3rd Wind Energy Systems Engineering Workshop Poster Session

Title	Abstract	First Author Biography
Data-driven modeling and analysis for load characterization, condition monitoring, adaptive predictions and wake effect quantification	To quantify and minimize the uncertainties in the design and operational stage, we model and analyze the dependency of wind turbine responses (e.g., power generation, loads and condition monitoring sensor measurement) on operating conditions and the interactions among turbines. Our research entails four areas: (a) extreme load characterization using stochastic simulations; (b) Condition monitoring; (c) Adaptive predictions; and (d) wake effect quantification: The performance of downstream turbines can be significantly decreased due to the wake effect among wind turbines. We model and analyze the interactions among wind turbines to quantify the power deficit due to wake effects.	Eunshin Byon is an Assistant Professor in the Department of Industrial and Operations Engineering at the University of Michigan, Ann Arbor, USA. She received her Ph.D. degree in Industrial and Systems Engineering from the Texas A&M University, College Station, USA, and joined the University of Michigan in 2011. Dr. Byon's research interests include reliability evaluation and optimal control for stochastic systems, predictive modeling and data analytics. Her recent research focuses on load modeling, operation and maintenance (O&M) optimization, and condition monitoring in wind power systems. Her research has been supported by National Science Foundation.
Integrated Design of Wind Turbine Layout and Controls using the FLOw Redirection and Induction in Steady-State (FLORIS) model	Using yaw offsets for example, turbine wake can be redirected away from downstream turbines. The FLOw Redirection and Induction in Steady-State (FLORIS) model has been developed for optimizing the yaw settings of wind turbines in a wind plant for improved electrical energy production of the whole wind plant. In recent work, we have used the FLORIS model in a system engineering approach to perform coupled wind plant controls and position layout optimizations of a model wind plant. Results show that we can increase the energy generated by the wind plant, reduce cable length, and/or reduce the area used for the plant.	Pieter Gebraad is a postdoctoral researcher at NREL's National Wind Technology Center. His research aims at applying control techniques in wind plants that mitigate wake effects, in order to increase production and reduce turbine fatigue loads. In December 2014, he obtained his PhD at TU Delft with his dissertation 'Data-Driven Wind Plant Control'.
Forecastability as a Design Criterion in Wind Resource Assessment	A methodology is proposed to include the wind power forecasting ability, or "forecastability," of a site as a design criterion in wind resource assessment and wind power plant design stages. In this study, the Unrestricted Wind Farm Layout Optimization (UWFLO) methodology is adopted to maximize the capacity factor of a wind power plant. The 1-hour-ahead persistence wind power forecasting method is used to characterize the forecastability of a potential wind power plant, thereby partially quantifying the integration cost. A trade-off between the maximum capacity factor and the forecastability is illustrated.	Dr. Jie Zhang is currently working at the National Renewable Energy Laboratory as a Research Engineer. Dr. Zhang received his Ph.D. (2012) from the Department of Mechanical, Aeronautical, and Nuclear Engineering at Rensselaer Polytechnic Institute (RPI). His research expertise and interests are multidisciplinary design optimization, complex engineered systems, big data analytics, wind energy, renewable integration, and power & energy systems. This research has resulted in over 70 peer-reviewed publications.
An Interactive Parametric Design-Through-Analysis Platform for Wind Turbine Blades	This work addresses some practical aspects of making the computational approach called Isogeometric Analysis (IGA) more accessible to design engineers and analysts, particularly in the field of wind energy. An interactive parametric design-through-analysis platform for wind turbine blades is proposed to help design engineers and analysts make more effective use of IGA to improve their product design and performance more quickly. We develop several Rhino 3D plug-ins with a user-friendly interface to take input design parameters, generate appropriate surface and/or volumetric models, perform mechanical analysis, and visualize the solution fields, all within the same Computer-Aided Design (CAD) program. The developed platform is specifically applied to and developed for wind turbine blades.	Austin Herrema is an IGERT (Integrated Graduate Education Research and Traineeship) fellow at pursuing a co-major Ph.D. in Iowa State University's Wind Energy Science, Engineering, and Policy Program and Mechanical Engineering. He received a B.S. in Mechanical Engineering from Dordt College in May of 2014. His current research is in the field of computational mechanics, specifically regarding the computational design and analysis workflow.
A New CFD-Based Optimization Framework for Wind Plant Layouts	Wind farm layout optimization is a challenging problem that couples atmospheric boundary layer turbulence, power production, mechanical loads, and construction costs. This high dimensional design space is amendable to gradient-based optimization using adjoint methods. This poster discusses WindSE, an adjoint LES flow solver NREL is developing for turbine layout optimization.	Ryan King is a PhD student at the University of Colorado, Boulder and joined NREL's Wind Energy Systems Engineering group in 2012 to work on drivetrain modeling. His current research focuses on turbulence modeling, Large Eddy Simulations (LES) and adjoint optimization of wind farm layouts.

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Application of WISDEM models to tower design optimization—the influence of tower height and RNA weight	In this work we used a subset of the models in the Wind-Plant Integrated System Design and Engineering Model (WISDEM) to illustrate the design optimization of a tower for a land-based wind turbine. We considered two different design driving objectives. One is to increase the annual energy production (AEP) by increasing the height of the tower for a given wind turbine rotor size. In principle, the cost of the added materials may be partially offset by the gain in AEP. This is a design concept that has been introduced by some wind turbine manufacturers to make sites with low wind resource at low altitudes more attractive economically. The other objective is the reduction of wind turbine installed cost through a reduction of the rotor-nacelle assembly (RNA) mass. A lighter RNA may yield a reduction in cost because the tower steel may be reduced. We used data found in the literature and similarity scaling rules to select boundaries for the design space, and gradient based optimization to find the optimized designs for different sets of constraints. In this manner, we illustrate the application of a systems engineering approach to the design optimization of an important component of wind turbines.	Braulio Barahona Garzón got his M.Sc. (2008) and Ph.D. (2012) from DTU Wind Energy, and joined NREL as a Postdoc in 2014. His research interests revolve around wind turbine integrated dynamics analysis and control, and integration of wind power to the power system.
A New Yaw system for a 6 MW Downwind Two-Bladed Offshore Wind Turbine	In order to drive down the costs of offshore wind energy, new wind turbine designs and concepts need to be considered. One such new design is being developed by 2-B Energy in Hengelo, The Netherlands. This company is designing a state-of-the-art 6MW downwind two-bladed wind turbine specifically for offshore deployment. A key step in the design process of a damped free-yaw turbine is the yaw mechanism. Several concepts can be employed to find the best trade-off in terms of loads and power output. In this study, the effects of different yaw damping values and different yaw controllers are investigated. Moreover, an integrated design approach of the yaw damping and the yaw controller is presented.	Edwin van Solingen was born on 20 September 1986 in Abbenbroek, the Netherlands. He received the B.Sc. degree in electrical engineering and the M.Sc. degree in systems and control from the Delft University of Technology, the Netherlands. He is currently pursuing the Ph.D. degree in the Delft Center for Systems and Control in the same university where his focus is on integrated control design of two-bladed wind turbines.
Co-Design for Wind Turbines	The design of physical (plant) and control aspects of a dynamic system have traditionally been treated as two separate problems, often solved in sequence. Optimizing plant and control design disciplines separately results in sub-optimal system designs that do not capitalize on the synergistic coupling between these disciplines. This coupling is inherent in most actively controlled dynamic systems, including wind turbines. In this case structural and control design both affect energy production and loads on the turbine. This poster will highlight an integrated approach to achieve system-optimal wind turbine designs using co-design, a design methodology that accounts directly for the synergistic coupling between physical and control system design. Recent results from a wind turbine case study, based on multidisciplinary simulation, will be presented that demonstrate a promising increase in annualized wind turbine energy production compared to the results of a conventional sequential design strategy. Lastly, specific synergistic mechanisms that enable performance improvements will be discussed which are accessible via co-design but not sequential design.	Anand Deshmukh is a doctoral student in Systems Engineering at the University of Illinois at Urbana-Champaign. His research interests span the area of mathematical optimization, control theory and their application to wind turbine system design.
Wind turbine blade failure, safety and quality assurance (WINDRISC)	The increasing number of large wind turbine installed near inhabited areas, buildings and community facilities has resulted in an increasing concern by authorities to determine risk levels associated with wind turbine blade failure. The objective of the project is to develop, validate and demonstrate software for risk analysis of external consequences of failure of wind turbine blades or ice throw from wind turbine blades. The maximal throwing distance and the associated probability are estimated if a blade fails completely or partly. Consequences of ice throw will also be included, such that the throw distance of an ice fragment will be determined both during the operating condition as well as in stand-still. Besides the development of the software, recommendations with respect to safety distances will be made for wind turbines located near roads, living areas, industrial buildings, and airports.	Hamid Sarlak Chivaee is a postdoctoral research associate at the Department of Wind Energy, Technical University of Denmark. Hamid's research interests include in the area of wind energy are numerical and experimental fluid mechanics and turbulence modeling.