

Executive Summary Form

Researching and developing the potential of VAWTs to double capacities of California's wind farms while preventing harm to birds – Phase I

DRAFT – A proposal in response to the CEC EPIC Program's grant opportunity GFO-16-310 - *Improving Performance and Cost Effectiveness of Wind Energy Technologies*

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1. Project description:

California faces problems in increasing the share of wind energy in the state's electricity mix. It is difficult to add more Horizontal Axis Wind Turbines (HAWTs) to wind farms because of the negative impacts they create for each other when placed too close together. It is also increasingly expensive to permit, buy land, build roads and provide transmission lines for new wind farms. Further, large HAWTs pose threats to migratory and native bird populations, resulting in additional costs and difficulties in obtaining permits and developing environmental impact mitigation plans.

The use of Vertical Axis Wind Turbines (VAWTs) as a solution to these problems has not yet been investigated, due to lack utility scale VAWTs and data on their impacts to neighboring HAWTs and wildlife. Before wind farm owners will allow the large-scale deployment of VAWTs near HAWTs, field research must demonstrate that wakes produced by VAWTs have neutral or positive effects on the energy production and maintenance of nearby HAWTs. Before permits can be obtained for installation of VAWTs in most California wind farms, research must demonstrate that the turbines do not negatively impact bird populations.

In this project, WHI will:

- Validate the modeling predictions of a 20% increase in energy output from pairs of VAWTs over single VAWTs.
- Produce the data needed to model how arrays of closely spaced VAWTs affect wake and turbulence and whether the VAWTs could increase the wind speeds that reach the rotors of HAWTs.
- Use field monitoring in combination with motion detection camera technology to evaluate how birds react to the VAWTs.
- Produce the information needed to conduct Phase II studies in wind farms, especially those in the San Geronio Pass.

If VAWTs can be safely deployed in the understories of HAWT arrays, this research will open up more than 5000 MWs of existing wind farms to make double use of the best wind resource lands in the state.

2. Project goals and objectives:

The goals are to:

- reduce the costs of producing wind energy from existing and new wind projects by developing strategies of infill with VAWT arrays in the understories of HAWTs; and to
- conduct research necessary to prepare WHI's G168 model VAWT for pilot project operations in CA wind farms with sensitive bird species.

Project objectives are to:

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- characterize and model the wakes produced by paired VAWTs in counter-rotating arrays on flat terrain;
- characterize and model the wakes produced by VAWT arrays in the turbulent wind conditions and terrain of the San Geronio Pass.
- determine optimal spacing of G168 type VAWTs within a linear array to maximize the capacity factor of the array and benefits of its induced wake;
- determine optimal spacing of a downwind array of VAWTs from an upwind array;
- determine how well the DTBird motion detection technology can work with arrays of VAWTs and recommend strategies for developing the research needed before VAWTs can be introduced in wind farms which are visited by rare and endangered birds.

3. Explanation of how project goals and objectives will be achieved, quantified, and measured:

In this project, the team will deploy state-of-the-art direct and remotely sensing instrumentation to develop high-fidelity data and analyses of wind inflow to and wakes and wind speeds produced by VAWT arrays. Data from strain gauges, sonic anemometers and Doppler Lidar will allow for confirmation of the coupled vortex effect predicted by previous modeling and characterization of the speed-up effect predicted to occur above and downwind of the VAWT arrays. Data will be used to calibrate CFD modeling done by Stanford University in order to begin predicting VAWT turbulence in differing terrains. The Annual Energy Production and related factors will be input into NREL's LCOE calculator to estimate the energy costs of VAWT – HAWT projects. The team will evaluate use of motion-activated cameras to supplement field data on any bird mortality caused by VAWT operation. Bird data will be analyzed and validated by a third party.

4. Project task description:

The work comprises 5 tasks. Tasks 1, 4, and 5 are mandatory general project management tasks. Tasks 2 & 3 are technical tasks.

- *Task 2 (Measurement of VAWT Wake Effects)* includes meteorology towers equipped with sensors, a Doppler Lidar unit, use of a two turbine G168 VAWT array set on rails at the UL Advanced Wind Turbine Testing Facility in Texas to produce baseline data needed for modeling, and the movement of the sensors to and the installation of a four-turbine array on land near the San Geronio Pass to conduct advanced wind wake (and bird) research needed to develop a pilot project on a wind farm in the Pass itself.
- *Task 3 (Analysis of Bird Impacts)* includes measurement of the effectiveness of the DTBird motion detection system at the UL test facility. Once this is done, the system will be moved to the CA test site where it will be used in conjunction with traditional mortality studies to record and evaluate the VAWTs' impacts on bird species that visit the Pass.

5. Agreement management description:

This research will be carried out in collaboration with independent certification company Underwriters Laboratory (UL); with researchers from the University of the Pacific (UOP) San Jose State University (SJSU); and Stanford University and with independent researchers in the fields of wind turbine aerodynamics (Neil Kelley) and wildlife biology (Garcia and Associates). The project team will work under the management of Wind Harvest International's Chief Operating Officer. Key personnel from WHI and the subcontractors will meet in person for an initial meeting at the research field site, and will conduct in-person technical meetings in conjunction with Critical Project Reviews. More frequent coordination will occur through Skype and other telecommunications platforms.