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: Atmosphere to Electrons (A2e)

Ben Hallissy, Technology Manager

August 2-5, 2021

Activity Leadership

Dr. Michael Robinson
A2e Senior Advisor

Michael Derby
WETO R&D Program manager

Dr. Shannon Davis
Atmospheric Science

Nate McKenzie
Offshore R&D

Ben Hallissy
Aerodynamics and Controls

Executive Management Committee

Dr. Paul Veers
NREL

Dr. Will Shaw
PNNL

Dr. Geoff Klise
SNL

FY21 Peer Review – A2e Overview

Activity Summary:

- **Objective:** Develop new wind turbine and plant technologies to reduce LCOE by 50% ($23 MWh by 2030) and enable low-cost wind nationwide
- **Approach:** Provide a better physical understanding of the atmospheric boundary layer interaction with wind plants and develop new technologies that maximize energy capture and optimize cost performance through integrated plant systems analysis, multi-disciplinary design and intelligent operation.
- **National Lab Partners:** NREL, SNL, LLNL, PNNL, ANL
- **Government Partners:** NOAA, NCAR, DOE SC, NSF
- **University Partners:** Wyoming, CU Boulder, Texas Tech, UT Dallas, DTU, Delft
- **Industry Partners:** GE, Engie, Enel, Nextera, Envision, Shell, Vaisalla

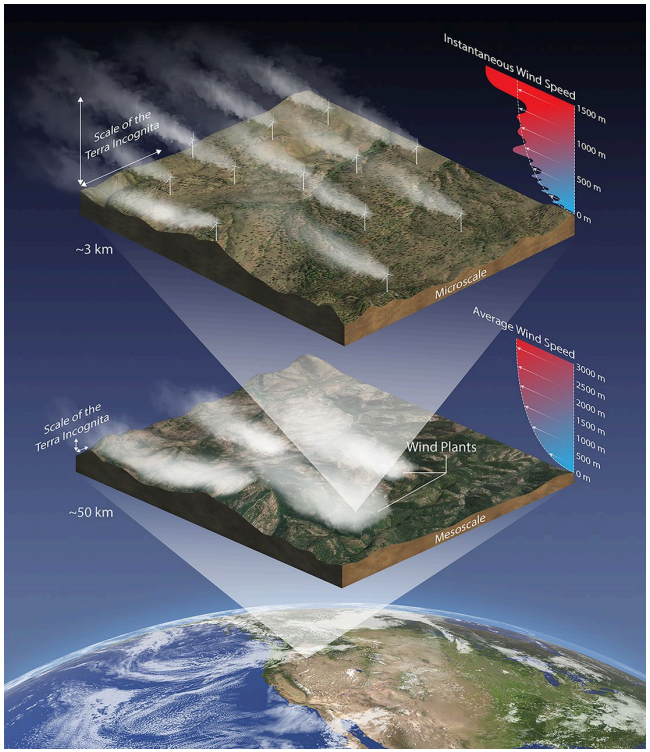
Activity Objective(s) 2019-2020:

- Enhance predictive capability for all spatial and temporal scales of wind energy – including transition across scales
- Develop and demonstrate novel wind farm control solutions and multidisciplinary whole-system design methods to reduce LCOE
- Lay groundwork for upcoming experimental campaigns:
  - AWAKEN – American WAKE experimeNt
  - RAAW – Rotor Aerodynamics, Aeroelastics, and Wake
  - WFIP3 – Wind Forecasting Improvement Project (not A2e)

FY19 - FY20 Budget Under Review: $37.6M (two-year total)

FY21 budget: $21.3M

Number of projects under peer review: 13



Projects Under Review (1/2)

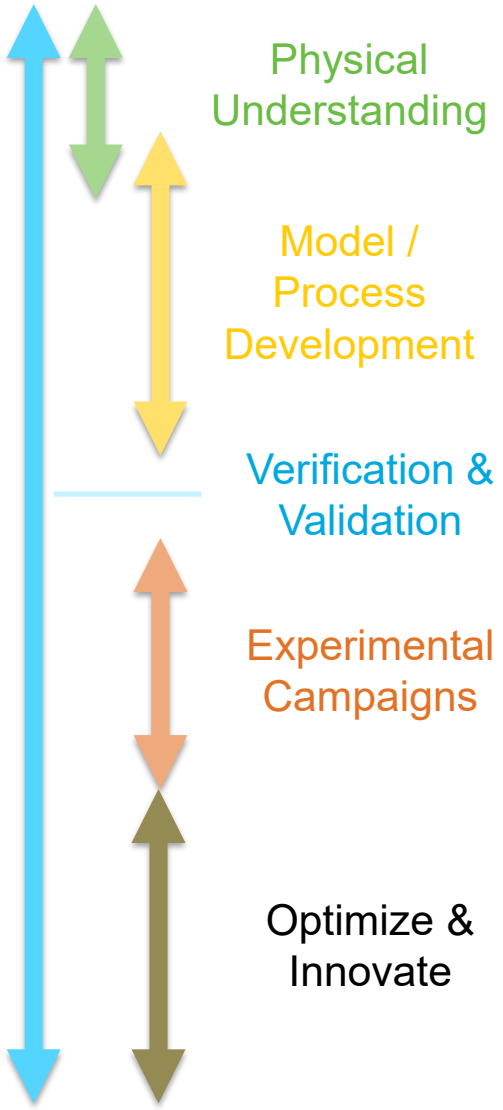
Wednesday, August 4, 2021 (Tech RD&T)	PI / Lab
T14 - Data Archive and Portal 9:15AM	**Chitra Sivaraman** PNNL
T15 - Wind Forecast Improvement Project (WFIP) II Extended Analysis 9:40AM	**Will Shaw** PNNL, ANL, LLNL, NREL
T16 - Mesoscale to Microscale Coupling (MMC) Model Development & Validation 10:20AM	**Sue Haupt (NCAR)** **Colleen Kaul (PNNL)** NCAR, PNNL, LLNL, NREL, LANL
T17 - Energy Research and Forecast Modeling (ERF) 10:45AM	**Jeff Mirocha (LLNL)** LLNL, ANL, NREL, PNNL
T18 - High-Fidelity Modeling (HFM) 11:25AM	**Michael Sprague** NREL, SNL
T19 - Advanced Flow Control Science for Wind Plants 11:50AM	**Paul Fleming** NREL
T21 - Systems Engineering and Optimization 1:15PM	**Garrett Barter** NREL

Projects Under Review (2/2)

Wednesday, August 4, 2021 (Tech RD&T)	PI / Lab
T22 - Multi Physics Model Validation and Uncertainty Quantification 1:40PM	**Jason Jonkman** NREL
T23 - Verification, Validation, and Uncertainty Quantification of Wind Plant Models Project 2:20PM	**David Maniaci** SNL
T24 - Modeling and Validation for Offshore Wind 2:45PM	**Amy Robertson** NREL
T25 - Aeroacoustic Assessment of Wind Plant Control 3:10PM	**Nicholas Hamilton** NREL
T26 - Rotor Wake Measurements and Predictions for Validation (RAAW) 3:50PM	**Jonathan Naughton (U. Wyoming)** NREL, SNL
T27 - American Wake Experiment (AWAKEN) 4:15PM	**Patrick Moriarty (NREL)** NREL, LLNL, PNNL, SNL

A2e Project Structure

Project
Wind Forecast Improvement Project (WFIP) II Extended Analysis
Mesoscale to Microscale Coupling (MMC)
Energy Research and Forecast Modeling (ERF)
High Fidelity Modeling (HFM)
Verification, Validation and Uncertainty Quantification (VVUQ) of Wind Plant Models
Multi Physics Model Validation and Uncertainty Quantification
Modeling and Validation for Offshore Wind
Rotor Wake Measurements and Predictions for Validation
American WAKE ExperimeNt (AWAKEN)
Systems Engineering and Optimization
Advanced Flow Control Science for Wind Plants
Aeroacoustic Assessment of Wind Plant Control
Data Archive and Portal



Build Physical Understanding

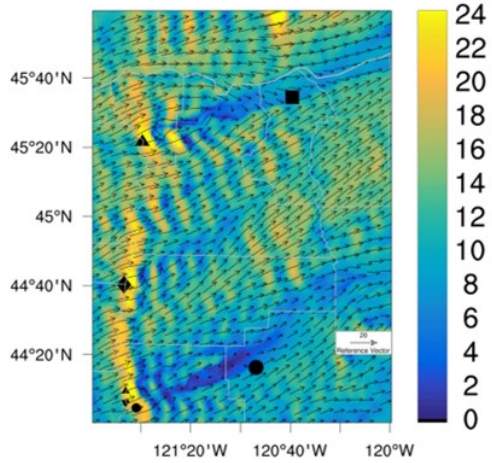
WFIP II Extended

Objective

To further improve the ability of numerical weather prediction models to accurately calculate winds at hub height in complicated environments

Impact

Model improvements assimilated into widely used models: NOAA's High-Resolution Rapid Refresh (HRRR) for operational forecasting and the weather research and forecasting (WRF) model for wind energy applications.



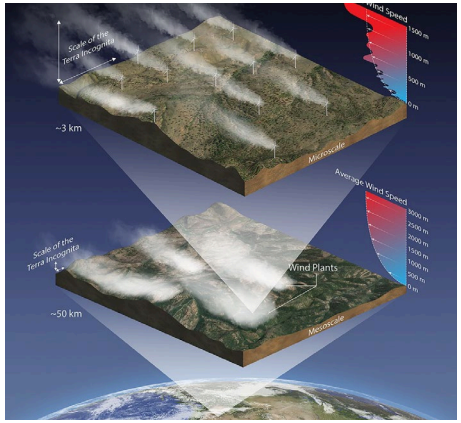
MMC

Objective

Improve coupling between mesoscale and microscale simulations via enhanced guidance and new strategies for setting up simulations and for the development of new tools that can be used across the community

Impact

- New surface layer treatment based on machine learning + new 3D planetary boundary layer scheme
- 200-person workshop held on atmospheric challenges for the wind energy industry



Model Development → Predictive Capability

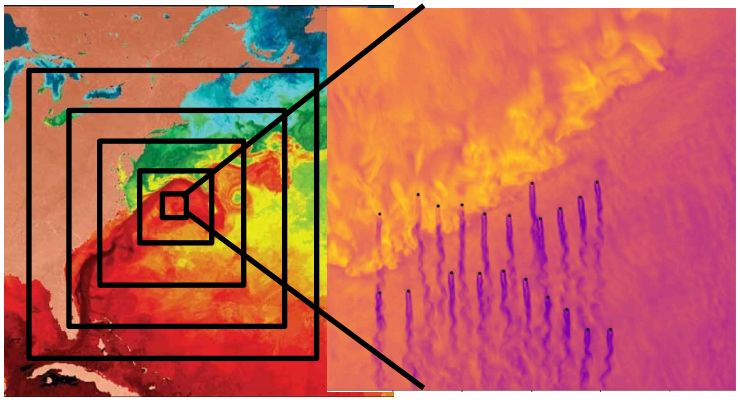
ERF

Objective

A modern code base to seamlessly couple mesoscale energy flows with microscale wind plant simulation to advance wind energy deployment.

Impact

Enabling multiscale atmosphere/wind plant simulations in a wide range of wind energy workflows is essential to ensure the reliability of an electrical grid dependent upon large inputs of wind energy.



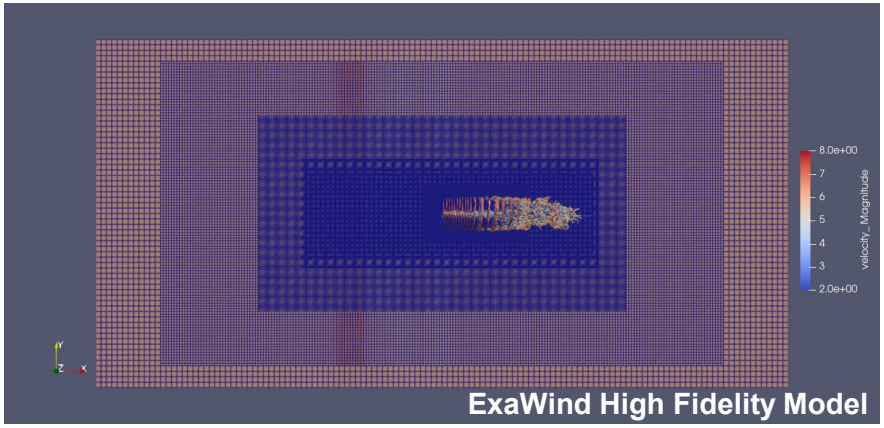
HFM

Objective

A well-tested, robust, open-source code suite that provides multi-fidelity simulations of wind farms that can run on workstations and next-generation high-performance computers.

Impact

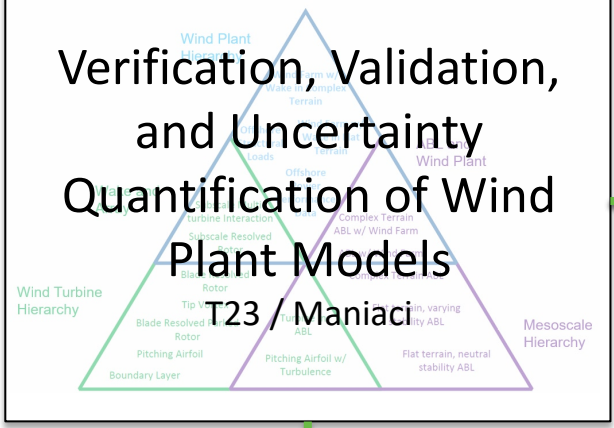
Significant partnership with GE using ExaWind software stack: supported by funding and compute time through DOE's Technology Commercialization Fund, NOWRDC, ASCR Leadership Computing Challenge



Verification and Validation is Key

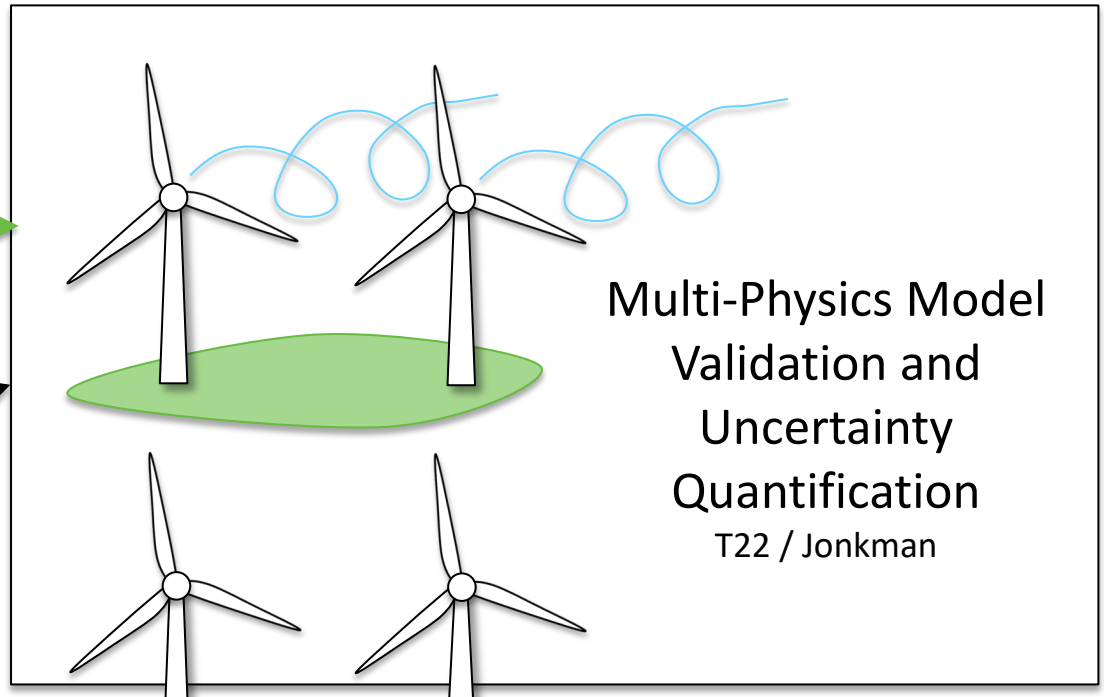
Verification, Validation, and Uncertainty Quantification of Wind Plant Models

T23 / Maniaci



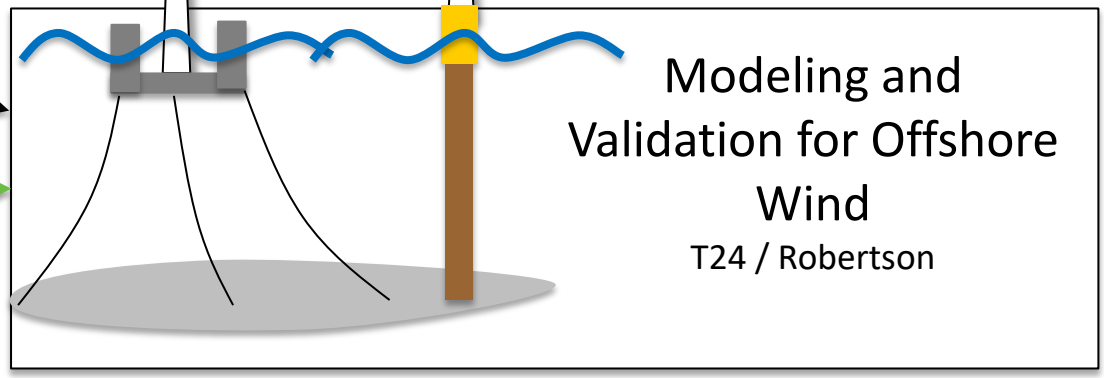
High Fidelity Modeling

T18 / Sprague



Multi-Physics Model Validation and Uncertainty Quantification

T22 / Jonkman



Modeling and Validation for Offshore Wind

T24 / Robertson

Verification and Validation → Trusted Tools

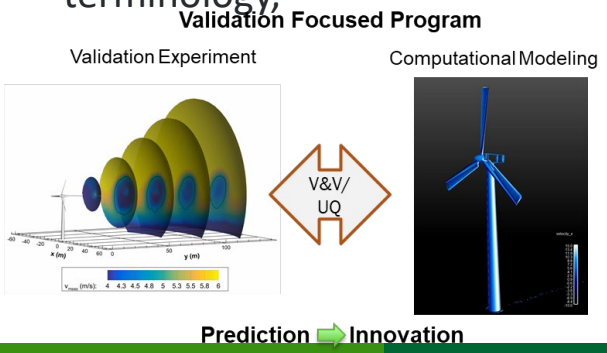
VVUQ (Maniaci)

Objective

Develop and apply verification, validation, and uncertainty quantification techniques to wind industry relevant applications, driving innovation through the trusted application of high-fidelity models.

Impact

Validation is a part of every A2e effort and IEA research community, based around a common framework and terminology,



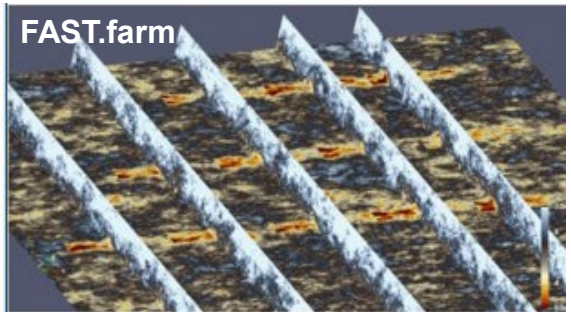
Multi-Physics (Jonkman)

Objective

Verify and validate OpenFAST and FAST.Farm against HFM and data. Improve engineering tools based on V&V outcomes and industry needs. Assess sensitivity to understand design drivers.

Impact

Improved accuracy and trust of key engineering tools for wind turbine and wind farm simulation



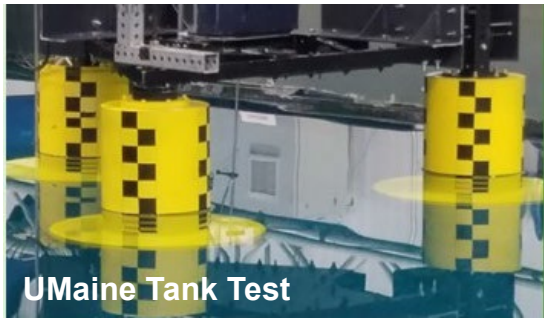
Offshore (Robertson)

Objective

Advance innovative offshore wind technologies to commercial maturity by validating offshore wind modeling tools with high-quality datasets under a variety of conditions.

Impact

- Lead OC6 project to mitigate underprediction of loads on offshore semi-sub platforms.
- Created new soil/structure interaction module in OpenFAST



Experimental Campaigns → Data and Insights

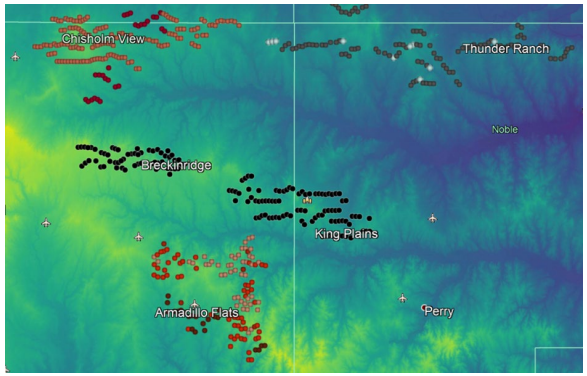
AWAKEN (Moriarty)

Objective

Gather the highest fidelity data on wind farm/ atmosphere interactions to date to better understand complex wind farm flow phenomena, and validate and improve wind farm modeling tools to use for future improved wind farm performance

Impact

Multi-agency, multi-institution, international collaboration with multiple industry partners, leveraging potentially $10M in external funding proposals, and deploying > 100 instruments.



Rotor Wake (Naughton)

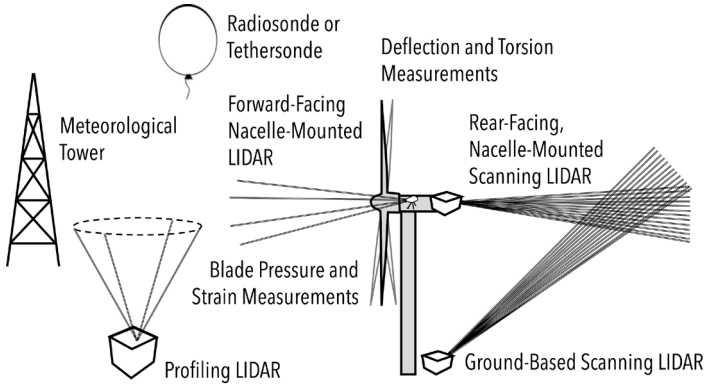
Objective

Enable the validation of cross-application simulation tools for wind-turbine and wind-plant modeling, and to further our understanding of modern wind turbine flow physics

Impact

New experiments, open data

- Utility-scale Wake Steering
- National Rotor Testbed
- Rotor Aerodynamics, Aeroelastics, and Wake



Optimize and Innovate → Reduce LCOE

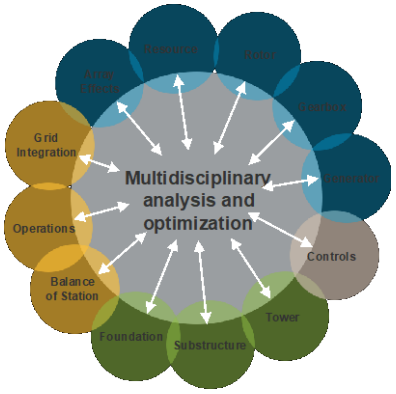
System Engineering and Optimization (Barter)

Objective

Integrate engineering and cost models in a public toolset to promote collaborative research and enable full system analysis. Apply advanced multidisciplinary methods to the study of wind plant systems to explore new pathways in performance and cost improvement

Impact

- Established new pathways for LCOE reduction by considering the entire wind plant life cycle
- IEA 15MW reference offshore wind turbine through leadership of IEA Wind Task 37



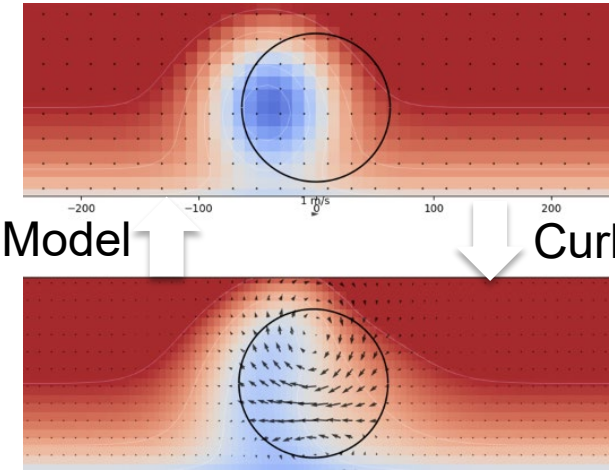
Advanced Flow Control Science (Fleming)

Objective

Develop models, methods, and validation of wind farm control and partner with industry to enable wide scale deployment and benefit.

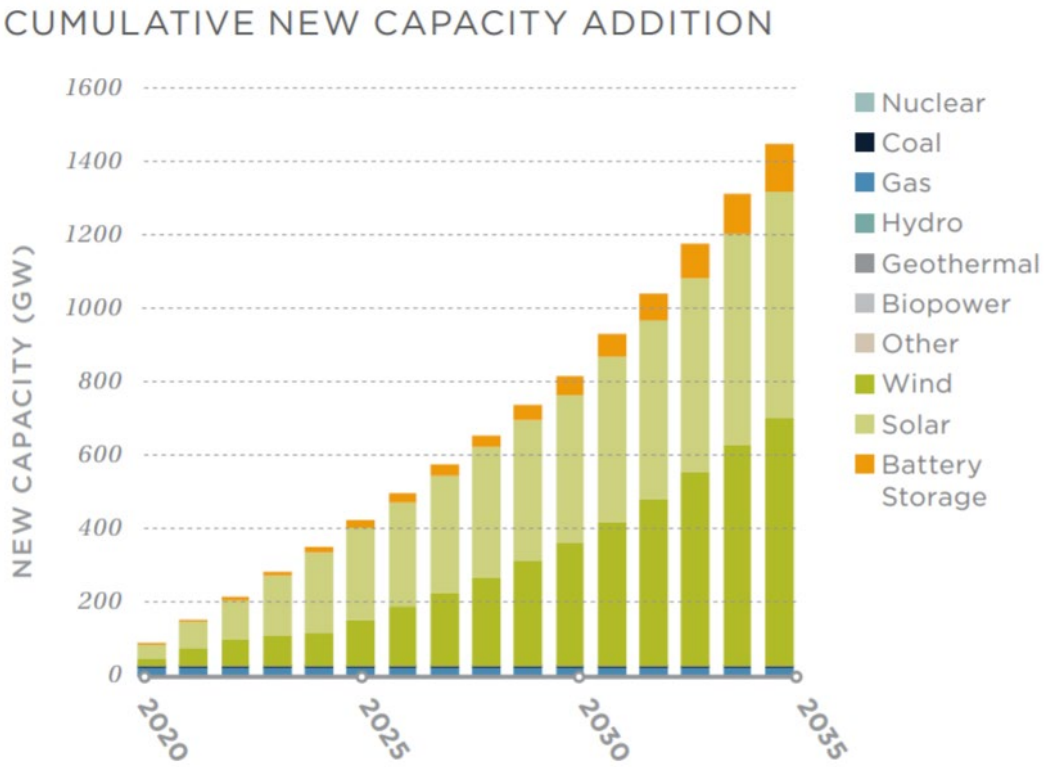
Impact

- Developed and improves de-factor standard wind farm control framework: FLORIS
- Consensus control developed and funded for commercialization
- Leading IEA task 44 on wind farm flow control



Future Work (FY21 and Beyond)

- AWAKEN Field Campaign
- RAAW Field Campaign
- Atmospheric science focus shifting offshore (WFIP3+)
- HFM focus shifting to building in offshore physics and applications of latest capability
- Deployment of MMC/HFM techniques, design tools, and wind farm controls to industry



ENERGY INNOVATION POLICY & TECHNOLOGY LLC

We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten.

– Bill Gates

Summary – FY19/FY20

- 76 Conference Reports
- 43 Journal Papers
- 12 Technical Reports
- 14 Workshops
- 10k+ Software Downloads
- 2 Technology Commercialization Projects
- Multiple industry CRADAs in development

"Our planet is on fire so our hair should be on fire"
– Secretary Granholm

Questions?

Ben Hallissy
DOE/WETO
benjamin.Hallissy@ee.doe.gov
240-267-0840