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A Systematic Evaluation of Wind Harvesting Potential in CA with Tall Towers

Additional submitted attachment is included below.

A Systematic Evaluation of Wind Harvesting Potential in CA with Tall Towers

With continued technical advances in wind energy technology, future wind farms are likely to include taller towers, larger rotors and bigger turbines. All of these advancements are expected to increase the wind power production, which in turn will reduce the Levelized Cost of Energy (LCOE). At elevated hub heights, wind resources will be steadier and of higher quality, enabling increase in the capacity factor (Fig. 1). By increasing the hub height from 80 m to 140 m, the potential area for generating land-based wind power will increase by 67% across the United States (DOE, 2017). Furthermore, in California, the land area that could be used for wind farm development with a minimum capacity factor of 35% will be expanded by more than 17 fold (Fig. 2). In addition, the elevated tower height will facilitate the use of larger rotors. Increasing the rotor diameter by 20 m will elevate the annual energy production further by as much as 30% to 40%.

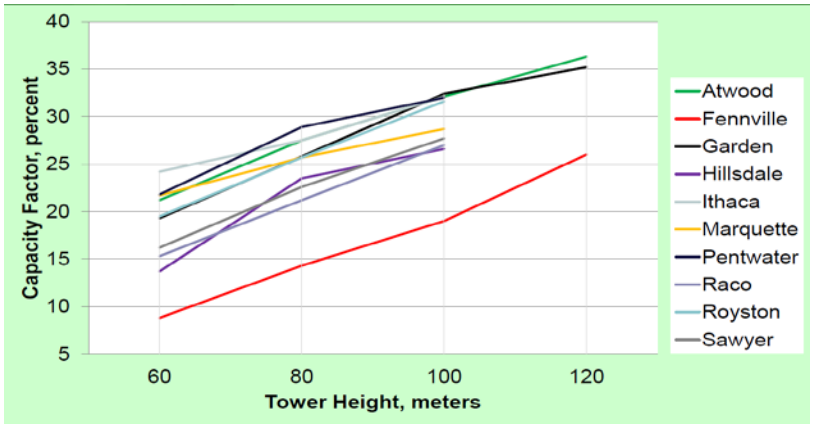

Fig. 1 - Capacity factors increase with tower heights (S. B. Harsh, 2010)

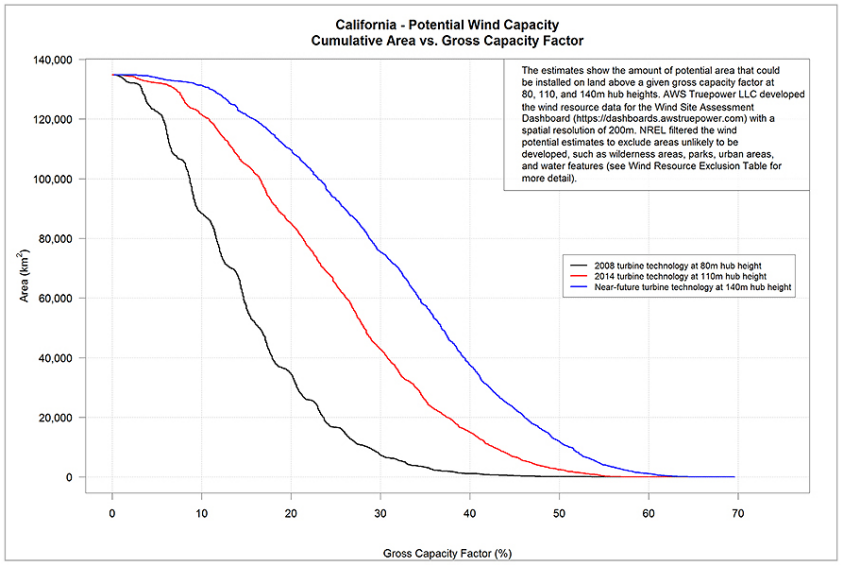

Fig. 2 - Potential wind capacity in California (DOE, 2017)

Within and outside of California, 80-m steel tubular towers continue to dominate the wind farm development, which is dictated by transportation limits. To overcome this, the Department of Energy invested on new technologies such as Hexcrete (Sritharan et al., 2015). The Hexcrete technology uses high strength concrete as the base material, eliminates transportation challenges, and is designed to invigorate the local work force development. The components of Hexcrete towers can be prefabricated locally at precast concrete plants including many across the state of California.

By eliminating the constraint associated with the tower height, it is unclear how high one should go to harvest the wind energy most cost effectively. This heavily depends on the ability to predict the wind energy production at new heights with sufficient accuracy. However, neither wind resource information at elevated heights, nor reliable models exist to estimate the wind energy production at higher hub heights. At Iowa State University, we have developed and validated a wind energy production model that can predict wind power at different hub heights. Therefore, this proposal will facilitate a systematic evaluation of the benefits of using tall towers (and larger rotors) for wind power production at different locations in California and enable wind farm developers to produce wind power at a reduced cost.

This investigation will deploy SoDARs (Sonic Detection and Ranging) such as a Triton sonic wind profiler to obtain actual wind measurements up to 200 m above ground for a period of three to six months. These units will capture the wind resources not only in the lower portion of the rotor layer, which is the height limit of routinely used 60-m tall meteorological towers, but also over the entire range of the swept area of the taller towers, providing critically needed information for estimating wind power. Furthermore, the on-site measurements will be combined with simulated wind data generated by National Renewable Energy Laboratory (Draxl et al., 2015) with appropriate corrections to quantify the effect of taller towers in broader regions (e.g., the entire wind farm). Additional refinements to the predicted wind power can be made based on similar investigations being completed in the Midwest, where wind measurements were obtained for a period of up to two years.

Promoting the use of taller wind turbine towers will also bring other innovations to California. For example, this will allow turbine and blade manufacturers to design suitable components for wind farm development in California. Mixing tower heights and turbine sizes within a wind farm would also minimize wake effects and improve the efficiency of the entire wind farm. This concept will promote new layouts for future California wind farms.

References

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