Wind Turbine ratings

- SMALL ≤ 100 kW
  - 2011 NEC, Article 694
  - Definition used by most local & state ordinances
- LARGE > 100 kW
  - Utility scale machines
  - Community scale wind projects & wind farms

Nameplate ratings and energy production

- A wind turbine’s nameplate rating doesn’t tell you much about energy production
- Nameplate ratings are often based off peak power output, when wind speeds are very high
- Large turbines often operate at a capacity factor of 30-40% or more
Small wind turbines
- Customer-owned
- Single- or three-phase
- Connected to customer’s existing electrical service
- Residential
- Farms, schools & businesses

Large wind turbines
- Usually developer- or utility-owned
- Connected to transmission or distribution lines

Wind farms
- By WI definition = more than one large wind turbine
- “Large” wind farms > 100 MW
- Follow CPCN process with PSC
- “Small” wind farms ≤ 100 MW
- Permitted through local ordinances
- Uniform state siting rules (PSC 128) currently suspended...

Community wind projects
- Large wind turbines, but customer-owned
- Usually only 1 or 2 turbines
- Common in MN & IA
- Cashton Greens – WI’s first & only
- La Crosse & La Farge
- Organic Valley & Gundersen Health System
- (2) 2.5 MW Clipper wind turbines
Distributed Generation (DG)
- WI limit: ≤ 15 MW (PSC 119)
- MN & IA limit: ≤ 10 MW
- Power is delivered in the exact same manner as “normal” power plants
- Wiring, grounding, infrastructure, and code requirements are the same
- Not just wind; includes solar, biomass & biogas, as well as icky non-renewables

How wind turbines generate electricity
- Wind is the prime mover & pushes blades
- Nacelle yaws (pivots) into the wind
- Gear boxes or direct-drive
- Induction or synchronous generators
- Blades pitch as wind speed changes
- Nominal AC output (600V typical in US)

How small wind turbines are connected to the grid
- Line-side connection:
  - Separate meter used to record customer kWh generation
  - Customer keeps consumption kWh meter
- Load-side connection:
  - Customer’s kWh meter replaced with bidirectional kWh meter
  - Turbine (inverter) AC output connected to customer’s load center

NOTE: Charge controllers & dump loads are only for battery-based systems
How large wind turbines are connected to the grid
- Nominal three-phase power is brought to a substation transformer
- Large wind farms are typically connected to transmission lines through transformers
- Smaller wind farms & community wind projects are connected to distribution lines through transformers

What is stray voltage?
- Neutral-to-earth voltages between two conductive points that an animal can touch simultaneously
- Not normally detected by or considered to be hazardous to humans
- Not related to electrical system faults
- Results from normal delivery & use of electricity

Sources of stray voltage
- **On-Farm:**
  - Missing or inadequate grounding systems
  - Inappropriate interconnection of neutral & equipment grounding conductors
  - Unbalanced 120V loads
  - Large motor loads (spikes) in remote areas
- **Off-Farm:**
  - Missing or inadequate grounding systems
  - Undersized neutral conductors
  - Loose neutral/ground connections

Do wind turbines affect levels of stray voltage?
1. Large wind farm connected to transmission system
2. Small wind farm or community wind project connected to distribution system
3. Small wind turbine(s) connected to distribution system
4. Small wind turbine(s) connected to farm wiring

1. Large wind farm connected to transmission system
- Installations follow same guidelines and regulations as other forms of generation
- No direct electrical connection to the distribution system neutral or farm wiring
- No single-phase loading
- Very unlikely to cause stray voltage
2. Community wind project connected to distribution system
- Installations follow same guidelines and regulations as other forms of generation
- Not much different than adding a large farm customer to the distribution system
- No single-phase loading
- Unlikely to cause stray voltage

3. Small wind turbine(s) connected to distribution system
- Installations must comply with all national, state, and local codes & standards
- Interconnected through a distribution system transformer
- Not much different than adding a residential customer to distribution system
- Not likely to cause stray voltage

4. Small wind turbine(s) connected to farm wiring
- Installations must comply with all national, state, and local codes & standards
- Turbine shall be connected using the 4- or 5-wire system, separating neutrals & equipment grounding conductors
- Much more likely to cause stray voltage if not properly wired and inspected

Summary
- Small wind turbines are connected to the customer’s existing electrical service
- Large wind turbines are connected to distribution or transmission lines
- Grounding & bonding requirements are the same for wind energy as all other loads and forms of electrical generation

Summary
- Wind turbines (large or small) are unlikely sources of stray voltage
- Poor wiring & grounding are likely sources of stray voltage (utility or customer)
- Harmful levels of stray voltage from any source can be easily identified and, if necessary, reduced to harmless levels

Proper farm wiring
- 4-wire systems for single-phase power
- 5-wire systems for three-phase power
- Separate neutrals & equipment grounding conductors after the service
- Check for proper continuity of neutrals & grounds; look for loose connections
- Balance 120V loads wherever possible
- Avoid using faulty & inefficient equipment
Resources:
- Distributed Wind Energy Assn. (DWEA): www.distributedwind.org
- Community Wind: www.industry.org
- Incentives/Interconnection Database – www.dsireusa.org

Resources:
- Home Power Magazine: http://homepower.com
- Small Wind Certification Council (SWCC) www.smallwindcertification.org
- MREC Stray Voltage publications: http://fyi.uwex.edu/mrec/publications-2/