Executive Summary Form

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

1. Project description:

California faces several challenges in its efforts to increase wind energy's share in the state's electricity mix. It is difficult to add more horizontal axis wind turbines (HAWTs) to wind farms because of the problems created when they are placed closely together. It is also increasingly expensive to permit, buy land, build roads and provide transmission lines for new wind farms. At the same time, valuable wind resource properties are blocked from HAWT development because of their impacts on aviation and views. 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 the lack of wind farm-scale VAWTs and corresponding data on their impacts on HAWTs and wildlife. Before wind farms will allow the testing of VAWTs near HAWTs, field research must demonstrate that VAWT wakes have neutral or positive effects on the energy production and maintenance of nearby HAWTs. And before permits can be obtained for large-scale installation of VAWTs in most California wind farms, research must demonstrate that these new types of turbines do not negatively impact bird populations. In this project, WHI will:

- Produce the data needed to validate the Stanford University's CFD Large Eddy Simulation (LES) model and analyze how arrays of closely spaced VAWTs affect key aspects of wake and turbulence;
- Determine whether VAWTs could increase the wind speeds that reach HAWTs;
- Verify that VAWT rows can be placed as close as five rotor diameters to each other;
- Use field monitoring in combination with motion-detection camera technology to evaluate how birds react to VAWTs and If they are harmed by VAWTs, how to mitigate this.
- Produce the information needed to permit and conduct Phase II studies among HAWTs in the Solano and other Wind Resource Areas in California and elsewhere.

If this research shows that VAWTs can be safely deployed in the understories of HAWTs, more than 5-10,000 MWs of existing California wind farms can be utilized to double the production of the state's best wind resources and allow for the expansion of another 10,000 plus 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 the amount of wind energy in California;
- Determine if VAWTs harm to birds, and if so, find ways to prevent this.

Project objectives are to:

- Develop and validate computational simulations of and the associated methodology to predict turbulent wakes of different VAWT configurations in atmospheric turbulent boundary layers and distances before winds return to ambient conditions;
- Determine how closely VAWT blades should pass beneath HAWT rotors in order to maximize the benefits to both types of turbines when VAWTs are placed immediately downwind;

- Evaluate how well the DTBird motion detection technology works with arrays of VAWTs. Collect and analyze field data on whether, as hypothesized, birds see and avoid VAWTs. If they don't, evaluate ways to operate the VAWTs so no harm is caused.

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 and sonic anemometers to develop high-fidelity data on turbulence and wind speeds produced by VAWT arrays. Data from the sensors will measure:

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

The CFD LES 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 in determining where VAWTs should be placed within wind farms in differing 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 interact 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 and 3 are technical tasks.

- *Task 2 (Measure and Model VAWT Wake Effects)* includes Doppler LIDAR and sonic anemometers collecting data from a two-to-four VAWT array on ranch land in Solano County near the wind farms in the Montezuma Hills. Data will be collected while the VAWT blades are operating in both directions. The data will be used to validate the methodology and improve the accuracy of the CFD LES model.

- *Task 3 (Analyze VAWT Impacts on Birds)* includes measurement of the effectiveness of the DTBird motion detection system at the UL test facility where WHI's VAWTs will be undergoing certification. Once this is done, a second system will be installed at the California 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 SJSU experts in LiDAR to measure turbulent boundary layer flow and wakes; Stanford University CFD LES modelers; independent wildlife biology firm Garcia and Associates and independent certification company Underwriters Laboratory (UL). 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 and produce the project deliverables. The team will coordinate with phone and in-person technical meetings as well as on-site visits timed for Critical Project Reviews.