Wind Power for Remote DC Powered Stations

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The University NAVSTAR Consortium (UNAVCO) Boulder Facility is assessing wind technology for powering remote GPS stations. This study is motivated by increasing station installations in Antarctica, Alaska and other regions where solar radiation can be very low or non-existent during parts of the year. Key factors of power generation - including power regulation, generator robustness, rigging and cost effectiveness - were studied and compared to solar.

Photo 1: *Air403 at Niwot Ridge, CU Mountain Research Station, 11,600 feet.*

For this study we evaluated the Windpower Air 403-series wind turbine. The Air403 series is currently available in both "Industrial" (no internal regulator) and "AirX" (internal regulator models). UNAVCO tested the Industrial unit using both the recommended Trace C40 and independent FlexCharge NC25A diversion controllers. Both units use "diversion loads", a 9 Ohm power resistor capable of handling 600 watts, to draw power from the unit once batteries are charged. Unlike solar, this energy must be diverted rather than disconnected, as an open circuit allows the turbine to spin uncontrolled, possibly causing damage by overspeed. With the Trace C40, the generator is connected directly to the batteries and the divert load is connected to the system through the controller. The divert load is activated to draw large amounts of power to keep from overcharging the batteries. The FlexCharge NC25A was desired over the Trace due to the fact that when charging is completed, the current is diverted to an isolated load. This method greatly reduces the noise to the system in high winds. Though there was concern that the 25A rated NC25A would not be able to handle possible current spikes of up to 50A, the device did not fail. Units are available from FlexCharge with greater current ratings. The new AirX models internally regulate power and put the generator into a "braking" mode when the batteries are charged or wind speeds are too high, thus removing the need for a heavy-duty diversion load. None of these options includes a Low Voltage Disconnect.

Photo 2: *Air403 and GPS antenna at Marshal Field Site outside Boulder.*

The Air403 is one of the smallest wind turbines offered, with a blade span of 46 inches and output power of 400W operated at wind speeds of 28mph at sea level. Efficiency drops approximately 3% for every 1000 feet of elevation. Our tests were conducted with a 360Ah battery bank and were located at elevations of ~5500 feet (UNAVCO Marshall Field test site) and ~12000 feet (Niwot Ridge Test Site, University of Colorado Mountain Research Center). We found the system produced more than enough power when functioning properly during times of reliable average wind speeds. Figure 2 illustrates regulation effects on the system and differences between solar and wind charging. As expected, the solar charging characteristic is far less erratic than wind, however both exhibit noise during regulation due to pulse width modulation charging techniques.

The turbine has proven itself to be quite robust in extreme weather and excessive winds, yet the unit and system suffered greatly from inadequate rigging. Because of the mechanical nature of the system, support and wiring must be over engineered, especially for adverse conditions. At Niwot ridge, the high altitude test site outside Boulder, tower failure due to poor rigging caused blade breakage and damage to internal parts. It was discovered that proper guy wire tension and base stability can only be achieved with generous anchoring. When assessing anchoring options at the site, it is extremely important to know the characteristics of the substrate. The base of the tower must be configured and anchored to provide both solid vertical and lateral rigidity. UNAVCO is assessing options for installation onto bedrock. For field installations, the entire wind assembly should be pre-built for easy assembly. Quick connectors and junction blocks are essential since working with heavy gauge wires in the field can be difficult. Of all system variables, the quality of the installation will have the greatest impact on the output of the system.

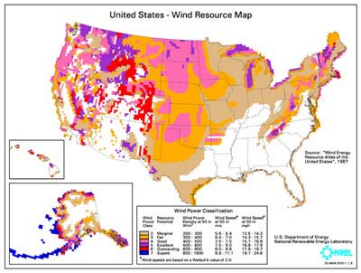

Figure 1: *Using wind energy maps and weather data is important in determining if a station could rely on continuous wind power.*

The cost of a well rigged wind power system (AirX), with 27' tower (recommended minimum) will be approximately $1000-1200 (Turbine-$800, Tower-$200, Hardware, etc-$200). Compared to a 300W solar system at approximately $2000-$2800 (Four SP75 panels-$1400, FlexCharge Controller-$200, Panel Frame-$200+ [UNAVCO security mounts run upwards of $1000+], Hardware, etc-$200), cost savings are apparent before considering battery requirements and climate variations. In fact, locations with good solar coverage that have large power requirements (VSAT installations, for example) may benefit economically from wind power given dependable wind characteristics. For example, a 40W continuous load in Elko, NV would require 8 panels and 12 batteries using solar alone or three panels, a turbine and 6-8 batteries. A 25W load could be sustained with 2 panels, an Air403 and 4 batteries. [Calculations from Solar Design Studio Pro]

In a year of testing, UNAVCO has experienced both successes and failures with the systems. These failures, primarily related to factors other than the turbine unit itself, cause great concern in reliability, especially when compared to solar. Currently, the facility is only considering wind power for polar regions that have no solar radiation during parts of the year. UNAVCO is continuing to develop and test Air403 configurations for more reliable installations and investigating whether wind power is dependable as an alternative to solar in cases of increased power demand.

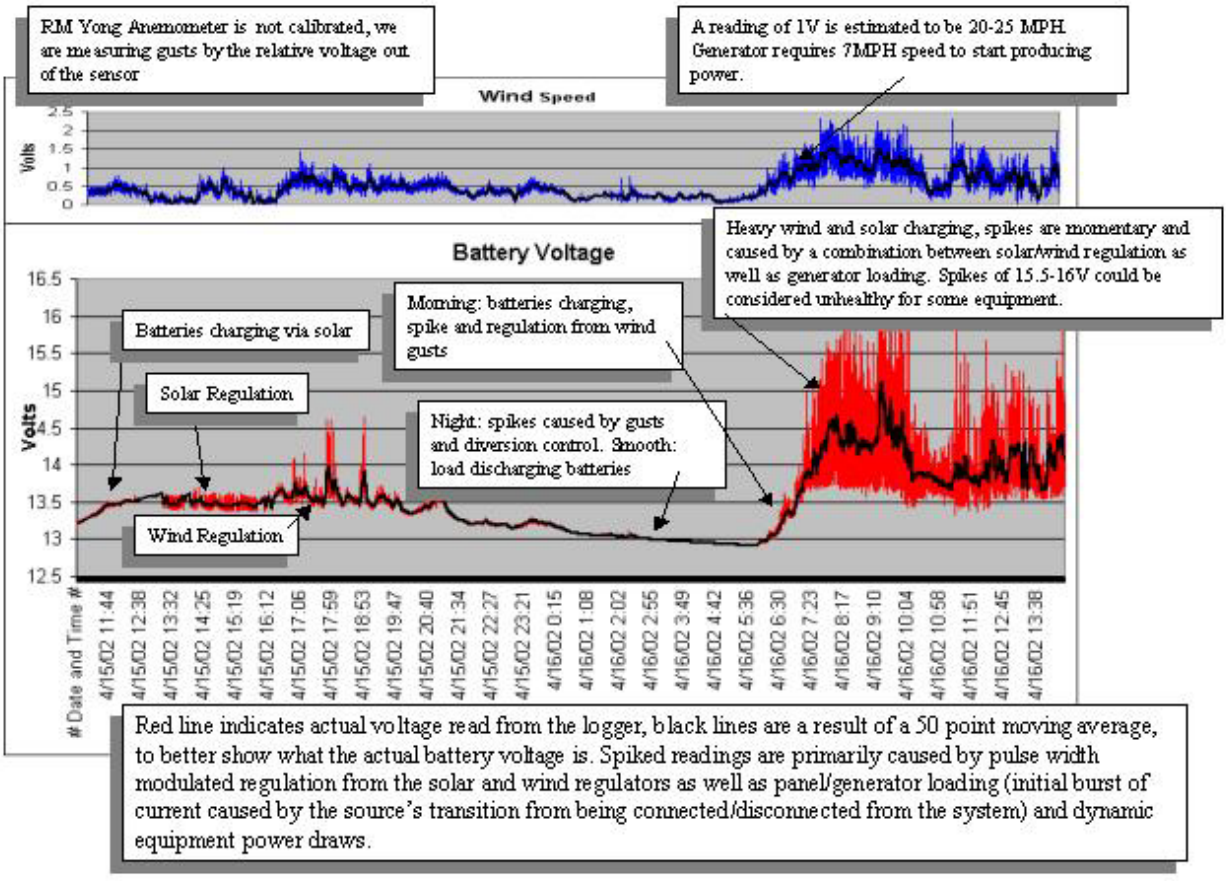

Figure 2: Battery and Anemometer graphs, illustrations demonstrate the differences between solar and wind charging on the system. System consisted of the Air Industrial and 4 SP75 panels for power, a Nanometrics VSAT system, Ashtech Z-12 with choke ring antenna and a Freewave radio for load.

Acknowledgements: Thanks to Jim Greenberg, Bjorn Johns and Shad O'Neel, UANVCO field and telemetry support.