



Wind Farm Noise and Health: Lay summary of new research released in 2011

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In February of this year, I wrote a column for Renewable Energy World¹ that addressed the recent increase in claims that wind farms are causing negative health effects among nearby neighbors. The column suggested that while many of the symptoms being reported are clearly related to the presence of the turbines and their noise, the relationship between wind farms and health effects may most often (though not always) be an indirect one, as many of the symptoms cropping up are ones that are widely triggered by chronic stress. In recent months, the dialogue around these issues has hardened, with both sides seemingly intent on painting the question in simple black and white—community groups assert that turbines "are making" people sick, while government and industry reports insist that there's "no evidence" that turbines can or do make people sick. The gulf between the conclusions of formal health impact studies and the experiences of some neighbors has widened to the point that both sides consider the other to be inherently fraudulent. I suggested that the rigidity of both sides' approach to this subtle and complex issue is likely increasing the stress and anxiety within wind farms communities that may in fact be the actual primary trigger for health reactions.

Here, I'll expand on that shorter column by taking a closer look at the few surveys and studies that have attempted to directly assess the prevalence of health effects around wind farms.

Even as the public becomes increasingly concerned about health effects, with a lot of focus on the role of inaudible infrasound, it's been striking to me to that the researchers investigating health effects – even clearly sympathetic researchers – are not talking about infrasound much at all, and are instead focusing on stress-related symptoms. Drawing from studies done in areas where health concerns have been most widely reported, we'll see that while some types of health problems may be more common near

¹ See www.renewableenergyworld.com/rea/u/AcousticEcologyInstitute/articles

wind farms, most of the studies find little difference in overall health based on proximity to turbines.

And, where health effects are reported (primarily sleep disruption and stress-related symptoms), those who have been most diligent and open in assessing community responses estimate that health problems (whether direct or indirect) appear to crop up in no more than 5-15% of those living nearest; this is a surprisingly small number, considering the central role health effects has taken in the public perception and debate about new wind farms. While we shouldn't discount the impact on these people, it appears that fears of widespread health impacts may be misplaced. Though impacts on even a few, whether direct or indirect, are certainly a valid consideration in making wind farm siting decisions, it's helpful to have a clearer picture of how widespread the issue may be.

Just last week, a news report² about a public presentation by Carmen Krogh of Ontario's Society for Wind Vigilance, one of the major voices in the health-effects debate, starkly illustrated the disconnect between public fear and the message actually coming from the voices of caution. I was struck to see that even as "the main concern" of the audience was the invisible dangers of infrasound and stray voltage, Krogh "focused on the stress affects of exposure and clinical annoyance. 'We find that the number one complaint that people come forward with is sleep disturbance,' she explained to the crowd." While including the audience's concerns in her assessment of five contributing factors, "Out of the five causes, Krogh focused on amplitude modulation (or the "swooshing" sounds) and audible low frequency..." As you'll read here, this is no anomaly; nearly all the sympathetic experts have a similarly grounded focus on audible noise, sleep disruption, and stress. While some researchers continue to investigate questions around infrasound levels and perception³, the public focus on infrasound as a primary or central contributor to reported health issues is not reflected in the actual findings of those studying the issues most diligently.

With this in mind, I hope that this detailed look at recent papers on health effects near wind farms will help to clarify the scope of the issue, and to provide useful context for decision-makers who are struggling to make sense of the complex and contradictory information that advocates on both sides of the issue present to them.

Investigating the health questions

Increasing public concern about health impacts has spurred a **slew of reports over the**

² See <http://www.shorelinebeacon.com/ArticleDisplay.aspx?e=3515675>

³ For more on this, see AEI's recent overview of research on low frequency noise and infrasound at <http://aeinews.org/archives/1711> The most interesting work is looking at rapid pulsing of low frequency and infrasonic sound, and the question of whether they be more perceptible than human perception curves generated using pure tones may suggest.

last three years from government entities and industry trade associations. Most of the official health impact studies have actually been literature reviews of previous research on noise from many sources, and have focused on questions such as whether inaudible infrasound around wind farms is strong enough to cause a direct physical reaction in neighbors (and just in case you've been out of the loop: they universally find that it's not). I will not be summarizing these reports here; they've all been summarized previously by AEI⁴, and as just mentioned, they generally steer clear of attempting to assess actual reported health effects, preferring to stay in the presumably more objective realm of published studies relating to noise and health in general. To the degree that they include studies of on-the-ground responses to wind turbines, they tend to note that the early studies are limited by relatively small sample sizes, which is true. Still, **we need to start somewhere, and as in most inquiries, the first investigations will tend to be smaller and more tentative**. In any case, the omission of detailed analyses of these literature reviews should not be viewed as an attempt to skew the evidence presented here, since AEI has covered them in depth, affirming their value while also noting their limitations.

Meanwhile, a few acousticians and epidemiologists have **begun taking a look at what is occurring in communities where health impacts are being reported, and this paper will summarize the recent findings of these attempts to dig into actual community responses**. It should be noted that a few governmental entities, including the nation of Japan⁵ and the Province of Ontario⁶, have initiated larger scale studies that will likely provide more comprehensive and statistically robust results over the next few years. But for now, we do have several worthwhile papers that examine actual reported health effects that can begin to help us move beyond the current quagmire.

Not too surprisingly, we'll discover that what these researchers are finding contradicts both the "all is well" literature survey findings, as well as the fear that worst-case scenarios – being driven from homes by lack of sleep, headaches, kids struggling in school – are likely to occur. Rather, these studies take us beyond the cartoons of sunshine and disaster, and drop us right down into an uncomfortably murky zone in which the answers are no longer presented in easily-understood black and white, but rather in harder-to-decipher shades of grey.

The bottom line appears to be that this first wave of research, undertaken by relatively cautionary and empathetic researchers, is finding that just **a small proportion of nearby residents are reporting actual health impacts, though far more report degradation of the overall quality of life and sense of place**. These studies use a diverse range of approaches and criteria, so can't all be directly compared, or compiled to suggest global

⁴ See <http://aeinews.org/archives/584> (AWEA/CanWEA), <http://aeinews.org/archives/915> and <http://aeinews.org/archives/937> (Ontario MOE), <http://aeinews.org/archives/1750> (Oregon Health Authority), <http://aeinews.org/archives/1782> (Massachusetts)

⁵ See <http://aeinews.org/archives/644>

⁶ See <http://aeinews.org/archives/1862>

patterns, but each of them offers a clear window into particular communities' responses to wind farms in their vicinity. As noted earlier, while all of the papers reviewed here come from researchers with much interest in and empathy for reports from affected neighbors, none of them propose inaudible infrasound as a central factor in health effects; the first four papers all focus on stress and sleep factors, and the last two, while including infrasound in their discussions, focus mostly on other factors (one on pre-existing risk factors, and the other on pulses in the dBG level, which includes substantial audible low-frequency sound as well as infrasound).

Seeking a clear path through murky ground

In the face of the growing clamor about health impacts, taking a direct, clear look at these studies may help to local and state regulators to step out of the confusing cross-fire of opinions, and to focus on the task at hand: designing siting standards that reflect the local best sense of how to balance the potential local economic and national climate change benefits with the likelihood of a diminished rural quality of life for some local citizens, and possible or likely health effects for a few. **There is no one "right answer" to these questions**, though wind promoters will suggest we must accept that we can't expect everyone to be happy, and wind opponents will say that any new illness is one too many. Both have a point, and some towns will set standards that allow relatively close siting in the name of money for local schools or other priorities, while others will establish large setbacks that effectively keep wind development away. Meanwhile, **many towns or counties will aim to find a middle ground that tries to minimize impacts while leaving some avenues for development to occur, either at a moderately greater distance or by encouraging or requiring developers to make agreements with neighbors before building**.

I think it's important to preface our consideration of these studies by acknowledging a key factor that has hampered the ability of some within both the public and the industry to clearly address the possibility that neighbors have experienced legitimate changes in their health, whether by direct or indirect means. Many of those most vehemently stressing the *potential* for health impacts in areas where wind farms are proposed are fundamentally anti-wind, anti-renewables, and anti-government incentives; health impacts are but one of a litany of arguments they make against new wind farms, and many simply dismiss all their claims as distorted rhetoric. This can too often **blind us to the fact that nearly all of the individuals who are telling us about their *actual* health impacts have no dog in the energy-policy fight**; their personal stories are often compelling and sober accounts of struggling with unexpected and disabling sleep issues, disorientation, and mood disorders. In my work with the Acoustic Ecology Institute, and in the papers that follow, the focus is on better understanding what's going on with those reporting health effects around existing wind farms, rather than on the fears and opposition being raised in places where wind farms have yet to be built.

Alright then, let's dive in. The approach here will be similar to the one I took in AEI's late 2011 summary of ten papers on low frequency noise⁷; I'll address one paper at a time, while pointing out connections and contradictions between them. We'll be looking closely at the following seven publications, in addition to referring to several others in the final sections of this post⁸:

Carl V. Phillips. Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Nearby Residents. *Bulletin of Science Technology & Society* 2011 31: 303 DOI: 10.1177/0270467611412554

Daniel Shepherd et al. Evaluating the impact of wind turbine noise on health-related quality of life. *Noise & Health*, September-October 2011, 13:54,333-9.

Daniel Shepherd, Witness Statement, Ontario MOE Environmental Review Tribunal, January 19, 2011.

Michael Nissenbaum, Jeff Aramini, Chris Hanning. Adverse health effects of industrial wind turbines: a preliminary report. 10th International Congress on Noise as a Public Health Problem (ICBEN) 2011, London, UK.

Bob Thorne (Noise Measurement Services). *Wind Farm Noise Guidelines*, 2011.

Nina Pierpont. *Wind Turbine Syndrome: A Report on a Natural Experiment*. 2009.
Nina Pierpont. Presentation to the Hammond (NY) Wind Committee, July 2010

Stephen E. Ambrose, Robert W. Rand. The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse health effects produced by large industrial wind turbines confirmed. December 14, 2011.

The famous “Overwhelming evidence (of) serious health problems” paper

Carl V. Phillips. Properly Interpreting the Epidemiologic Evidence About the Health Effects of Industrial Wind Turbines on Nearby Residents. *Bulletin of Science Technology & Society* 2011 31: 303 DOI: 10.1177/0270467611412554
The online version of this article can be purchased at:
<http://bst.sagepub.com/content/31/4/303>

This paper is one of the "crown jewels" for community activists who have raised health impacts into prominence in the public policy debate over wind farm siting. Phillips' paper was one of several on wind farm siting policy published last summer in the *Bulletin of Science, Technology, and Society*, thus breaking through the invisible, and

⁷ <http://aeinews.org/archives/1711>

⁸ Many of these papers can be downloaded from AEI's wind noise resource page at <http://aeinews.org/archives/category/wind-turbines>

(as Phillips himself points out) somewhat illusory, threshold of appearing in a "peer-reviewed journal."⁹ Most of the paper is devoted to detailed epidemiological critiques of the arguments that deny the validity of any evidence of health effects among wind farm neighbors; much of this material is effective and well worth taking into consideration, though some of it is less sharp or relevant, and at times, rather vitriolic. But this paper's claim to fame is its oft-quoted opening phrase: "There is overwhelming evidence that large electricity-generating wind turbines cause serious health problems in a nontrivial fraction of residents living near them." That phrase, touted as published in a peer-reviewed journal, shows up as Exhibit A in more than a few letters to the editor in towns considering wind farm proposals.

Yet, while the paper does make a strong case for disregarding easy dismissals of the problem, it does not provide any concrete data to suggest just how widespread health impacts actually are. The closest it comes to quantifying is to note, "Since several research groups and nongovernmental organizations have collections (of reported health effects, or "adverse event reports"¹⁰ that number in the three-figure range, it seems safe to conclude that the total number published or collected in some form is in the four-figure range, and it is quite conceivable that the total numbers of adverse event reports are in five figures." I would probably grant him that there may well be over a thousand clear reports of health impacts worldwide at this point; the very existence of so many people making such reports can justifiably be considered reason enough to dig deeper and find out what's going on. Yet this doesn't get us any closer to assessing whether these impacts are rare, or common; even his conceived-of 10,000 such reports would represent a small proportion of residents living within a mile or so of today's several thousand large wind farms worldwide.

But those who hold up Phillips' paper as clear published evidence of the vast scope of an insidious hidden health risk (most commonly tied in public imagination to

⁹ Setting aside for the sake of celebration the fact that within the scientific community, the 20,000+ refereed or peer-reviewed journals represent a spectrum of reputation and quality that might be compared the spectrum within culinary arts, from chefs whose work is respected in kitchens around the world, to a local Denny's, both of which can boast of passing their local health inspections; still, wind proponents had harped on the lack of peer-reviewed input from the cautionary perspective, despite the fact that most of their "conclusive" reports were also white papers published outside the peer-reviewed journal process, so this became a big deal.

¹⁰ To those who may consider unsolicited reports of problems to be meaningless "self-selection," Phillips says: "In cases of emerging and unpredictable disease risk, adverse event reports are the cornerstone of public health research. Since it is obviously not possible to study every possible exposure-disease combination using more formalized study methods, just in case an association is stumbled on, collecting reports of disease cases apparently attributable to a particular exposure is the critical first step. The most familiar examples of hazards revealed by adverse event reporting are infectious disease outbreaks or side effects from pharmaceuticals, but the case of turbines and health also fits the pattern. Pharmaceutical regulators rely heavily on clearinghouses they create for adverse event reporting about drug side effects (and often become actively concerned and even implement policy interventions based on tens of reports). The WindVOiCe report collection is an example of this same well-accepted kind of active-recruiting data collection system."

physiological reactions to inaudible infrasound) conveniently **overlook the second sentence in his paper, the one following his incendiary opening salvo: "...many people living near them have reported a collection of health effects that appear to be manifestations of a chronic stress reaction or something similar."**

Indeed, Phillips goes even further in this direction, in a critique of the claim that health effects should be dismissed because they are "subjective" responses. He notes that such arguments "seem to be confusing 'subjective' with 'psychologically mediated,' which most of the observed effects might well be (though there are hypotheses about nonpsychological pathways)."

Phillips then offers **his most valuable contributions to this discussion: "Being subjective or psychologically mediated does not mean that these effects are minor or less real.** Indeed, there is a case to be made that such diseases (i.e. psychologically-mediated ones), which include everything from transient headaches to chronic pain and depression, account for the majority of the total burden of disease in our society."

On a similar note, Phillips stresses that the lack of an officially recognized labeled disease (ala "wind turbine syndrome") should not be reason to discount the health effects being reported: "...the individual diseases people are suffering from, such as chronic stress and sleep disorders, are often well defined (they are just not defined in terms of a specific cause)....There is no epistemic significance to the health outcomes in question having or not having a label."

And, he also points out, convincingly, that while not everyone who hears turbines gets sick, those who do get sick uniformly report some sensory experience of the turbines that's clearly not imaginary (*ed. note: and, being sensed, are thus apparently not related to inaudible infrasound*), and further, that:

"It is, of course, possible that some personal characteristic sensitizes them to be more bothered by the sensory effects, increasing the psychologically-mediated effects. But **it is inevitable that some personal characteristics will be causal cofactors (factors that, along with the turbine, are part of the necessary constellation of causes for there to be a disease effect). This is true for every exposure-disease combination:** Some exposed people get the disease and some do not, and sometimes we can identify other differences between the two groups."

While this paper makes no attempt to quantify just what the asserted "nontrivial fraction of residents" who experience health effects may be, Phillips did offer an estimate during a presentation to the Lee County (IL) Zoning Board of Appeals in late 2011¹¹. When asked what percentage of residents report health problems, he told the Board that there have not been solid studies of that, but that **his best guess, based on what research has**

¹¹ See <http://aeinews.org/archives/1591>

been done, is about 5 percent of those within a mile or so, with some reports of health effects out to two miles.

While this low estimate may surprise some, we'll see that other cautionary researchers also come to generally similar conclusions (estimates range from 5-15% of those close enough to hear turbines regularly). This more dramatically affected (and indeed non-trivial) minority may be those who are more sensitive in some way – to sound, air pressure fluctuations, or annoyance-induced stress. These relatively low percentages may also remind us of the need to separate the equally important, and more widespread, impacts on quality of life and sense of place from the more dramatic but apparently less widespread question of acute or chronic health impacts.

Health Related Quality of Life (HRQOL) Survey in New Zealand

Daniel Shepherd et al. Evaluating the impact of wind turbine noise on health-related quality of life. *Noise & Health*, September-October 2011, 13:54,333-9.

Daniel Shepherd, Witness Statement, Ontario MOE Environmental Review Tribunal, January 19, 2011.

Our second paper offers an interesting contrast and complement to the first – a contrast in that it's a rigorous field research project, and a complement in that it highlights the quality of life element that plays such a big factor in community responses to wind farms. A team researchers from New Zealand led by Daniel Shepherd conducted a comprehensive survey of residents living within 2km of a wind farm in the Makara Valley, just west of Wellington, with a comparison group of residents at least 8km from any wind farm. The survey was given a generic title, and included no questions specifically asking about wind turbines, in order to mask its intent to compare health-related quality of life (HRQOL) in two areas where the only substantial difference was the presence or absence of turbines.

The study utilized a well-known protocol, the health-related quality of life survey, which uses a series of questions to rate HRQOL in Physical, Psychological, and Social domains, while also assessing many specific sub-factors that contribute to these three main overall HRQOL scores; additional sections addressed general health, Environmental quality of life, neighborhood amenity, and annoyance. The authors note that "A variety of outcome measures have been proposed to assess the impacts of community noise, including annoyance, sleep disturbance, cardiovascular disease, and cortisol levels," and that the World Health Organization "recommends the use of HRQOL measures as an outcome variable, arguing that the effects of noise are strongest for those outcomes classified under HRQOL rather than illness."

The local wind farm consisted of 66 turbines running along a ridgeline, with homes

mostly in the bottomland of the river valley below; as in many locations, field measurements indicate that the turbines are generally compliant with their consent conditions, but complaints have been widespread nonetheless.

One of the most striking findings in this study was that **23 of the 39 respondents in the group living within 2km of turbines (59%) wrote in a comment that turbines were a noise source that bothered them, and rated it as extremely annoying**, with a mean of 4.5 on a 5-point scale (the noise annoyance questions included only two noise sources, traffic and neighbors, with a space to specify an "other" source if they chose; **no "other" source besides turbines spurred notation by more than 3 people**). Also of note is that "scrutiny of the comments provided by the turbine group revealed no mention of the impact of turbines on the landscape, reinforcing suggestions made by other (researchers), that wind farm noise is more dominant than their visual aspects."

The HRQOL ratings that showed the strongest impacts among the turbine group were reductions in Physical quality of life (with sub-factors of **sleep quality and energy level being the primary contributors**), as well as Environmental quality of life. There was **no statistical difference between the groups in Social or Psychological quality of life, or – notably – in the self-rated general health scores**; this lack of a difference in average self-reported health is replicated in some of the other surveys we'll address here.

It's worth noting that these are overall averages; the data as presented does not clarify whether an increased proportion of individuals (even just, say, 10-15%) closer to turbine reported lower health ratings, while the overall average remained relatively unchanged. In both this study and the one that follows, researchers chose to use standard, widely-recognized health-related rating systems, rather than to detail specific complaints. This may allow the moderate sample sizes to be assessed in ways that are less prone to distortions by a few individuals, while also having the benefit of matching well-established protocols.

In this study, **the most dramatic difference was in the separately-assessed Amenity score, where the turbine group scored dramatically lower** (this is where the very high annoyance at turbine noise factored in, in stark contrast to finding no differences between the two groups in annoyance at other noise sources). Amenity is a term used in environmental planning in Australia and New Zealand, which correlates closely with what we would tend to call "sense of place," relationship with home and landscape, or perhaps overall quality of life. Those living near turbines reported much lower overall Amenity scores, indicating a substantial decrease in rural quality of life.

The authors also note a strong correlation between self-reported noise sensitivity and annoyance in response to the turbines in that group. In the paper we'll briefly discuss next, Shepherd stresses this factor, suggesting that rural areas attract a higher proportion of noise-sensitive individuals, and that this should be factored into permit conditions.

In conclusion, the authors of this paper suggest (based largely on the high levels of annoyance, decreased sleep quality/energy level, and reduced amenity) that "night-time wind turbine noise limits should be set conservatively to minimize harm," and that "setback distances need to be greater than 2km in hilly terrain."

We'll turn briefly now to another contribution from Daniel Shepherd, a statement submitted to a 2011 Environmental Review Tribunal considering an appeal to the permits issued to a wind farm in Ontario.

Here, Shepherd repeats from the above paper a constructive contribution to the discussion: a flow chart illustrating the complex pathways by which wind turbine noise can lead to "primary health effects" of annoyance and sleep disturbance, and on to "secondary health effects" of quality of life and stress-related disease:

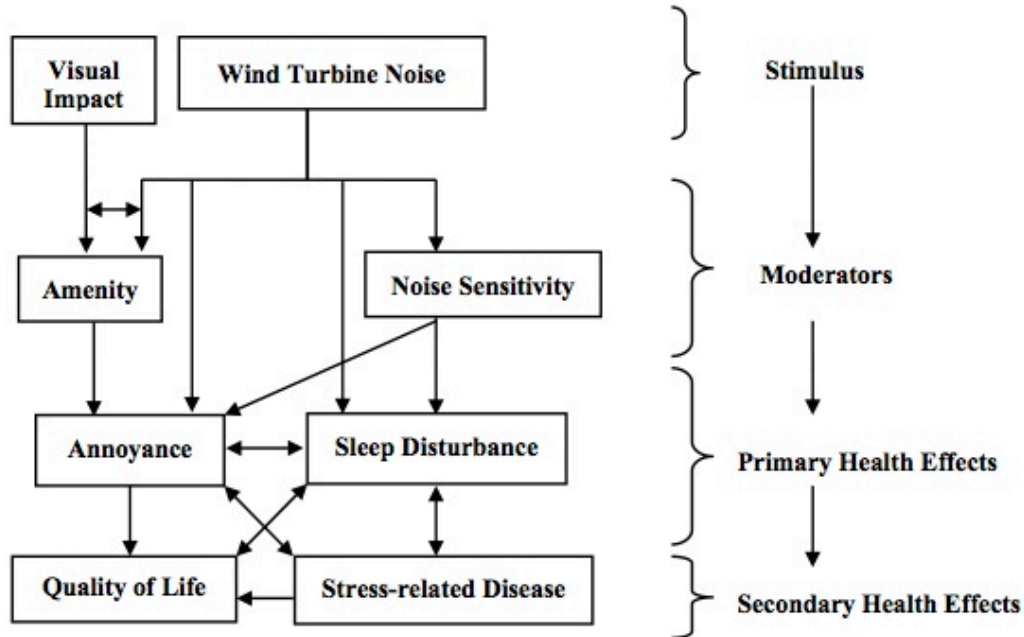


Figure 1: A schematic representation of the relationship between wind-turbines and health in a rural setting such as that proposed with the Kent Breeze Wind Farms. Arrows represent cause-and-effect relationships, which maybe bidirectional. The multiplicity of relationships emerges due to variability in the response of individuals to noise.

He also stresses the finding from many other studies, that noise annoyance is not readily correlated with noise exposure; **only about 20-25% of the annoyance effect can be explained by the noise level itself.** While some claim that visual impact or general attitude toward the wind farm drives annoyance, Shepherd stresses the inherent complexity of individual reactions to any noise source. As noted above, visual/landscape impacts did not seem to be a factor in the annoyance reported in the

Makara Valley; and further, Shepherd stresses individual psychological factors, as did Phillips. In particular, Shepherd puts forth the **high proportion of noise-sensitive individuals in rural areas (roughly 20%, about twice the proportion found in cities) as an indicator that annoyance rates will be at least that high, leading to associated stress-related effects in 10-15% of residents who can hear the proposed wind farm.**

Sleep quality survey in Maine

Nissenbaum, Aramani, Hanning. Adverse health effects of industrial wind turbines: a preliminary report

This paper, presented at the 2011 IC BEN Noise as a Public Health Problem conference, like the Shepherd study above, uses widely recognized standard assessment questionnaires to assess mental and physical health, sleep disturbance, and sleepiness in two sets of residents in rural Maine, one living within 1.5km (just under a mile) from wind turbines, and the other 3.5-6km from any turbines. About two-thirds of adults living within 1.5 km of the Mars Hill wind farm participated, along with about half of the adults within that distance of the Vinalhaven turbines; the near-turbine group was about evenly split between those within a half-mile and those between a half-mile and mile. The total number of participants (38 near turbines and 41 at a greater distance) is slightly smaller than the Shepherd survey; both would benefit from larger sample sizes, especially in the measures that show no statistical difference. However, both also boast a very good response rate among the local residents, adding to confidence in the validity of the findings.

Also as in the Shepherd survey, the results are presented as overall averages, contrasting near and far groups, so, again, there is no direct reporting of the proportion of either group reporting any particular health effects. In addition, in the categories where a significant difference was found between the groups, the results were presented on graphs scaled over the full range of distances.

Following on a preliminary survey at Mars Hill that found "sleep disturbance was the main health effect," this larger study also found that the **sleep measures showed "a clear and significant relationship, with the effect diminishing with increasing distance" from the turbines.** The Pittsburgh Sleep Quality Index and Epworth Sleepiness Scale both showed significantly worse sleep for the turbine group; likely following from this, the most statistically significant result was a dramatically lower SF36 Mental Component Score (MCS) for the turbine group, indicating worse mental health (the MCS includes vitality, social functioning, and emotional health) – MCS scores dropped rapidly within the turbine group with increasing proximity to the turbines, especially moving in closer than a half mile. The authors note that this "first controlled study of the effects of IWT noise on sleep and health shows that those living within 1.4km of IWT have suffered **sleep disruption which is sufficiently severe as to affect their daytime functioning and**

mental health." They note that "while not proven, it is highly likely that IWT noise will cause arousals (brief lightening of sleep which are not recalled) which may prove to be the major mechanism for sleep disruption."

Notably, given concerns about physical health effects, the SF36 Physical Component Score (PCS) showed **no difference in average overall physical health between those close to turbines and farther away**; the PCS assesses physical functioning, bodily pain, and general health perceptions.

The results here closely parallel those reported above by Shepherd in New Zealand, where the Physical sub-factors of sleep quality and energy level were one of the strongest differences between those close and far from turbines, while neither study found a measurable difference in general health ratings. By contrast, Shepherd did not find the dramatic impact on psychological measures resulting from the sleep issues that were found in Maine; instead, his study saw a similarly dramatic increase in annoyance and decreased Amenity.

The study design used here does not provide any data on individual reports of specific health or annoyance reactions, so we can't speculate on what proportion of the turbine group may have experienced any given health or sleep impacts; likewise, this study does not assess annoyance rates. (The introduction to the paper suggests that such questions were included in the questionnaire, but this paper presents only results from the more standardized assessment instruments.)

The **earlier preliminary study** (shared in public forums by Nissenbaum during 2009 and after; currently submitted for publication), which included just under half of the Mars Hill residents living within 3400 feet, indicated that the majority of those surveyed were experiencing sleep disturbance on most nights (which is likely directly related to 40% reporting new onset of headaches); **20% or less reported specific symptoms such as dizziness, tinnitus, or unusual sensations in their chest or ears.** These figures are a notch above the 5-15% estimated by other investigators, but we may do well to remember that Mars Hill could be a worst-case scenario: ridgetop turbines close to sheltered valley homes, operating with a state-issued exception that allows them to run at 5dB louder than state regulations otherwise require (ie 50dB at night, rather than 45dB).

Comprehensive guidelines proposal aims to reduce 5-10% health effects rate near wind farms

Bob Thorne (Noise Measurement Services). Wind Farm Noise Guidelines, 2011.

In this comprehensive 116p document, Thorne, an acoustician who has specialized in human responses to moderate noise, reviews basic acoustics as well as field

measurements made at operating wind farms, and assessment of previous research into health effects. For these review qualities, it deserves a place in any basic wind farm noise document library. Of particular note – though unrelated to our purpose here – Thorne stresses that noise models cannot account for all the transient atmospheric factors that routinely increase temporary noise levels well above the average levels that the models predict reasonably well; he includes his field observations of "heightened noise zones" which match observations often made by people living around wind farms. For more on this, see the paper, or **AEI's recent summary of low-frequency noise research**.

Thorne's conclusions are straightforward:

It is concluded that, based on professional opinion, serious harm to health occurs when a susceptible individual is so beset by the noise in question that he or she suffers recurring sleep disturbance, anxiety and stress. The markers for this are (a) a sound level of LAeq 32 dB outside the residence and (b) above the individual's threshold of hearing inside the home.

It is concluded that there are **sufficient credible observations, measurements and peer reviewed research papers and affidavits indicating that for 5% to 10% of the individuals living in the vicinity of a large rural wind farm its operation will cause serious harm to their health.**

It is recommended that no large-scale wind farm or large turbine should be installed within 2000 metres of any dwelling or noise sensitive place unless with the approval of the landowner.

(Ed. Note: it appears that Thorne's 32dBA threshold is chosen because as sound levels rise past this point, audibility increases in quiet rural areas, so that negative responses begin to be reported; or, to look at it from a slightly different perspective, 5-10% of those hearing noise levels above 32dB are likely to experience negative health affects (the current state-of-the-art large community response surveys, from Pedersen et al, show annoyance rates in rural areas of around 5-12% at 30-35dB, rising substantially as noise increases to 40dB and beyond). It also appears that Thorne is especially concerned about the fact that peak noise levels are often quite a bit louder than average (Leq) noise levels; he makes it clear that 40dBA (Leq) is not likely to prevent a significant number of amenity complaints and health changes, so it's probably safe to presume that he feels that 32dBA (Leq) is a low enough average to assure that transient peaks and heightened noise zones do not cause widespread problems.)

Thorne's conclusion, which is based on both the possible health effects on this 5-10% of neighbors, and on his studies of reduced rural amenity in a much larger proportion of residents around two existing wind farms, is **shared by regulators in at least two Australian states (New South Wales and Victoria), where a 2km buffer has been proposed, with provisions to allow closer siting to willing neighbors.** These much more stringent standards are designed to minimize the audibility of wind turbines in otherwise quiet rural areas, thereby largely preventing annoyance and health reactions. As Thorne

notes in this paper:

Wind farms are now causing concerns regarding noise, especially from those residents immediately near to the turbines. In this regard, the Board of Inquiry into the proposed Turitea (New Zealand) wind farm is important, as it is the outcome of nearly two years' deliberations. The Board, in its draft decision of February 2011, says:

"Creating an environment where wind farm noise will be clearly noticeable at times of quiet background sound levels is not an option the Board condones, especially where large numbers of residents are affected. It is the Board's view that energy operations in New Zealand will have to learn not to place wind farms so close to residential communities if they are not prepared to accept constraints on noise limits under such conditions."

The decision highlights the duty of care that decision-makers, developers, acoustical consultants and regulatory authorities have to themselves and potentially affected communities.

What Nina Pierpont really found: pre-existing conditions underlie most health impacts

Nina Pierpont, *Wind Turbine Syndrome: A Report on a Natural Experiment*. K-Select Books, 2009.

Nina Pierpont, Presentation to the Hammond (NY) Wind Committee, July 2010

Even Nina Pierpont, the godmother of wind farm health concerns, **does not suggest that the problems she documents in her *Wind Turbine Syndrome* book are common**; she affirms that her research gives no indication of how widespread the issues are (while recognizing ways others researchers might begin to find out), and has suggested that the same 5-15% estimation we've seen from others here is a likely range.

Regular readers of AEI's wind farm noise materials may have noticed how rarely I reference Nina's work, other than defenses of the value of case series studies as a first step, in the face of unwarranted attacks on the work for not being something it isn't designed to be.¹² This has partly been because of what a hot button her research has become (especially as others make more of her results than even she does), and partly because I've been put off by some of the over-reach in the narratives that Nina and Calvin (her husband and website editor) have themselves used, both in the book and their website.¹³ But that has not affected my ability to listen to what she and her

¹² See <http://aeinews.org/archives/298>

¹³ Such narrative over-reach includes sections of the book itself, which while calling the "low-frequency/infrasound" and vestibular effects connection a "hypothesis," read as if they are presenting proof, rather than conjecture. More egregious has been the tendency of the website to underplay the point of the book, which is about "risk factors" and instead to foster the impression that health effects are very common among the population at large. For example, the website routinely trumpets outside

interviewees have to say about their actual experiences. The case histories in the book, and the interviews she has done with Falmouth residents,¹⁴ are most often **compelling and sober testimonies, from grounded citizens who are not out to "get" wind power, but simply were shocked at the ways their bodies reacted to the nearby turbines.** In the book, and in later case studies conducted by Pierpont, not all family members had health impacts; a key part of the initial study was aimed to begin to understand why some people reacted more dramatically than others.

In the book itself and several other documents, the actual findings of the "Wind Turbine Syndrome" research are quite simple, and perhaps even reassuring to many: As Pierpont has written:

Not everyone near turbines has these symptoms. This does not mean people are making them up; it means there are differences among people in susceptibility. These differences are known as risk factors.¹⁵

Centrally, she found that common WTS symptoms are most apt to occur in people with particular pre-existing conditions; specifically, she found "strong and statistically significant relationships" between three pre-existing conditions and the likelihood that residents would report new or aggravated health responses when turbines are operational nearby¹⁶:

- Pre-existing **motion sensitivity** appears to be make it more likely to experience symptoms of waking in alarm and/or a sense of internal pulsations in the chest or abdomen
- People with **migraine disorders** report even more severe headaches than they're used to when turbines are operational
- Residents with **previous inner-ear damage** from noise or chemotherapy are more apt to report new onset of tinnitus.

Similar to the findings of all of these studies, chronic sleep disturbance is the most common symptom Pierpont has identified. Exhaustion, mood problems, and problems with concentration and learning are natural outcomes of poor sleep. She also often stresses that her work suggests that older people and young children are more at risk than adolescents and young to middle-aged adults. (*Ed. Note: The very young and the*

mention of any health effects as further proof of Wind Turbine Syndrome, or as attempts to ignore WTS; and, one abstract of a Pierpont talk presents figures that, while including qualifiers, can easily be oversimplified by casual readers, eg, "70% of school-age children and teens in the affected WTS families had worsening of schoolwork, concentration, or test-taking" and "Tinnitus affected 58% of the adults and older teens in the affected families, compared to 4% in the general population" (it would be easy to read "affected families" as "families living near wind farms," when in fact that's not what she has investigated). In some ways, their promotion of the concept of WTS has undermined the value of the much more focused study that actually took place, as well as the human decency message in the case studies and interviews.

¹⁴ See <http://www.windturbinesyndrome.com/articles.html>

¹⁵ Nina Pierpont, Review of the Noble Environmental DEIS for Ellenburg, NY. May 31, 2006.

¹⁶ Nina Pierpont, Presentation to the Hammond (NY) Wind Committee, July 2010

old are well known to be more sensitive to sound/noise in general, as highlighted by WHO noise guidelines)

As for how common any of this may be, her most specific statements on that question basically build from the risk factors identified above:

I estimate **the proportion of the population likely to be susceptible to the symptoms of Wind Turbine Syndrome to be in the range of 20-30%**, including the 12% of the American population with migraine disorder, older people with age-related problems with inner ear function, children with disabilities (especially autism spectrum disorders, of which a common attribute is auditory oversensitivity and scrambling of incoming auditory signals), and some proportion of people with noise-induced hearing loss.¹⁷

Note that this "susceptibility" estimate does not imply that all of them will fall ill; this is the population with what Pierpont suggests are the possible risk factors.

Ambrose/Rand: Acousticians experience health effects

Stephen E. Ambrose, Robert W. Rand. The Bruce McPherson Infrasound and Low Frequency Noise Study: Adverse health effects produced by large industrial wind turbines confirmed. December 14, 2011.

A recent report from acousticians Stephen Ambrose and Robert Rand provides both the **first case study of health effects involving trained acoustics professionals**, and some affirmation of Pierpont's risk factor associated with motion sensitivity. Within a half hour of arriving at their study site (a home in Falmouth, MA), both Ambrose and Rand experienced disorientation and a difficulty in concentrating on the routine task of setting up their equipment. Both of them have a history of being prone to motion sickness. The authors note:

This research revealed that persons without a pre-existing sleep deprivation condition, not tied to the location nor invested in the property, can experience within a few minutes the same debilitating health effects described and testified to by neighbors living near the wind turbines. The debilitating health effects were judged to be visceral (proceeding from instinct, not intellect) and related to as yet unidentified discordant physical inputs or stimulation to the vestibular system.

They elaborate:

As is our custom on field surveys, we were enthusiastic and ready to begin our work. It was a beautiful spring afternoon, warm with a strong westerly wind aloft

¹⁷ See Nina Pierpont, Review of the Noble Environmental DEIS for Ellenburg, NY. May 31, 2006.

at the wind turbine blade height. We observed that there was a soft southeasterly wind extending from ground level to tree top (about 60 feet). Within twenty minutes of being inside their house, while setting up our instruments, each of us started to lose our initial enthusiasm and actually started to feel less well. As time went on, we got progressively worse. We each experienced unpleasant symptoms of motion sickness, including ear pressure, headache, nausea, dizziness, vertigo, especially when moving about. We had a sense that the room was moving or slightly displaced from where it appeared. We experienced a loss of appetite, cloudy thinking, fatigue, some anxiety and an inexplicable desire to get outside; similar to motion sickness we have experienced on a boat or plane. We felt slightly better when we did go outside.

On the morning of the second day we left the house to go out for breakfast. About 30 minutes later and a few miles away we shared a light conversation about the night before... We talked about the difficulties we had staying motivated and the challenges we encountered performing our usual work. As time went we started to feel better, and then by the contrast in our state of mind, it hit us. We realized and understood the true extent of the debilitating symptoms expressed by neighbors; we had experienced many of them the previous evening.

As this was a short (just over two days) study, it is impossible to draw definitive conclusions from the results, though there appear to be correlations between higher winds and the appearance and disappearance of the symptoms in these two unplanned subjects. In addition, their noise measurements and analysis, following on some innovative techniques recently developed by Wade Bray, revealed the presence of **rapidly pulsing low frequency sound. Using the dBG weighting, which is centered on 10-30Hz (the frequencies at the very low end of the normal "audible" range and the higher end of infrasound)** along with considerable contribution from frequencies up to 70Hz and down to 2Hz, the authors report dramatic fluctuations of dBG levels, with peaks over 60dBG. Their symptoms appeared to worsen when the dBG levels varied in a regular pulse, and to be ameliorated when dBG levels varied in a more random fashion.

I will refrain here from detailed discussion of low frequency perceptual thresholds, which has been subject to some debate within the acoustics community over the past year or so. The key new factor is the contention by some acousticians that rapidly pulsing sound, with peaks much higher than the levels measured using longer time-averaging techniques, can be perceived at lower dB levels than is indicated by standard hearing threshold curves, which are generated using simple, pure-tone sounds. For much more discussion of these questions, including Wade Bray's rapid timescale measurement techniques, see AEI's lay summary of recent low-frequency noise research.¹⁸

¹⁸ <http://aeinews.org/archives/1711>

Ambrose and Rand conclude their paper with the observation that the ramping-up onset of symptoms that they experienced, along with the more gradual dissipation of the symptoms after they left the site, both mimic a classic dose-response relationship; they suggest that the peak sound pressure events, which occurred on average once every 1.4 seconds, can be considered the recurring "dose" that triggered their "response." They mention a standard dose-response equation for considering cumulative effects that could be used to explore this idea further.

You may have noticed that this paper stands apart from the others reviewed here, in that it involves reported health effects that are presumably NOT stress-mediated or related to sleep disruption. That is, Ambrose and Rand may indeed have experienced an effect triggered directly by the noise exposure itself. They cannot, and do not, claim to have proven that in this short study, but their experience is an important reality check that **even if the vast majority of reported health problems may be indirect, stress-mediated effects, it is also likely that some people are being directly affected**. Whether these people have a pre-existing condition (such as motion sensitivity), or are part of the most perceptive fringe of the normal auditory perception curve, so that they actually do hear or sense some of the low-frequency sounds more readily than most, **we need to be careful not to lump all reports into any easy-to-accept framework**. This applies equally to those who seem to imply that all health issues are "merely" psychological, as well as to those who might fear that everyone near turbines will get vertigo. While it appears to me that many, likely most, of the health effects being reported are stress-related, I do not for a minute presume that they all are.

We might also bear in mind that **in addition to the sound waves that are the focus of virtually all discussion of community responses and health effects, turbines also create air pressure vortices** that travel in the downwind direction (turbine spacing is carefully designed to avoid having downwind turbines impacted by these significant pressure differentials). Some of the reported turbine-related symptoms, including pressure in ears or chest, and a general sense of discomfort, could be related to these pressure waves. The only community response researcher to consider them that I am aware of is Bob Thorne, who feels these vortices may contribute to his observed "heightened noise zones."

A few more things to keep in mind

Much Ado About Nothing?

Some observers suggest that if actual, acute symptoms appear in as few as 5-10% of the people living near wind farms, then **we may simply be hearing from people who represent the normal baseline rates for conditions like headaches, dizziness, tinnitus, and insomnia**. This is an important question to keep in mind as we move forward and

have larger studies to draw conclusions from.

However, the papers considered here are assessing **changes in health**: typically, subjects report symptoms appearing, or increasing, after wind farms began operation, and decreasing when turbines are not operating or the subjects are away from the area. The fact that most of these studies use self-reporting of current health conditions, and retrospective reporting of earlier health status, is considered by some to be a weakness; people's memories can be distorted by recent upsets at the wind farm. Some of the studies now beginning will be attempting to redress this by doing health surveys before wind farms begin operation, and following up later with the same subjects.

But again, for now, we start where we are, and these initial studies, while perhaps not ideal, can be assessed on their merits. The authors generally are quite forthright about their methods, making it relatively easy to see both the strengths and shortcomings of the data we currently have to work with.

Other surveys old and new

Scandinavia

As further evidence of the trend suggesting that health effects may occur in just 5-15% of the nearby population, we can also look to the three seminal Scandinavian surveys by Pedersen et al. These are much larger than the recent papers considered here, ranging from 350 to 750 people each. They were primarily assessing annoyance levels, but also asked some questions about health and sleep.¹⁹

The studies found that **in rural areas, annoyance ranged from 5-12% at 30-35dB, 15-20% at 35-40dB, and 25-45% at 40-45dB.** These annoyance rates dropped by half when inside homes, decreasing the stress-related risk group dramatically. And, relevant to our inquiry here, less than a third of those reporting outdoor annoyance reported any physical/health effects at all...bringing us right into the 5-10% range for people hearing 35-45dB, which generally coincides with living between a third of a mile and a mile of modern wind farms. For more on these studies, see AEI's presentation to the webinar presented by the New England Wind Energy Education Project in the summer of 2010²⁰.

¹⁹ In considering the results of these surveys, it is important to keep in mind that the first two focused on sites that generally had only one turbine nearby, most of which were relatively small by today's standards (hundreds of kW); only the third centered predominantly on wind farms, and included some turbines up to 3MW. In addition, about half the respondents lived in "suburban" areas in which existing noise levels and noise tolerance were notably higher than in most rural areas. Still, the detail collected in these studies provides a valuable grounding for discussions that are more often based on vague impressions of annoyance rates.

²⁰ Cummings. Wind Farm Noise: Public Perception and Annoyance. NEWEEP, 2010. Available online at <http://www.acousticecology.org/wind/> and <http://aeinews.org/archives/972>

The Scandinavian data has also provided raw data that has been analyzed in two recent papers. Both of these focused on a statistical analysis of many factors, rather than on rates of any specific factor; both suggest that annoyance is a better predictor of negative effects than are noise levels. Eja Pedersen²¹ found that **several measures of stress were associated with annoyance due to wind farm noise in all three studies, specifically, feeling “tense” and “irritable.”** Headache was associated with annoyance in two of the studies, and undue tiredness in one. Pedersen points out, however, that we should not assume that this is clear evidence of even an indirect causal relationship between turbine noise and stress, mediated by annoyance; she points out that people already under stress may be more apt to attend to turbine noise as an additional contributor to their pre-existing discomforts.

Roel Bakker is lead author of a forthcoming paper that was summarized in the 2011 book *Wind Turbine Noise*²², and is just about to be published in the journal *Science of the Total Environment*²³. This analysis looked at sleep disturbance and psychological distress (as measured by a 12-item questionnaire). Here, too, the effects were related to annoyance levels, rather than noise levels. Perhaps most importantly, **sleep disruption and psychological distress was far more significantly related to annoyance among those living in quiet rural areas** than in more built up areas, where the relationships were weak or non-existent.

Australia

The **most recent survey to address annoyance and health effects comes from South Australia.** It's part of a Masters dissertation by a Zhenhua Wang, student at the University of Adelaide; a few-page summary of the results²⁴ was publicly released in early 2012, with the full dissertation to follow. There are several wind farms in Australia and New Zealand where complaints are numerous at distances much greater than those we generally hear about in the US, Canada, and Europe – many complaints beyond 2km (1.25mi), and quite a few at 3-4km, with a few scattered complaints out as far as 10km (over 6 miles). I'm not sure whether this reflects wind farms being built in areas that are otherwise particularly pristine and quiet, or a different cultural attitude toward outside noise Down Under. It appears that most of these wind farms are on ridges, with homes below; some have suggested that the landscape in some of these areas may funnel the sound further than normal, as well; such topographic factors could be responsible for the higher annoyance rates.

This new survey was returned by 64% of the residents living within 5km (3.1mi) of the

²¹ Eja Pedersen. Health aspects associated with wind turbine noise—Results from three field studies. *Noise Control Eng. J.* 59 (1), Jan-Feb 2011.

²² Dick Bowdler and Geoff Leventhall, *Wind Turbine Noise*. Multi-Science Publishing Co. Ltd., 2011.

²³ R.H. Bakker, E. Pedersen, W. Lok, G.P. van den Berg, R.E. Stewart, J. Bouma. Effects of wind turbine sound on health and psychological distress. *Science of the Total Environment* (in press, 2012).

²⁴ Wang, Zhenhua. Evaluation of Wind Farm Noise Policies in South Australia: A Case Study of Waterloo Wind Farm. 2011.

Waterloo Wind Farm, and in keeping with the apparently greater annoyance levels Down Under, its results are striking: **70% of respondents said they'd been negatively affected by noise, including 54% who rated themselves moderately or very affected.** Of those affected, 38% reported health effects (i.e., 26.6% of the total number of respondents); i.e. about half of those moderately or very affected by noise. Even if the entire 36% of local residents who did not respond to the survey were totally unaffected, those reporting effects in the survey represent **32% of all residents within 5km being moderately or very affected by the noise, with 18% reporting health effects.** Huh.

For reference on the other end of the spectrum, the Netherlands surveys suggest that just 8% of those within 2.5 km (1.5mi) of turbines are "rather" or "very" annoyed with wind farm noise. This has become a commonly referenced "general" annoyance rate; though the Pedersen studies (which this one builds on) also tend to show substantially higher annoyance in rural areas than in suburban ones (these overall averages include about half suburban respondents; see also footnote 20).

van den Berg "Effects of sound on people" chapter

Likewise, Frits van den Berg's chapter in *Wind Turbine Noise*²⁵, which was also presented as a paper²⁶ at the Wind Turbine Noise 2011 meeting in Rome, provides a **detailed overview of earlier and more recent studies of looking at annoyance, sleep disruption, and health effects around wind farms** (it includes the Shepherd and Hanning papers summarized above). Rather than repeat much of this here, I encourage you to read the chapter or paper; the latter will be available on AEI's wind farm noise resource page²⁷. I will note that van den Berg manages to summarize the essence of each paper's findings far more concisely than I have!

But for now, our focus is health effects, rather than annoyance; look to the AEI Wind Farm Noise 2012 annual report (forthcoming, summer 2012) for more comprehensive summaries of annoyance rate surveys, including summations in the van den Berg chapter and paper.

Meet the New Stress, Same as the Old Stress

Geoff Leventhall, a British acoustician who's become one of the most widely-cited critics of the idea that infrasound and low-frequency sound from wind farms is strong enough to cause health problems, has also been **quick to acknowledge that noise-related stress is likely to be a significant factor in community responses to wind farms.**

²⁵ Dick Bowdler and Geoff Leventhall, *Wind Turbine Noise*. Multi-Science Publishing Co. Ltd., 2011.

²⁶ Frits van den Berg. An overview of residential health effects in relation to wind turbine noise. Fourth International Meeting on Wind Turbine Noise, Rome, Italy, 12-14 April 2011.

²⁷ See <http://www.acousticecology.org/wind/>

In a detailed article in Engineering and Technology Magazine²⁸, published in 2009 just prior to the publication of Nina Pierpont's Wind Turbine Syndrome book, Leventhal opined, "The wind developers are going to rubbish her book, and quite rightly so, but **what must be accepted – and developers don't want to accept this – is that yes, people are disturbed. If people are consistently disturbed, and their sleep is consistently disturbed, then they will develop some very 'unclever' stress symptoms. That will lead to stress-related illness.**"

Elaborating in a white paper he wrote entitled, "Wind Turbine Syndrome – An appraisal," Dr Leventhal critiques Pierpont's approach and conclusions, but says of the identified stress symptoms:

"I am happy to accept these symptoms, as they have been known to me for many years as the symptoms of extreme psychological stress from environmental noise, particularly low frequency noise. The symptoms have been published before... The so called "wind turbine syndrome" cannot be distinguished from the stress effects from (any) persistent and unwanted sound. These are experienced by a small proportion of the population and have been well known for some time."

In other words, Leventhal believes that the stress-mediated health effects we're hearing about around wind farms are not due to any special qualities of turbine noise, but rather simply to people dealing with unwanted turbine noise in their environment and homes.

Doctors Down Under urging people to move from homes?

While most of my energy and attention has been focused on community responses in the U.S., along with following the publications in journals and conferences and press reports worldwide, I should mention at least in passing that I've come across several news reports from Australia that mention doctors urging patients move from their homes after they experienced negative health effects. This is not something I've found any solid studies on, but it has stood out in my ongoing monitoring of wind farm siting; I'm not aware of other regions in which doctors have made such recommendations (update: I just came across reference to an initiative in Quebec that was signed on to by 40 physicians²⁹). Two General Practitioners are seen in a short video by the Waubra Foundation³⁰ on health issues near wind farms, as are two apparently hearty men who

²⁸ See <http://eandt.theiet.org/magazine/2009/17/quiet-revolution.cfm>

²⁹ See <http://terrecitoyenne.qc.ca/?p=325>

³⁰ The Waubra Foundation is closely associated with Landscape Guardians, which is widely seen as a climate-change denialism organization, with significant ties to the oil and gas industry. Dr. Sarah Laurie, who spearheads their health-related efforts, affirms in personal communication that some board members have a broader agenda, but says she was strongly pro-wind until 2010 when she began hearing from GPs about patients with health issues, that her sole concern is health of neighbors, and that board members "respect each others' differences." As suggested above, and as studied by Robert Thorne, reports of both quality of life impacts and health effects are more commonly reported at relatively large distances in Australia and New Zealand, with many complaints at 2km, and quite a few out to 3-4km. Waubra

had to move from their homes after wind farms became operational nearby; the video can be viewed at <http://www.youtube.com/watch?v=IEh3sooKU8A>

The Waubra video is actually **a perfect example of the difficulty we confront in considering the health effects issue**. The testimonials are heartfelt and compelling; as I mentioned, I wouldn't wish this on any of the folks living in my valley. Yet also, the end of the video highlights that after years of working on this issue, the Waubra Foundation has identified 90 people in four southeastern Australia states who are struggling with health effects (and that "over 20 families" have abandoned their homes across the country). I think it's **safe to say that those 90 people once again represent 10% or less of the total population living within earshot of the thirteen wind farms they list as locations of issues, and certainly of the thirty wind farms operating in the four states**³¹ (though it would be interesting to know if the bulk of those 90 families live around just a few of the thirteen).

So again, I find myself turning to the Thorne and Shepherd studies from Australia and New Zealand that focus on the much higher rates of severe annoyance and impacts on rural quality of life and amenity. And again, I find myself wondering how we can begin to discern the differences between the few wind farms triggering widespread noise issues – the 13 in this region – and the 17 others where even Waubra hasn't heard of any problems. In the US, it's likely that the proportion of "problem wind farms" is even lower, since most of our installed capacity is still in the wide-open spaces of the west. What are the indicators that might clue us in to where we need to be more sensitive to more significant community reactions to wind farm noise? **Looking at typical setbacks, population density, or community make-up of places with lots of complaints, as compared to places with few or no noise issues**, might help us to move forward in a way that both protects rural quality of life and maintains our momentum toward increased wind energy generation.

Conclusions

So, what have we found? Remembering that to get a full picture of health impacts research, you should also be familiar with some of the larger literature reviews published by government entities and industry trade associations, this overview of direct research in communities where health impacts are being reported suggests a few things:

- First, health effects may be more common in a relatively small subset of the population that have pre-existing conditions that could make them more

Foundation appears to take an especially hard line, urging setbacks of 10km, since that's the greatest distance they've heard of problems. This extreme position raises questions about whether Waubra's goal is simply health, or effectively stopping wind development.

³¹ See <http://ramblingsdc.net/Australia/WindPower.html>

- susceptible to being affected by noise, perhaps especially low-frequency noise.
- Second, those who are noise sensitive (roughly 20% of the population, especially in rural areas) are more likely to be annoyed by sound in general, and wind turbines in particular. This annoyance, and/or a related increase in sleep disruption caused by turbine noise, can lead to stress-related disease symptoms.
 - Third, among the rest of the population, especially among the 30-50% who are neither especially noise sensitive nor extremely noise tolerant, those who are annoyed by wind turbine noise (due to being woken, or simply because they resent the new noise intrusion in their rural landscape) may also develop some stress-related responses. This group is also more likely to simply resent the new noise intrusion in their community, even if they are not experiencing any health effects.

The evidence currently available from community surveys suggests that while in some types of communities, **a quarter to half of those close enough to turbines to hear them at 40dB or more may find them particularly annoying and unwelcome, a much smaller proportion of the nearby population is actually reporting negative health effects.** (For more on rural annoyance rates, see AEI's Wind Turbine Noise 2011 report³², and the upcoming 2012 version, which will summarize all known community response surveys.)

If this inquiry is being undertaken in order to inform decisions about siting standards, then it will always be important to look at both annoyance rates and health impact rates among those closest to the turbines. It tells us nothing to hear that, say, 95% of community members feel fine about a wind farm, when most in the community live miles away from turbines. Analysis of annoyance (as a possible precursor to stress-related health effects) and of reported health changes needs to consider rates within a half mile or kilometer, as well as rates between a half mile and mile or 1-2km, in order to provide useful information for deciding what setback between wind turbines and neighbors is appropriate.

But **however we analyze these questions, we will be left with a social choice.** Some people will be negatively affected by almost any new noise source or change in the local landscape. A tiny proportion of the population could well experience authentic health effects from turbine sounds that are over a mile away and just barely audible; at the other end of the spectrum, in some types of communities, a large proportion of those hearing nearby turbines regularly may hate the new noise and become quite worked up over it.

Communities will need to decide what level of impact is acceptable. Some may decide that they don't want to subject any neighbors to even occasionally audible wind turbine noise (some such communities have adopted large setbacks, up to 2km or even 2 miles). Others might feel that contributing to a national push toward renewable energy

³² See aeinews.org/archives/1393

is worth the trade-off of knowing that 5-10% of those within a mile may have more headaches, or sleep disruption that leads to poor concentration and work performance (such communities, aiming for a "happy medium," have chosen setbacks of a mile, or sometimes 3000 feet). I suspect that few would welcome the thought of half of the nearby neighbors feeling that their homes were far less welcoming and relaxing than they used to be (which has been the experience in some of the communities that adopted setbacks of a third of a mile or less). But the question will always be there: where do we want to draw the line?

I would be remiss if I didn't also stress here that the annoyance rates and health effects rates reported in communities with strong negative reactions to wind farms are not representative of all wind farms. By contrast, it's notable that **in ranching country, where most residents are leaseholders and many live within a quarter to half mile of turbines, health and annoyance complaints are close to non-existent**; some have suggested that this is evidence of an antidote to wind turbine syndrome: earning some money from the turbines. More to the point, though, the equanimity with which turbine sound is accommodated in ranching communities again suggests that those who see turbines as a welcome addition to their community are far less likely to be annoyed, and thus to trigger indirect stress-related effects. Equally important to consider, ranchers who work around heavy equipment on a daily basis are also likely to be less noise sensitive than average, whereas people who live in the country for peace and quiet and solitude are likely more noise-sensitive than average. And, there are some indications that in flat ranching country, turbine noise levels may be more steady, less prone to atmospheric conditions that make turbines unpredictably louder or more intrusive. When considering the dozens of wind farms in the midwest and west where noise complaints are minimal or non-existent, it remains true that **the vast majority of U.S. wind turbines are built either far from homes or in areas where there is widespread tolerance** for the noise they add to the local soundscape.

Here we find ourselves once again at the crux point that needs to be factored in to wind farm siting standards: **not every community will respond similarly to the new noise that wind farms undeniably add to the local soundscape. Siting standards need to be flexible enough to recognize these differences; one setback, or one dB limit, clearly does not fit all.** Let's not forget, either, that a large proportion of US wind farms are still being built in the vast expanses of the Great Plains and intermountain west. Many of these, likely still representing the majority of US wind generating capacity, are miles from any home. This is clearly the best place for them to be, as recently stressed by wind historian Robert Righter³³.

One of the purposes of this summary is to ease the fear that health impacts will be widespread around any new wind farm. But I certainly am not implying that the 10%, or 5%, who are suffering, should be disregarded. To make it personal, if faced with the

³³ Robert Righter. Windfall: Wind Energy in America Today. University of Oklahoma Press, 2011. See summary of his point on noise and siting at <http://aeinews.org/archives/1726>

possibility that two of the forty families in my valley would likely experience substantial health effects (whether because they were prone to motion sickness or just hated the sound enough to rile them up) from a wind farm on the ridge that sits – as indeed one does – a third to half mile from our homes, I would likely not want to trade their well-being for a few megawatts of green energy, despite my commitment to a renewable future.

Of course, the **simple solution for communities would be to keep turbines farther away**; opinions differ, but somewhere in the half mile to mile or so range is likely to greatly reduce audibility, annoyance, stress, and stimulation of pre-existing conditions. Some suggest 1.25 miles, or 2km, in order to be more sure that peak sound levels, triggered in worst-case atmospheric conditions, remain barely audible.

It's not my intention or my place to pick a solution to this quandary, especially given the clear differences between communities as to what is likely to be the best choice. My goal is simply to help clarify what has been found by those looking most closely at these questions in communities where it has become an issue.