U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW

U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

NREL Transforming ENERGY

Sandia National Laboratories

OAK RIDGE National Laboratory

BERKELEY LAB

T03 - Big Adaptive Rotor

Technology RD&T and Resource Characterization - Materials, Manufacturing, and Design Innovation

Nick Johnson

NREL

August 3rd, 2021

FY21 Peer Review - Project Overview

Project Summary:

- **Challenge:** Turbine and rotor scaling have been the main drivers for continuous levelized-cost-of-energy (LCOE) reductions in wind energy during the past decade. Increased rotor size has led to wind power plants with higher capacity factors and less variability in power production. Transportation logistical issues exist for blades > 70m.
- **Approach:** National labs will identify and develop innovative technologies outside of the current industry pathway to enable continued rotor scaling at the lowest possible LCOE as compared to conventional technology.
- **Project Partners**: SNL, NREL, LBNL, ORNL, DNV-GL

Project Objective(s) 2019-2020:

- Advance innovative blade technologies to overcome transportation logistics challenges, and enable the most economical turbines possible
- Assess the historical trends and value of low-specific-power turbines to inform the direction of the project
- Develop requisite modeling capability and complete a detailed design and techno-economic analysis
- Determine R&D pathways for alternative transportation methods
- Assess the impact of optimized carbon fiber materials to enable large lightweight structures

Overall Project Objectives (life of project):

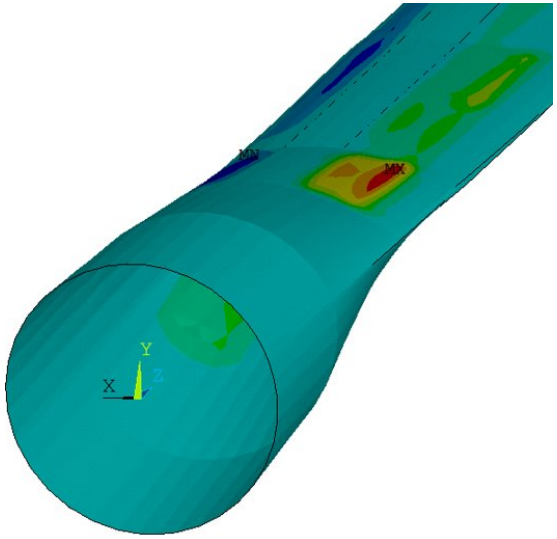
- Develop boundary pushing technologies to reduce the cost of energy and maximize deployment of wind energy.

Project Start Year: 2018
Expected Completion Year: FY2021
Total expected duration: 3 years

FY19 - FY20 Budget: $3,492,411

Key Project Personnel: Nick Johnson – NREL
Josh Paquette (co-PI)– SNL
Mark Bolinger – LBNL
Bob Norris – ORNL

Key DOE Personnel: Ben Hallissy, Mike Derby, Ben Murray, Mike Robinson



Project Impact

Issue

- Trend between low LCOE and low-specific-power
- Scaling trends challenged by technological and logistical transportation barriers.

Approach

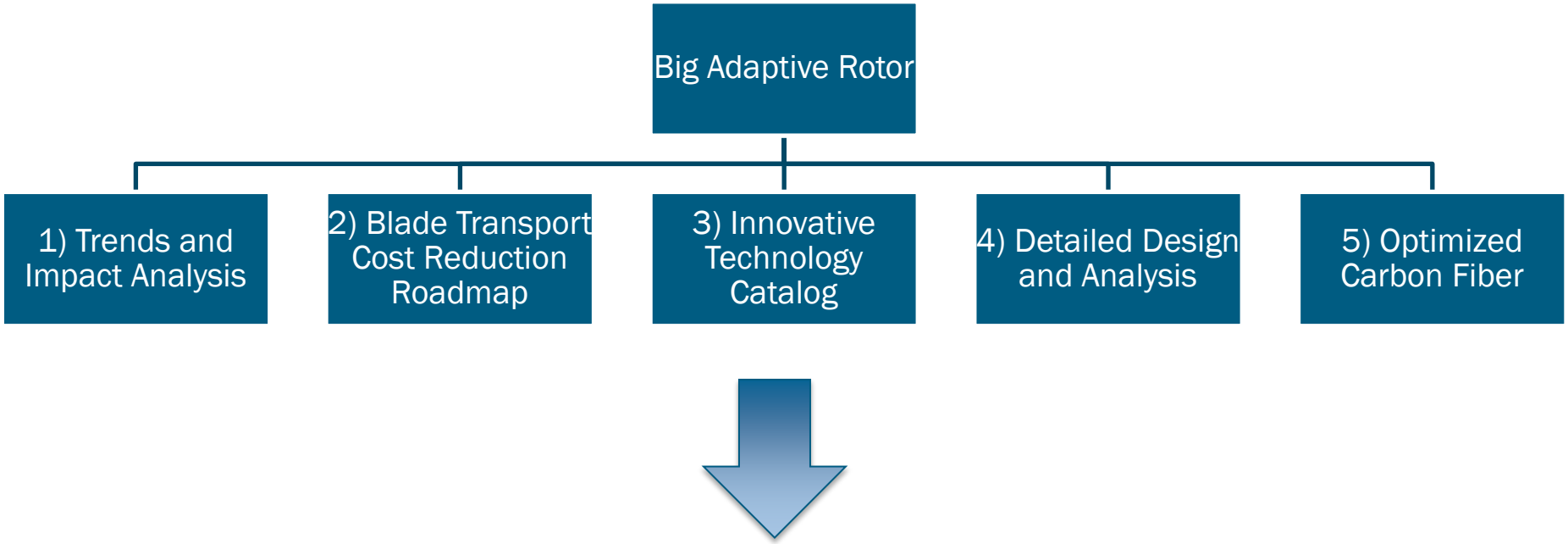
- Determined R&D pathways for transportation challenges
- Identified innovative technologies beyond current industry activity (downwind, highly flexible rail transportable blades, active aerodynamic devices, inflatable blade, bi-wing blade)
- Identified challenges for innovative technologies
- Advanced the state-of-the-art for the innovative concepts
- Developed modeling capability
- Conducted techno-economic analysis and detailed design
- Matured the optimized carbon fiber technology

Result

- Designs with lower LCOE than conventional solutions

BAR designs show LCOE reductions compared to conventional industry designs

Program Performance – Scope, Schedule, Execution

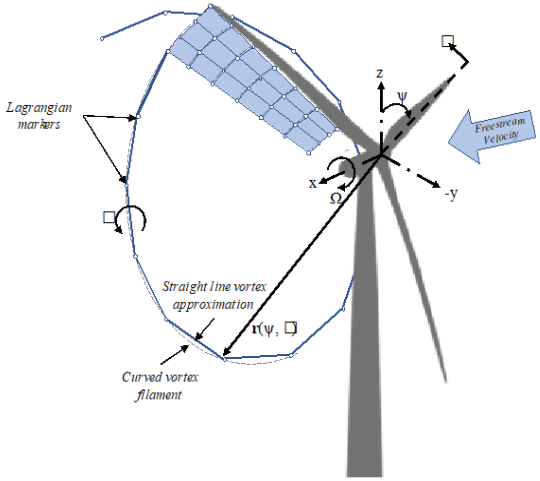


- Lower-SP turbines have reduced LCOE
- Rail-transportable blades have reduced LCOE
- Advanced materials reduce LCOE

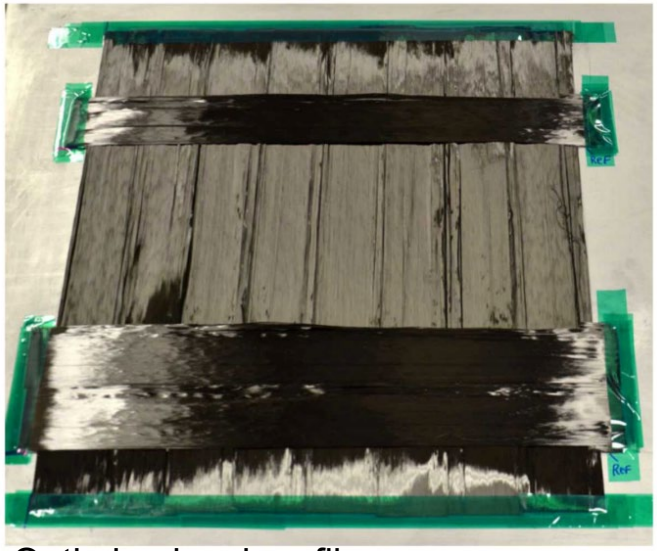
Program Performance – Scope, Schedule, Execution

Key Milestones and Deliverables from **2019**:

- Historical trends for turbine size, specific power, and hub height
- Value of low-specific-power turbines
- 20 innovative concepts evaluated
- Key technical challenges identified
- Modeling gaps identified and upgrades implemented
- Development of optimized carbon fiber

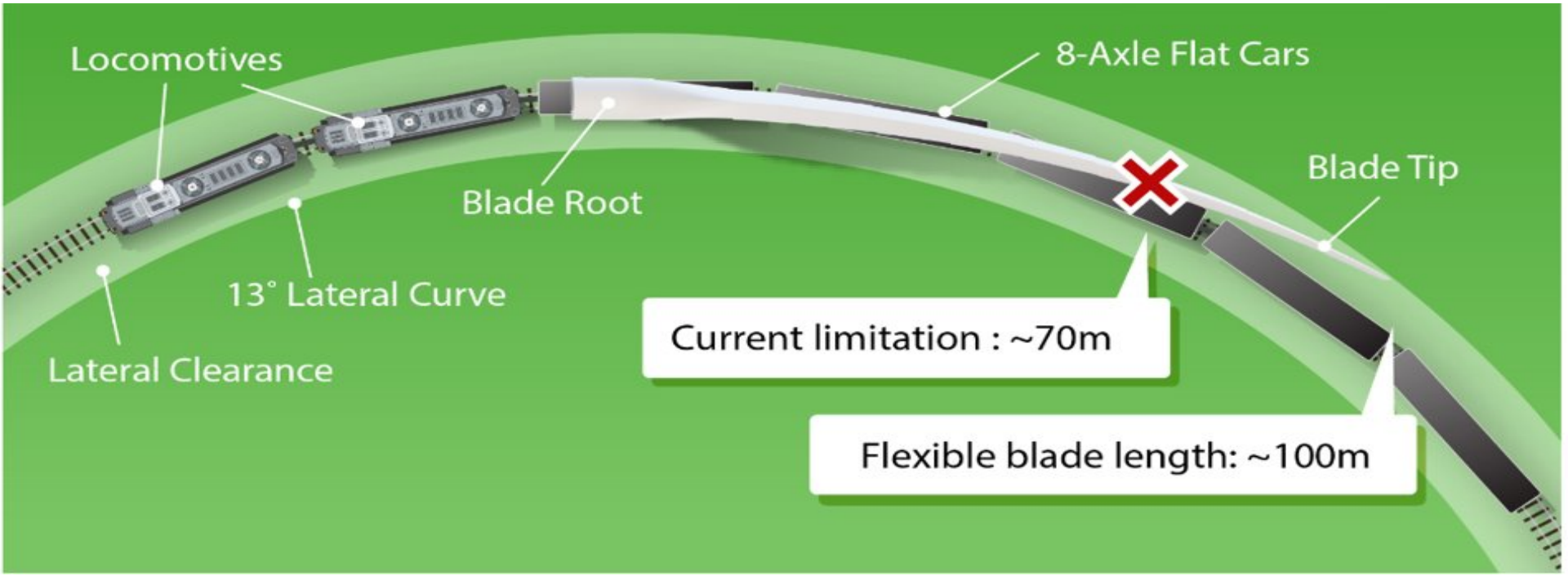


Vortex code implemented in OpenFAST



Optimized carbon fiber

Program Performance – Scope, Schedule, Execution



Key Milestones and Deliverables from **2020**:

- Rail-transport co-design tool in WISDEM
- Active aerodynamic device and blade co-design implementation and analysis
- Detailed designs and initial techno-economic analysis of downwind and highly flexible rail-transportable blades
- Initial design and techno-economic analysis of the inflatable blade and bi-wing rotor concepts

Program Performance – Scope, Schedule, Execution

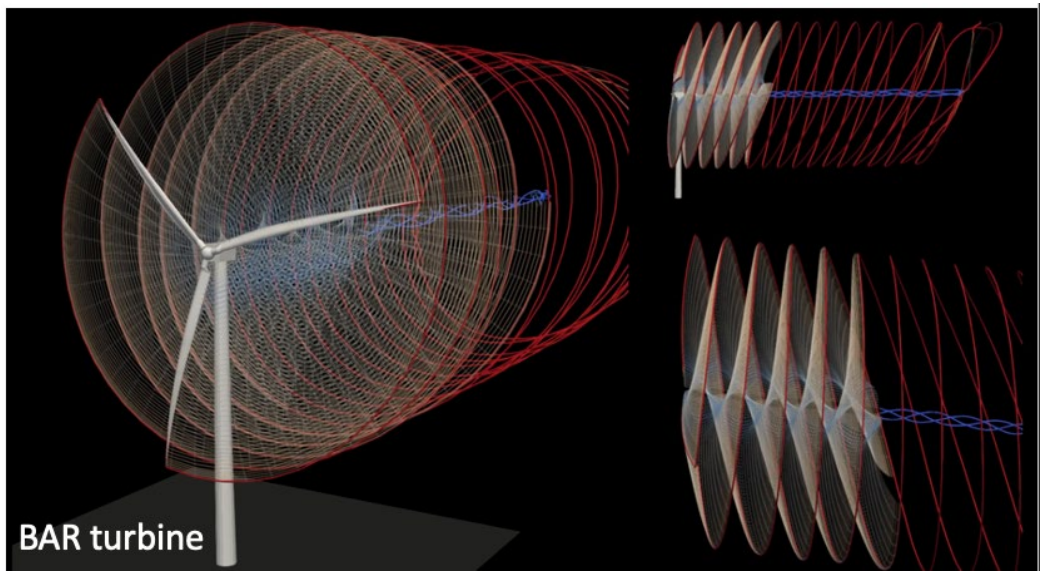
Task	FY19				FY20				FY21	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1: Trends and Impact Analysis										
Trends Analysis for Low-SP Turbines			▲							
Value of Low-SP Turbines				▲						
Geospatial Analysis										
Scaling Analysis							▲			
Task 2: Blade Transport Cost Reduction										
Rail Transportable Blade Study					▲					
Task 3: Innovative Technology Catalog										
Complete Quantative Analysis										
Down-select to 5 Technologies		▲								
Identification of Technology Challenges										
Submit Technical Report and Summary			▲							
Task 4: Detailed Design and Analysis										
Modeling Gaps Analysis										
Complete Model Integration				▲						
Co-Design of Active Aero and Blade						▲				
Detailed Design of Downwind								▲		
Detailed Design of Highly Flexible Blade								▲		
Initial Design of Inflatable and Bi-Wing										
Complete Techno-economic Analysis										
Initial Vortex Validation										
Task 5: Optimized Carbon Fiber										
Analyze and summarize findings of materials								▲		

▲ = Milestone due date

Project Performance - Upcoming Activities

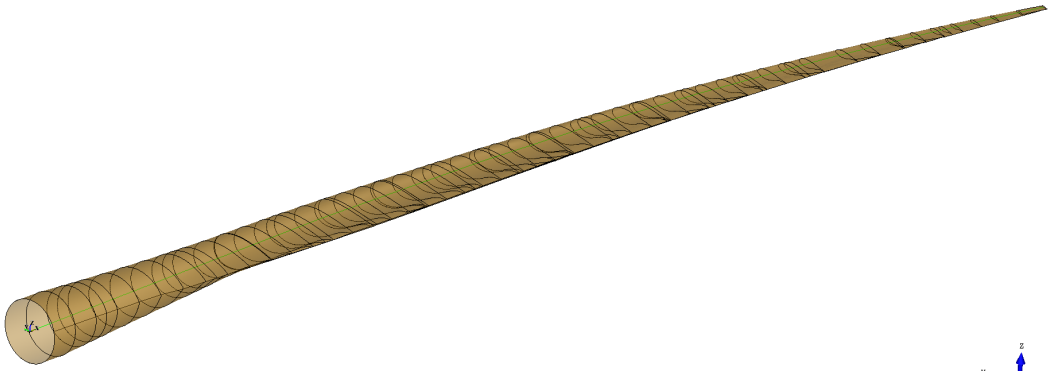
- BAR Phase I concluded March 31, 2021
- Work to be completed in FY21:
  - Complete publications on findings from detailed design studies
  - Complete co-design framework for distributed aerodynamic controls
  - Complete initial verification and validation of newly implemented vortex code
  - Identify technical challenges to be addressed in Phase II
  - Complete work plan and proposal for Phase II
  - Complete final report

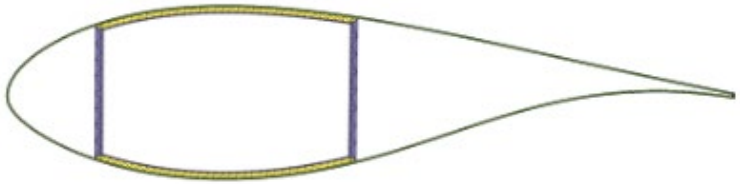
FY19 FY20 FY21



Stakeholder Engagement & Information Sharing

- 13 publications between 2019 and 2020
- Presented at: AWEA, WESC 2019, NAWEA 2019, TORQUE 2020
- Hosted 3 webinars for dissemination of Task 1 and 2 results
- Hosted 5 model trainings
- Regular meetings with the industrial advisory panel
  - Members represent GE, SGRE, TPI composites, DNV-GL, DTU, TUM, and other industry experts.

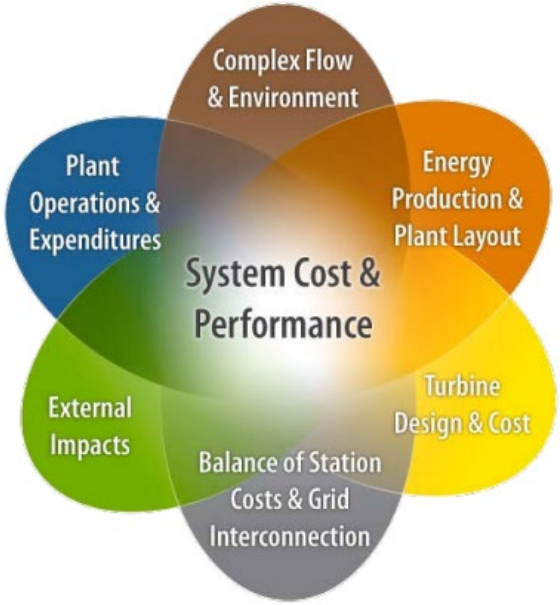




Key Takeaways and Closing Remarks

Project Impact:

- Identified innovative concepts and R&D challenges to reduce LCOE
- Successfully shown that low-specific-power turbines have value beyond LCOE
- There are pathways to continue this industry trend without segmented blades
- Developed advanced computational design and optimization tools that were publicly released



Project Performance:

- Project was successful in completing major milestones on time and on budget

Stakeholder Engagement:

- Industry advisory panel
- Publications and conference presentations