after the talk:
optional guided visit of the wind channel!

CARL VON OSSIETZKY universität OLDENBURG
Institut für PHYSIK

PHYSICAL COLLOQUIUM

INVITATION

Monday, 13.05.2019, 4.15 p.m., W2-1-148

speaks

Assoc. Prof. Martin Wosnik, PhD,

Director, Center for Ocean Renewable Energy (CORE)
Mechanical & Ocean Engineering, University of New Hampshire (UNH)

about

"Wind turbine wakes and wind farm fluid dynamics"

Research on Fluid Energy Conversion at the UNH Center for Ocean Renewable Energy (CORE) covers tidal, wave and offshore wind energy. It spans various scales, levels of complexity and environments – from the "blade scale" in a cavitation tunnel, to tests with scale model turbines in a tow/wave tank or large wind tunnel, to deployments of instrumented process models at open-water test sites.

The wind energy research has been focused around the UNH Flow Physics Facility (FPF), a large flow-physics quality turbulent boundary layer wind tunnel with test section dimensions of 6.0 m wide, 2.7 m tall (at inlet), and 72 m long, which provides a unique test environment due to its large size.

Turbulent wakes generated by two 1 m diameter turbine models were studied. Streamwise velocity profiles were measured downstream of a 1 m porous disk up to 50 m downstream. The disk wake elongates in the vertical direction as it evolves downstream, due to interaction with wall boundary layers, and shifts downward due to the presence of the wind turbine model tower. Streamwise and azimuthal velocity profiles were measured in the wake of a 1 m diameter scale model wind turbine to 20 diameters downstream. The mean azimuthal (swirl) velocity W exhibits a $W \propto U_o^{3/2}$ scaling at intermediate downstream locations, as predicted by a similarity analysis, where U_o is the wake centerline velocity deficit. Both disk and wind turbine wakes exhibit distinct asymptotic high-Reynolds number scaling for axisymmetric turbulent wakes up to 20 diameters downstream.

Wake meandering was studied downstream of single model turbines (D=0.25m) in a boundary layer flow, and within a large array of model turbines (D=0.25m, array with 19 rows and 5 columns) that were positioned within a simulated atmospheric boundary layer. For single turbine models, frequencies and peak energies observed in the velocity spectrum in the wake return to those of the incoming turbulent boundary. Wake meandering also presents itself in the large wind turbine array. Here, frequencies and peak energies observed in the velocity spectrum in the wake *do not* return to those of the incoming turbulent boundary. Instead, a lower dominant frequency corresponding to the wind velocity at hub height and array spacing is observed, indicating a type of resonance of the turbine array itself.

In a current collaboration with researchers at the University of Oldenburg (with: P. Hulsman, V. Petrović, M. Hölling and M. Kühn), the new large wind tunnel at the WindLab (dimensions 3 m x 3 m x 30 m) is being used to investigate the wakes of a model turbine operating under different yaw angles and inflow conditions, with velocity measured with a Lidar WindScanner. Wind turbines operating in the wake of upstream turbines experience power losses due to wake effects. Upwind turbines can intentionally be yawed to deflect the wakes to increase the power output of the downstream turbines, which may increase the overall power production of a wind farm. The goal of this study is to help develop a wind farm controller to maximize power output. Preliminary results of this study will be shown.

All interested persons are cordially invited.
Sgd. Prof. Dr. Martin Kühn, Prof. Dr. Joachim Peinke