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SMALL TURBINE COLUMN:

Home-sized Wind Turbines and Flying Ice

--Mick Sagrillo, Sagrillo Power & Light

One nagging question that frequently comes up at zoning permit hearings for home-sized wind turbines is the possibility of ice being thrown from the blades and causing property damage or injury. It seems that some anti-wind farm NIMBY (not in my back yard) groups around the country have slowed the permitting of wind farms by raising this concern, and the issue is beginning to show up at home-size turbine hearings too. Fortunately, there are factual ways to show that, while ice is a valid concern, wind turbines flinging ice is not.

A review of the literature available identifies several papers and reports that address ice throws at large wind farms, but none about home-sized turbines. Nonetheless, it is worthwhile examining these reports to understand their relevance to home-sized wind systems, and draw any applicable conclusions.

But, first, let's look at the ice-throw concerns raised on the anti-wind Web sites. These sites typically describe a conjured-up scenario where a large chunk of ice is dislodged from a blade tip rotating at the turbine's design speed or, worse, when the turbine is unloaded and spinning at maximum speed. The chunk of ice is then assumed to fly quite far along an ideal trajectory resulting in a maximum amount of damage at the end of its long path.

The described scenario is laid out as a classic physics problem with lots of idealized assumptions, or, as physics professors often stipulate, "on a frictionless plane." The professor will lay out a perfect scenario to prove a point. However, the assumptions in the anti-wind turbine scenario reveal either an ignorance or a disregard of the physics of wind turbines. A blade coated in ice can not achieve anywhere near its top speed, and therefore the ice, if it could be thrown, would not move very far from the base of the turbine. Other "perfect" but unrealistic assumptions built into this theory are:

- The blade rotation is in the right plane to maximize the ice trajectory, distance, and subsequent damage;
- The ice chunk has an aerodynamically ideal shape for long-distance travel;
- The wind speed and direction are optimal; and
- The ice chunk remains in one piece long after detaching from the blade.

Looking more closely at the aerodynamics of wind turbine blades, one sees that they are designed as airfoils that operate on the principle of lift, just like an airplane wing. On airplanes, the lift caused by air rapidly passing over the wing's airfoil raises the wing and the plane off the ground. For wind turbines, it is this same aerodynamic lift that pulls the turbine blade through the air. However, there is also friction between the surface of the plane's wing or turbine's blade and the moving airflow which causes a certain amount of aerodynamic drag. The circular movement of a wind turbine blade, like the success of an airplane getting off the ground, depends upon a very high lift to drag ratio, and both are designed to optimize the lift-drag relationship. Reduce lift, or increase drag, and the wind turbine slows significantly. Similarly, the airplane cannot continue to fly.

Ice forms on a wind turbine's blades in relatively thin sheets, just as it does on trees, utility poles, power lines, and communication towers during an ice storm. But any ice buildup on a turbine's airfoil changes its shape, radically reducing the lift-drag ratio and increasing its surface friction. This results in the airfoil's lack of ability to develop any speed. If you watch a wind turbine operating during an ice storm, you will notice that it gradually slows down as ice adheres to the leading edge and windward surface of the blades. This phenomenon is well known to anyone who flies on a commercial airliner during the winter. Jets' wings are often "de-iced" before takeoff to prevent ice buildup on the wings that would result in the plane crashing on take-off, if it could take off at all.

A very interesting thing happened in my neighborhood this past January during one of our infrequent ice storms. Madison Gas & Electric (MGE) operates an eight-turbine wind farm about three miles west of my house. During the ice storm, the wind was still, and ice built up on roads, trees, utility poles, houses, cars, and the MGE's wind turbines. The next day, the sun broke through the clouds long enough to melt the ice off one of the MGE Vestas V-47 turbines. When the wind picked up, that turbine spun up to its normal rotor operating speed of 28 rotations per minute (rpm), while the others lagged along at about seven or eight rpm. The turbine that was spinning normally had shed its ice. Since the other seven did not shed their ice, the remaining ice destroyed the aerodynamics of their airfoils. It was a wonderful display of wind turbines operating side by side with and without ice, leaving me to lament the fact that I do not own a video camera.

What does all of this have to do with the aforementioned physics problem? When compared to the idealized ice-throw scenario postulated by wind turbine opponents, which assumes high speed blade rotation, this was a excellent display of the fact that ice covered wind turbine blades cannot "get up to speed." One experienced wind turbine dealer I know likened the situation to trying to drive a car with four flat tires. You can move, but not very fast. Anyone who has a home-sized wind turbine that has experienced ice buildup can verify this fact, as can wind farm operators. As a result, the ability of a wind turbine to fling ice great distances is pretty much an impossibility – a conclusion supported by the fact that this phenomenon has not been documented in the real world.

On the few occasions when ice does form on wind turbine blades, many homeowners and utility turbine operators will shut their wind machines down until the sun or warmer temperatures melt the ice off of the blades. The ice coating on blades is in sheets, just as it forms on trees, houses, cars, roads, and utility lines during an ice storm. As it melts, it breaks up into small fragments and falls from the tower and turbine – not large chunks as assumed by the "perfect" scenario.

This situation does bring up a valid safety concern, however. As the ice sheds, it falls to the base of the tower unless there is a wind, in which case it will fall with the wind. Any prudent person would be well advised to stay away from the tower base during this time, the same safety precaution anyone would take with ice falling off of trees, building roofs, utility poles, cell phone towers, or power lines. This is just common sense.

In the real world, wind farm operators report that the ice does not fall beyond the tower base during light breezes, and not even as far as the tower's fall zone during heavier winds. In fact, the biggest concern expressed about ice buildup on commercial turbines is not even about ice shedding, but about the loss of production time when the turbine is covered in ice and can't spin properly.

There has been one excellent paper done on the risk assessment of injury or property damage due to shedding ice. The work is titled "Assessment Of Safety Risks Arising From Wind Turbine Icing," by Colin Morgan, Ervin Bossanyi, and Henry Siefert. The study notes that, "there has been no reported injury from ice thrown from wind turbines, despite the installation of more than 6,000 MW of wind energy worldwide." The paper concludes that the risk of anything or anyone being hit by ice from a wind turbine is "10-6 strikes/m2/year, which is the typical probability of (being hit by a) lightning strike in the UK" (The authors are from the UK.)

Since it's essentially a nonexistent problem, there have been few studies of the ice throw scenario with wind farms, no studies on home-sized turbines, and no reports of personal injury or property damage. As even our wind turbine opponent friends would have to admit, any problems with wind turbines are well documented and well reported. One can only conclude that it is less than fruitful to spend valuable financial and personal resources to study a nonexistent problem.

[Editor's Note: The opinions expressed in this column belong solely to the author.]