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# Establishment of Small Wind Regional Test Centers

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T. Jimenez, T. Forsyth, A. Huskey, I. Mendoza, and K. Sinclair
*National Renewable Energy Laboratory*

J. Smith
*Windward Engineering*

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# ESTABLISHMENT OF SMALL WIND REGIONAL TEST CENTERS

Tony Jimenez
Trudy Forsyth
Arlinda Huskey
Ismael Mendoza
Karin Sinclair
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401

Joe Smith
Windward Engineering
10768 S. Covered Bridge Canyon
Spanish Fork, UT 84660 USA

Abstract
The rapid growth of the small wind turbine (SWT) market is attracting numerous entrants. Small wind turbine purchasers now have many options, but often lack information (such as third-party certification) to select a quality turbine. Most SWTs do not have third-party certification due to the expense and difficulty of the certification process. Until recently, the only SWT certification bodies were in Europe. In North America, testing has been limited to a small number of U.S. Department of Energy (DOE) subsidized tests conducted at the National Renewable Energy Laboratory's (NREL) National Wind Technology Center (NWTC) under the ongoing Independent Testing Project.

During the past few years, DOE, the National Renewable Energy Laboratory (NREL), and some states have worked with the North American SWT industry to create a SWT certification infrastructure. The goal is to increase the number of certified turbines and gain greater consumer confidence in SWT technology. The American Wind Energy Association (AWEA) released the AWEA Small Wind Turbine Performance and Safety Standard, AWEA Standard 9.1 – 2009, in December 2009. The Small Wind Certification Council (SWCC) and Intertek, North American SWT certification bodies, began accepting applications for certification to the AWEA standard in 2010.

To reduce certification testing costs, DOE and NREL are providing financial and technical assistance for an initial round of tests at four SWT test sites, which were selected through a competitive solicitation. The four organizations selected are Windward Engineering (Utah), The Alternative Energy Institute at West Texas A&M (Texas), a consortium consisting of Kansas State University and Colby Community College (Kansas), and Intertek (New York). Each organization will test two small wind turbines as part of their respective subcontracts with DOE and NREL. The testing results will be made publically available. The goal is to establish a lower-cost U.S. small wind testing capability that will lead to increased SWT certification.

Turbine installation is ongoing. Testing began in early 2011 and is scheduled to conclude in mid-late 2012.

## 1. INTRODUCTION/BACKGROUND

The past few years have seen rapid growth in the U.S. small wind turbine (SWT) market. Due to a proliferation of incentives, SWT installation capacities (defined as wind turbines with a rated capacity of up to 100 kW) in the United States have increased from 8.5 MW in 2006 to more than 20 MW in 2009.(1) The growing SWT market has attracted numerous new entrants with products of widely varying quality. Potential SWT buyers face a wide array of choices and, for the most part, lack the knowledge to adequately evaluate the claims made by the various SWT manufacturers. State incentive fund managers face a similar dilemma when attempting to determine which SWTs should be eligible for limited incentive funds.

Until recently, little incentive and many barriers existed for manufacturers seeking to certify their small wind turbines. There have been no legal requirements for turbine certification and little market pressure to do so. Barriers to certification included high costs associated with field testing, which is required for certification of SWTs, and the time required for field testing, which is typically a year or more from the time a testing contract is signed. Another obstacle has been the lack of U.S.-based certification bodies. Manufacturers were forced to use European certification bodies. Finally, field testing options were limited. The only accredited SWT test organizations in the United States were the National Renewable Energy Laboratory's (NREL) National Wind Technology Center (NWTC) and DNV (formerly Global Energy Concepts). Therefore, certification testing that occurred prior to 2010 in the United States was limited to three to four turbines annually under the DOE-funded Independent Testing project.

To address this issue, the North American SWT industry began working in 2006 with DOE, NREL, and some states (IA, IL, NV, NY, OR, WI), to create an SWT certification infrastructure. The goals were to increase the number of certified turbine models and gain greater consumer confidence in SWT technology. The strategy to achieve these goals was to reduce barriers to certification by 1) Establishing a North American SWT Performance and Safety standard; 2) Establishing North American-based certification bodies; and 3) Encouraging the establishment of entities to conduct the field testing required for SWT certification. These efforts bore fruit in late 2009 and 2010. The American Wind Energy Association (AWEA) released AWEA Small Wind Turbine Performance and Safety Standard (AWEA Standard 9.1 – 2009) in December 2009. In 2010, two North American certification bodies began accepting applications for certification to the AWEA standard. Finally, as of the end of 2010, over two dozen organizations were offering field testing services. (2)

It is expected that many states will eventually require certification for SWTs to be eligible for state incentive funds. In addition, it is expected that over time, consumers will demand certified turbines and reject uncertified turbines.

To increase the availability and quality field testing for certification, DOE and NREL are providing general technical assistance to the SWT certification testing community. This assistance takes the form of organizing an annual SWT Testing Workshop and providing informational support on an informal basis. In addition, DOE and NREL are establishing a network of Regional Test Centers (RTCs). The RTCs are SWT testing partner organizations that DOE and NREL provide with financial support and enhanced technical assistance. It is intended that these RTCs can act almost as satellite testing organizations to the NWTC.

## 2. SWT CERTIFICATION AND TESTING OVERVIEW

The AWEA standard was developed using a consensus process through a group representing various SWT industry stakeholders. The AWEA Standard refers to, and closely follows, the pre-existing suite of IEC standards (IEC 61400-2, 61400-11, and 61400-12-1). To be eligible for certification under the AWEA standard, a turbine must have a rotor swept area equal to or less than 200 $m^2$ (in general, this covers turbines with a rated power approximately up to 65 kW) and generate electricity either for grid interconnection or battery charging. Turbine evaluation consists of both a mechanical/loads design review and field testing.

In addition to testing by accredited test organizations, the AWEA standard allows testing by non-accredited test organizations and manufacturer self-testing. The testing entity conducts the testing mandated by the test standard.

The AWEA standard designates the SWCC or a Nationally Recognized Testing Laboratory (NRTL) as certification bodies. (3) At the time of this writing, the SWCC and one NRTL, Intertek, are accepting applications for certification to the AWEA Standard. These certification bodies will conduct the mechanical/loads design review, evaluate the test results, and grant (or withhold) certification.

Performance and safety certification have several goals and purposes. These include:

- Accurately characterize the turbine
- Provide consumers with objective information about SWT energy production and sound levels
- Verify that the turbine's safety features function according to the manufacturer's specifications. (This does not necessarily mean the turbine is safe.)
- Provide data needed to objectively determine turbine eligibility for state incentive programs.

The purpose of certification is less about declaring whether a given small wind turbine model is good or bad, and more about accurately characterizing the performance of the turbine, so that consumers can make an apples-to-apples comparison between different turbine models. Figure 1 outlines the SWT certification process and the various parties involved.

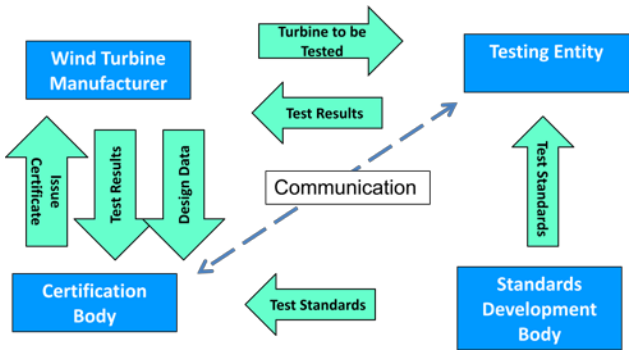


**Fig. 1: SWT certification process.**

Field testing for certification consists of four distinct tests. These tests are summarized in Table 1.

**TABLE 1. SWT CERTIFICATION TESTS**

| |
|---|
| **Duration (IEC 61400-2)**<br>• Investigates structural integrity and material degradation (corrosion, cracks, deformations); quality of environmental protection of the wind turbine; and the dynamic behavior of the turbine<br>• "Turbines must achieve an operational time fraction of at least 90% over a minimum of 2,500 operating hours (over a range of wind speeds) with no major failures, significant degradation of wind turbine components, or degradation in power production at comparable wind speeds."(4)<br>• No changes are allowed to the turbine configuration during this test |
| **Power Performance (IEC 61400-12-1):**<br>• Measures electrical output of the turbine vs. wind speed<br>• Estimates the turbine's annual energy production<br>• Provides an independent check of the manufacturers' claimed performance. |
| **Safety and Function (IEC 61400-2):**<br>• Verifies that the wind turbine displays the behavior predicted in the design and that provisions relating to personnel safety are properly implemented. (5) |
| **Acoustic Noise Emissions (IEC 61400-11):**<br>• Determines the turbine's noise-emission characteristics |

## 3. REGIONAL TEST CENTER (RTC) PROJECT

In the process of conducting years of SWT accredited IEC testing under the Independent Testing project, NREL staff have gained in-depth experience and expertise in this field. A key component of DOE and NREL efforts to expand U.S.-based SWT certification testing is to share this experience and expertise. Efforts began in 2008, with the organization and hosting the first annual SWT Testing Workshop at the NWTC by DOE and NREL. This workshop brought together experts and interested stakeholders to share experiences, knowledge, and best practices. DOE and NREL hosted successive SWT Testing Workshops in 2009 and 2010. Planning for the 2011 workshop, which will be held in July in Amarillo, TX, is already underway.

In addition, NREL staff responds to numerous inquiries related to SWT certification and testing, from both domestic and international entities.

In further support of SWT certification testing, DOE and NREL initiated the Regional Test Center (RTC) project. This project established RTCs capable of testing small wind turbines to AWEA standard. DOE and NREL

selected (through a competitive solicitation) four RTC partners: Windward Engineering (UT), Kansas State University & Colby Community College (KS), the Alternative Energy Institute (AEI) at West Texas Agricultural &Mining University (TX), and Intertek (NY). RTC partners were selected for their technical excellence and the quality of their business plans. DOE and NREL are contributing funds and technical assistance (through subcontracts) for the RTCs to conduct certification testing for two SWTs at each RTC. DOE and NREL intend to work closely with the RTCs, who will act as satellite testing organizations. The test reports for the turbines tested under this project will be placed in the public domain. These test reports, along with the test reports created under the IT program, provide valuable examples for the SWT testing community.

The assistance provided by DOE and NREL to the RTCs includes:

- Annual SWT Testing Workshop
- Assistance with site assessment
- Assistance with selection of test equipment to ensure compliance with IEC Standard
- Site visits (confirm general readiness, commissioning)
- Assistance with data acquisition, processing, and management
- Review test plan and commissioning plan
- Review of draft test reports
- Informal consulting and informational support

Figure 2 shows the locations of the RTC test sites. Table 2 gives the current project status.

**TABLE 2: TURBINES TO BE TESTED AS PART OF THE RTC PROJECT**

| RTC | Turbine Manufacturer and Model | Turbine Type | Turbine Rated Power |
|---|---|---|---|
| Intertek | Fortis Montana | upwind HAWT | 5 kW |
| | Fortis Alize | upwind HAWT | 10 kW |
| KSU/CCC | Enertech E13 | downwind HAWT | 45 kW |
| | 1SkyEnergy (Formerly ARI) 7.5 | upwind HAWT | 7.5 kW |
| AEI / WTA&M | Potencia Hummingbird | upwind HAWT | 20 kW |
| | Nikko Eolia NWG-1K | downwind HAWT | 1 kW |
| Windward Engineering | Windspire Energy (Formerly Mariah) Windspire | VAWT | 1.2 kW |
| | Endurance S-343 | upwind HAWT | 5 kW |

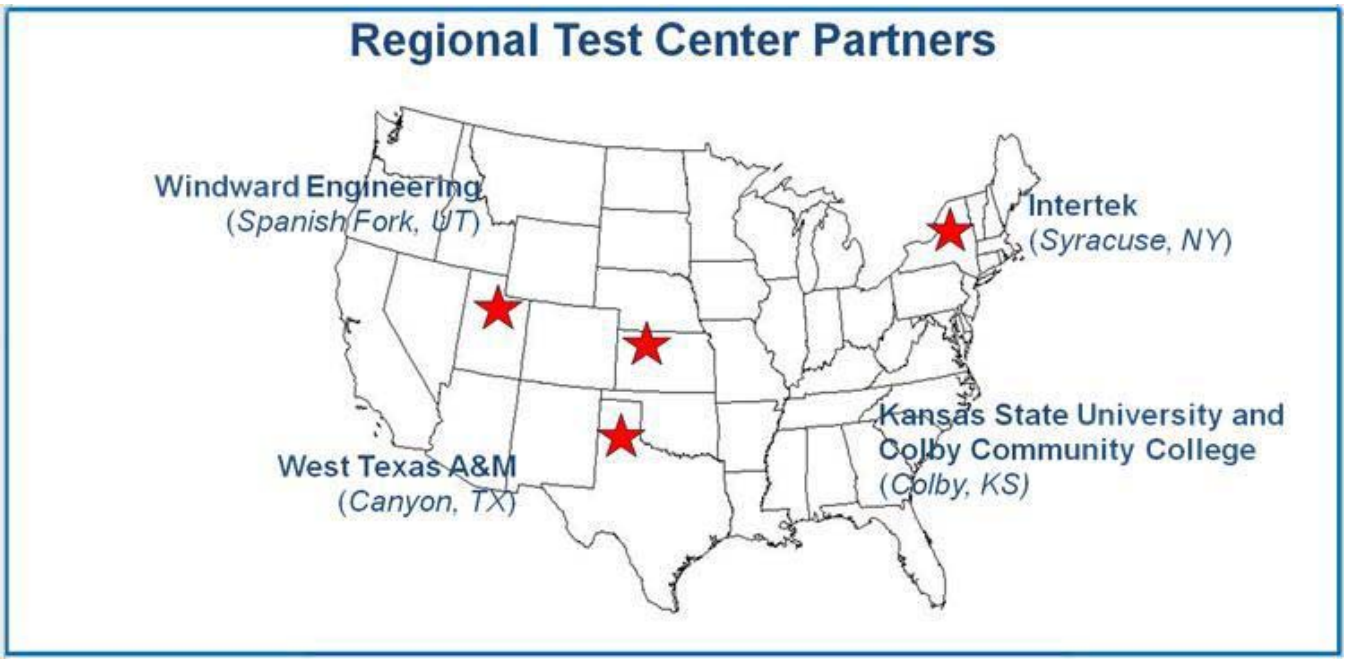


**Fig. 2. RTC Test Site Locations**

At the time of this writing, two turbines have been installed, four turbine installations are pending, and two turbine installations are on-hold awaiting redesign of the turbines.

The Independent Testing and RTC projects have resulted in numerous lessons learned. A key lesson is the need for careful site selection when choosing a SWT test site. Considerations for a wind turbine test site include:

- Wind resource
- Construction privileges
- Terrain
- Surrounding area

The primary consideration for a wind test site is the wind resource. There must be enough strong winds to complete tests in a reasonable time. For example, a duration test on a design class II turbine (designed for moderate to high winds) requires operation for 25 hours in winds of at least 15.3 m/s. In order to complete the duration test in one year, a site with a Rayleigh wind resource distribution would need an average speed of greater than 6m/s. Thus, a site with low wind speeds could not complete a duration test on a turbine designed for high winds within one year.

An important site concern is access and privileges with regard to construction. Test sites require substantial infrastructure. Beyond the turbine and the met tower, there will probably be a test shed to house the grid interconnection and data acquisition equipment. There also may be conduit for power and data cables. Owning the land or having a long term agreement is important. Other items to consider for a testing site include potential zoning requirements, as a height restriction may severely limit testing, and the ability to arrange for a utility interconnection agreement.

Another aspect when considering a test site is the terrain. High correlations between the anemometer and the turbine are critical for power performance testing. The AWEA standard only allows relatively flat sites, without many obstructions, to avoid a site calibration. A site calibration ensures high correlations between measurements from an anemometer upwind of the turbine and what the turbine experiences at hub height. Calibration generally is time and resource consuming.

The surrounding area is also important to a test site. Convenient access to the site is important for regular maintenance on turbines and test equipment, construction equipment access, and deliveries. An unobstructed upwind fetch is important, too. To ensure undisturbed inflow, AWEA power performance testing also does not allow another operating turbine within two diameters (using the larger turbine's diameter). For AWEA power performance testing, obstacles out to 20 rotor diameters are assessed for their impact on the test. Acoustic testing requires relatively low background noise; airports, roadways, and heavy manufacturing sites are not easily compatible with acoustic testing.

Other lessons learned include:

- Length of Time to set up a Test Site: It has taken longer than expected to move from contract signing to the beginning of turbine testing. The RTC subcontracts were signed in July 2010. At the time of this writing, two, out of the eight turbines to be tested under the project, have been installed. In two of the RTC test site installations, the delays stem from delays in gaining National Environmental Policy Act (NEPA) approvals.
- Premature Testing for Certification: Manufacturers are under tremendous pressure to get their products to market. This may tempt some manufacturers to start field testing for certification purposes earlier in the development process before all the bugs are worked out. This pressure should be resisted. Any significant change to the turbine requires that testing be restarted. This will add additional cost to the testing process.
- Involve the certification body early: It is the responsibility of the manufacturer to select both the field test site and the certification body. The certification body should be selected at the same time, or even prior, to the field test site, especially if the latter is not accredited. It is much easier and less costly for the certification body to deal with issues during testing rather than after the fact.
- Study the standard carefully: It is very easy for individuals and organizations to interpret the standards differently. For example, NREL participated in an international Power Performance round robin with several other testing organizations. Each organization was given the same set of data to analyze. Analysis results varied dramatically between the organizations. A similar site assessment round robin (using identical site data) also yielded widely differing analysis results. Given the complexity of the standard, it is not surprising that different organizations interpret the standards differently. Testing organizations can mitigate this problem by participating in periodic round robins with other testing organizations, and by participating in regular discussions and meetings with other test organizations and the certification bodies.
- National Environmental Policy Act (NEPA) Approvals: While this only affects projects that receive federal funding, it is worth pointing out. While two (of four) RTC project sites received NEPA approvals within four months, the approval for

the final site took seven months. There appear to be two reasons for this delay. First, some U.S. Fish & Wildlife Service (USFWS) officials appear to be conflating large and small turbines, attributing the environmental effects of the former to the latter. Second, the body of literature covering the environmental effects of SWTs is small. In the absence of a large body of literature, some USFWS offices want proof that a proposed SWT installation will not harm wildlife, particularly birds. This is difficult to do given the aforementioned lack of literature on the subject. Those working on a SWT project that is subject to NEPA should understand the process and submit their paperwork early.

## 4. CONCLUSIONS

The U.S. SWT industry has recently created an SWT certification infrastructure. The purpose of this infrastructure is to encourage certification of small wind turbines, with the ultimate goal of maintaining consumer confidence in SWT technology. Key components of this infrastructure include the AWEA SWT standard and U.S.-based certification bodies, such as the Small Wind Certification Council and Intertek. DOE and NREL have been working to transfer NREL's SWT certification testing expertise to the wider SWT testing community in support of expanded certification field testing. DOE and NREL are providing general technical support to the SWT testing community, as well as, financial and enhanced technical support to NREL's RTC partners.

## 5. REFERENCES


(1) http://www.awea.org/documents/2010_AWEA_Small_Wind_Turbine_Global_Market_Study.pdf

(2) http://www.smallwindcertification.org/pdfs/small_wind_test_orgs_SWCC.pdf

(3) AWEA Small Wind Turbine Performance and Safety Standard (AWEA 9.1 – 2009) Section 1.4.1 (Page 2)

(4) IEC 61400-2 Ed.2 Design requirements for small wind turbines, Section 9.4 (Page 99)

(5) IEC 61400-2 Ed.2 Design requirements for small wind turbines, Section 9.6 (Page 107)

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