# Wind Power: Frequently Asked Questions



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## WIND POWER IS A CRITICAL PART OF IMPLEMENTING THE TOMPKINS COUNTY ENERGY ROADMAP

Tompkins County has set goals to reduce greenhouse gas emissions by at least 80 percent (from 2008 emission levels) by the year 2050, and to reduce fossil fuel use across all sectors. It is also a priority of Tompkins County to increase the use of local and regional renewable energy sources and technologies.[1] Achieving those goals requires substantial commitment to building wind, solar, micro-hydro, and biomass facilities in the County. Of all of these options, utility scale wind turbines are currently the lowest cost installations per kilowatt-hour of energy produced.

Although the wind we have here is less intense than in other areas of the U.S., using a range of right-sized turbines—small and medium scale turbines for home, farm, or small business use in areas of lower wind speeds plus larger utility scale turbines located where wind speeds are highest—could theoretically provide us with 327 percent of our total 2008 electricity demand.[2]

While Tompkins County has been experiencing a rapid build out of solar installations, the County has no utility scale wind turbines yet operational. The County's Energy Road Map projects wind resources that would support the following wind turbine development: small-scale, 18.4 MW; medium-scale, 745.5 MW; and utility scale, 180 MW.[3]

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**What is the size of a utility scale turbine?**

Utility-scale wind turbines consist of a tubular steel tower supporting both a "hub" that secures the wind turbine blades, and a "nacelle" that houses the turbine's shaft, gearbox, generator, and controls. Tower heights of 200-330 feet are common. When blade length is added, total height can typically range from 400-500 feet. These measurements vary depending on manufacturer and model. Towers are commonly constructed to be about 10 feet in diameter at their base.

**How is a wind turbine constructed?**

A turbine is trucked to the site in several parts, including 3-4 tower segments, 3 blades, the hub (where the blades and pole connect), and the nacelle. These parts are assembled onsite using a specialized crane and other power equipment. While construction of a commercial turbine requires a flat staging area of about 3 acres, the final footprint of an individual turbine, including the base on which it is mounted, is about a quarter acre.

**How are turbines anchored to the ground?**

Construction of a commercial turbine base requires a flat spot of about a quarter acre, depending on the turbine capacity, rotor diameter, tower height, and soil characteristics. The base of the steel tower is anchored to a platform consisting of more than a thousand tons of concrete and steel rebar. Such a foundation would typically be 6 to 10 feet deep, depending on the soil type. If needed by the geology of the site, anchor pilings may be driven down to bedrock to further stabilize the platform.

**How does wind power generate electricity?**

A wind turbine is a machine that converts wind energy into electrical energy. Wind blowing past the blades causes them to rotate. Blade rotation spins the internal shaft connected to the gear

[1] Tompkins County 2020 Energy Strategy (2010) and Tompkins County Comprehensive Plan (2015)

[2] Tompkins County Energy Roadmap, Wind Energy, Executive Summary (2016)

[3] Tompkins County Energy Roadmap, Wind Energy, Executive Summary (2016)
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box. The gears control and multiply the spin of the shaft and turn the generator, which creates electricity. The voltage is then increased via a step-up transformer and delivered by the transformer into the electricity grid.

**If the turbines are on farm land, does that take much of the land out of production?**

No. The land around and between commercial size wind turbines can be used to graze livestock or grow crops. For typical wind turbines in the U.S. the amount of land that remains impacted during the operation of a typical 2 MW turbine (including access roads) is just 1.5 acres.[4] Further, the lease on this land can provide supplemental income to the farmer.

**If the wind stops blowing does our energy supply stop?**

No, it does not. Today's electric grid consists of a vast network of interconnected power transmission lines that span the U.S. and Canada. Power transmission on the grid is managed by regional system operators whose sophisticated technology allows them to measure and adjust, within seconds, the power supply to any given area. The electric grid is in a constant state of flux—one moment a large industrial motor starts up, at another moment, a squirrel shorts out a transformer—but these supply and demand fluctuations are readily accommodated, just as wind (and solar) intermittency are accommodated. Wind and solar resources become less variable if aggregated across a broader geographic region. The bigger the geographical area linked up by power lines, the more likely it is that the sun is shining or the wind is blowing somewhere within that area.

Even as wind power generation becomes a higher percentage of New York's electric generation than currently exists, modeling shows it will be effectively and economically managed, and thus the intermittent nature of wind will not result in negative impacts on grid reliability or efficiency.[5] In addition, through improved forecasting, geographic distribution, and other techniques, wind power does not have to rely on reserve capacity to back up 100 percent of its generation. For example, a study of Minnesota's grid found that going to 25 percent wind power in the State by 2020 would have no impact on spinning or non-spinning reserve capacity requirements and would require a minimal increase of total operating reserves from 5 percent before the increase in wind power to just over 7 percent.[6]

A modern wind turbine produces at least some electricity 70-85 percent of the time, generating varying quantities of electricity at different wind speeds. The wind is generally stronger at night than in the day, and stronger in the winter than in the summer which makes wind a good complement to solar electric generation. System operators in California, New York and New England have released data showing that wind power provided critical energy when they needed it most in the winter of 2014.

**How much electricity does one utility scale turbine generate?**

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[4] Denholm et al. 2009

[5] EnerNex 2006, Lew et al. 2010, Milligan 2010, GE 2010, EnerNex 2011, Lew et al. 2013, Miller et al. 2014, Corbus et al. 2014, and Ela et al. 2014

[6] EnerNex 2006

An average onshore 2 MW wind turbine will produce approximately 4.1 million kWh in a year in New York, or the equivalent electric use of more than 620 average NYS households.[7] The capacity factor (actual average power generated divided by the rated peak power) for an average New York wind turbine is 23 percent, comparable to the 29 percent capacity factor of natural gas generators in NYS.[8] This gap would be smaller were it not for the fact that presently grid operators in New York prefer wind farms rather than fossil fuel plants to shut down when excess generation is taking place.

**How well-established is the technology?**

Commercial wind farms have been in existence for over 35 years. The world's first commercial scale wind turbine (1 MW) was built and connected to the grid in Vermont in 1941. In the 1970's NASA began research into large-scale commercial turbines and installed 13 experimental units in Ohio. In 1980, the world's first commercial wind farm, consisting of 20 turbines was installed in New Hampshire. Today, every state in the United States has an operational wind energy project, a wind-related manufacturing facility, or both.

As of the end of 2015, world wind turbine capacity is approximately 428 GW (428 billion watts). In the U.S. and Puerto Rico alone, there was nearly 66 GW of wind capacity generated by roughly 46,000 operational turbines in 2014. During the last decade there has been a more than seven fold increase in wind power generation in the U.S.[9]

General Electric (GE) turbines account for more than 40 percent of U.S. installed wind capacity. Along with manufacturers Vestas and Siemens, these three companies account for roughly three-quarters of all wind power installed in the U.S. The leading turbine designs from these manufactures have extensive experience in the U.S. and around the world. For example, through 2014, the GE 1.5 MW family of turbines has accumulated more than 92,000 turbine-years of experience in the U.S. alone.[10] The Siemens 2.3 MW family of turbines and the Vestas 1.65 MW and 1.8 MW turbines have accumulated more than 25000,14,000, and 10,000 turbine-years of experience respectively. In New York alone, operating wind farms have accumulated more than 4,000 turbine-years of experience with GE turbines, and more than 2,300 turbine-years of experience with Vestas turbines. Even newer models, such as the GE 2.5 MW family of turbines that has been proposed for use at the first wind farm proposed in Tompkins County, has significant operating experience. For example, the North and South Hurlburt Wind Farms and the Horseshoe Bend Wind Farm in northern Oregon have already accumulated more than 1,250 turbine-years of experience with these turbines. Finally, turbines with larger blades than those so far proposed for use in Tompkins County also have significant operating experience in the U.S.

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[7] EIA 2009, EIA 2015, and EIA 2015b

[8] EIA 2015 and EIA 2015b

[9] DOE 2016

[10] A turbine-year is a way to express the cumulative operating time of a collection of wind turbines. For example, 10 wind turbines operating over 5 years would amount to 50 turbine-years of experience.

with more than 1,500 turbine-years of operation accumulated to date for wind turbines with blades more than 107 meters in diameter.[11]

While the industry is experimenting all the time with measures to make turbines more efficient and less expensive, this is now a very proven technology.

**What is wind's capacity to contribute to renewable energy in the US?**

The more than 48,000 wind turbines operating in the U.S. generated enough electricity to power more than 16 million homes and accounted for more than 4.4 percent of all electricity generated by U.S. utilities in 2014. Between 2003 and 2013, wind energy provided nearly 40 percent of all new, net electricity generation capacity installed in the United States. New York is currently home to more than 1,730 MW of wind capacity accounting for nearly three percent of the state's electricity generation.[12]

A report from the U.S. Department of Energy estimates that wind energy could provide up to 20 percent of our nation's electricity by the year 2030, while supporting roughly 500,000 jobs, increasing annual property tax revenues and payments in lieu of taxes by nearly $1.9 billion, generating nearly $800 million in land lease payments, and reducing greenhouse gas emissions by 825 million metric tons (equivalent to removing 180 million or 70 percent of today's light-duty vehicles from the road).[13]

**Do wind turbines bring environmental benefits?**

Wind turbines produce no greenhouse gas emissions during their operation, produce no waste or water pollution, and do not require water for cooling purposes. Using wind energy to create electrical energy is a significant net positive for the environment. In 2014, wind turbines in the U.S. prevented the emission of roughly 100 million metric tons of $CO_2$ (carbon dioxide) by displacing conventional fossil fuel generation from the U.S. electric sector. This is equivalent to the emissions savings from taking more than 20 million cars off the road in the U.S. In addition, wind power also helped reduce $SO_2$ (sulfur dioxide) emissions (a cause of acid rain and a respiratory human health hazard) in the U.S. by nearly 160,000 metric tons, and reduced $NO_x$ (nitrogen oxides) emissions (a cause of smog and acid rain) by more than 93,000 metric tons in 2014.[14] In New York alone, the amount of wind power produced in 2014 was enough to displace nearly 13 million cubic feet of natural gas from the electric sector, equivalent to the natural gas use of nearly 200,000 homes.[15]

In terms of the life cycle of the turbine, the energy created far exceeds the energy used to make and then, much later, recycle the components. Turbines typically have a useful life of 20-25 years. In the first 6-12 months of operation, depending on the quality of the site's wind resource,

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[11] Diffendorfer 2015 and EIA 2015e (Note: The turbines deployed in Oregon are in the same family as those proposed for use in Tompkins County, however, their blade diameter is 100 meters versus 107 meters. The largest blades deployed in the U.S. through mid-2014 are 117 meters in diameter.)

[12] EIA 2009b, Diffendorfer 2015, EIA 2015, EIA 2015b, and EIA 2015e

[13] DOE 2008 p. 14, 205-206, and 209

[14] EIA 2015 and EIA 2015c

[15] EIA 2009b, EIA 2015 and EIA 2015d

a turbine creates as much energy as is used to produce and decommission the turbine. During its lifetime a wind turbine delivers up to 80 times more energy than is used in its production, maintenance and removal. In this regard, wind energy has an even better energy return than solar panels.

**What sounds do turbines make?**

Modern low RPM (Revolutions Per Minute) turbines are very quiet, with sound levels usually below that of typical ambient noise in the home. Wind turbine sounds come from two primary sources, mechanical and aerodynamic. As with many technologies, there have been substantial improvements over time. Noise reduction often coincides with increases in turbine efficiency, so industry has been particularly motivated to make these improvements. Measured sound levels from wind turbines depend on several factors, including weather conditions, the number of turbines, turbine layout, local topography, the particular turbine being used, distance between the turbines and the listener, local vegetation, and the time of day and time of year. As noted above wind power and thus wind turbine noise tends to be greater at night and in the winter.

*Mechanical* sounds originate from the various moving parts within the wind turbine: the generator, the hydraulic systems, and the gearbox. The sound is associated with the rotation of mechanical and electrical equipment as it produces electricity. Strategies to mitigate these mechanical sounds including suppression and isolation of vibration and fault detection are commonly used in modern turbines. In turbines using these strategies, mechanical noise is not generally audible above the aerodynamic noise of the blades or the ambient noise in the environment other than during the brief application of mechanical brakes.[16]

*Aerodynamic* noise is associated with the movement of the blades through the air. This is the dominant source of audible noise from wind turbines. However, these aerodynamic sounds can often be masked, at least in part, by other sources of ambient noise such as wind blowing through the trees or over houses, the movement of nearby cars and trucks on the road, or other sounds in the home like the compressor on a refrigerator or the blower fan of a furnace.

Aerodynamic sound generally increases with the rotational speed of the blades when turbulence in the air layers near the blades is more strongly generated. Strategies for reducing aerodynamic noise include adaptive approaches and wind turbine blade modification methods.[17] While the aerodynamic sounds associated with turbine blades are complex, two types of sound—“swooshing" and "low frequency"— are the most commonly discussed. The swooshing effect is caused by the blade tip passing through the air and its changing distance from the observer as it rotates. Environmental factors including wind speed variations in space, thermal inversions and other meteorological effects, the presence of other wind turbines, and the topography of the site, may interact to modulate the swooshing sound into what is described as a thumping sound, but this thumping (more formally known as impulsive sound) is an unusual occurrence that is often transient, disappearing when the particular set of circumstances that created it pass. For example, a study by the University of Salford concluded that of 155 wind farm sites surveyed, only four exhibited instances of impulsive noise generation and at those sites, impulsive noise

[16] Tonin 2012

[17] Barone 2011 and Jianu et al. 2012

occurred 7-15 percent of the time and was able to be mitigated by changes in how the turbines were operated.[18]

Modern turbines employ a number of advanced blade design features that significantly reduce aerodynamic noise. For example, changes to blade designs have been found that can reduce the power intensity of audible sound from wind turbines by as much as half.[19]

In addition to mechanical and aerodynamic sounds, wind turbines can also produce *low frequency sound* and inaudible vibrations called *infrasound.* Low frequency sound contains frequencies in the range 20 to 100 Hz and is primarily associated with the operation of older turbine designs that had the rotor downwind of the tower. The low frequency sound in these turbine designs was caused when the blades encountered localized disturbances in the wind that had first passed around the tower. This style of turbine is no longer common.

*Infrasound* is sound with frequencies below 20 Hz. Infrasound may be generated, at least in part, by turbulence in the air interacting with the leading edge of the blade, but it is more likely caused by small variations in the flow of air over the blade as it passes in front of the tower. The sources of infrasound in modern turbines are yet to be fully explained.[20] However, measurements of sounds emitted by operating utility-scale wind turbines (low-frequency sound, infrasound, tonal sound emission, and amplitude-modulated sound) have found that the intensity of infrasound at a distance of 300 m (984 feet) from homes are well below audibility thresholds.[21]

**Is there evidence of adverse health effects from audible turbine sounds?**

With respect to wind turbine noise, the one adverse impact that is supported by epidemiological data is an association between wind farms and annoyance.[22] However, the rates of self-reported annoyance do not appear to correlate strongly, if at all, with quantitative assessments of the sound levels experienced by the population. Instead they appear more strongly influenced by other factors, including the nature and properties of the landscape, the personal views of the residents toward wind power, and whether the residents are personally benefiting from the operation of the facility.[23]

In addition, there is limited and contradictory evidence for whether annoyance or the noise created by the wind turbine blades can cause sleep disturbance. Some studies have found limited evidence associating annoyance from wind turbine noise and sleep disruption when the intensity of the sound exceeds certain levels.[24] The largest and most comprehensive study conducted to date used both subjective assessments of sleep quality as self-reported by study participants, as well as objective and quantifiable measures of sleep duration, time to the onset

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[18] Tonin 2012
[19] Barone 2011 and Jianu et al. 2012
[20] Tonin, 2012
[21] McCunney, et al. 2014
[22] Schmidt and Klokker 2014, Onakpoya et al. 2015, and Council of Canadian Academies 2015
[23] McCunney et al. 2014
[24] Schmidt and Klokker 2014, Onakpoya et al. 2015, Council of Canadian Academies 2015

of sleep, and the number of nightly awakenings. Unlike the previous works, this study found no association between exposure to noise from a nearby wind farm and any increase in the prevalence of sleep disturbances at noise levels up to 46 dB(A).[25]

Individuals vary considerably in their sensitivity to stimuli, making it difficult to rule out a given individual person experiencing effects not generally seen in the population. However, it is important to note in this context that all of the existing sources of electricity generation used in the U.S. have significant and well documented health impacts, both direct (such as particulates and mercury emitted by coal, or the impacts associated with fossil fuel extraction and transport) and indirect (such as those associated with climate change). As far back as 2004, the World Health Organization noted that "[t]he increased use of renewable energy, especially wind, solar and photovoltaic energy, will have positive health benefits."[26]

Looking at the larger picture, studies of the impact of wind farms on overall quality of life have also found conflicting results. Two large studies found that the presence of an operating wind farm had no negative effect on the quality of life of nearby residents, while one smaller study found a negative impact.[27] Of note is the finding of the largest and most recent study that impact on quality of life was reported for those living near <u>proposed</u> wind farms, but that these effects not only disappeared once the facility was in operation, but were later reversed, with those living closest to a wind farm reporting a higher quality of life than those farther from the facility.[28] This finding is similar to those of an earlier study that found that many health complaints of residents near wind farms are likely to be caused by negative expectations regarding the impact of wind turbines and stress resulting from negative publicity, rather than from direct physiological effects.[29]

### Does infrasound from utility scale wind farms cause health impacts?

There are more than 240,000 turbine-years of experience with wind turbines larger than 1 MW in size in the U.S. alone.[30] Around the world, hundreds of thousands of people live near and work at operating wind turbines without health effects attributable to infrasound.

The term "wind turbine syndrome" was coined by Dr. Nina Pierpont who, in 2009, wrote a self-published, non-peer-reviewed book in which she described a variety of symptoms that were reported to her in phone interviews by 23 people from 10 families who lived near wind farms and who responded to a wide-spread advertisement placed by Pierpont.[31]

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[25] Michaud et al. 2016. [NoteL dB(A) stands for A-weighted decibles. This is a logrithmic measure of sound intesnity that has been filtered to mimic the auitory response of the human ear to sounds of different frequencies.]

[26] WHO 2004 p. 85 and 101

[27] McCunney et al. 2014 and Mroczek et al. 2015

[28] Mroczek et al. 2015

[29] Crichton et al. 2014b

[30] Diffendorfer 2015 and EIA 2015e

[31] Pierpont 2009

Since 2009, many peer-reviewed scientific studies have been conducted and government reports issued in the United States, Canada, Australia, New Zealand, and the United Kingdom to explore the health impacts of wind farms. None of the reports have found any credible or convincing evidence of adverse health impacts attributable to infrasound.[32]

In 2012 the Massachusetts Departments of Environmental Protection and of Public Health commissioned a panel of experts with backgrounds in public health, epidemiology, toxicology, neurology and sleep medicine, neuroscience, and mechanical engineering to analyze "the biological plausibility or basis for health effects of turbines (noise, vibration, and flicker)." The review of existing studies included both peer-reviewed and non-peer reviewed literature.[33]

**Among the key findings of the panel were:**

- There is no evidence for the existence of a set of health effects from exposure to wind turbines that can be characterized as **"Wind Turbine Syndrome."**
- Claims that infrasound from wind turbines directly impacts the **vestibular system** have not been demonstrated scientifically. Available evidence shows that the infrasound levels near wind turbines cannot impact the vestibular system.
- The strongest epidemiological study suggests that there is not an association between noise from wind turbines and measures of **psychological distress** or mental health.
- None of the limited epidemiological evidence reviewed suggests an association between noise from wind turbines and **pain and stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and headache/migraine.**

Earlier studies and conclusions include:

> "The body of accumulated knowledge provides no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects."
>
> *Wind Turbine Sound and Health Effects: An Expert Panel Review* (December 2009)

> "There are no health data available to observe the effects of exposure to the low frequencies and infrasonic vibrations generated by these machines. Inside homes, with the windows closed, no nuisance has been recorded–or its impact is very unlikely given the level of noise perceived."
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> *Health Impacts of the Noise Generated by Wind Turbines,* French Agency for Environmental and Occupational Health Safety (AFSSET) (March 2008)

> "Low frequency sound and infrasound from current generation upwind model turbines are well below the pressure sound levels at which known health effects occur. Further, there

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[32] Bellhouse 2004 p. 37, DTI 2006 p. 62 and 66, AFSSET 2008, Colby et al. 2009 p. ES-1 and 5-1, CMOH 2010 p. 5, 6, and 10, Knopper and Ollson 2011 p. 8 of 10, Bolin et al. 2011 p. 5, Ellenbogen et al. 2012 p. 55-56, Crichton et al. 2014 p. 4-5, Evans, Cooper & Lenchine 2013 p. iii and 41, Chapman and St. George 2013, Chapman et al. 2014 p. 2 and 14, Crichton et al. 2014b, and McCunney et al. 2014

[33] Ellenbogen et al. 2012

is no scientific evidence to date that vibration from low frequency wind turbine noise causes adverse health effects."

*The Potential Health Impact of Wind Turbines,* Chief Medical Officer of Health (CMOH) of Ontario (May 2010)

"Based on current evidence, it can be concluded that wind turbines do not pose a threat to health if planning guidelines are followed."

*Wind Turbines and Health: A Rapid Review of the Evidence,* Australian Government National Health and Medical Research Council (July 2010)

"Infrasound (1–20 Hz) from wind turbines is not audible at close range and even less so at distances where residents are living. There is no evidence that infrasound at these levels contributes to perceived annoyance or other health effects."

*Infrasound and Low Frequency Noise from Wind Turbines: Exposure and Health Effects*, Environmental Research Letters, Vol. 6 035103 (6pp), September 2011

### Have there been successful lawsuits related to the health impacts of wind farms?

In August 2014 the Energy & Policy Institute published a report that surveyed legal cases in the U.S., United Kingdom, Canada, Australia, and New Zealand pertaining to health impacts of wind farms. It found that since 1998, 49 hearings have been held under rules of legal evidence in at least five English-speaking countries and four types of courts regarding wind energy, noise, and health. Forty-eight assessed the evidence and found no potential for harm to human health. The one outlier case did not involve testimony of a medical expert.[34]

### What is shadow flicker?

Shadow flicker is the flickering effect caused when rotating wind turbine blades periodically cast shadows through constrained openings such as windows or neighboring properties. Shadow flicker generally occurs only during early morning and late afternoon hours on sunny days when the rotating blades of a turbine are between the sun and the observer. The phenomenon is more pronounced during sunrise and sunset and is less common in much of the U.S. than in Europe due to the lower latitudes and thus higher sun angles in the United States. Shadow flicker can fluctuate in different seasons of the year depending on the geographic location of the turbine such that some sites report flicker during the winter, while others may report it during summer. Shadow flicker rates and intensity are influenced by objects in the landscape (e.g., trees and other existing shadows), by the topology of the site, and by weather patterns. For instance, there is no significant shadow flicker on cloudy days.

Shadow flicker can be a source of annoyance for people living near wind farms particularly if the shadows cross windowed surfaces in the home. There is no evidence that shadow flicker at the frequency produced by wind turbines can induce an epileptic event, as the rotational velocity of the blades is too low. Because shadow flicker is caused by the relative location of the sun, turbine blades, and observer it can be calculated exactly for all locations and thus it can be mitigated by proper siting of the turbines.

[34] Barnard 2014

**Are there other conditions that might put the public at risk?**

Under adverse weather conditions, ice can form on wind turbine blades, and this ice could potentially fall or be thrown off. To address this problem, manufacturers equip wind turbines with automated control systems that sense ice formation on the blades and shut the turbine down. In addition to these automated systems, wind farm operators can manually shut turbines down under icy conditions. These safety features both help to limit the possibility of ice being thrown from the blades and protect the tower from damage from the weight of ice. Generally, any ice shed from wind turbine blades falls, without harm, to the ground in an area directly under the turbine. The industry recommendation that setbacks from occupied structures be on the order of 1.5 times the tower height plus the rotor diameter has been shown to be sufficient to ensure the protection of property as this is further than both the theoretical maximum ice throw distance resulting from aerodynamic models as well as actual measurements of ice throw found in multi-year field studies.[35]

Under high wind conditions, modern turbines have the ability to turn their blades out of the wind to lessen the forces on the blades and towers. Typical wind turbines and towers can be designed and rated to withstand maximum wind speeds between 90 and 160 mph without suffering damage. The choice of turbine design (and thus the maximum wind speed it can sustain) is a function of the meteorological conditions expected at the site. At the low end, 90 mph is equivalent to the sustained wind speeds found in a Category 1 hurricane, while the upper wind speeds are equivalent to the sustained winds of a Category 5 hurricane.

**Do wind turbines adversely impact real property values?**

While development of all kinds – not just wind power development – can both positively and negatively affect property values, numerous studies have shown that wind turbines do not affect property values long-term.

A joint study of Massachusetts wind farms by the University of Connecticut and the U.S. Department of Energy in 2014 found "no net effects due to the arrival of turbines in the sample's communities." The analysis also showed no unique impact on the rate of home sales near wind turbines.[36] These results were consistent with earlier findings, such as a 2009 study of roughly 7,500 homes near 24 wind facilities across the U.S.; a 2012 study of home sales in New Hampshire; a 2013 study of home sales in Rhode Island; and a 2013 study of more than 50,000 homes within 10 miles of 67 different wind facilities across the U.S. Each of these studies, conducted by academics and personnel at U.S. national laboratories, found no statistically significant impact on the sale price of homes according to their proximity to a wind farm.[37] Of note is the fact that one study did find weak evidence to suggest that the announcement of a planned wind farm might have a temporary and modest impact on home values, however, these effects (if present at all) disappeared entirely after construction of the facility commenced and

[35] René at al. 2009 and Renström 2015

[36] Atkinson-Palombo and Hoen 2014

[37] Hoen et al. 2009, Hoen et al. 2011, Magnusson and Gittell 2012, Hoen et al. 2013, and Lang and Opaluch 2013

remained absent during operation of the wind farm.[38] While there is one study from 2011 that found a measureable impact on the value of homes in New York from the development of wind farms and every community's real estate markets are unique,[39] the preponderance of evidence from the Northeast and across the U.S. suggests that wind power development is unlikely to have a substantive and sustained impact on home prices in our region.

**What other environmental impacts are related to wind farm development?**

Fossil fuels that include imbedded environmental impacts are used in the manufacture, transport, and installation of turbines (accounted for as embedded energy). Installation/service roads with resulting soil and vegetation disturbance are needed to connect the wind farm to paved roads. The installation of high voltage transmission lines necessary to connect the turbines to the electric grid will also cause soil disturbance. In the U.S., the average amount of land disrupted either temporarily or throughout operation for a typical 2 MW turbine is less than five acres.[40] This can be compared to an estimated impact on more than seven acres for the construction of 2 MW of natural gas capacity due mainly to the impact of the pipelines needed to bring gas to the generating plants.[41]

**How do wind farms impact wildlife?**

Research is always in progress but three general types of impact have been documented to date: habitat fragmentation, collision or aerodynamic fatalities for flying vertebrates (birds & bats), and avoidance behavior (when wildlife avoids the project site potentially reducing their available habitat in a region). Habitat fragmentation and avoidance issues can be largely minimized by siting wind turbines in agricultural land. While poorly sited wind turbines can have significant impacts, collision fatalities can be substantively minimized by raising wind turbines in sites without migration concentration dynamics (e.g., shorelines), and by minimizing steady-burning artificial light sources near wind turbines.

Small numbers of bird fatalities and moderate numbers of bat fatalities have been documented at existing wind farms in NY. Bat fatalities are most likely to occur during mid to late summer. Bird fatalities may occur throughout the year but are most frequent during the migration and breeding periods. Direct impacts to ground-level wildlife populations have not been documented (e.g., effects on movements by big game and other large animals). On the other hand, there is a wealth of experience with farmers grazing livestock within close proximity to wind turbines in the western U.S. without adverse effect.

While wind turbines do represent a source of avian mortality, it is important to note that these impacts are in no way unique to wind power and similar impacts are inherent in many aspects of modern infrastructure that are often taken for granted in other contexts. While studies of impacts on birds are difficult and have meaningful uncertainties, estimates for the total number of birds that would be killed by the onshore wind turbines required to generate 20% of U.S. electricity

[38] Atkinson-Palombo and Hoen 2014

[39] Heintzelman and Tuttle 2011

[40] Denholm et al. 2009

[41] NRC 1996

from wind would likely be no greater than number of birds killed each year from the existing network of communication towers in the U.S.[42]

More significantly, the present sources of electricity used in New York result in substantial numbers of bird fatalities from the impacts of ecosystem destruction from mining and fossil fuel transportation as well as from the impacts of toxic emissions like mercury and those associated with climate change.[43] For example, a 2008 study found that

> Although not all species will be affected adversely, some of the Northeast's iconic species, such as common loon and black-capped chickadee, and some of its most abundant species, including several neotropical migrants, are projected to decline significantly in abundance under all climate change scenarios. No clear mitigation strategies are apparent, as shifts in species' abundances and ranges will occur across all habitat types and for species with widely differing ecologies.[44]

Even at the higher end of estimates for the impact of turbines on birds, wind power likely causes a smaller number of bird deaths per unit of electricity generated than fossil fuels (even without considerations of climate change being taken into account) and comparative studies have found that wind likely represents a smaller impact on birds than the present fuel mix in New York.[45] Thus switching from conventional sources of electricity to properly sited wind is likely to be a net positive overall for birds in New York.

To try and reduce the impacts of wind development and to ensure that proper consideration is given to siting and monitoring such facilities, the New York State Department of Environmental Conservation (NYSDEC) has published bird & bat study guidance for proposed commercial-scale wind energy development. This guidance includes two to three years of post-construction monitoring evaluating collision fatalities and impacts to habitat. Through such data, NYDEC has acquired a sense for the level of avian & bat impacts across the state, and is actively engaged in assessing and mitigating impacts to state listed species (endangered, threatened, special concern). A draft update to this guidance was published by the NYDEC in April 2016 and is currently undergoing comment as of the writing of this FAQ.

The New York State Energy Research and Development Authority (NYSERDA) has a recently developed a tool to aid wind developers in siting decisions that help to minimize potential wildlife impacts. In addition, the United States Fish and Wildlife Service (USFWS) has extensive guidance for wind energy development and encourages wind developers to work with them early in the siting process to minimize wildlife impacts. USFWS actively enforces laws involving federally protected species.

**What are the economic benefits from wind farm construction?**

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[42] Manville 2005, Smallwood 2013, Longcore et al. 2012, Loss et al. 2013, Erickson et al. 2014, Diffendorfer 2015 and EIA 2015e

[43] Thomas et al. 2004, Rodenhouse et al. 2008, Sovacool 2009, and Sovacool 2013

[44] Rodenhouse et al. 2008 p. 517-518

[45] Sovacool 2009, Sovacool 2013, and EIA 2015

In the U.S. and Puerto Rico, every state or territory has at least one wind farm, wind production facility, or both.[46] Nationwide, wind energy has created more than 73,000 jobs, including construction, maintenance, manufacturing, legal support, and marketing jobs. A 2005 report by the New York State Office of the Comptroller estimated that a 25 percent annual increase in installed wind capacity in New York would generate close to 5,500 direct jobs and more than 6,000 indirect jobs in the state. Of the directly generated jobs, about 3,100 would be manufacturing jobs and 2,000 would be year-long construction jobs, with the remainder in maintenance and operation.[47]

A wind farm puts tax money in the coffers of the host town, and provides some supplemental income to farmers whose fields are leased. The use of a payment in lieu of taxes (PILOT) agreement is common for wind farms across New York and the U.S. Typical PILOT agreements for wind farms in New York range from $6,000 per MW to $9,200 per MW annually, thus generating meaningful financial support for school systems and the broader community.[48] Some farmers may earn more income from their wind turbine leases than from their farm production. Locally produced power can reduce the energy bills for local users of power and may lessen or delay the need for new infrastructure investment to support conventional fossil fuel utilities.

Wind turbine manufacturing is roughly analogous to that for automobiles. On average, the high wages paid to skilled employees in the manufacturing sector translate into more of a "multiplier" effect in the economy where the manufacturing plant is located.

**What is the expected lifespan of a wind turbine, and how is it decommissioned?**

Wind turbines, on average, have a 20-25 year lifespan. Responsibilities for decommissioning wind turbines are addressed before the wind farm is built. Typically, the developer will post a bond for the cost of decommissioning. If the wind farm is to be decommissioned, the developer will remove the structures and return the land to its previous condition. The bulk of the material used in the turbine, such as the steel for the tower and the metals used in making the magnets inside the generator, will be recycled at the end of their lifecycle. In contrast, none of the steel and cement used in drilling oil or gas wells is recyclable. However, since the wind resource remains, and infrastructure (roads, transmission, etc.) is already in place, most wind farm developers prefer to "repower" rather than decommission. In repowering, old turbines at the end of their lifespan are replaced with new ones in the same locations.

[46] AWEA 2016

[47] NYS Comptroller 2005

[48] PILOT Agreements 2009-14

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