Hybrid Power Test Bed

In a remote Alaskan village, wind turbines and back up diesel generators provide electricity for lighting, heating, and hot water on a short winter day. This is one of many hybrid power systems researchers can simulate at the National Renewable Energy Laboratory's (NREL's) Hybrid Power Test Bed at the National Wind Technology Center (NWTC).

Hybrid power systems combine multiple power sources such as wind turbines, photovoltaic (PV) arrays, diesel generators, and battery storage systems. They typically are used in remote areas, away from major electric grids.

The Hybrid Power Test Bed is designed to assist the U.S. wind industry in developing and testing hybrid power generation systems. Using simulated village loads, researchers can evaluate the interaction of these power sources under realistic conditions at the test bed. Design engineers are able to work through actual problems the system might encounter in the field.

The test bed allows engineers to evaluate system performance, cost-effectiveness, and reliability using real or simulated solar and wind energy resources. Simulated energy resources allow designers to repeat experiments as they improve system designs. This feature is important for developing new components, advanced hybrid systems, and dispatch and control systems.

U.S. wind companies can use the Hybrid Power Test Bed to train customers from other countries. By providing technical assistance to potential users, the Center encourages the growth of international markets for the U.S. wind industry.

Warren Gretz, NREL PIX 02142

The Atlantic Orient Corporation AOC 15/50 wind turbine, shown here, operates in combination with a diesel generator, rotary converter, battery storage, and system controller at the National Wind Technology Center. The 50-kW hybrid power system was developed by New World Power Technology Company.

Test Bed Capabilities

Engineers can evaluate the moment-by-moment dynamics of hybrid power system operation, gather data on long-term performance, or demonstrate innovative design concepts with the Hybrid Power Test Bed. High-speed data acquisition equipment monitors power quality, harmonic distortion, and electrical transients. A village load simulator—a load bank with resistive and inductive elements—can create power factors down to 0.5, allowing test engineers to evaluate system operation under severe conditions that may be encountered in real power systems. Engineers can also investigate the power system's dynamic response to sudden load changes and to conditions of phase imbalance or loss of phase.

Engineers can evaluate the long-term performance of a hybrid power system, including its energy delivery (in kilowatt-hours) and diesel fuel consumption. They can monitor wind speed, insolation, and the performance of battery energy storage. They can characterize system performance under a range of operating conditions, evaluate alarms, emergency shut-down procedures, and other critical functions.

The research test bed provides a good environment for developing, testing, and evaluating new concepts with less technical and financial risk than proving them in the field at a remote location. New power conversion devices, emerging energy storage technologies, prototype control systems, and innovative system architectures are examples of concepts that could be evaluated using the Hybrid Power Test Bed.

Test Bed Features

The Hybrid Power Test Bed boasts a number of unique features, including the ability to test up to three hybrid power systems simultaneously, use either real or simulated renewable energy sources, simulate a local electric grid, test with real or simulated village loads, and test wind turbine systems producing direct or alternating current (DC or AC).

A custom-designed switch panel with three AC and three DC buses gives the test bed the flexibility to connect or disconnect various system components to meet the objectives of a specific testing program. The switch panel can connect selected components, with combined capacities of up to 100 kW, onto common power buses. Engineers can rapidly change testing configurations by opening and closing a few switches.

Simulated renewable energy sources allow engineers to conduct repeatable testing. A large induction generator functions as a 75-kW AC source simulator. The DC source simulator is a solid-state device that provides up to 20 kW of reproducible DC power.

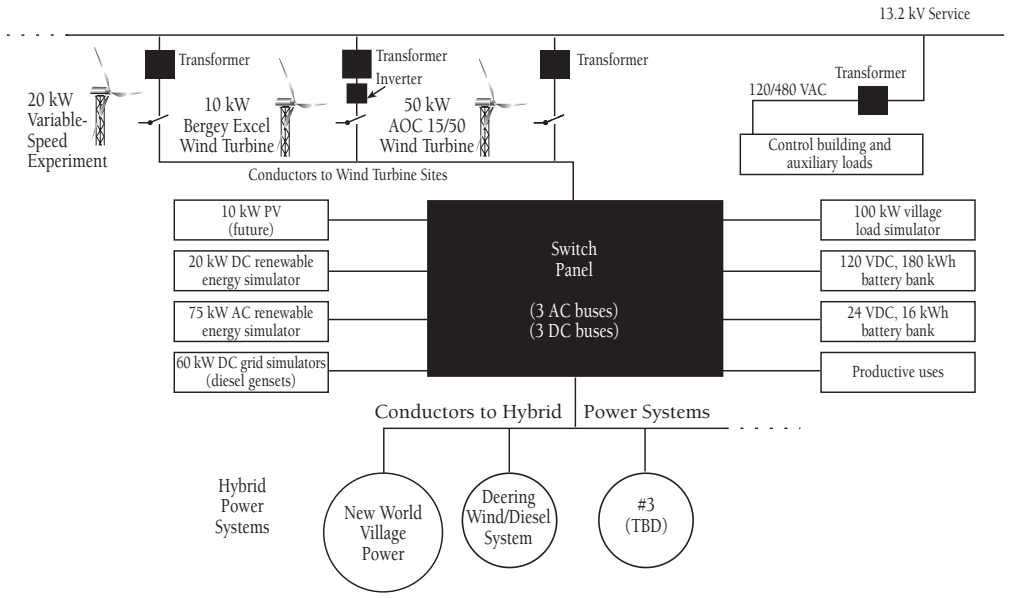
Two 60-kW diesel generator sets are available for use in hybrid systems under test. They may also serve as grid simulators, allowing researchers to test a hybrid power system's ability to synchronize its power output and connect with an existing small grid.

Renewable energy technologies at the facility include three wind turbines, rated from 10 to 50 kW. A PV array between 10 and 20 kW is planned. The Center's good solar and wind resources allow a full range of power system testing under normal operating conditions.

The test bed incorporates a 100-kW village load simulator. The computer-controlled simulator mimics typical electric loads for a small village. The test bed also has the flexibility to incorporate real village loads such as power tools, lighting systems, water pumps, or an icemaker into its tests.

The Hybrid Power Test Bed includes a personal-computer-based control and data acquisition system with a graphical interface.

Hybrid Power Test Bed



Hybrid Power Test Bed Equipment

Component	Rating
AOC 15/50 Wind Turbine	50 kW
Bergey Excel Wind Turbine	10 kW
Variable-Speed Wind Turbine	20 kW
PV Array (to be added)	N/A
DC Renewable Energy Simulator	20 kW
AC Renewable Energy Simulator	75 kW
Diesel Gen-Set Grid Simulator	60 kW
Two Village Load Simulators	100 kW
DC Battery Banks	24 and 120 volts

For more information, please contact
Jim Green, Senior Engineer
National Renewable Energy Laboratory
National Wind Technology Center
1617 Cole Boulevard
Golden, Colorado 80401
(303) 384-6913 • fax: (303) 384-6901
e-mail: jimg@nrel.gov
http://nwtc.nrel.gov

Hybrid2 Software

The National Renewable Energy Laboratory and the University of Massachusetts developed Hybrid2, a computer simulation of the long-term performance of hybrid systems. The software models a range of system configurations, including multiple wind turbines, multiple diesel generators, a PV array, battery storage, various power-conversion devices, and different types of loads. It can be used to predict the technical and economic performance of hybrid power system designs. It runs under Windows on a personal computer. Hybrid2 is available, along with an electronic library of input data, from NREL. To request Hybrid2, call (303) 384-7401 or send e-mail to Hybrid2@nrel.gov.

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