local	None	None	None	None	None	None	None	None
Utah	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	None	Existing limits or 60 dB(A)	None	1.1 times turbine height	1.1 times turbine height to public/utility rights-of-way	None	None
Vermont	None, State	None	None	None	None	None	None	None	None
Virginia	Yes,* Local	Voluntary, Local jurisdictions are responsible for determining zoning/siting requirements, however the state provides a model ordinance	> 5 MW or 2 or more turbines	60 dB(A) at property line	1.1 times turbine height	1.1 times turbine height; 1.5 times turbine height for non-participating landowner	None	Reasonable effort to minimize disruption	Submit a decommissioning plan and provide proof of financial security

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
Washington	Yes, State	County jurisdiction, but projects can choose state Energy Facility Site Evaluation Council jurisdiction	None	State noise law, limits residential noise to 55 dB(A) day, 45 dB(A) night	None	None	None	None	None
Washington DC	None, PUC[5]	None	None	None	None	None	None	None	None
West Virginia	None, State	None	None	None	None	None	None	None	None
Wisconsin	Yes, Local[6]	Mandatory	Up to 100 MW	50 dB(A) Day, 45 dB(A) Night	1.1 times turbine height	Lessor of 1250 feet or 3.1 time height from nonparticipating residence	1.1 times turbine height from public/utility rights-of-way	No more than 30 hours per year, mitigation required if more than 20 hours per year	Maintain proof of financial security
Wyoming	Yes, State	Mandatory, Counties retain jurisdiction of siting requirements outside of	> 0.5 MW	None	1.1 times turbine height unless waived by landowners	1,000 feet or 5.5 times turbine heights, whichever is greater,	1.1 times turbine height to road, 5.5 times turbine	None	Submit a decommissioning plan

State	Relevant Policy, Primary Authority[3]	Mandatory or Voluntary[4]	Size	Noise	Property Setback	Residence Setback	Other Setbacks	Shadow Flicker	Decommissioning
		minimum setbacks defined by the state				unless waived by landowner	height (or minimum of 1000 feet) to "platted subdivisions", 1/2-mile to city limits		

***** State provides lesser jurisdictions with a model wind siting ordinance. The siting criteria in the model ordinances are recommendations and are not legally binding, unless otherwise noted.

[1] Sources include 1) Stanton (2012), 2) DSIRE: Database of State Incentives for Renewables & Efficiency, 3) internet searches regarding state policies and ordinances. Information is considered current up to 09/15/2014.

[2] PSC 128 also outlines rules on signal interference and stray voltage which are not addressed in this table. Wisconsin is the only state that has a policy for wind energy systems regarding stray voltage and one of only six states with policies regarding television or radio interference. Michigan's model, non-binding model ordinance recommends no siting that would cause signal interference, Oregon, New York, Virginia, and Pennsylvania recommend mitigation of interference and Wisconsin requires mitigation of interference.

[3] "Primary Authority" is taken directly from Stanton (2012).

[4] Note that some wind siting policies may be mandated by states (e.g., noise restrictions) while other policies may be regulated by local jurisdictions.

[5] Public Utility Commission

[6] May not be more restrictive than PSC 128.

Appendix H

Town of Newport, North Carolina, Adopted Ordinance on Property Protection

9-6.1(e) Real Property Value Protection Requirement

a. The WEF Owner (Applicant) or their successor shall assure The Town of Newport that there will be no loss in real property value due to the WEF.

b. To legally support this claim, the Applicant shall hereby consent to this Real Property Value Protection Agreement ("Agreement"). This Agreement provides assurance to nonparticipating real property owners near the WEF (not lessors to the Applicant), that they have some protections from real property values losses due to the WEF.

c. Applicant guarantees that the property values of all real property partially or fully within two (2) miles of the WEF, will not be adversely affected by the WEF. The two (2) miles shall be within the Newport Zoning and Planning Jurisdiction. Any real property owner(s) included in that area who believe that their property may have been devalued due to the WEF, may elect to exercise the following option:

d. All appraiser costs are paid by the Applicant, from the Escrow Account. Applicant and the property owner shall each select a licensed appraiser. Each appraiser shall provide a detailed written explanation of the reduction in value to the real property ("Diminution Value"), if any, caused by the proximity to the WEF. This shall be determined by calculating the difference between the current fair market value of the real property (assuming no WEF was proposed or constructed), and the fair market value at the time of exercising this option:

1. If the higher of the Diminution Valuations submitted is equal to or less than twenty five percent (25%) more than the other, the two values shall be averaged ("Average Diminution Value": ADV).

2. If one of the Diminution Valuations submitted is more than twenty five percent (25%)higher than the other, then the two appraisers will select a third licensed appraiser who shall present to Applicant and property owner a written appraisal report as to the Diminution Value for the real property. The parties agree that the resulting average of the two highest Diminution Valuations shall constitute the ADV.

3. In either case, the property owner may elect to receive payment from the WEF Owner of the ADV. Applicant is required to make this payment within sixty (60) days of receiving said written election from property owner, to have such payment made.

e. Other Agreement Conditions:

1. If a property owner wants to exercise this option, they must do so within ten (10) years of the WEF receiving final approval from the town.

2. A property owner may elect to exercise this option only once.

3. The applicant and the property owner may accept mutually agreeable modifications of this Agreement, however, the Applicant is not allowed to put other conditions on a financial settlement (e.g. confidentiality). If the property owner accepts some payment for property value loss, based on an alternative method, then that is considered an exercise of this option.

4. This Agreement applies to the property owner of record as of the first notification of intent to apply for a WEF permit by the Applicant to DENR, as required by HB-484, is not transferable to subsequent property owners.

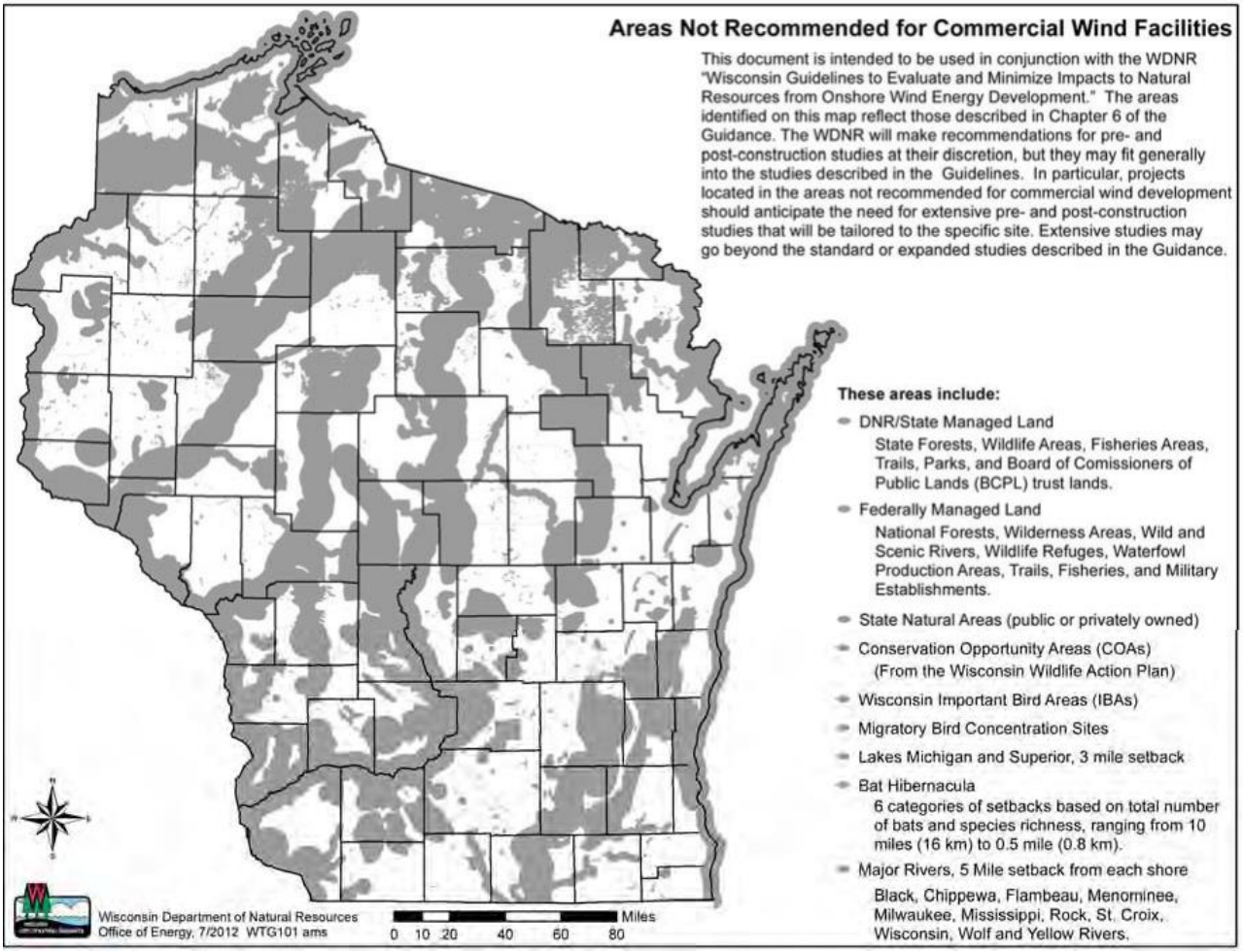
5. The property owner of record as of the first notification of intent to apply for a WEF permit by the Applicant to DENR, as required by HB-484, must reasonably maintain the property from that time, until they choose to elect this option.
6. The property owner must permit access to the property by the appraisers, as needed to perform the appraisals.
7. The property owner must inform the appraisers of all known defects of the property as may be required by law, as well as all consequential modifications or changes to the property subsequent to the first notification of intent to apply for a WEF permit by the Applicant to DENR, as required by HB-484.
8. This Agreement will be guaranteed by the Applicant (and all its successors and assigns), for ten (10) years following the WEF receiving final approval from the Town, by providing a bond (or other surety), in an amount determined to be acceptable by the Town.
9. Payment by the Applicant (per 9-6.1(e)d.3.) not made within sixty (60) days will accrue an interest penalty. This will be twelve (12) percent annually, from the date of the written election from property owner.
10. For any litigation regarding this matter, all reasonable legal fees and court costs will be paid by the Applicant.

Appendix I

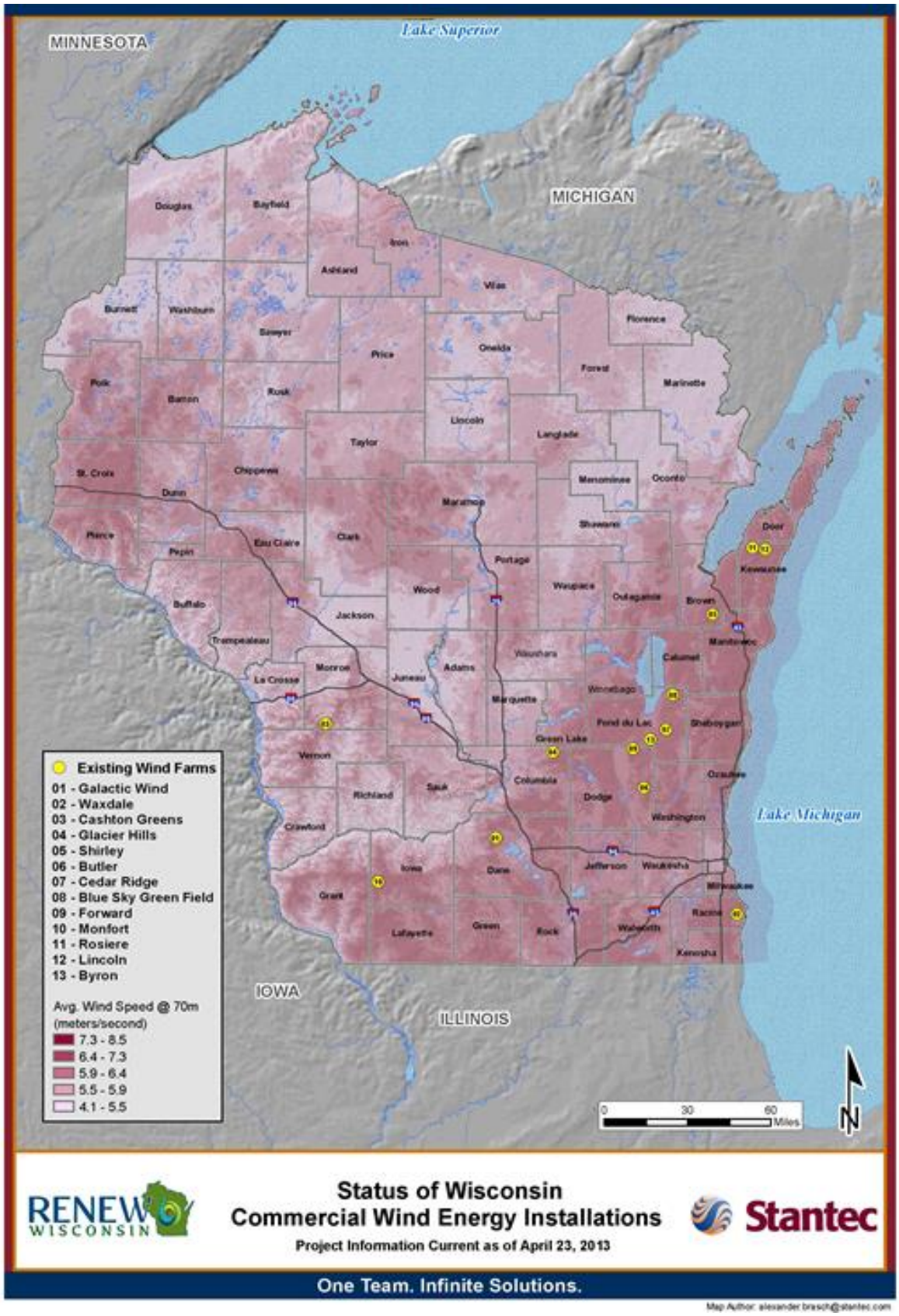
Guidance for Minimizing Impacts to Natural Resources from Terrestrial Commercial Wind Energy Development

The Wisconsin DNR has developed guidance to aid in the planning of commercial wind energy facilities. The guidance was developed to help wind project reviewers, planners and owners identify areas that are not suitable for wind development, address potential impacts, and prevent unwanted and avoidable conflicts with area or site-specific natural resource management objectives. This guidance is consistent with general guidance from the US Fish and Wildlife Service, but is guidance, and not a formal regulatory framework. The DNR does have regulatory authority over certain aspects of wind energy system development, including any wetland or waterway impacts, erosion control and protection of state-listed threatened or endangered species.

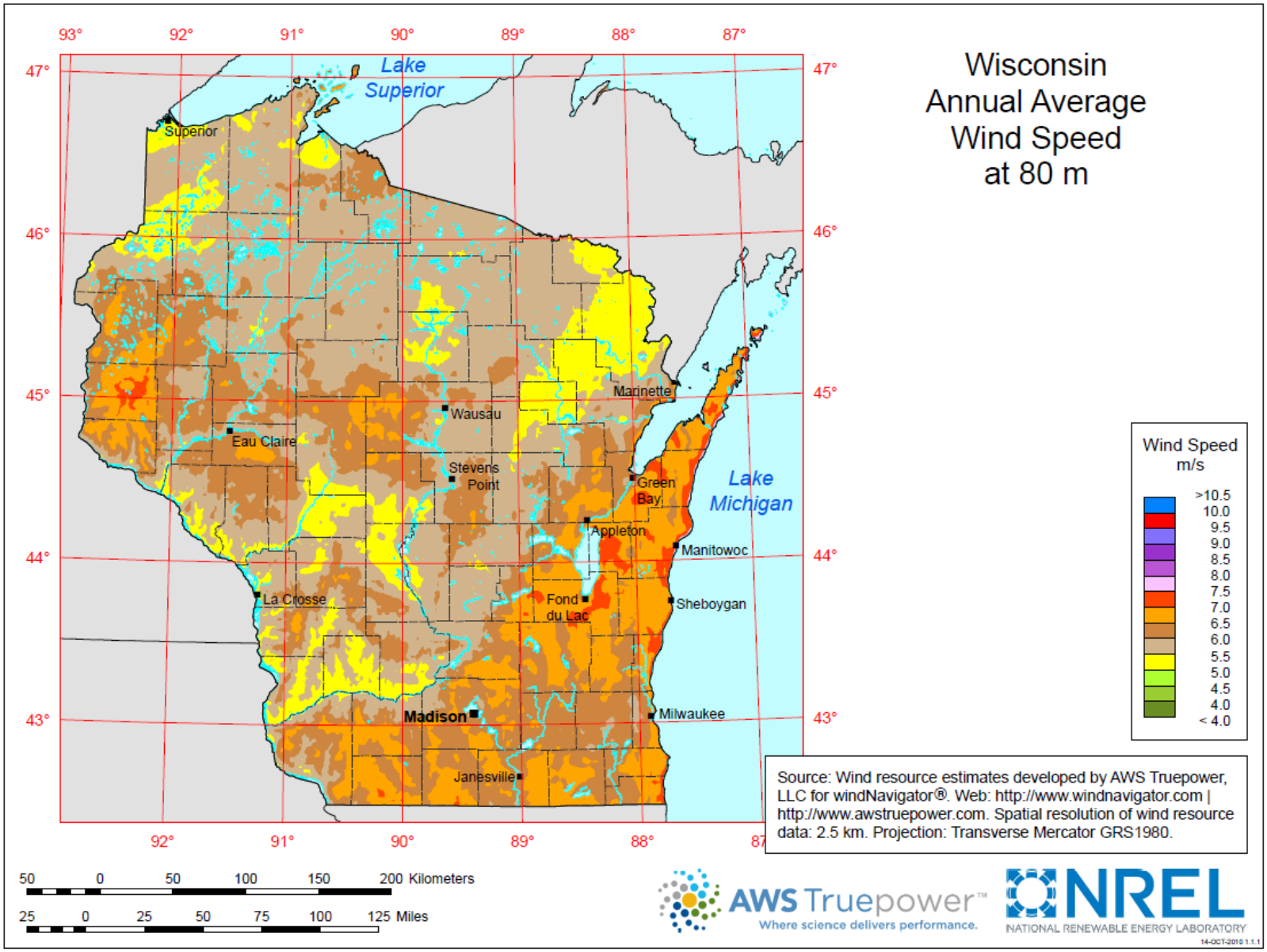
For the full guidance document, please visit the WI DNR website at:
http://dnr.wi.gov/topic/sectors/documents/energy/windguidelines.pdf



Appendix J: Map of Commercial Wind Energy Installations in Wisconsin 1998-2013



Appendix K: Map Showing Wisconsin Annual Average Wind Speed at 80 Meters



Appendix L: Population Densities in areas of Midwestern Wind Energy System Development

The purpose of this spreadsheet is to provide population density data, at the township level, for the major wind projects in operation in six Midwestern states: Wisconsin, Minnesota, Michigan, Illinois, Iowa, and Indiana. An effort was made to identify wind energy systems and their associated townships. Although wind project county locations are readily available, oftentimes township location data is not provided. In such cases, email inquiries were sent to county officials in the respective project location counties, requesting the names of the townships in which specific wind projects were located. Requests were sent to multiple officials in each county and included emails to county assessors, recorders, surveyors, engineers or GIS/mapping personnel, planning department supervisors, and county clerks.

Responses were gathered and compiled in this spreadsheet. In some cases, county officials provided additional wind project township information for projects not specifically requested. In those cases, those wind project names and townships were added to the spreadsheet. 2010 population density data was then gathered from the U.S. Census Bureau website and added to the spreadsheet. The population density data for both the counties and the townships where the listed wind projects were located within each state were each added together and divided by the number of counties or townships listed, respectively, to arrive at the average population per square mile for the counties and townships in each state. Where there were multiple wind energy systems in either a town or county, the values for those were not additionally summed for the average, but rather each added once to the calculation of the average. For states in the Upper Midwest, Wisconsin shows a comparatively higher population density at the county and township level in areas where there has been wind energy system development.

This approach is useful in allowing for a quick comparison of population densities at the county and town level, however, dense population centers within some counties or townships will influence the results and may create data outliers that are not accurate representations of the population density in the areas immediately surrounding wind energy systems. Other potential ways of comparing population densities around wind energy systems such as evaluating population density within a specified distance around each system, or assessing population density down to the square mile, present difficulties in obtaining the data needed for comparison.

Below is a summary table of the state comparison data, with a more detailed table that follows; showing the particular wind energy systems, counties, and towns that form the basis for the assessment.

State	Illinois	Indiana	Iowa	Michigan	Minnesota	Wisconsin
County Population Density per Sq.Mi. where Wind Energy Systems exist	84	105.8	21.8	101.5	27.1	163.2
Town Population Density per Sq. Mi. where Wind Energy Systems exist	28.5	24.3	11.3	30	7.6	35.1

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Big Sky Wind Farm	240	Illinois	Bureau	40.2	Ohio	21.6	CPH-2-15 p.15
Big Sky Wind Farm	240	Illinois	Bureau	40.2	Walnut	47.5	CPH-2-15 p.15
Big Sky Wind Farm	240	Illinois	Lee	49.7	East Grove	7.2	CPH-2-15 p.43
Big Sky Wind Farm	240	Illinois	Lee	49.7	May	8.6	CPH-2-15 p.43
Bishop Hill 1	200	Illinois	Henry	61.3	Weller	12.3	CPH-2-15 p. 32
Bishop Hill 1	200	Illinois	Henry	61.3	Cambridge	68.4	CPH-2-15 p. 32
Bishop Hill 1	200	Illinois	Henry	61.3	Galva	82.8	CPH-2-15 p. 32
Bishop Hill 1	200	Illinois	Henry	61.3	Burns	7.3	CPH-2-15 p. 32
Bishop Hill 1	200	Illinois	Henry	61.3	Clover	26.9	CPH-2-15 p. 32
Grand Ridge	210	Illinois	LaSalle	100.4	Grand Rapids	9.4	CPH-2-15 p. 42
Grand Ridge	210	Illinois	LaSalle	100.4	Brookfield	23.9	CPH-2-15 p. 41
Grand Ridge	210	Illinois	LaSalle	100.4	Otter Creek	82.9	CPH-2-15 p. 42
Lee-Dekalb Wind Energy Center	217.5	Illinois	DeKalb	166.6	Milan	9.4	CPH-2-15 p. 24
Lee-Dekalb Wind Energy Center	217.5	Illinois	DeKalb	166.6	Afton	24.5	CPH-2-15 p. 23
Lee-Dekalb Wind Energy Center	217.5	Illinois	DeKalb	166.6	Shabbona	42	CPH-2-15 p. 24
Lee-Dekalb Wind Energy Center	217.5	Illinois	DeKalb	166.6	Clinton	53	CPH-2-15 p. 23
Lee-Dekalb Wind Energy Center	217.5	Illinois	Lee	49.7	Alto	16.2	CPH-2-15 p. 43
Lee-Dekalb Wind Energy Center	217.5	Illinois	Lee	49.7	Willow Creek	19.6	CPH-2-15 p. 43
Minonk	200	Illinois	Woodford	73.3	Panola	9.7	CPH-2-15 p. 72

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Minonk	200	Illinois	Woodford	73.3	Minonk	62.6	CPH-2-15 p. 72
Minonk	200	Illinois	Livingston	37.3	Nebraska	39.3	CPH-2-15 p. 44
Minonk	200	Illinois	Livingston	37.3	Waldo	7	CPH-2-15 p. 44
Streator Cayuga Ridge South Wind Farm	300	Illinois	Livingston	37.3	Odell	35.4	CPH-2-15 p. 44
Streator Cayuga Ridge South Wind Farm	300	Illinois	Livingston	37.3	Union	6.8	CPH-2-15 p. 44
Streator Cayuga Ridge South Wind Farm	300	Illinois	Livingston	37.3	Saunemin	15.4	CPH-2-15 p. 44
Top Crop Wind Farm	300	Illinois	LaSalle	100.4	Grand Rapids	9.4	CPH-2-15 p. 42
Top Crop Wind Farm	300	Illinois	LaSalle	100.4	Brookfield	23.9	CPH-2-15 p. 41
Top Crop Wind Farm	300	Illinois	LaSalle	100.4	Otter Creek	82.9	CPH-2-15 p. 42
Twin Groves Wind Farms I & II	396	Illinois	McLean	143.3	Arrowsmith	13.9	CPH-2-15 p. 46
Twin Groves Wind Farms I & II	396	Illinois	McLean	143.3	Dawson	15.8	CPH-2-15 p. 46
Twin Groves Wind Farms I & II	396	Illinois	McLean	143.3	Cheney's Grove	27.3	CPH-2-15 p. 46
Average County Pop/Sq.Mi. (Illinois Projects)			**84**				
Average Township Pop/Sq.Mi. (Illinois Projects)			**28.5**				

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Benton County Wind Farm	130	Indiana	Benton	21.8	Richland	15.1	CPH-2-16 p. 14
Benton County Wind Farm	130	Indiana	Benton	21.8	York	6.6	CPH-2-16 p. 14

Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Bolivar	34.7	CPH-2-16 p. 14
Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Center	51.2	CPH-2-16 p. 14
Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Grant	29.4	CPH-2-16 p. 14
Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Hickory Grove	14.2	CPH-2-16 p. 14
Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Oak Grove	44.5	CPH-2-16 p. 14
Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Parish Grove	5.3	CPH-2-16 p. 14
Fowler Ridge (multiple phase)	600	Indiana	Benton	21.8	Union	7.1	CPH-2-16 p. 14
Hoosier	106	Indiana	Benton	21.8	Pine	9.3	CPH-2-16 p. 14
Hoosier	106	Indiana	Benton	21.8	Union	7.1	CPH-2-16 p. 14
Hoosier	106	Indiana	Benton	21.8	Gilboa	7	CPH-2-16 p. 14
Wildcat	200	Indiana	Madison	291.3	Duck Creek	22.9	CPH-2-16 p. 29
Wildcat	200	Indiana	Madison	291.3	Boone	21.9	CPH-2-16 p. 29
Wildcat	200	Indiana	Tipton	61.2	Madison	31.3	CPH-2-16 p. 39
Wildcat	200	Indiana	Tipton	61.2	Wildcat	40.8	CPH-2-16 p. 39
Meadow Lake (Phase I, II, III)	402	Indiana	White	48.8	Prairie	47.8	CPH-2-16 p. 43
Meadow Lake (Phase I, II, III)	402	Indiana	White	48.8	Big Creek	24.8	CPH-2-16 p. 43
Average County Pop/Sq.Mi. (Indiana Projects)			**105.8**				
Average Township Pop/Sq.Mi. (Indiana Projects)			**24.3**				

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Adair Wind Farm	174	Iowa	Cass	24.7	Massena	14.7	CPH-2-17 p. 19
Barton Wind Farm	160	Iowa	Worth	19	Barton	5.3	CPH-2-17 p. 58
Buena Vista (Storm Lake)	193	Iowa	Buena Vista	35.2	Maple Valley	6.3	CPH-2-17 p. 17
Century Wind Farm	200	Iowa	Hamilton	27.2	Blairsburg	10.3	CPH-2-17 p. 30
Century Wind Farm	200	Iowa	Wright	22.8	Wall Lake	3	CPH-2-17 p. 59
Century Wind Farm	200	Iowa	Wright	22.8	Vernon	2.9	CPH-2-17 p. 59
Crystal Lake Wind Farm	416	Iowa	Hancock	19.9	Crystal	12.4	CPH-2-17 p. 31
Crystal Lake Wind Farm	416	Iowa	Hancock	19.9	Bingham	12.1	CPH-2-17 p. 31
Crystal Lake Wind Farm	416	Iowa	Hancock	19.9	Orthel	6.2	CPH-2-17 p. 31
Crystal Lake Wind Farm	416	Iowa	Hancock	19.9	Britt	64.7	CPH-2-17 p. 31
Eclipse Wind Project	200	Iowa	Audubon	13.8	Audubon	5.3	CPH-2-17 p. 14
Eclipse Wind Project	200	Iowa	Guthrie	18.5	Grant	5.4	CPH-2-17 p. 30
Franklin County Wind Farm		Iowa	Franklin	18.4	Hamilton	4.3	CPH-2-17 p. 28
Franklin County Wind Farm		Iowa	Franklin	18.4	Oakland	5.9	CPH-2-17 p. 28
Franklin County Wind Farm		Iowa	Franklin	18.4	Lee	4.9	CPH-2-17 p. 28
Franklin County Wind Farm		Iowa	Franklin	18.4	Grant	9.2	CPH-2-17 p. 28
Gamesa Wind Farm		Iowa	Pocahontas	13	Colfax	4.4	CPH-2-17 p. 47
Gamesa Wind Farm		Iowa	Pocahontas	13	Bellville	9.7	CPH-2-17 p. 47
Gamesa Wind Farm		Iowa	Pocahontas	13	Lizard	5.5	CPH-2-17 p. 47
Garden Wind Farm		Iowa	Hardin	30.8	Sherman	20.5	CPH-2-17 p. 32
Garden Wind Farm		Iowa	Hardin	30.8	Concord	9.7	CPH-2-17 p. 31

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Garden Wind Farm		Iowa	Hardin	30.8	Grant	6.6	CPH-2-17 p. 32
Intrepid Wind Farm	160	Iowa	Buena Vista	35.2	Maple Valley	6.3	CPH-2-17 p. 17
Intrepid Wind Farm	160	Iowa	Sac	18	Cook	4.5	CPH-2-17 p. 50
Intrepid Wind Farm	160	Iowa	Sac	18	Eureka	26.1	CPH-2-17 p. 50
Morning Light Wind Project		Iowa	Adair	13.5	Summit	27.2	CPH-2-17 p. 13
Morning Light Wind Project		Iowa	Adair	13.5	Walnut	5	CPH-2-17 p. 13
Morning Light Wind Project		Iowa	Adair	13.5	Prussia	4.9	CPH-2-17 p. 13
Pioneer Prairie Wind Farm	293	Iowa	Howard	20.2	Oak Dale	6.5	CPH-2-17 p. 33
Pioneer Prairie Wind Farm	293	Iowa	Mitchell	23	Stacyville	24.3	CPH-2-17 p. 43
Pioneer Prairie Wind Farm	293	Iowa	Mitchell	23	Wayne	12.6	CPH-2-17 p. 43
Pomeroy Wind Farm	286	Iowa	Pocahontas	12.7	Cedar	21.2	CPH-2-17 p. 47
Pomeroy Wind Farm	286	Iowa	Pocahontas	12.7	Colfax	4.4	CPH-2-17 p. 47
Pomeroy Wind Farm	286	Iowa	Pocahontas	12.7	Grant	4.1	CPH-2-17 p. 47
Pomeroy Wind Farm	286	Iowa	Calhoun	17	Butler	24.5	CPH-2-17 p. 18
Rolling Hills Wind Project	444	Iowa	Adair	13.5	Jackson	9.7	CPH-2-17 p. 13
Rolling Hills Wind Project	444	Iowa	Adair	13.5	Washington	4.1	CPH-2-17 p. 13
Story County Wind Farm I & II	300	Iowa	Hardin	30.8	Sherman	20.5	CPH-2-17 p. 32
Story County Wind Farm I & II	300	Iowa	Hardin	30.8	Concord	9.7	CPH-2-17 p. 31
Story County Wind Farm I & II	300	Iowa	Hardin	30.8	Grant	6.6	CPH-2-17 p. 32
Top of Iowa (I,II,II)	190	Iowa	Worth	19	Brookfield	6.6	CPH-2-17 p. 58

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Top of Iowa (I,II,II)	190	Iowa	Worth	19	Danville	9.7	CPH-2-17 p. 58
Whispering Willow Wind Farm	200	Iowa	Franklin	18.4	Hamilton	4.3	CPH-2-17 p. 28
Whispering Willow Wind Farm	200	Iowa	Franklin	18.4	Reeve	7.4	CPH-2-17 p. 28
Whispering Willow Wind Farm	200	Iowa	Franklin	18.4	Lee	4.9	CPH-2-17 p. 28
Whispering Willow Wind Farm	200	Iowa	Franklin	18.4	Grant	9.2	CPH-2-17 p. 28
Average County Pop/Sq.Mi. (Iowa Projects)			**21.8**				
Average Township Pop/Sq.Mi. (Iowa Projects)			**11.3**				

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Beebe Wind Farm	82	Michigan	Gratiot	74.7	Emerson	27.8	CHP-2-24 p. 22
Beebe Wind Farm	82	Michigan	Gratiot	74.7	North Star	26	CHP-2-24 p. 23
Beebe Wind Farm	82	Michigan	Gratiot	74.7	Hamilton	13.4	CHP-2-24 p. 23
Garden Wind Farm	8	Michigan	Delta	31.7	Garden	4.7	CHP-2-24 p. 20
Gratiot Farms	213	Michigan	Gratiot	74.7	Lafayette	16.4	CHP-2-24 p. 23
Gratiot Farms	213	Michigan	Gratiot	74.7	Emerson	27.8	CHP-2-24 p. 22
Gratiot Farms	213	Michigan	Gratiot	74.7	North Star	26	CHP-2-24 p. 23
Lake Winds Energy Park	101	Michigan	Mason	58	Riverton	32.7	CHP-2-24 p. 32
Lake Winds Energy Park	101	Michigan	Mason	58	Summit	72.2	CHP-2-24 p. 32
Michigan Wind 2	90	Michigan	Sanilac	44.8	Minden	15.1	CHP-2-24 p. 42

Michigan Wind 2	90	Michigan	Sanilac	44.8	Bridgehampton	23.6	CHP-2-24 p. 41
Michigan Wind 2	90	Michigan	Sanilac	44.8	Delaware	18.4	CHP-2-24 p. 41
Michigan Wind 2	90	Michigan	Sanilac	44.8	Marion	46	CHP-2-24 p. 42
Pheasant Run Wind 1	75	Michigan	Huron	39.6	Brookfield	21.4	CHP-2-24 p. 24
Thumb Wind Park	34	Michigan	Sanilac	44.8	Delaware	18.4	CHP-2-24 p. 41
Thumb Wind Park	34	Michigan	Sanilac	44.8	Marion	46	CHP-2-24 p. 42
Thumb Wind Park	34	Michigan	Sanilac	44.8	Minden	15.1	CHP-2-24 p. 42
Tuscola Bay Wind	120	Michigan	Tuscola	69.4	Gilford	21.3	CHP-2-24 p. 43
Tuscola Bay Wind	120	Michigan	Tuscola	69.4	Akron	28.5	CHP-2-24 p. 42
Tuscola Bay Wind	120	Michigan	Bay	243.7	Merritt	45.5	CHP-2-24 p. 15
Tuscola Bay Wind	120	Michigan	Saginaw	250.2	Blumfield	55	CHP-2-24 p. 40
Wind project name and township data shown in the following eight line grouping for Huron County was received from a Huron County official, but the response did not itemize which of the provided projects were located in which of the provided townships, but only that these projects exist in Huron County and that they are located in the various townships listed. Therefore, the particular Huron County township listed in this grouping may not necessarily correspond to the particular Huron County wind project located on the same line in the table where the township is listed.							
		Michigan	Huron	39.6	Brookfield	21.4	CHP-2-24 p. 24
Big Turtle Wind	20	Michigan	Huron	39.6	Chandler	13.4	CHP-2-24 p. 24
Brookfield Wind Park	75	Michigan	Huron	39.6	Fairhaven	51.5	CHP-2-24 p. 24
Echo Wind Park	112	Michigan	Huron	39.6	Grant	25.8	CHP-2-24 p. 24
Pheasant Run 1	75	Michigan	Huron	39.6	McKinley	22.1	CHP-2-24 p. 24
Thumb Wind Park	76	Michigan	Huron	39.6	Oliver	42	CHP-2-24 p. 24
		Michigan	Huron	39.6	Sigel	13	CHP-2-24 p. 24
		Michigan	Huron	39.6	Winsor	54.1	CHP-2-24 p. 24
Average County Pop/Sq.Mi. (Michigan Projects)			**101.5**				
Average Township Pop/Sq.Mi. (Michigan projects)			**30**				

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Bent Tree Wind Farm	201	Minnesota	Freeborn	44.2	Manchester	11.9	CPH-2-25 p. 25
Bent Tree Wind Farm	201	Minnesota	Freeborn	44.2	Hartland	7.1	CPH-2-25 p. 25
Bent Tree Wind Farm	201	Minnesota	Freeborn	44.2	Bath	12.3	CPH-2-25 p. 25
Bent Tree Wind Farm	201	Minnesota	Freeborn	44.2	Freeborn	7.5	CPH-2-25 p. 25
Bent Tree Wind Farm	201	Minnesota	Freeborn	44.2	Bancroft	29.1	CPH-2-25 p. 25
Buffalo Ridge Wind Project	225	Minnesota	Lincoln	11	Lake Benton	7.3	CPH-2-25 p. 33
Buffalo Ridge Wind Project	225	Minnesota	Pipestone	20.6	Altona	3.6	CPH-2-25 p. 42
Buffalo Ridge Wind Project	225	Minnesota	Pipestone	20.6	Burke	6.1	CPH-2-25 p. 42
Buffalo Ridge Wind Project	225	Minnesota	Pipestone	20.6	Grange	5.6	CPH-2-25 p. 42
Buffalo Ridge Wind Project	225	Minnesota	Pipestone	20.6	Rock	5.1	CPH-2-25 p. 42
Elm Creek (I & II)	249	Minnesota	Jackson	14.6	Kimball	3.6	CPH-2-25 p. 29
Elm Creek (I & II)	249	Minnesota	Jackson	14.6	Enterprise	5.2	CPH-2-25 p. 29
Elm Creek (I & II)	249	Minnesota	Jackson	14.6	Wisconsin	6.6	CPH-2-25 p. 29
Elm Creek (I & II)	249	Minnesota	Martin	29.3	Elm Creek	5.4	CPH-2-25 p. 35
Elm Creek (I & II)	249	Minnesota	Martin	29.3	Cedar	6.4	CPH-2-25 p. 35
Fenton Wind Farm	206	Minnesota	Murray	12.4	Fenton	4.9	CPH-2-25 p. 38
Fenton Wind Farm	206	Minnesota	Murray	12.4	Moulton	5.8	CPH-2-25 p. 38
Fenton Wind Farm	206	Minnesota	Nobles	29.9	Wilmont	5.2	CPH-2-25 p. 39
Lakefield Wind Project	206	Minnesota	Jackson	14.6	Hunter	6.3	CPH-2-25 p. 29
Lakefield Wind Project	206	Minnesota	Jackson	14.6	Heron Lake	8.6	CPH-2-25 p. 29
Lakefield Wind Project	206	Minnesota	Jackson	14.6	Des Moines	7.5	CPH-2-25 p. 29

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Lakefield Wind Project	206	Minnesota	Jackson	14.6	Belmont	6.1	CPH-2-25 p. 29
Nobles Wind Farm	201	Minnesota	Nobles	29.9	Larkin	5.3	CPH-2-25 p. 39
Nobles Wind Farm	201	Minnesota	Nobles	29.9	Summit Lake	9	CPH-2-25 p. 39
Nobles Wind Farm	201	Minnesota	Nobles	29.9	Olney	5.8	CPH-2-25 p. 39
Nobles Wind Farm	201	Minnesota	Nobles	29.9	Dewald	7.1	CPH-2-25 p. 39
Wind project name and township data shown in the following three line grouping for Mower County was received from a Mower County official, but the response did not itemize which of the provided projects were located in which of the provided townships, but only that these projects exist in Mower County and that they are located in the various townships listed. Therefore, the particular Mower County township listed in this grouping may not necessarily correspond to the particular Mower County wind project located on the same line in the table where the township is listed.							
Mower County Wind		Minnesota	Mower	55.1	Clayton	4.4	CPH-2-25 p. 37
Prairie Star Wind		Minnesota	Mower	55.1	Frankford	12.4	CPH-2-25 p. 37
Adams Wind		Minnesota	Mower	55.1	Grand Meadow	8.6	CPH-2-25 p. 37
Average County Pop/Sq.Mi. (Minnesota Projects)			**27.1**				
Average Township Pop/Sq.Mi. (Minnesota Projects)			**7.6**				

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Blue Sky Green Field Wind Energy Center	145	Wisconsin	Fond du Lac	141.2	Marshfield	33.5	CPH-2-51 p. 23
Blue Sky Green Field Wind Energy Center	145	Wisconsin	Fond du Lac	141.2	Calumet	48.8	CPH-2-51 p. 22
Glacier Hills Wind Park	162	Wisconsin	Columbia	74.2	Randolph	22	CPH-2-51 p. 19
Glacier Hills Wind Park	162	Wisconsin	Columbia	74.2	Scott	25.4	CPH-2-51 p. 19
Forward Energy	129	Wisconsin	Dodge	101.4	Leroy	27.7	CPH-2-51 p. 20

Wind Project	MW Capacity	State	County	Pop/Sq.Mi.	Township	Pop/Sq.Mi.	Census Reference
Forward Energy	129	Wisconsin	Dodge	101.4	Lomira	33.3	CPH-2-51 p. 20
Forward Energy	129	Wisconsin	Fond du Lac	141.2	Byron	44.9	CPH-2-51 p. 22
Forward Energy	129	Wisconsin	Fond du Lac	141.2	Oakfield	19.8	CPH-2-51 p. 23
Cedar Ridge	68	Wisconsin	Fond du Lac	141.2	Eden	28.7	CPH-2-51 p. 23
Cedar Ridge	69	Wisconsin	Fond du Lac	141.2	Empire	97.3	CPH-2-51 p. 23
Butler Ridge	54	Wisconsin	Dodge	101.4	Herman	30.5	CPH-2-51 p. 20
Shirley Wind	20	Wisconsin	Brown	468.2	Glenmore	34.6	CPH-2-51 p. 16
Monfort Wind Farm	30	Wisconsin	Iowa	31.1	Eden	10.1	CPH-2-51 p. 25
Average County Pop/Sq.Mi. (Wisconsin Projects)			**163.2**				
Average Township Pop/Sq.Mi. (Wisconsin projects)			**35.1**				