Dear IAB Members,

On behalf of the WindSTAR I/UCRC Directors and Faculty members, we would like to thank you for your continued support and membership. We’re proud of what we’ve accomplished having faculty and students work side by side with company members. We have finished our second year as a Phase II Center having completed dozens of projects, published numerous papers, had multiple M.S. and Ph.D. students graduate (several have been hired by member companies and national labs), implemented several software and hardware systems that are in use by the WindSTAR company members, and created a new WindSTAR Webinar Series. For every dollar coming from a Full IAB member, ~16 dollars are invested in the Center from another source. For small business IAB members, the leveraging is approximately 48:1. Without operating through the National Science Foundation’s I/UCRC program, this level of commitment and value to industry would not be possible.

Every year WindSTAR continues to grow and more people in the wind industry are learning that the Center is a platform that enables universities, industrial partners, and government to collaborate on developing novel solutions to wind energy problems. As we progress through our eighth year of operation (Phase II), we will continue to grow the Center, strengthen existing collaborations, and increase awareness of WindSTAR within the wind industry. In 2022, we believe there will be many new growth opportunities due to increased interest in the decarbonization of the electric grid and the planned U.S. procurements for offshore wind energy.

The WindSTAR Center is working to improve the performance and availability of wind energy conversion systems. The Center’s efforts will help drive down the cost of wind-generated electricity and make the use of wind energy more widespread within the United States and globally. Results from projects have provided valuable data to Center members who have acquired various multi-million dollar grants augmenting their R&D capacity. Through continued advancements in technology, we believe that wind power will be a major player in improving the sustainability of the Nation’s electricity portfolio and enable new applications of this renewable source of energy. We are happy you are participating in the WindSTAR I/UCRC and look forward to working with you in the years to come.

Sincerely,
Christopher Niezrecki, Ph.D.
Distinguished University Professor, Mechanical Engineering
Co-Director, RIST Institute for Sustainability and Energy
Co-Director, Structural Dynamics and Acoustics Systems Laboratory
Director, WindSTAR I/UCRC
University of Massachusetts Lowell

Mario A. Rotea, Ph.D., F. IEEE
Professor, Mechanical Engineering
Professor (affiliate), Electrical and Computer Engineering
Director, Center for Wind Energy (UTD Wind)
Site Director, WindSTAR I/UCRC
University of Texas Dallas

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The mission of WindSTAR is to bring together university and industry researchers to conduct basic and applied research on topics important to wind industry members. The Center combines capabilities, facilities, and knowledge to execute projects of interest to industry partners, train students in advanced technologies, and foster a community for industry/university networking and collaboration.

WindSTAR is an NSF-funded Industry/University Cooperative Research Center for Wind Energy, Science, Technology and Research, established in 2014. A collaboration between UMass Lowell, the University of Texas at Dallas, and its members, the Center aims to solve the pressing needs of the wind industry.

The University of Massachusetts Lowell is the lead WindSTAR site and focuses on projects that advance the materials, manufacturing, reliability, testing, modeling, and monitoring of turbines as well as energy storage, transmission and zero-carbon fuel generation. The University of Massachusetts Lowell is a public national research university in Lowell, Massachusetts.

The University of Texas at Dallas is a WindSTAR site with foci on high-fidelity simulation of wind power systems and components, LiDAR measurements and analysis of wind fields for diagnostics and model validation, wind tunnel testing, control system design for wind turbines and wind farms, large rotor design, grid integration and energy storage, data analytics for forecasting, performance and health assessment. The University of Texas at Dallas is a public research university in Richardson, Texas.
WindSTAR’s industry membership is diverse across the wind energy supply chain, including wind farm owner and operators; turbine, blade and tower manufacturers; material suppliers; condition monitoring & control electronics manufacturers; actuator technology developers; and other organizations with a stake in the growth of the wind energy market.

**2021-2022 IAB Chair**
Brian Hill  
General Manager North America  
Bachmann Electronic Corp

**2021-2022 IAB Vice Chair**
Brandon Fitchett  
Program Manager, Wind Power R&D  
Electric Power Research Institute (EPRI)

**2020-2021 IAB Chair**
Nathan Bruno  
Composites Manager - Epoxy  
Hexion

**2020-2021 IAB Vice Chair**
Brian Hill  
General Manager North America  
Bachmann Electronic Corp

**Past IAB Chairs:**
2019-2020: Neal Fine, Arctura
2018-2019: Nicholas Althoff, GE Renewable Energy
2017-2018: Ben Rice, Pattern Energy
2015-2016: Justin Johnson, EDP Renewables
2014-2015: Steve Nolet, TPI Composites, Inc

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**Previous Members include:**
Huntsman  
Keuka Energy  
LM Wind Power  
Maine Composites Alliance  
National Instruments  
NRG Renew
MEMBERSHIP LEVELS 2020-2021

Full Membership: $44,944 Annually
Small Business Associate: $16,856 Annually

CUMULATIVE INVESTMENT

- NSF Award: $1,201,654
- University Contribution (Cost Share): $1,235,527
- IAB Contributions: $2,755,451
- In-Kind: $527,508

TOTAL INVESTMENT: $5,720,140

FINANCIAL OVERVIEW: RETURN ON INVESTMENT

PAST PROJECTS

Composites and Blade Manufacturing (A)
- Adhesion Test Device for Evaluating Adhesive/Sealant for Lap Joints in Wind Turbine Blades
- Structural Repair of Wind Turbine Blades
- Cure Cycle Optimization of Wind Turbine Blades Adhesive Bondlines
- Mechanical Properties Enhancement Prediction for Matrix Material
- Engineered Sandwich Core Construction: Experiment and Evaluation
- Structural Wind Blade Repair Optimization
- Residual Stresses in Thick Paste Adhesive Bondlines
- Curing of Thick Adhesive Joints
- Mechanical Properties Enhancement Prediction for Matrix Materials
- Automation for Blade Manufacturing
- Effects of Manufacturing Induced Defects
- Mechanical Property Enhancement Prediction for Matrix Materials
- Performance Effects of Adhesive Bond Defects
- Design for Composite Wind Turbine Blade Manufacturing
- Self-Healing Materials for Wind Turbine Blades
- Development of a Unique Fiber-Optic Resin Cure Sensor
- Large Area Turbine Blade Inspection

Structural Health Monitoring, Non-Destructive Inspections, and Testing (B)
- Long Duration Testing of the Acoustic Blade Monitoring System
- Monitoring of Wind Turbine-Foundation and Technology Assessment System
- System integration of a Wind Turbine Blade Acoustic Monitoring System
- Intelligent Damage Detection from Wind Turbine Blades Using Acoustic Excitation
- Low Cost Optical Fiber Strain Sensor Interrogator for Wind Turbine Blades
- Low-Cost Wind Turbine Blade Structural Health Monitoring
- Diagnosis of Electrical Faults of Wind Turbine DFIGs

2020-2021 PROJECTS

- Developing a Multi-physical Computational Model for Predicting Process-Induced Residual Stress and Distortion In Fiber Reinforced Composites, Project ID: A1-20
- Structural Wind Blade Repair Optimization, Project ID: A3-20
- Cure Cycle Optimization of Low CTE Adhesives for Wind Turbine Blade Bondlines, Project ID: A4-20
- Development of a Next-Generation Low-power Acoustic Sensor for Wind Turbine Blade Structural Health Monitoring, Project ID: B1-20
- Data Driven Remaining Useful Lifetime Modelling of Inverters in Renewable Energy Applications, Project ID: B2-20
- Assessment and Improvement of Industry-standard Wind Farm Models based on Physics-informed Reduced Order Model, Project ID: C2-20
- Decision Support with OpenFAST Digital Twin - Case Studies Applied to IAB-owned Assets, Project ID: C3-20
- Fatigue Loading Effects and Power Fluctuations Due to Wake Steering Within A Wind Farm-A Wind Tunnel Study, Project ID: D1-20
- Design of UHPC Towers for Offshore Wind Turbine, Project ID: F1-20

Wind Farm Modeling and Measurement Campaign (C)
- Data-driven Reduced Order Model Based on LiDAR Measurements for Predictions of Wind-Farm Annual Energy Production
- Decision Support Using FAST Aero-elastic Models of Operating Wind Turbines
- Modeling of Power Losses due to Leading Edge Erosion
- Proactive Monitoring of Wind Farm Performance Through Wind LiDAR Data and a Reduced Order Model
- Uncertainty quantification of wind farm performance through high fidelity simulations and wind LiDAR measurements
- Proactive Detection of Under-Performing Wind Turbines Combining Numerical Models, LiDAR and SCADA Data

Control Systems for Turbines and Farms (D)
- Development of a Computational Tool to Maximize Wind Farm AEP by Yaw Angle Optimization
- Advanced Control System for Evaluation of on-Blade Load Mitigation Technologies
- NREL FAST Modeling for Blade Load Control with Plasma Actuators
- Evaluation of Nested Extremum Seeking Wind Farm Control with SWIFT Facility
- Extremum Seeking Control for Wind Turbine Power Maximization
- Two-layer Optimization for Maximizing Wind Farm, Power Output
- Wind Turbine Aerodynamics Modified Gurney Flaps
- Wind Turbine Characterization and Design of High-Efficiency DC Motors

Foundations and Towers (F)
- Wind Turbine Foundation Monitoring Sensor Development
- Mechanical Properties, Micro-structure Property Relationship and Manufacturing/Construction Methods for UHPFRC for Both the Foundation and Towers
- Wind Turbine Foundation Monitoring Sensor Development

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2020-2021 PROJECT HIGHLIGHTS

Developing a Multiphysical Computational Model for Predicting Process-Induced Residual Stress and Distortion in Fiber-Reinforced Composites

**Principal Investigators:**
Dong Qian, Hongbing Lu (University of Texas at Dallas)

**Student Researchers:**
Runyu Zhang, Yingjian Liu, Vijay Kulkarni (University of Texas at Dallas)

**IAB Mentors:**
Steve Nolet (TPI Composites)
Yi Ling "Ivan" Liang, Huifeng Qian (Olin)
Paul Ubrich, Nathan Bruno, Mirna Robles (Hexion)

Polymer matrix composites (PMC) such as glass fiber reinforced epoxy composites have dominated the manufacturing of wind turbine blades due to the combination of high strength/stiffness, low mass density, and ease of manufacturing. These blades including various structural components such as the spar cap are typically manufactured using vacuum-assisted resin infusion molding (VARIM). Residual stress and micro-distortion of fibers and fiber tow in spar cap may develop during the VARIM process. Defects occur more often on the thickest section of the spar cap component and at or near peak exotherm temperature. Such kind of manufacturing defect leads to reduced compressive strength and long-term cycle life. Residual stress/distortion can be alleviated by increasing cure time and lowering temperature; however, these will extend the manufacturing cycle. Replicating such a phenomenon in the lab is challenging. Understanding the mechanism and the effects of the process is the key for the blade manufacturing industry to reduce defective parts and increase productivity. In this project, a multiphysics computational approach has been established for predicting the process-induced residual stress and distortion in PMC spar caps. Detailed mechanisms of residual stress and micro-distortion of fibers and fiber tow in glass fiber composite were studied. Multiple VARIM experiments of different setups were performed in the lab and mechanical properties of the finished composite parts were characterized. Micro-distortion was observed in the VARIM process of thin composite plates with 3-ply glass fiber. Based on the simulation and experimental studies, it is concluded that the differential curing leads to the temperature gradient and provides the main mechanism of micro-distortion when combined with the high aspect ratio of the composite spar cap.

**Figure 1.** Experimental observations of buckling in a thin composite plate made by VARIM process.

**Figure 2.** Multiphysics model simulation results (Top: CAE model for a 3-ply composite with 7 points marked for temperature and curing monitoring. Bottom: Multiphysics simulation of micro-distortion/local buckling in 3-ply composite).
Damaged wind turbine blades are typically repaired on-site and up-tower, which can take several days to complete. The time-consuming repair process can be attributed to the complexity and difficulty in accessing the damaged sections, as well as the need to replace and cure the fiber-reinforced composite (FRC) materials used in state-of-the-art blade design. As repairs are performed on-site, environmental conditions such as the temperature and relative humidity can have an impact on the steps necessary to rehabilitate the blade, and ultimately on the final properties of the restored structure. Currently, there are no best practices to repair damaged blades effectively, and each repair varies with respect to environmental conditions as well as the unique geometry and FRC materials used in each repair. Insights on the effect of these parameters thus presents opportunities for repair optimization to reduce the turbine downtime. This work builds upon the material characterization of resin systems (infusion, hand lamination, bonding paste) commonly used in turbine blade repairs the computational tools developed in the previous years of this project.

Four tasks which coupled experimental and computational work were executed during this year’s project. Cure kinetics of a new Hexion cold temperature resin, which is suitable for processing at temperatures as low as 5°C, were characterized. Long-term absorption quantification of a composite substrate was performed to set a baseline for worst-case scenarios when evaluating the effect of moisture on adhesion of repairs to the existing blade structure. A larger and more complex lab-scale experiment designed to be representative of real-world repair geometries was performed, and validation of the computational tools developed in previous years and advanced in this year’s work was performed. The knowledge gleaned from these tasks has been studied and implemented in ongoing development of the on-site repair tool/application for on-demand cure cycle optimization. The app now features a preliminary graphical user interface (GUI) designed for ease-of-use by repair personnel, and work continues on migration to an open-source platform more mobile device usage. This work continues to address and contribute to providing insight into factors which influence every repair, including environmental conditions, extent of the damaged area, and material systems used in state-of-the-art blade rehabilitation efforts. Ultimately, an understanding of these critical parameters offers a way to analyze and optimize each repair in a way that has never been done before. Through computation and experiment, the potential of extended repair season and thus cost savings for owners and operators is possible.
2020-2021 PROJECT HIGHLIGHTS

Development of a Next-Generation Low-power Acoustic Sensor for Wind Turbine Blade Structural Health Monitoring

Principal Investigator:
Murat Inalpolat (University of Massachusetts Lowell)

Co-Principal Investigators:
Christopher Niezrecki, Yan Luo (University of Massachusetts Lowell)

Student Researchers:
Caleb Traylor, Fei Zhou (University of Massachusetts Lowell)

IAB Mentors:
Adam Johns (EDP Renewables)
Ben Rice (Pattern Energy)
Ron Grife (Leeward Renewable Energy)
Lothar Breuss (Bachmann Electronic Corp)

High operational loads cause significant bending and shear and thus are detrimental to wind turbine blades. Currently available condition monitoring systems are not capable of detecting different types and severity levels of damage and defects such as leading and trailing edge splits, holes and cracks. A comprehensive damage detection system that can monitor the blades for leading and trailing edge splits, delaminations, cracks and holes is currently not available. Consequently, it is vital to provide a low cost yet highly capable condition monitoring solution that will reduce the need for unscheduled maintenance. Deployment of a previously developed wind turbine blade acoustic monitoring system requires complete understanding and mitigation of the mechanical, electrical and structural problems associated with the installation and operation of the system. This project is on further development of a blade damage detection and monitoring system. The project team will continue the efforts from our previous project, which has successfully shown the feasibility of the proposed technique in the laboratory environment as well as in the field (at the WTTC). This year’s project entails integration of this novel acoustic monitoring system on a full scale operational turbine blade and mitigating the potential problems with the system and the blade interface. After the aforementioned tests, the team has focused on improving the sensor design and will deploy the new sensor on a full-scale wind turbine in a wind farm under the next project cycle. The final report will highlights the sensor development related research activities. Lessons learned will be leveraged in order to improve the current system design and its integration. The team will focus on the field tests on a full-scale turbine as well as improving and implementing the developed signal processing and machine learning algorithms to enable this technology in the near future.

Figure 1. Acoustic sensing node circuitry.

Figure 2. A close-up view of the blade-internal acoustic sensor (microphone) from a lab test.

Blade internal microphone

PROJECT ID: B1-20

RECENT CENTER EVENTS

Webinar Series:
» Data-driven Wind Farm Modeling Based on Wind LiDAR Measurements, Giacomo Valerio Iungo, March 24, 2021
» Current Status and Future Directions in Wind Farm Modeling, Stefano Leonardi, November 4, 2020
» Control of Wind Energy Systems, Mario Rotea, June 19, 2020

IAB Meetings:
» University of Massachusetts Lowell (Virtual), June 16-17, 2021
» University of Texas at Dallas (Virtual), February 3-4, 2021

Invited Keynote Speakers for Center Banquets:
**2020-2021 PROJECT HIGHLIGHTS**

**Data Driven Remaining Useful Lifetime Modeling of Inverters in Renewable Energy Applications**

**Principal Investigator:**
Bilal Akin (University of Texas at Dallas)

**Student Researchers:**
Shi Pu, Saurabh Kumar (University of Texas at Dallas)

**IAB Mentors:**
Adam Johs, Aditya Krishna (EDP Renewables)

The world is adding wind/solar energy capacity at a rapid pace as the serious consequences of climate change are becoming increasingly obvious. Given the remoteness of most wind and solar farms, reliable and predictable operation of wind turbines is very critical. For this purpose, we propose remaining useful lifetime (RUL) estimation for power converters used in wind turbines and solar systems simply by processing Scada data.

In power converters, the power modules including IGBTs / PowerFETs are one of the most fault prone components. To prevent unexpected system down-time, several switch health monitoring and early warning techniques have been proposed in literature. Most of the techniques require access to internal converter hardware. However, wind EPCs and operators may not have low level access to the power converters. Therefore, it is important to develop system level converter health monitoring and RUL techniques that minimize the need for low-level hardware access. The proposed technology can potentially be leveraged by EPCs and operators to reduce O&M costs and provide value-added-services. The equipment agnostic nature of proposed methods allows supplier optimization without compromising on monitoring features.

Moreover, the decoupling of power conversion and inverter health monitoring functions allows independent, incremental and scalable testing of next-gen smart monitoring features without them being subject to the typically long design cycles of power inverters.

High level schematic of the proposed large-scale DC power cycling test bench.

GUI of developed toolbox when analyzing process is finished.
There is an increasing awareness in the wind energy industry that pressure-induced effects due to the interaction between wind turbine rotors and the incoming atmospheric boundary layer (ABL), such as blockage and speedups, have a significant impact on the performance of the wind turbines and annual energy production (AEP) of the entire wind power plant. These phenomena, which have been long disregarded by wind farm modelers, require new modeling paradigms based on high-quality experimental data to characterize robustly the relatively subtle effects of the pressure field, yet leading to significant effects on power capture. This project aims at investigating experimentally the impact on the wind resource of a wind farm induction field. To this aim, an field LiDAR campaign has been carried out at an onshore wind farm before and after the commissioning of a multi-MW project. In a first phase of the project, the pre-construction wind data collected by five profiling LiDARs are analyzed to identify possible flow heterogeneity induced by the site topography or the local micro-climatology as a function of wind direction, wind speed, and atmospheric stability conditions. In a second phase, the accuracy of the various remote sensing instruments is quantified through simultaneous and co-located measurements. Finally, the wind resource is investigated again after the construction of the wind power plant, also including the use of a scanning Doppler wind LiDAR. For the latter, the measurement scans are optimally designed through the LiSBOA procedure. The blockage and speedups observed in the preliminary results are a valuable source of information for the development and calibration of a reduced-order wind farm model.
Accurate numerical tools for both design and asset management are one of the key needs for achieving and maintaining a market-competitive levelized cost of energy (LCOE) throughout the lifetime of the turbine. The C3-20 project addresses this need by developing and evaluating a new approach for creating an aero-servo-elastic digital twin model. The overall aim of this project is to deliver wind turbine aero-elastic models for existing turbines to support decision-making in wind farm operations. Maximizing the revenue of an operating wind fleet requires making decisions involving power performance, component maintenance costs, and selection of performance upgrades. In the developed technique, experimental data from an operating wind turbine is used to calibrate the properties of a baseline turbine model to represent the loads and dynamic behavior of the target wind turbine of interest. A key focus in the current study for the C3-20 project has been how to accomplish an accurate digital twin model for the case of having limited experimental data sets or limited turbine specifications. The digital twin model was created as an OpenFAST (FAST) model and the turbine’s controller was created in Simulink and tuned to maintain the desired operating properties of the digital twin. In addition, a study was performed to gain further confidence in the model accuracy by analyzing the sensitivity of the model response (e.g.; sensitivity of blade deflections or tower loads) to changes in the calibrated model input parameters.
Fatigue Loading Effects And Power Fluctuations Due To Wake Steering Within A Wind Farm-A Wind Tunnel Study

Principal Investigator:
Yaqing Jin (University of Texas at Dallas)

Co-Principal Investigator:
Mario Rotea (University of Texas at Dallas)

Student Researchers:
Emmanuvel Joseph Aju, Devesh Kumar (University of Texas at Dallas)

IAB Mentors:
Neal Fine (Arctura)
Ben Rice (Pattern Energy)
Brandon Fitchett (EPRI)
Adam Johs (EDP Renewables)

Wake steering has proven to be effective for increasing the power output of a wind farm. However, practical control strategies for turbine yaw angles and induced fatigue loading effects remain less understood. In this work, systematic wind tunnel experiments were conducted to characterize the wake dynamics, power outputs and wind loading of turbines within a wind farm under wake steering. Model wind turbines with yaw control capability and power coefficients similar to utility-scale turbines were fabricated and tested in the Boundary Layer and Subsonic Tunnel at UT Dallas. High-resolution force load and time-resolved particle image velocimetry system were applied to measure the variation of wind loads and wake flows across time. Our measurements show that, with the growth of turbine yaw angles in the front row, the wake flows can be significantly deflected and therefore increase the effective incoming flow velocity impinging the downstream turbines. For a wind farm with aligned turbine layout and five times rotor diameter distance in streamwise direction, the maximum wind farm power output is achieved with the first row yawing at 30° and second row at 20° in the same direction. This results in ~8.5% power output growth compared to the baseline case (without wake steering). Comparatively, the impact of wake steering control on staggered wind farm is less distinctive with maximum of ~2.5% power increase. Measurements on the instantaneous wind loading of turbines in the first row reveal that the growth of yaw angle increases the fatigue loading in the side-force direction across all frequency components. A state-of-the-art Log-of-Power Extremum Seeking Control (LP-ESC) is also implemented in this project to determine optimal yaw angles from power measurements autonomously. LP-ESC is applied to most upstream turbines only to maximize the power of properly defined clusters of turbines. The experimental results show that LP-ESC matches the measurements from power output static maps for both aligned and staggered layouts; thus, optimizing wind farm power output in real-time with no models.

![Figure 1: Wake steering control for maximizing the power output of wind farms. a) Variation of turbine yaw angles under LP-ESC; b) Instantaneous wind farm power output under LP-ESC; c) Photograph of model wind farm; d-e) Static map of power output with aligned and staggered turbine layouts; LP-ESC on first row only in agreement with optimum from static map (marked with a star in figure 1d).](image-url)

![Figure 2: Fatigue loading and wake dynamics of turbines under wake steering. a-c) Spectrum of thrust load, side-force and yaw torque across yaw angles for turbine located in the first row; d) and e) are time-averaged streamwise wake velocities for turbine located in first row under no misalignment and yaw angle at 30°.](image-url)
Ultra-High Performance Concrete (UHPC) is a relatively new construction material that is mainly composed of high-performance concrete and fiber materials. The combination of higher binder and fiber dosage with low water to binder ratio provides UHPC with exceptional mechanical properties such as high strength, energy absorption capability, strong resistance to a corrosive environment, and excellent durability. While these outstanding properties make UHPC an ideal structural material for offshore applications, studies on the potential benefit of developing offshore UHPC wind towers remain elusive. In this project, a combined experimental/modeling approach has been established to study the application of UHPC for offshore wind tower applications. The experimental work focused on key material properties such as stiffness, compressive strength, flexural strengths, fatigue endurance limit, water absorption, and resistance to crack imitation and propagation. To mimic the effects of offshore environment, UHPC samples have been immersed in saline solution after cast and measured properties are compared to the ones that have not been treated with saltwater. The bulk density of 3% steel fiber volume fraction UHPC is 2,405 kg/m³. The permeability test results show that water absorption of 3% steel fiber volume fraction UHPC is 0.45%, while the volume of permeable voids of UHPC is 1.2%. The 28-day cured UHPC has a compressive strength of 159 MPa with a modulus of elasticity of 36 GPa, and Poisson’s ratio of 0.22. Three-point bending testing results indicate that the average flexural strength of 3% steel fiber volume fraction UHPC is 35 MPa. Fatigue experiments provide fatigue endurance limit of UHPC of around 70% of flexural strength. Based on the experimental results, modeling work focused on the design analysis of a 15MW offshore UHPC wind tower. Using finite element (FEM) analysis, initial design parameters were obtained by considering static, dynamic loading conditions and fatigue. The initial design was further optimized to reduce material consumption. The optimized design was then evaluated in terms of the total cost based on the material consumption. Comparisons were made to the conventional concrete and all-steel offshore towers and UHPC design provided significant cost savings. Aside from the economic benefit, the dimensions of the UHPC tower were comparable to those for the steel tower due to its excellent mechanical properties. Construction solutions were recommended based on the optimized dimension.
Products:

1. Software: Multiphysical computational model for predicting process-induced residual stress and distortion in fiber-reinforced composites
2. Software: FAST Model V1.0: Aero-elastic Model
4. Software: A user-based subroutine written in Fortran for use in the finite-element software Abaqus, to calculate the degree of cure and temperature of an adhesive under exothermic curing reaction.
5. Software: A tool to simulate blade active load control systems using NREL FAST and any actuation system (plasma actuators in particular) that can command changes in the local lift coefficient along the blade span.
6. Software: A Matlab-based GUI that can predict the axial, transverse, and shear properties of composite laminates used in wind turbine blades based on CPM advanced micromechanics model
8. Software: Simulink code forExtremum Seeking Control of NREL CART3 (Controls Advanced Research Turbine, 3-bladed).
9. Hardware: Fiber Optic Interrogator for Strain Monitoring
11. Hardware: Active Acoustic Damage Detection System for Blades

Journal Papers:


Conference Papers:


Selected Presentations:


PhD Dissertations:

1. Stefano Letizia, "Wind farm flow and power capture: optimal design of LiDAR experiments, flow physics, and mid-fidelity modeling," Ph.D. in Mechanical Engineering, University of Texas at Dallas, November 11, 2019.
4. Lu Zhan, "LiDAR measurements for the characterization of wind turbine wakes, wake interactions and their effects on wind farm performance," Ph.D. in Mechanical Engineering, University of Texas at Dallas, December 2019. Now Postdoc at University of Minnesota.

Interns at Member Companies:

1. Stefano Letizia, recipient of WindSTAR NSF INTERN at UT Dallas, Intern at EDP Renewables.
2. Alessandro Cassano, recipient of WindSTAR NSF INTERN at UMass Lowell, Intern at TPI Composites.

Students Hired at Member Companies:

1. Liliana Haus, MS, University of Texas at Dallas, EPRI
2. Sara Najafian, PhD, University of Massachusetts Lowell, TPI Composites

ACTIVE PROJECTS: 2021-2022

» Structural Wind Blade Repair Optimization
Project ID: A1-21
Pl: Marianna Maiaru (University Of Massachusetts Lowell)
Mentors: Olin Epoxy, Hexion

» Long-Term Environmental Durability of Adhesive Joints
Project ID: A3-21
Pl: Amir Ameli (University of Massachusetts Lowell)
Mentors: TPI Composites, Hexion, Olin Epoxy

» Cure Cycle Optimization of Low CTE Adhesives for Wind Turbine Blade Bondlines
Project ID: A4-20
Pl: Scott Stapleton (University of Massachusetts Lowell)
Mentors: Hexion, TPI Composites, Olin Epoxy

» Design of VARIM Process Based On A Digital Twin Approach
Project ID: A4-21
Pl: Don Qian (University of Texas at Dallas)
Mentors: Hexion, TPI Composites, Olin Epoxy

» Analysis/Interpretation of Data Collected Using Robust Acoustic Blade Monitoring Sensors
Project ID: B1-21
Pl: Murat Inalpolat (University of Massachusetts Lowell)
Mentors: EDP Renewables, Bachmann, Pattern Energy Group, WindEsco

» Decision Support OpenFAST Digital Twin-Component Loads and Control System Extensions
Project ID: B4-21
Pl: Todd Griffith (University of Texas at Dallas)
Mentors: Bachmann, Arctura, EDP Renewables, EPRI, WindEsco

» Observations, Characterization and Modeling of Blockage for Utility-scale Wind Farms
Project ID: C1-21
Pl: Giacomo Valerio Jungo (University of Texas at Dallas)
Mentors: Arctura, EPRI, Bachmann, GE Renewables, Pattern Energy Group

» Determining Best Practices for YAW Control In Real Window Farms
Project ID: D1-21
Pl: Stephano Leonardi (University of Texas at Dallas)
Mentors: Arctura, Bachmann, EPRI, WindEsco, GE Renewables

» Wake Steering Control On Complex Terrain Under Time-varying Flow
Project ID: D2-21
Pl: Yaying Jin (University of Texas at Dallas)
Mentors: Arctura, Bachmann, EDP Renewables, GE Renewables, Shell, WindEsco

» Co-located Wind Farm and Hydrogen Plant Energy System Study
Project ID: E1-21
Pl: Jie Zhang (University of Texas at Dallas)
Mentors: Arctura, EDP Renewables, Shell

» Assessment of Wind Turbines’ Structural Dynamic and Foundation Integrity Using Optical Motion Amplification
Project ID: F1-21
Pl: Alessandro Sabato (University of Massachusetts Lowell)
Mentors: EDP Renewables, Leeward Energy