February, 2014

Wind Turbines & Farm Stray Voltage

Do wind turbines affect levels of stray voltage?

Wind turbines generate electrical power in the same way as all other generation technologies. The only difference is in the source of the mechanical power supplied to the electrical generator: wind, rather than a diesel engine or steam turbine, provides the energy.

Wind turbines affect stray voltage on farms in the same way as other electrical generation methods. The way that wind turbines and other generation technologies are connected to the electrical system affects their impact on stray voltage levels. A large wind farm is a very unlikely source of stray voltage because there is no direct connection to the utility distribution system or farm wiring system.

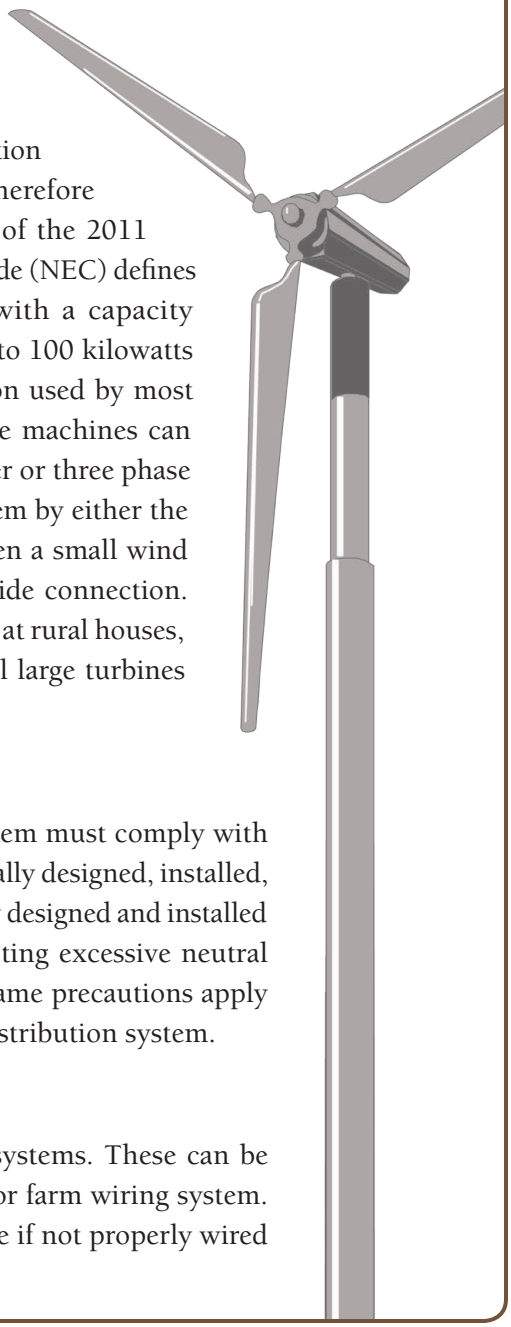
Single large turbines and small wind turbines connected directly to a distribution system can affect stray voltage levels. Small wind turbines connected directly to farm wiring systems are the most likely type of wind installation to cause stray voltage if not properly wired and inspected.

A fact sheet developed by the
Midwest Rural Energy Council

Wind farms – transmission connection

Large wind turbines (>100 kW) are usually installed in groups that make up a wind farm. Turbines in a wind farm typically generate three-phase power that is delivered to a substation transformer that converts the power to the proper voltage and connects to a transmission line. Wind farms are connected to the transmission system and have no direct connection to the local distribution system or farm wiring systems, the same as for large coal, natural gas, nuclear and hydro power plants. These large-scale generation facilities are typically owned and operated by electric utilities or other independent energy suppliers. Wind farms are permitted and regulated by state ordinances and rules. They must follow the same electrical system design guidelines and regulations as other large power plants. Wind farms are a very unlikely contributor to stray voltage because they connect to transmission systems and are designed, installed and inspected using strict safety rules and regulations.

Small wind installations



Single large wind turbines and small wind turbines connected directly to a distribution system can affect the amount of current on the distribution system neutral conductor and therefore stray voltage levels. Article 694 of the 2011 version of the National Electric Code (NEC) defines small wind turbines as those with a capacity (maximum power output) of up to 100 kilowatts (≤ 100 kW). This is the definition used by most local and state ordinances. These machines can produce either single-phase power or three phase power. Small wind turbines may be connected to the distribution system by either the utility (line-side connection) or the user (load-side connection). When a small wind turbine is connected directly to the farm wiring system it is a load-side connection. Load-side connection is common for customer owned turbines installed at rural houses, farms, schools or businesses as single turbine applications. Individual large turbines are sometimes line-side connected to distribution lines.

Line-side distribution connection

Generation facilities that are line-side connected to a distribution system must comply with local, state and national codes and standards. These installations are usually designed, installed, inspected and maintained by the distribution system operator. A properly designed and installed distribution system can accommodate its design load without generating excessive neutral voltage levels and contributing to stray voltage levels on farms. The same precautions apply to any other form of distributed generation or additional loads on a distribution system.

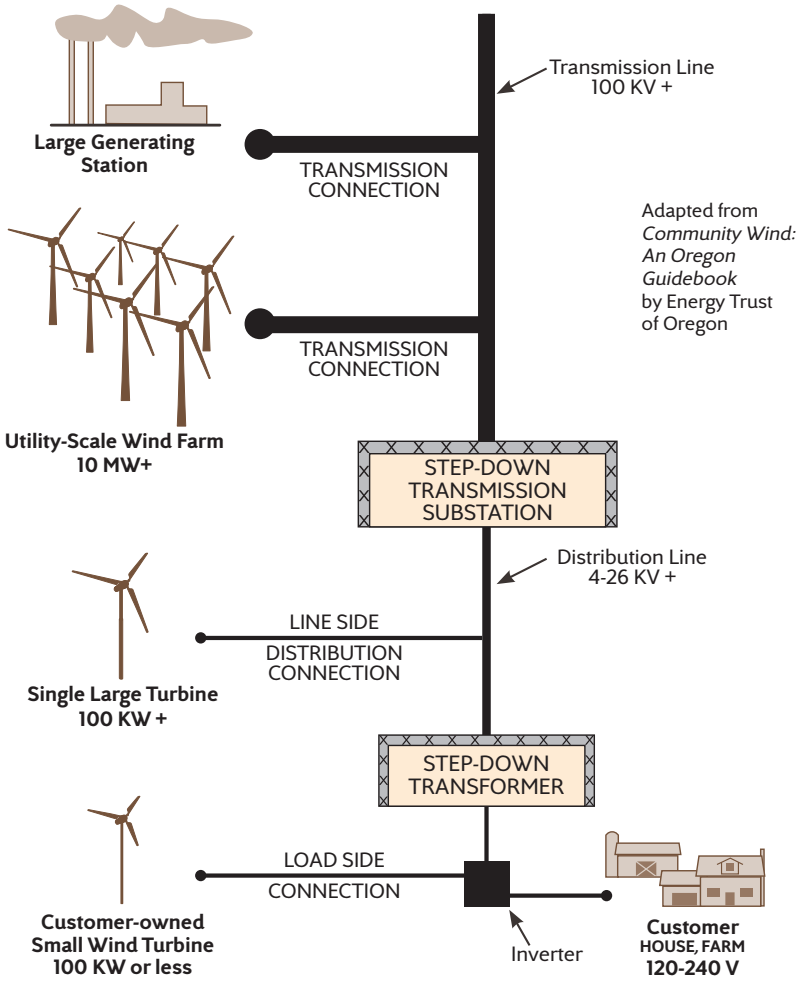
Load-side distribution connection

Small wind turbines can also be connected directly to farm wiring systems. These can be customer-owned and are usually load-side connected to a residential or farm wiring system. They are the most likely type of wind installation to cause stray voltage if not properly wired

Cover background photo by Jeffrey J. Strobel; farm photo by Lynn Betts, USDA NRCS

and inspected. Small wind turbines require an inverter that is located where the farm wiring system is connected to the electrical distribution system. Inverters must meet the UL 1741 and IEEE 1547 standards for any electrical system that is interconnected to a utility distribution system. The inverter acts as a control system to allow power from the distribution system to supply the farm load whenever the wind turbine is not producing enough power to meet the demand. The inverter also allows power that is being generated by the wind turbine and not needed on the farm to be exported to the distribution system and sold to the power company. Separate meters may be installed to measure the energy generated by the wind turbine and/or sold back to the utility company.

WIND TURBINE CONNECTIONS



These installations must also comply with all national, state and local electrical codes and standards. Electrical codes applicable to small wind turbines are defined in Articles 705 and 694 of the National Electric Code. The wind turbine tower is usually made of metal and, if so, must be connected to the grounding electrode system of the facility (barn, house, business electrical system). Towers may not be used as the sole electrode of a grounding system. Small load-side connected wind turbines may be installed by technicians without specialized knowledge about stray voltage. These systems are the most likely type of wind installation to cause stray voltage if not properly wired and inspected.

An understanding of stray voltage sources and farm wiring systems is required to ensure that these installations will not cause a stray voltage problem. If you install a wind turbine on your farm, make sure that you have a competent electrician wire the system and have the installation inspected by a state certified electrical inspector to make sure that all of the relevant safety rules have been followed. You should also consult your electrical power supplier to evaluate their distribution system for the extra load before installation and perform a stray voltage investigation on your livestock operation before and after the installation of a wind turbine.

These same precautions should also be observed for any other type of electrical generation system installed on a farm. Before connecting a wind turbine or any type of electrical generating system to a farm electrical system, it is highly recommended that you upgrade the farm electrical system to meet the current electrical code.

What is stray voltage?

Stray voltage on the farm refers to small voltage differences that can exist between two surfaces that are accessible to animals (stanchion, waterer, floor, etc.). When an animal touches both surfaces simultaneously, a small electric current will flow through its body. If the current is high enough, it can be felt by the animal and may cause behavioral changes. Stray voltage is usually caused by electrical currents that flow on the neutral and grounding conductors of a farm's electrical system.

There are two ways to control farm stray voltage:

1. Reduce the voltage source by reducing current flow on the neutral and grounding conductors.
2. Prevent voltages from appearing in animal confinement areas by using proper wiring techniques and equipotential planes (electrically conductive grids embedded in concrete floors and connected to both the animal accessible barn metal and the electric grounding system). There are well-developed methods to measure stray voltage, determine stray voltage sources and reduce stray voltage levels. This requires an understanding of the wiring and grounding on both the farm and distribution system. Your electrical power supplier and a licensed electrician can provide you with assistance in assessing stray voltage on your farm.

COMMON ON-FARM AND OFF-FARM SOURCES OF STRAY VOLTAGE

Some common on-farm wiring issues that should be assessed to prevent stray voltage problems are:

- Proper function of 4-wire electrical system for single-phase power
- Proper function of 5-wire electrical system for three-phase power
- Neutrals and equipment grounding conductor separation after the point of service
- Quality of neutral/ground connections
- Adequacy of grounding systems
- 120V load balance
- Proper wiring for large motor loads in remote areas
- No other faults in the wiring system and electrical equipment

Some common off-farm or utility distribution system issues that should be assessed to prevent stray voltage problems are:

- Adequacy of grounding systems
- Sizing of neutral conductors
- Quality of neutral/ground connections

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This publication was developed by the Midwest Rural Energy Council (MREC).

The mission of the MREC is to initiate, develop, support, and coordinate education, research, and communication programs on significant and emerging rural energy issues for the consumer, energy suppliers, and allied industries through cooperative efforts of council members.

For more publications and information on this topic visit the MREC website at: **www.mrec.org**

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