RSVP RENEWABLES FOR SUSTAINABLE VILLAGE POWER

PROJECT BRIEF

NREL's Hybrid Power Test Bed

by Jim Green 12/97

Background

In a remote Alaskan village, wind turbines and back-up diesel generators can hypothetically 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 (HPTB) 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.

Scope

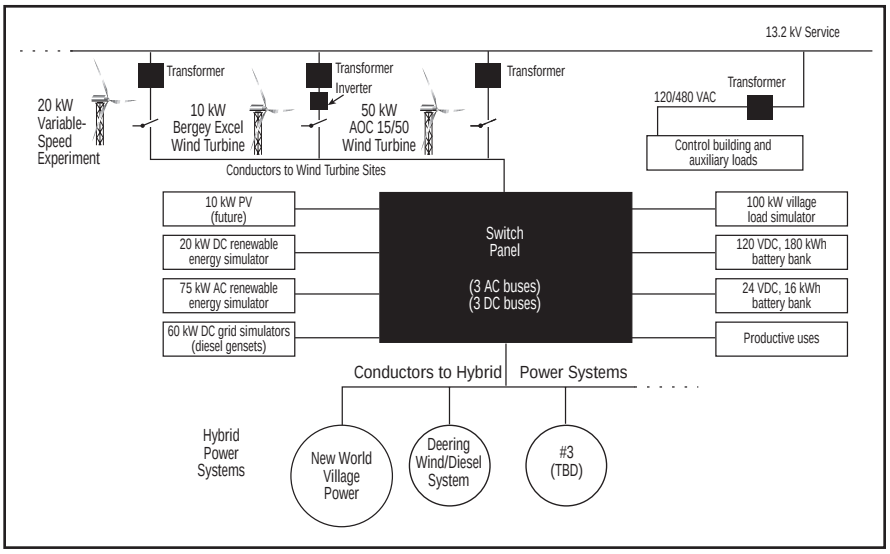
The HPTB is designed to assist the U.S. industry in developing and testing hybrid power generation systems. Using simulated village loads, researchers can evaluate the interaction of hybrid power systems under realistic conditions. Design engineers are able to work through actual problems the system 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. companies can use the HPTB to train customers from other countries. By providing technical assistance to potential users, the NWTC encourages the growth of international markets for the U.S. wind industry.

Test Bed Capabilities and Features

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 HPTB. 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



Components of NREL's Hybrid Power Test Bed.

test engineers to evaluate system operation under severe conditions that may be encountered in real operations. Engineers can also investigate the power system's dynamic response to sudden load changes and to conditions of phase imbalance or loss of phase.

Test bed 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 shutdown procedures, and other critical functions.

The research test bed provides a minimal risk environment for developing, testing, and evaluating new concepts when compared to proving them in the field at remote locations. New power conversion devices, emerging energy storage technologies, prototype control systems, and innovative system architectures are examples of concepts that can be evaluated using the HPTB.

The HPTB has a number of unique features. These features include 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 3 AC and 3 DC buses gives the test bed the flexibility to connect or disconnect various system components for tailored testing programs. 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. An induction generator functions as a 75-kW AC source simulator. A DC source simulator is planned for future and will be 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 photovoltaic array rated between 10 and 20 kW is planned. The NWTC'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 icemakers into its evaluations.

The HPTB includes a PC-based control and data acquisition system with a graphical interface in LabVIEW8.

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 (to be added)	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

The HPTB was operational in mid-year 1997, with the testing of a control system for a high penetration wind/hybrid project in Alaska, and completion of a New World Village Power 50-kW power system characterization. We anticipate the HPTB will be a very valuable and heavily used test capability for the next several years.

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