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SMALL TURBINE COLUMN:

Residential Wind Systems and "Stray Voltage"

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One question that is raised at zoning hearings with increasing frequency is: "Will this wind turbine cause stray voltage at my house or farm?". The question is usually raised by a neighbor who has heard through the grapevine or read on an anti-wind Web site that stray voltage is a problem with wind generators. While a hot topic is some locales, in many areas of the country folks have never come across the term, so are understandably concerned that a residential wind system could somehow harm them or their family.

Electricity remains a complete mystery to most people. You can't see it, but everybody knows that it can hurt you. Before plunging into a response, it would be helpful to develop some background and define a few terms to help you understand exactly what "stray voltage" is.

A hundred years ago, working conditions in cities were poor, and living conditions for workers were worse. There were few enforceable building codes, and fires caused by faulty electric wiring was a leading cause of death in worker tenements. Considerable labor strife eventually led to, among other things, upgrades that were codified for construction and electrical wiring for all buildings. That was the beginning of the National Electrical Code (NEC).

It takes two wires to complete an electrical circuit. One wire leads from the source of electricity (the utility, a battery, or a generator), to the load (say, a light bulb), while a second wire goes from the load back to the electricity source, completing the circuit. Note that both wires are connected to the electricity source, and both carry electricity. A switch in one of the wires makes or breaks the circuit, turning on or off the load. In addition, we could add a fuse or circuit breaker in a wire to protect from shorting the wires together or overloading the circuit.

In the U.S., the NEC requires that alternating current (AC) systems connected to the utility must have one of the current-carrying wires grounded to the earth at the electrical service entrance. This grounded wire is termed the "neutral" wire, and is un-fused. The other wire, termed the "hot" wire, is wired through a fuse or circuit breaker. This configuration, involving a grounded current-carrying conductor, was adopted for perceived safety reasons, essentially to protect folks working on the electrical lines or wiring from getting zapped. The rationale was that, since one wire is connected to the earth, if the other wire is shorted to the earth due to, say faulty wire insulation, the circuit breaker or fuse will blow, safely shutting down the flow of electricity. This system is somewhat unique to the U.S. In most other parts of the world, both wires are treated as hot wires, where the entire electrical system "floats," with neither wire connected to the earth, or "grounded." Grounding one current-carrying conductor provides the benefit of assuring a good conductive short circuit return path to allow circuit protection devices (fuse or circuit breaker) to interrupt the circuit and remove the hazard as quickly as possible.

However, this practice has also created some problems – the primary one being that the earth can and does serve as a parallel path for the flow of electricity in the circuit. It is this grounded un-fused "neutral" wire that actually creates two potential paths for electricity to follow: through the wire itself as well as through the earth.

Because one of the current-carrying conductors is connected to the earth, there can be situations where small amounts of electricity can flow to complete a circuit through the earth that is below the threshold that will blow a fuse or trip the circuit breaker in the hot wire. This unintentional flow of electricity is what is referred to as "stray voltage." Stray voltage is usually defined as a measurable level of voltage that may occur between a metal object and the adjacent floor or earth. (Note: stray voltage is a unique condition associated with grounding problems and should not be confused with other electrical utility system concerns, such as earth currents.)

This parallel path problem is exacerbated because, in practice, the neutral wire is often "bonded" to earth ground by attaching it indoors to a home's main water supply pipe in addition to an outdoor dedicated ground rod. When a water supply pipe is used as an additional neutral grounding point, stray voltages may appear in your house faucets, sink, or even tub. In a barn, stray voltage may appear at the watering system, dairy stanchions, animal pens, or even the metal siding on the building.

It is important to realize that while the design of the electric system creates the *potential* for stray voltage, the actual appearance of stray voltage is not normal and indicates a problem with the home or farm's electric wiring. On the "neutral" grounded wire, these problems can include a damaged wire, or a poor connection or corrosion at either end of this wire. In addition, a neutral wire undersized for the load can act as a resistance to electrical flow. Any of these conditions can cause the electricity to flow through the earth, in parallel with the neutral wire.

Problems with the condition of the hot wire can also cause stray voltage. These problems can include poor or weak insulation on the hot wire, especially in electric motors, electric water heaters, well pumps, and water pumps. In addition, wet splices or connections of the hot wire can cause current to flow in parallel with the hot wire, through the earth. Finally, seriously unbalanced loads on a circuit breaker or fuse panel can overload the "neutral" wire, causing current to flow through the earth.

One particular place where stray voltage becomes a serious issue is in a dairy barn, where you have all the components for parallel electrical paths: concrete or dirt floors that are likely wet from manure, urine, and moist animal breath; metal confinement structures and water systems; metal rebar in the concrete floor; and metal walls often with moisture condensed on them. In addition, it turns out that dairy cattle (with an electrical resistance of only about 500 ohms) can detect electrical currents at a level about one one-fiftieth to one one-hundredth of what humans are able to detect. It's no wonder that stray voltage concerns were first reported by dairy farmers!

However, all of these problems are a direct result of poor grounding practices, improper or inadequate wiring, or the breakdown of insulation in old wires or loads. In other words, they are problems on a particular customer's side of the utility billing meter that result in electricity seeking an alternate path back to the generating source, the utility. They are not a problem beyond the electrical system of a particular home or farm.

Nor can stray voltage move or be transferred from one farm to another, since it is an "on site" wiring or grounding problem. Stray voltage problems are electric distribution and wiring problems – not electric generation problems. The addition of a wind generator will not create (nor will it solve) any on-site stray voltage problems.

When I posed the question to the residential wind turbine manufacturers in the U.S. as to whether they had gotten any complaints about the utility intertie wind systems that they manufacture causing stray voltage at neighboring residences or farms, I came away with blank stares. They all know what stray voltage is, since the question does come up periodically. However, that survey revealed that stray voltage is not a problem that they have ever encountered with the systems they provide. They all stated they have never received any such complaints.

It should be noted that residential wind turbine generators are designed as electrically "floating" systems. That is, the wind system (regardless of whether it produces alternating or direct current) and its tower wiring are not earth-grounded the same way home electric systems are grounded in the U.S. Essentially, a residential wind generator is just like all the other wiring circuits serving the house or farm, except that it doesn't have a grounded neutral wire. Utility-connected residential wind systems only become "grounded" after the energy flows through an inverter at the point where it ties into the house or barn electric service panel, as required by the NEC.

It should also be noted that wind generators and towers are, however, grounded for lightning protection (See the March, 2003 issue of the *Windletter* Small Turbine Column, "Residential Wind Turbines and Lightning" for more information.) This is not the same grounding system as the NEC neutral wire grounding described here.

In response to the neighbor, or zoning committee, who wonders whether or not a proposed wind turbine can cause stray voltage, the answer is "no, not on your farm or at your house, and not on my farm or my house." Remember, if stray voltage is a problem, it can only be a problem on the customer's side of the billing meter, due to faulty wiring or a faulty installation on that side of the meter. So, if a neighbor has a stray voltage problem, your wind generator will have no impact on it.

[Editors Note: The opinions expressed in this column are those of the author and may not reflect those of AWEA staff or board.]