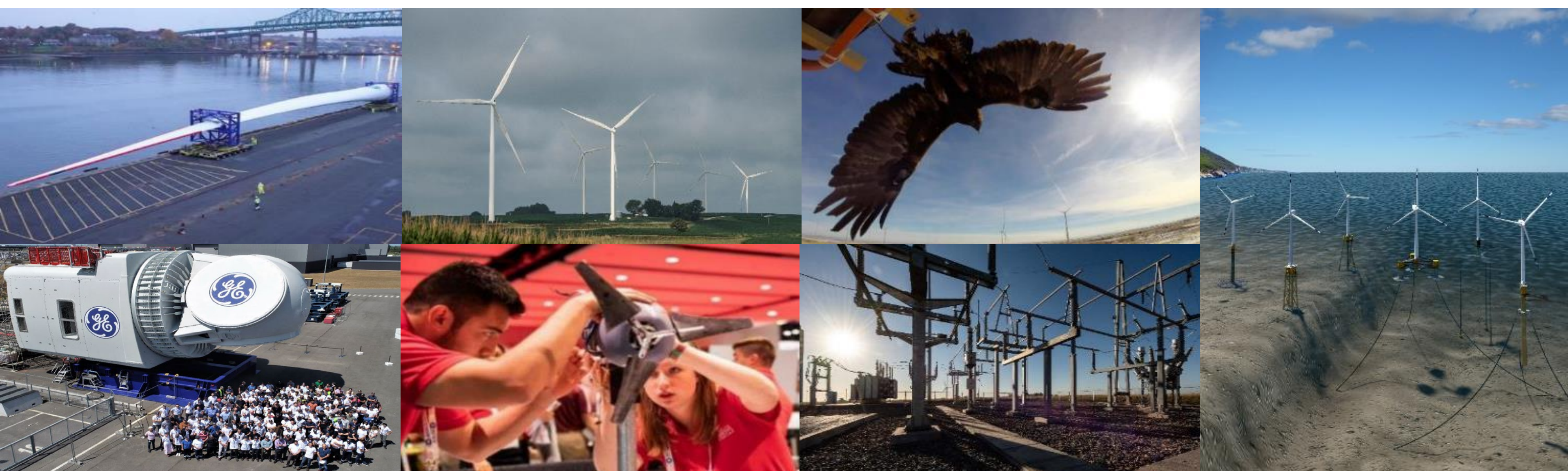
U.S. DEPARTMENT OF ENERGY
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

2021 PROJECT PEER REVIEW
U.S. DEPARTMENT OF ENERGY
WIND ENERGY TECHNOLOGIES OFFICE

Activity Area Overview Presentation:
Offshore Wind Specific R&D

Nathan McKenzie
Technology Manager for Offshore Wind R&D

August 2–5, 2021



Activity Team

Michael Derby
WETO R&D Program manager

Dr. Michael Robinson
A2e Senior Advisor

Dr. Shannon Davis
Technology Manager for Atmospheric Science

Nate McKenzie
Technology Manager for Offshore R&D

Ben Hallissy
Technology Manager for Aerodynamics and Controls

Monica Maher – Offshore wind specialist
Ben Murray – Manufacturing
Tyler Christoffel – O&M

Rich Tusing – Critical Materials, Recycling, Hydrogen, etc.
Dan Beals – Project Manager

FY21 Peer Review – Activity Overview

Activity Summary:
- Reducing offshore wind energy costs
- Reducing financing & permitting risks
- Accelerating the rate of offshore wind deployment
- Enabling efficient and effective deployment of lidar buoys and disseminating hub-height offshore wind data in support the U.S. offshore wind industry
- Improving the ability to characterize the wind energy resource offshore

Partners:
- NYSERDA
- National Laboratories (PNNL, NREL, ANL, LLNL)
- GE, AMSC, WEG

Activity Objective(s) 2019-2020:
- Setup National Offshore Wind R&D Consortium
- Expand environmental sensing campaigns & increase knowledge
- Develop lightweight, efficient high-capacity generators
- Buoy upgrades, additional deployments, improved characterizations
- OSW FOA Development

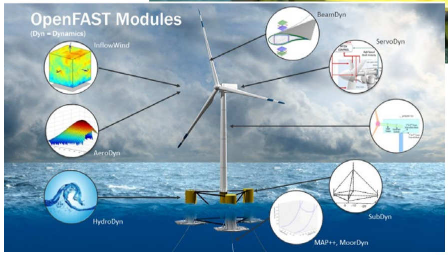
Overall Activity Objectives (life of Activity):
- Reduce the cost of energy
- Address regional challenges and opportunities
- Reduce perceived industry risks
- Expedite development of the U.S. offshore wind industry

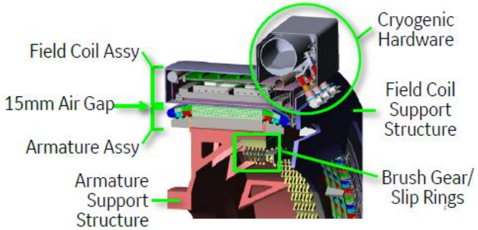
FY19 - FY20 Budget Under Review (Labs): $8.7M

FOA Project Budget Under Review: $40.8M
- Total DOE: $19.8M
- Total Cost Share: $21M

Current lab budget (FY21): $14.4M

Number of projects under peer review: 7





Projects Under Review

Project Name	Presenter/Performer
T28 - National Offshore Wind Research and Development Consortium	NYSERDA
T29 - Advanced Next Generation High Efficiency Lightweight Wind Turbine Generator (ASC)	American Superconductor Corporation
T31 - High Efficiency Ultra-Light Superconducting Generator (SCG) for Offshore Wind (GE)	General Electric
T32 - Model Test of an Innovative Offshore Floating Wind System (TCF)	NREL
T33 - DOE Offshore Wind Lidar Buoy Deployments	PNNL
Lidar Buoy Science	PNNL
T35 - Offshore Wind Resource Sciences Work	Multi (PNNL, ANL, LLNL, NREL)

Context: U.S. - Specific Offshore Challenges

Steep learning curve required –
European solutions may not be optimal or appropriate to:

- Challenging physical conditions – e.g. hurricanes, ice, geophysical characteristics
- Available vessels and Jones Act restrictions
- Supply chain, port infrastructure, and workforce training needs
- Permitting processes and state or federal regulations
- Wildlife considerations, visual impacts, and potential marine use conflicts
- Deep water – nearly 60% of the offshore wind resource in the U.S. is in deep water, nearly 100% on Pacific Coast




Offshore Wind

Challenges and Opportunities

- More than 2,000 GW of resource potential
- ~25 GW of firm commitments, but still a nascent industry in the U.S.
- Technology innovation and cost-reduction so that offshore wind can be broadly competitive without subsidy
- Finding acceptable solutions to siting and environmental challenges
- Integrating wind energy at scale into the grid (see Systems Integration)

Goals

- Reduce costs (fixed): 5.0¢/kWh in 2030; from 8.6¢/kWh in 2020
- Reduce costs (floating): 7.0¢/kWh in 2030; from 13.5¢/kWh in 2020
- Expand access to offshore wind resources through siting, permitting, and grid interconnection research

Deployment Goal

- 30GW by 2030
- Carbon-Free Electricity sector by 2035, Net-zero by 2050

R&D Priorities – Technology

- Science of atmospheric and oceanographic conditions
- Whole plant performance and design
- Economies of scale, installation, operation, maintenance, and reliability
- Floating platform design and systems innovation
- Simulation and scaled testing to reduce need for field demonstrations

R&D Priorities – Environment and Siting

- Wildlife and environmental impacts
- Radar interference mitigation
- Siting research and development
- Community acceptance research and support

Photo by NREL

Photo by PNNL

National Offshore Wind R&D Consortium

- ❖ A nationally-focused, independent not-for-profit organization initiated through a DOE solicitation
- ❖ Collaborates with members on focused R&D to reduce cost of offshore wind and maximize economic benefits

Members Include

All major project developers; states (MA, MD, ME, NJ, NY, VA); energy companies

NEW YORK STATE OF OPPORTUNITY. | NYSERDA Supported; Shell; CARBON TRUST; nationalgrid; Ørsted; GE Renewable Energy; BROOKHAVEN NATIONAL LABORATORY; EPRI | ELECTRIC POWER RESEARCH INSTITUTE; AVANGRID; MASSACHUSETTS CLEAN ENERGY CENTER; NEW YORK STATE OF OPPORTUNITY. | NY Power Authority; rcg | Renewables Consulting Group; EDF renewable energy; ANBARIC; e·on; Maryland Energy Administration; Governor's Energy Office; DMME Virginia Department of Mines Minerals and Energy; HITACHI ABB; edp renewables; equinor; VINEYARD WIND; EnBW North America; NORTHLAND POWER

Administrator

- New York State Energy Research and Development Administration (NYSERDA)
- Goal is to become self-sustaining

Current Funding

- >$48M ($20.5M in DOE funds matched by NYSERDA; plus member dues, and funding from states (MA, MD, ME, NJ, VA)

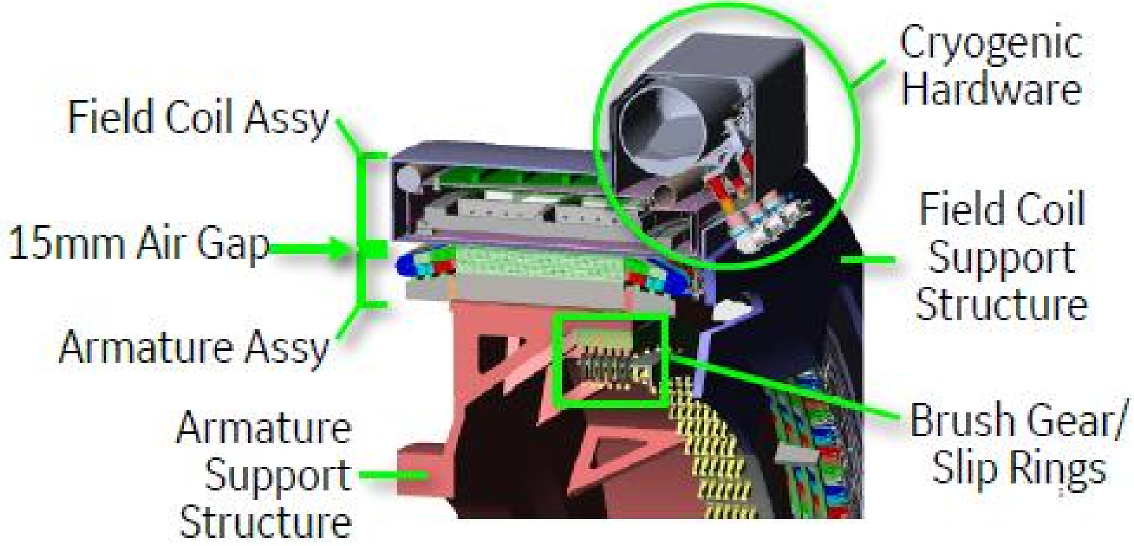
Highlights and Status

- 2019/20 solicitations for R&D proposals led to 40 awards totaling $28M
- DOE actively monitors and provides contractual oversight of solicitations and awarded projects

Lightweight Generators

- **Primary objective: lightweight, more efficient system**
  - Significantly decrease up-tower mass,
  - Reduce tower structural mass,
  - Improve performance, and
  - Reduce operations and maintenance (O&M) and replacement costs.
  - Reduce vulnerability to price fluctuations for rare earth elements

Metric/ Key Performance Indicator (KPI)	Unit	Min	Stretch Target
Impact on Wind turbine LCoE	$/kWh	-10%	-15%
Mass reduction*	Kg	35%	50%
System Efficiency (full load)	%	+1%	+2%
Reduction in rare earth elements	%	25%	100%
Torque density	kN/kg	+35%	+50%



* For systems includes the weight of the gearbox and shafting in addition to the generator

Atmospheric Science for OSW

Present needs:

- Accurate hi-resolution measurements of the MABL and LT which relate the structure of turbulence, wind shear, and wave spectra to inform OSW design, controls, and resource prediction
- Models and tools to adapt LBW and present resource science tools to the OSW environment.

Active projects engaging these challenges:

- Lidar Buoy Deployments: observation platforms gathering hub-height hi-res met-ocean and environmental observations; completed campaigns in Mid Atlantic Bight and SE Atlantic; active campaigns of Central and Northern California; disseminate data freely through the Data Access Portal (DAP):
- Lidar Buoy Science (LBS): Improve understanding of the physics of the OSW resource and its predictability
- Offshore Wind Atmospheric Coupling (OWAC) : evolution of the Mesoscale to Microscale (MMC) project; investigating coupling between weather and plant inflow scales in numerical models and bearing of particular atmospheric processes
- Energy Research and Forecasting Model (ERF): development and application of a next-generation scalable (weather to plant inflow) marine-atmospheric model capable of running on exascale/gpu-enhanced architectures.
- Offshore Wind Resource Sciences (OWRS): multi-lab research in the air-sea dynamics of OSW

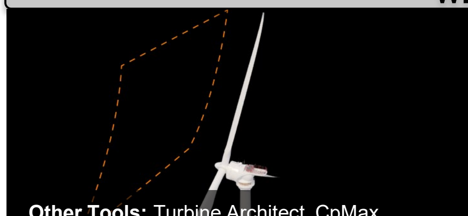
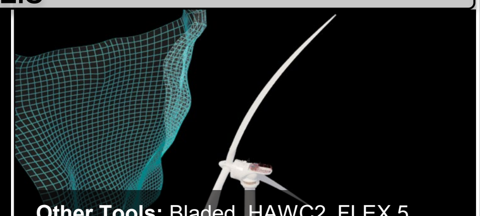
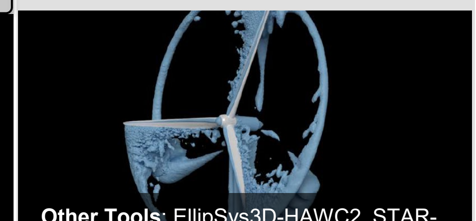
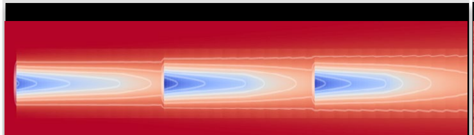
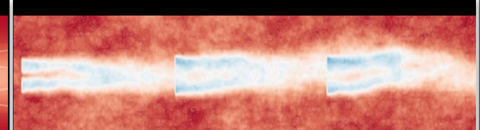
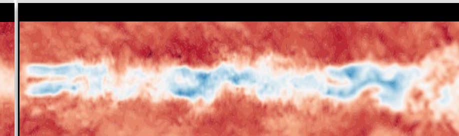
Coming Soon:

- Wind Forecast and Improvement Project 3 (WFIP 3): the third WFIP large scale field campaign and first offshore. This will be a collaboration with WHOI, multiple DOE labs, NOAA, as well as other federal, industry, and academic partners beginning 11/21 and conducted in the New England lease region south of Martha's Vineyard

Modeling/Tool Development/Application

- Ongoing & Future work around fundamental physics understanding, controls, tool development, validation, and application

Model Fidelity / Computational Intensity →

Application	Design Exploration	Detailed Design	Highly Resolving
Single Turbine Performance and Loads	**WISDEM, RAFT** Multidisciplinary design optimization and cost modeling	**OpenFAST** Turbine loads analysis, detailed turbine design, IEC standards	**ExaWind/SOWFA** Understand physics, final turbine design check, calibrate / validate lower fidelity
	WEIS	WEIS	
			
	Other Tools: Turbine Architect, CpMax, HawtOpt2	**Other Tools:** Bladed, HAWC2, FLEX 5	**Other Tools**: EllipSys3D-HAWC2, STAR-CCM+
Full Wind-Plant Performance and Loads	**FLORIS** Wind-plant controls and siting optimization	**FAST.Farm, WindSE** Turbine siting within plant, wind-plant controls, plant loads analysis, detailed plant design	**ExaWind/ERF/SOWFA** Understand physics, final plant design check, calibrate / validate lower fidelity
			
	Other Tools: WAsP, WindFarmer, Fuga	**Other Tools:** openWind, MeteoDyn WT, DWM	**Other Tools**: EllipSys3D, PALM, WRF-LES, W2A2KE3D, VFS-Wind

* **Other Tools** are other widely-used tools with similar capabilities

Test Facilities

- Clemson University: hardware-in-the-loop capability enabling concurrent mechanical, electrical, and controller testing on the 7.5-megawatt (MW) dynamometer at its Wind Turbine Drivetrain Testing Facility.
- Lehigh University: upgrade its soil-foundation interaction laboratory to combine computer simulation with physical testing to model impacts of wind, waves, currents, and other factors on offshore wind turbine structures.
- Massachusetts Clean Energy Center: upgrade its Wind Technology Testing Center to enable structural testing of 85 to 120-meter long blades.
- Oregon State University: use numerical models to simulate the combined effects of wind and waves on floating offshore wind turbines in a wave basin.
- Tufts University: quantify the effects of fatigue on the stiffness, strength, and durability of various marine concrete mixtures to facilitate development of cost-effective, resilient concrete offshore wind support structures.
- The University of Massachusetts–Lowell: develop and validate a novel autonomous method of using measured acoustic pressure to detect degradation and damage in wind turbine blades.

Future Work (FY21 & Beyond)

- Floating Platform development & Industrialization
- Supply Chain Analysis and Development
- Continued understanding of underlying physics
- Tool development, V&V, and application
- Operations & Maintenance