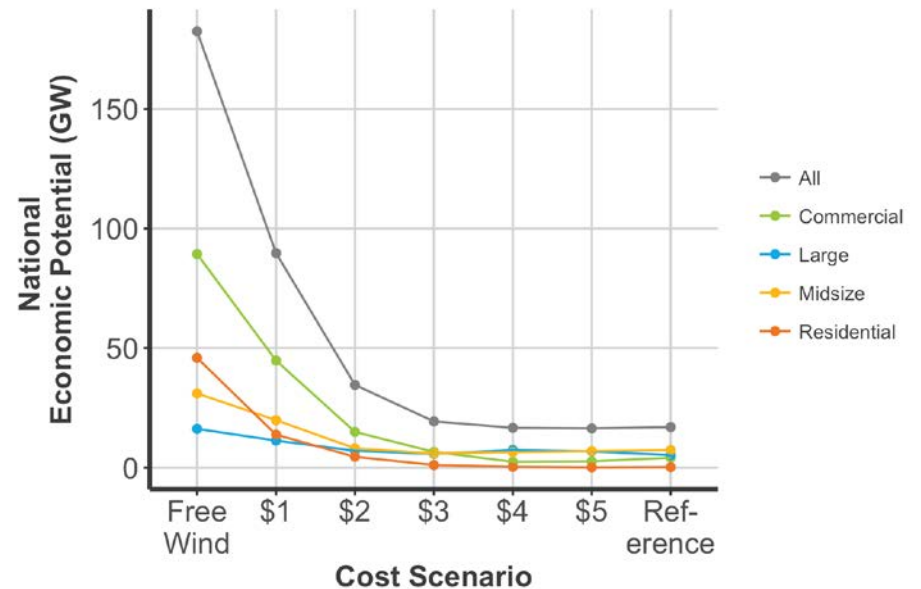


Techno-Economic Modeling, Analysis, and Support for HQ Taskers/Urgent Needs

Project ID #A4

Eric Lantz

National Renewable Energy Laboratory



FY17-FY18 Wind Office Project Organization

“Enabling Wind Energy Options Nationwide”

Technology Development

Atmosphere to Electrons

Offshore Wind

Distributed Wind

Testing Infrastructure

Standards Support and International
Engagement

Advanced Components, Reliability, and
Manufacturing

Market Acceleration & Deployment

Stakeholder Engagement, Workforce
Development, and Human Use Considerations

Environmental Research

Grid Integration

Regulatory and Siting

Analysis and Modeling (cross-cutting)

Project Overview

A4: Techno-Economic Modeling, Analysis, and Support for HQ Taskers/Urgent Needs

Project Summary

- This project provides analytic support at the request of the Wind Energy Technologies Office to meet needs that arise from executive leadership, Congress, senior EERE management, and the WETO director.

Project Objective & Impact

- The objective of this project is to provide subject-matter expertise in economic, technological, policy, and other analysis, in direct support of the wind program, especially for high-priority needs.

Project Attributes

Project Principal Investigator(s)

Eric Lantz (Lead)
Trieu Mai
Ben Sigrin
Galen Maclaurin
Carol Laurie

DOE Lead(s)

Patrick Gilman (Lead)
Richard Tusing (Senior Advisor)
Daniel Beals (Activity Lead)

Project Partners/Subs

Renewable Energy Consulting Services
Others, depending on needs

Project Duration

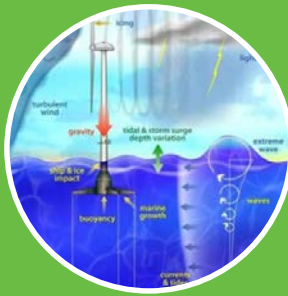
2 years: FY17 and FY18

Technical Merit and Relevance

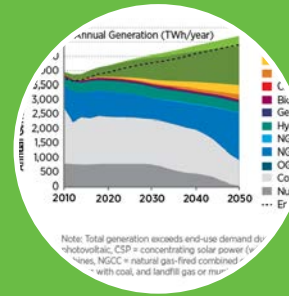
Project Scope: Research spans turbine component modeling to system integration of wind across the U.S.



Land-Based
Technology
Characterization



Offshore Wind
Technology
Characterization



Electric Sector
Modeling



Wind Energy
Integration
Analysis (e.g.,
grid, society,
economics, radar)



Potential scope executed in this project extends beyond that of other analysis efforts, depending on the specific needs and priorities of the moment and the specific leadership

Technical Merit and Relevance

- **This project provides subject-matter expertise for:**
 - High-priority responsive analysis
 - Executive, congressional, and senior management requests
- **Expertise is often requested that is focused on:**
 - Wind technology
 - (Techno) economics
 - Policy
 - Capacity expansion modeling
- **Example requests during the period of review include:**
 - Impacts from potential radar setbacks on wind power's technical potential
 - Impacts from broad-based, wildlife-driven curtailment on wind energy generation and revenue
 - Economic development impacts from wind power deployment
 - Analysis to inform offshore wind cost targets

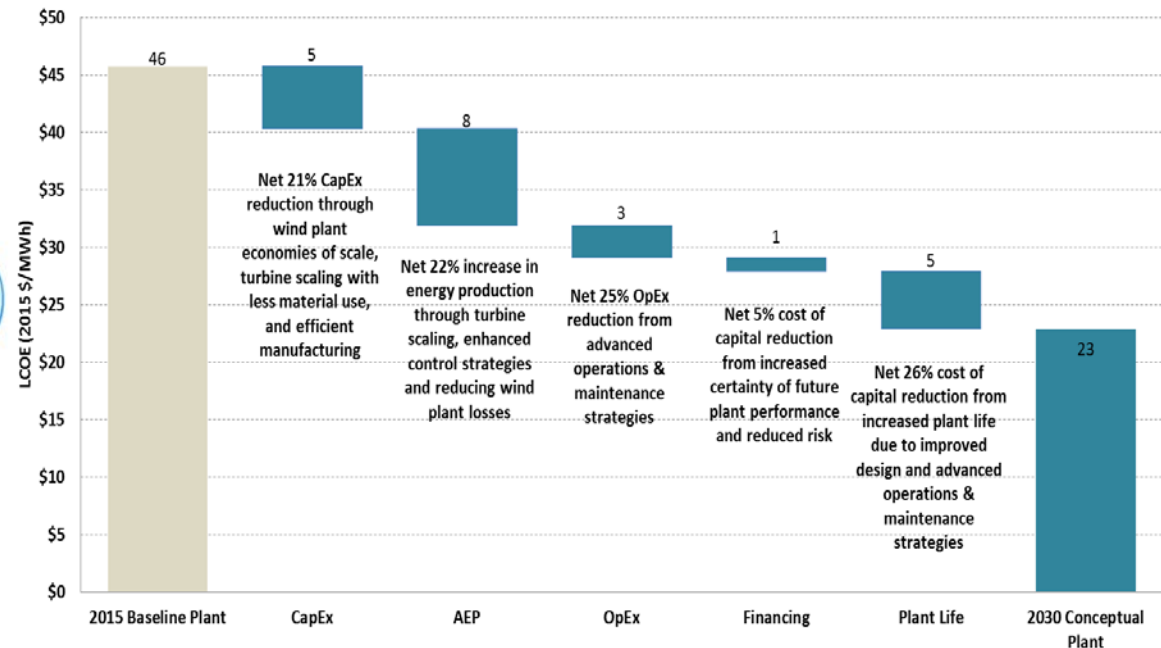
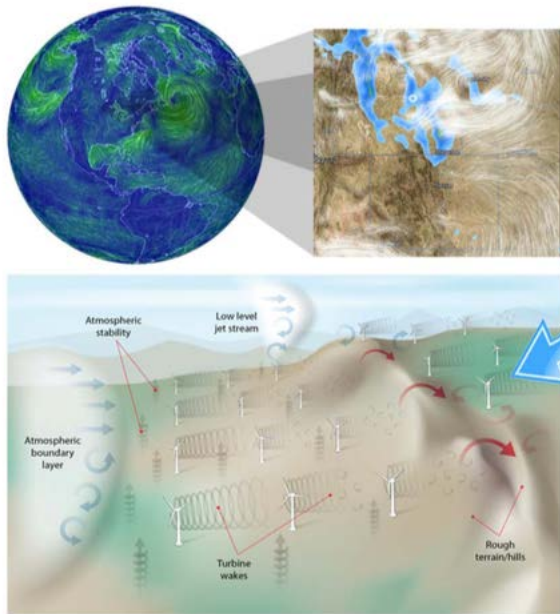
Approach and Methodology

Methods in this project are always tailored to the specific research question. Core capabilities include:

- **Techno-economic cost modeling**
- **Capacity expansion modeling**
- **Cash-flow analysis**
- **Wind power system analysis**
- **Semi-structured interviews**
- **Policy analysis**
- **Case study synthesis and evaluation**

Accomplishments and Progress: Land-Based Wind Technology Characterization

- **Goal:** Characterize the cost-reduction pathway for wind technology resulting from programmatic investments in wind energy science
- **Product:** “Enabling the SMART Wind Power Plant of the Future Through Science-Based Innovation” (Dykes et al. 2017)

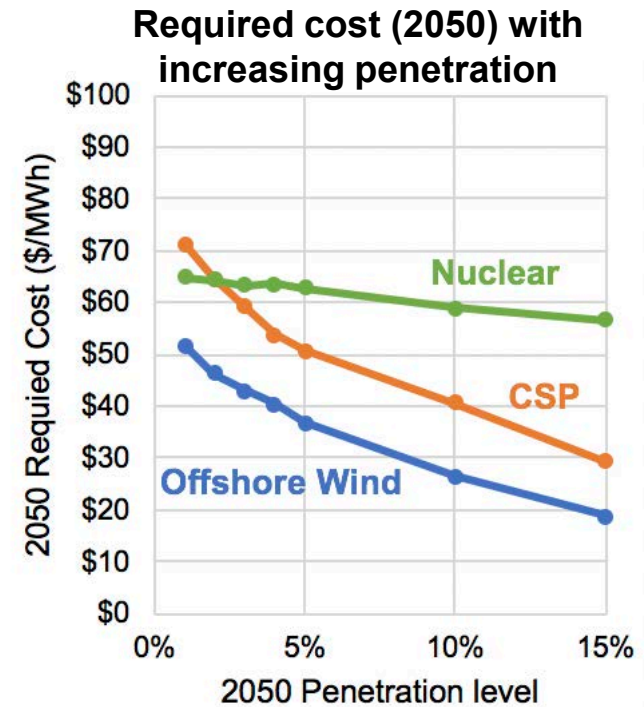
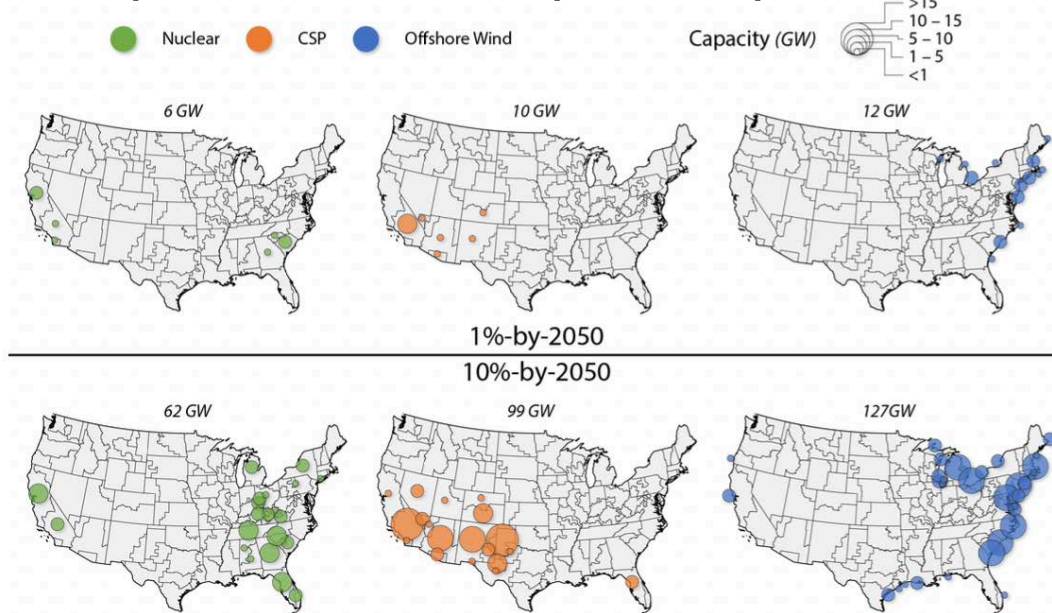


Analysis of science-driven levelized cost of energy reduction potential indicates that capital expenditures and annual energy production remain the most significant drivers of continued cost decline

Accomplishments and Progress: Offshore Wind Technology Characterization/Electric Sector Modeling

- **Goal:** Illuminate cost levels for offshore wind required to achieve increasing offshore wind penetration
- **Product:** “Setting Cost Targets for Zero-Emission Generation Technologies” (Mai et al. in process)

Modeled locations of deployment for nuclear, concentrated solar power and offshored at prescribed penetration levels



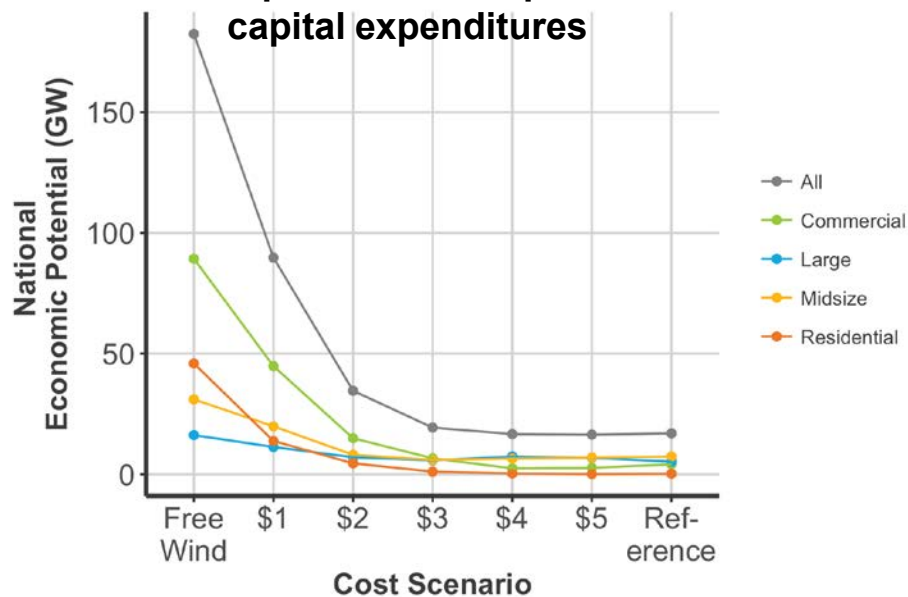
Achieving 5% of total U.S. electricity supply from offshore wind could require costs as low as 4 cents/kWh in 2050, if land-based wind, solar PV, and natural gas maintain their current cost trajectories

Accomplishments and Progress:

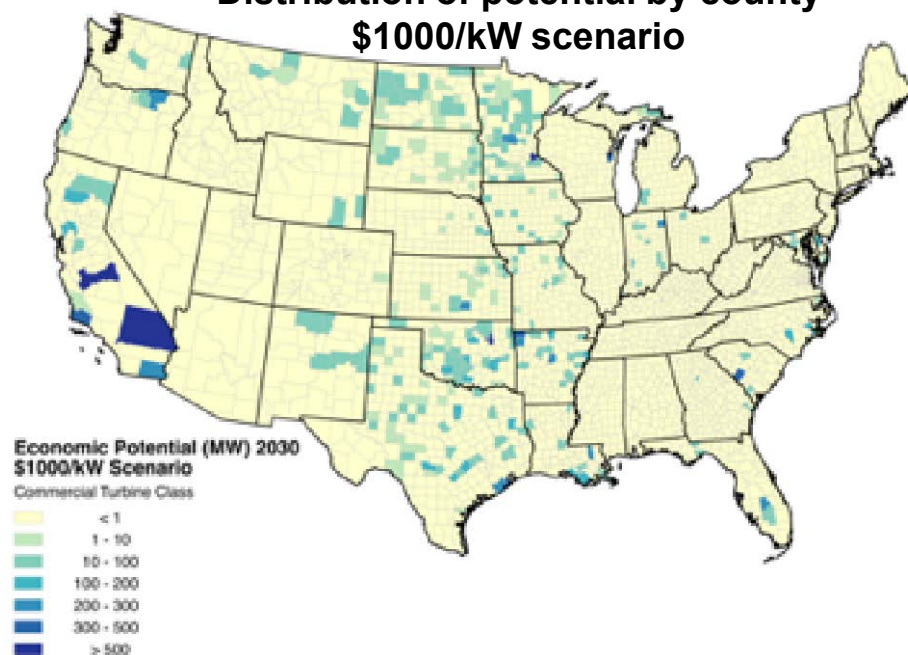
Electric Sector Modeling

- **Goal:** Illuminate cost levels for distributed wind required to achieve increasing economic potential
- **Product:** Internal sensitivity analysis explored the change in economic potential associated with reductions in plant capital expenditures (Sigrin et al. internal analysis)

Relationship of economic potential and capital expenditures



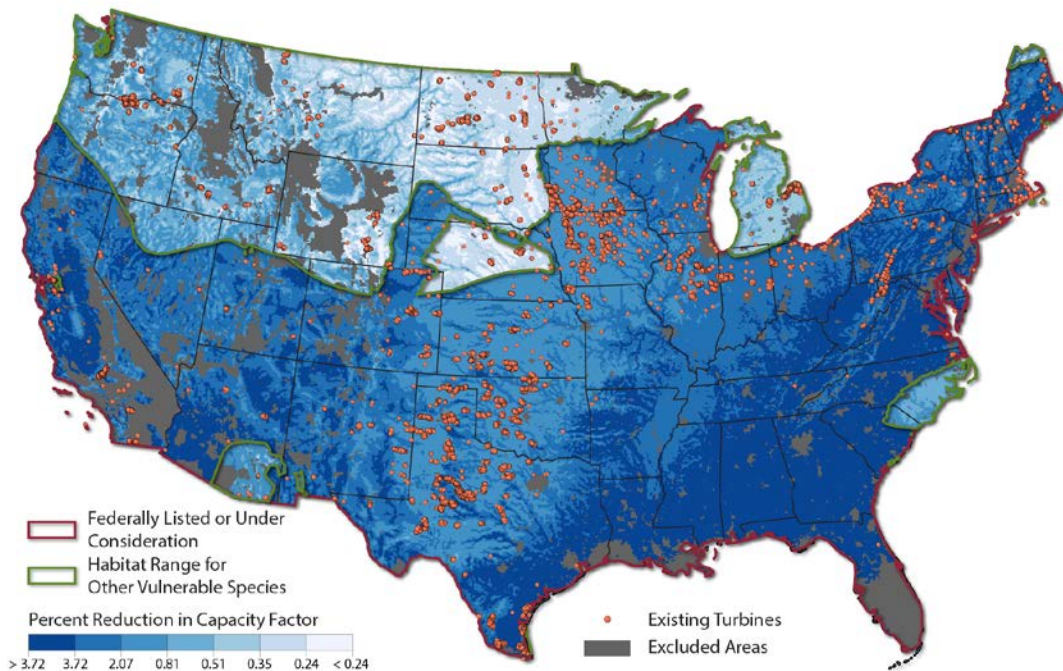
**Distribution of potential by county
\$1000/kW scenario**



Reduction of distributed wind capital expenditures to \$2/W increased potential to 4.5 GW in the residential-scale segment and 14.9 GW in the commercial-scale market; this represents a 20-times and nearly 4-times increase over the reference case projection for these respective market segments

Accomplishments and Progress: Wind Energy Integration Focused Analysis

- **Goal:** Begin to characterize and quantify the impact to capacity factor at continental scale from broad-based curtailment conditions
- **Product:** Internal analysis and power point summary (Maclaurin and Lopez)



On average, capacity factor impacts for the high scenario are on the order of 2%; however, the variance is quite large, indicating that location matters a great deal

*High scenario: Curtail generation when wind speed is below 6.9 m/s (red) or 5 m/s (green) from April through October

Accomplishments and Progress: Sampling of Other Activities

“Jobs and Economic Development Impacts analysis of Xcel Energy’s Rush Creek Wind Farm” (Stefek et al. in process)

“Status Update and New Priorities for the DOE Wind Vision Technology Roadmap” (DeMeo et al. 2018)

“Internal assessment of turbine scaling trends and projections, to inform future radar planning dialogue” (internal analysis)

“Evaluation of impacts from radar setbacks of various forms” (internal analysis)

“50-state wind resource map for AWEA Offshore conference” (October 2017)

“Exploratory estimate of “behind-the-meter” wind resource potential supporting WETO Multi-year Program Plan” (internal analysis)

Milestones and Schedule: FY17-FY18

- Formal milestones listed in narrative summary of project—not repeated here
- Often milestones are “dynamic” and established once priorities are known and articulated
- In practice, additional deliverables may be completed beyond formal milestones, or funds may be carried over into future years
- **All go/no-go decision points achieved: go/no-go decision points:**
 - FY17: N/A
 - FY18: Proceed to drafting either an NREL technical report draft manuscript or a draft journal article, based upon JEDI Rush Creek Wind Project data collection activities and outcomes during the first half of the fiscal year: **Go**, draft NREL Technical Report

Communication, Coordination, and Commercialization

This project includes an array of outreach and dissemination activities focusing on the full wind analysis portfolio, including:

- **Articles in the NREL wind newsletter**
- **Program news articles on nrel.gov**
- **Conferences (papers, posters, and speaking engagements)**
- **Social media (Twitter and LinkedIn)**
- **Articles in the WETO R&D newsletter**
- **Website content**

Communications Products Featured in Newsletters and DOE/NREL Outreach Products

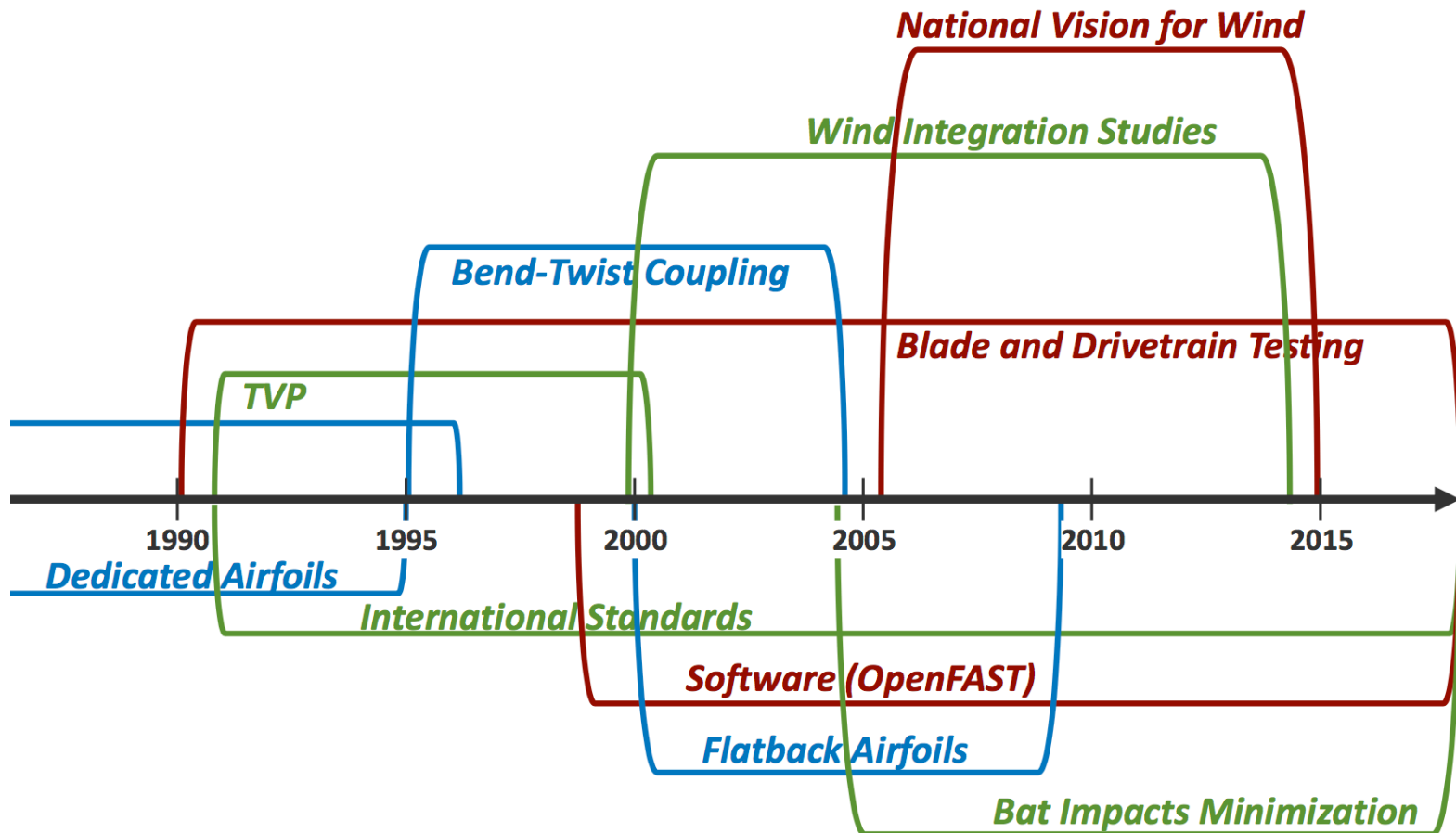
- **“Policies, Performance, and Prices Promise Wind Industry Growth,” August 28, 2018**
- **“Wind Energy Curtailment Greatly Reduced with Longer Duration Storage,” August 14, 2018**
- **“Minimum Generation Is Key to Maximum Renewable Integration,” February 28, 2018**
- **“NREL Researcher Advises on New International Offshore Wind Designs,” July 3, 2018**
- **“Working Groups Tackling Wind Performance and Estimation Accuracy,” June 20, 2018**

Social Media: Survey of Early Efforts

- **Wind Analysis Twitter Statistics**
 - Served to people’s feeds more than 12,000 times
 - Users engaged with this content by liking, clicking, expanding, or sharing the posts 151 times
 - The average engagement rate for these posts was 1.6%, as compared to an average engagement rate across all industries of 0.05%.
- **Applied Energy journal article posted on LinkedIn:**
 - “Analyzing storage for wind integration in a transmission-constrained power system.”
<https://www.linkedin.com/pulse/storage-delivery-wind-energy-paul-denholm/?published=t>
- **A. Lopez presentation at the CARTO Locations conference**
 - Facebook (NREL), Posted May 23, 2018
 - LinkedIn (NREL), Posted May 23, 2018
 - Twitter (@Mech_Therm), Posted May 18, 2018, Posted May 23, 2018
- **W. Musial and G. Barter presentations at the U.S. Offshore Wind 2018 Conference**
 - Facebook (NREL), Posted June 7, 2018
 - LinkedIn (NREL), Posted June 7, 2018
 - Twitter (@Mech_Therm), Posted June 1, 2018; Posted June 5, 2018, Posted June 11, 2018
- **J. Lee presentation at the European Meteorological Society Annual Meeting 2018**
 - Facebook (NREL), Posted September 7, 2018
 - Twitter (@Mech_Therm), Posted September 5, 2018, Posted September 7, 2018

Upcoming Project Activities

- Evaluation and analysis of major wind innovations and WETO's role



Upcoming Project Activities

- Dissemination of work exploring types and quantities of required grid services and wind's ability to support the grid
- New study evaluating curtailment of wind and solar (co-funded by DOE SETO) as a means to provide grid services and dispatchable power

