National Renewable Energy Laboratory
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Office of Energy Efficiency & Renewable Energy
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Optimization of Sodar Wind Profile Measurements in Low-Humidity Climates at High Altitudes

Cooperative Research and Development Final Report

CRADA Number: CRD-07-00246

NREL Technical Contact: Neil Kelley

CRADA Report
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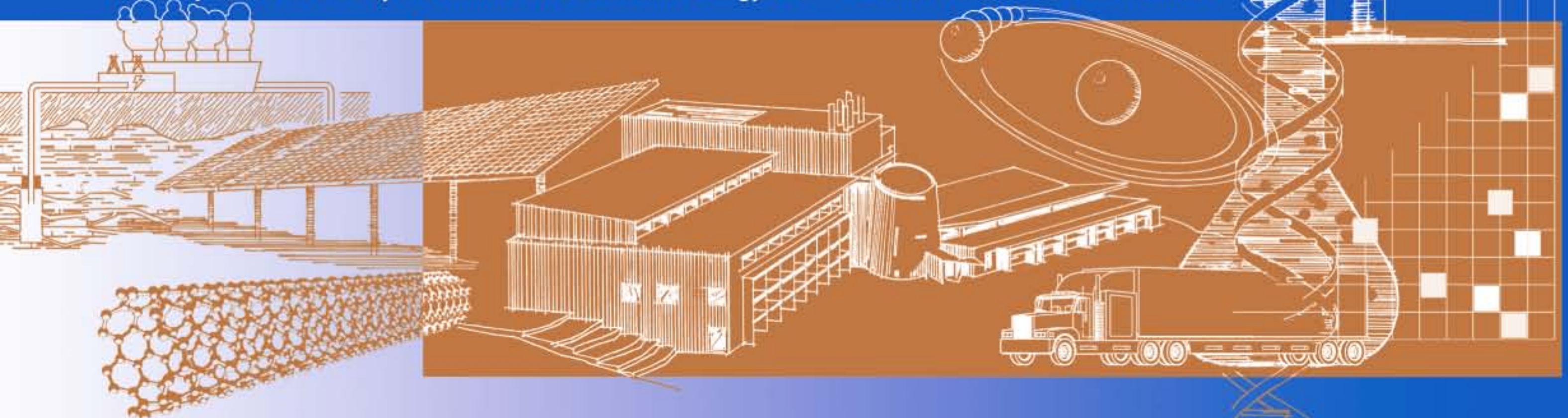

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Cooperative Research and Development Final Report

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CRADA Title: Optimization of Sodar Wind Profile Measurements in Low-Humidity Climates at High Altitudes

Parties to the Agreement: Oak Creek Energy Systems Inc. + NREL

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	**NREL** Shared Resources
Year 1	$ 180,000.00
Year 2	$ 00.00
Year 3	$ 00.00
TOTALS	$ 180,000.00

Abstract of CRADA work:

There has been rapid deployment of wind energy technology in the U.S. accompanied with the increasing size and capacity of wind turbines. With these larger machines, the demand for detailed wind resource measurements at higher and higher altitudes has grown exponentially. Previously wind resource assessment of potential wind energy sites were accomplished with tower- or mast-mounted instruments extending up to 50 to 60m above ground level (AGL). As the maximum height of turbine rotors has increased, direct measurements using instruments mounted on towers is no longer economical and the remote sensing of the wind resource has become a necessity. The assessment of potential wind energy sites in the region of the U.S. from the Rocky Mountains westward often present an even more challenging problem due to the complex nature and high altitudes of much of the terrain.

The U.S. wind industry is beginning to embrace the use of modern Doppler acoustic wind profiles or sodars that use emitted sound energy in which to measure the wind speeds at the altitudes of current and future generations of wind turbines. A basic requirement of wind resource assessment is to obtain a minimum of one year of record of wind speeds of a candidate development site with minimal data loss (preferably less than 15%). The most common type of sodar used by the industry is the low-range or "mini-sodar". These instruments typically have a maximum vertical height measurement range of 200 m

which is generally sufficient for wind energy siting assessments. Like all remote sensing technologies sodar has its limitations. There is one in particular that can severely limit the data capture performance of the mini-sodars in much of the Western U.S. This is the persistence of low air humidity. The acoustic energy emitted and received back by these sodars suffers high losses as result of atmospheric absorption in the dry air (relative humidity less than 50% of saturation) and the relatively low level of emitted acoustic power and high operating frequency (4500 Hz). These losses limit the maximum altitude in which accurate wind measurements can be obtained and is often well below the range of heights occupied by the rotors of most modern, multi-megawatt wind turbines.

In many parts of the Western U.S. and in the Great Basin region in particular, the terrain is dominated by range and basin topography. In such terrain the best wind resources are generally found at higher altitudes in which the air is frequently even drier. As part of the FY08 DOE Wind Research Program, NREL is planning to develop suggested methodologies for the use of sodar for wind resource assessments and operational wind measurements particularly in the low-humidity climates found in the western portions of the U.S. NREL has previously used a more powerful medium-height range (1 km) or “midi” sodar that operates at lower acoustic frequencies in the low-humidity environment of the high plains of southeastern Colorado. This experience showed that by employing an optimized set of operating parameters the maximum height of observed wind horizontal wind profiles could be reliably obtained up to 500 m. The results of a comparative operation and optimization of two representative low-range or mini sodars of different manufacturers in conjunction with a medium-height range instrument that are supported by local meteorological measurements in a low-humidity climate is essential to the success of this effort is important to the collaborators immediately and the U.S. wind industry as a whole upon its authorized dissemination. ‘

Oak Creek Energy Systems, Inc. (OCES) and Mountain Wind Energy LLC (MWE) are requesting assistance from DOE/NREL in developing optimization techniques for employing sodar technology to obtain a high frequency of reliable wind profiles up to 200 m in a low-humidity atmosphere and at high elevations (8000 ft above MSL or more). The installation of productive wind farms consisting of multi-megawatt turbines in the complex terrain of the range and basin topography of the Great Basin as well as much of the Western U.S. depends heavily on the initial wind resource assessment and siting. OCES/MWE in conjunction has operated a low-range sodar commonly used by the U.S. Wind Industry for a period of twelve months at a representative high-elevation site in Western Nevada. An initial analysis of the data collected showed very poor performance for measuring reliable wind speeds above 60-80 m. Much of this lack of performance also occurred during periods in which the ambient relative humidity was well below 50% of saturation. The decision to proceed with any wind farm development in this area has been postponed due to the lack of reliable wind speed data above 60-80 m particularly during the nighttime hours when terrain-induced and modulated wind flows are likely to occur.

The success of the application of new multi-megawatt turbine installations in the topography typical of the Great Basin and much of the Western U.S. depends heavily on the adequacy of the initial wind farm siting. The challenge of applying sodar technology in such environments is universal to the U.S. Wind Industry and not unique to the OCES/MWE situation. Because of this need an element of the DOE/NREL FY08 research program has been dedicated to establishing the feasibility of optimizing the use of sodar in low-humidity environments including those at high elevations. OCES/MWE has agreed to provide a suitable location that would allow for the collection of both low-range (mini) and mid-range (midi) sodars from the same manufacturer which is also the vicinity of the currently operating mini sodar. The proposed site has commercial power available and high-speed internet connectivity. There is a fully-configured meteorological station in the vicinity. This arrangement will allow for the simultaneous measurement performance of up to two low-range and one mid-range sodars through the ability to collect data and optimize the overall and maximum altitude performance of each of the collocated sodars via the high-speed internet connection for ambient humidity conditions. The resulting optimizing procedures and the documentation of any system limitations derived by this collaboration will be available to NREL to publish and share with the wind industry through conference proceedings and presentations. The resulting data set will be made available for public dissemination until two months after the conclusion of the field measurements program which is expected to take a total of 9 months. Additional collaborators may join with OCES/MWE and NREL after sufficient data has been collected to evaluate any improvements in mesoscale numerical wind resource predictions that can be realized for this site if the availability of such information is included in the models initialization. Such an effort is a high priority for the U.S. Wind Industry. This effort will be performed as an “equipment loan” CRADA with no exchange of funds between OCES/MWE and DOE/NREL. The entire NREL support for this effort has been included in the proposed FY08 AOP budget.

Summary of Research Results:

The equipment was installed however inclement weather conditions damaged said equipment therefore limiting the data that was collected.

Subject Inventions listing: None

Report Date: 3/1/10 Responsible Technical Contact at Alliance/NREL: Kelley, Neil

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