WindSTAR
Wind-Energy Science, Technology, and Research
Industry/University Cooperative Research Center

Decision Support Using FAST Aero-elastic Models of Operating Wind Turbines

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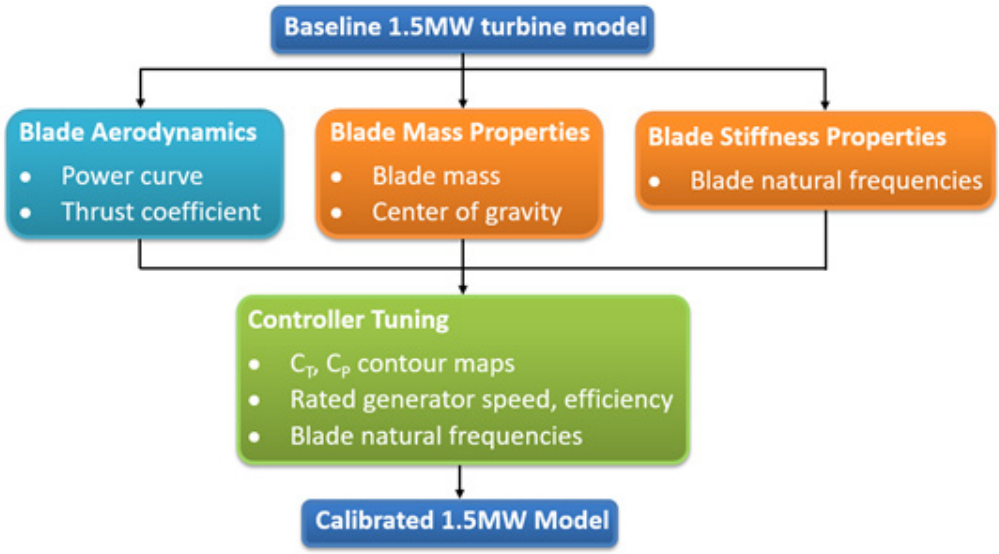
In modern wind turbines, the wind energy industry looks to the development of new technologies and/or new processes to achieve goals for profitability in producing electricity at a competitive market rate. In this respect, validated tools for design and asset management are one of the key needs for achieving and maintaining a market-competitive levelized cost of energy (LCOE) throughout the lifetime of the turbine. The C2-19 project addresses this need by focusing on a new approach for developing an aero-elasto-servo digital twin model of an operating utility-scale 1.5MW wind turbine. In this technique, experimental data from an operating wind turbine is used to calibrate the properties of a baseline turbine model to represent the loads and dynamic behavior of the target wind turbine. The blade aerodynamics and structural dynamics are the primary focus of this technique. For the aerodynamic model, the power curve and thrust coefficient data of an experimental turbine is used to calibrate the digital twin's blade aerodynamic properties. For the structural model, experimental data on the blade center of gravity, total mass, and natural frequencies is used to calibrate the digital twin's blade mass and stiffness property distributions. The digital twin model was created as an OpenFAST (FAST) model and the turbine's controller was created in Simulink and tuned to maintain the desired operating properties of the digital twin. A primary benefit of this methodology is its versatility of implementation in the creation of models of multiple similar turbines (such as those in a fleet) once a baseline model is in place. Finally, the model is used to perform a de-rating case study and a fatigue case study to illustrate some of the many potential uses of this digital twin in asset management for decision support in wind farm operations. The overarching goal of the project is to provide and explore a new and simple model development methodology to create a digital twin, and explore its uses and potential benefits for LCOE reduction and overall fleet management.



Pictorial representation of the model calibration process. The process begins with an uncalibrated baseline model. The baseline aerodynamic and structural properties are tuned separately using experimental data and then the controller is tuned to maintain desired turbine properties during operation.