

Abstract

The Department of Energy's National Renewable Energy Laboratory (NREL) is testing five small wind turbines (SWTs) through the first round of its Independent Testing project. Three SWTs have been selected for a second round of Independent Testing. These tests include duration, power performance, safety and function, acoustic noise emissions, and power quality (where applicable). These tests are conducted according to the international Electrotechnical Commission (IEC) standards. Results of the tests conducted on each of the SWTs will be publicly available and also may be used to partially fulfill the requirements for SWT certification. Small wind turbine certification provides a high degree of confidence for the U.S. consumer by showing that small wind turbines will perform as advertised.

NREL has completed tests on three of the five turbines (Gaia-Wind 11kW, ARE 442, and the Mariah Windspire) and partial results are available for the remaining two turbines (Entegry EW50 and the Ventura VT10). Updates of the Department of Energy's support for the second round of Independent Testing are also available.

References

- IEC 61400-2 Ed.2 Design requirements for small wind turbines, Section 9.4 (Page 99)
- IEC 61400-12-1 Ed.1 Power performance measurements of electricity producing wind turbines (Annex H)
- IEC 61400-2 Ed.2 Design requirements for small wind turbines, Section 9.6 (Page 107)
- IEC 61400-11 Ed.2 Acoustic noise measurement techniques (with modifications for small wind turbines)
- IEC 61400-21 Ed.2 Measurement and assessment of power quality characteristics of grid connected wind turbines

Test Methods

Duration (IEC 61400-2)

- The purpose of the duration test is to investigate:
 - Structural integrity and material degradation (corrosion, cracks, deformations);
 - Quality of environmental protection of the wind turbine; and
 - The dynamic behavior of the turbine.
- Turbines must achieve an operational time fraction of at least 90% over a minimum of 2500 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"

Power Performance (IEC 61400-12-1)

- Characterizes power output from the turbine
 - Power curve
 - Estimated annual energy output

Safety and Function (IEC 61400-2):

"...verify that the wind turbine under test displays the behavior predicted in the design and that provisions relating to personnel safety are properly implemented." Measurements and observations are documented for turbine functions and design.

Acoustic Noise Emissions (IEC 61400-11)

- Characterizes the noise emission of the turbine
 - Sound power level
 - One-third octave levels
 - Tonality

Power Quality (IEC 61400-21)

- Determine the electrical characteristics of the grid connected wind turbine
- Wind turbine specifications
- Voltage quality (emissions of flicker and harmonics)
- Voltage drop response
- Power control (control of active and reactive power)
- Grid protection
- Reconnection time

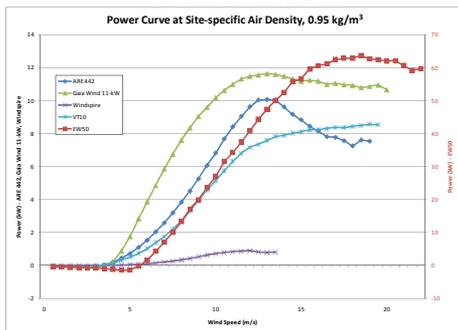
Test Articles



Turbine	Manufacturer	Configuration	Rating kW	Hub height m	Rotor diam. m	Install date
Windspire	Mariah	vertical axis, permanent magnet	1	6.1	1.2	May - 2008
ARE442	Abundant Renewable Energy	upwind, side-furling, permanent magnet	10	31	7.3	Jun - 2008
Gaia-11kW	Gaia-Wind Power	downwind, induction	11	18.2	13	May - 2008
EW50	Entegry	downwind, induction	50	30.5	15	Mar - 2009
VT10	Ventura	downwind, permanent magnet	10	21.3	6.7	Feb - 2010
Swift	Swift	upwind, permanent magnet	1	13.7	2.1	Mid 2010
Viryd 8000	Viryd	upwind, variable speed, induction	8	24.4	8.2	Mid 2010
Proven 7	Proven	downwind, permanent magnet	3.2	11	3.7	Mid 2010

Independent Testing Results to Date

Power Performance



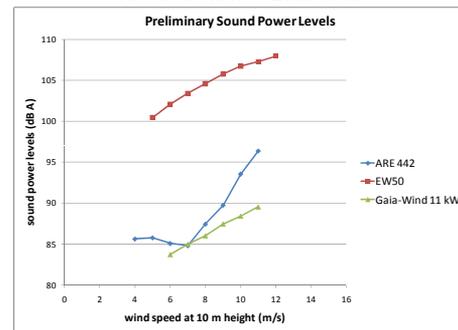
Power Quality



Characteristics of Start at Cut-in Wind Speed

Case of switching operation:	Start at cut-in wind speed			
	30°	50°	70°	85°
Maximum number of switching operations, N_{10} :	120			
Maximum number of switching operations, N_{120} :	120			
Network impedance angle, ψ_n :	30°	50°	70°	85°
Flicker step factor, $k(\psi_n)$:	4.165	4.956	5.128	4.856
Voltage change factor, $k_v(\psi_n)$:	0.095	0.071	0.049	0.056

Acoustic Noise Emissions



Reference air density:	1.225	kg/m ³	
Cut-out wind speed:	25.00	m/s	
Hub height annual average wind speed m/s	AEP-measured kWh		
	ARE 442	Gaia-Wind 11kW	Entegry EW50
4	7,884	17,716	11,006
5*	15,327	32,122	41,796
6	23,516	46,292	83,543
7	30,967	58,690	130,785
8	36,718	68,525	178,132
9	40,459	75,474	220,869
10	42,350	79,617	255,754
11	42,770	81,326	281,396

* AWEA Rated Annual Energy

Test reports are published at NREL's Independent Testing website

http://www.nrel.gov/wind/smallwind/independent_testing.html

Duration

Turbine	Hours of Power Production Above:			O (%)
	0 m/s	1.2V _{AVE}	1.8 V _{AVE}	
ARE 442	3241	553	157	91.2
Gaia-Wind 11kW	2705	711	215	90.8
Entegry EW50*	1383	266	40	98.2
Mariah Windspire**	831	133	12	93.2
Minimum Required	2500	250	25	90

*Duration testing on the Entegry EW50 is currently in progress
**The Duration test on the Mariah Windspire was ended before enough data could be collected

Testing Events



ARE 442 Cracked Blade



Gaia-Wind 11kW Burned Contactor



Entegry EW50 Bent Yaw Lock



Mariah Windspire Separated Air Foil