A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

National Renewable Energy Laboratory

Innovation for Our Energy Future

Testing Small Wind Turbines at the National Renewable Energy Laboratory

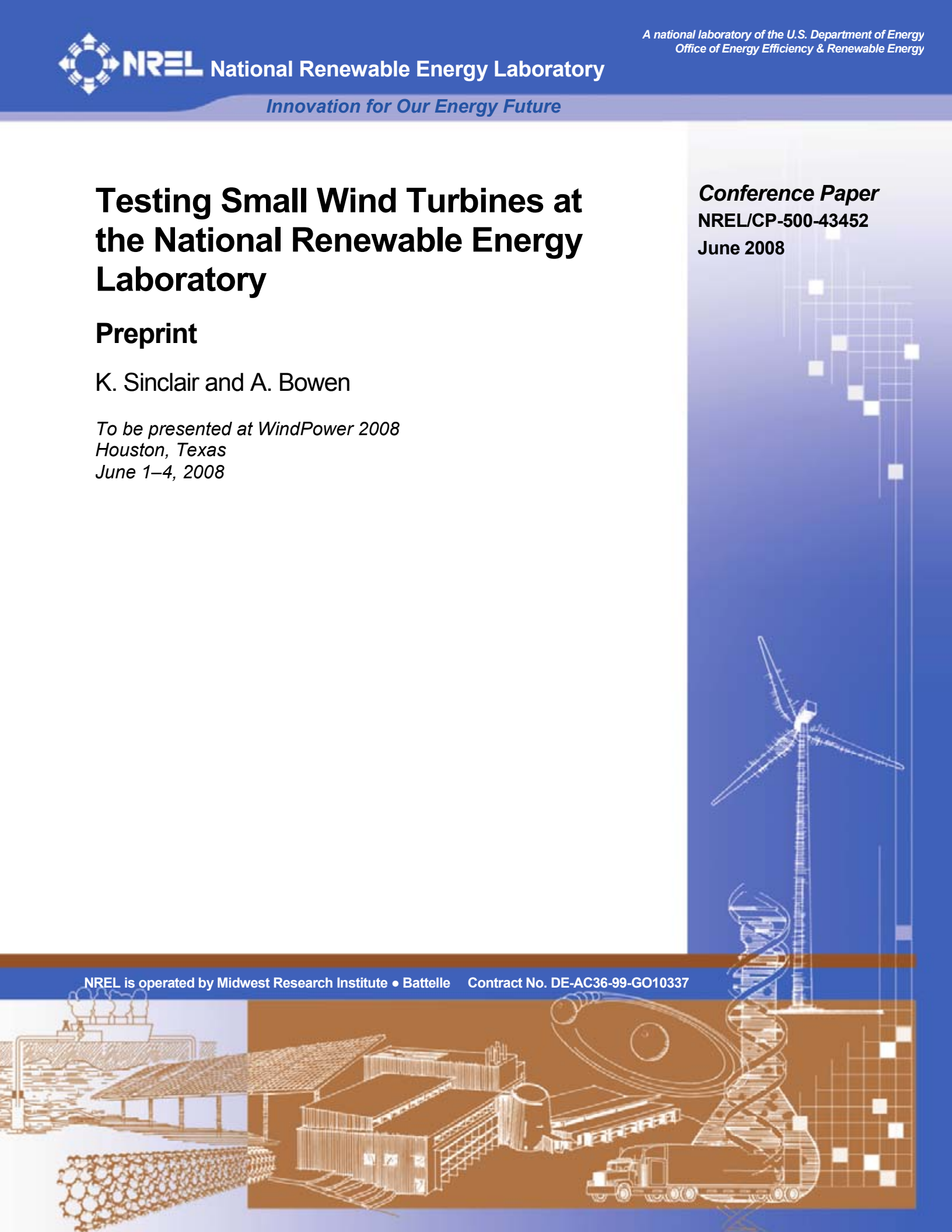
Preprint

K. Sinclair and A. Bowen

To be presented at WindPower 2008
Houston, Texas
June 1–4, 2008

Conference Paper
NREL/CP-500-43452
June 2008

NREL is operated by Midwest Research Institute • Battelle Contract No. DE-AC36-99-GO10337



Testing Small Wind Turbines at the National Renewable Energy Laboratory

Karin Sinclair and Amy Bowen
National Renewable Energy Laboratory
National Wind Technology Center
1617 Cole Blvd, Golden, CO 80401
Karin_sinclair@nrel.gov; 303 384-6946
Amy_Bowen@nrel.gov; 303 384-6931

Introduction

Reducing barriers to wind energy expansion, stabilizing the market, and expanding the number of small wind turbine (SWT) systems installed in the United States are important goals for the Department of Energy's (DOE) Wind and Hydropower Technologies Program. One of the barriers for the distributed wind market is the lack of SWT systems that are independently tested and certified.

The National Renewable Energy Laboratory (NREL) has testing capabilities that are accredited by the American Association of Laboratory Accreditation (A2LA). Currently, NREL is one of only two facilities in the United States that are A2LA accredited. To help industry provide consumers with more certified SWT systems, DOE/NREL launched a project in 2007 called Independent Testing. Through a competitive solicitation, NREL selected four commercially available SWT systems to test in 2008/2009. The turbines will be tested to standards adopted by the International Electrotechnical Commission (IEC) and in compliance with the draft American Wind Energy Association (AWEA) standards for small wind turbine systems.

The resultant test data may be used by the Small Wind Certification Council (SWCC), a nonprofit organization formed with support from DOE, AWEA, state energy offices, and turbine manufacturers to certify SWT systems. Certification by the SWCC is expected to commence in 2009. Test data could also be submitted to a certifying body as partial input for international certification.

SWTs that are tested and certified will give consumers greater confidence that the systems they install will perform within specified wind regimes as advertised by the manufacturer.

Turbines Selected

Of the four turbines selected from NREL's competitive solicitation, subcontracts have been executed with three of the turbine manufacturers (Mariah Power, Abundant Renewable Energy, and Gaia Wind). The fourth subcontract (Entegrity Wind Systems) is awaiting subcontracting approval, which is anticipated to be completed in the summer of 2008. Each of the turbines in the current test cycle is described in the following section.

Mariah Power

Mariah Power's Windspire is a 1.2-kW vertical-axis Giromill wind turbine. The turbine's tower is 9.1-meters tall and its rotor area is 1.2 x 6.1 meters. The turbine has a permanent-magnet generator that has a single-phase output at 120 volts AC.

Mariah Power's Windspire Giromill wind turbine (NREL PIX 15704).

Abundant Renewable Energy

The Abundant Renewable Energy ARE 442 is a 10-kW 3-bladed horizontal-axis upwind turbine. It has a hub height of 30.9 meters and a rotor diameter of 7.2 meters. The turbine has a three-phase permanent-magnet generator that operates at variable voltages up to 410 volts AC.

Abundant Renewable Energy ARE 442 (NREL PIX 15734).

Gaia-Wind

The Gaia-Wind 11-kW turbine is a three-phase induction generator that operates at 480 volts. The turbine's downwind rotor has a 13 meter diameter and its tower is 18 meters tall. The two-bladed, oversized rotor is designed for low to moderate wind speeds.

Gaia-Wind 11-kW turbine (NREL PIX 15705).

Entegrity Wind Systems

The Entegrity Wind Systems EW50 is a 50-kW 3-bladed horizontal-axis downwind turbine. The turbine's rotor diameter is 15 meters and its hub height is 30.5 meters. It has a three-phase induction generator that operates at 480 volts AC.

Entegrity Wind Systems EW50 (NREL PIX 15568).

Tests and Testing Approach

The suite of tests that will be conducted on each of the SWTs will include duration, power performance, acoustic noise emissions, safety and function, and power quality. Each is briefly described below. Tests are performed to IEC standards and in compliance with NREL's A2LA accredited Quality Assurance (QA) system. Duration, power performance, and safety and function test data will be collected using a National Instruments-based data acquisition system and compiled through custom LabVIEW software.

Duration testing is performed to summarize the turbine's performance over long periods of time. Test data will be sorted monthly into time classes specified by the standard and submitted to the client in an informal report. Duration testing will be performed according to IEC Standard 61400-2.

Power performance testing produces a power vs. wind speed graph to summarize the turbine's power generation performance at different wind speeds. This test will be performed according to IEC Standard 61400-12-1, referencing Appendix H for small

turbines. Data are analyzed for rejections based on wind direction, turbine status, and instrument readings, and then compiled through an Excel-based program to produce a power curve.

Acoustic Noise Emissions testing summarizes typical noise levels emitted from the turbine at different wind speeds. Sound data are recorded (one tower height plus half a rotor diameter down wind from the tower base) and processed using Noiselab software. Noise testing will be performed according to IEC Standard 61400-11.

Safety and Function testing is performed to verify the turbine displays the behavior it is designed to have as represented by the manufacturer. Features to be tested will be drawn from the wind turbine documentation and may possibly include additional NREL specified features. The testing will be conducted in accordance with IEC Standard 61400-2.

Power Quality testing will be performed on the Gaia-Wind 11-kW and Entegrity EW50 turbines according to IEC Standard 61400-21. This testing includes assessment of power, flicker, and harmonics levels for compliance with the standard. Turbines with a UL 1741 compliant inverter will not undergo power quality testing.

Accomplishments of the Project to Date

After the four turbines were selected, two data-shed sites were developed, one existing and the other a new installation. With a possible second solicitation on the horizon, the data sheds, turbine sites, and data acquisition software were all designed to be non-turbine specific. The data sheds were outfitted with wire ways to allow easy installation and removal of data and power cables. Conduit was laid and buried from the data shed to the individual metrology tower sites to allow for future removal and new installation of power and data cables. In the case of future turbine installations, metrology tower locations will remain constant while turbine locations will vary depending on turbine sizing.

Custom data-acquisition software was developed in LabVIEW for duration, power performance, and safety and function tests. The software has built-in flexibility to allow for a varying number of data channels and signal types. This allows for minimal code-user interaction while setting up the software for new turbines.

Foundation kits for the four turbines were received ahead of the turbine system itself to allow time for foundation pouring and curing. NREL used a subcontractor for the foundation installations for the Gaia-Wind 11-kW turbine, ARE 442, and Entegrity EW50. The Windspire foundation was installed by NREL site operations crew.

The installation and commissioning of the Mariah Windspire was completed during the week of May 5, 2008; this was the first installation in the Independent Testing Project. The Gaia-Wind 11-kW turbine was installed and commissioned during the week of May

12, 2008. Installation and commissioning of the ARE 442 was completed the week of June 9, 2008.

Instrument calibration and laboratory check out (a process of validating that all systems are working as designed) to A2LA requirements and IEC recommendations have been completed for three of the turbine sites. NREL staff have completed the safety review and documentation that permit operation of the three installed turbines in an "unattended" mode. This permits the turbines to operate continuously as required for some of the test protocols. Data have been collected for several items in the safety and function test for the Gaia-Wind 11-kW turbine. Data are currently being collected for the duration and power performance tests for both the Windspire and the Gaia-Wind 11-kW turbines.

Plans to Expand with Second Solicitation

DOE is planning a second competitive solicitation to test additional SWTs in the FY 2010 timeframe. It is anticipated that the second round RFP will be released in fall 2009. In addition, DOE/NREL may consider expanding this project to support testing additional SWT systems at the NREL site with funding from non-DOE sources.

For More Information

For progress on DOE/NREL's Independent Testing Project, go to NREL's web page under a section titled Small Wind Turbine Independent Testing at: http://nrel.gov/wind/technical_support.html Test reports will be posted as they become available.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ORGANIZATION.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
June 2008	Conference Paper	June 2008

4. TITLE AND SUBTITLE
Testing Small Wind Turbines at the National Renewable Energy Laboratory

5a. CONTRACT NUMBER
DE-AC36-99-GO10337

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
K. Sinclair and A. Bowen

5d. PROJECT NUMBER
NREL/CP-500-43452

5e. TASK NUMBER
WER8.3001

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401-3393

8. PERFORMING ORGANIZATION REPORT NUMBER
NREL/CP-500-43452

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)
NREL

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

13. SUPPLEMENTARY NOTES

14. ABSTRACT *(Maximum 200 Words)*
To describe the small wind turbine testing and certification program at NREL (NWTC).

15. SUBJECT TERMS
Wind; wind energy; small turbines; small turbine testing; Small Wind Certification Council; IEC; NWTC

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
Unclassified	Unclassified	Unclassified	UL		19b. TELEPHONE NUMBER (*Include area code*)

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18