Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

An LES study of vertical-axis wind turbine wakes aerodynamics
MAHDI ABKAR, Center for Turbulence Research, Stanford University, Stanford, California 94305, USA, JOHN O. DABIRI, Dept. of Civil and Environmental Eng. Dept. of Mechanical Eng., Stanford University, Stanford, CA 94305, USA — In this study, large-eddy simulation (LES) combined with a turbine model is used to investigate the structure of the wake behind a vertical-axis wind turbine (VAWT). In the simulations, a recently developed minimum dissipation model is used to parameterize the subgrid-scale stress tensor, while the turbine-induced forces are modeled with an actuator-line technique. The LES framework is first tested in the simulation of the wake behind a model straight-bladed VAWT placed in the water channel, and then used to study the wake structure downwind of a full-scale VAWT sited in the atmospheric boundary layer. In particular, the self-similarity of the wake is examined, and it is found that the wake velocity deficit is well characterized by a two-dimensional elliptical Gaussian distribution. By assuming a self-similar Gaussian distribution of the velocity deficit, and applying mass and momentum conservation, an analytical model is developed and tested to predict the maximum velocity deficit downwind of the turbine.

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Date submitted: 03 Aug 2016 Electronic form version 1.4