OHIO DEPARTMENT OF HEALTH
WIND TURBINES AND WIND FARMS
SUMMARY AND ASSESSMENTS

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Introduction

The Ohio Department of Health's (ODH) role in the Ohio Power Siting Board has historically been to assess cases to determine whether the construction, alteration, or decommissioning of any power-generating structure or facility will have an impact on the health and wellness of the public. ODH works in partnership with fellow state agencies, including the Ohio Department of Natural Resources (ODNR), which assesses ecological impacts, and the Ohio Environmental Protection Agency (OEPA), who is responsible for environmental licensing and regulation, to provide a robust, holistic assessment.

The purpose of this document is to assess, based on existing research, whether living proximal to industrial wind turbine projects has the potential to cause harm to human health. ODH did not conduct independent, peer-reviewed research in order to produce this document. ODH has developed this document at the request of the Ohio Power Siting Board (OPSB) in response to an increase in the construction of new wind turbine projects in Ohio.

The determinations within this document were made based on a review of the scientific literature available at the time of its original publication. As scientific information changes over time, and as wind turbine technologies and wind energy policies within Ohio change, ODH will reevaluate these conclusions as needed. This document supersedes a similar document developed by ODH at the request of the Logan County Health Department and provided to the OPSB in 2008. It reviews the significant amount of research, investigations, and large-scale scientific reviews conducted by individual scientists and by a number of government agencies that have been published since 2008.

Reliance on power derived from industrial wind turbines has increased dramatically over the course of the last decade (6,100 Megawatts in 1996 up to 539,123 megawatts in 2017). As of 2017, there are over 3,300 megawatts (MW) of new wind projects either approved or proposed in Ohio. If completed, these projects would generate up to $4.2 billion in local economic activity and provide enough power for more than 900,000 Ohio homes (Renewable America, 2017).

The increase in construction of new wind farms in Ohio has given rise to public concerns about potential related health effects. Reported to be caused by visual phenomena (shadow flicker) or noise (audible sound and infrasound), concerns include a range of adverse health effects from ringing in ears (tinnitus), headaches, lack of concentration, vertigo, and sleep disruption to epileptic seizures, cardiovascular issues, miscarriage, cancer, and death (Chapman and Crichton, 2017). This collection of effects has been given the name Wind Turbine Syndrome (Pierpont, 2009). Information about the proposed Wind Turbine Syndrome is largely based on a small number of anecdotal reports from people living near operating wind turbine installations. However, this syndrome is not a clinically recognized diagnosis and is not generally accepted by the scientific and medical community to date (Farboud et. al., 2013). To establish whether there was some correlation, if not causation, between proximity to wind turbine installations and negative health effects described as Wind Turbine Syndrome, further research would be needed so that more robust, complete data could be assessed.

Audible Wind Turbine Noise

There have been numerous studies that have investigated the assertion that the mechanical and aerodynamic noise created by operating wind turbines caused various physical health effects collectively called "Wind Turbine Syndrome." Wind turbine noise (WTN) is complex and spans a broad band of frequencies, including audible noise (air pressure waves 100-1,000 Hertz), low-frequency noise (LFN) (20-100 Hertz), and infrasound (< 20 Hertz). A Hertz is a unit of frequency equal to one wave per second (1 Hz). People sense the frequency of sound by its "pitch" – high pitch is linked to high frequencies and low pitch is linked to low frequencies. Pitch is a function of the frequency and also the level of sound pressure (its loudness). Loudness or volume of sound pressure is measured in decibels (dB). Decibels can also be presented as A-weighted decibels (dBA). The difference between dBA and dB is that dBA is a scale more appropriate to use when considering healthy sound levels. dBA are based on the intensity of the sound *and* on how the human ear responds. dBs are solely based on sound intensity.

Mechanical noises from the physical movements of the gearbox, generator, and other components produce low-frequency tones and have been reduced significantly by design improvements to turbines during the past several decades, including sound-proofing the nacelles, modifying blade airfoils to make them more efficient and less noisy, and development of direct-drive turbines with no gearbox. Aerodynamic noise is associated with interactions between the surface of the turbine blades and the wind flowing over it. Aerodynamic wind turbine noise is greatly reduced by the strategic upwind placement of the wind turbines which greatly reduces the amount of air turbulence produced by the turbine action. Industrial wind turbines today are designed to minimize noise, weight, and drag and are predominantly horizontal axis wind turbines equipped with three-bladed propellers facing into the wind.

Besides noise reductions due to improvements in the mechanical and aerodynamical operation of the individual turbines, it was also determined that increasing the set-back distances between the wind turbines and the closest residences also significantly reduced the audible noise levels. Ohio House Bill 413, passed in 2014, required that wind turbines from any Ohio wind turbine project must be located at least **1,125 feet from the tip of the turbine blade to the nearest adjacent property line**. In practice, this requires set-backs of 1,300 feet from each turbine's base to the edge of the neighboring property, even if that means the distance to the actual residence is actually much further. Ohio's current set-back law is 2-3 times larger than those required by most other states in the U.S. (Runnerstone, 2014). In addition, in Ohio, wind farms must be operated so that facility noise does not result in noise levels at non-participating residences within one mile of the project's boundary that exceed the project area ambient nighttime average sound level by five dB (OPSB, 2018). Average nighttime ambient sound levels reported for the largely rural wind turbine sites for which OPSB has received applications, range from 29 to 55 dB, and average about 42 dB (OPSB, personal communication, 3/06/2019).

A large study of wind turbine noise and health conducted by Health Canada in 2012 of residents living within 600 m (=1,800 feet) of 18 wind turbine projects in Ontario and Prince Edward Island (N= 2,004) determined that the audible WTN levels in homes participating in the studies reach a maximum of 46 dBA at turbine speeds of 8m/s (Health Canada, 2014). A study by the National Health and Medical Research Council of Australia (2015), similarly determined that WTN from wind farms typically range from 35 to 45 dBA for residences located from 500 m to 1,500 m (1,500 – 4,500 feet) from the wind turbines. Beyond a distance of 1,500 m (4,500 feet), WTN drops to levels below 35 dbA, below the noise levels of household devices and similar to a quiet residential area. The findings from both studies indicate that typical WTN from wind farms are only slightly higher than the World Health Organization (WHO) recommended outdoor nighttime average of 40 dBA – the level below which no health effects are expected to occur, even among the most vulnerable people (WHO, 2009).

Summary and ODH Assessment: Information to date does not indicate a public health burden from audible wind turbine noise. Peer-reviewed scientific articles and government-sponsored policy review papers regarding wind turbines and human health published during the past decade have concluded that the scientific evidence collected to date does not support a direct association between audible WTN and physical health problems or disease. These included self-reported illnesses like dizziness, tinnitus, frequent migraines and headaches, and sleep disturbances and diagnosed chronic health conditions including heart disease, high blood pressure, and diabetes, diagnosed sleep disorders, and stress.

ODH supports using the existing set-back distance requirements and noise level requirements in Ohio (as described above) to ensure audible WTN does not cause negative health effects.

Low-Frequency Noise (LFN) and Infrasound

Following significant reductions in the audible noise produced by wind turbines, concern shifted from the audible noise spectrum (200-2,000 Hz) to LFN (20-100 Hz) and infrasound (barely audible airborne pressure waves with frequencies of less than 20 Hz). Human hearing becomes gradually less sensitive as frequency decreases, so that LFN needs to be louder to be heard as loudly as mid-frequency noise (1,000 Hz). LFN and infrasound is emitted from wind turbines at maximum levels of 50 to 70 dB, which is well below the audible threshold for these low frequency sounds (McCunney, 2009). Low-frequency sounds are associated primarily with the mechanical sound generated by an operational wind turbine and were a significant component of the aerodynamic noise produced by air turbulence resulting from the operation of "downwind" turbines. However, current operating wind turbines are almost entirely now "upwind" turbines, which has greatly reduced the levels of infrasound associated with industrial wind turbines. LFN and infrasound isn't unique to wind turbine operations. Sources of LFN and infrasound are around us everywhere, including natural sources like earthquakes, volcanic eruptions, running water, the wind, and waves as well as man-made sources like automobiles, trucks, trains, aircraft, watercraft, heavy machinery, compressors, HVAC systems in buildings, and household appliances such as washing machines.

Pierpont (2009) linked exposure to LFN and infrasound to "visceral vibratory vestibular disturbance (VVVD)," where low levels of airborne infrasound (4-8 Hz) allegedly enters the lungs via the mouth and vibrates the diaphragm, transmitting vibrations to the viscera which sends neural signals to the part of the brains that receives information from the human vestibular system (i.e. inner ear) leading to development of vertigo, balance issues, disorientation, and nausea characteristic of "Wind Turbine Syndrome." McCunney (2009), the Massachusetts Department of Environmental Protection and Department of Public Health (MDEP/MDPH, 2012), and McCunney et al. (2014) have pointed out that the visceral receptors proposed as the mechanism for VVVD respond to gravitational body position changes, not to vibrations. If vibration-sensitive receptors were in the abdominal viscera, they would likely be constantly barraged by low-frequency body sounds like pulsatile blood flow and bowel sounds. In addition, wind turbine sound at realistic distances from nearby residents possesses little, if any acoustic energy at 4-8 Hz above ambient noise levels, providing insignificant sound energy necessary to generate these vibrations.

Research conducted by a research group headed by Castelo-Branco and Alves-Pereira (2004) suggested that infrasound and LFN may cause "vibroacoustic disease" (VAD), characterized by increased risk of epilepsy and cardiovascular effects resulting from the effects of infrasound on pericardial or cardiac valve thickening, leading to an increased risk of coronary heart defects. This illness has been suggested by studies of high-intensity occupational noise exposures (90-130 dB) involving aircraft maintenance and other aviation workers (Castelo-Branco and Alves-Pereira, 2004). An experimental animal study by Lousinha et al. (2018) linked infrasound at low frequencies (<20 Hz) and high intensities (120 dB) with development of coronary perivascular fibrosis in rats. The common denominator in these studies is exposure to infrasound (1-20 Hz) or LFN (20-200 Hz) coupled with high sound intensities (90-140 dB). None of these studies were of human populations exposed to infrasound from wind turbine projects. As indicated above, the maximum levels of infrasound associated with wind turbine farms is on the order of 50-70 dB, significantly below the sound intensities linked experimentally to this illness.

The table below shows common sources of sounds and how intense (loud) those sounds are (Kollman, 2010). A wind turbine at 1,000 feet typically generates the same intensity of sound as a large transformer at 200 feet or light traffic at 100 feet. As discussed above, Ohio's setbacks are greater than 1,000 feet, and the sound intensity would be reduced even further. The health effects on humans and animals described above do not occur until sound intensities reach volumes similar to ambulance sirens at 100 feet or lawn mowers at 3 feet. A wind turbine at 1,000 feet is too quiet to generate any of the negative health outcomes described above.

Source	**dBA**

Civil Defense Siren	140-130
Jet Takeoff at 200 feet	120
Rock Music Concert	110
Pile Driver at 50 feet	100
Lawn Mower at 3 feet	95
Ambulance Siren at 100 feet	90
Freight Cars at 50 feet	90
Vacuum Cleaner at 3 feet	85
Pneumatic Drill at 50 feet	80
Freeway at 100 feet	70
Speech Range	50-70
Light Traffic at 100 feet	50
Wind Turbine at 1,000 feet	**40-50**
Large Transformer at 200 feet	40
Soft Whisper at 5 feet	30
Rural Background at Night	20-40

Summary and ODH Assessment: Information to date does not indicate a public health burden from low-frequency noise and infrasound generated by wind turbines. Peer-reviewed scientific literature indicates that:
1) infrasound near wind turbines does not exceed audibility thresholds.
2) infrasound and LFN from wind turbines do not present unique health risks to nearby residents.
3) available evidence shows that infrasound levels near wind turbines do not impact the vestibular system.
4) there is very little or no evidence linking infrasound or LFN from wind turbines with "vibroacoustic disease" as the levels of sound associated with these effects in the laboratory are several orders of magnitude higher than what has been measured in the field in the vicinity of operating wind turbines.

Shadow-Flicker

The main health concern associated with "shadow flicker" (wind turbine blade flicker created by the turbine blades movements interrupting or reflecting sunlight) is the risk of seizures in people with photosensitive epilepsy. Studies by Harding et al. (2008) and Smedley et al. (2010) suggested that shadow flicker from turbines at frequencies greater than 3 Hz (=blade rotation speed of 60 rpm) pose a risk of inducing photosensitive seizures in 1.7 people per 100,000 of the photosensitive population. Spin rates for Siemens, Repower, GE, and Vestas, four of the most popular turbines in use in wind turbine farms today, range from 6 to 17.1 rpms (Knopper et al., 2014), well below this 60 rpm threshold. This has led the Massachusetts Department of Environmental Protection and Department of Public Health (2012) to conclude that the scientific evidence suggests that shadow flicker associated with wind turbine operations does not pose a risk of inducing seizures in people with photosensitive epilepsy.

Summary and ODH Assessment: Information to date does not indicate a public health burden from shadow-flicker caused by wind turbines.

Electromagnetic Fields (see the separate Summary Sheet on EMF)

Concerns about the ever-present nature of EMF and possible health effects have been raised globally for a number of years. However, the science around EMF and possible health concerns has been extensively researched, with tens of thousands of scientific studies published on the issue and many government and medical agencies weighing in on the issue. The weight of scientific evidence does not support a causal link between EMF and health issues at the levels typically encountered by most people (Knopper et al., 2014).

Recently, concerns about exposure to EMF from wind turbines, and associated electrical transmissions, have been raised at public meetings and legal proceedings. There has been only limited research conducted on wind turbine emissions of EMF, either from the turbines themselves, or from the power lines required for the distribution of the generated electricity. Israel et al. (2011) conducted investigations of EMF, sound, and vibration measurements surrounding one of the largest wind turbine energy parks in Bulgaria. The park consisted of 55 Vesta V90 3 MW towers. EMF levels within 2-3 m of the wind turbines were between 0.133 and 0.225 mG (milligauss) (equal or lower than magnetic field measurements reported proximal to typical household electrical devices). These levels were more than four orders of magnitude below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guideline of 2,000 mG for the general public for acute exposure (ICNIRP, 2010). These authors determined that "the studied wind power park complies with requirements of the national and European legislation for human protection from electric and magnetic fields up to 1 kHz and does not create risk for both workers in the area of the park and the general population living in the nearest village."

Summary and ODH Assessment: Information to date does not indicate a public health burden from electromagnetic fields generated by any part of a wind turbine or wind farm.

Overall Summary

There is no significant body of peer-reviewed, scientific evidence that clearly demonstrates a direct link between adverse physical health effects and exposures to noise (audible, LFN, or infrasound), visual phenomena (shadow flicker), or EMF associated with wind turbine projects.

Epidemiological studies have shown associations between living near wind turbines and annoyance. Annoyance is related to personal factors (such as noise sensitivity) and negative attitudes and expectations (the nocebo effect) towards wind turbines rather than being related to specific physical characteristics of wind turbine projects (McCunney et al., 2014; Chapman and Crichton, 2017). In their 2017 report "Wind Turbine Syndrome: A Communicated Disease", authors Chapman and Crichton conclude based upon a review of studies on Wind Turbine Syndrome available at the time:

> "…that annoyance can sometimes generate health problems consistent with those associated with stress and anxiety, but that there is no strong evidence of direct health effects from turbine exposure. Moreover, [the studies] conclude that pre-existing negative attitudes to windfarms are generally stronger predictors of annoyance than distance from the turbines or recorded levels of noise." (pp. 130-131)

To summarize, there may be some amount of negative health impact caused by stress and anxiety resulting from annoyance and negative emotions surrounding the construction of new wind installations, but not because of noise, shadow-flicker, or EMFs. In the case of wind farms, it is very likely that education which emphasizes a lack of a proven correlation between noise, visual phenomena, and EMFs and direct health effects will mitigate much of the pre-existing negative attitudes and prevent or reduce stress.

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