DOE/Golden Field Office • NREL • National Wind Technology Center

FIELD VERIFICATION PROJECT
FOR SMALL WIND TURBINES

April 2002 | QUARTERLY REPORT | April–June 2001
2nd Quarter, Issue #5

DOE and NREL Visits to the Sites

Windward Engineering, LLC

The site visit to Windward Engineering is planned for October 2001.

Endless Energy Corporation

Lizana Pierce, Department of Energy (DOE), and Trudy Forsyth, National Renewable Energy Laboratory (NREL), talked with Ralph Chapman, Endless Energy Corporation, on June 14, 2001 about several facets of the Endless Energy project using the Atlantic Orient Corporation (AOC) 15/50 wind turbine (Figure 1). Discussion topics included the installation and commissioning of the AOC 15/50, the completion of the interconnection agreement with Central Maine Power for net billing, and the value of the wind and turbine performance data. Sites under consideration for the second Endless Energy wind turbine site were also discussed. These sites included the Maine Maritime Academy, an organic chicken farm, the Maine Audubon society, a hay drying facility, a pollution control wastewater treatment facility, a second turbine at the Blueberry plant, and an island with an electric cooperative. However, each of these sites have issues: the Maine Maritime Academy is located in a historic area; the organic chicken farm is not located in an area with a strong wind resource; the Maine Audubon society is uncertain about the large size of the turbine; the Blueberry plant cannot exceed 100 kW in order to keep its net billing agreement; and the other sites are not located on the coast of Maine.

Figure 1. AOC 15/50 at the Allen Blueberry Plant, Orland, Maine.

Siyeh Development Corporation

The site visit was discussed in issue #3.

Offshore Services, Ltd.

On June 11, 2001, Lizana Pierce and Ruth Adams, DOE; Henry DuPont, Offshore Services; Jonathan and Jo-An Evans, turbine owner; and Trudy Forsyth, NREL, reviewed the Goose and Garden Greenhouse project (Figure 2) and the Evans project (Figure 3). They also visited potential turbine sites for the remaining three projects. During the site visits, introductions were made between the current host site people and the people at the potential host sites such as the airport and west side (off-grid installation) of the island.

Figure 2. Bergey Excel/R 7.5 kW at the Block Island, Goose and Garden Greenhouse, Block Island, Rhode Island.

Figure 3. Bergey Excel-S/E 10 kW at Jonathan and Jo-An Evans Residence, Block Island, Rhode Island.

Figure 4. Bergey Excel-S/E 10 kW at the Liberty Science Center in Jersey City, New Jersey.

AWS Scientific, Inc.

Lizana Pierce, DOE; Jim Stickler, Betty Faber, Daniel Smith, Larry Sragow of Liberty Science Center; Bob Putnam of AWS Scientific; and Trudy Forsyth, NREL, met on June 12, 2001, at Liberty Science Center to review the projects. They also saw the completed installation at the Liberty Science Center (Figure 4) and read the wind energy information that is being distributed. The Liberty Science Center is a hands-on science museum for children, which includes a renewable energy exhibit that illustrates wind energy. It offers IMAX shows, special exhibits, and programs on different science topics. The Bergey Excel wind turbine can be seen from a patio and there are plans to expand the wind exhibit to include wind turbine production information.

Host Sites

The five recipient organizations manage 13 sites. Figure 5 and Table 1 show the names of the organizations and contacts, locations, turbine types, applications, and the dates the turbines were commissioned.

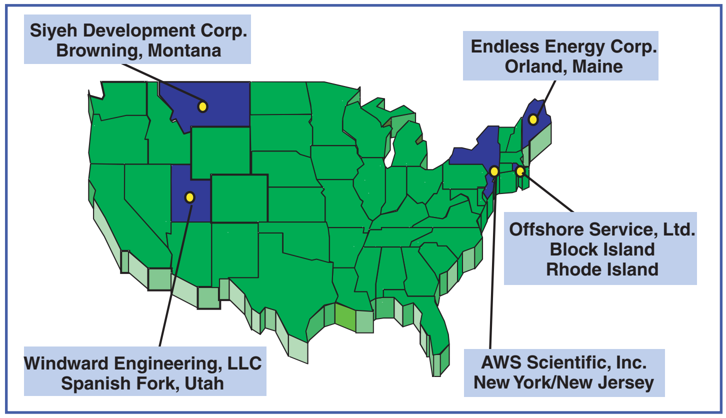


Figure 5. DOE Field Verification Project turbine locations

Table 1. Field Verification Project Locations and Participating Organizations

Organization/Contact	SWT #	Turbine Location	Quantity/Type of Turbine	Application	Date Commissioned
Windward Engineering 4661 Holly Lane Salt Lake City, UT 84117 Contact: Craig Hansen/Dean Davis	Turbine #1	Spanish Fork, Utah	One Whisper H40 (previously named Whisper 900)	Grid Connected	February 26,2000
Endless Energy Corporation 57 Ryder Road Yarmouth, ME 04096 Contact: Harley C. Lee/Michael Boice	Turbine #1	Allen Blueberry Plant, Orland, Maine	One AOC 15/50	Grid Connected	February 14, 2001
	Turbine #2	Monhegan Island, Rockland, Maine	One AOC 15/50	Grid Connected	
Siyeh Development Corporation P.O. Box 1989 Browning, MT 59417 Contact: Dennis Fitzpatrick	Turbines #1–4	Waste Water Treatment Facility, Browning, Montana	Four Bergey Excel—S/E 10 kW	Pumping and Purification	October 2000
Offshore Service, Ltd. P.O. Box 457 Block Island, RI 02807 Contact: Henry G. duPont	Turbine #1	Block Island Goose and Garden Greenhouse, Block Island, Rhode Island	One Bergey Excel/R 7.5 kW	Off-grid Residential Consumption	June 2, 2000
	Turbine #2	TBD	One Bergey Excel—S/E 10 kW	Residential Consumption	
	Turbine #3	TBD	One Bergey Excel—S/E 10 kW	Residential Consumption	
	Turbine #4	TBD	One Bergey Excel—S/E 10 kW	Residential Consumption	
	Turbine #5	Jonathan & Jo-An Evans Residence Block Island, Rhode Island	One Bergey Excel—S/E 10 kW	Residential Consumption	August 23, 2000
AWS Scientific, Inc. 251 Fuller Road Albany, NY 12203-3656 Contact: Bob Putnam/Dan Bernadett	Turbine #1	Webster, New York	One Bergey Excel—S/E 10 kW	Distributed Generation	June 1, 2001
	Turbine #2	Liberty Science Center Jersey City, New Jersey	One Bergey Excel—S/E 10 kW	Distributed Generation	April 22, 2001
	Turbine #3	Southhampton College Long Island, New York	One Bergey Excel—S/E 10 kW	Distributed Generation	
	Turbine #4	Peconic Land Trust's North Fork Stewardship Center Long Island, New York	One Bergey Excel—S/E 10 kW	Distributed Generation	

Second Quarter Status and Statistics Summary

Windward Engineering, LLC

Windward Engineering staff is testing a grid-connected Whisper H40 at an existing wind energy test site (Figure 6) in Spanish Fork, Utah. Since the turbine was commissioned in February 2000, it has produced a total of 1,893 kWh; 24% of the energy has been used at the test site and 76% of the energy has been sold to the grid.

Spanish Fork, Utah

The following tables and figures contain the test results of the Whisper H40 at the site in Spanish Fork, Utah. Note that the Windward Engineering tables and figures report the measured power data. Power curves are not corrected to sea-level air density unless otherwise noted. The elevation at Spanish Fork, Utah, is 4,800 ft. All wind speeds reported are the average of the two values measured by the primary anemometer (at hub height plus the rotor radius) and the secondary anemometer (at hub height minus the rotor radius).

Highlight

Windward presented the results from their Field Verification Project at the American Wind Energy Association (AWEA) Windpower 2001 Conference in Washington, D.C. A report can be found in the Windpower 2001 proceedings.

Figure 6. Whisper H40 at the host site, Spanish Fork, Utah.

Table 2 shows the quarterly project summary through June 30, 2001. The Whisper H40 produced 340 kWh under an average quarterly wind speed of 5.32 m/s. The Whisper H40 operated with 100% availability, while the data acquisition system had an availability of 99.42%. See Table 3 for the detailed downtime summary.

Table 2. Project Summary

Quarterly Summary	
kWh Total	340
kWh/m^2	95.1
Capacity Factor*	17%
Capacity Factor**	30%
Unavailable Hours***	12.7
Turbine Availability	100%
Max Watt****	668.8
Concurrent Wind Speed***** (m/s)	12.5
Average Wind Speed at Hub Height (m/s)	5.32

* Based on the published rated output of 900 watts

** Based on the measured rated output of 525 watts

*** Unavailable hour events are shown in Table 3 and include data from the DAS system and from site operation log sheets

**** Maximum Power is the peak 10-minute-average output

***** The concurrent wind speed is a 10-minute-average wind speed

Table 3. Downtime Summary by Type for Whisper H40

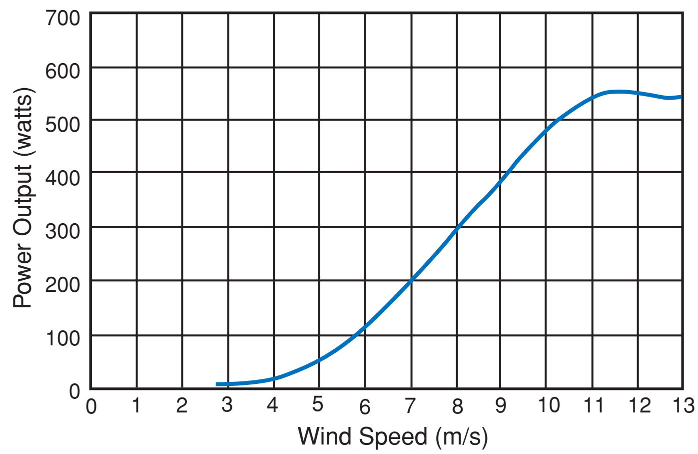
Category	Hours	Lost Energy KWh	Remarks
Fault: Wind Turbine			
Fault: Inverter			
O&M			
Turbine Measurements (related to modeling)	1.67	0.0	Measuring yaw friction and checking furl weather protection
Ground Testing (related to modeling)			
Instrumentation Installation or Calibration			
DAS Disable	0.67	0.0	Extended grid power loss resulting in backup battery drained
Host Site System Disable			
Battery Over Voltage			
Blown Fuse			
Brake Cooling Cycle			
Inverter Faults			
Unknown			
Others	10.33	0.00	Anemometer iced
Total	12.67	0.00	

Windward Engineering, LLC

The test results indicate that the Whisper H40 wind turbine power curve reached a maximum power of 554 watts at a wind speed of 12.0 m/s and then decreased to 543 watts at 13.0 m/s (Figure 7). The H40 showed its furling capabilities at high wind speeds.

Figure 8 shows the wind speed distribution at the Spanish Fork, Utah, test site for this quarter. The most productive wind speeds range from 5 -12 m/s. There was little energy produced for wind speeds above 13 m/s or below 4 m/s.

Figure 9 shows that only 3 days of this quarter (out of 91) produced daily energy below 0.25 kWh. The site's steady diurnal wind patterns make the wind turbine productive 97% of the time.



Wind Speed (m/s)	Power (watts)
0.5	2
1.0	2
1.5	2
2.0	2
2.5	2
3.0	3
4.0	13
4.5	27
5.0	48
5.5	79
6.0	113
6.5	148
7.0	193
7.5	239
8.0	290
8.5	339
9.0	383
9.5	435
10.0	483
10.5	517
11.0	541
11.5	553
12.0	554
12.5	544
13.0	543

Figure 7. Whisper H40 Wind Turbine Power Curve

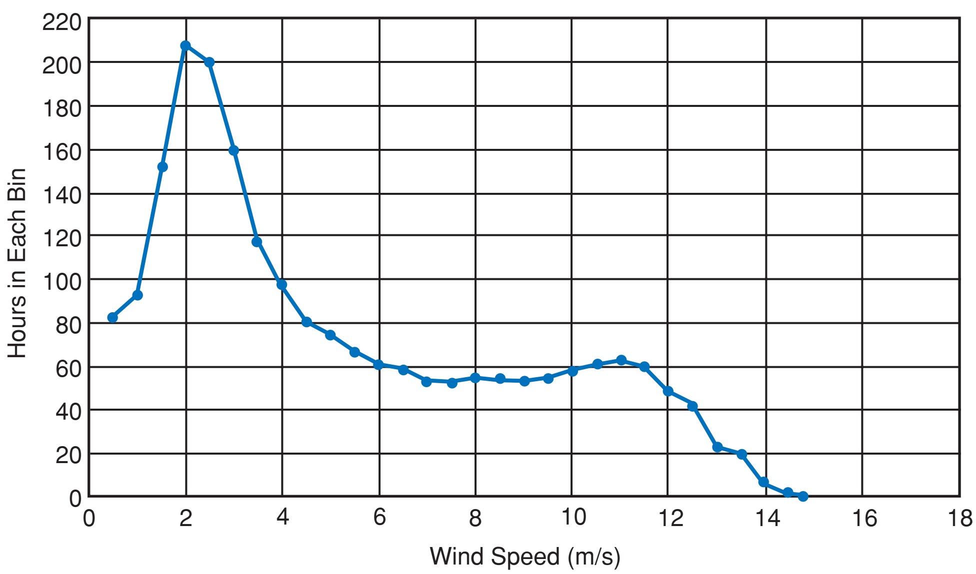


Figure 8. Wind Speed Distribution Curve

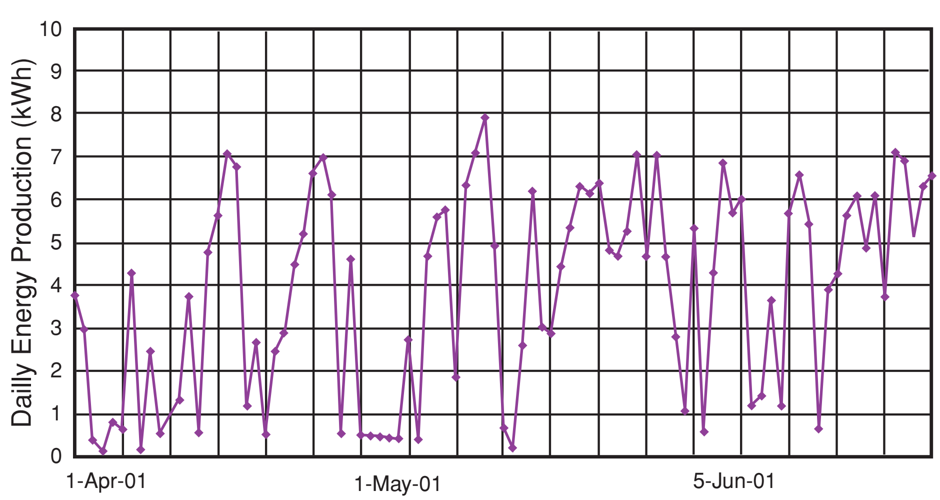


Figure 9. Daily Energy Production

Windward Engineering, LLC

Figure 10 shows an example of measurements made by Windward for furl and yaw angle. The Whisper H40 has a quick furling response with the turbine fully furled at 70 degrees (Figure 11). Collecting these data are part of Windward's project of building ADAMS models (dynamic simulation tool).

Table 4 shows the maximum measured values for the average wind speed when the maximum instantaneous rotor speed was measured. Other maximum values are shown as well.

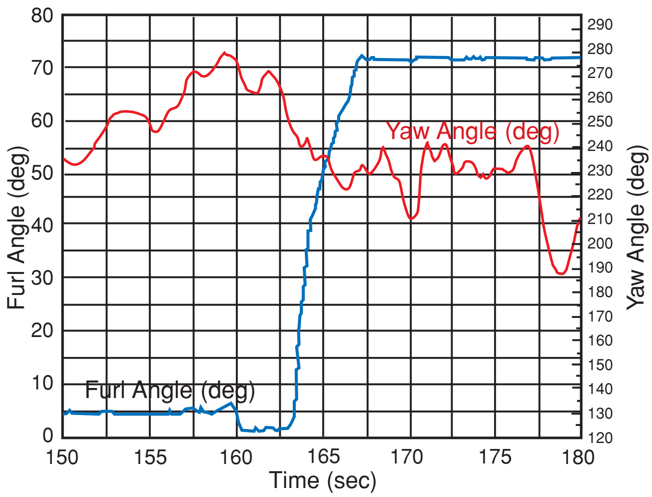


Figure 10. Furl Angle and Yaw Angle Plot for Highest Recorded Rotor Speed

Figure 11. Whisper H40 shows its furling capabilities.

Table 4. Maximums from Calculated Labview Channels

Channel Description	Measured or Calculated Values
Max. Instantaneous Ave. Wind Speed	27.4 m/s
Max. Instantaneous Rotor Speed	1,467 RPM
Max. Yaw Rate	84 degrees/sec
Max. Furl Rate	47 degrees/sec

All channels monitored at 5 Hz.

Instantaneous wind speed calculated from two anemometers (27 & 34 feet).

Rate calculations use a linear regression to determine the slope. The calculations use 5 data points (1 second of data) where the data flows through the array in a FIFO operation.

Endless Energy Corporation

Endless Energy Corporation (EEC) will install two AOC 15/50 turbines along the windy Maine coast for several commercial power customers. The goals of the project are to verify the performance of the turbine under harsh coastal conditions and to create a model for commercially competitive wind power installations in small, distributed settings. The project will benefit from the convergence of essential factors for successful wind-powered generation: windy, buildable locations; the use of well-engineered wind turbines; and the existence of the necessary regulatory scheme and power markets for financial success.

Allen Blueberry Plant, Orland, Maine

Regarding the Net Energy Billing discussed last quarter, in June, Maine Public Utilities Commission (PUC) issued its ruling requiring Central Maine Power (CMP) to offer a net energy billing contract to G.M. Allen & Son. The ruling further determined that the net energy billing contract should be retroactive to the date the turbine first generated electricity and that Endless Energy was not acting as a transmission and distribution company. All of the documents filed in the case (2001-259) and an audio recording of the Commissioner's session are available online at http://www.state.me.us/mpuc

Last quarter, Atlantic Orient Corporation (AOC) installed a software modification as part of their effort to verify the performance characteristics of the wind turbine per the purchase and sale agreement. Data analysis this quarter showed that the turbine was performing satisfactorily and the final payment was issued to AOC per the purchase and sale agreement. In addition, EEC queried the town tax collector about the process for requesting a tax abatement. The estimated town tax bill for the year is approximately $1,300.00. EEC designed an informational sign (2x3 feet) to be placed near the turbine (Figure 12). It is being produced and will be installed. Future tasks include installing fencing, making the DAS operational, and establishing a method for reporting data.

Figure 12. AOC 15/50 wind turbine at the Allen Blueberry Plant in Orland, Maine.

Monhegan Island, Rockland, Maine-project in planning process

EEC is in the process of project evaluation and site selection.

Siyeh Development Corporation

Siyeh Development Corporation (of the Blackfeet Indian tribe) in conjunction with the Town of Browning, Montana; Bergey WindPower; the Indian Health Service; the Blackfeet Indian Housing Authority; and Glacier Electric Cooperative will partner to install four Bergey turbines at Browning's Waste Water Treatment Facility. These project partners represent a broad base of experience and interests ranging from local government and utility functions to state-of-the-art wind turbine systems engineering. It is believed that the project will assist in the improvement of the community waste water treatment system by offsetting energy costs and promote a cohesive and integrated experience base for future wind power development.

Waste Water Treatment Facility, Browning, Montana

During this quarter, performance data continued to be collected on two turbines; however valid or reliable data were not available to report this quarter. Siyeh staff continue to make adjustments to the collection software as needed in order to properly analyze the wind speed and electrical generation information. Inverters #1 and #3 remained inoperable. Inverter #1 remained with Trace this quarter due to scheduling difficulties involving installation of the inverter. Inverter #3 is awaiting service when Trace technicians return to the site with Inverter #1. Siyeh needs to collect data on the site's wind conditions and the generating system output, work with Trace on the ongoing retrofit of the inverters, and repair the furling mechanism on turbine #4.

Offshore Services, Ltd.

Offshore Services will install five Bergey Excel wind turbines on Block Island, Rhode Island, to evaluate the effectiveness of wind power in a harsh marine environment at five different locations with different types of ownership structures. In addition, Block Island Power Company has a number of circuits that experience low voltage at the ends of the distribution system during peak demand periods. Some of these turbines will be placed at the end of the distribution system to measure the effect of adding distributed power sources.

Block Island Goose and Garden Greenhouse, Block Island, Rhode Island

The turbine only produced more power than the greenhouse could use on a few occasions, and in general, the turbine provided all the power needed except during low winds when the generator ran to charge the batteries.

Offshore ordered and received the equipment to automate the harvesting of excess power, which was discussed last quarter. The only newly reported problem was that the data cable from the wind vane/speed sensor was pinched or chaffed by a tower cable clamp causing intermittent erroneous wind speed and direction data. This has been corrected. The result was a number of weeks in which the wind speed measurements were lower than those that actually occurred. Offshore removed the erroneous wind speed data from the data within this report because inclusion of false wind speed data would result in an incorrect power curve.

Review

This wind turbine, a Bergey 7.5-kW Excel/R (for DC battery charging) on an 18-m tower, was erected in May 2000 and was commissioned on June 2, 2000. Wind velocity and direction measurements began on that date, with the power transducer data being available on June 11. This turbine is identical to the Bergey 10-kW machines used for generating power with a utility synchronous interphase, except that the battery charging electronics do not have the range of power output of the utility synchronous model. Thus, the top end of the power production is limited to 7.5 kW.

The leased Ford Electric Ranger pickup truck, which is charged with power from the wind turbine, was hit in the right rear quarter panel by the Island's only street sweeper in early May, causing $2,200.00 of damage. It was repaired and put back in operation in early June. The vehicle adds flexibility to the wind/battery system by increasing the storage capacity of the entire system and providing an additional system load that can be used in windy conditions. The vehicle has been driven slightly more than 6,000 miles since May 2000, displacing approximately 400 gallons of gasoline, 366 pounds of carbon monoxide, 6,900 pounds of carbon dioxide, 24 pounds of nitrogen oxides, and 46 pounds of hydrocarbon, which would have come from a conventional vehicle.

Data results are on the following page.

Offshore Services, Ltd.

Block Island Goose and Garden Greenhouse, Block Island, Rhode Island

The following tables and figures show the project summary (Table 5), distribution of quarterly average wind speed (Figure 13), and wind speed distribution curve (Figure 14) for the quarter ending June 30, 2001.

Table 5. Project Summary

kWh Total	kWh/m2	Capacity Factor	Max kW	Concurrent Wind Speed* (m/s)	Ave. Wind Speed at Hub Height (m/s)
1,439.5	36.4	28%	6.8	unavailable	4.9

* The concurrent wind speed is an hourly average wind speed.

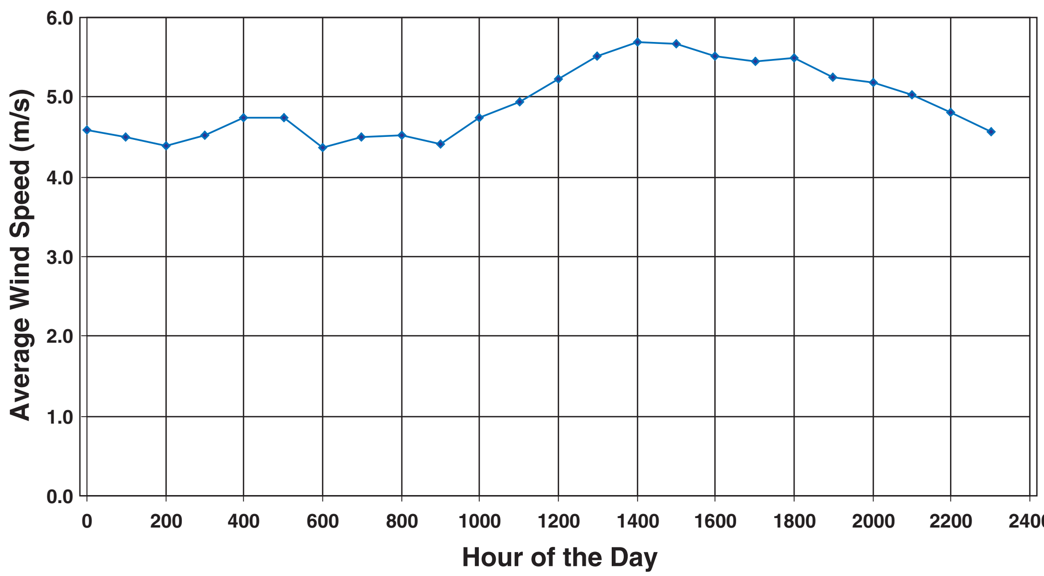


Figure 13. Distribution of Quarterly Average Wind Speed

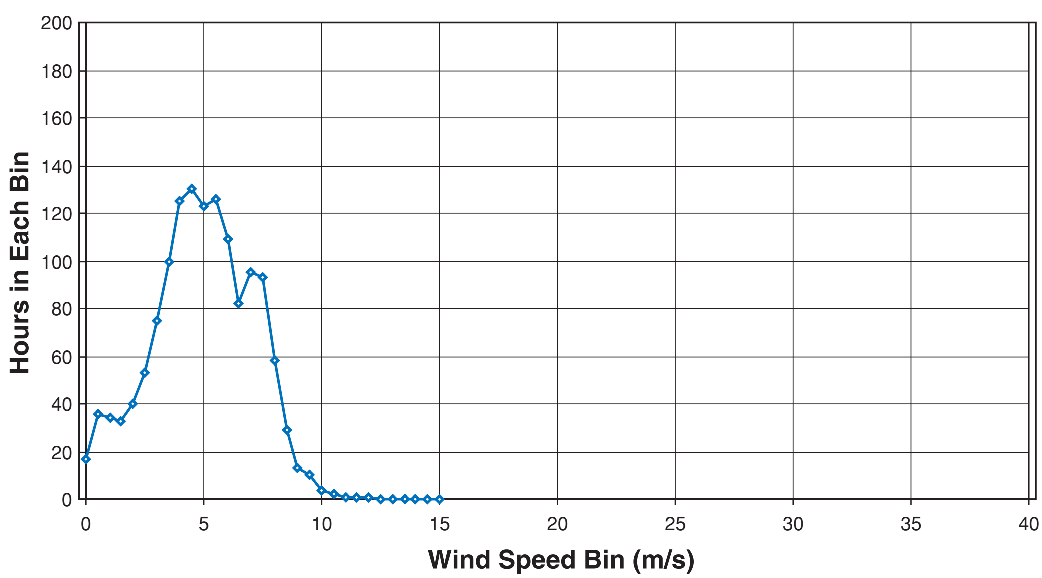


Figure 14. Wind Speed Distribution Curve

Offshore Services, Ltd.

Block Island Goose and Garden Greenhouse, Block Island, Rhode Island

Figure 15 shows the power curve for the Bergey 7.5 kW Excel/R. The low wind speeds (Figure 13) explain part of the low power curve (figure 15). (Summer is the low wind speed time for most locations in the U.S.) This power curve (Figure 15) was generated for a battery charging system, which has a lower power curve due to the effect of the batteries.

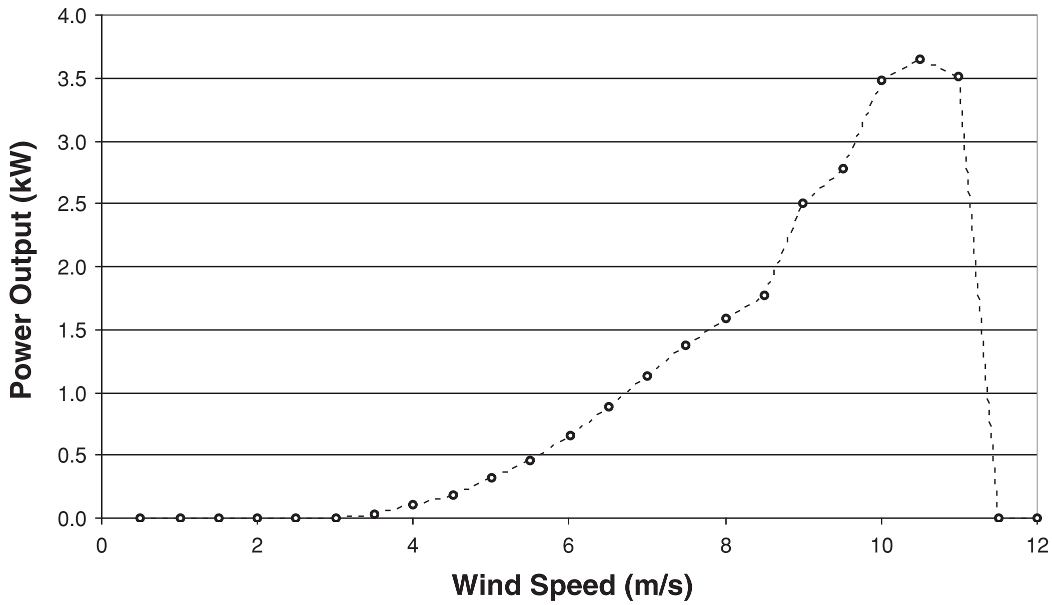


Figure 15. Bergey Excel Power Curve

Jonathan & Jo-An Evans Residence, Block Island, Rhode Island

The turbine was recommissioned and started operating again in June after overcoming the issues discussed in past quarterly reports. This turbine displaced 240 kWh of power that would have been used by the residence from the utility and sold 12 kWh back to the utility under Public Utility Regulatory Policies Act (PURPA). In addition, staff replaced the transducer, which solved the noise issue discussed in previous quarterly reports (Issues #2 and #3). Bergey WindPower has finished the testing of a new blade design for this machine, which will significantly reduce the turbine's operating noise. A set of these new blades will be installed this fall.

Alternate Site 1, North Dumpling Island near Fishers Island, New York-project in planning process

The owner of North Dumpling Island has signed a lease agreement to participate in the project. The turbine has been transported to the island and is ready for installation.

Alternate Site 2, Block Island, Rhode Island-project in planning process

Offshore signed an agreement with the wind-turbine-friendly neighborhood group, which owns 23 acres of land, to participate in the project. Offshore has also applied for a building permit. This site presents a number of opportunities to the project: (1) it is a good site with respect to wind resource exposure, (2) it allows a wind turbine under the new restrictive zoning ordinance, (3) it will provide important information about cooperative ownership of a wind turbine, and (4) Offshore is applying to the Rhode Island Public Utilities Commission to allow the neighbors to share the power in a "Neighborhood Power System" by wheeling the excess power generated to the neighbors' residences through the local electrical utility distribution network.

Alternate Site 3, Block Island Airport, Rhode Island-project in planning process

The Block Island Airport is a suitable site and it is anticipated that noise or visual concerns of wind turbines will not be installation barriers. The airport meets all the requirements of the new zoning ordinance even though State properties are exempt. And, the airport has an opportunity to significantly reduce the cost to the taxpayer of operating this and other facilities. If successful, the State has interest in placing turbines at their other airports. Meetings with the State Airport Planning Department has led to a siting review, which should be concluded in September.

AWS Scientific, Inc.

AWS Scientific will install, operate, maintain, and monitor the performance of one Bergey Excel at each of its four sites. These four sites are geographically diverse and characterized by challenging weather extremes. These projects will demonstrate the use of wind for distributed power needs for grid-connected generation under diverse ownership scenarios.

Webster, New York

The foundation and wire run were installed May 7-14, 2001. The turbine was installed May 29 to June 1 and was commissioned on June 1 (Figure 16). The turbine was in service for 710 hours during this quarter and produced 371.6 kWh for a capacity factor of 5.2%. This wind turbine system is grid connected and was available 100%. There were three unavailable time events due to line outages for a total of 2.8 hours. These outages resulted in approximately 7.2 kWh of lost energy production. Figure 17 shows the 10-minute-averaged power curve for this quarter and Figure 18 shows the distribution of the quarterly average wind speed at hub height.

Figure 16. Bergey Excel-S/E 10 kW installed in Webster, New York.

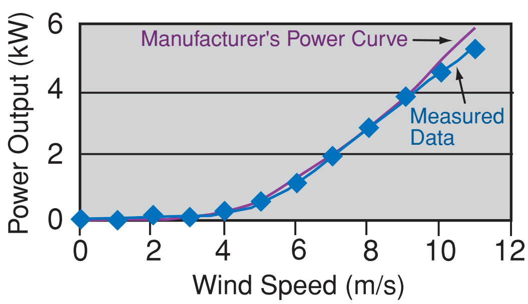


Figure 17. Bergey Excel-S/E 10 kW Wind Turbine Power Curve

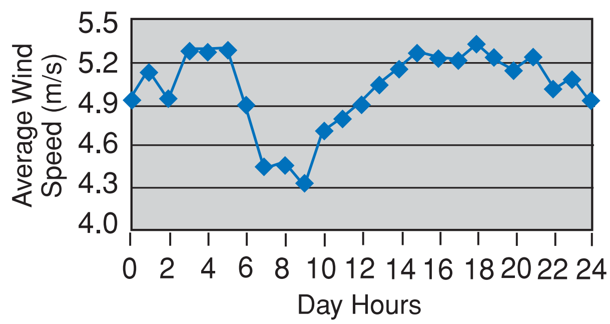


Figure 18. Bergey Excel-S/E 10 kW Distribution of Quarterly Average Wind Speed at Hub Height

AWS continues to wait for the results of the UL (Underwriters Laboratories) testing of the GridTek inverter to determine if it will meet the additional New York State Standard Interconnection Requirement.

Total installed costs were higher than originally budgeted because a new foundation had to be poured due to the agreement with the Town to relocate the base pad on the property. This also resulted in the crew having to make an additional trip to the site in order to complete the installation.

Liberty Science Center, Jersey City, New Jersey

The wind turbine was installed April 17-22, and the turbine was commissioned on April 22 (Figure 19). After installation, AWS found that the DAS was producing suspect values. Their initial attempts to troubleshoot the problem were unsuccessful, but staff continued to research the situation. They found an inconsistency between the wiring configuration and the DAS programming. AWS engineers returned to the site on May 10 and corrected the problem. The DAS was commissioned on May 10. During this quarter, the turbine was in service for 1,668 hours. Total energy production recorded was 463.8 kWh for a capacity factor of 3.9%. The wind turbine system was available 100%, but there were two unavailable time events due to the DAS and a line outage. The DAS accounted for 432 hours of the downtime (estimated 162 kWh was generated but not recorded) and the line outage accounted for 3.3 hours of downtime (1.7 kWh of lost energy production).

Figure 19. Bergey Excel-S/E 10 kW installed at the Liberty Science Center in Jersey City, New Jersey, with the New York skyline in the background.

AWS Scientific, Inc.

Liberty Science Center, Jersey City, New Jersey

Total turbine installed costs were higher than originally budgeted due to the site needing to have a self-supporting tower instead of a guyed tower. Self-supporting towers are more expensive than guyed towers, but they take up less space since the need for guy wires is eliminated. Further the foundation costs for the self-supporting tower were greater than the guyed tower foundation costs. However, lower than expected operation and reporting costs are expected to offset these increases.

Figure 20 shows the power curve for this quarter that was averaged over 10 minutes and Figure 21 shows the distribution of the quarterly average wind speed at hub height.

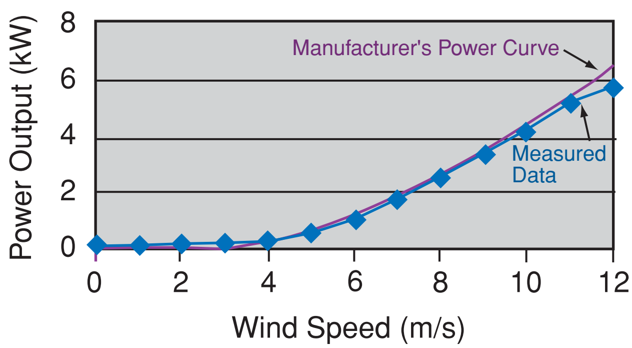


Figure 20. Bergey Excel-S/E 10 kW Wind Turbine Power Curve

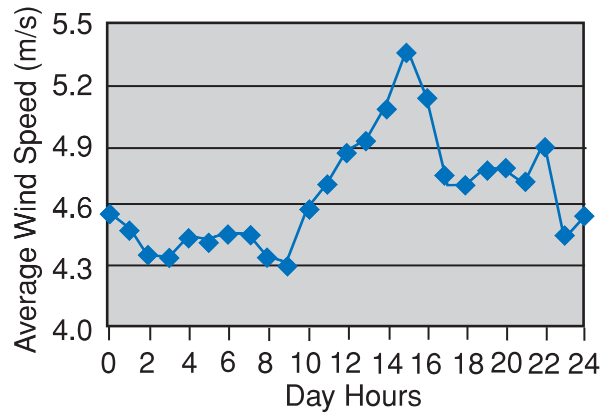


Figure 21. Bergey Excel-S/E 10 kW Distribution of Quarterly Average Wind Speed at Hub Height

Alternate Site 1, Southampton College, Long Island, New York-project in planning process

On June 14, 2001, a completed variance application was submitted to the Southampton Town Zoning Board of Appeals for the construction of a wind energy conversion system at Long Island University's Southampton College campus. The application seeks a 92-foot variance from Section 330-77.C., which states that the height of an accessory building shall not be more than 20 feet. The Zoning Board has been asked to schedule this project for review as soon as possible in order to integrate wind turbine construction, operation, and performance evaluation into the fall curriculum at the College.

An interconnection plan is being developed by Keyspan Electric Services, LLC, the manager of the Long Island Power Authority's transmission and distribution system, and AWS, assuming that the testing of the GridTek inverter is not completed in time for turbine installation and commissioning. (Note: In Issue #2, AWS reported that the state of New York requires them to obtain an additional certification beyond UL listing for the Trace GridTek 10-kW inverter. This is part of the New York State Standard Interconnection Requirements.)

The Southampton Town Zoning Code under Section 330-76.K.(4). requires that computations be submitted by a registered professional engineer in the state of New York certifying that the tower (including footings and rotor system) is designed to comply with the wind load requirements of the New York State Building Construction Code. AWS received a quote of $8,080.00 to perform this work. The zoning application will also seek a variance from this requirement, requesting that the tower manufacturer's calculations be accepted.

Peconic Land Trust's North Fork Stewardship Center, Long Island, New York

AWS continues to work with the Peconic Land Trust to put a professional and technical services agreement in place and to address any permitting and approval issues. AWS plans to use a self-supporting tower, which costs more than other towers. It will require additional money for concrete and rebar for the foundation, fencing, and installation labor, which were not covered in the original project proposal and award. AWS and Peconic are exploring additional sources for funding.

Testing at the NWTC

NREL has been conducting power performance, noise, safety, and duration tests in accordance with international standards on each of the three turbine models used in the Field Verification Project at the National Wind Technology Center (NWTC). The relevant standards are IEC 61400-12 for power performance, IEC 61400-11 for noise, and IEC 61400-2 for safety and reliability. The IEC organization is currently updating the provisions for reliability testing in a revision to IEC 61400-2.

Whisper H40

NREL has completed testing of the Whisper H40. The Whisper H40 has a horizontal axis, is orientated upwind, has three blades, a rigid rotor hub, a rotor diameter of 2.1 m, a hub height of 9.1 m, and has a rated electrical power of 900 W. During 14 months of testing that concluded in May 2001, this turbine operated 3,107 hours and produced 2,101 kWh of electricity with an operational time fraction of 100%. (Operational time fraction is a carefully defined interpretation of availability as specified in the draft standard, IEC 61400-2. Operational time fraction is not reduced due to interruptions from testing activities or grid outages.) The turbine exhibited one minor problem in the later part of the test when its furling mechanism caused it to remain furled inappropriately in light winds. This occurred last quarter and NREL staff took action. However, this did not result in any reduction of operational time fraction. NREL measured the turbine's noise emissions (a weighted apparent sound power level in 8 m/s wind) as 84.9 dBA, which is very quiet for a wind turbine. The measured performance characteristics for the AC power curve are shown in Figure 22. At a mild wind site such as the NWTC test site (5 m/s average wind speed) this turbine would produce 511 kWh/yr and an estimated 663 kWh/yr at sea level.

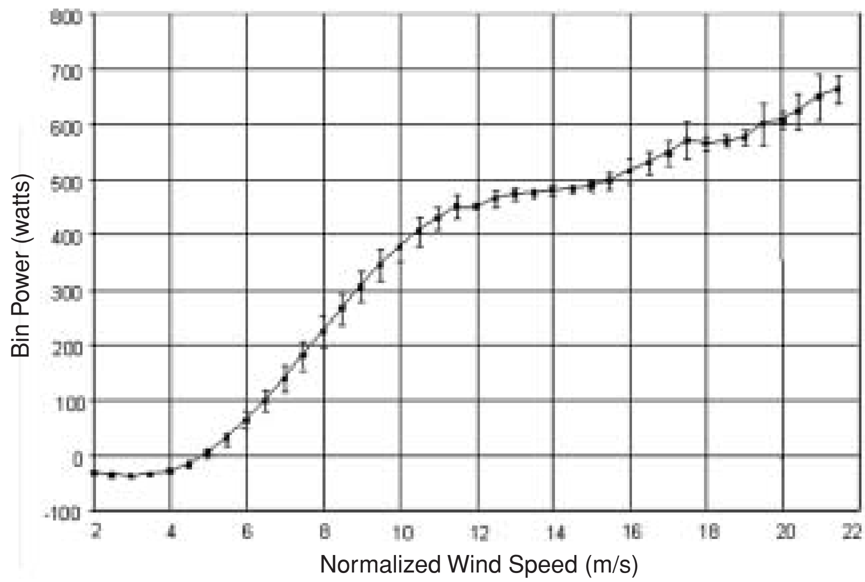


Figure 22. Whisper H40 Performance Characteristics
Note: Site average air density of 1.007 kg/m3
Note: This power curve is different from Figure 3 based on this figure's data out to 21 m/s.

AOC 15/50

This turbine completed a 19-month duration test in May 2001, having operated for 1,550 hours with 25,455 kWh of production and an operational time fraction of 90.5%. Most of the downtime was caused by problems in the control panel design that has already been improved in newly produced turbines. NREL has also completed power performance and noise tests and will report these results in the future. The safety test is planned after the turbine controller is upgraded to the new production configuration later this year.

Bergey Excel 10 kW

At the end of June, the Bergey turbine had run for 1,004 hours with 88 hours above 10.2 m/s winds and 13 hours above 15.3 m/s winds. During this quarter the maximum 3 second gust was recorded at 43.7 m/s and a maximum turbulence intensity of 17.5 measured at 15 m/s winds. There was one significant failure of a control card. NREL has obtained some noise emissions data, but researchers are waiting until the autumn winds arrive to complete noise testing.

Produced for the
U.S. Department of Energy
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NREL/TP-500-31271
April 2002