Abstract Submitted
for the DFD17 Meeting of
The American Physical Society

Wind Turbine Performance in an Atmospheric Boundary Layer: Betz Analysis Revisited JACOB WEST, SANJIVA LELE, Stanford University — Using large eddy simulation of an infinite (periodic in x and y) wind farm, we compute momentum and mean mechanical energy budgets. We focus on the control volume defined by a streamtube of the mean flow that intersects with a turbine actuator disk, in a similar way as traditional Betz analysis is done for a streamtube in inviscid, irrotational flow through an actuator disk. This analysis reveals that many of the same phenomena from Betz analysis are found in the atmospheric boundary layer case. The streamtube expands as the fluid decelerates through the turbine, and the pressure increases and then drops sharply across the actuator disk. However, away from the turbine, the downstream streamtube shrinks and fluid accelerates due to turbulent mixing. In this way, turbulence alters the idealization of the Betz streamtube. We anticipate that the Betz analysis can be applied most effectively to a wind turbine in the atmospheric boundary layer by focusing on the immediate vicinity around the turbine, where inviscid, potential flow effects dominate. Adjustments can be made to account for the vertical energy flux in wind farms, as well as the energy contained in velocity fluctuations.

Jacob West
Stanford University

Date submitted: 31 Jul 2017 Electronic form version 1.4