Distributed Wind in Rural America

Michael Leitman, Senior Analyst, Economics & Business
NRECA RADWIND Project Manager
(michael.leitman@nreca.coop)

March 3, 2020

2020 TECHADVANTAGE® EXPERIENCE

PNNL-SA-151038

Distributed Wind Market Overview

Alice Orrell
Pacific Northwest National Laboratory
March 3, 2020

What is Distributed Wind?

750 kW NEG Micon / Basin Electric Power Cooperative

Photo Credit: Jeff Ledermann / Minnesota Pollution Control Agency

Delta Junction Wind Farm / Golden Valley Electric Association
Two 900 kW EWT, one 100 kW NPS, and seven 2.4 kW Skystream wind turbines

Photo Credit: Mike Craft

Bergey 15 kW wind turbine / Cass County Electric Cooperative

Photo Credit: Bill Schwankl / Alternative Energy Services

Hybrid Systems: Wind and Solar PV

Small Scale Example

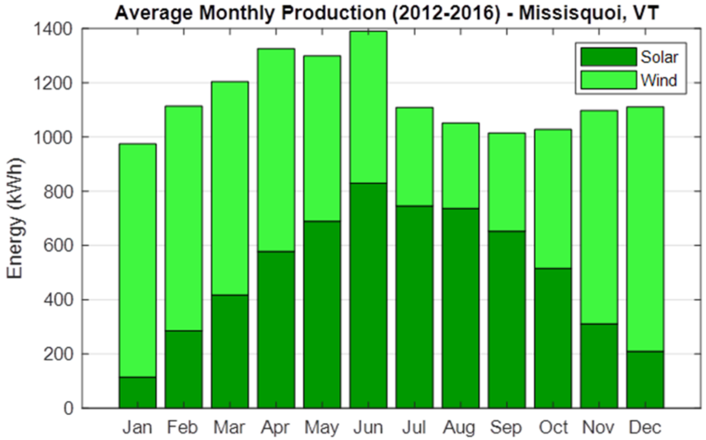


Photo Credit: Bergey Windpower

The 10-kW wind turbine and 15-kW solar PV array at Missisquoi National Wildlife Refuge (serviced by Vermont Electric Cooperative) demonstrate wind generation's complementary value to solar PV generation on a monthly basis.

Hybrid Systems: Wind and Solar PV

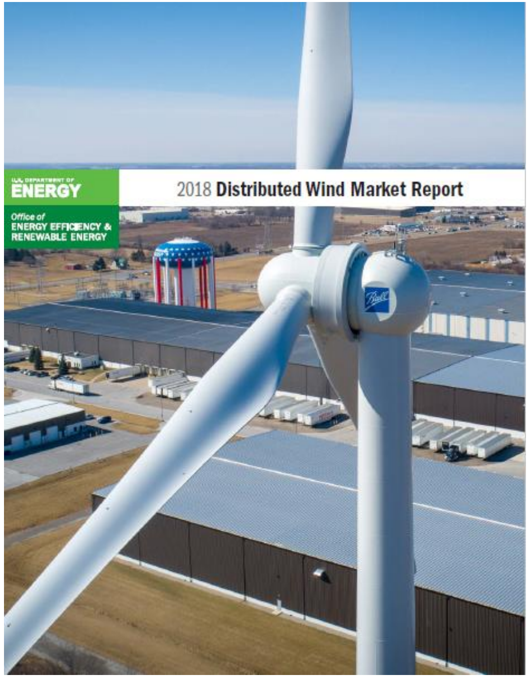
Large Scale Example

- 2.7-MW wind turbine and 500 kW solar PV array combined through General Electric's Wind Integrated Solar Energy technology platform.
- The energy produced will be distributed over local Lake Region Electric Cooperative power lines and help provide rate stability for the entire cooperative membership.

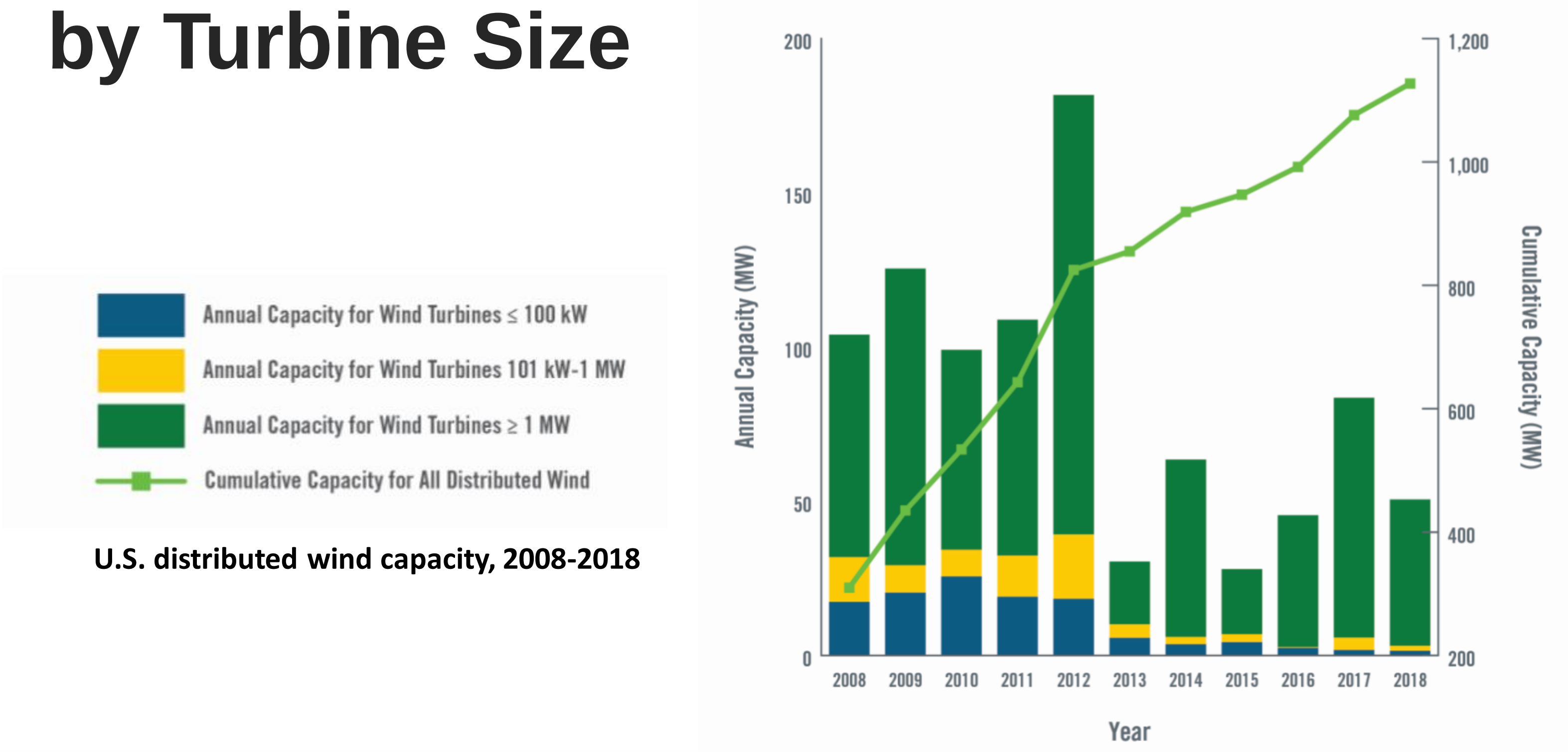
Photo Credit: Lake Region Electric Cooperative

Annual Distributed Wind Market Reports

- Deployment
- Projects, Sales, and Exports
- Policies, Incentives, and Market Insights
- Cost Trends
- Turbine Performance
- Levelized Cost of Energy
- And More

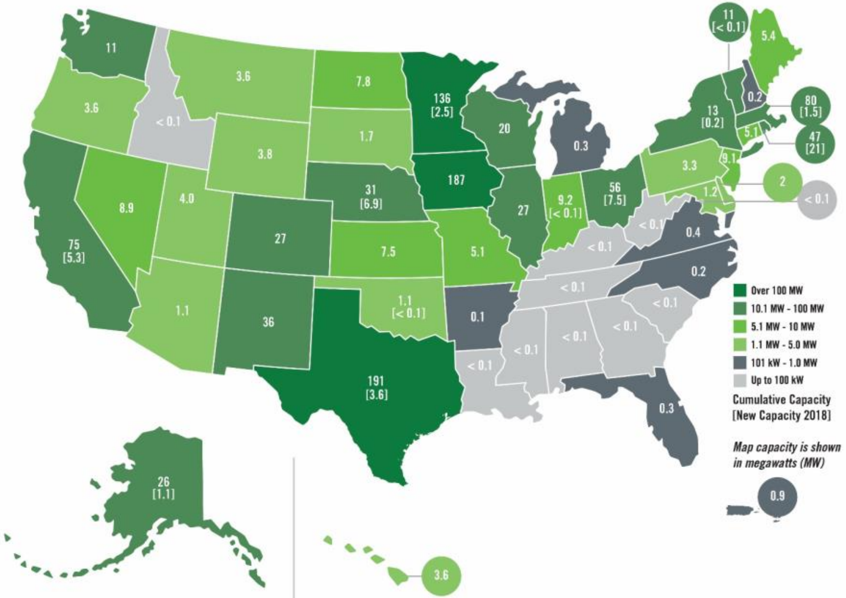


U.S. Distributed Wind Deployment by Turbine Size



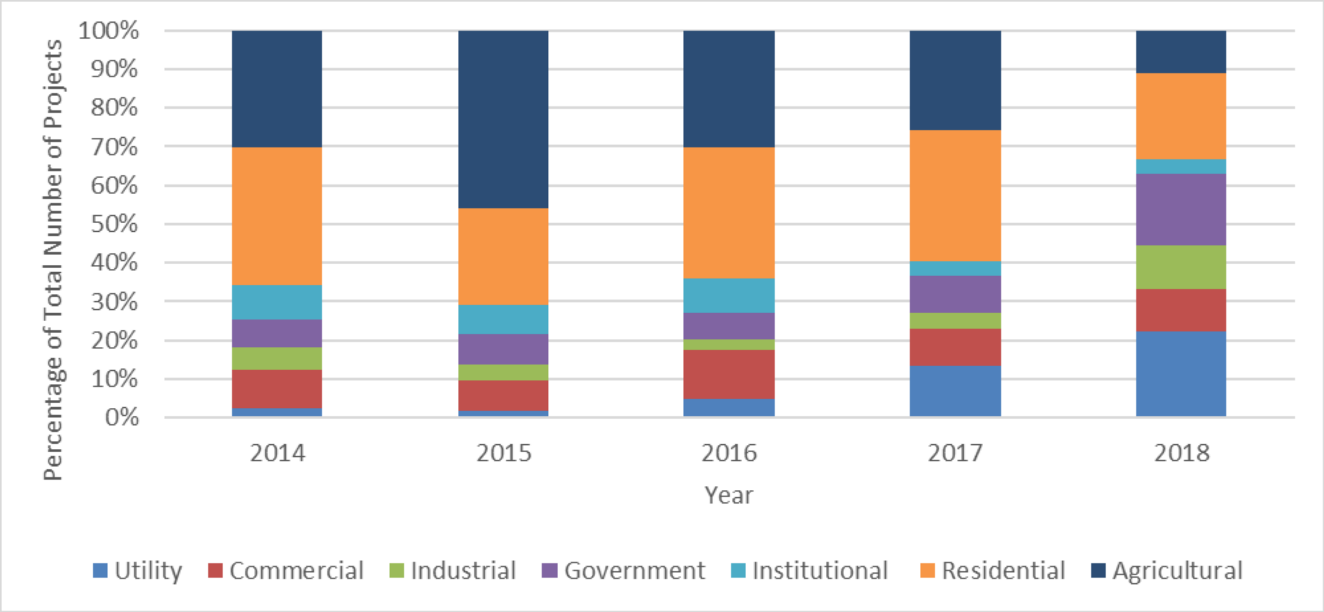
U.S. distributed wind capacity, 2008-2018

U.S. Distributed Wind Deployment by State



U.S. cumulative (2003–2018) capacity and 2018 capacity additions for distributed wind by state

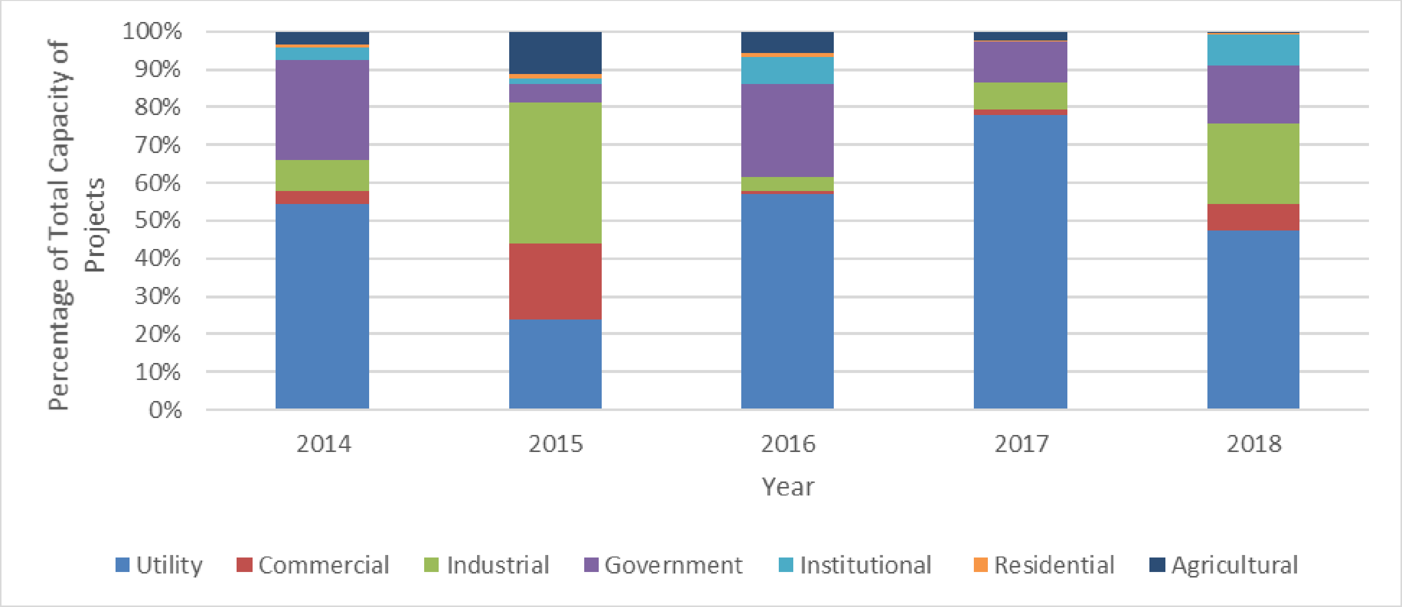
U.S. Distributed Wind Deployment by Customer Type - Number of Projects



Distributed Wind Customer Types by Number of Projects, 2014-2018

Draft. The final graphic and data will be presented in the 2019 Distributed Wind Market Report.

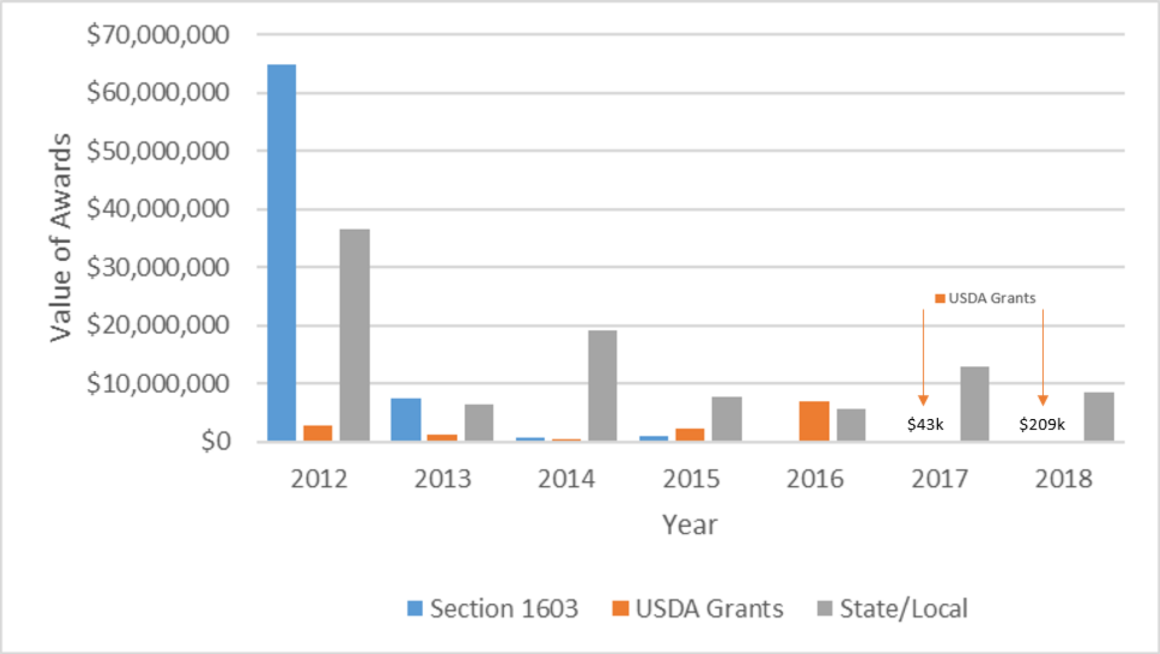
U.S. Distributed Wind Deployment by Customer Type - Capacity of Projects



Distributed Wind Customer Types by Capacity of Projects, 2014-2018

Draft. The final graphic and data will be presented in the 2019 Distributed Wind Market Report.

U.S. Distributed Wind Incentive Awards



Distributed Wind Incentives, 2012-2018

Draft. The final graphic and data will be presented in the 2019 Distributed Wind Market Report.

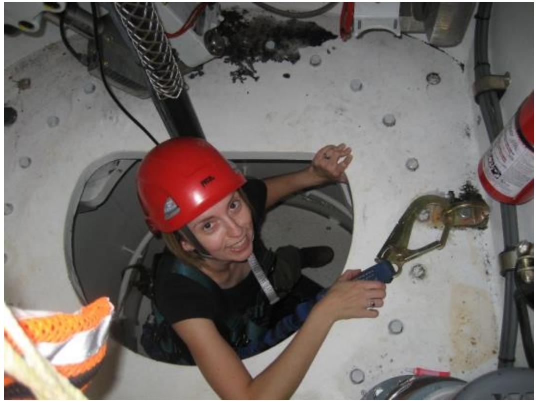
Takeaways

- Distributed wind deployment varies from year to year, by turbine size, by state, and by customer type.
- Market conditions, policies, and customer demands do not impact the different sectors of the distributed wind market uniformly.
- Small wind turbine projects can be good fits for farms and homes in rural areas with strong wind resources.
- Large-scale turbine projects are likely to continue to dominate distributed wind capacity deployment.

Photo Credit: © David Nevala Photography for CROPP Cooperative

Photo Credit: Jake West / Van Wall Energy

Contact Information



Alice Orrell

alice.orrell@pnnl.gov

509-372-4632

https://wind.pnnl.gov/distributedwind.asp

U.S. DEPARTMENT OF ENERGY

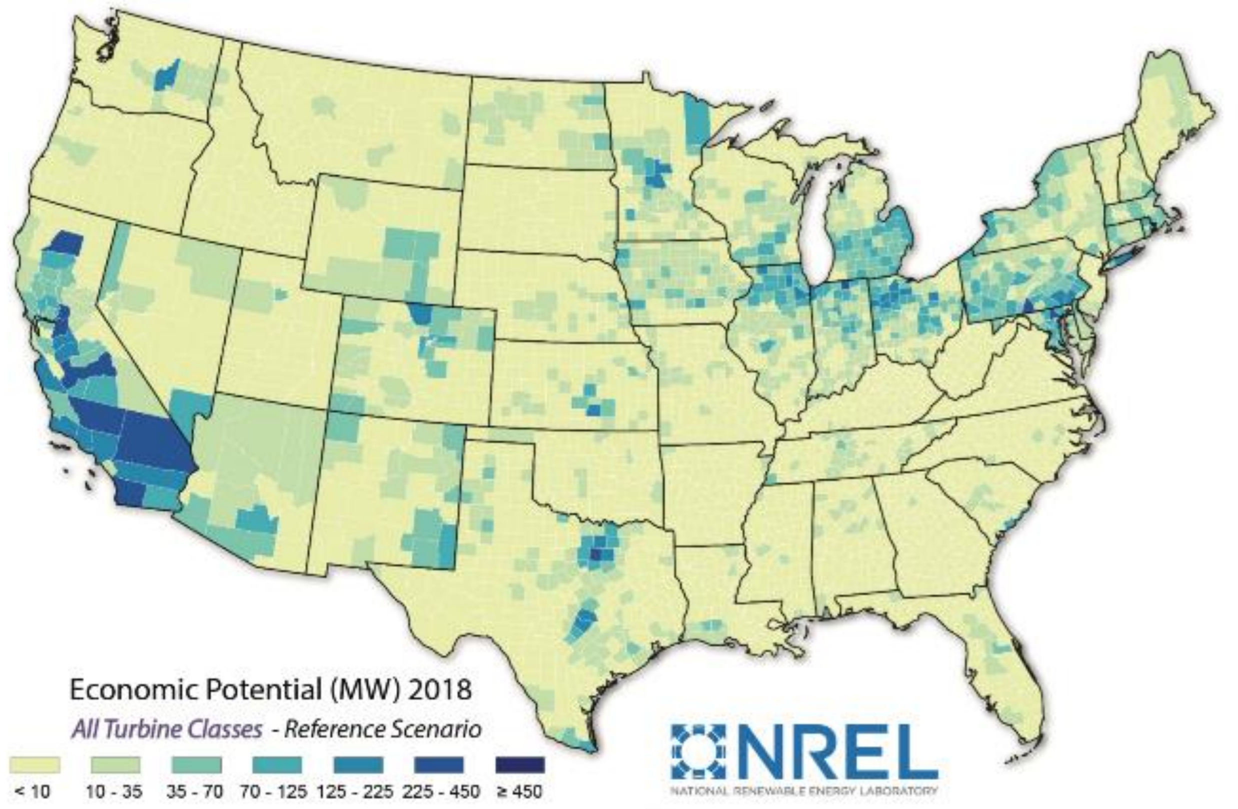
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Advancing Wind as a Distributed Energy Resource

Patrick Gilman, Program Manager, Wind Energy Technologies Office

Distributed Wind in Rural America , TechAdvantage, March 3, 2020 | New Orleans, LA

NREL Analysis Shows Significant Economic Potential



Modeled Distributed Wind Economic Potential Map for All Turbine Classes by U.S. County Source: Assessing the Future of Distributed Wind (NREL, 2016)

- Through 2019, cumulative U.S. distributed wind installed capacity is greater than 1 GW
- R&D investment could unlock more - an estimated 48 GW of economic potential deployed profitably in 2030, and more than 85 GW in 2050
- DOE seeks to advance distributed wind through R&D at the national labs and cost-shared partnerships with academia and industry

Goals, Challenges, and Opportunities

Our Goal:

Enable wind technology as an affordable, accessible and compatible Distributed Energy Resource (DER) option for individuals, businesses, and communities building smart energy systems and resilient infrastructure.

Challenges and Opportunities We See:

1) Reduce hardware cost and increase performance, particularly for systems under 1 MW

2) Improve distributed wind site assessment and evaluation tools

3) Reduce soft costs and barriers to deployment, especially for rural electric utilities and communities

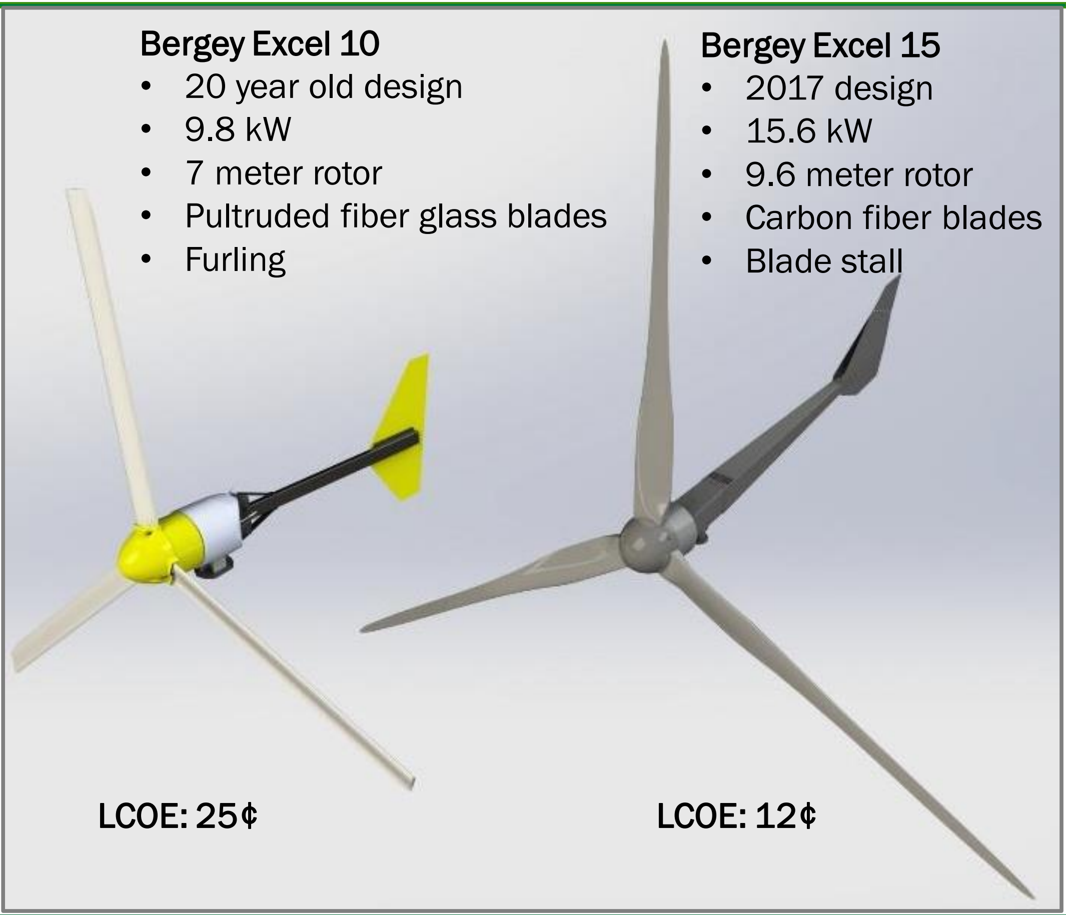
4) Enable plug-and-play integration of wind energy technology with other distributed resources at multiple scales

Competitiveness Improvement Project (CIP)

Small and medium wind installed costs have not experienced the same reductions as solar PV and large wind technology over the past 10 years. The pace of innovation in distributed wind needs to accelerate.

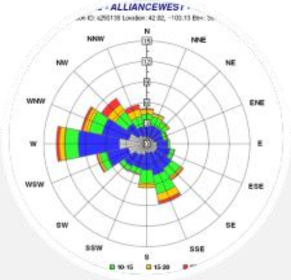
Through CIP, we partner with small and medium wind technology manufacturers to:

1. Develop optimized designs for increased energy production and grid support
2. Conduct turbine testing to national standards to verify performance and safety
3. Develop advanced manufacturing processes to reduce hardware costs

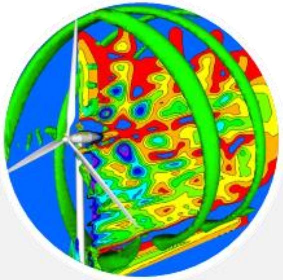


Tools Assessing Performance (TAP)

Stakeholder Engagement



Wind Resource Dataset



Flow Modeling

Computational Framework

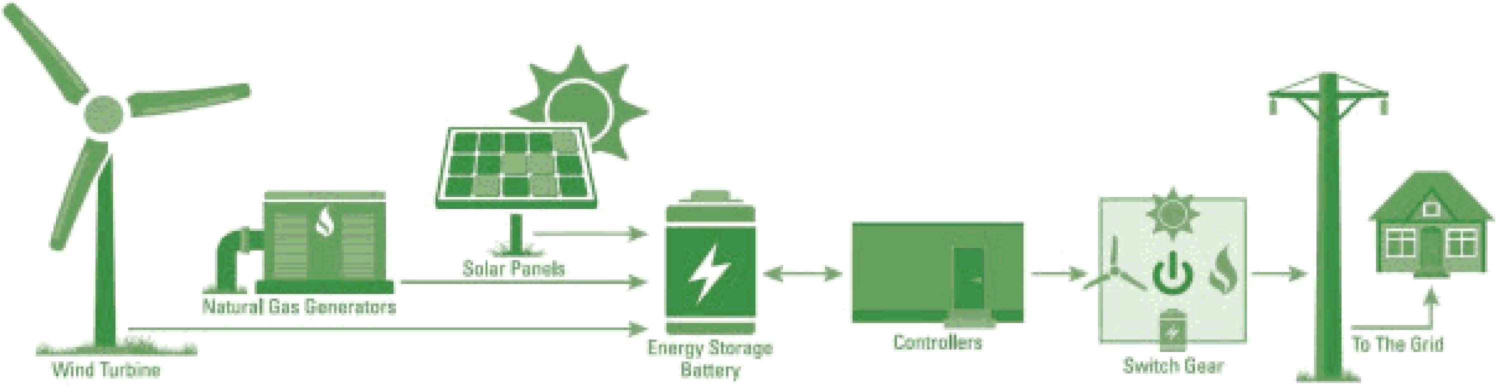
User-facing Tool Design

Accurately predicting distributed wind performance is essential to enable scale, <u>But</u>

- Standard wind resource campaigns are too costly and time consuming
- Current modeling approaches are not good enough

TAP is aiming at bankable desktop site assessment and performance estimation

Microgrids, Infrastructure Resilience and Advanced Controls Launchpad (MIRACL)



Collaborative research to advance wind-hybrid distributed energy systems to provide flexibility, security, and resilience to distribution systems and microgrids, R&D priorities include:

- Accurately value grid system contributions from wind as a DER
- Advance controls for wind-hybrid DER systems
- Understand and guard against cyber threats in distributed wind applications

Wind Innovations for Rural Economic Development (WIRED)

WIRED Workshop held October 2018, workshop report released December 2018

- Developed a better understanding for the challenges and opportunities facing rural electric utilities with development of wind and other distributed energy resources

2019 Funding Opportunity Announcement provided $6M across 2 WIRED topics

1. Wind-hybrid solutions to support utility operations, enhance end user benefits, and show broad applicability to the rural electric utility market
2. Standard solutions to reduce the technical risk and market barriers impacting the time and cost of stand-alone and wind-hybrid DER system deployment for rural electric utilities.

4 WIRED FOA Proposals Selected

Topic 1: Wind-hybrid solutions to support utility operations

IOWA STATE UNIVERSITY — System design tools and controls development to enable rural utilities to leverage distributed wind in coordination with other DERs to shave peak demand and provide emergency power.

EPRI — System planning, design, and operating tool development for cost effective and reliable operation of wind energy and battery storage on distribution networks.

Topic 2: Standard solutions to reduce the technical risk and market barriers

NRECA America's Electric Cooperatives — Evaluation of wind as a DER at multiple scales to establish business cases, define standardized engineering solutions, and develop best practices for cost effective rural electric utility development of distributed wind projects

BERGEY WINDPOWER — Evaluation of a business model in which rural electric utilities sell, finance, and install wind hybrid micro-grid systems to their customers to provide energy costs savings and back up power

Takeaways

- DOE is working to advance wind as a distributed energy resource
- Analysis suggests significant potential market opportunity but adoption slow and there are significant challenges
- To overcome these challenges, DOE is working to:
  - Develop low cost, efficient wind technology optimized for DER applications
  - Improve characterization of wind energy in next generation DER planning, design and operating tools
  - Enable wind as plug-and-play option for distribution systems, flexible hybrid DER systems and microgrids
  - Reduce soft costs and barriers to adoption, particularly by rural utilities and communities

Huerfano River Wind

Clinton Smith

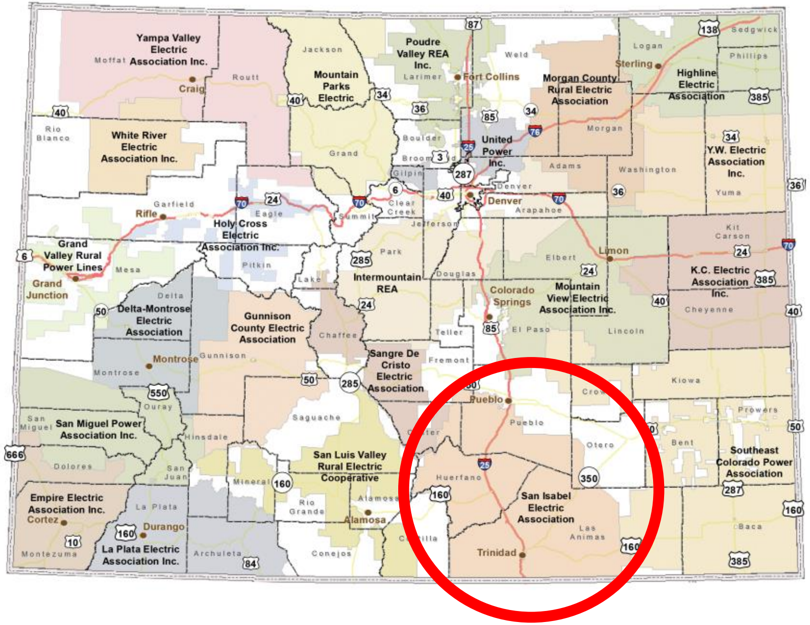
San Isabel Electric Association, Inc.

San Isabel Electric Mission

To provide our Membership with electric power and other needed products and services which will improve their quality of life. We will provide excellent service and maintain the highest social and ethical standards as we evaluate and utilize new technologies and resources to meet the needs of our Membership.

San Isabel Electric

Background



- 24,000 Meters
- 83 MW Summer Peak
  - Winter Peak about 78 MW
- 453,000 MWh in 2019
- San Isabel is a member of Tri-State G&T
- 5.2 Meters per Mile of Line

Huerfano River Wind

- Conversations started in 2010
- Commissioned 4 – 2MW Turbines in 2014
  - Manufactured by Sany
- Scouted the site through local partnerships
- Doubly-fed Induction Generators
- Location central to service territory

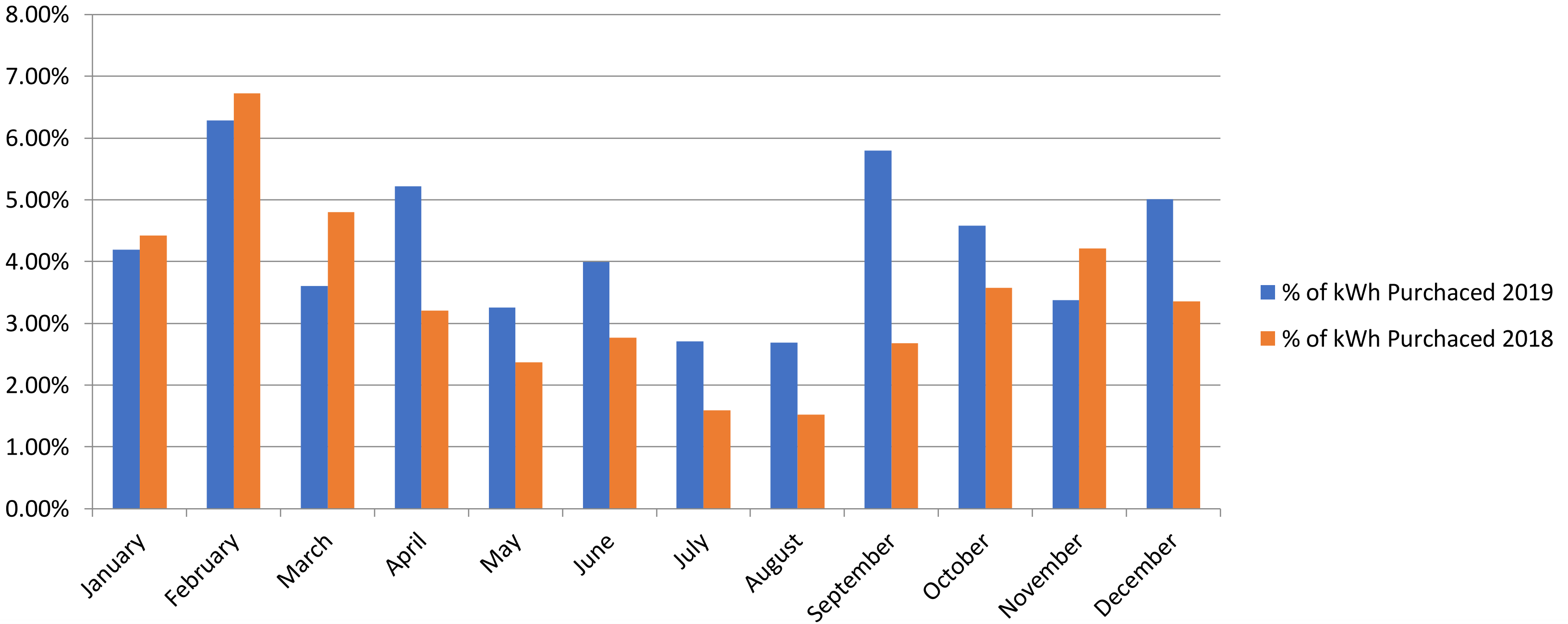
Huerfano River Wind

San Isabel Electric

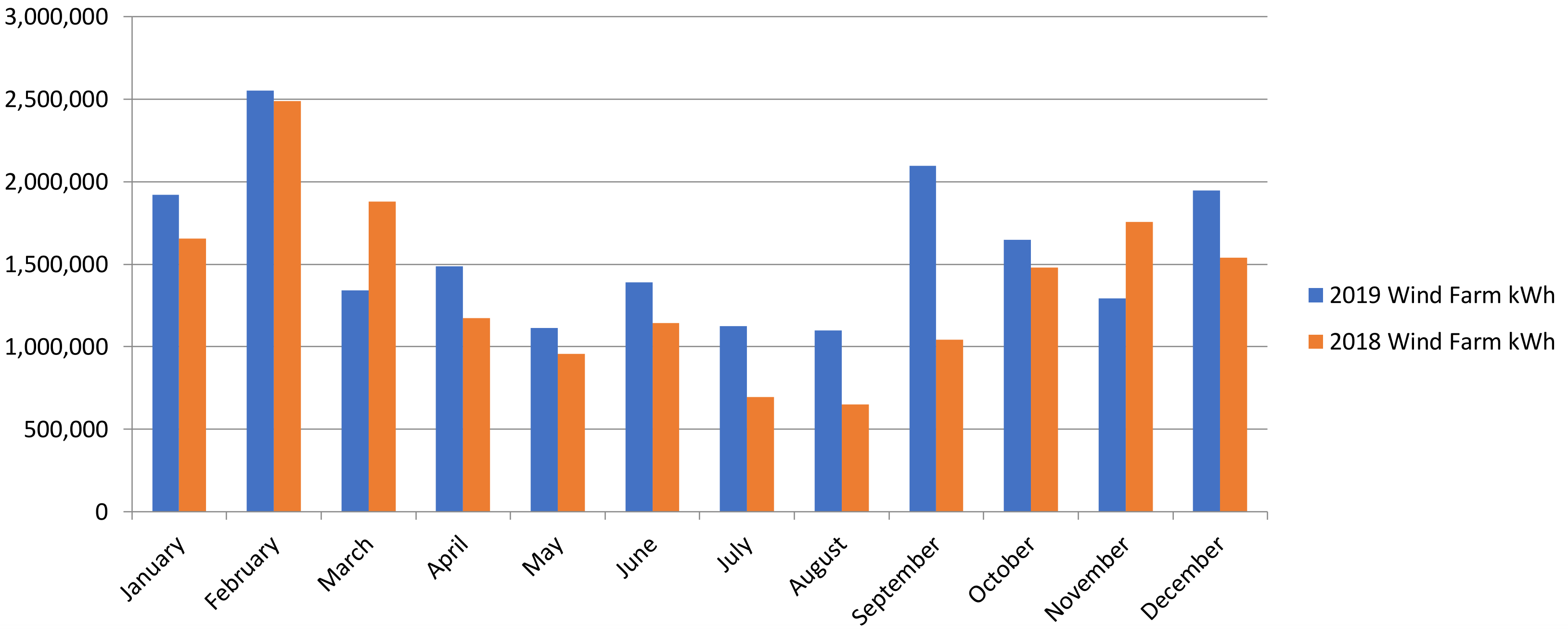
- State of Colorado requires 20% of generation portfolio to be renewable. 10% must be self generation.
- The wind project satisfied the 10% self generation requirement at the time that is was built.
- Tristate provides other 10%
- The project met financial requirements
  - San Isabel buys the energy of the Wind Farm under a PPA
  - San Isabel is billed by Tri-State at the delivery point
  - Tri-State provides production credits

Percent of Total kWh from Wind Farm

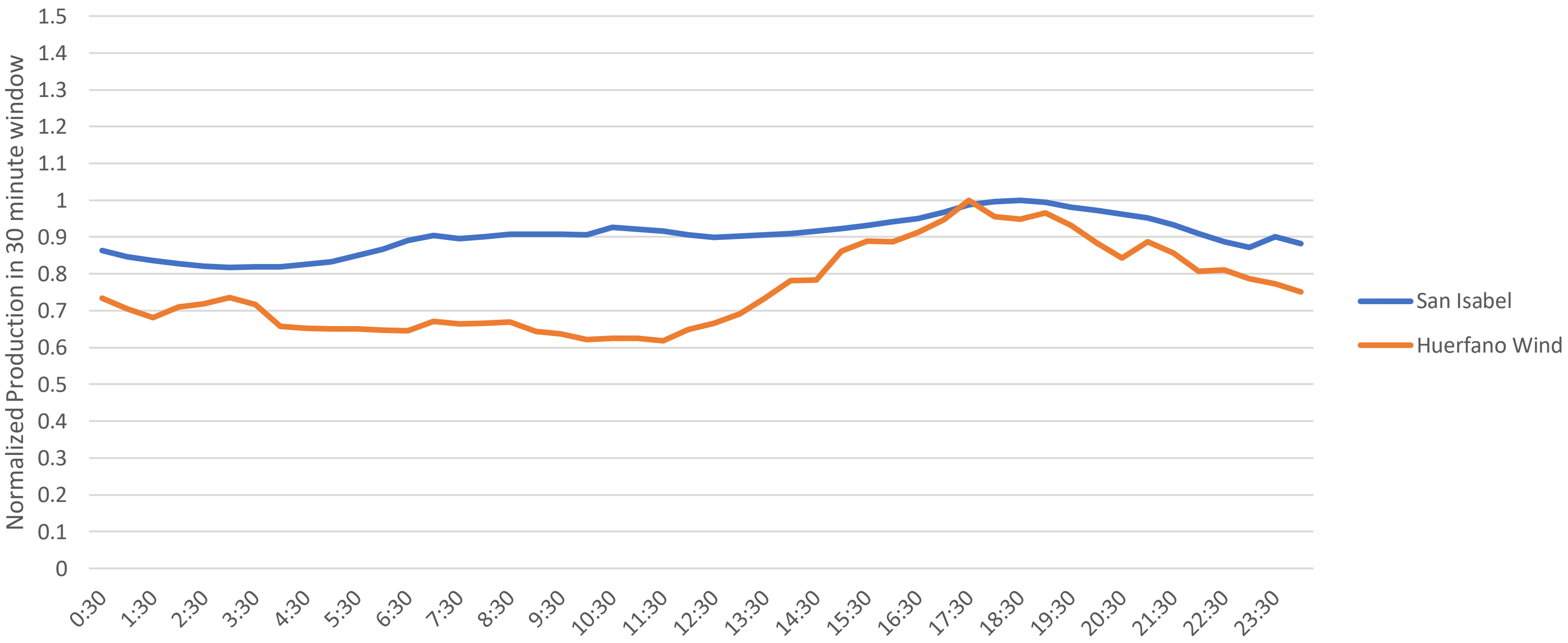
San Isabel Electric



Monthly Wind Farm kWh Purchased



Production Curve



2019 Production Details

- Capacity Factor of 27%
- Produced 19,018,000 kWh
  - 2019 is the best production year to date.
- Supplied 4.2% of San Isabel's KWh for 2019

Experience and Challenges

- Huerfano Substation was an existing distribution substation at the start of the project.
  - Coordinate and setup relaying
  - Substation serves rural residential load
- Prevailing winds from the West
- In a NESC special wind region.
  - 135 mph winds in 2017

Experience and Challenges

- The project would change ownership before commissioning
  - Sany (Manufacture) currently owns the project
- When evaluated, Wind was cheaper than Solar

Experience and Challenges

- We considered sharing the PPA with another Colorado Cooperative, but could not meet the contractual requirements of our power supplier.
- The PPA and participation from Tri-State met our financial requirements.
- There was a short evaluation for storage, but Tri-State’s wholesale power purchase rate structure at the time didn’t provide any financial benefit.
- We contractually cannot allow any production to feed onto the bulk transmission system. This avoids FERC regulation.

Rural Area Distributed Wind Integration Network Development (RADWIND) Project

Michael Leitman, Senior Analyst, Economics & Business
NRECA RADWIND Project Manager
(michael.leitman@nreca.coop)

March 3, 2020

2020 TECH ADVANTAGE® EXPERIENCE

Rural Area Distributed Wind Integration Network Development (RADWIND)

- Part of the DOE WIRED project ($3 million project, two years)
- Subtopic 1b: Balance of system cost reduction through standardization
- Builds on discussions at the Oct. 2018 WIRED Workshop about NRECA's successful DOE Sunshot project, SUNDA, that ran from 2013-2018
- NRECA has identified ~130 MW of distributed wind capacity owned or under contract by ~30 electric cooperatives (distribution and G&T), roughly in line with the electric co-op market share
- But this is just a fraction of the ~10 GW of technical capacity DOE has estimated for rural distribution grids

RADWIND Continued

- The first priorities are raising awareness of what co-ops and others are already doing in this space, and identifying other value streams beyond LCOE (e.g. resiliency benefits, peak capacity cost reductions, and local economic development)
- Ultimately the goal is to identify gaps and barriers to deployment of distributed wind at all scales by rural utilities and produce resources and industry networks that address these challenges to reduce soft costs, bridging the gap between what is technically possible and what is economically attractive
- There is particular interest in how distributed wind can be paired with other DER resources to provide increased value to the grid

RADWIND Project Team Partners

- **NRECA-Project Lead**
  - Michael Leitman, Project Manager
  - Venkat Banunarayanan, Prime Investigator
- **Hoss Consulting-Technical Lead**
  - Patrick Kelly, President
  - Charles Newcomb, VP Portfolio Strategy & Implementation
- **PNNL-Data & Analysis Lead**
  - Alice Orrell, Energy Analyst
  - Juliet Homer, Systems Engineer
- **The Mana Group-Industry Lead**
  - Jennifer Jenkins, Principal

RADWIND Advisory Group

- **As part of the Advisory Group, you will:**
- Assist the Project Team in evaluating the market, challenges, opportunities and gaps for distributed wind technologies, including deployment with other DER, providing co-op perspectives.
- Work directly with your peers to suggest solutions that can assist in successfully deploying diverse types of distributed wind projects and reduce soft costs of deployment.
- Build connections with stakeholders within the distributed energy community.