JOHNS HOPKINS
Center for Environmental & Applied Fluid Mechanics

FALL 2020 CEAFM VIRTUAL SEMINAR

"The Dynamics of Large-Scale Vortices Generated by Yawed Wind Turbines"

Presented by Dr. Carl R. Shapiro

U.S. Department of Energy Building Technologies Office
Hosted by Dennice Gayme & Charles Meneveau (JHU - MechE)

Winner of the 2019 Corrsin-Kovasznay Outstanding Paper Award

With the continued growth of global wind power production, ongoing efforts to increase the power density and controllability of wind power plants are becoming more important. In this talk, I will discuss the application of vortex dynamics to improve wind turbine modeling. Vortex dynamics are particularly important for yawed wind turbines, which generate counter-rotating vortex pairs (CVPs) that deflect and deform the turbines' wakes as they advect and turbulently diffuse downstream. Application of the Prandtl's lifting line theory and integration of the mean streamwise vorticity transport equation yield accurate models of the initial CVP vorticity and velocity fields. Analytic integration of the simplified vorticity transport equation, combined with an eddy viscosity approach, provide analytical expressions for the vorticity and circulation of the CVP as the vorticity cancels at the line of symmetry of the wake through cross-diffusion. Further application of the vorticity equation generates models for the wake curling induced by the yawed turbine CVP. These types of models developed from vortex dynamics profile a framework for fully realizing the potential of yawing for wind farm power maximization and regulation.

Carl Shapiro is a AAAS Science & Technology Policy Fellow at the U.S. Department of Energy Building Technologies Office. Carl received his PhD from Johns Hopkins University in Mechanical Engineering in 2018. Previously, Carl was a Postdoctoral Fellow at Johns Hopkins and an Engineer at Steven Winter Associates. His research interests include building energy efficiency, wind energy, fluid mechanics, control systems, and power grid integration.

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