Title: Wind Turbine Design Optimization: development of a framework and a comparison of two approaches

Abstract: This talk presents a framework for wind turbine (WT) aerodynamic design optimization (ADO) and the two approaches that we have tested for ADO. The framework is developed by integrating 3D parametric modeling, physics-based optimization schemes, and 3D RANS and 4D URANS simulations. The first approach using the framework is based on the Inverse Blade Element Momentum (IBEM) Theory , 3D RANS single-blade simulation and 3D parametric modeling to optimize the blade twist angles along the span to exploit the 3D delayed stall effect to maximize lift/drag ratio of the blade; the second approach in the framework is based on 4D URANS model with multi-block grid for whole rotor simulation, 3D parametric modeling, goal driven/gradient based design optimization of the flap angle along the blade to maximize power output.

The NREL Phase VI rotor blade is used as a case study for the validation of the framework and the two approaches. The associated experimental data are used to validate the 3D RANS and 3D URANS solvers. In the first approach, the simulation results, as well as experimental data, were then used in the IBEM optimization routine to generate the local 3D AOA, lift and drag coefficients which are used later to guide the search for an optimal blade geometry in an iterative process. And in the second approach, the search process takes place to guide the optimization of flap angle along the blade to achieve maximum power output. The results obtained from the case study indicate that 1) the 4D URANS whole rotor simulation in the second approach generates more accurate results than the 3D RANS single blade simulation with periodic boundary conditions in the first one; 2) the second approach can produce a blade geometry that satisfies the optimization objective, while the first approach is less desirable as the 3D stall delay is not prominent enough for this particular case study.

Biography: Dr. Michael Yong Zhao received his PhD and MSc from the University of Manchester, UK on a Sino-British Friendship Scholarship from the PRC/UK governments, and his BEng from Xi'an Jiaotong University, PRC. He has held faculty and admin positions at Nanyang Technological University (NTU), Singapore from 1992-2010 and Alfaisal University, KSA from 2010-2016. Since 2016 he is a professor of Mechanical and Aerospace Engineering at the Nazabayev University in Kazakhstan. His research interests include computational fluid dynamics (CFD) and computational structural dynamics (CSD) and their engineering applications in biomedical engineering, combustion engines and renewable energy systems. He has been a consultant to international companies in the energy and automotive engineering fields. He has also received a number of awards for his research work, including a Blue Challenge bronze award from IBM, a Cray Quest gold award from Silicon Graphics and a MIT conference fellowship from the 2nd MIT conference on Computational Fluid and Solid Mechanics. Recently he and his co-author have just published a book entitled “Computational Fluid Structure Interaction: Methods, Models and Applications” by Academic Press in 2018.