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. At the same time, large areas of valuable wind resource properties are blocked from development of HAWTs because of their impacts on aviation. 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:

- Produce the data needed to model and analyze how arrays of closely spaced VAWTs affect key aspects of wake and turbulence and whether the VAWTs could increase the wind speed that reaches the rotors of HAWTs above *and be placed as close as five rotor diameters downwind of a first row of VAWTs.*
- Use field monitoring in combination with motion detection camera technology to evaluate how birds react to and whether they are harmed by VAWTs, and if they are, how to reduce the harm.
- Produce the information needed to conduct Phase II studies among HAWTs in wind farms such as those in the Solano and San Gorgonio Wind Resource Areas.

If VAWTs can be safely deployed in the understories of HAWT arrays, this research will open up more than 5000 MWs of existing CA wind farms to make double use of the best wind resource lands and allow for the expansion of another 1000+MWs of new wind farms on the grazing land in the Solano Wind Resource Area where Travis Air Force Base prevents turbines taller than 100 feet from being installed.

2. Project goals and objectives:

The goals are to:

- reduce the costs and double or more the amount of wind energy in California
- determine how to operate VAWTs so they won't harm birds.

Project objectives are to:

- using CFD, model the key characteristics of the wakes produced by paired VAWTs
- determine how close a downwind row of VAWTs can be placed behind an upwind row

- determine how close beneath HAWTs should the tops of VAWT blades pass in order to maximize the benefits VAWTs can provide the HAWT when immediately downwind.
- determine how well the DTBird motion detection and avoidance technology can work with arrays of VAWTs and collect and analyze field data on whether birds, as hypothesized, see and avoid VAWTs, and if they don't how VAWTs can be operated to avoid creating harm.

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 Doppler LiDAR to develop high-fidelity data and analyses of wind flow into and turbulence and wind speeds produced by VAWT arrays. Data from a Doppler LiDAR will measure:

- Height and intensity of Increased wind speeds above the VAWT array
- Changes in downwind shear.
- Distance downwind of VAWT array before wind speeds return to ambient
- Changes in radial turbulence intensity at different heights and distance downwind

The CFD model will focus on prediction of these parameters and how they change with turbine configuration and atmospheric conditions. The results will be compared to an empirical analysis of the LiDAR field data. Many of the needed algorithms to evaluate the LiDAR data are already available and well tested. This validated CFD model will be important to determining where VAWTs should be placed within wind farms in different terrains and conditions.

Data from third-party evaluation of the DTBird videos and on-site mortality studies will be used to evaluate how birds in the area interacted with the VAWTs. If birds are being harmed, the R&D will employ and evaluate the effectiveness of dissuasion techniques and turbine operational changes (e.g. significant reductions in blade tip speed).

4. Project task description:

The work comprises five 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: Doppler LIDAR collecting data from a two to four VAWT array on ranch land in Solano County near the wind farms in the Montezuma Hills. LiDAR data will be collected while the VAWT blades are operating in both directions. The data will be used to improve the accuracy of the CFD model.

- *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, a second system will be installed at the CA site where it will be used in conjunction with traditional mortality studies to record and evaluate VAWT impacts on bird species.

5. Agreement management description:

This research will be carried out in collaboration with lead investigators with experience in using LiDAR to examine turbulent boundary layer flow and wakes; independent certification company Underwriters Laboratory (UL); Stanford University CFD modelers; and independent wildlife biology firm Garcia and Associates. The project team will work under the management of WHI's Chief Operating Officer. Key personnel from WHI and the subcontractors will meet to finalize the Data Collection and Analysis Plan. They will conduct in-person technical meetings in conjunction with Critical Project Reviews. More frequent coordination will occur through Skype and other telecommunications platforms.