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

FIELD VERIFICATION PROGRAM FOR SMALL WIND TURBINES

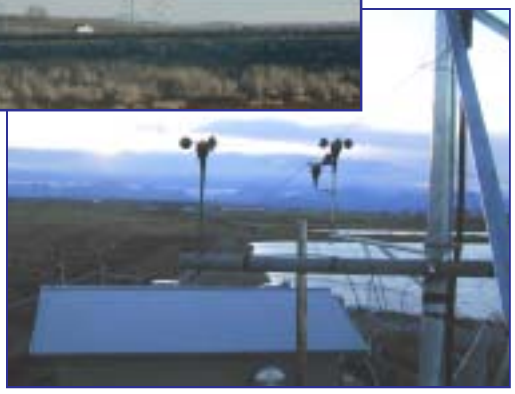
June 2001 QUARTERLY REPORT October–December 2000
4th Quarter, Issue #3

Siyeh Development Corporation Field Verification Profile

Siyeh Development Corporation is a federally chartered corporation of the Blackfeet Tribe. The tribe's 3,000-square mile, federally recognized Blackfeet reservation is in northwest Montana, a class-V wind area that produces an excellent wind resource with recorded average annual wind speeds of 22 miles per hour. The Blackfeet Tribal Council is interested in creating wind power and energy development projects on the reservation. They hope to see the creation of wind jobs, as well as payment for the electricity that is produced. In 1996, a 100-kW Vestas turbine was installed on the reservation, approximately one mile southwest of Browning, Montana. It interconnects to Glacier Electric Cooperative's distribution line and has been owned and operated by the Blackfeet Community College and managed by Martin Wilde. Today, Siyeh is working with Seawest on another project, a 22-MW windfarm north of Browning, Montana. In addition to these wind projects, Siyeh has a field verification project in Browning, Montana, which serves Browning's Waste Water Treatment Plant. The plant includes three treatment ponds and a pump house.

Three Bergey wind turbines are on the north side of the Browning Waste Water Treatment Plant aeration ponds.

Four Bergey Excel 10-kW wind turbines installed on 100-foot towers, four Trace GridTek 10-kW inverters, and the balance of system components produce grid-quality electricity to displace utility-grid electricity. Three turbines are on the north side of the aeration ponds, and one turbine is on the south side of the ponds next to the pumphouse. The system includes two anemometers installed on the southern turbine at 60 ft and 80 ft, one wind vane at 80 ft, a temperature sensor, pressure sensor, and four power transducers to measure inverter power. The data will be used to produce the Siyeh quarterly report, a cooperative agreement deliverable to the U.S. Department of Energy (DOE). Currently, no data have been collected.



One Bergey wind turbine is on the south side of the aeration ponds next to the pumphouse.

Siyeh has experienced problems along the way. First, Siyeh's project manager resigned after the turbines were installed, and no one remaining on the project management team had wind experience. As a result, Siyeh asked the National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) to provide technical support on the installation and check-out of the data acquisition system (DAS) and instrumentation and to create a spreadsheet tool for data analyses.

NWTC staff arrived on October 16, 2000. The DAS and instrumentation had been delivered and were awaiting installation, but the electrical-system design and installation plans for the DAS and instrumentation boxes had not been started. Mark Meadors, an NREL technician, worked with local electricians to determine the placement of the electrical boxes and conduits needed to house the DAS and instrumentation. Meadors stayed in Browning for two weeks to install, program, and bench test the DAS and instrumentation. Meadors also commissioned the turbines and found that one of the four turbines was not operating. The fourth turbine was having tail damper problems and no one at Siyeh had the knowledge to fix it. To help Siyeh fix the problem, NREL sent tower-climbing videos and catalog information for ordering safety harnesses, lanyards, belts, and hardhats.

Also, the new Trace GridTek 10-kW inverters that the site used had been experiencing problems with high turbine RPM, which is typically found at sites with high wind speeds and high turbulence (i.e., the Siyeh site). Trace technicians have been working closely with Siyeh to troubleshoot problems in the new inverter. The site's inverter software and hardware has been updated, and NWTC staff will gather data in Spring 2001 to confirm that the inverters are working properly.

Charles Newcomb, an NREL test engineer, wrote a specific spreadsheet to analyze the data from the sensors. Newcomb has been training Willy Morris, mayor of Browning and the project data analyst, to use the spreadsheet.

Host Sites

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

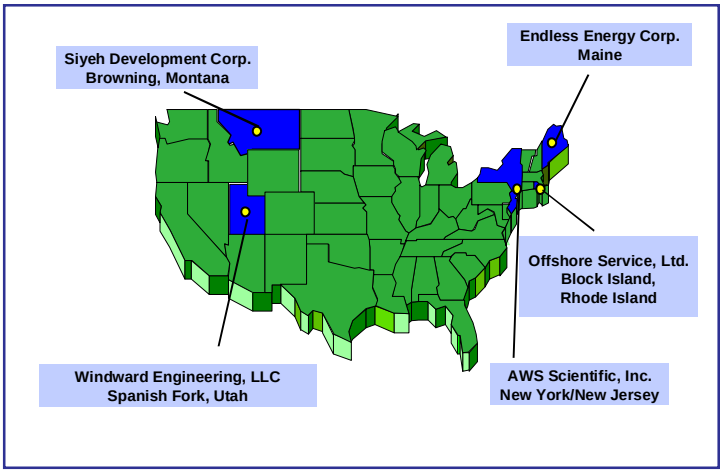


Figure 1. DOE Field Verification Program turbine locations

Table 1. Field Verification Program Locations and Participating Organizations

Organization/Contact	SWT #	Turbine Location	Quantity/Type of Turbine	Application
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
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
	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
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-S/E 10 kW	Residential Consumption
	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
AWS Scientific, Inc. 251 Fuller Road CESTM, Suite B220 Albany, NY 12203-3656 Contact: Bob Putnam/Dan Bernadett	Turbine #1	Webster, New York	One Bergey Excel-S/E 10 kW	Distributed Generation
	Turbine #2	Liberty Science Center Jersey City, New Jersey	One Bergey Excel-S/E 10 kW	Distributed Generation
	Turbine #3	TBD	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

Fourth Quarter Status and Statistics Summary

Windward Engineering, LLC

Windward Engineering staff are testing a grid-connected Whisper H40 at an existing wind energy test site (Figure 2) in Spanish Fork, Utah. Since the turbine was commissioned in February 2000, the turbine has produced a total of 1,258 kWh, and 76% of the energy produced has been sold to the grid. Another Whisper H40 has been tested at the NWTC since February 2000.

Figure2. Whisper H40 at the host site, Spanish Fork, Utah

Spanish Fork, Utah

For the period ending December 31, 2000, the Whisper H40 turbine in Spanish Fork, Utah, ran normally with complete data acquisition systems operational. The test site produced 375 kWh under an average quarterly wind speed of 5.29 m/s.

The following tables and figures contain the test results of the Whisper H40 at the site in Spanish Fork, Utah. Table 2 shows the quarterly project summary through December 31, 2000. Note that the Windward Engineering tables and figures report the measured power data. Power curves are not corrected to sea-level air density. 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).

The turbine operated with 100% turbine availability and 99.95% system availability. The DAS was down for one hour due to extended power grid failure. The DAS is configured to receive its power from the grid and has an uninterruptible power supply (UPS) battery backup. When the power grid fails, the DAS uses its UPS to continue operating. When the power grid is down for extended periods, the UPS will become depleted. This was the case this quarter.

The DAS has an NRG 9300 data logger connected to it. It has its own battery backup and requires little energy, so data collection was not interrupted. Some of the signals into the DAS system were incorrect, because the signal conditioners on the DAS did not have any power. See Table 3 for the detailed downtime summary.

Table 2. Project Summary

Quarterly Summary	
kWh Total	375
kWh/m²	105
Capacity Factor*	19 %
Unavailable Hours**	1.0
Turbine Availablility	100 %
Max Watt***	667
Concurrent Wind Speed**** (m/s)	13.4
Ave. Wind Speed at Hub Height (m/s)	5.29

* Rated output is 900 watt

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

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

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

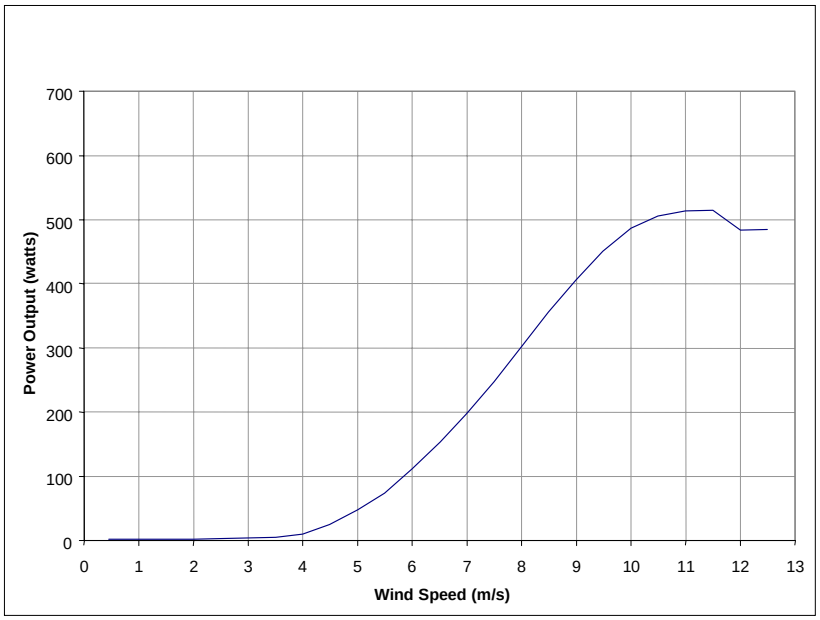
Table 3. Downtime Summary by Type for Whisper H40

Category	Hours	Lost Energy (kWh)	Remarks
Fault: wind turbine			
Fault: inverter			
O&M			
Turbine measurements (related to modeling)			
Ground testing (related to modeling)			
Instrumentation installation or calibration			
DAS disable			
Host site system disable			
Battery over voltage			
Blown fuse			
Brake cooling cycle			
Inverter faults			
Unknown			
Others	1.0	0.32	Extended grid power loss (depleting UPS battery on DAS)
Total	1.0	0.32	

The test results indicated that the H40 wind turbine reached a maximum power of 515 watts at a wind speed of 11.5 m/s and then decreased to 485 watts at 12.5 m/s (Figure 3). The H40 showed its furling capabilities at high wind speeds.

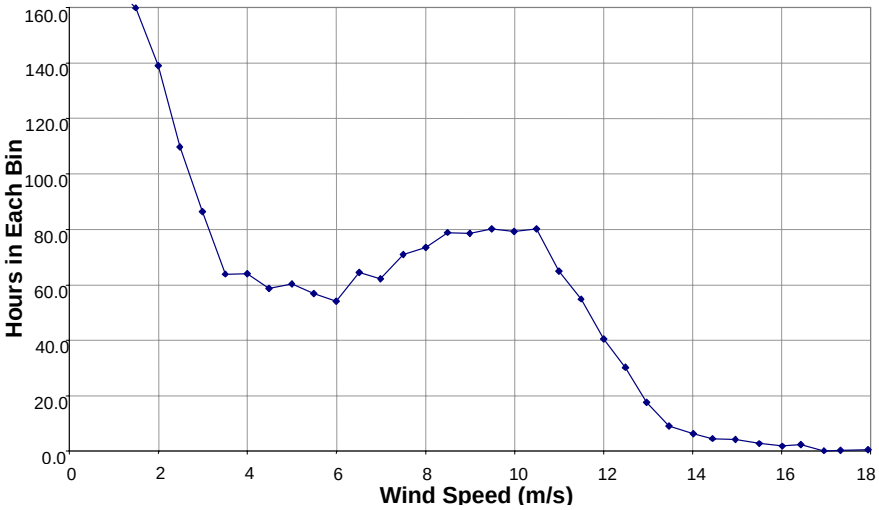
Windward has added some data processing capabilities to their LabView DAS to determine extreme loading events in the furling turbine. The data processing includes six new calculated outputs: max instantaneous rotor speed, max instantaneous wind speed, max yaw rate, time of max yaw rate event, max furl rate, time of max furl rate event.

Figure 3. Whisper H40 Wind Turbine Power Curve



Wind Speed (m/s)	Power (watts)
0.5	2
1.0	2
1.5	2
2.0	2
2.5	3
3.0	4
3.5	5
4.0	11
4.5	25
5.0	48
5.5	74
6.0	112
6.5	154
7.0	198
7.5	248
8.0	302
8.5	356
9.0	406
9.5	451
10.0	487
10.5	505
11.0	514
11.5	515
12.0	484
12.5	485

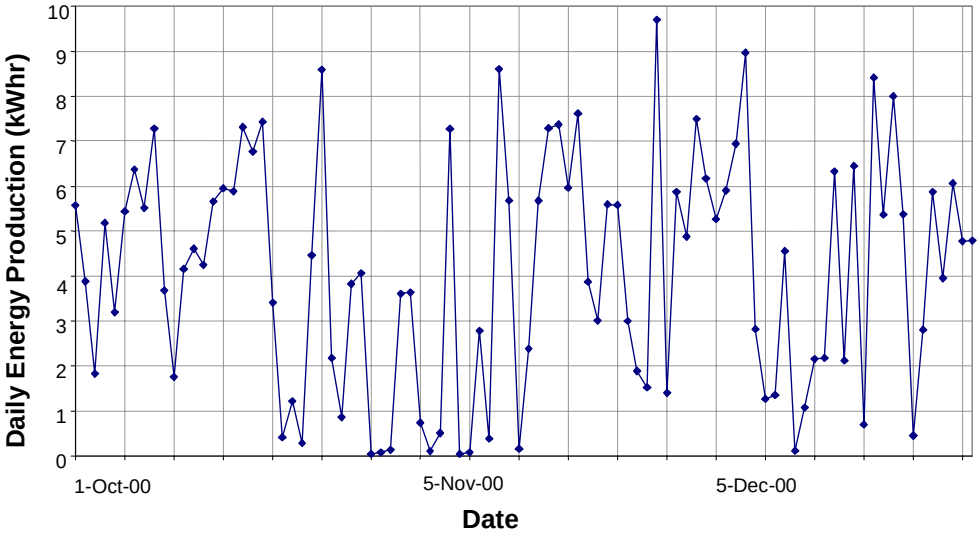
Figure 4. Wind Speed Distribution Curve



Wind turbine energy output is a product of power measured (Figure 3) and hours in each wind speed bin (Figure 4). By combining the two figures, the most productive wind speeds would range from 6–13 m/s. There was little energy produced for wind speeds above 14 m/s or below 4 m/s.

Figure 5 shows that only 8 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 91% of the time.

Figure 5. Daily Energy Production



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; the existence of the necessary regulatory scheme and power markets for financial success.

Allen Blueberry Plant, Orland, Maine

During this quarter, EEC received the gearbox, erected the 100-ft tower, assembled the blades onto the gearbox (Figure 6), and set the AOC 15/50 turbine on the tower (Figure 7). Additional photos of the installation can be seen on EEC's Web site at http://www.endlessenergy.com.

Figure 6. Assembly of the blades into the gearbox.

EEC continued to address the concern of voltage and frequency control systems for grid interconnectivity. Central Maine Power, the utility company, and Atlantic Orient Company, the turbine vendor, needed to agree on the level of grid-monitoring, relay-protection equipment to connect the system to the grid. They agreed that two protective relay units would be added. EEC established protocols for calibrating the relays for the initial installation and future scheduled maintenance. EEC is awaiting final, written approval for interconnecting the wind turbine to the utility grid. Finally, a windsmith was hired to provide on-site operation and maintenance of the wind turbine.

Future tasks include making the DAS operational, confirming the performance of the wind turbine, and installing fencing and signage at the installation. In addition, Central Maine Power and G.M. Allen & Son (the customer producing wind energy) need to resolve differences regarding the applicability of the Net Energy Billing rules of the Maine Public Utilities Commission.

Figure 7. AOC 15/50 wind turbine at the Allen Blueberry Plant in Orland, Maine.

Monhegan Island, Rockland, Maine

In October, after an extensive effort was spent on the Deer Island Elementary School, the School Board officially withdrew their plans to install a wind turbine. EEC has identified other possible locations, and discussions with one promising site are underway.

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 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 and promote a cohesive and integrated experience base for future wind power development.

Waste Water Treatment Facility, Browning, Montana

NREL staff helped Siyeh install the DAS equipment and data measurement instrumentation and commission the turbines. During commissioning, the inverter for turbine #3 displayed an over temperature fault and would not reset. A Trace Technology technician was on site after the commissioning and installed software upgrades for the inverters and diagnosed the fault message that was displayed during commissioning. Siyeh continues to work with Trace on the ongoing retrofit of the inverters, and the furling mechanism on turbine #4 still needs to be repaired. Siyeh began collecting partial performance data and expects that once the final retrofits to the inverters are complete and the furling mechanism on turbine #4 is repaired, their data will be useful. Siyeh will use software developed by NREL staff to analyze wind data.

Siyeh was removed from funding suspension after the Department of Energy reviewed its plan for the successful completion of the project within budget.

Offshore Services, Ltd.

Offshore Services will install five Bergey Excel wind turbines on Block Island, Rhode Island, to evaluate the effectiveness of wind power at five different locations with different types of ownership structure in a harsh marine environment. 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

During this quarter, the DAS logged nearly 2,200 hours of data (a 99.6% capture rate). The wind turbine produced 2,950 kWh, which is due to increasing average wind speed and a reduction in inverter faults.

Table 4. Project Summary

kWh Total	kWh/m²	Capacity Factor	Max kW*	Concurrent Wind Speed** (mph)	Ave. Wind Speed at Hub Height (mph)
2,952.7	74.6	13 %	5.7	18.4	15.3

* Maximum power is the peak hourly average wind speed.
** The concurrent wind speed is an hourly average wind speed.

Figure 8. Distribution of Monthly Average Wind Speed

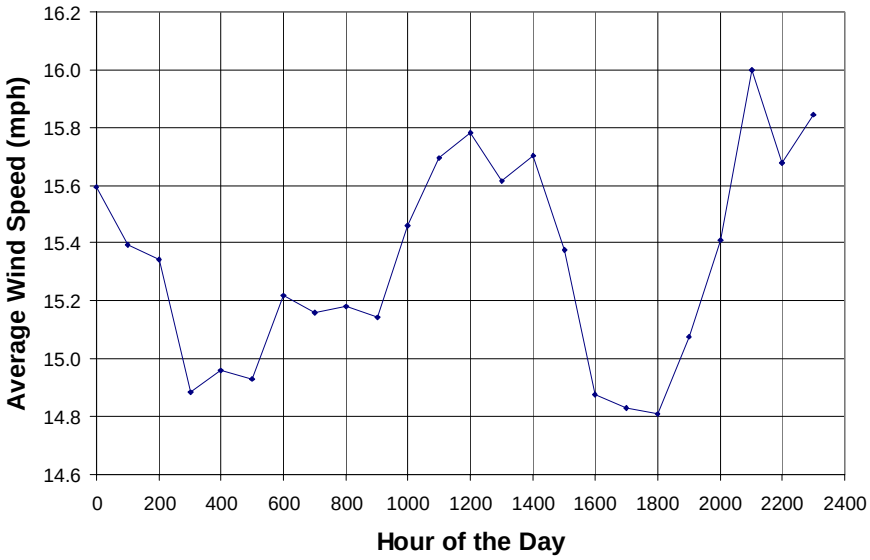
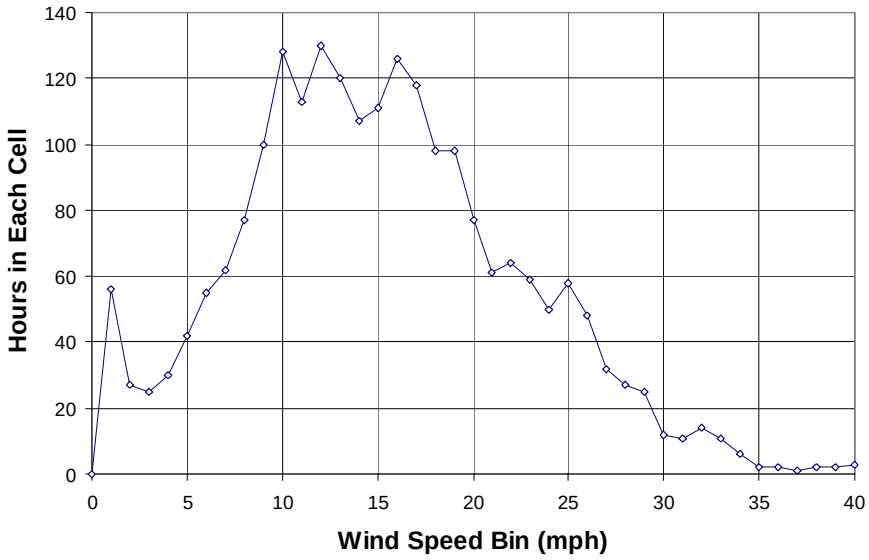


Figure 9. Wind Speed Distribution Curve



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

Though the wind turbine produced power during this period, the power it produced was not recorded by the on-site DAS due to a systemic power transducer error. It is anticipated that this problem will be rectified.

Table 5. Project Summary

kWh Total	kWh/m²	Capacity Factor	Max kW*	Concurrent Wind Speed** (mph)	Ave. Wind Speed at Hub Height (mph)
362.8	9.2	2 %	0.7	9.7	13.4

* Maximum power is the peak hourly average wind speed.

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

Figure 10. Distribution of Monthly Average Wind Speed

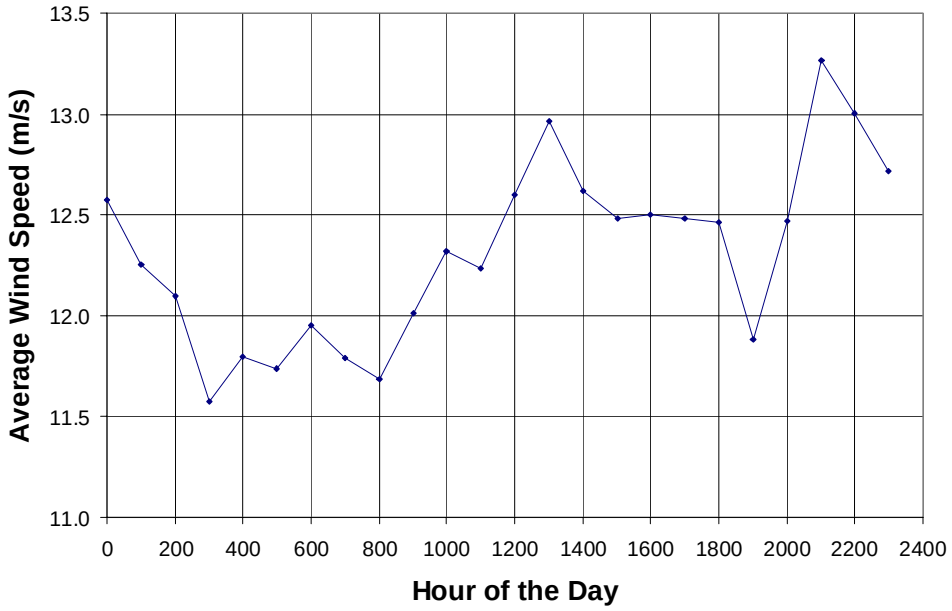
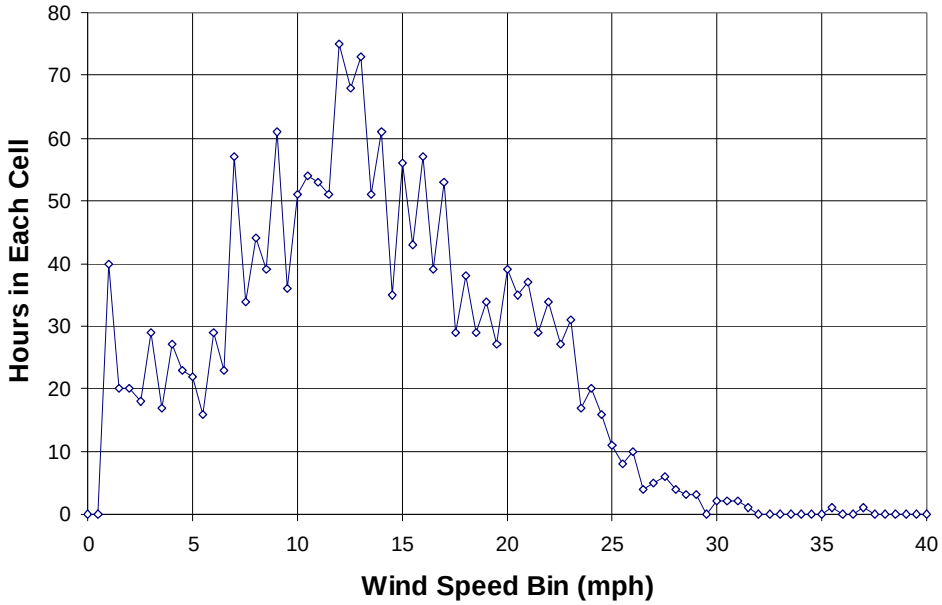


Figure 11. Wind Speed Distribution Curve



During this period, Offshore Services did not provide any updated information on their three alternate sites.

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 are 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 turbine installation that was planned for November 2000 has been rescheduled due to some changes as a result of a town meeting. The turbine's location on the property needs to be moved; thus, requiring a new foundation to be poured. Weather and ground conditions dictate that the new foundation will likely be poured in March 2001. The additional New York State Standard Interconnection Requirement testing for the Trace GridTek 10-kW inverter continued this quarter. AWS awaits final status.

Liberty Science Center, Jersey City, New Jersey

AWS has received all required approvals, and the installation date of the tower foundation has been rescheduled from November 2000 to January 2001. Turbine installation continues to be set for the first quarter of 2001. The shipment of the Trace GridTek 10-kW inverter is on schedule.

Environmental Education Center, Babylon, New York

The town of Babylon decided not to proceed with turbine installation.

Alternate Site 1, Southampton College, Long Island, New York

AWS received a letter of interest from Southampton College and has proposed it to DOE as an alternate site. Southampton College is part of Long Island University and includes the Institute for Sustainable Development. The college is adjacent to Shinnecock Bay and receives strong winds. AWS will work with the university's board of directors to put a professional and technical services agreement in place and address any permitting and approval issues.

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

AWS will continue to work with the Peconic Land Trust to put a professional and technical services agreement in place and address any permitting and approval issues.

Testing at the NWTC

One goal of the Field Verification Program is to provide U.S. manufacturers with opportunities to verify performance and reliability of their small (0.3 to 100-kW) wind turbines (SWT). To accomplish this goal, recipients are required to purchase, install, and test a SWT at NREL's NWTC for safety, performance, noise, and duration. The five recipients are using one of three manufacturer's turbines: Whisper H40, AOC 15/50, or Bergey Excel-S/E 10 kW (Table 1). The safety test is based on the manufacturer's owners manual, and the performance test is based on International Electrotechnical Commission (IEC) 61400-12 standards. The noise test follows the IEC 61400-11 Acoustic Noise Measurement Techniques Standard for reporting the apparent sound power level, noise dependence on wind speed, directivity, and tonality. For noise dependence on wind speed, the reported wind speed range was increased to include wind speeds where overspeed control is employed. To better characterize the noise at higher wind speeds, the measurement procedure was modified by using an averaging time of 10 seconds instead of 1 minute.

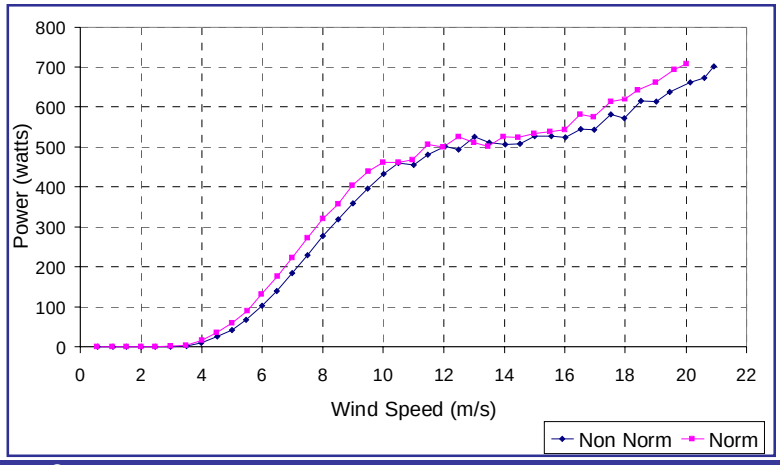
The duration test is defined as at least 1,500 hours of run time that includes 250 hours of normal operation at hub height with wind speeds greater than or equal to 10 meters per second (m/s) and 25 hours with wind speeds at greater than or equal to 15 m/s.

Whisper H40 NWTC staff continued to collect duration data, power performance data, and performed some preliminary noise testing.

AOC 15/50 NWTC staff collected data for the duration test. Noise and power performance testing was previously completed.

Bergey Excel 10 kW Testing at the NWTC has been delayed due to Trace GridTek 10-kW inverter problems.

Figure 12. Whisper Power Curve
October - December 2000



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For more information on renewable energy,
contact Energy Efficiency and Renewable Energy Clearinghouse (EREC)
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