Bulletin of Science, Technology & Society
http://bst.sagepub.com/

Occupational Health and Industrial Wind Turbines : A Case Study

Robert W. Rand, Stephen E. Ambrose and Carmen M. E. Krogh

Bulletin of Science Technology & Society 2011 31: 359 originally published online 22 August 2011
DOI: 10.1177/0270467611417849

The online version of this article can be found at:
http://bst.sagepub.com/content/31/5/359

Published by:
SAGE
http://www.sagepublications.com

On behalf of:
National Association for Science, Technology & Society

Additional services and information for *Bulletin of Science, Technology & Society* can be found at:

Email Alerts: http://bst.sagepub.com/cgi/alerts

Subscriptions: http://bst.sagepub.com/subscriptions

Reprints: http://www.sagepub.com/journalsReprints.nav

Permissions: http://www.sagepub.com/journalsPermissions.nav

Citations: http://bst.sagepub.com/content/31/5/359.refs.html

>> Version of Record - Mar 7, 2012

OnlineFirst Version of Record - Aug 22, 2011

What is This?

Downloaded from bst.sagepub.com at SAGE Publications on January 8, 2013

Ex K 4 - 1

Bulletin of Science, Technology & Society
31(5) 359–362
© 2011 SAGE Publications
Reprints and permission:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/0270467611417849
http://bsts.sagepub.com
SAGE

Occupational Health and Industrial Wind Turbines: A Case Study

Robert W. Rand[1], Stephen E. Ambrose[2], and Carmen M. E. Krogh[3]

Abstract

Industrial wind turbines (IWTs) are being installed at a fast pace globally. Researchers, medical practitioners, and media have reported adverse health effects resulting from living in the environs of IWTs. While there have been some anecdotal reports from technicians and other workers who work in the environs of IWTs, little is known about the occupational health sector. The purpose of this case study is to raise awareness about the potential for adverse [redacted] effects occurring among workers. The authors propose that there is a need for research regarding occupational worker exposure relating to IWTs.

Keywords

industrial wind turbines, occupational health, adverse health effects, case study

Industrial wind turbines (IWTs) are becoming more prolific worldwide. Ongoing technical support from engineers, technicians, and other personnel are required to maintain and operate the wind energy facility. As well, farm and other operators such as truck drivers are frequently exposed to the emissions associated with the operations of the wind turbines.

There is a paucity of information relating to the risks to occupational exposure. This article will report on an incident involving worker exposure. It is expected this case study will encourage research on this topic to ensure protection and mitigation of worker exposure.

Setting the Stage

The authors were commissioned to conduct a study at a wind turbine facility where residents were complaining about noise issues and [redacted] The complaints were correlated with the start of operations of two IWTs. The study was privately funded under a grant and was independent of any developer or group opposing IWTs.

The purpose of the study was to evaluate the presence or absence of sound in the low-frequency and infrasonic range. The primary area of interest was from 1 to 200 hertz.

Two IWTs were involved—one owned by the township and the other privately owned. Operation of the facilities started in 2010. Prior to the operation of the IWTs, there were no noise complaints such as those now being reported postoperation. The requests for mitigation ranged from complaints, to appeals to stop the noise, to requests for stays of operation with legal representation.

As a result of the complaints, the township capped the operations of its turbine so that at 10 meters per second wind speed at the hub, the turbine was shut off. This is reported to have provided some relief. However, the privately owned turbine was not capped and continued to operate.

The study took place over a 2-day period inside a home where people [redacted] e home owners reported symptoms of nausea, dizziness, irritability, and cloudy thinking; had incurred falls and injury from loss of balance; and were severely affected to the point where abandoning the home was being considered. It is a custom-built, highly insulated, solidly constructed retirement home of 10 years. The home is 1,700 feet (520 meters) from the privately owned turbine and 4,200 feet (1,280 meters) from the township-owned turbine. The terrain is predominately gently rolling rural countryside with modest changes of elevation including glacial moraine, stream valleys, and sand quarries.

Technical Details and Conditions

The study took place over a 2-day period.

Weather Conditions During Study

The weather generally showed an early summer pattern with wind speeds at the hub of 20 to 25 m/s by midmorning. Ground wind speed was light during the day. At night, hub wind speed was light, with ground wind speed about zero

[1]Rand Acoustics, Brunswick, ME, USA
[2]S. E. Ambrose & Associates, Windham, ME, USA
[3]Killaloe, Ontario, Canada

Corresponding Author:
Robert W. Rand, Rand Acoustics, Brunswick, ME 04011, USA
Email: rrand@randacoustics.com

Downloaded from bst.sagepub.com at SAGE Publications on January 8, 2013

and no background noise except that of distant traffic, which died off in the early hours of the day. Average wind shear at hub height was documented previously by two independent researchers at 0.47.

Day 1: Changeable with wind speeds 25 to 30 meters per second at the hub, gusting to more than 35 meters/second. Wind direction west–southwest. Barometer "low" and variable. Sunny and partly cloudy. Temperature 45 to 50 degrees Fahrenheit

Day 2: Sunny with wind speeds 15 to 20 meters per second at the hub, gusting to 25 to 30 meters/second. Wind direction west–southwest. Barometer "low" and rising during the day. Temperature 45 to 50 degrees Fahrenheit

Day 3: Winds stopped and the study concluded

Turbine Make and Model

Vestas V82, 1.65 megawatts, hub height 80 meters, diameter 82 meters. Both turbines were manufactured and shipped at the same time.

Distance From the Wind Turbine

Private home, 1,700 feet (520 meters).

Instrumentation

The table below lists the instruments used to perform the study.

Instrumentation list
Outdoor/indoor dual-channel system
Microphone: GRAS, Model 40AN, sn 27538
Preamplifier: Larson Davis, Model 2221, sn 0107
Microphone: Bruel & Kjaer, Model 4165, sn 844497
Preamplifier: Larson Davis, Model 902, sn 0235
Sound meter: Larson Davis, Model 824, sn 0914
Audio interface: Sound Devices USB Pre 2, sn HB0411005004
Acoustic calibrator: Bruel & Kjaer, Model 4230, sn 1103065
Digital audio recorder: M-Audio, Model Microtrack II, sn 138AOC8107245
Computer: Acer 5745 i3cpu, Win7; Spectraplus 5.0, sn 5879.
Roving and stepped distance measurement system
Microphone: Svantek, Model SV22, sn 4012682
Preamplifier: Svantek, Model SV12L, sn 5552
Sound meter: Svantek, Model 949 SLM, sn 6028
Acoustic calibrator: Larson Davis, Model CAL200, sn 2425
Digital audio recorder: Tascam, Model DR100, sn 0030486
Computer: Sony VAIO, Win7, Spectraplus 5.0

Method

Testing was performed primarily inside the home. At times sound measurements were taken simultaneously inside and outside the home. Particular attention was given to measurements below 20 hertz and included determining the noise reduction that occurred between the inside and outside values. Standards ANSI S12.9, ANSI S12.18, and ASTM E966-02 were used. In later analysis, data were digitally compensated for flat response to 1 hertz.

Study Results

Day 1

The authors were unable to prepare their instrumentation or acquire calibrated data from arrival to midnight due to encountering unexpected and severe [redacted] similar to those described by the home owners. At midnight they left the house and conducted a series of stepped measurements at 275, 830, and 1340 feet (84, 253, and 408 meters) from the turbine. They concluded outdoor measurements due to rain and returned to the house at 1:50 a.m. Long-term recording was conducted indoors from 2 a.m. to 8 a.m. during sleeping hours.

Day 2

The authors left the house to have breakfast and experienced relief from symptoms once they were more than a mile away from the IWTs. They returned later and found that the symptoms returned almost as strongly as the previous day. They conducted a series of tests with inside–outside microphones during the afternoon with winds at the strongest of the day. The wind turbine noise controlled the outdoor sound levels at 42 to 44 dBA.

Day 3

The winds were calm in the morning and the nearest turbine was off. The authors found that the [redacted] symptoms were considerably lessened from the previous 36 hours. Recordings were made of the ambient sounds of the morning for comparison to turbine sound during later analysis. Sounds included vehicle operations in a quarry some distance away, distant and occasional local traffic, and birds, with sound levels 32 to 28 dBA.

Findings

Overall, there was a strong correlation between the wind speed, resulting wind turbine operation level, and [redacted] e strongest effects were experienced indoors with hub height winds at 25 meters per second with gusts to 35 meters per second. The strongest correlation between physical symptoms and wind turbine acoustic emissions was judged to be the change in the modulated infrasonic sound level measured in dBG over a quiet background. Low background sound levels and infrasonic levels modulating or pulsing above 60 dBG were found to be

Downloaded from bst.sagepub.com at SAGE Publications on January 8, 2013

Ex K 4 - 3

Table 1. Nearest Turbine Data and [redacted] House Under Study

Hub wind speed (meters/second)	Industrial wind turbine output (kilowatt)	Study location	dBA	dBG	Symptoms experienced
25, gusts to 35	1,600-1,700	Indoors	NA	NA	Nausea, dizziness, irritability, headache, loss of appetite, inability to concentrate, need to leave anxiety
		Outdoors	NA	NA	Felt miserable, performed tasks at a reduced pace
18-20, gusts to 30	1,350-1,500	Indoors	18-20	51-64	Dizzy, no appetite, headache, felt miserable, performed tasks at a reduced pace. Desire to leave
		Outdoors	42-44	54-65	Dizzy, headache, no appetite. Slow. Preferred being outdoors or away
<6, calm	OFF	Indoors	18	39-44	Improvement in health. Fatigue and desire to leave
		Outdoors	32-38	49-54	Improvement in health. Fatigue and desire to leave

present when adverse health symptoms were also present. This was noted as consistent with the research findings of Salt and Hullar (2010) that certain structures in the inner ear are sensitive to infrasound and can be stimulated by low-frequency sounds at levels starting at 60 dBG, well below levels that can be heard. The stimulation is maximal at low background sound levels (e.g., indoors). The authors found that when the wind turbine modulating, pulsing infrasonic levels dropped below 60 dBG (nearest wind turbine OFF), there was improvement in [redacted] status.

Worker Exposure and Adverse Health Effects

The authors experienced severe [redacted] during the study procedures. One author experienced a high degree of irritability within a few minutes of arriving at the home. This was not usual as the author is normally calm. The irritability rapidly progressed to loss of cognitive function to the point where there was an inability to perform routine tasks. Dizziness progressing to apparent vertigo occurred.

The second author experienced headache, loss of appetite, and anxiety and also was not able to perform routine tasks. He was unable to concentrate and had difficulty finishing a thought or sentence. There was a strong desire to leave the area to seek relief.

Overall, there was a loss of ability to perform tasks that were second nature. Simple tasks such as calibrating a meter, which were "automatic" functions due to 30 years of experience, were beyond the ability of the authors for some hours.

A summary of the impacts is that on Day 1 when the winds were high, the authors felt terrible and were debilitated and unable to perform simple tasks. On Day 2, when the winds were lower, the technicians felt a bit better but were still miserable and continued to have difficulty focusing on completing required tasks. On Day 3, with the turbine off, there was improvement in [redacted] status, but there remained a desire to leave the area.

In both cases, it took about 7 days for the recovery from the adverse [redacted] effects. One author was still experiencing some symptoms 7 weeks later.

Conclusion

Globally, there are reports of adverse [redacted] effects correlated with the onset of operations of IWTs (Harry, 2007; Krogh, Gillis, Kowen, & Aramini, 2011; Nissenbaum, 2009; Phipps, Amati, McCoard, & Fisher, 2007; Pierpont, 2009). Pedersen, van den Berg, Bakker, and Bouma (2009) and Pedersen and Waye (2004, 2007) have published peer-reviewed articles regarding the negative effects being reported.

There have been some anecdotal reports from technicians and workers in specialized fields such as electrical and engineering. In addition, there have been several anecdotal reports from other workers such as farmers and operators of heavy equipment (CK, personal communications, 2009 to 2011).

Those working in the environs of IWTs may be at risk for occupational exposure. Technicians and other workers such as farmers and IWT site staff employed for maintenance and other duties may be at risk to symptoms. Others at risk could include truck drivers and other equipment handlers.

This case study report is intended to raise the awareness of occupational [redacted] risks. There are unanswered questions about worker exposure. This will require independent research to determine the risks.

Authors' Note

Throughout this article, the term *author(s)* applies to Rand and Ambrose.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Downloaded from bst.sagepub.com at SAGE Publications on January 8, 2013

Ex K 4 - 4

References

Harry, A. (2007). *Wind turbines, noise and health*. Retrieved from http://docs.wind-watch.org/wtnoise_health_2007_a_harry.pdf

Krogh M. E., Carmen, Gillis L., Kouwen N., & Aramini J. (2011). WindVOiCe, a Self-Reporting Survey: Adverse Health Effects, Industrial Wind Turbines, and the Need for Vigilance Monitoring. *Bulletin of Science Technology & Society*, *31*, 334. doi: 10.1177/0270467611412551

Nissenbaum, M. (2009). *28 wind turbine installations at Mars Hill, Maine: Health survey with control group, prepublication preliminary analysis*. Retrieved from http://docs.wind-watch.org/nissenbaum-mars-hill.pdf

Pedersen, E., van den Berg, F., Bakker, R., & Bouma, J. (2009). Response to noise from modern wind farms in the Netherlands. *Journal of the Acoustical Society of America*, *126*, 634-643.

Pedersen, E., & Waye, K. P. (2004). Perception and annoyance due to wind turbine noise: A dose-response relationship. *Journal of the Acoustical Society of America*, *116*, 3460-3470.

Pedersen, E., & Waye, K. P. (2007). Wind turbine noise, annoyance and self-reported health and well being in different living environments. *Occupational and Environmental Medicine*, *64*, 480-486. doi:10.1136/oem.2006.031039

Phipps, R., Amati, M., McCoard, S., & Fisher, R. (2007). *Visual and noise effects reported by residents living close to Manawatu wind farms: Preliminary survey results*. Retrieved from http://www.wind-watch.org/documents/visual-and-noise-effects-reported-by-residents-living-close-to-manawatu-wind-farms-preliminary-survey-results/

Pierpont, N. (2009). *Wind turbine syndrome: A report on a natural experiment*. Santa Fe, NM: K-Selected Books.

Salt, A. N., & Hullar, T. E. (2010). Responses of the ear to low frequency sounds, infrasound and wind turbines. *Hearing Research*, *268*, 12-21. doi:10.1016/j.hears.2010.06.007

Bios

Robert W. Rand is a principal author with over 30 years of experience in industrial noise control, environmental sound, and general acoustics. A member of the Institute of Noise Control Engineering since 1993, he runs a small business providing consulting, investigator, and design services in acoustics.

Stephen E. Ambrose is a principal author with over 35 years of experience in industrial noise control. A member of the Institute of Noise Control Engineering since 1978, he runs a small business providing cost-effective environmental noise consulting services for industrial and commercial businesses, municipal and state governments, and private citizens.

Carmen M. E. Krogh, BScPharm, who provided health-related research and reference support, is a retired pharmacist with more than 40 years of experience in health. She has held senior executive positions at a major teaching hospital, a professional association, and Health Canada. She was a former Director of Publications and Editor in Chief of the *Compendium of Pharmaceutical and Specialties* (*CPS*), the book used in Canada by physicians, nurses, and other health professions for prescribing information on medication.

Downloaded from bst.sagepub.com at SAGE Publications on January 8, 2013

Ex K 4 - 5