Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Effect of blade loading and rotor speed on the optimal aerodynamic performance of wind turbine blades CHRISTOPHER BRYSON, FAZLE HUSSAIN, ALAN BARHORST, Texas Tech University — Optimization of wind turbine torque as a function of angle of attack - over the entire speed range from start-up to cut-off - is studied by considering the full trigonometric relations projecting lift and drag to thrust and torque. Since driving force and thrust are geometrically constrained, one cannot be changed without affecting the other. Increasing lift to enhance torque simultaneously increases thrust, which subsequently reduces the inflow angle with respect to the rotor plane via an increased reduction in inflow velocity. Reducing the inflow angle redirects the lift force away from the driving force generating the torque, which may reduce overall torque. Similarly, changes in the tip-speed ratio (TSR) affect the inflow angle and thus the optimal torque. Using the airfoil data from the NREL 5 MW reference turbine, the optimal angle of attack over the operational TSR range (4 to 15) was computed using a BEM model to incorporate the dynamic coupling, namely the interdependency of blade loading and inflow angle. The optimal angle of attack is close to minimum drag during start-up phase (high TSR) and continuously increases toward maximum lift at high wind speeds (low TSR).

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Date submitted: 31 Jul 2015 Electronic form version 1.4