U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Session (Activity Area) Overview Presentation: Materials, Manufacturing, and Design Innovation

(Formerly Advanced Components, Reliability and Manufacturing)

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FY21 Peer Review – Activity Overview

Activity Summary:

Issue/Challenge:

- Enable access to new markets, onshore and offshore; and reduce the levelized cost of energy for wind energy in all markets
  - Scaling Wind Technology
  - Overcoming U.S transportation/logistical problems
  - Wind turbine reliability issues (bigger turbines, bigger issues)

Approach:

Novel Materials, & Manufacturing & Innovations that:

- Support development of "tall wind" technologies that are scalable, lightweight, and transportable
- Increase domestic manufacturing capacity through advanced processes (automation/optimization)
- Ensure durability and reliability of these next generation designs for offshore and land-based

Key Activity Partners:

- Labs: ANL, LBNL, NREL, ORNL, SNL
- Academia and Domestic and International Industry

Activity Objective(s) 2019-2020:

- Study and analyze the feasibility and potential Impact of 3D printing, advanced materials, and advanced design procedures, in Wind Energy Production, including tooling, prototyping and design, and end use applications of AM components.
- Support development of lightweight materials and designs for drivetrains and blades
- Investigate large and transportable components to enable access to new markets
- Analyze, model, and develop solutions for reliability issues in blades and drivetrains

Overall Activity Objectives (life of Activity):

- Continue to decrease full life cycle costs of wind systems through advanced materials, manufacturing, and design research:
  - Lower CapEx: light weighting, scaling
  - Lower O&M: Durable & damage tolerant design; ease of inspection/repair
  - Lower transport/logistics constraints and costs
  - Decrease cycle time/cost: Higher production capacity increase domestic manufacturing

FY19 - FY20 Budget:
FY19: $8,663,313 (FY19BU $3,177,428)
FY20: $7,463,278
TOTAL: **$16,126,591**

Current budget:
FY21: $11,548,051 (FY21BU $4,267,379)

Number of projects under peer review: 10

Projects Under Review

Strategic Area/Objective: Decreasing Manufacturing Cycle Time/Cost	
Additive Manufacturing in Wind Turbine Components and Tooling	Brian Post
3D Printed Blade Core	Scott Carron
Manufacturing and Additive Design of Electric machines enabled by Three-dimensional printing (MADE3D)	Latha Sethuraman
Strategic Area/Objective: Scaling Components that are Transportable	
Big Adaptive Rotor (BAR)	Josh Paquette
Carbon Fiber Material Design for Targeted Performance Enhancement	Robert Norris Jr.
Strategic Area/Objective: Improve Reliability and lower O&M for larger, novel designs	
Wind Turbine Drivetrain Reliability	Jon Keller
Wind Turbine Drivetrain Reliability: Advanced Materials	Aaron Greco
Wind Turbine Drivetrain Reliability Assessment and Remaining Useful Life Prediction	Shawn Sheng
Wind Turbine Blade Durability and Damage Tolerance	Josh Paquette
Fusion Joining of Thermoplastic Composites using Energy Efficient Methods	Robynne Murray

Activity Impact

Although significant progress has been made in reducing the LCOE for wind, the wind industry has much farther to go to enable deployment offshore and expand "Tall [land-based] wind" to unlock wind resource energy potential in U.S.

Lower costs for these new technologies with higher certainty and a robust domestic supply chain will result in greater investment in U.S. wind energy and enable the U.S. to meet current deployment goals

Activity Goal:

Decrease levelized cost of energy to enable deployment of floating offshore wind and large land-based wind systems that are transportable, reliable, and cost-effective by decreasing turbine technology costs associated with capital expenditure, operating and maintenance, and manufacturing cycle time.

Activity Impact

Strategic Area/Objective	Challenges	Goals	Approach

Decrease Manufacturing Cycle Time/Cost	Fabrication of wind energy components is time-consuming, labor-intensive, and can result in unnecessary defects and waste.	Enable rapid prototyping, improve design flexibility, optimize material use, and support domestic manufacturing.	• Additive manufacturing R&D projects to explore novel designs and manufacturing technologies
			  • AM in WTC and Tooling
			  • 3D Printed Blade Core Material
			  • MADE3D

Larger, Transportable, Components	Scaling technology is necessary to decrease LCOE, the size and design of these components have been limited due to transportation and installation limitations and are already limiting U.S. wind technology deployment	Enable transportation & installation of larger components for both Land-based wind & future offshore wind	• Larger, lighter blades R&D
			  • Big Adaptive Rotor
			  • Carbon Fiber Material Design for Targeted Performance Enhancement
			• Taller Towers (FY20 FOA)
			• Drivetrains (FY20 FOA)- OSW review

Improve Reliability and lower O&M for larger, novel designs	As the existing fleet ages, newer turbines increase in size, and the industry expands offshore, reliability and logistics issues will only grow over time. Damage can be hard to detect, and maintenance may be even harder to perform, resulting high and unplanned O&M costs.	Assess and resolve reliability issues, reduce project risk, and increase overall project financial performance to decrease full lifecycle costs.	• Damage/Failure Assessment, Mitigation, and O&M Optimization & Tools:
			  • Drivetrain Reliability
			  • Drivetrain Reliability: Advanced Materials
			  • Drivetrain Reliability Assessment and Remaining Useful Life TCF
			  • Blade Durability and Damage Tolerance
			  • Fusion Joining of Thermoplastics TCF

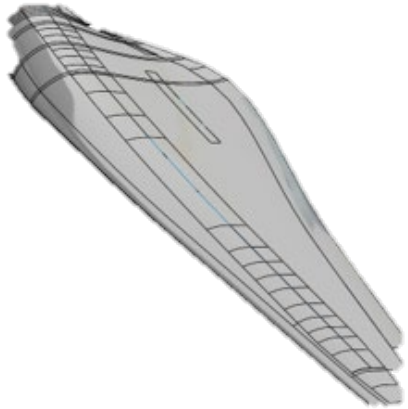
Accomplishments: Decreasing Manufacturing Cycle Time/Cost

AM in Wind Turbine Components and Tooling

- Completed fabrication of a large-scale Wind Turbine component utilizing three different AM technologies; completed testing and published final report.

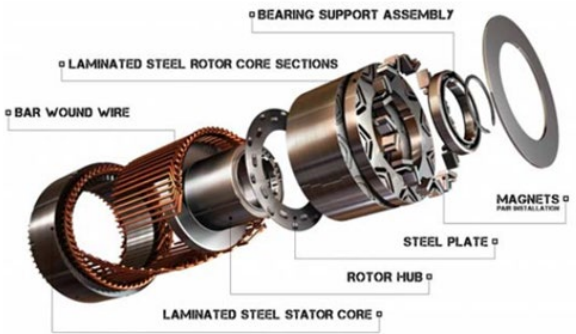
3D Printed Blade Core

- Established the technical foundational specifications and requirements that will drive the development of innovative blade core structures utilizing additive manufacturing technologies.



MADE3D

- Developed a new optimization software capable of identifying novel, 3D-printable, high-strength, multi-material geometries with reduced rare-earth content capable of reducing weight by more than 30% from generator active parts



Collaborators: Oak Ridge National Lab, NREL; Domestic and International Industry: Vestas, Carpenter Technology, ExOne, Renishaw

Accomplishments: Larger, Transportable Components

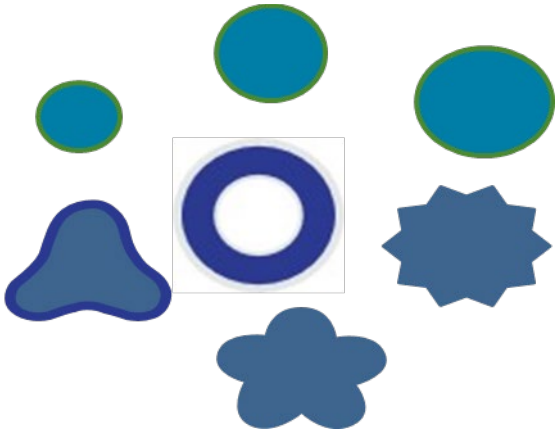
Big Adaptive Rotor (BAR)

- Completed evaluation of various design concepts
- Identified and implemented enhancements to modeling and optimization tools and continued material research
- Characterized lower cost textile carbon fiber material with improved cost-specific mechanical properties, and system-level benefits

Source: Dacotrans with Goldhofer FTV

Carbon Fiber Material Design

- Developed customized varying diameter carbon fibers with improved mechanical properties while scaling up production capabilities; initial manufacturing and testing approaches developed
- Developed a fiber shape optimization methodology for down-selecting promising carbon fiber geometries to improving composite compressive strength per cost
- Finite element failure model- predict compressive performance of alternative fiber geometries (Composites Science and Technology journal)

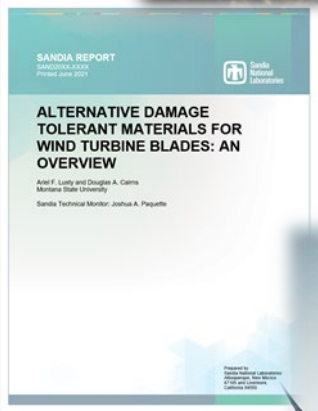


Collaborators: NREL, SNL, LBNL, ORNL; Montana State University, Domestic & International Industry: Solvay, Zotek, Hexcel, Kaltex, Strongwell, TPI

Accomplishments: Improve Reliability and Lower O&M for Larger, Novel Designs

Drivetrain Reliability Collaborative

- Characterized, investigated contributing factors, and developed models and solutions for White Etching Crack
- Developed novel benchtop methods to replicate various drivetrain failures
- Characterized and experimentally studied failures and potentially related operational conditions
- Developed and performed initial validation for a gearbox remaining useful life (RUL) prediction tool



Blade Durability and Damage Tolerance

- Further developed autonomous blade inspection robot with advanced inspection capabilities
- Investigated blade material failure mechanisms and possible design solutions

Fusion Joining of Thermoplastics (TCF)

- Proved viability of a lightning protection system for thermally-welded thermoplastic composite blades

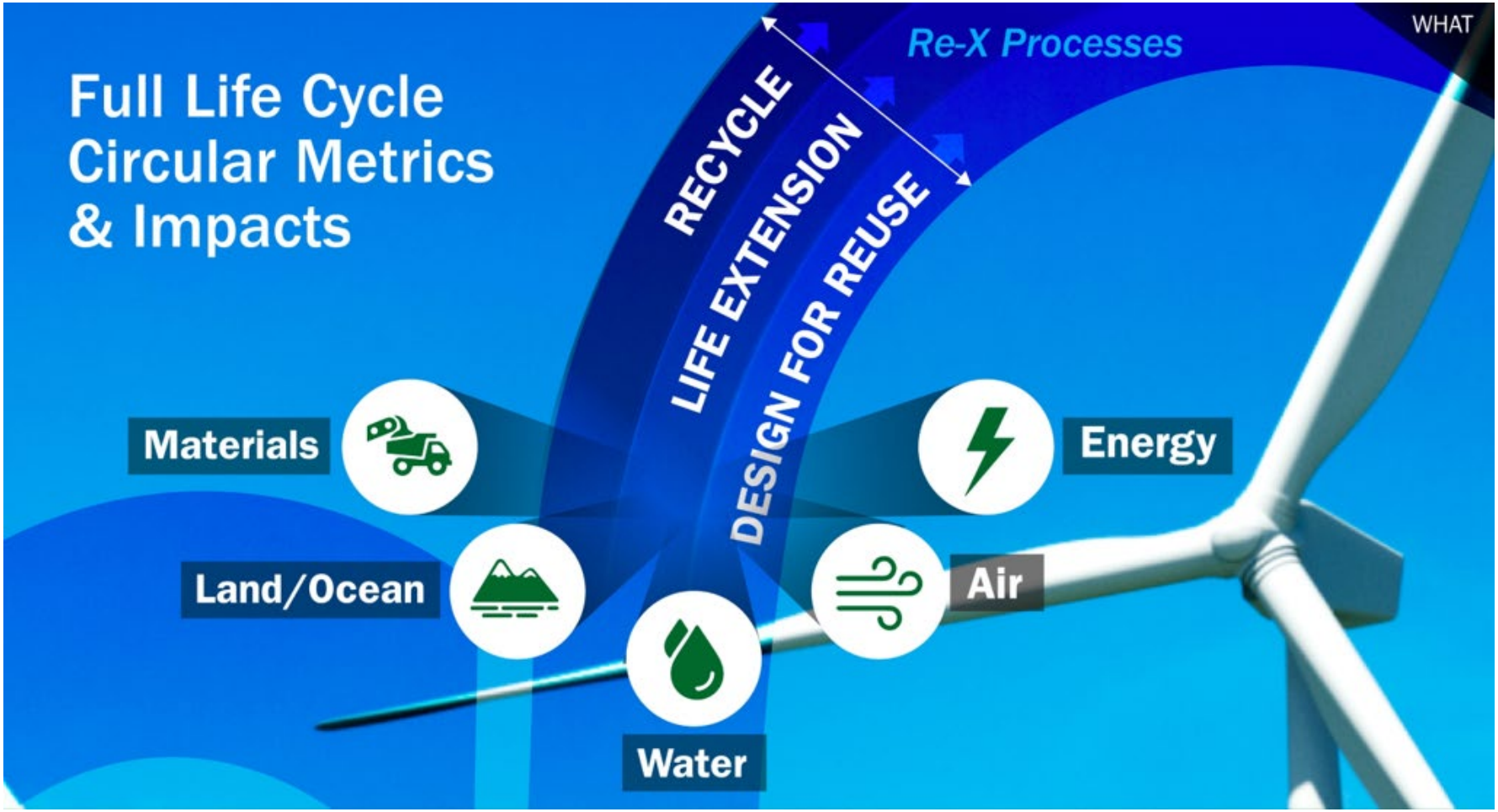
Collaborators: NREL, SNL, ANL ; Montana State University; Domestic and international industry : GE, SKF, WindESCo

Future Priorities (FY21 and beyond)

Strategic Areas/Objectives	Future Priorities	Collaborators
Decrease Manufacturing Cycle Time/Cost (>50%) Increase U.S. Manufacturing Capacity (>3X)	**Goal: Enable Rapid prototyping, improve design flexibility, optimize material use, and increasing domestic manufacturing capacity** • *Advanced manufacturing* methods & integrated tools to decrease cost, time, energy, material usage for more complex geometries: • In-situ data collection with AI, advanced sensors for damage detection, automation/robotics • Optimize wind blade manufacturing through processes such as automated fabrication and finishing to reduce manual operations • Precision manufacturing and serial production of components for OSW	• National Labs • Academia • Industry Stakeholders • Advanced Manufacturing Office • Turbine Manufacturers
Larger, Transportable, Components (Towers >140m; ~120m blades)	**Goal: Enable transportation & installation of larger components for both Land-based wind & future offshore wind** • Novel materials, modular designs, manufacturing for light weighting and near/on-site manufacturing/assembly • Logistics Solutions: Transportation, Installation	• National Labs • Academia • Industry Stakeholders • Turbine Manufacturers
Improve Reliability and lower O&M for larger, novel designs (decrease unplanned maintenance and O&M costs by 50%)	**Goal: Assess and resolve reliability issues, reduce project risk, and increase overall project financial performance to decrease full lifecycle costs.** • Drivetrains: Identify material, design, and operational root causes to drivetrain failures; develop design, control, material, coating, and lubricant solutions; • Develop novel sensing techniques, life data analysis tools, algorithms, • Blade Reliability- Leading edge erosion, lightning damage & protection • Development and improvement of O&M decision-making tools based on prognostic health monitoring	• National Labs • Academia • Industry Stakeholders • International research entities • Small Businesses
Recycling and Circular Economy (near zero waste, fully recyclable)	**Goal: Increase the recyclability and decrease the lifecycle negative impacts of wind energy technologies while ensuring sustainable long-term growth of the industry** • Mature recycling technologies for all wind materials (100% recyclable turbines) • Support new designs and manufacturing practices with lower waste, water use, carbon emissions, and air pollutants • Extend the life of wind energy components • Increase the reusability of wind materials	• National Labs • Academia • Industry Stakeholders • Other EERE Offices • International research entities • Small Businesses

Recycling and Circular Economy Program Introduction

The Energy Act of 2020 includes language instructing WETO to pursue research across the space of circular economy, with special focus on recycling and recovery of wind materials



Thank You

Source: PowerEngineering