



Sandia National Laboratories



Project Accomplishment Summary

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Sandia National Laboratories

Operated for the U.S. Department of Energy by
Sandia Corporation
Albuquerque, New Mexico

PROJECT ACCOMPLISHMENTS SUMMARY

Cooperative Research and Development Agreement (#1750)

between **Sandia National Labs** and Verdant Power Inc.

Note: This Project Accomplishments Summary will serve to meet the requirements for a final abstract and final report as specified in Article XI of the CRADA.

Title: Preliminary Structural Design Conceptualization for Composite Rotor for Verdant Power Water Current Turbine

Final Abstract:

Sandia National Laboratories (SNL) and Verdant Power Inc. (VPI) have partnered under a Cooperative Research and Development Agreement (CRADA) to develop a new kinetic hydropower rotor. The rotor features an improved hydrodynamic and structural design which features state-of-the-art technology developed for the wind industry. The new rotor will have higher energy capture, increased system reliability, and reduction of overall cost of energy.

Background:

Marine hydrokinetics (MHK) is a new area of renewable energy research. It differs from what is referred to as "conventional hydro" (dams) in that kinetic energy is extracted from moving water as opposed to extraction of potential energy from an elevation difference. MHK can refer to devices that operate in waves or water currents, and come in a wide variety of machine types. The VPI machine is a downwind turbine which can be located in rivers or tidal areas. The machine operates similar to a free-yaw, downwind wind turbine. The initial rotor design featured metal blades which experienced early, unexpected failures. This was thought to be due to an inadequate design caused by a poorly understood loading environment. Thus, VPI entered into collaborations with SNL and the National Renewable Energy Laboratory (NREL) to develop accurate models of the operational environment and design a robust, high-performing rotor drawing on the best technology developed for wind energy.

Description:

This project was divided into six tasks:

Task 1: Composite Rotor Project Planning and Design Specification

A kickoff meeting was held with NREL, SNL, and VPI participating. The meeting reviewed the design shape and load parameters provided by VPI. It also reviewed VPI's understanding of the design constraints and previous experience. Conventional wind turbine blade aerodynamic and structural design approaches were considered and evaluated in terms of how they might be technically and practically applied to the kinetic hydro blades. The output of the meeting was a definition of the specific project goals and design requirements for the VPI composite rotor.

Task 2: Baseline Fatigue Testing and Failure analysis

SNL provided technical support for a fatigue test of an existing VPI rotor blade, including non-destructive measurement. The load test was based on a lifetime fatigue load formulation taking into account all major load cases. The fatigue load spectrum was provided by VPI, while NREL wrote and executed the test plan in accordance with their past experience with wind turbine blades.

Task 3: Develop Blade/Rotor Performance Model

SNL provided consultation in support of rotor performance modeling performed by NREL. NREL used its existing wind turbine performance codes and adapt them to analyze the baseline VPI rotor in terms of its current operating parameters and verify the code accuracy using available test data and existing models provided by VPI. VPI compared NREL's results to their existing models to help refine the model accuracy. Candidate rotor options were then evaluated using variations of rotor geometry and hydrofoil options. In consultation with SNL, NREL code analysts and structural modelers converged on the most promising preliminary design concepts.

Task 4: Hydrofoil Survey and Selection

SNL provided consultation and analysis to survey the existing hydrofoils (airfoils) used for wind turbines and down-selected candidate airfoils based on best performance, resistance to cavitation, and other requirements deemed important during the design requirements review. The most promising foils were modeled in the performance and structural codes and the best choice was selected for the design concept. This task relied heavily on past experience from wind turbine airfoil development.

Task 5: FEM Structural Design

SNL used its NuMAD composite structural design code to analyze the baseline VPI blade. The new design was modeled and compared to the baseline blade, and evaluated based on the VPI design requirements. Both extreme and fatigue loads were analyzed and damage indices were developed.

Task 6: Develop Candidate Rotor Designs and Prepare Final Report

SNL provided design review and analysis support to develop candidate rotor designs for VPI. A composite structural design consultant was hired by NREL to review integrated blade design studies to produce the outer mold geometry for the candidate blade designs, assist in the laminate design details, and perform engineering integration of the rotor system to the overall VPI hub and turbine. The consultant worked with NREL and SNL staff closely to review candidate designs for strength, fatigue resistance, cost, energy production, environmental performance, manufacturability, and usability with the balance of the rotor system.

Benefits to the Department of Energy:

This project enhanced and expanded laboratory knowledge or skills in the area of MHK device design, which will support future mission-related program activities. This was accomplished by leveraging the wind power work that has been performed for DOE. This work will increase the technological experience and know-how of both national laboratory staff and industry, which will allow for future work in this area.

Economic Impact:

This work will contribute to the growth of the kinetic hydropower industry, allowing for the creation of domestic renewable energy jobs. Additionally, it will increase U.S. competitiveness in the kinetic hydropower industry by utilizing technology and expertise gained through DOE investment in wind power. Finally, this work will further kinetic hydropower technology, a domestic, renewable energy resource that will reduce dependence on foreign energy importation.

Project Status:

The project has been completed and the results have been compiled into a series of reports.

ADDITIONAL INFORMATION

Laboratory/Department of Energy Facility Point of Contact for Information on Project

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Albuquerque, NM 87185

505.844.7766 (office)

505.844.6541 (FAX)

Company Size and Points of Contact

VPI qualifies as a small business

Point of Contact: Dean Corren

CRADA Intellectual Property

None

Technology Commercialization

The design that was developed through this project is in the final manufacturing and testing phase. Upon successful completion, the design will be commercially available.

Project Examples

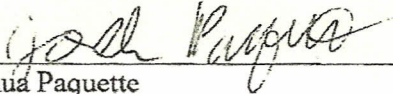
Hydrofoils and blade materials were incorporated in to the design based on the analysis work and experience of SNL engineers and contractors.

A modified inflow analysis simulation tool was developed by engineers from SNL and NREL for use in modeling underwater turbines.

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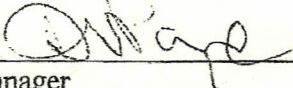
This summary has been approved for public release by Sandia and Verdant Power Inc.

Sandia National Laboratories

By 
Joshua Paquette
Principal Investigator

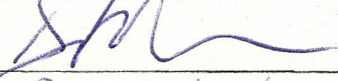
9/12/11
Date

Sandia National Laboratories

By 
Manager
WFO/CRADA Agreements

9/9/2011
Date

Verdant Power Inc.

By 
Title: Dir. Technology

9/15/11
Date

In order to expedite the process, if we do not receive your signed reply by 10/12/2011
we will assume your concurrence for the release of this document to the public.