Updating Domestic and International Standards for Distributed Wind Technology

Draft

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Completed in conjunction with IEA Wind Technical Collaboration Program
Task 41-Enabling Wind to Contribute to a Distributed Energy Future

Introduction

Based on extensive industry discussions, members of the International Energy Agency (IEA) Wind Technical Collaboration Program (TCP), Task 41-Enabling Wind to Contribute to a Distributed Energy Future have identified the design and testing standards for distributed wind as a barrier to innovation and a source of increased cost of energy for wind technologies. Sometimes, especially for turbines that have a rotor swept area (RSA) greater than 200 m^2 company representatives do not see the value of certifying their turbine models under current market conditions because the costs of doing so outweigh the value that certification provides. Even if companies see the value in obtaining certifications, the cost and time commitments to do so, combined with a lack of a defined conformity assessment that is approved through the IEC—Renewable Energy (IECRE), hinder bringing more advanced technology to the market in a timely fashion.

Although many national governments maintain their own standards relative to small and large wind turbines, the International Electrotechnical Commission (IEC) 61400-2 standard[1] and any conformity requirements defined through the IECRE SG 554[2] working group generally serve as a baseline for small wind turbines. Under normal circumstances, the next time the IEC 61400-2 standard would be open to revision would be early in 2022. To allow real consideration of revising the international standard, efforts need to be undertaken to initially understand the key concerns with the existing standard, secondarily to conduct the needed research to document a problem or concern, and then if possible to conduct research to allow justification for any potential revisions. Additionally, it is important to get broad international buy-in for proposed changes, thus leasing to a strong international effort bringing in stakeholders from around the world.

Historically, efforts were made to conduct targeted research under the IEA Wind TCP to produce technical research results for IEC standards-making experts to consider when working on the fourth revision of the IEC 61400-2—Small Wind Turbine standard. The new IEA Wind TCP Task 41 includes an activity to coordinate research around improving international and domestic standards for distributed wind turbines, which is the basis for this document.

To gain a better understanding of current challenges being faced relating to the current standards, two international meetings were held in 2019 to assess the status of relevant distributed wind standards.

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[1] For example, the American Wind Energy Association [AWEA] Small Wind Turbine (SWT) Performance and Safety Standard 9.1-2009 and the proposed updated AWEA Small Wind Turbine Standard [SWT-1]

[2] https://www.iecre.org/sectors/windenergy/sg554/

The first discussion was a half-day meeting held in conjunction with the Distributed Wind Energy Association (DWEA) business conference in February 2019. This meeting included companies from across North America and focused on U.S. standards (the AWEA 9.1 and SWT standards). The challenges identified were the basis of discussions held during the International Standards Assessment Forum in Dundalk, Ireland, in June 2019 that included representation from Austria, Denmark, Germany, Ireland, Korea, Spain, and Taiwan. This second meeting was held under the auspices of IEA Wind TCP Task 41. The European meeting was longer and included more detailed conversations about specific issues relating to the 61400-2 standard.

The goal of these meetings was to identify weak sections of the IEC 61400-2 standard and areas in which near-term research results could be added, as well as identify and prioritize future research efforts under the banner of IEA Task 41. Task 41 is an international collaboration of wind experts conducting research that will be the technical backbone for potential change to IEC 61400-2.

To continue to broaden the industry engagement and support of this effort an Asia International Standards Assessment Forum (scheduled for the Spring of 2020 in Inner Mongolia, China) and a second more detailed North American International Standards Assessment Forum (scheduled for the spring or summer of 2020) will also be held. Additionally, the National Renewable Energy Laboratory (NREL) in collaboration with DWEA are concurrently undertaking an effort to finalize an update of the AWEA SWT 9.1 2009 standard.

Based on the meetings conducted to date, the following topics were identified as requiring further investigation. This list will be further discussed and refined during the additional pre-mentioned forums.

Key Technical Challenges and Gaps of Third Revision of IEC 61400-2 Small Wind Turbines and/or AWEA 9.1/SWT	North American Forum	European Forum
Meeting duration test requirements slows innovation and time to market. *Number one challenge for domestic and international stakeholders*	**X**	**X**
Use of Simplified Loads Methodology (SLM) has made the engineering design heavier due to high factors of safety, and SLM does not address fatigue, a common failure mode for small wind turbines. *Need VAWT SLM with fatigue case*	**X**	**X**
Validated aeroelastic modeling is the most accurate method of understanding design loads, dynamics, and structural strength but is currently limited for U.S. manufacturers due to weaknesses with FAST modeling modern turbines. *Need aeroelastic models of directly couple generators, a common Danish design, especially for drivetrain fatigue loads*	**X**	**X**
Tower dynamics are not well addressed in IEC 61400-2, leaving turbine systems vulnerable to system dynamics initiated by the tower.		**X**
Power performance results are rarely matched at consumer sites, leading consumers to assume that small wind doesn’t work.		**X**

Based on Task 27 work, the typical small wind turbine site has an alpha of 0.2 or higher, which directly impacts the power curve and production		
Currently medium wind turbines are kept out of the market for certified turbines because of the current limit for IEC 61400-2, 200 m^2 of rotor swept area. (NPS NW 100 is just shy of 500m^2.) *Need certifications for small wind turbines up to 100 kW or 500 m2 and classifications for micro wind with reduced requirements*	**X**	**X**
Many of the current requirements found in the design classification, normal turbulence model, and turbulence intensity don't reflect the commercial reality that micro and small wind turbines are installed in locations that have high turbulence intensity due to human clutter. *Need to validate preliminary work done under Task 27*	**X**	**X**
There are no defined considerations for conformity assessment. *This was not really discussed at the North American forum outside of needing a more defined way to address conformity if minor changes are made to a turbine design*		**X**
Acoustic testing is considered the most difficult of all the small wind turbine test methods, and the output data are not self-explanatory to consumers.		**X**

The following provides an overview of the research questions and priorities to address the issues identified above. Working to better understand these issues will provide information for IEC standards-making experts under TC-88 to consider when determining whether a revision of IEC 61400-2 is necessary and if so, providing the research that will be needed to underpin any potential revisions. The expectation is that following a revision of 61400-2, other national standards related to distributed wind turbines will also be revised.

Reconsidering Turbine Size Specifications under Existing Standards

Outside of the current challenges identified in the meetings, one of the key issues that was raised at both meetings was a need to reconsider the current criteria used to define the size of the turbine(s) that are applied to the IEC standards, currently set at 200 m^2 RSA. Historically, the first edition of IEC 61400-2 had an upper bound of 40 m^2 or approximately 10 kW. The second edition expanded this size limit to 200 m^2 or approximately 55 kW, which was based on existing data from small wind turbines under 200 m^2. A method to compare these existing datasets—wind turbine measurements and aeroelastic models—was created by Windward Engineering and NREL staff Jeroen van Dam, Jason Jonkman, and Trudy Forsyth; it informed the SLM and the increased upper size limit.

The identification of new proposed size criteria will serve as a starting point for further discussions planned during the Asia International Standards Assessment Forum, the North American International Standards Assessment Forum (scheduled for 3Q FY20), future IEA Task 41 meetings, and by standards-making experts on behalf of the IEC TC88—Wind.

Turbine size categories serve as "guard rails" on standards requirements and help focus the designer, certification body, and test laboratories in evaluating a particular turbine size. International industry members selected RSA as one criterion because of its clear relationship to wind energy generation; rated power has many variables and interpretations, making comparisons difficult.

In general, size limits should cluster similar wind turbine characteristics in terms of control, RPM, electrical output, and market application. There is a further goal of minimizing any interruptions to the syntax of smaller, distributed wind turbines. In general, micro turbines have little active control, relying on passive control and simple approaches. China is the dominant manufacturer of micro turbines to sell to the global market for rural, battery-charging applications that likely will be part of a hybrid system. Manufacturers of micro turbines focus on repeatable manufacturing in an attempt to drive profit margin by high volume.

From a design perspective, there is a dramatic change as turbine size increases above approximately 3 kW. This change includes the ability to design more robust and reliable control methods, some of which may still be passive (such as stall). Wind turbines in this size category may produce AC or DC output, typically controlled by inverters if a permanent magnet alternator is used. Loads design methods include the SLM, which uses high safety factors to overcome the weaker technical approach and lack of computer simulation models.

The U.S. industry has moved away from the SLM toward aeroelastic simulation tools such as FAST. The Small Wind Certification Council consulted with industry members regarding whether they use SLM or aeroelastic models. The resounding response was for use of aeroelastic models. Simulation modeling produces more accurate design loads, comparisons of impacts of design change, and comparisons of turbine response as a function of external wind conditions, to name a few of the tool’s uses.

Because of the general advancement in the development of simulation tools, global partners suggest that requiring aeroelastic simulation is key to providing higher-quality certification data. It is the difference between a design that takes an empirically dominated approach and uses the SLM and the design that evolves based on computer simulation results, thereby reducing testing time and accelerating the turbine’s timeline to market entry.

The second proposed size limit is 50 m^2 for those turbines wanting to use the simplified approach to design loads, but the industry push toward simulation modeling and reducing the size requirement for the use of aeroelastic simulation modeling is a step toward market maturation. The industry could transition to calling the sector between 5-50 m^2 (proposed) “small wind turbine.”

Wind turbines larger than 50 m^2 could then assume the distinction and clarification in syntax to be “medium” wind. The question then becomes, “What is the upper size limit for medium wind?” A study that uses simulation models and measurements from specific wind turbines can form the technical basis for raising the upper size limit.

There is a need to collect existing measurement and modeling data for turbines up to 500 m2 or higher and likely get more measurements and model development. The larger the turbine size, the more likely it is to influence raising the medium turbine size limit. Task 41 partners must find international “medium-size turbine” manufacturers with data to share for their turbines. The United Kingdom and Italy have had incentive policies for turbines up to 500 kW and 200 kW, respectively.

The size limits proposed here will likely change. The table below elucidates the discussion topics as a function of wind turbine size. Future discussions will improve and refine these initial thoughts.

	Micro up to 3-5 m^2 800 W – 2 kW?	Small 5-50 m^2 2-11 kW?	Medium 50-500 m^2 11-150 kW?
PRINCIPLE ELEMENTS AND EXTERNAL CONDITIONS			
Streamline micro wind requirements	X		
Raise the size limit > 200 m^2 based on aeroelastic model and measurement data			X
Design class requirements	choose one	X	X
Normal Turbulence Model	X	X	X
STRUCTURAL DESIGN			
SLM	Use 300 N-m requirement	X	NA
Factors of safety		X	NA
Aeroelastic model	NA	If aeroelastic model used, reduce duration test?	Validated aeroelastic model required, no SLM allowed
Aeroelastic models don't address modern turbine configurations (i.e., FAST)		X	X
Tower dynamics and interactions	X	X	
TYPE TESTING			
Duration Testing	Reduced time with strength analyses	Testing at multiple sites?	Not required
Power Performance	No site calibration, don't test past peak power	No site calibration	Can power curve be used to reduce loads test requirements?
Loads Testing	NA	At a minimum, tower loads testing should be performed	Streamline - 3 requirements for aeroelastic model validation
Acoustics Testing	No tonality	No tonality	X
Safety and Function Testing	RPM and power control only	X	NA

Blade Testing	Fatigue full rotor	Static, if fatigue test reduces factor of safety?	Fatigue
CONFORMITY ASSESSMENT			
	X	X	X

Research Priorities

The process of revising the IEC 61400-2 standard will require a strong basis in scientific research to justify any proposed modifications. Based on the challenges identified to date, proposed research efforts have been identified to address specific areas around the IEC 61400-2 standard. The efforts are included in the separate document; Research Priorities, Domestic and International Standards for Distributed Wind Technology. This list of research priorities will be revised following further consultations within IEA Task 41, as part of planned meetings and through engagement with additional stakeholders.