Activity Area Overview Presentation:
Grid Integration

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FY21 Peer Review – Activity Overview

Activity Summary:
- <u>Challenges and opportunities</u>:
  - Complexity in transmission planning and permitting hinders deployment
  - Increased wind requires grid flexibility, reliability support, storage, and hybrid systems integration
  - Wind growth can offer an array of grid services
  - Digitization increases risk of cyberattack risk
- <u>R&D priorities</u>
  - Transmission access
  - Grid services
  - Grid reliability and resilience support
  - Wind Cybersecurity
- <u>Key Activity partners</u>:
  - NR Can, ESIG, GE, NOAA, WindSim, BPA, Universities, and more
  - Other EERE and DOE offices through cross-cutting R&D initiative

FY19 - FY20 Budget Under Review (Labs): $10,611,285

Current budget (FY21): $6,786,650

Number of projects under peer review: 10

Activity Objective(s) 2019-2020:
- Understand the benefit of interregional transmission and international collaboration for future grid with high levels of renewable resources.
- Advance the provision of grid services for reliability and resilience
- Analyze grid stability with IBRs using impendence measurement
- Increase transmission utilization through enhanced DLR
- Identify challenges and opportunities for wind cybersecurity

Overall Activity Objectives (life of Activity):
- Enable cost-effective, reliable, resilient, and secure grid with large-scale wind deployment
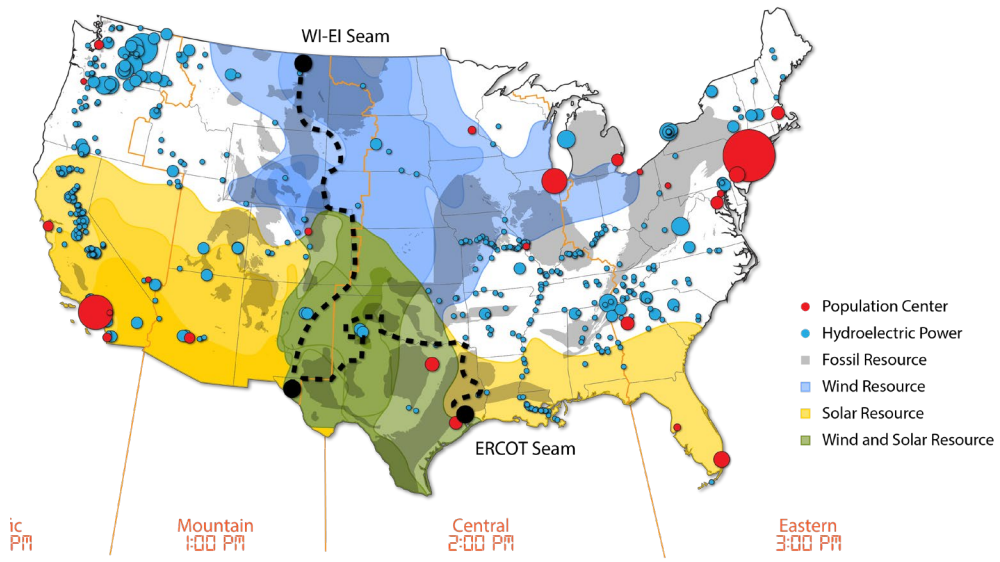
Projects Under Review

R&D Priorities	Project Title	Performer
Transmission Adequacy and Asset Utilization	E03 – North American Renewable Integration Study	NREL
	E04 – Continental-Scale Transmission Modeling Methods for Grid Integration Analysis	NREL
	E05 – Enhancing Reliable and Accurate Weather Forecasts for Increased Grid Reliability for Wind with Dynamic Line Rating	INL
Provision of Grid Services	E06 – Atmosphere to Electrons to Grid (A2e2G)	NREL
	E07 – Wind Power as Virtual Synchronous Generation (WindVSG)	NREL
Grid Reliability and Resilience Support	E08 – Advanced Modeling, Dynamic Stability Analysis, and Mitigation of Control Interactions in Wind Power Plants	NREL
	E11 – North American Energy Resiliency Model (NAERM)	NREL
Wind Cybersecurity	E09 – Cybersecurity Roadmap for Wind	INL, SNL, NREL
	E10 – Hardening Wind Energy Systems from Cyber Threats	SNL, INL
All	E12 – Wind Grid Integration Stakeholder Engagement	NREL

Transmission Adequacy and Asset Utilization

Key Challenges

- Complexity in transmission planning and permitting hinders wind deployment.
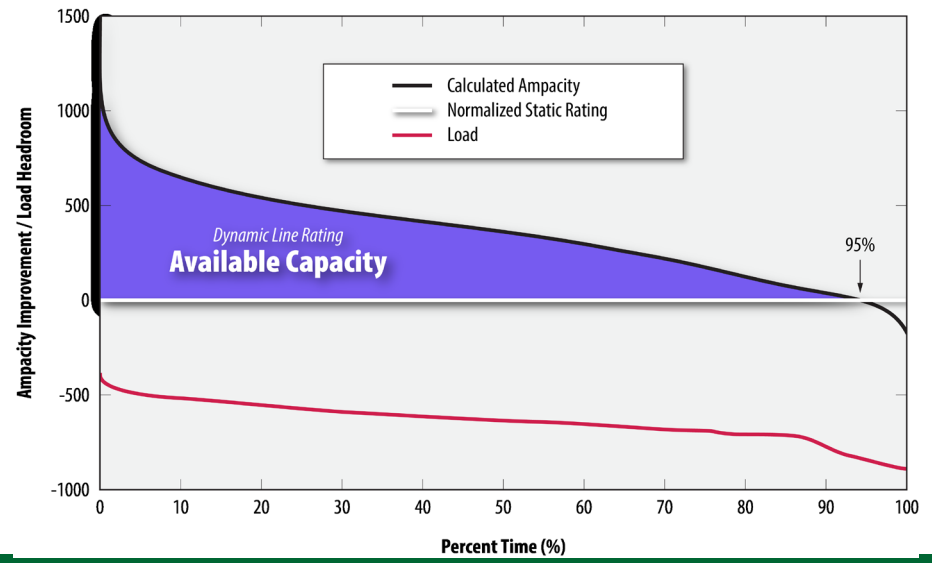- Existing transmission assets are not fully utilized.

Legend:
- Population Center
- Hydroelectric Power
- Fossil Resource
- Wind Resource
- Solar Resource
- Wind and Solar Resource

WI-EI Seam
ERCOT Seam

ic PM | Mountain 1:00 PM | Central 2:00 PM | Eastern 3:00 PM

The North American Renewable Integration Study: A U.S. Perspective

Gregory Brinkman,[1] Dominique Bain,[1] Grant Buster,[1] Caroline Draxl,[1] Paritosh Das,[1] Jonathan Ho,[1] Eduardo Ibanez,[2] Ryan Jones,[3] Sam Koebrich,[1] Sinnott Murphy,[1] Vinayak Narwade,[1] Joshua Novacheck,[1] Avi Purkayastha,[1] Michael Rossol,[1] Ben Sigrin,[1] Gord Stephen,[1] and Jiazi Zhang[1]

[1] National Renewable Energy Laboratory
[2] GE Energy
[3] Evolved Energy Research

Dynamic Line Rating **Available Capacity**

95%

Legend:
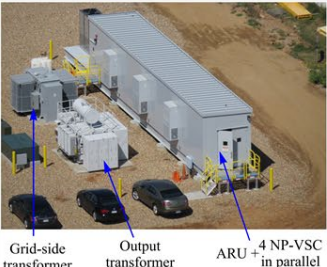- Calculated Ampacity
- Normalized Static Rating
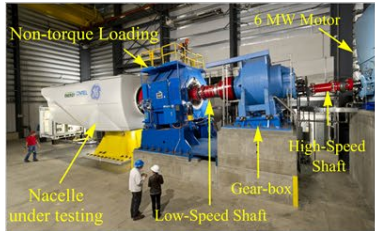- Load

Grid Reliability and Resilience Support

Key Challenges

- Maintaining and Increasing grid reliability and resilience with large deployment of inverter-based resources are challenging.
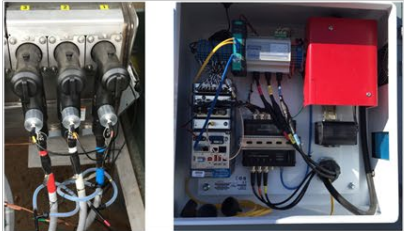

Injection of Perturbation in Turbine Voltages

Response in Turbine Output Currents

Measured Impedance of a 4 MW Wind Turbine
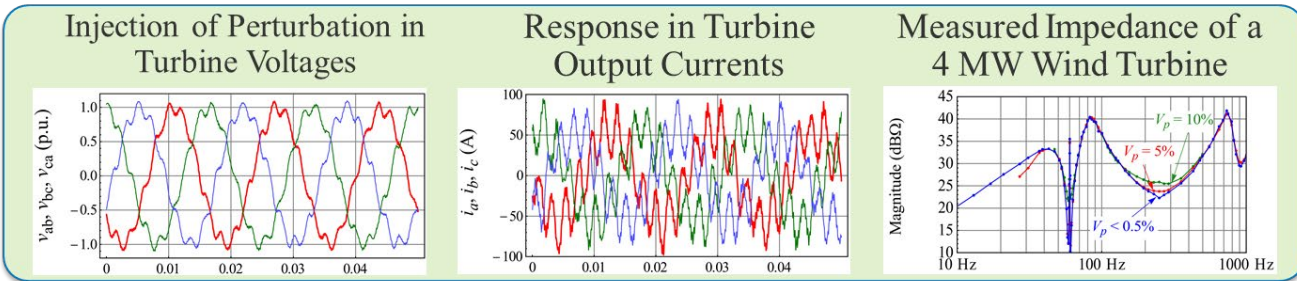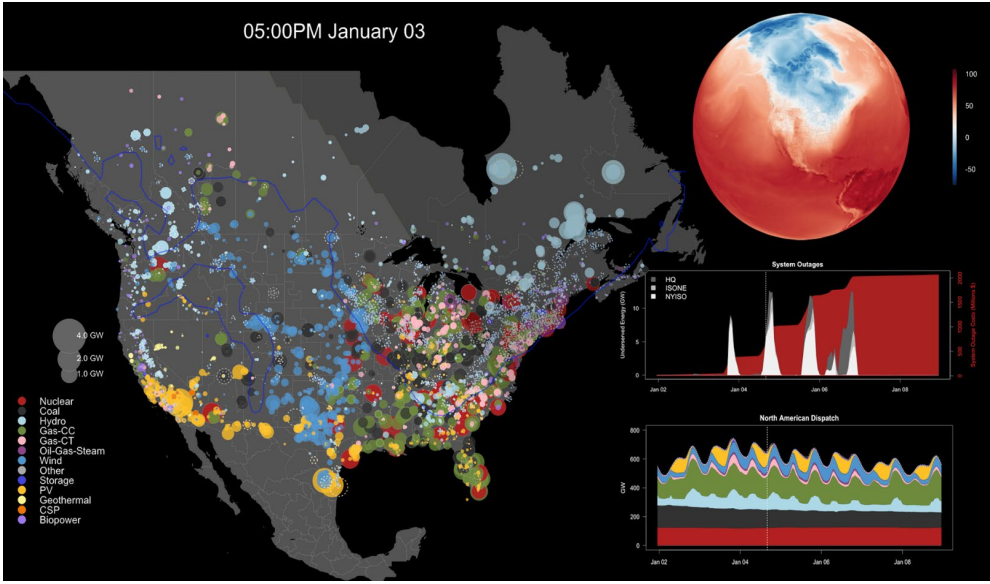
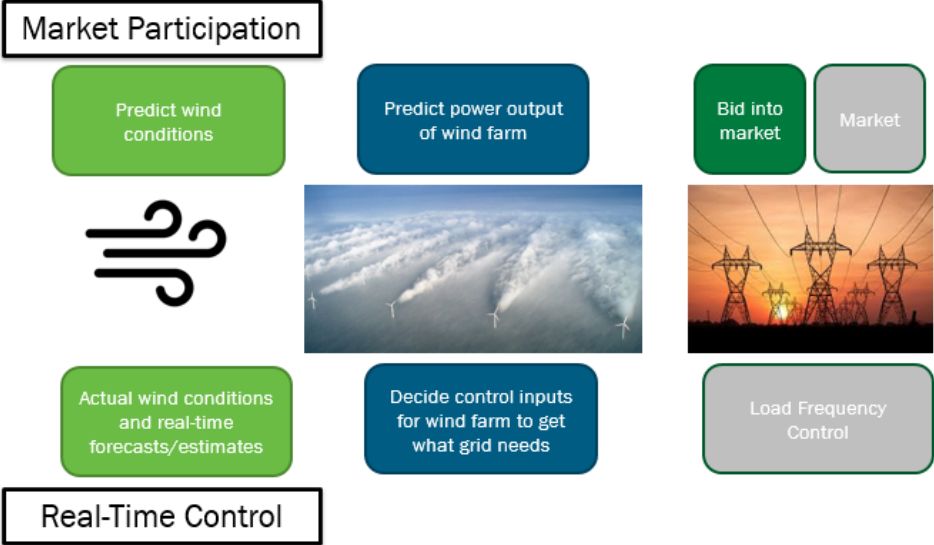7-MVA grid simulator

5-MW dynamometer
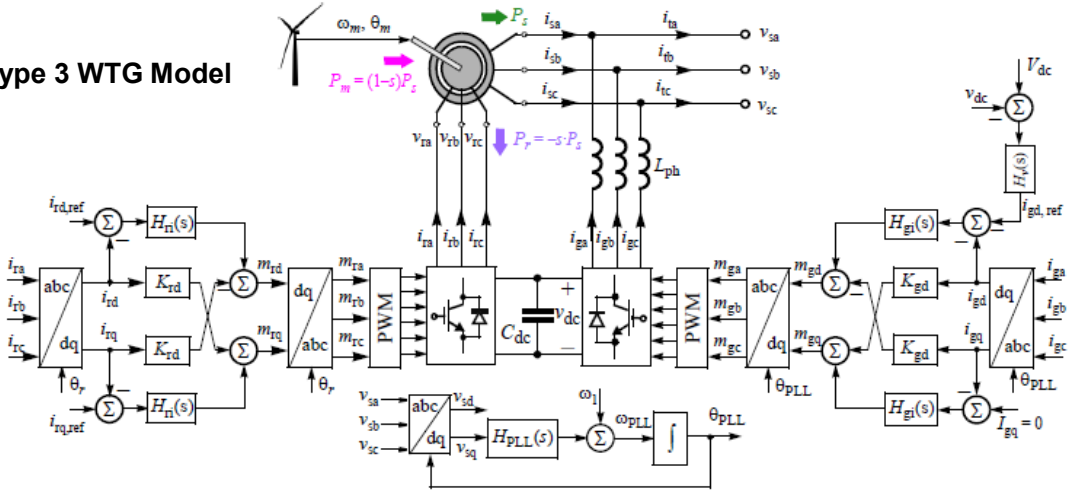
Medium-voltage sensing

Provision of Grid Services

Key Challenges

- Continued research is needed to advance provision of grid services from wind.
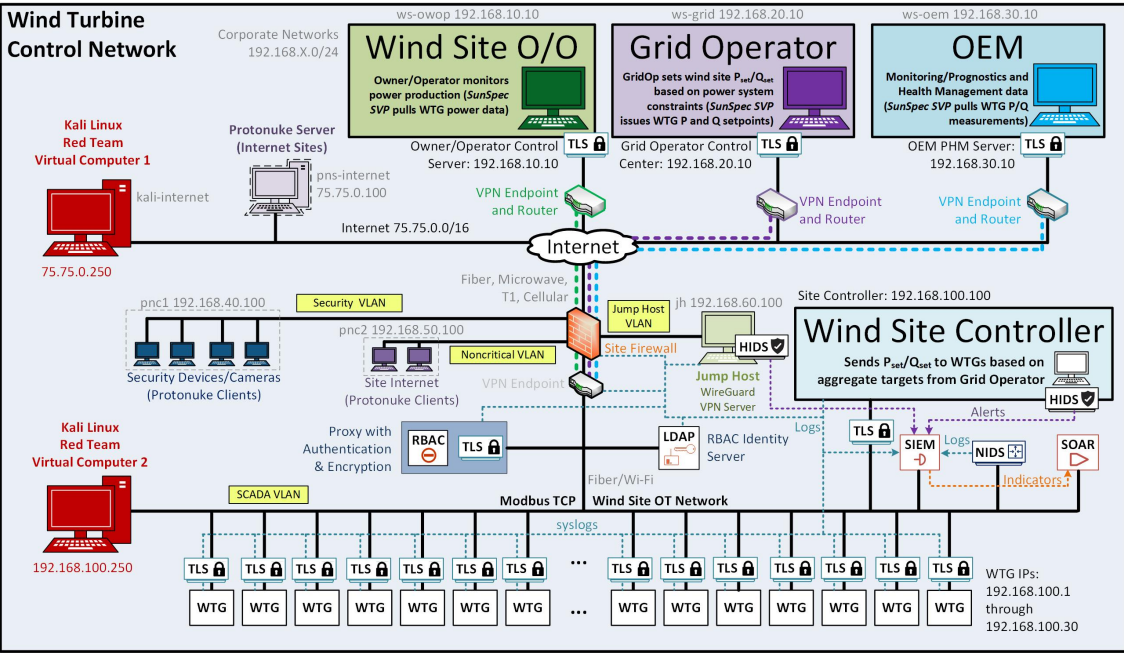- New technologies like grid forming control are promising to support high IBR grid.

GFM Type 3 WTG Model

Wind Cybersecurity

Key Challenges

- Cyber activities targeting energy sector are more frequent and sophisticated.
- There are gaps in identifying wind specific needs for cybersecurity, especially in Operational Technology environment.

Activity Accomplishments & Progress

- Completed North American Renewable Integration Study and Interconnection Seams Study

- Developed uncertainty assessment tools for dynamic line rating

- Led demonstrations that prove wind energy can provide a full array of essential grid services, in collaboration with industry, regulators, national laboratories, and a major electric utility

- Developed a theoretical basis of grid-forming operation and services by wind power and created grid forming models of Type 3 and 4 wind power plants

- Designed wind plant control that merges forecasting tools with aerodynamic and economic models to maximize a wind plant's value streams for energy and ancillary services

- Developed impedance-based testing, modeling, and analytical tools to evaluate the stability impacts of wind generation

- Designed, developed, and conducted modeling scenarios and sensitivities of a Polar Vortex use case

- Published wind cybersecurity roadmap.

- Established co-simulation environment that can fully assess the effectiveness of cybersecurity defense.

- Numerous publications, presentations, and extensive stakeholder engagement

Future Work (FY21 and Beyond)

- Offshore Wind transmission
- ISO/RTO Technical Support (GMLC)

- Grid-Forming Technologies Consortium

- Power electronics
- Advanced grid services and demonstration

- Flex Power (GMLC)
- Offshore wind hybrid

System planning and market

Reliable and Resilient System Operation

Wind hardware and Control

Wind Hybrid System

Wind Cybersecurity