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Applicable Standards for Small and Medium Wind Turbines for Electric Cooperatives

Summary

- While less common than solar PV in recent years, small- and medium-scale wind turbines have been widely deployed in behind-the-meter applications across the U.S.
- Understanding standards applicable to small- and medium-size wind turbines is important, as a variety of designs are available in the market.
- There are opportunities for cooperatives to act as the Trusted Energy Advisor for member-owners interested in deploying wind as a distributed energy resource.

Background

This advisory is a resource of the *Rural Area Distributed Wind Integration Network Development* (RADWIND) project,[1] which aims to understand, address, and reduce the technical risks and market barriers to distributed wind adoption by electric cooperatives and other rural utilities.

From 2003 to 2020, more than 87,000 wind turbines (WTs) were installed on U.S. distribution grids. In recent years, most distributed wind capacity, including projects deployed by electric cooperatives, have utilized larger-size wind turbines (1 MW or larger). Smaller-size models (up through 100 kW) of wind turbines have been deployed behind-the-meter (BTM) or in off-grid locations (primarily microturbines under 1 kW). In the past three years, most of the installations of smaller WTs have repurposed existing towers and structures (retrofits). It is expected that these retrofits for smaller WTs will continue as consumers take advantage of technology advancements to upgrade existing infrastructure.[2,3] Due to the opportunity to retrofit, member-owners can install smaller-size WTs at a reduced cost. Medium-scale turbines (101-999 kW) usually serve larger commercial, industrial, or agricultural BTM loads, as well as some utility deployed projects, though these have become less common in recent years outside of those installed in Alaska.

What is the impact on cooperatives?

While small- and medium-size turbines are less likely to be utilized directly by electric cooperatives for their owned or contracted projects, there is an opportunity to leverage their role as Trusted Energy Advisors to educate member-owners about the importance of purchasing wind energy technologies that

[1] ***This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and RenewableEnergy (EERE) under the Wind Energy Technologies Office Award Number DE-EE0008958.***
[2] *Distributed Wind Market Report: 2021 Edition*, available here.
[3] Gipe, Paul. 2021. "Bergey 15 Installed in Tehachapi—New Era for Bergey." Wind-works.org. Posted March 4, 2021, available here.

follow relevant and applicable standards when considering deployment of BTM small- or medium-scale WTs. There are several value streams that might motivate member-owners to consider installing small- or medium-size WTs, either on their own or hybridized with other technologies (e.g., solar PV or battery energy storage). Some of these value streams include utility energy bill reduction, peak demand reduction, hedging against increasing retail electricity rates, and monetizing renewable energy generation through Renewable Energy Credits (RECs).[4]

This short advisory provides a list of industry accepted standards that co-ops and their member-owners should consider adopting, when installing and operating distributed wind generation.[5] Also, cooperatives can advise their member-owners to verify that the wind turbines that they consider purchasing meet these standards as the cooperatives want their member-owners to purchase turbines that are tested and validated.

Applicable Standards

Below are brief descriptions of the relevant standards for small- and medium-scale wind turbines.[6]

1) Underwriters Laboratories (UL) Standards

As it relates to WTs, there are multiple relevant UL standards. These include the following:

- **UL 1741**: This standard covers the requirement of interconnection system equipment, including any power electronic converters (e.g., inverters) and charging controller, for both stand-alone and grid-connected distributed generation (DG). For the latter, it is meant to complement the IEEE 1547 and IEEE 1547.1. UL 1741 was recently updated and published in September 2021.[7]

- **UL 4143**: This standard covers the rules and the process of WTs risk assessments and the methodology for lifetime extension (LTE) for WTs, and it is approved by ANSI to be the national standard for the lifetime extension of wind turbines.[8]

- **UL 6141:** This standard covers the requirements for large WTs that are equipped with electrical subassemblies. These WTs are meant for use in grid-connected applications at different levels depending on the specifications of the turbine. Although the scope of UL 6141 primarily covers the requirements for large WT systems, both UL 6141 and UL 6142 define the small WTs and electrical subassemblies as "*wind turbines where a user or service person is not intended or required to enter the WT to operate or perform maintenance on the WT*".

- **UL 6142:** This standard addresses the electrical safety of small WTs as it relates to the national electric safety code (NESC). These WTs can be for off-grid/isolated (not connected to the

[4] Business Case for Distributed Wind in Rural Electric Cooperative Service Areas, April 2022, available here.
[5] Co-ops might include some of these standards into their Distributed Generation application if they are not already there (NRECA's updated DG toolkit is here)
[6] There are some standards that are applicable only for large wind turbines (1MW or larger).
[7] UL 1741 Standard, Edition 3, Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources, Edition date: September 28, 2021 available here
[8] UL 4143 Standard, Edition 1, Standard for Wind Turbine Generator - Life Time Extension (LTE): Feb 2018 available here

distribution grid), or grid-connected applications. It also references the present control and protection systems equipment, and functions for DG. The requirements of the UL 6142 covers WTs at rated voltage 1.5kV$_{AC}$ or less.[9,10]

2) The U.S. National Electrical Code (NEC)

The U.S. NEC covers the requirements for the installation and removal of electric equipment and electric and communications conductors. In chapter 6, article 694 covers the WT electric system that comprises one or more WT and its associated electronics and controls. It also covers the system's circuit requirements (e.g., maximum voltage and current, overcurrent protection, power transformers), discounting means, and permitted methods of wiring. Also, chapter 7 covers the interconnected electric power production.[11]

3) IEEE 1547

As mentioned under UL 1741, IEEE 1547 is the *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces* with its testing companion IEEE 1547.1. It covers the interconnection aspects of grid-connected distributed generation technologies, including wind turbines, solar PV, energy storage, and others. It sets the communication requirements, voltage regulations, voltage, and frequency ride through, and other islanding requirements. The most recent edition of the standard was published in 2018, and the testing standard in 2020.[12] National Renewable Energy Laboratories (NREL) published a report that provides guidance on considerations around distributed wind generator compliance with IEEE 1547-2018 and IEEE 1547.1-2020.[13] More information on IEEE 1547 can be found on cooperative.com.

4) International Electrotechnical Commission (IEC) 61400 Standards

IEC 61400 standards are the international standard and do not reference the U.S. standard. However, it applies to all different sizes of wind turbines. The IEC 61400 is comprised of multiple parts that cover different technical aspects.[14] The following are some relevant parts:

- Part 1 covers the design requirements.
- Part 2 covers the design requirements for small WT with rotor swept area smaller than 200 m^2 rated at 1000 V$_{AC}$/1500 V$_{DC}$.
- Part 11 covers acoustic noise measurement techniques.
- Part 12 covers wind turbine power performance testing.
- Part 21 covers measurement and assessment of power quality characteristics of grid connected wind turbines.

[9] UL 6141 Standard, Edition 1, Wind Turbines Permitting Entry of Personnel, Edition date: May 2016 available here
[10] UL 6142 Standard, Edition 1, Small Wind Turbine Systems, Edition date: Nov 2012 available here
[11] National Electrical Code®, 2020 edition, available here
[12] "IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces," in *IEEE Std 1547-2018 (Revision of IEEE Std 1547-2003)* vol., no., pp.1-138, available here.
[13] Distributed Wind Considerations From the IEEE 1547-2018 Revision, available here
[14] IEC 61400 standards, Wind turbine generator systems available here.

5) ACP 101-1 and AWEA 9.1

The American Clean Power Association (ACP), the successor to the American Wind Energy Association (AWEA), has developed a new American National Standards Institute consensus standard, ACP 101-1, but it is not yet publicly available. The ACP 101-1 standard defines small wind turbines as having a peak power of 150 kW or less and microturbines as having a peak power up to 1 kW. The Distributed Wind Energy Association and the U.S. Department of Energy have recommended that the U.S. Internal Revenue Service (IRS) recognize certification to either AWEA 9.1-2009 [15] or ACP 101-1[16] going forward for tax credit eligibility. AWEA 9.1-2009 was created to provide consumers with comparable performance ratings across small wind turbines. The ACP 101-1 standard has been designed to facilitate easier compliance, so the industry expects that new turbine models will be certified to this standard.

Additional Resources

Certified Wind Turbines, Interstate Renewable Energy Council (IREC), available here.

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Additional Information on NRECA Research's RADWIND Project

For more information on the RADWIND project and additional resources, please visit the project landing page at www.cooperative.com/radwind.

Want to stay informed of our progress with the RADWIND project, and provide your input and feedback? We welcome all NRECA voting members to join the project as advisors. Contact our team at: RadwindProject@nreca.coop.

[15] AWEA Small Wind Turbine Performance and Safety Standard, 2009, available here
[16] American Clean Power, Standards Development webpage: https://cleanpower.org/standards-development/