WindSTAR

Wind-Energy Science, Technology, and Research
Industry/University Cooperative Research Center

2025 ANNUAL REPORT

UMass Lowell ✦ UT Dallas

MESSAGE FROM OUR CENTER DIRECTORS

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 sixth year as a Phase II Center having completed dozens of projects, published numerous papers, had multiple M.S. and Ph.D. students graduate, several hired by member companies and national labs. Software and hardware systems are in use by the WindSTAR company members and the WindSTAR Webinar Series continues to disseminate important information. In 2025, for every dollar that came from a Full IAB member, ~17 dollars was invested in the Center from another source. For small business IAB members, the leveraging was approximately 46:1. Without operating through the National Science Foundation's I/UCRC program, this level of commitment and value to industry would not be possible.

Center Director
Christopher Niezrecki, Ph.D.
University of Massachusetts Lowell

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 twelfth year of operation (Phase III), we will continue to grow the Center, strengthen existing collaborations, and increase awareness of WindSTAR within the wind and the hybrid power generation industries.

Site Director
Mario Rotea, Ph.D.
University of Texas at Dallas

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 and hybrid power will be a strong player in improving the resilience of the Nation's electricity portfolio and enable new applications of this 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, Department of Mechanical Engineering
Co-Director, RIST Institute for Sustainability and Energy
Co-Director, Structural Dynamics and Acoustics Systems Laboratory
Director, Center for Energy Innovation
Director, WindSTAR I/UCRC
University of Massachusetts Lowell

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

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A NATIONAL SCIENCE FOUNDATION SUPPORTED INDUSTRY-UNIVERSITY COLLABORATION DRIVING DOWN THE COST OF WIND POWER

MISSION STATEMENT

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.

IAB MEMBER COMPANIES

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.

2025 IAB Chair
Phil Gauthier
Sr. Mgr., Innovation and Technology Commercialization, EDF power solutions North America (EDps)

2025-2026 IAB Vice Chair
Chris Ludlow
Chief Growth Officer
Mide Technology - A Hutchinson Company

2024-2025 IAB Chair
Lauren Magin
Innovation Program Manager
Avangrid Renewables

2024-2025 IAB Vice Chair
Phil Gauthier
Sr. Mgr., Innovation and Technology Commercialization, EDF power solutions North America (EDFps)

Past IAB Chairs:
2023-2024: Ti Ling (Ivan) Liang, Olin Epoxy
2022-2023: Brandon Fitchett, EPRI
2021-2022: Brian Hill, Bachmann Electronic Corp
2020-2021: Nathan Bruno, Westlake Epoxy
2019-2020: Neal Fine, Arctura
2018-2019: Nicholas Althoff, GE Renewable Energy
2017-2018: Ben Rice, Pattern Energy
2016-2017: Steve Johnson, GE Renewable Energy
2015-2016: Justin Johnson, EDP Renewables
2014-2015: Steve Nolet, TPI Composites, Inc

Previous Members include:
EDP Renewables, Electric Power Research Institute, Huntsman, Keuka Energy, LM Wind Power, Maine Composites Alliance, National Instruments, NRG Renew, Olin Epoxy, Shell, Texas Wind Tower, WindESCo, Windscape AI

FINANCIAL OVERVIEW: RETURN ON INVESTMENT

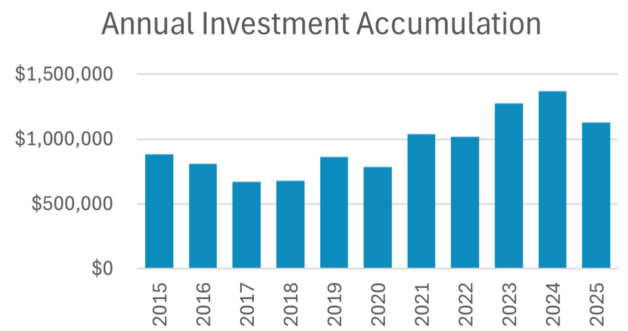
MEMBERSHIP LEVELS 2024-2025

Full Membership
$47,641 Annually

Small Business Associate
$17,865 Annually

CUMULATIVE INVESTMENT

TOTAL INVESTMENT: $9,979,292



NSF Awards
$2,138,614
(NSF Awards # 1916715, 1916776, 1362022, 1362033)

IAB Contributions
$5,383,233

University Contribution (Cost Share)
$2,457,446

In-Kind
$527,508

THRUST AREAS (PROJECT COUNTS ARE CUMULATIVE)

- (A) Composites and Blade Manufacturing - 37 Projects
- (B) Structural Health Monitoring, Non-Destructive Inspections, and Testing - 23 Projects
- (C) Wind Farm Modeling and Measurement Campaign - 14 Projects
- (D) Control Systems for Turbines and Farms - 5 projects
- (E) Energy Storage and Grid Intergration - 1 Project
- (F) Foundations and Towers - 3 Projects

2024-2025 PROJECTS

- Investigation of Riblet Surface Durability and its Impact on Wind Farm Performance
  Project ID: A1-24
- Integration of Machine-Learning Based Approach for Curing Cycle Process Optimization of Vacuum Assisted Resin Infusion Process (VARIM)
  Project ID: A2-24
- Structural Wind Blade Repair Optimization
  Project ID: A3-24
- Recycling Epoxy Composites through Vitrimerization
  Project ID: A4-24
- Internal and External Inspection of Wind Turbine Blades Using Computer Vision and Artificial Intelligence achine Learning-enabled Condition Monitoring of Wind Turbines Using High-Resolution Voltage and Current Signals
  Project ID: B1-24
- Advancing Condition Monitoring and Predictive Maintenance for Turbine Electrical Components: A Digital Twin Framework Approach
  Project ID: B2-24
- Benchmarking of Commercially Available Acoustic Blade Monitoring Systems through Field Testing
  Project ID: B3-24
- Condition Monitoring of Wind Turbine Foundations Using Accelerometers and Generative AI
  Project ID: B4-24
- Local Sensor Energy Harvesting to Monitor Blade Structural Health
  Project ID: B5-24
- Multiscale Data-driven Modeling of Neighboring Wind Farms
  Project ID: C1-24
- Repowering of Wind Farms with Digital Health Audits of Turbine Components
  Project ID: F1-24

For a cumulative list of all center projects 2014-2026, visit uml.edu/WindSTAR

Investigation of Riblet Surface Durability and its Impact on Wind Farm Performance

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

Co-Principal Investigators:
Stefano Leonardi, Mario Rotea
(University of Texas at Dallas)

Student Researchers:
Nir Saar Maor, Miguel Andres Guzman Hernandez, Pengyao Gong, Emmanuel Aju (University of Texas at Dallas)

IAB Mentors:
Takashi Yuito, Shintaro Tsuchihashi, Takaya Higashino (Nikon)

Enhancing energy production while reducing turbine loads is essential for lowering the Levelized Cost of Energy (LCOE) in wind turbines. In our previous project, we demonstrated that riblet treatments applied to blade surfaces can effectively enhance aerodynamic performance. Numerical simulations further indicated that riblets can contribute positively to a turbine's annual energy production. Nevertheless, long-term exposure to real environmental conditions can lead to surface degradation, and the durability of riblet treatments under harsh operating environments remains poorly understood. In addition, the influence of riblet-treated blades on power output at the wind-farm scale has yet to be fully explored. In this project, leveraging the new experimental platform, sand particle blaster channel, we investigated the durability of riblet films impinged by air-sand two phase flows. The impact of riblet on wind farm performance was assessed via both wind tunnel measurement with multiple G06 turbines and numerical simulation with a cluster of 5MW wind turbines. The results underscored that due to the inertia of sand/dust particles, their impingement on wind turbine blades concentrate on the leading-edge region across various angle of attacks. This mitigates the erosion on riblet films which are not directly located on the blade leading edge. The investigation with riblet films attached to G06 model turbines in wind tunnel experiments highlights the effectiveness of riblet blade treatment in both single-turbine and two-turbine systems. For a single turbine, the optimal power enhancement reaches 4.1%. For two-turbine system, the downstream turbine with riblet treatment has maximum power enhancement of 5.8% with upstream turbine yaw angle of -10 degrees. Results from the numerical simulation indicate that riblet blade treatment can enhance the power output of an entire wind farm by 6.7% despite the slightly lower incoming flow impinging on the second and third row turbines.

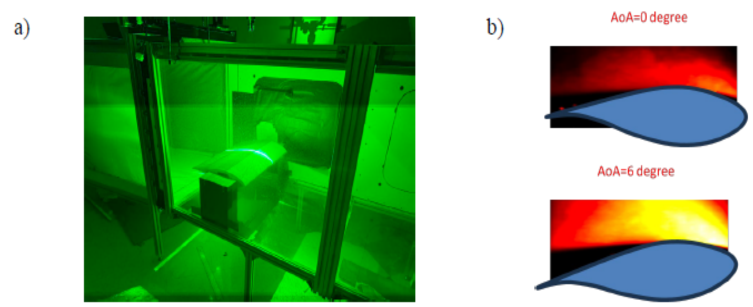


Figure 1. a) Photograph of riblet films exposed in air-sand mixing flows in the testing channel; b) Probability density function of particle distributions over the blade surface.

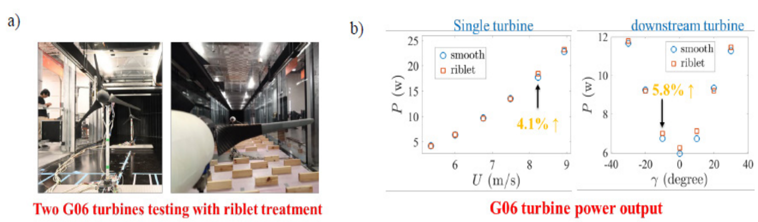


Figure 2. a) Photograph of G06 turbines with riblet blade treatment in wind tunnel test; b) Power output of upstream and downstream G06 turbines with/without riblet blade treatment.

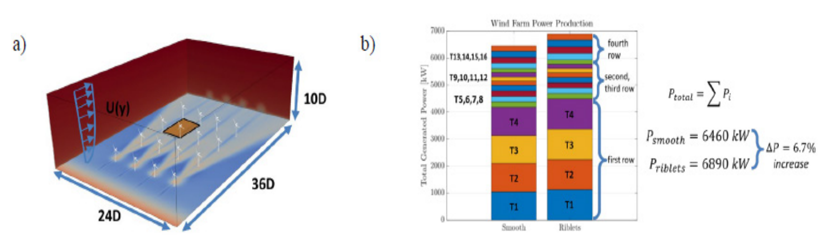


Figure 3. a) Schematic of turbine layout and simulation volume; b) summation of power output from each row and the power enhancement across the entire wind farm.

PROJECT ID: A1-24

Integration of Machine-Learning Based Approach for Curing Cycle Process Optimization of Vacuum Assisted Resin Infusion Process (VARIM)

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

Student Researchers:
Ehsan Mehrdad, Niloufar Adab, Sahil Kamath
(University of Texas at Dallas)

IAB Mentors:
Stephen Nolet, Shaghayegh Rezazadeh, Joseph Wilson,
Amir Salimi (TPI Composites)
Xu Chen (GE Vernova)

Composites are widely manufactured using the Vacuum-Assisted Resin Infusion Molding (VARIM) process, which has become one of the most popular techniques for producing large and complex composite parts. In this process, dry fiber lay-ups along with core structures are first arranged on a heated table. A vacuum is applied, and resin is infused through the fiber network. The resin then cures under heat through an autocatalytic polymerization reaction, gradually transforming into a solid matrix that binds the fibers together. The quality of the final part strongly depends on how uniformly and effectively this curing process takes place.

One of the primary challenges in VARIM manufacturing is the presence of complex geometries within the parts. These arise from the varying thicknesses of the core materials and the number of fiber plies laid up in different regions. As a result, the thermal conductivity and heat transfer rates differ across the part. These variations in thermal properties directly affect the local curing rates of the resin. Some areas may cure faster, which creates non-uniformities in the crosslinking process. Such non-uniform curing often results in subpar mechanical performance, residual stresses, and defects such as voids, incomplete cure, or delamination. These issues make it difficult to consistently achieve high-quality components, especially for critical applications in aerospace, automotive, and renewable energy sectors.

To address these challenges, industries have been moving toward multizone heating systems. In such systems, the composite is divided into multiple independently controlled heating zones, allowing temperature tailoring across the part. By carefully adjusting the heating profile in each zone, manufacturers can, in principle, achieve uniform curing throughout the structure. However, the complexity quickly escalates when dealing with very large components such as wind turbine blades, which may involve hundreds of controllable heating zones. Iterating manually through all possible heating strategies to identify an optimal curing profile is practically infeasible, both due to time constraints and the sheer size of the design space.

In this study, we propose a gradient-free optimization framework that incorporates a machine learning (ML) model acting as a digital twin of the curing process. This digital twin learns the relationship between heating inputs, material responses, and cure evolution. By embedding this model within the optimization loop, the framework can efficiently explore the large search space of possible heating profiles without relying on gradient information. The approach intelligently narrows down combinations and produces an optimized multizone curing profile tailored for each region of the part. The result is a significant reduction in overall curing cycle time while ensuring consistent resin polymerization and improved part quality, making the method highly promising for industrial-scale composite manufacturing.

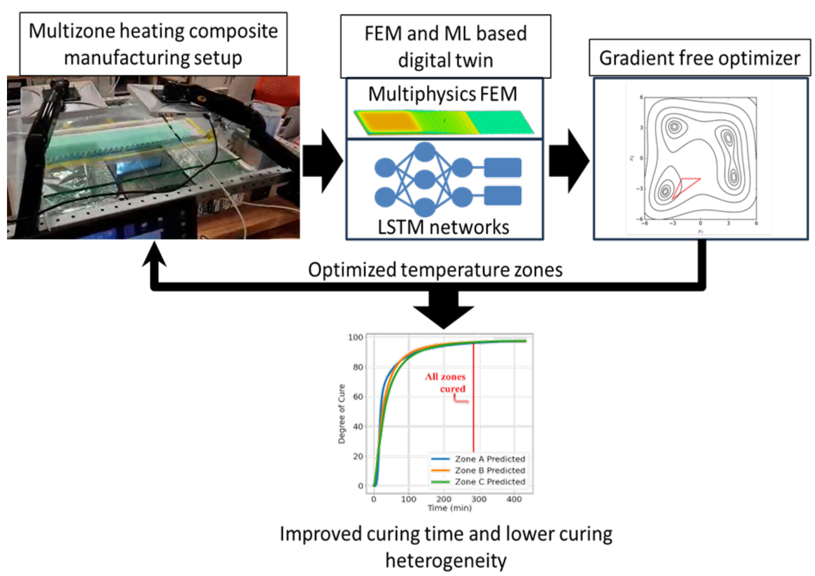


Figure 1. Project Overview

PROJECT ID: A2-24

Recycling Epoxy Composites through Vitrimerization

Principal Investigators:
Amir Ameli, James Reuther
(University of Massachusetts Lowell)

Student Researchers:
Shayesteh Aghamohammadi, Sophie Harris
(University of Massachusetts Lowell)

IAB Mentors:
Steve Nolet (TPI Composites)
Lauren Magin (Avangrid)
Nathan Bruno (Westlake Epoxy)

Wind energy is one of the largest industrial sectors that uses glass fiber/epoxy composites, primarily in wind turbine blades (WTB). The WTB is an ever-growing market expected to reach US$ 28.3 Billion by 2028. Over 95 wt.% of WTB is polymer composites, mostly glass fiber/epoxy. Currently, the majority of WTBs end up in landfills or are incinerated . To date, the recycling efforts of glass fiber/polymer composites have been limited to mechanical, chemical, and pyrolysis. These approaches are hindered in their viability and sustainability, primarily due to the use of energy-intensive processes as well as the inferior performance of the recyclates. Recently, scientists have demonstrated that vitrimerization of epoxies using mechanocatalysis routes provides a promising re-processing approach . During the vitrimerization process, the cross-linked, pre-existing thermoset epoxy resin is mixed in stoichiometric ratios with a catalyst to facilitate a bond exchange, allowing for additional reprocessing of end-of-life materials. However, the feasibility and applicability of this approach for polymer composites, specifically glass fiber-reinforced epoxies, has had limited studies.

To date, we have investigated the effectiveness of mechanocatalysis of an amine cured epoxy resin, finding that a ball milling process of 2 hours using 5% $ZnCl_2$ as a catalyst to be somewhat effective. Other parameters that have been tested and refined are catalyst weight percentage (relative to the epoxy powder), speed, and time of the ball milling process. New parameters are still being evaluated, such as milling media size or the introduction of liquid assisted grinding (LAG). Another new parameter is curing the epoxy in-house by mixing the EPIKOTE-035c resin system with the curing agent EPIKURE-037 in a double barrel mixing nozzle. This hardened resin is ground up into a powder to be used as a new variable in the ball milling conditions. If the right set of conditions is found to reprocess this into a vitrimer, then the new material can be reprocessed multiple times using twin screw extruder (micro-compounder) and compression mold, in which the material undergoes a high shear and temperature condition which enables the vitrimerization and reshaping process.

Fourier transform infrared (FTIR) spectroscopy, differential scanning calorimetry (DSC) and thermogravimetric analyses (TGA) have been conducted on the processed materials. With further trails and success on the vitrimerization, additional testing and characterizations will include elemental analysis using spectroscopy, cross-linking density evaluation of vitrimers using rubber elasticity theory, stress relaxation analysis using parallel plate shear rheometry, viscoelastic behavior using capillary or oscillatory rheometry, thermal analysis using DSC and TGA and mechanical performance using tensile, compression, flexural and/or hardness testing. Figure 1 provides an overview of the project.

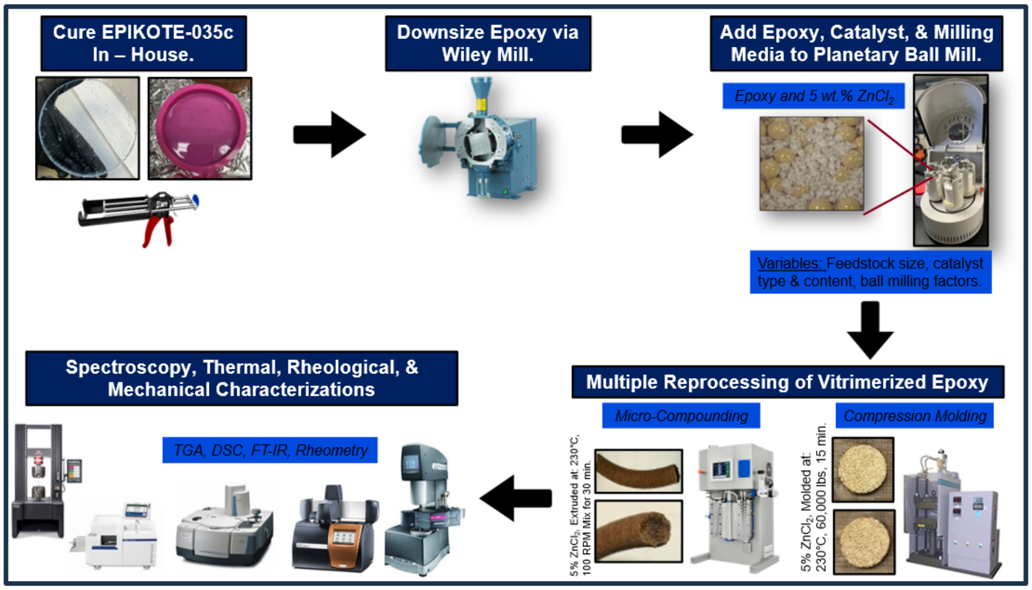


Figure 1. Project Overview

PROJECT ID: A5-24

Internal and External Inspection of Wind Turbine Blades Using Computer Vision and Artificial Intelligence

Principal Investigator:
Alessandro Sabato (University of Massachusetts Lowell)

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

Student Researchers:
Fabio Bottalico, Jabbar Shah Syed
(University of Massachusetts Lowell)

IAB Mentors:
Mike Purcell (Leeward Energy)
Joshua Morris (GE Vernova)
Bin Jou (FM Global)
Traci Pashley (Pattern Energy)
Carly Lavender (Massachusetts Clean Energy Center)

This project investigated the application of computer vision (CV) and artificial intelligence (AI) for external wind turbine blade (WTB) inspection, with the goal of developing scalable, automated methods that reduce costs, improve reliability, and enhance operational safety. Traditional inspection practices rely on rope-access technicians and turbine shutdowns, making them costly, hazardous, and disruptive to energy production. To address these limitations, the study evaluated the performance of multi-image Stack-Average (SA) super-resolution for enhancing UAV-acquired imagery and YOLO-based object detection models for defect identification and classification.

Experiments conducted at the Wind Technology Testing Center (WTTC) with artificial cracks on a utility-scale blade demonstrated that SA consistently enhanced image sharpness and reduced noise compared to single-frame and interpolation-based methods. Quantitative evaluation using the crack-to-region ratio (CRR) confirmed that SA preserved defect fidelity across increasing distances, with cracks remaining visible up to ~80 m where conventional methods failed. Additional tests on blade sections containing cracks as wide as 2 mm further validated these findings under real-world conditions, showing that SA effectively compensated for UAV motion and reconstructed fine-scale damage features at distances relevant to industrial practice.

The AI component complemented these imaging advances by automating defect detection. A baseline YOLOv8 model achieved an accuracy of 77.4% mAP@50 when trained on a curated dataset containing cracks, lightning damage, erosion, and surface dust. To improve robustness in noisy or complex conditions, attention mechanisms were integrated into YOLOv8. Among the tested variants, the Efficient Multi-Scale Attention (EMA) model delivered the best performance at 93.95% mAP@50, demonstrating superior ability to capture both fine and large-scale defect features. Multi-class detection tests confirmed that enhanced YOLO models could accurately identify and localize multiple categories of defects on full-blade imagery. Furthermore, a mixture-of-detectors approach—in which specialized models were trained for individual defect types—improved precision and reduced false positives, particularly for rare classes such as lightning strikes.

Taken together, the results confirm that combining CV-based super-resolution with AI-based object detection provides a robust and scalable framework for WTB inspection. The demonstrated improvements in image clarity and automated detection accuracy highlight the potential of this approach to replace hazardous, labor-intensive practices with efficient UAV-enabled inspection pipelines, ultimately contributing to safer, more reliable, and cost-effective wind energy operations.

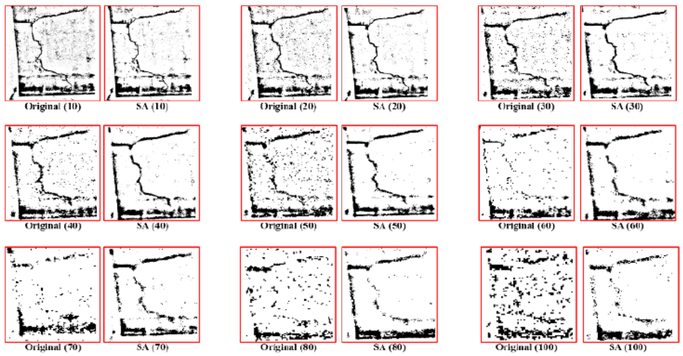


Figure 1. Example of image enhancement with the SA method, enabling crack identification at distances greater than 50 m

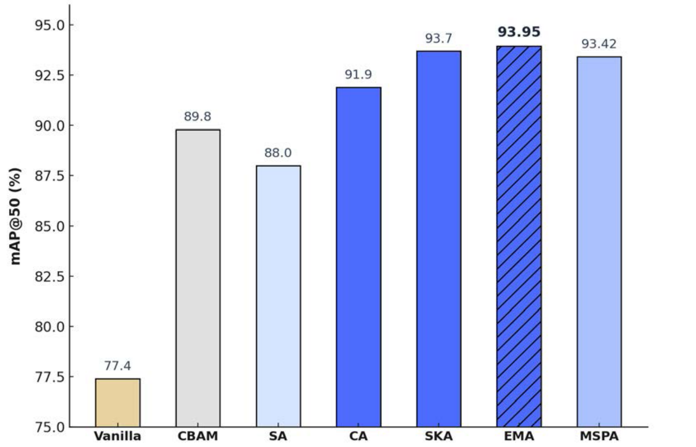


Figure 2. Performance of YOLOv8 with attention mechanisms

PROJECT ID: B1-24

Advancing Condition Monitoring and Predictive Maintenance for Turbine Electrical Components: A Digital Twin Framework Approach

Principal Investigator:
Jie Zhang (University of Texas at Dallas)

Student Researchers:
Jingyi Yan, Fazlur Rahman Bin Karim, Nanhong Liu
(University of Texas at Dallas)

IAB Mentors:
Phillip Gauthier (EDFps)
Hariram Arni, Bin Jou (FM Global)
Lauren Magin, Alex Encinas (Avangrid)

Unplanned maintenance costs for wind turbines (WTs) exceed 8 billion dollars globally every year. Ensuring the reliable operation of wind turbine components is essential for sustaining our energy supply. Therefore, continuous monitoring of the health of these components is paramount. During FY24, we extended our FY23 WindSTAR project, focusing on condition monitoring and health assessment of wind turbine electrical components, particularly WT generators. Specifically, we collaborated with Industrial Advisory Board (IAB) mentors, FM Global and EDFps, to validate the proposed method through experimental testing. We furthermore developed a software prototype with a user interface for WT components condition monitoring.

Leveraging high-resolution sensors and fast Fourier transform (FFT), fault-related frequency features can be extracted to inform data-driven models for effective fault detection. We developed a non-intrusive cascading FFT-informed machine learning (FIML) framework for detecting both electrical and mechanical faults in induction machines. All results are based on experimental datasets from FM Global Research. Three machine learning (ML) algorithms are studied to verify the proposed FIML framework: long short-term memory (LSTM), gated recurrent unit (GRU), and two-dimensional convolutional neural networks (2D CNN). Initially, the ML models perform four-class classification (three fault conditions and one healthy condition). Incorporating the selected FFT components as input improves testing accuracy from below 60% for all ML models to over 96% for the LSTM on previously unseen experimental data. Furthermore, implementing the cascading workflow with the GRU algorithm further enhances accuracy to 98.12%.

In another part of this project, supervisory control and data acquisition (SCADA) low-resolution electrical time-series signals from real-world WT generators are utilized to detect incipient faults and abnormalities at their early stages through health index (HI) values derived from multi-temporal sequence analysis. An LSTM-based autoencoder (LSTM-AE) framework is developed and validated using real-world SCADA datasets. The framework effectively identifies early-stage anomalies by detecting elevated HI values prior to operational disruptions.
A software prototype for condition monitoring has also been developed and compiled into an executable (.exe) file with a user-friendly graphical interface. Based on the prior ML work, the software supports the application of LSTM, GRU, and CNN models to condition monitoring of WT generators, using both high-resolution sensor data and SCADA datasets. Furthermore, upon completion of the analysis, the software can automatically generate a report summarizing key results, including model accuracy, confusion matrix, and loss function curves.

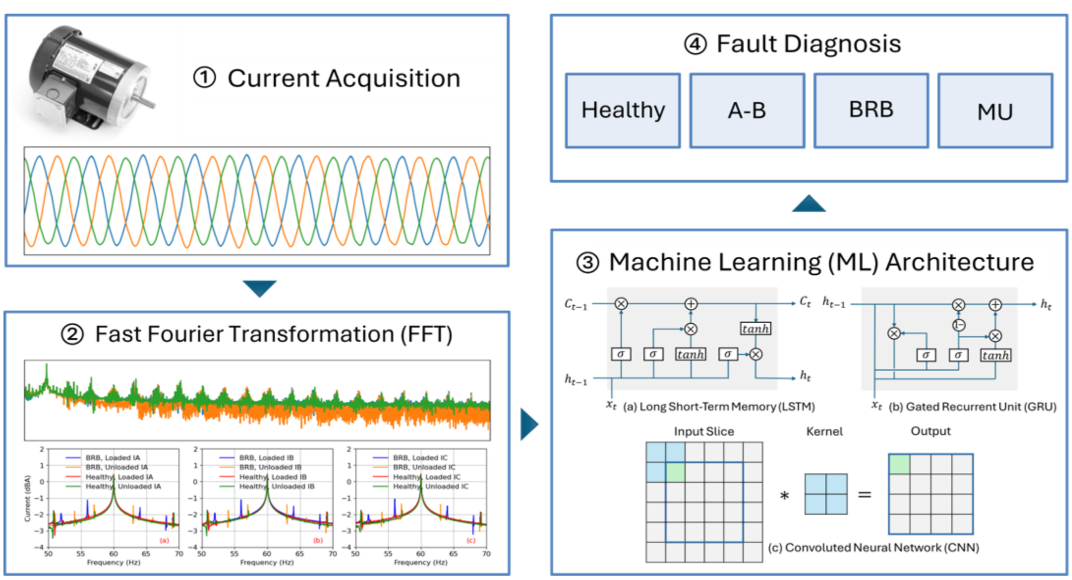


Figure 1. Knowledge-based condition monitoring framework, i.e., FIML, for induction motor condition monitoring.

PROJECT ID: B2-24

Benchmarking of Commercially Available Acoustic Blade Monitoring Systems through Field Testing

Principal Investigator:
Murat Inalpolat (University of Massachusetts Lowell)

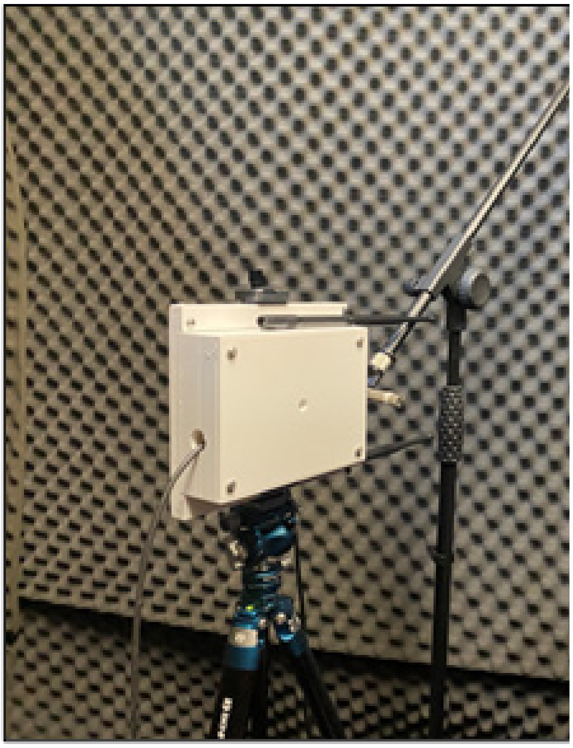
Co-Principal Investigator:
Christopher Niezrecki (University of Massachusetts Lowell)

Student Researcher:
Christopher Lowell (University of Massachusetts Lowell)

IAB Mentors:
Phillip Gauthier, Ken Lee, Kate Leitner, Yael Mata (EDFps)
Traci Pashley (Pattern Energy)
Teja Dasari (Xcel Energy)
Bin Jou (FM Global)
Chris Ludlow, Sauro Liberatore (Hutchinson)
Lothar Breuss (Bachmann Electronics)
Alex James (GE Vernova)

A comprehensive damage detection system that can monitor the blades for leading and trailing edge splits, delaminations, cracks and holes is currently not available. There are a few commercially available acoustic-based systems that have recently surfaced but their efficacy is unclear. This project continued the efforts from our previous projects, which has successfully shown the feasibility of the proposed technique in the field. This project focused on comparative benchmarking of existing commercially available wind turbine acoustic blade monitoring systems during their field deployment. A commercial system (Ping) was field deployed with the help of EDFps, a WindSTAR Member, and using one of their wind turbines. Data collected from these commercially available systems was benchmarked against data collected using the UML developed integral blade monitoring system. However, the ping system has revealed limited quantitative outputs that can be benchmarked against the detailed data obtained through the UML BAMS. This process entailed data collection, post-processing, statistical analysis, and interpretation of data collected from the wind farm. The UML integral blade monitoring consists of a few blade-internal sensors and a complementary single blade-external (tower) sensor responsible for real-time surveillance of the structural health of the blades during their operation. Initial laboratory testing of these systems was conducted at UML in a prior project. The findings from both projects are expected to shed light on some of the unknown characteristics and field performance of these systems. An objective evaluation of the test data and installation experiences was documented and shared with the IAB members.

a)



b)

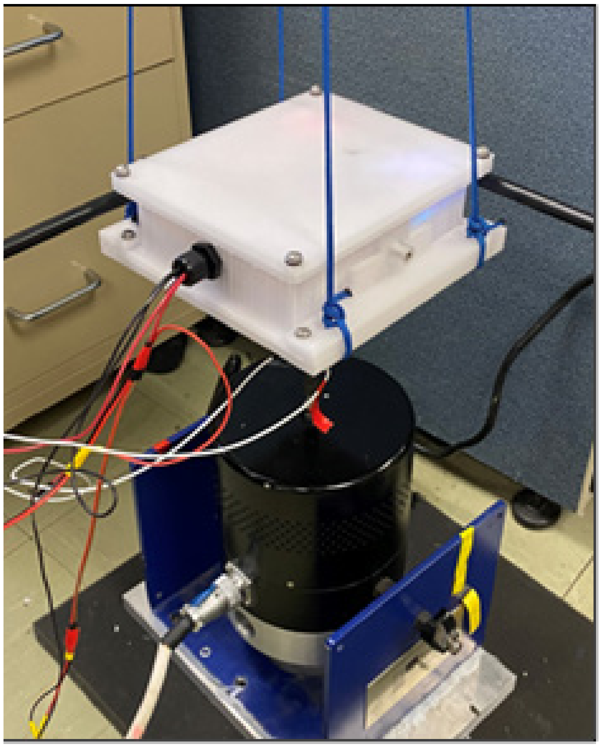


Figure 1. UML Sensor Node Testing a) Down Tower Node Acoustic Frequency Response Testing, b) In-Blade Node Vibration Frequency Response Testing.

PROJECT ID: B3-24

2024-2025 PROJECT HIGHLIGHTS

Condition Monitoring of Wind Turbine Foundations Using Accelerometers and Generative AI

Principal Investigator:
Nasser Kehtarnavaz (University of Texas at Dallas)

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

Student Researcher:
Jiazhi Dai, Reillan Sawyer (University of Texas at Dallas)

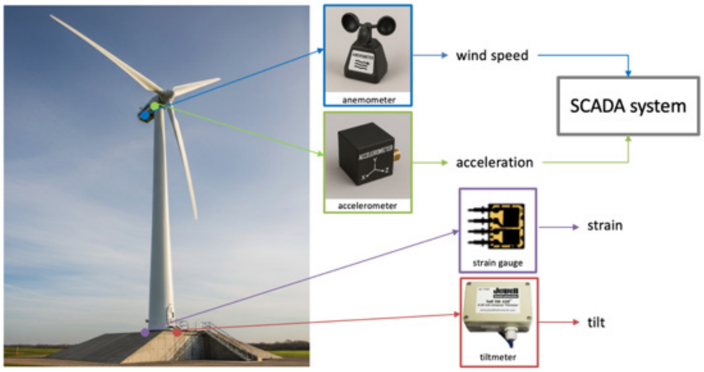
IAB Mentors:
Mike Purcell, Emily Palmer, Ron Grife (Leeward Energy)
Phillip Gauthier, Jon Pohlman, Raphael Janssen, Michael Cassidy, Trevor Taylor (EDFps)
Chris Ludlow (Hutchinson)
Lauren Magin, Jesus Hurtado, Carlos Guzman (Avangrid)
Bin Jou, Hariram Arni (FM Global)

This project involved the development of a data-driven solution for obtaining the rotational stiffness of wind turbine foundations using only acceleration and wind speed signals from Supervisory Control and Data Acquisition (SCADA) data. By relying on standard SCADA measurements, this solution reduces the need for costly installation of tiltmeters and strain gauges on the foundation and the tower, respectively (an illustration is shown in Figure 1). The primary motivation for this project was to lower the overall expense of foundation monitoring and also to conduct continuous monitoring of foundation stiffness, which is essential for ensuring turbine health and performance.

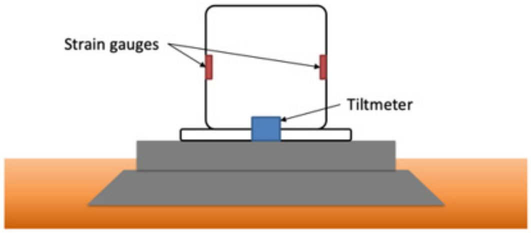
The solution developed consisted of a Convolutional Neural Network (CNN) model which was trained to map sliding windows of SCADA acceleration data, represented in the frequency domain, together with wind speed data in the time domain, to the corresponding tilt and moment values (an illustration is shown in Figure 2). The current practice of finding foundation rotational stiffness involves finding the slope of a line fitted to direct measurements of moment-tilt data samples. The data collected from five turbines were used to train and validate the developed model which achieved stiffness estimates within 7% of the ground-truth values.

To address the lack of real-world foundation stiffness data at lower stiffness slopes, an autoencoder generative AI network was designed to synthesize acceleration and wind speed signals corresponding to artificial moment–tilt data samples at lower stiffness slopes. The inclusion of these synthetic signals in the training set allowed the model to detect drops in the stiffness slope.

The solution developed has been incorporated into a software tool which can be used to monitor foundation rotational stiffness based on only SCADA data. By allowing less frequent utilization of tiltmeters and strain gauges, this software tool not only allows a more cost-effective way of measuring foundation stiffness in-between direct tilt and moment measurements but also enables a continuous monitoring of foundation stiffness via SCADA data.



(a)



(b)

Figure 1. (a) Illustration of the sensors and their locations for measuring foundation rotational stiffness, (b) side view of the locations of tiltmeter and strain gauges on a wind turbine tower.

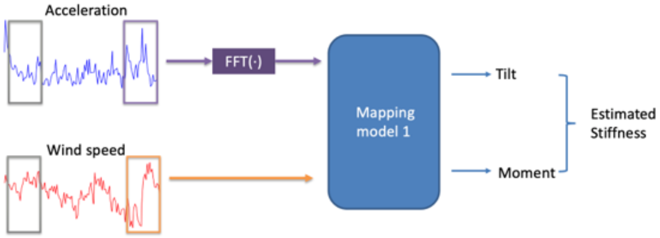


Figure 2. Illustrated deep learning model for estimating tilt/moment values from SCADA data.

PROJECT ID: B4-24

Local Sensor Energy Harvesting to Monitor Blade Structural Health

Principal Investigator:
Murat Inalpolat (University of Massachusetts Lowell)

Co-Principal Investigator:
Christopher Niezrecki (University of Massachusetts Lowell)

Student Researcher:
Jared Shepard (University of Massachusetts Lowell)

IAB Mentors:
Sauro Liberatore, Christopher Ludlow (Hutchinson)

A comprehensive damage detection system requires implementing multiple sensors inside the blades. Most sensing systems that are available require using lengthy, heavy and costly cables to transfer power and or data. One commercially available blade monitoring solution (Ping) uses a kinetic power harvester that is connected to the blade close out and harvests energy from the rotational motion of the blades. There currently is no other solution available to provide power to distributed sensors positioned at almost any location inside the blade. This project has enabled the team to investigate the feasibility of energy harvesting via micro-air turbines that are placed on the exterior of the blade and can simultaneously be used to replace vortex generators. The results of this research would benefit structural-health monitoring systems within turbine blades by providing distributed power at virtually any location. Two different protoypes (Figures 1 and 2) of micro-air turbines that can generate energy enough to power a sensor were developed. The project entailed developing a computational fluid dynamics model of the air turbine designed. This model was used to improve the energy output of the micro-air turbine through simulations and design sensitivity analyses. The developed prototypes were experimentally tested in the UML wind tunnel (Figure 3) to understand energy harvesting operating performance over a range of wind speeds.

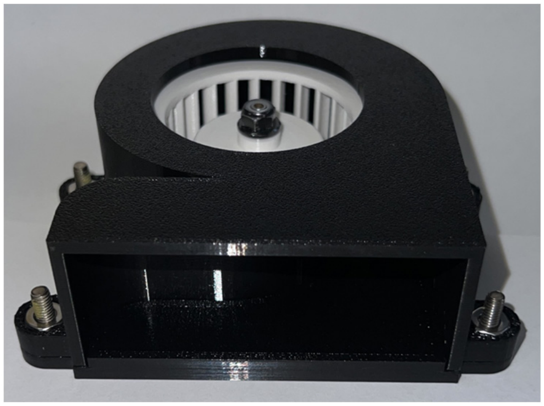


Figure 2. A prototype of a Vertical Axis Wind Turbine.

Figure 1. Image of a Horizontal Axis Wind Turbine prototype

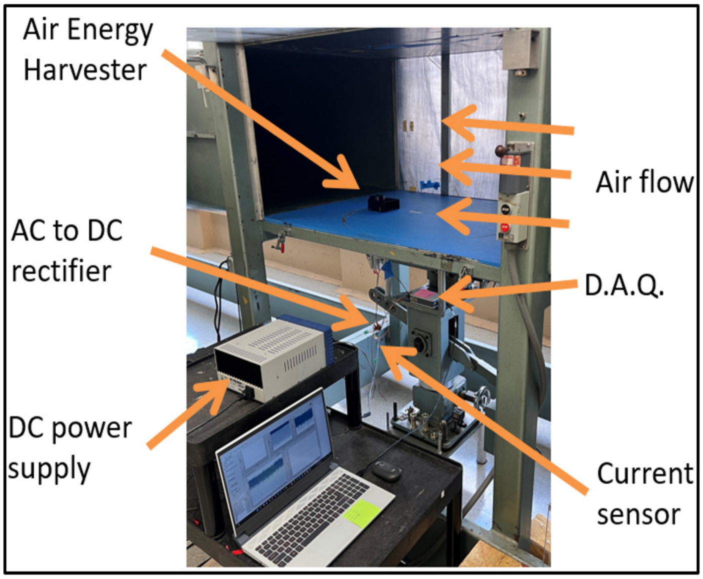


Figure 3. Image of the experimental test setup in the wind tunnel.

PROJECT ID: B5-24

2024-2025 PROJECT HIGHLIGHTS

Multiscale Data-driven Modeling of Neighboring Wind Farms

Principal Investigator:
Valerio Iungo (University of Texas at Dallas)

Student Researchers:
Emmanuvel Aju, Yujie Zhang, Reillan Sawyer (University of Texas at Dallas)

IAB Mentors:
Rupert Storey (GE Vernova)
Shintaro Tsuchihashi (Nikon)
Lauren Magin (Avangrid)
Teja Dasari (Xcel Energy)
Jason Dubois (EDFps)

With the increasing growth of wind farms, studying farm-scale phenomena becomes increasingly important to ensure optimal wind farm performance. In this project, we consider limitations in studying farm-scale phenomena utilizing SCADA data as well as investigate the specific farm-scale phenomena of low-level jets (LLJs). We investigate first the variability of wind speed and power across large wind farms and try to explain this variability with mesoscale or topographic influences. To assist in this analysis, we use machine learning to identify the ideal averaging periods for SCADA data to remove the influence of random or small-scale fluctuations that are not correlated between pairs of turbines. These ideal periods vary depending on the separation between turbines and provide a flexible set of guidelines for improving data analysis at farm scale. Using the appropriately averaged data, we find that farm-scale variabilities are highly scattered and difficult to tie to mesoscale or topographic effects in a way that could lead to consistent predictability and reproducibility.

We conclude that simulation data is needed to address this shortcoming and enable studies downstream of farm-scale variability studies, such as the study of the wind farm wake. Then, we consider the effect of the LLJs on wind turbine performance and wakes. We first develop an automatic method to extract wake characteristics from scanning lidar data. This allows us to utilize the large amount of data collected during the American WAKE experimeNt (AWAKEN) field campaign, where LLJs occurred around 50% of the time. We show sample cases indicating that the LLJ has a direct impact of wake recovery and deficit. More generally, we introduce a characterization of the jet for the site, which can assist in farm planning and design. For instance, we demonstrate the cold-weather jets have higher wind speeds and greater veer, which could lead to enhanced loading over the turbine rotor. Eventually, this knowledge could be incorporated in updated analytical wind farm models or AEP models to accommodate predictions for seasonal effects of the jet, improving AEP estimates in regions with high jet occurrence.

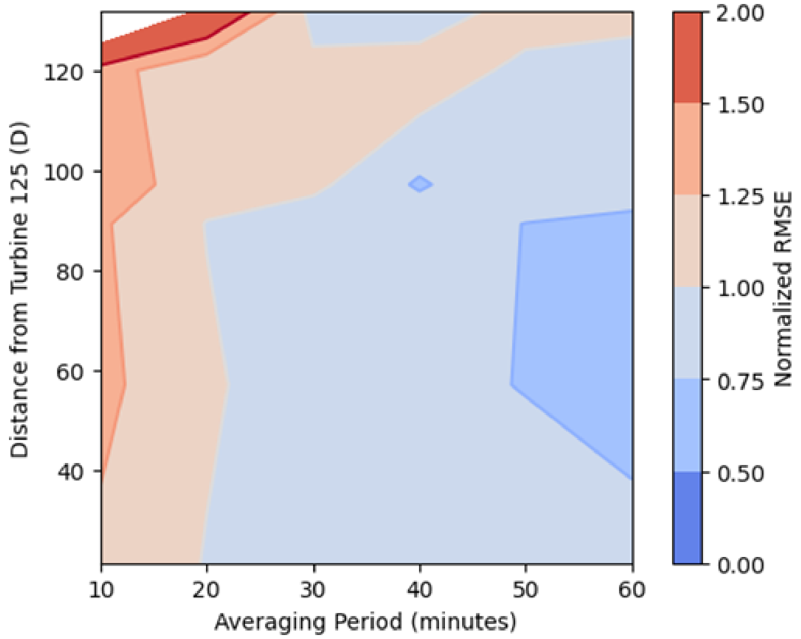


Figure 1. Machine-learning error in pairwise turbine predictions. To identify the ideal averaging period for a given separation distance, find the averaging period that gives a normalized RMSE of 1 for the specific distance.

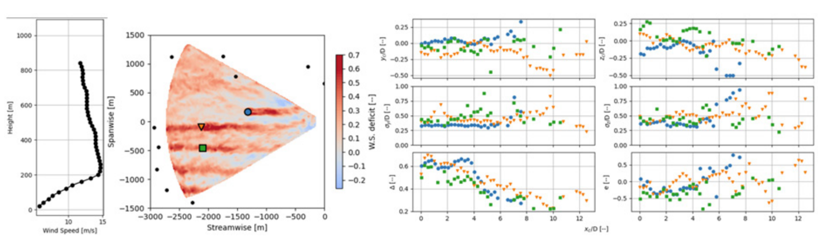


Figure 2: Automatic characterization of several wind turbine wakes for a case with a low-level jet.

PROJECT ID: C1-24

Repowering of Wind Farms with Digital Health Audits of Turbine Components

Principal Investigator:
Todd Griffith (University of Texas at Dallas)

Student Researchers:
Dan Bouzolin, Ipsita Mishra, Md. Sanower Hossain
(University of Texas at Dallas)

IAB Mentors:
Phillip Gauthier, Brandon Gerber (EDFps)
Bin Jou (FM Global)
Lauren Magin, James Jackett (Avangrid)

Currently, wind plants are designed for 20-30 years of operation, with decommissioning typically planned at end-of-service. However, repowering is an option that provides many benefits versus decommissioning to extend the lifetime of a wind plant by leveraging upfront investments of capital, permitting, footprint, electrical infrastructure, grid connection, etc. of the original wind plant. Consider that about 40% of US wind turbines are beyond 10 years of life. Thus, there is growing interest and need in repowering the numerous aging turbine assets. Figure 1 illustrates an example of repowering, called partial repowering, where only some components (e.g., blades) are replaced while other components continue in operation. The other type of repowering is called full repowering where the site of a wind farm is repurposed by removing old machines and installing new machines (which are typically larger machines, but installed in smaller numbers).

Figure 1. Illustration of Partial Repowering. Example: blades are replaced while other major turibne components are re-used.

The accurate estimation of a wind turbine's Remaining Useful Life (RUL) is essential for modern asset management strategies, enabling operators to make informed decisions regarding repowering, maintenance, life extension, and decommissioning. This project addresses this need by developing and demonstrating a new methodology to estimate the RUL of the wind turbine components. The RUL estimate is an important input to the Digital Health Audit (DHA) framework introduced in this project. The DHA framework quantifies and certifies the health state of critical wind turbine components through an integrated approach that combines sensing, inspection data, and digital twin simulations, as shown in Figure 2. The overall aim of this project was to develop the DHA framework and combine it with future proof structural engineering (FPSE) based repowering analysis to determine optimal timing, strategies, and costs, enabling more certain and informed repowering investments.

The F1-24 "Repowering of Wind Farms with Digital Health Audits of Turbine Components" project contributed to the following three needs: 1) developed a new asset management concept called DHA (digital health audit), which combines sensors, inspections, digital twins, and loads analysis to quantify component state of health (remaining life and its uncertainty), 2) performed additional study of FPSE (future proof structural engineering) to quantify the technical and cost requirements for over-building options, and 3) expanded the repowering cost analysis. This report documents the work completed in the F1-24 project for the WindSTAR members, and builds on the F2-23 project that focused on a new concept called Design for Repowering or DFR .

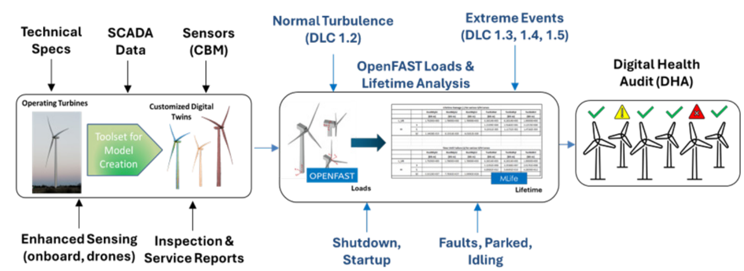


Figure 2. Graphic representation of Digital Health Audit (DHA) methodology that certifies the health of the wind turbine components by (1) leveraging digital twins of actual operating wind turbines created from sensing, inspection and operational data (left block), (2) integrating OpenFAST for loads and lifetime analysis to simulate the as-experienced site wind conditions (center block), and (3) estimating the remaining useful life (RUL) of the components for accurate health assessment via DHA (right block).

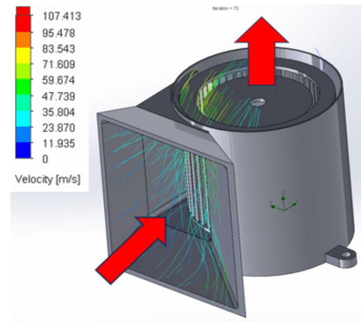
PROJECT ID: F1-24

Wind Turbine Blade Sensor Energy Harvester

Project Instructor:
Christopher Niezrecki (University of Massachusetts Lowell)

Sudent Researchers:
Javier Menjivar, Yash Patel, Fiorino Sakaj, Kervens Soirilus (University of Massachusetts Lowell)

An undergraduate capstone team of students focused on developing a micro-energy harvester that can be used to power sensors within wind turbine blades. They performed CFD simulations and optimized several design parameters.



PROJECT ID: U1-25

ACTIVE PROJECTS: 2025-2026

- **Recycling Epoxy Composites through Vitrimerization - Phase II**
  Project ID: A1-2
  PIs: Amir Ameli (University of Massachusetts at Lowell), James Reuther (TBD)
  Mentors: Hutchinson, Avangrid

- **Holistic Assessment of Riblet Performance on Utility-scale Wind Turbine**
  Project ID: A3-25
  PIs: Yaqing Jin, Stefano Leonardi, Mario Rotea (University of Texas at Dallas)
  Mentors: Arctura, EDFps, Nikon, Pattern Energy

- **Predicting Remaining Useful Life for Wind Turbine Gearboxes**
  Project ID: B2-254
  PIs: Matthew Gardner, Jie Zhang (University of Texas at Dallas)
  Mentors: Avangrid, Bachmann, EDFps, Hutchinson

- **Feasibility Study of Principal Component Thermography for Defect Detection in Wind Turbine Blade Components** Project ID: B3-25
  PIs: Alessandro Sabato, Christopher Niezrecki (University of Massachusetts Lowell)
  Mentors: Massachusetts Clean Energy Center, GE Vernova

- **Automatic Detection of Deviations from Normal Turbine Operation Based on Entire SCADA/CMS Data as a Heatmap**
  Project ID: B4-25
  PI: Nasser Kehtarnavaz, Mario Rotea (University of Texas at Dallas)
  Mentors: Avangrid, Bachmann, EDFps, Hutchinson, Pattern Energy

- **Development of a Low-cost Real-time Blade Root Monitoring System**
  Project ID: B6-25
  PIs: Murat Inapolat, Christopher Niezrecki (University of Massachusetts Lowell)
  Mentors: Avangrid, GE Vernova, EDFps, Hutchinson

- **Wind Farm Modeling under the Occurrence of Low-Level Jets and Improved AEP**
  Project ID: C2-25
  PI: Giacomo Valerio Iungo (University of Texas at Dallas)
  Mentors: GE Vernova, Arctura, Avangrid, Hutchinson, Leeward Energy, Nikon

2024-2025 OUTCOMES

Through August 31, 2025

For a cumulative list of all center outcomes visit uml.edu/WindSTAR

Products:

1. Software - Machine learning model for icing prediction in wind turbines from SCADA data
2. Software - Machine learning model for predicting temperature and curing degree in vacuum assisted resin infusion process
3. Software: OpenFAST digital twin model developed for Gamesa 3.465MW turbine
4. Software: Multiphysical computational model for predicting process-induced residual stress and distortion in fiber-reinforced composites
5. Software: FAST Model V1.0: Aero-elastic Model
6. Software: Matlab code for cure optimization as a function of the repair thickness, kinetic of two resin systems as a function of temperature and humidity.
7. 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.
8. 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.
9. Software: A Matlab-based GUI that can predict the axial, transverse, and shear properties of composite laminates used in wind turbine blades based on CPFM advanced micromechanics model
10. Software: A Matlab based GUI for prediction of power production and wind turbine wakes for the Panhandle Phase II wind farm.
11. Software: Simulink code for Extremum Seeking Control of NREL CART3 (Controls Advanced Research Turbine, 3-bladed).
12. Patent: Foundation and Deflection Monitoring Device #10808374, Awarded 10/20/20.
13. Hardware: Fiber Optic Interrogator for Strain Monitoring
14. Hardware: Passive Acoustic Damage Detection System for Blades
15. Hardware: Active Acoustic Damage Detection System for Blades
16. Patent Filing: "Structural Health Monitoring Systems, Energy Harvesters, and Methods of Use Thereof", Inalpolat, M., Niezrecki, C., Luo, Y., UML 2023-011-02 (103440-059PCT)
17. Software: Filed copyright for Stack-Average image processing algorithm developed during the time of the project.
18. Software: ERSA for Estimating Rotational Stiffness from Acceleration.
19. Software: Code for curing cycle optimization for composites manufactured by Vacuum Assisted Resin Infusion process.

Journal Papers:

1. Lyon, S., Ng, C. A., Pozzi, C., Inalpolat, M., Niezrecki, C., and Luo Y., "Signal Strength and Network Performance Optimization of a Wireless Acoustic Sensor for Wind Turbine Blade Health Monitoring," IEEE Sensors Journal, Accepted for Publication, December 2025. DOI: 10.1109/JSEN.2025.3647370
2. Hamid, S., Niezrecki, C., Eberle, A., "Contextualizing Wind Turbine Blade Waste: Comparison to Other Global Waste Streams, SAMPE Journal, Issue Paper 2, May/June 2025. DOI: 10.33599/SJ.v61no3.02
3. Eniola, V., Cimorelli, J., Niezrecki, C., Jin, X., and Willis, D., "Investigating the impact of wind speed variability on optimal sizing of hybrid wind-hydrogen microgrids for reliable power supply, International Journal of Hydrogen Energy, Volume 106, March, 2025, Pages 834-849, ISSN 0360-3199, https://doi.org/10.1016/j.ijhydene.2025.01.444
4. Abootorabi, S., Leonardi, S., Rotea, M., & Zare, A. (2025). Short-term wind forecasting via surface pressure measurements: Stochastic modeling and Sensor Placement. Journal of Renewable and Sustainable Energy, 17(1). https://doi.org/10.1063/5.0216465
5. Dai, J., Rotea, M., & Kehtarnavaz, N., "Obtaining Rotational Stiffness of Wind Turbine Foundation from Acceleration and Wind Speed SCADA Data, & Sensors," 25(15), paper no. 4756, 2025. https://doi.org/10.3390/s25154756
6. Yan, J., Senemmar, S. and Zhang, J., (2025), Bi-Level Inter-Turn Short Circuit Fault Monitoring for Wind Turbine Generators with Benchmark Dataset Development, Journal of Mechanical Design, Vol. 147, Issue 4, 2025, pp. 041704. https://doi.org/10.1115/1.4067056
7. Aliheidari, N., Ameli, A. "Retaining high fracture toughness in aged polymer Composite/Adhesive joints through optimization of plasma surface treatment, Composites Part A: Applied Science and Manufacturing, Volume 176,2024,107835,ISSN 1359-835X.
8. Zani, Md. R., Maor, N. S., Bhamitipadi Suresh, D., & Jin, Y. (2024). Turbulent boundary layer control with multi-scale Riblet design. Energies, 17(15), 3827.
9. Cao, D., Xu, T., Zhang, M., Wang, Z., Griffith, D. T., Roy, S., Baughman, R. H., &Lu, H. (2024). Strengthening sandwich composites by laminating ultra-thin oriented carbon nanotube sheets at the skin/core interface. Composites Part B: Engineering,111496.
10. Zhang, Y., Kehtarnavaz, N., Rotea, M., & Dasari, T. (2024). Prediction of icing on wind turbines based on SCADA data via temporal convolutional network. Energies,17(9), 2175.
11. Zhang, Y., Rotea, M., Kehtarnavaz, N. (2024), Wind Farm Prediction of Icing Based on SCADA Data. Energies, 17, 4629.
12. Bian, N., Ren, Y., Shrivastava, A., Wang, Z., Yang, D. J., Roy, S., Baughman, R., &Lu, H. (2024). Enhancing the interlaminar adhesion of carbon fiber composites via carbon nanotube sheets. Academia Materials Science.
13. Cao, D., Lu, H., & Griffith, D. T. (2024). Cohesive zone modeling of the buckling behavior of a fusion-joined, additive-manufactured wind blade. Academia Materials Science.
14. Aju, E. J., Gong, P., Kumar, D., Rotea, M. A., & Jin, Y. (2024). Power output fluctuations and unsteady aerodynamic loads of a scaled wind turbine subjected to periodically oscillating wind environments. Journal of Renewable and Sustainable Energy, 16(5).
15. Bernardoni, F., Rotea, M. A., & Leonardi, S. (2024). Impact of yaw misalignment on turbine loads in the presence of wind farm blockage. Wind Energy, 27(6), 535–548.
16. Lingad, M V and Rodrigues, M and Zare, A and Leonardi, S. (2024). Three-dimensional stochastic dynamical modeling forwind farm flow estimation. Journal of Physics: Conference Series. 2767 (5) 052065.
17. Zhang, R., Liu, Y., Zheng, T. et al. A fast spatio-temporal temperature predictor for vacuum assisted resin infusion molding process based on deep machine learning modeling. J Intell Manuf 35, 1737-1764 (2024).
18. Bouzolin, D., Settelmaier, K., and Griffith, D.T., (2024). Design for Repowering of Wind Farms: An Initial Framework, Journal of Physics: Conference Series, Volume 2767.
19. Dai, J., Rotea, M., & Kehtarnavaz, N. (2024). An ensemble network for high-accuracy and long-term forecasting of icing on wind turbines. Sensors, 24(24), 8167. https://doi.org/10.3390/s24248167

Conference Papers:

1. F. Bottalico, J. S. Syed, C. Niezrecki, and A. Sabato, Improving image resolution for drone-borne inspection of wind turbine blades, accepted to IWSHM 2025, Palo Alto, CA, September 9-11, 2025.

2024-2025 OUTCOMES

Through August 31, 2025

For a cumulative list of all center outcomes visit uml.edu/WindSTAR

2. Bottalico, F., Niezrecki, C., and Sabato, A., "Wind turbine foundation monitoring with motion magnification: Lessons learned and best practices," Proceedings of the IMAC XLIII, A Conference on Structural Dynamics, February 10-13, Orlando, FL, 2025.
3. Karim, F. R., Liu, N., & Zhang, J. (2025a). Early anomaly detection in wind turbine generators using SCADA data. 2025 IEEE Symposium on Diagnostics for Electric Machines, Power Electronics and Drives (SDEMPED), 01–07. https://doi.org/10.1109/sdemped53223.2025.11154170
4. Tubije, J. M., Jin, Y., & Leonardi, S. (2024). Numerical investigation of effects of Riblets on wind turbine performance. Journal of Physics: Conference Series,2767(2), 022023.
5. Yan, J., Senemmar, S., and Zhang, J., (2024), Inter-turn short circuit fault diagnosis and severity estimation for wind turbine generators, In Journal of Physics: Conference Series, Vol. 2767, IOP Publishing, p. 032021.
6. S. Abootorabi, S. Leonardi, M. Rotea, and A. Zare (2024), Short-term wind forecasting using surface pressure measurements, In Proceedings of the 2024American Control Conference, Toronto, Canada, pp. 1022-1027.
7. M. V. Lingad, M. Rodrigues, S. Leonardi, and A. Zare (2024), Three-dimensional stochastic dynamical modeling for wind farm flow estimation, J. Phys. Conf. Ser., vol. 2767, no. 5, p. 052065.
8. Ahmed, W. U., Moss, C., Roy, S., Shams Solari, M., Puccioni, M., Panthi, K., Moriarty, P., & Iungo, G. V. (2024). Wind Farm wakes and farm-to-farm interactions: Lidar and wind tunnel tests. Journal of Physics: Conference Series, 2767(9),092105.
9. Rotea, M. A., Kumar, D., Aju, E. J., & Jin, Y. (2024). Multi-row extremum seeking for Wind Farm Power Maximization. Journal of Physics: Conference Series, 2767(3),032043.
10. F. Bottalico, and A. Sabato, Natural pattern tracking for 3D digital image correlation, in proceedings SPIE Smart Structures/NDE 2024, Long Beach, CA, March 25-28, 2024.
11. F. Bottalico and A. Sabato, Pattern-less stereophotogrammetry for structural dynamic measurements, in proceedings IMAC XLII, Orlando, FL, January 29 – February 2, 2024.
12. Ng, C., A., Pozzi, C., Lyon, S., Inalpolat, M., Niezrecki, N., and Luo. Y., "IoT acoustic sensor design and antenna selection for a wind turbine structural health monitoring system", Proceedings of SPIE Smart Structures+Nondestructive Evaluation, Long Beach, CA, March 25–28, 2024.
13. F. Bottalico and A. Sabato, Assessment of three-dimensional displacements via a novel natural-pattern tracking algorithm, in proceedings ISMA-USD Conference, Leuven, Belgium, September 9 - 11, 2024, in press.
14. M. V. Lingad, M. Rodrigues, S. Leonardi, and A. Zare, Three-dimensional stochastic dynamical modeling for wind farm flow estimation, J. Phys. Conf. Ser., vol. 2767, no. 5, p. 052065, 2024.
15. Bouzolin, D., Settelmaier, K., & Todd Griffith, D. (2024). Design for repowering of wind farms: An initial framework. Journal of Physics: Conference Series, 2767(8), 082009. https://doi.org/10.1088/1742-6596/2767/8/082009
16. Kamath, S., Caselato Gandia, G., Adab, N., Mehrdad, E., Qian, D., & Lu, H. (2024). Machine-learning based curing cycle optimization in wind blade manufacturing. Volume 2: Advanced Manufacturing. https://doi.org/10.1115/imece2024-146131

Selected Presentations:

1. A. Sabato, "Improving image resolution for drone-borne inspection of wind turbine blades," presented to IWSHM 2025, Palo Alto, CA, Septmber 11, 2025.
2. Cimorelli, J., Eniola, V., Niezrecki, C., Jin, X., and Willis, D., "Modeling and Comparison of Wind and Solar-Hydrogen Integrated Systems for Reliable Microgrid Operation," NAWEA/WindTech 2025 Conference, Dallas, TX, October 15- October 17, 2025.
3. Eniola, V., Cimorelli, J., Jin, X., Willis, D., and Niezrecki, C., "Optimization of Hybrid Wind–Hydrogen Microgrids with Overbuilt Wind Capacity Using a Rule-Based Energy Management Scheme and Metaheuristic Algorithm," NAWEA/WindTech 2025 Conference, Dallas, TX, October 13-17, 2025.
4. Niezrecki, C., Eberle, A., and Hamid, S., "Wind Turbine Blade Waste Compared to Other Global Waste Streams," NAWEA/WindTech 2025 Conference, Dallas, TX, October 15- October 17, 2025.
5. Cimorelli, J., Eniola, V., Niezrecki, C., Jin, X., and Willis, D., "Modeling of Wind-Hydrogen Integrated Systems for Resilient Microgrid Operation," Future Energy Summit, Boston, MA, February 17-19, 2025.
6. Eniola, V., Cimorelli, J., Niezrecki, C., Willis, D., and Jin, X., "Assessing Wind Speed Variability for Optimal Design of Reliable Hybrid Wind-Hydrogen Microgrids," Future Energy Summit, Boston, MA, February 17-19, 2025.
7. Keynote Speaker, C. Niezrecki: The Future Energy Summit, "Coupling Wind and Solar Energy with Hydrogen Energy Storage," Newton, MA, February 17, 2025.
8. Dai, J., Rotea, M., & Kehtarnavaz, N., "Estimation of Wind Turbine Foundation Stiffness Based on Nacelle Acceleration and Wind Speed," NAWEA/WindTech Conference, Dallas TX, October 15-17, 2025.
9. Sahil G. Kamath, Ehsan Mehrdad, Nilofar Adab, Rajat Srivastava, Yingjian Liu, Hongbing Lu, *Dong Qian, "A machine learning based multizone heating framework for composite manufacturing", NAWEA/WindTech Conference, Dallas TX, October 15-17, 2025.
10. J. Yan, H. Arni, B. Jou, M.C. Gardner, and J. Zhang, "FFT and Machine Learning-Based Electrical Fault Detection in Wind Turbine Induction Machines," NAWEA/WindTech Conference, Dallas TX, October 15-17, 2025.
11. Karim, F. R. B., Liu, N. and Zhang, J., (2025), Early Anomaly Detection in Wind Turbine Generators Using SCADA Data, IEEE International Symposium on Diagnostics for Electrical Machines, Power Electronics and Drives (SDEMPED), Dallas, TX, August 24-27, 2025.
12. E. Aju, Y. Zhang, R. Sawyer, Y. Jin, and M. Rotea, "Hub and tower loads under closed loop wake steering – a wind tunnel study," NAWEA/WindTech Conference, Dallas TX, October 15-17, 2025.
13. N. Maor, J.M. Tubije, S. Leonardi, M. Rotea, Y. Jin, "Riblet Blade Treatments on Energy Production of Wind Turbines," NAWEA/WindTech Conference, Dallas TX, October 15-17, 2025.
14. Bottalico, F. and Sabato, A. Pattern-less stereophotogrammetry for structural dynamic measurements IMAC XLII, Orlando, FL, January 29 – February 2, 2024.
15. A. Sabato: Revolutionizing structural monitoring: advancing aerial-borne 3D computer vision for assessment of large-scale engineering systems, invited seminar at University of Central Florida, Orlando, FL, February 1, 2024.
16. A. Sabato: Revolutionizing structural monitoring: advancing aerial-borne 3D computer vision for assessment of large-scale engineering systems, invited seminar at Rensselaer Polytechnic Institute, Troy, NY, February 7, 2024
17. A. Sabato: Advancement of drone-borne 3D computer vision measurements for assessment of large-scale engineering systems, invited seminar at University of New Mexico, Albuquerque, NM, March 4, 2024.
18. Ng, C., A., Pozzi, C., Lyon, S., Inalpolat, M., Niezrecki, N., and Luo. Y., "IoT acoustic sensor design and antenna selection for a wind turbine structural health monitoring system", SPIE Smart Structures+Nondestructive Evaluation, Long Beach, CA, March 25–28, 2024.

19. Bottalico, F. and Sabato, A. Natural pattern tracking for 3D digital image correlation, SPIE Smart Structures/NDE 2024, Long Beach, CA, March 25-28, 2024.
20. Cimorelli, J., Eniola, V., Niezrecki, C., Jin, X., and Willis, D., "Wind Energy and Hydrogen Energy Storage System Modeling for Navy Microgrids," Student Research and Community Engagement Symposium, Lowell, MA, April 2, 2024.
21. Zare, "A stochastic framework for quantifying and data-enhanced dynamical modeling of uncertainty," (a) University of Michigan–Ann Arbor, MI, February 2024;(b) The University of Toledo, OH, March 2024; (c) Sapienza University of Rome, Rome, Italy, June 2024.
22. Cimorelli, J., Eniola, V., Niezrecki, C., Jin, X., and Willis, D., "A Design and Optimization Tool for Integrated Renewable-Hydrogen Microgrid Systems," Offshore Energy and Storage Symposium 2024, New Beford, MA, July 10-12, 2024.
23. Eniola, V., Cimorelli, J., Niezrecki, C., Jin, X., and Willis, D., "Investigating Wind Speed Fluctuation Effects on Optimal Sizing of Hybrid Wind-Hydrogen Energy Subsystems," Offshore Energy and Storage Symposium 2024, New Beford, MA, July 10-12, 2024.
24. C. Niezrecki - Keynote Speaker: Offshore Energy and Storage Society (OSES), "Offshore Wind: Challenges and Opportunities," New Bedford, MA, July 11, 2024.
25. Speaker: 5th International Congress on Advanced Materials Sciences and Engineering (AMSE-2024), "Wind Turbine Blade Recycling and Repurposing: Challenges and Opportunities," Opatija, Croatia, July 24-26, 2024 (invited)
26. Bottalico, F. and Sabato, A. Assessment of three-dimensional displacements via a novel natural-pattern tracking algorithm, in proceedings ISMA-USD Conference, Leuven, Belgium, September 9 - 11, 2024
27. Mario A. Rotea, "Wake Steering via Log-of Power Extremum Seeking Yaw Control,"2024 Sandia Blade Workshop, Sep 16-20, 2024, Albuquerque
28. Hamid, S., and Niezrecki, C., "End-of-Life Management of Wind Turbine Blades: Challenges, Innovations, and Comparative Perspectives on Composite Material Recycling," NAWEA/WindTech 2024 Conference, New Brunswick, NJ, October 30 - November 1, 2024 (poster).
29. Cimorelli, J., Eniola, V., Niezrecki, C., Jin, X., and Willis, D., "Modeling of Wind-Hydrogen Integrated Systems for Resilient Microgrid Operation," NAWEA/WindTech 2024 Conference, New Brunswick, NJ, October 30- November 1, 2024.
30. Invited speaker – M. Inalpolat, Wind Turbine Blades conference hosted by AMI, "Structural health monitoring of operational wind turbine blades using an acoustics-based approach", Boston, MA (10/2/2024).
31. Bouzolin, D. Todd Griffith, D. "Design for Repowering of Wind Turbines Through Future-Proof Structural Engineering: Case Study of Tower Repowering, "NAWEA/WindTech 2024, Rutgers University, New Brunswick, NJ, USA, Oct. 30-Nov. 1, 2024.
32. Mario. A. Rotea, "Wind farm control," NAWEA/WindTech 2024, Oct 30 – Nov 1,2024, Rutgers-New Brunswick
33. Eniola, V., Cimorelli, J., Niezrecki, C., Willis, D., and Jin, X., "Optimizing Wind-Hydrogen Integrated Microgrid Design: Accounting for Wind Speed Fluctuations," NAWEA/WindTech 2024 Conference, New Brunswick, NJ, October 30-November 1, 2024.
34. Inalpolat, M., and Niezrecki, C., "Operational Blade Monitoring using a Sparse Acoustic Sensor Array" NAWEA/WindTech 2024, New Brunswick, NJ, October 30-November 1 2024.
35. A. Sabato, "Monitoring wind turbine blades: current approaches and future direction," invited seminar at Johns Hopkins University, Baltimore, MD, February 26, 2024.
36. D. Qian, R. Zhang, S. Kamath, N. Adab and H. Lu, "Machine learning-based prediction of multiphysical responses in vacuum assisted resin infusion molding process," 2024 ASME IMECE Conference, Portland, OR, November 7, 2024

Master of Science Thesis:

1. Nir Saar Maor, "Experimental study of riblet treatments on aerodynamic performance and energy production of wind turbines." Mechanical Engineering, University of Texas at Dallas, Fall 2024.
2. Michael Lingad, "Control-oriented modeling and preview control of wind turbines enabled by ground-level air-pressure measurements," MS Mechanical Engineering, University of Texas at Dallas, Summer 2025.

PhD Dissertations:

1. Wasi Uddin Ahmed, "Wind-Tunnel investigations of wind-turbine blade aerodynamics with plasma actuators and rotor interactions with the incoming boundary layer." Mechanical Engineering, University of Texas at Dallas, Spring 2024.
2. Nahal Aliheidari, "Long-Term Environmental Durability Assessment of Fiber-Reinforced Composite/Adhesive Joints," Plastics Engineering, University of Massachusetts Lowell, Spring 2024.
3. Emmanuvel Joseph Aju, "Wind-Tunnel investigations of wind-turbine performance: winglet pitching, yaw misalignment, and periodically oscillating wind environments." Mechanical Engineering, University of Texas at Dallas, Spring 2024.
4. Fabio Bottalico, "Development of a UAV-Borne Stereophotogrammetry System for Dynamic Measurements on Large-Scale Str." Fabio_Bottalico@student.uml.edu, Ph.D. Mechanical Engineering
5. Yujie Zhang, "Machine Learning Solutions for Wind Turbine and Wind Farm Applications." Electrical and Computer Engineering, University of Texas at Dallas, Fall 2024.
6. Fabio Bottalico, "Development of a UAV-borne stereophotogrammetry system for static and dynamic measurements on large-scale structures," PhD Mechanical Engineering, University of Massachusetts at Lowell, July 28, 2025.
7. Seyedalireza Abootorabi, "Coherence-Based Stochastic Modeling and Estimation of Wall-Bounded Turbulence," PhD Mechanical Engineering, University of Texas at Dallas, Spring 2025
8. Keshav Panthi, "Field Investigations on the Leading-edge Erosion of Wind Turbine Blades and Wind Tunnel Experiments of a Floating Offshore Wind Turbine Emulator," PhD Mechanical Engineering, University of Texas at Dallas, Fall 2025

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

IAB Meetings:

- University of Massachusetts Lowell, June 4-5, 2025
- University of Texas at Dallas, January 28-29, 2025

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