Non-Deterministic Design of Utility-Scale Wind Energy Systems

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Introduction

The wind is an increasingly significant source of energy with the rising price of non-renewable fuels. The purpose of this project is to determine the specific intensity and frequency of wind speed required to sustain a large-scale wind farm with power output on the order of hundreds of megawatts. To this end, a non-deterministic methodology will be developed to analyze the viability of wind energy systems.

A deterministic analysis method considers the majority of design parameters to be known or fixed and may only perform trade studies on a few parameters at a time to optimize performance. In the case of the energy market though, this is not an advantageous strategy since several factors related to economic viability such as energy prices, interest rates, government incentives, acquisition costs and maintenance are highly variable and cannot be assumed to be known. A non-deterministic, statistical approach to wind turbine design has the advantage of predicting with corresponding levels of certainty the power output and economic viability of an energy system. The resulting data can be correlated to wind surveys of the United States along with state-by-state tax incentive information to find the best locations for wind energy expansion in the nation.

Objectives of Research

The primary goal of this project is to define the envelope of operating conditions for a large-scale wind project while considering variables of both engineering and economic significance. The National Renewable Energy Laboratory's (NREL) Hybrid Optimization Model for Electric Renewables (HOMER) will be incorporated into the previous analysis using YawDyn and PROPID to determine the economic returns on investment in hypothetical financing cases. Cost factors will now be assigned a mean value along with a probability distribution. Monte Carlo simulations will be run for a large number of variations in the assumed economic and engineering cost factors to develop an accurate estimate of the life cycle cost of the design. A documented analysis methodology using HOMER in addition to YawDyn and PROPID will be presented for use on large scale wind energy development.