Wind Turbines and Shadow Flicker: Facts and Proven Mitigation Strategies

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As wind development continues to grow and expand into new regions, the industry understands community concerns regarding potential shadow flicker from wind turbines. Wind developers prioritize being a good neighbor and long-term partner with host communities and recognize the need to collaborate with community members on wind turbine siting to limit potential impacts. The overwhelming majority of homes within a project footprint usually do not experience any shadow flicker.

What is Shadow Flicker?

Shadow Flicker occurs when rotating wind turbine blades pass between the sun and an individual's home, casting a periodic shadow that may result in a flickering phenomenon. However, it cumulatively only occurs for a few hours per year. Shadow flicker is more common around sunrise and sunset when the shadows are long since the sun is low on the horizon. Shadow flicker duration can be longer at high latitudes due to the sun's low position on the horizon, which results in longer shadows.[1]

The orientation of and the distance between the wind turbine and a home affect the perception and intensity of the shadows cast by the blades. The closer the home is to the wind turbine the more intense the shadow flicker appears. However, obstacles including vegetation, terrain, or other structures between receptors and wind turbines may greatly reduce or eliminate shadow-flicker at the receptor. It is important to note that shadow flicker does not occur when fog or clouds obscure the sun, or when turbines are not operating. As the sun's position changes seasonally, the potential for shadow flicker may be limited to certain months.

Modeling and Mitigation

Shadow flicker can be minimized with proper planning and siting. The duration of shadow flicker in hours per year can be calculated using software routinely used in wind energy project design. These models can provide the results in graphical and tabular format. The models incorporate project information such as proposed wind turbine locations, along with homes and other potentially sensitive locations; site topography data; weather data; and wind turbine dimensions (e.g., hub height and rotor diameter). Because developers have techniques to model the potential shadow flicker at neighboring residences, they can often adjust wind turbine locations to reduce the shadow flicker. However, given the spacing requirements between turbines as well as the presence of scattered residences in rural areas, it is difficult to reduce shadow flicker to zero hours at all residences.

A study funded by the Department of Energy's Office of Energy Efficiency and Renewable Energy investigated the impacts of shadow flicker to residents living within 1 mile of the nearest wind turbine around 15 wind farms. They reported "Relatively few participants perceived shadow-flicker on their property, particularly in the U.S."[2]

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[1] U.S. Department of Energy (DOE). 2015. Wind Vision: A New Era for Wind Power in the United States. Accessed October 5, 2020: https://www.energy.gov/sites/prod/files/2015/03/f20/wv_full_report.pdf

[2] Gundula Hübner, Johannes Pohl, Ben Hoen, Jeremy Firestone, Joseph Rand, Debi Elliott, Ryan Haac. 2019. Monitoring annoyance and stress effects of wind turbines on nearby residents: A comparison of U.S. and European samples. Accessed October 30, 2020: https://www.sciencedirect.com/science/article/pii/S0160412018323353.

Shadow Flicker Is Not A Health Concern

In 2012, the Massachusetts Department of Environmental Protection, in collaboration with the Massachusetts Department of Public Health, commissioned a study that included a panel of independent experts to identify any documented or potential health impacts that may be associated with exposure to wind turbines.[3] The panel of experts concluded that there is no scientific evidence to suggest that shadow flicker negatively effects health.

Some people have wondered if shadow flicker can increase risk of seizures in the small percentage of those people with photosensitive epilepsy. Photosensitive epilepsy affects approximately 3 percent of people with epilepsy, where flashing lights can trigger seizures . The Epilepsy Foundation reports:

"Generally, flashing lights most likely to trigger seizures are between the frequency of 5 to 30 flashes per second (Hertz)." [4]

The Massachusetts study found that for these individuals, shadow flicker from wind turbines does not pose a seizure risk due to the fact that shadow flicker from modern commercial wind turbines occurs at "flash" frequencies between 0.3 and 1 Hertz. Massachusetts Institute of Technology (MIT) researchers also concluded shadow flicker "would pose negligible risk to developing a photoepileptic seizure."[5]

Industry Position

The industry understands neighboring residents may have concerns about shadow flicker. Throughout the United States a common regulatory target is 30 hours per year at homes, which represents less than 0.3 percent of annual daylight hours. The target of 30 hours per year is based on an expected or realistic scenario incorporating cloud cover and operational statistics. This results in an acceptable balance of those wishing to host turbines on their land and their neighbors, and it means homes in proximity to wind turbines will not experience shadow flicker 99.7 percent of the year. Therefore, the industry recommends a limit of no less than 30 hours per year at a nonparticipating home.

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3 Wind Turbine Health Impact Study: Report of Independent Expert Panel. Prepared for: Massachusetts Department of Environmental Protection Massachusetts Department of Public Health, January 2012. Accessed October 6, 2020: https://www.mass.gov/doc/wind-turbine-health-impact-study-report-of-independent-expert-panel/download.

4 Epilepsy Foundation.

5 Robert J. McCunney, MD, MPH, Kenneth A. Mundt, PhD, W. David Colby, MD, Robert Dobie, MD, Kenneth Kaliski, BE, PE, and Mark Blais, PsyD. 2014. Wind Turbines and Health. A Critical Review of the Scientific Literature. Accessed October 30, 2020: https://journals.lww.com/joem/Fulltext/2014/11000/Wind_Turbines_and_Health__A_Critical_Review_of_the.9.aspx.