Validation and Uncertainty Quantification Proposal for a Solar-driven Vortex Apparatus

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Much of the solar energy incident on the Earth's surface is absorbed into the ground, which in turn heats the air layer above the surface. This buoyant air layer contains considerable gravitational potential energy. The basic idea behind this approach is to convert the potential energy in this buoyant air layer to kinetic energy in an anchored vortex, and to use that kinetic energy to drive a vertical-axis turbine coupled with an electric generator in order to produce electrical power. Computational Fluid Dynamics (CFD) is used to simulate this Solar-Driven Vortex (SoV). These computer simulations are intended to discover the optimal system configuration for a range of scenarios and system sizes. In order for these simulations to be generally useful, they must first be validated against existing experimental data and high fidelity simulations. These models will then explore regimes and scales where no experimental measurements presently exist. Characterizing the uncertainty of predictions resulting from extrapolation is a critical component in enabling reliable assessments of field performance of the SoV, as it will guide the commercialization strategy of the product.

This report provides a "validation roadmap" detailing the process by which an analysis of the uncertainties inherent to this problem may be characterized. It will begin with a discussion of the physics scenario and the mathematical model, as well as detailing the reliability of each submodel and the systems inputs. We will then discuss the validation of these models against existing experimental data and high fidelity simulations. Finally, we will formulate a Bayesian analysis for a sub-problem, to serve as a representative example of a probabilistic analysis applied to this project.

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