Wind Turbine Upscaling and Thick Airfoil Implementation – Measurements and Simulations

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Interest in the wind turbine industry originally spawned from the oil embargo in the 1980s and ever since has increasing the efficiency and lowering the cost of energy (COE) been aspired by wind turbine designers and manufactures. This continues to be the primary target of the wind turbine manufactures today, who must lower the current COE of wind energy by 40% by 2020 to stay competitive. This project investigates one of the most critical challenges in reaching this target; innovative blade design.

The possible power output from a wind turbine, is given by the so-called power expression

$$P = \frac{1}{2} C_p \rho A V^3$$

where C_p is the power coefficient, ρ is the density of air, A is the area swept by the rotor and V is the wind speed. It is seen that even the best improvement in the blade design and thereby an increased power coefficient, would increase the power output only modestly compared to an increase in the swept area. This fact is well recognized by the industry and has led to a continuous upscaling of wind turbines from the first commercial 50 kW rated wind turbines, to the 8MW rated turbines in operation today.

While increasing the power output and thereby lowering the COE, the increase in rotor diameter and blade length, does bring about some technical challenges. Innovative blade design is of increasing importance in obtaining feasible turbine blade designs, to withstand the heavier weight and larger loads acting on the blades. The demand for a stronger structure, initially calls for thicker and stronger structures at the root of the blade, a design that has no impressive aerodynamic performance. Combining a strong structure with a good aerodynamic performance has become a major challenge for wind turbine rotor design and thick airfoils designs (thickness > 35% chord) meet this requirement are of high value. During wind turbine rotor design, rotor aerodynamics is often represented by blade element momentum method, where the aerodynamic forces on the blades are represented by airfoil polars, i.e. lift and drag coefficients. These can be estimated by CFD or by dedicated wind tunnel measurements. Good knowledge exist measuring airfoil data, however with some uncertainty for very thick airfoils. Further the accuracy of CFD predictions are of even poorer accuracy. The challenges estimating these data include highly instability and very unpredictable three-dimensional flow structure. Proper correction methods are therefore of great importance and have investigated thoroughly in the project to optimize the design of wind turbine blades through the exploitation of thick airfoil designs.

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