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NATIONAL OFFSHORE WIND
RESEARCH & DEVELOPMENT CONSORTIUM

Organization	Areas of Expertise	Description	Key test facilities
Binghamton University Binghamton, NY	**Power System Stability** Contact: Ziang Zhang, Eva N. Wu, ziang.zhang@binghamton.edu evawu@binghamton.edu **Power System State Estimation** Contact: Ning Zhou, ningzhou@binghamton.edu **Power Electronics Converters** Contact: Pritam Das, pdas@binghamton.edu	Binghamton University has four faculty with power systems and power electronics background. With collaboration with local utilities (NYSEG/AVANGRID and New York Power Authority), the team has research projects on renewable energy integration, power systems stability analysis, power systems stage estimation, and power electronics converter design. Research and implementation projects are supported by NSF, NYSERDA, and local industries.	• High-performance data center for power system simulation • One OPAL-RT OP5600 system for hardware- in-the-loop simulation • Fully equipment power electronics lab
Brookhaven National Lab (BNL) Upton, NY	**Electric Grid** Contact: James Misewich, misewich@bnl.gov **Energy Storage** Contact: Esther Takeuchi, etakeuchi@bnl.gov **Energy Materials** Contact: John Hill, hill@bnl.gov	Brookhaven is working together with New York State providing tangible solutions to help lower costs and assure reliable power delivery to consumers. Brookhaven scientists are conducting basic electrochemical research to significantly improve the efficiency and reliability of fuel cells and batteries. They have launched a concerted effort of basic and applied research for the development of improved energy-storage materials and systems with high energy densities, fast cycling rates and long cycling lifetimes in efficient, economical and safe media. Characterization facilities at NSLS-II & CFN provide an understanding of the structural and functional properties of energy materials, under operating conditions to help us design better battery materials.	• National Synchrotron Light Source-II (NSLS- II) • Center for Functional Nanomaterials (CFN) • Long Island Solar Farm

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Case Western Reserve University Cleveland, Ohio	**Offshore Wind Foundation: Research, design, testing, and performance monitoring** Contact: Prof. Xiangwu (David) Zeng xxz16@case.edu	The Research Group of Prof. Zeng in the Department of Civil Engineering at Case Western Reserve University has been conducting research on offshore wind foundation in the past ten years. They have one patent and published more than 30 papers on the static, dynamics, and earthquake response of a wide range of types of offshore wind foundations. They do geotechnical tests to determine soil properties for foundation design. They can do 1g tests, small scale centrifuge tests, engineering calculations and numerical simulations.	• Geotechnical centrifuge • Geotechnical lab testing facilities • Large scale structure testing facility • Numerical simulation software
City College of New York *Experimental Fluid Mechanics and Aerodynamics Laboratory* New York, NY	**Laboratory Simulations & Field Evaluations of Wind Turbines** Contact: Yiannis Andreopoulos andre@ccny.cuny.edu **Designed Special Attachment to Wind Tunnel for Wind-Sea Waves Interactions with Offshore Turbines** Contact: Yiannis Andreopoulos andre@ccny.cuny.edu **Atmospheric Wind Measurements with LIDAR** Contact: Marl Arend marend@ccny.cuny.edu	Niche capability to study wind/wave interactions with offshore turbines or farms in wind tunnel Capability to measure atmospheric boundary layer characteristics	• 4ft x 4ft x 28ft Wind tunnel modified to investigate wind/wave interactions with turbines • Related instrumentation to measure time- dependent velocities, forces and moments • Rooftop weather stations including Lidar

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Cornell University Ithaca, NY	**High-fidelity modeling, wind resources and extremes, array-array interactions** Contact: Prof S.C. Pryor sp2279@cornell.edu **Offshore wind resources, wind turbine wakes, offshore measurements** Contact: Prof R.J. Barthelmie rb737@cornell.edu	Cornell University has a reputation for excellence in research and will bring years of experience in wind energy research to creating a better understanding of the science of offshore wind energy in the US. We have a broad range of instruments and years of experience in experiment design and deployment in on- and off-shore wind energy for quantifying wind resources and wind turbine wakes. We also have expertise in measurements and modeling relevant to quantifying wakes and their extent from individual wind turbines to multiple arrays, both on- and offshore. Our modeling capabilities include the Weather Research and Forecasting model (with Fitch and Explicit Wake parameterization) and microscale modeling of large arrays. For characterization of extreme events in an offshore wind energy context we use COAWST (WRF with waves and oceans). Our research includes quantifying the impact of climate change. We work also in quantifying the drivers of leading-edge erosion both via modeling and measurements.	• Long-range scanning and vertical pointing lidars • Meteorological instrumentation including sonic anemometers, ceilometer • Disdrometers, microrain radar for hydrometer measurements • WRF experience and capability with Fitch and EWP wake parameterizations • Microscale wake/wind farm model experience and capability e.g WAsP, Fuga, Pywake • COAWST (WRF with waves and oceans) • Experience with blade leading edge erosion models e.g. kinetic energy, springer,impact • Leading Edge erosion classification via machine learning

ERM (Environmental Resource Management) Inc.	**Metocean modeling** Contact: Tayebeh Tajalilbakhsh Tayebeh.Tajallibakhsh@erm.com , Tajallibakhsh@gmail.com	ERM assisted BOEM in developing methodologies, procedures, and approaches applicable to all future U.S. offshore wind projects. Dr Tayebeh TajalliBakhsh leads the metocean modeling efforts in ERM, and has been the PI on a few BOEM projects assessing the geohazards impacting floating offshore windfarms, and assessing the impacts of offshore wind developments on hydrodynamic circulation and ocean condition. Tayebeh has also worked with offshore wind developers to assess the ambient and extreme metocean conditions needed for the design of the offshore turbine, the cables, and the impact of sea level rise on the cable landing site; and has been involved in the AWEA standards development groups.	

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Johns Hopkins University Baltimore, Maryland	**Wind Farm Fluid Mechanics, Turbulence and Large Eddy Simulations** Contact: Charles Meneveau meneveau@jhu.edu **Wind Farm Modeling and Control, along with Optimization for Grid Integration of Wind Energy and Electricity Market Design** Contact: Dennice Gayme gayme@jhu.edu **Aerodynamics, wind turbine modeling, piezo-electric wind energy harvesting.** Contact: Rajat Mittal mittal@jhu.edu **Systems Optimization of Wind Farm Electricity Generation and Grid Integration** Contact: Sauleh Siddiqui siddiqui@jhu.edu	Johns Hopkins has long-standing expertise in high-fidelity Large Eddy Simulation (LES) studies of wind farms. LES results have been used to develop reduced models for wind farm design and optimization. Reduced models derived from LES insights have also led to novel control methodologies. Computational aerodynamics, sharp interface immersed boundary methods to model wind energy harvesting using flag motion and piezo-electric transducers. In addition to wind farm control to perform grid services Johns Hopkins has expertise in using other renewable resources for freq. control in low inertia grids, voltage collapse prevention, and co- optimization of fast and slow resources in multi-timescale markets. Johns Hopkins has a history of modeling integration of renewable resources into the grid as well as market and policy design that can aid in planning this integration. JHU also extensive experience in using optimization and economics to simulate markets, evaluate plans, and optimize dispatch, with staff providing advice to several US ISOs. Johns Hopkins also has expertise in collapse modeling of wind turbine towers and with the improving the methods engineers employ to optimize their tower designs.	• LESGO, an open source LES code for wind energy applications, available publicly on Github. Both actuator disk and actuator line wind turbine models available. • Vicar3D, a viscous Cartesian grid solver using immersed boundaries, can be applied to simulate complex flow conditions such as off- shore structures and interactions.

Johns Hopkins University Baltimore, Maryland *(Continued)*	**Frequency Control, Low Inertia Systems, Electricity Markets, DER Coordination** Contact: Enrique Mallada mallada@jhu.edu **Power markets, planning, and operations simulation** Contact: Ben Hobbs bhobbs@jhu.edu **Tower Structural Modeling, Tower Manufacturing and Design** Contact: Ben Schafer schafer@jhu.edu		

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Pacific Northwest National Laboratory, Richland, WA	• **Wind Resource Characterization** • **Environmental Monitoring and** • **Wind-wildlife Impacts** • **Community Values and Ocean Co-use** • **Grid Integration and Transmission** • **Wind Data Management** Contact: Alicia Mahon alicia.mahon@pnnl.gov	Pacific Northwest National Laboratory (PNNL) leverages multidisciplinary teams with diverse backgrounds to tackle the most complex challenges facing offshore wind development in the United States. Our unique expertise in wind resource characterization, environmental monitoring and wind-wildlife impacts, community values and ocean co-use, grid integration and transmission, and wind data management is enabling the innovations needed to accelerate offshore wind development by addressing offshore wind energy market and deployment barriers. In addition, the PNNL-Sequim campus, in Sequim, Washington, houses the only marine research facilities in the Department of Energy complex. The campus is uniquely positioned for marine-based research which provides our researchers unique capabilities and expertise in how to plan, design, install, monitor, and maintain energy infrastructure and technology in harsh, extreme, and remote marine environments.	- PNNL-Sequim: marine reaearch facility that can support the design and testing of sensors and instrument packages, building integrated observing platforms, and developing advanced methods for data collection and analysis in a variety of marine and coastal environments. - DOE lidar buoys: using atmospheric and oceanographic measurement capabilities, the lidar buoys capture data, such as wind speed and direction at multiple heights using wind profiling lidar, air and sea surface temperatures, ocean current speeds and directions, and wave heights and directions. - Aquatic Research Laboratory: monitor and predict the impacts of renewable energy development and operation on water resources - Atmospheric Measurements Laboratory: understanding atmospheric processes through measurements, including

Rutgers, The State Univeristy New Jersey, Brunswick New Jersey	**Environmental Research, monitoring, and stakeholder engagement.** Contact: Dr. Josh Kohut kohut@marine.rutgers.edu **Energy economics, policy, and system analysis** Contact: Dr.Frank Felder ffelder@ejb.rutgers.edu **Materials Engineering, Manufacturing, and Infrastructure Engineering.** Contact: Dr. Dunbar Birnie dunbar.birnie@rutgers.edu **Workforce development, supply chain and sourcing.** Contact: Dr. Kevin Lyons klyons@business.rutgers.edu	The vast expertise and broad effort across Rutgers fully encompasses the expansive scope of offshore wind. Existing Rutgers faculty, staff and students are working on the environmental, engineering, policy, planning, and workforce development that must all be considered to implement an innovative research and workforce development program relevant to the developing US offshore wind activity. Ongoing work at Rutgers is organized across 3 research themes: 1) Environmental resource assessment and stewardship; 2) Energy economics, policy, and system analysis; 3) Materials Engineering, Manufacturing, and Infrastructure Engineering. Additionally, 2 cross cutting elements integrate across the participating Rutgers units: 1) Stakeholder Engagement and compatibility; 2) Education and workforce development. These efforts span the Rutgers units listed below and include environmental observations and models, electricity market analysis of offshore wind for the New Jersey State Offshore Wind Master Plan, materials and infrastructure engineering, impacted stakeholder engagement, and workforce development programming partnering with high school, 2 year, and 4 year institutions throughout the state.	• Center for Ocean Observing Leadership (RUCOOL) • Center for Advanced Infrastructure and Transportation (CAIT) • Laboratory for Energy Smart Systems and the • John J. Heldrich Center for Workforce Development • Labor Education Action Research Network (LEARN) • Center for Energy, Economic and Environmental Policy

Sandia National Laboratories Albuquerque, NM and Lubbock, TX	**Rotor design and aeroelasticity research** Contact: Brandon Ennis blennis@sandia.gov	Sandia has been researching wind turbine rotor systems with programs studying vertical-axis wind turbines (VAWT) and evolving to horizontal-axis wind turbine designs. Sandia has conducted research on the rotor system spanning composite materials and structural optimization to active and passive aerodynamic load control designs. Specific capabilities include: • Recent experience in scaled design with the National Rotor Testbed design project – a highly instrumented blade design to validate design models • Numerical Manufacturing and Design (NuMAD) blade structural optimization tool and design tool to assess aeroelastic performance • Extensive experience in composite materials research, including reliability and damage detection, and material optimization for rotor designs • Assessment of aerodynamic improvements and degradation (e.g., erosion)	• Scaled Wind Farm Technology Facility
	High Fidelity Modeling: Verification, validation and uncertainty quantification Contact: David Maniaci dcmania@sandia.gov	Sandia has built on decades of investment in high-performance computing hardware and software development to tailor computational fluid dynamics codes for the wind plant application. This is further supported by an array of codes used to perform uncertainty quantification and multi-fidelity analysis tailored to the specific problem. Sandia capabilities include: • Nalu – an open source computational fluid dynamics code scalable to petascale computing platforms *(continued on next page)*	

Sandia National Laboratories Albuquerque, NM and Lubbock, TX *(Continued)*	**Extreme load detection and structural health monitoring** Contact: Joshua Paquette japaque@sandia.gov	• A Verification and Validation framework to systematically assess and improve the predictive capability of the computational code • DAKOTA code for optimization and uncertainty quantification For the past 10 years Sandia has been developing rotor sensing technologies to monitor blade loading and damage. Acceleration and strain-based force and deflection estimation methods have been developed for normal and extreme operations of modern wind turbines. Damage detection methods have been developed that can be used in wind turbine controllers to control damage growth rate. This work has involved: • Instrumenting over 25 field-operating wind turbine blades at various scales and locations with accelerometers, fiber optic strain gages, pitot tubes, pressure taps, hot-film sensors, and other sensors throughout the turbine • Performance assessment and wake impact quantification via SCADA data	

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Stevens Institute of Technology, Hoboken, NJ	**(1) Hydrodynamics and control: Fixed and Floating offshore platforms,** Contacts: Muhammad Hajj (mhajj@stevens.edu), Raju Datla (rdatla@stevens.edu) **(2) Marine Mammal Detection,** Contact: Alexandar Sutin (asutin@stevens.edu) **(3) Scouring and Coastal Resiliency,** Contact: Jon Miller (jmiller@stevens.edu)	Stevens Institute of Technology has several faculty members with background in ocean, naval and coastal engineering. They have established relations with NJEDA and companies involved in development of offshore wind along the NJ/ NY shores. Stevens has	**1) Davidson Lab towing / wave tank:** A facility with unique capabilities for testing marine and naval systems. 2) The **New York Harbor Observing and Prediction System (NYHOPS)** provides maritime forecasts for an area centered on the New York Harbor rangi

Stony Brook University Stony Brook, NY	**High fidelity computational fluid dynamics for offshore wind farm control co-design and optimization** Fotis Sotiropoulos fotis.sotiropoulos@stonybrook.edu Ali Khosronejad ali.khosronejad@stonybrook.edu **High resolution atmospheric modeling for offshore wind resource assessment and prediction using field data and data assimilation approaches** Brian Colle brian.colle@stonybrook.edu **Active and passive remote sensing, boundary layer meteorology, multi-scale wind and turbulence measurements, observing networks design and optimization** Pavlos Kollias pavlos.kollias@stonybrook.edu	Stony Brook University faculty in the College of Engineering and Applied Sciences (CEAS) and the School of Marine and Atmospheric Science (SOMAS) have extensive experience and expertise in a very wide range of issues relevant to offshore wind. Our researchers have developed cutting edge computational tools for high-resolution atmospheric modeling and wind resource assessment and large-eddy simulation (LES) of wind farms, including modeling of atmospheric turbulence, ocean waves, FSI of floating structures, advanced control strategies and reduced order models. Expertise also includes laboratory scale modeling of floating turbines and mooring lines, remote sensing meteorology, wind and wave data collection in real-life marine environments, fatigue behavior of mooring lines, and survey and modeling of pelagic marine resources, biology, and eco-systems. We also have expertise in high resolution modeling of power systems to simulate the impact of high penetration of offshore wind to the power grid, cost, emissions, etc., and investigate environmental, economic and employment impacts of offshore wind projects.	• VFS-Wind, an open source LES code for offshore wind energy applications, available publicly on Github. Coupled atmospheric turbulence, ocean waves and turbine dynamics with advanced controls and novel actuator surface models for control co- design of large offshore wind farms • Weather Research and Forecasting (WRF) model and the DART (Data Assimilation Research Testbed) used to simulate a wide range of weather regimes. • Coastal and Hydraulics Engineering Research Lab (CHERL) equipped with state-of-the-art wave, surge and current modeling facilities (see http://www.stonybrook.edu/cherl/);

Stony Brook University Stony Brook, NY *(Continued)*	**Physical Modeling; Ocean and Coastal Morphodynamics Modeling; Lake and Ocean Hydrokinetic Renewable Energy** Ali Farhadzadeh ali.farhadzadeh@stonybrook.edu **Energy Storage** Contact: Esther Takeuchi esther.takeuchi@stonybrook.edu **Fatigue behavior of materials in mooring systems; developing materials with enhanced resistance to fatigue failure; developing synthetic high strength composite materials.** T. A. Venkatesh t.venkatesh@stonybrook.edu **Benthic ecology, population and community structure in space and time.** Robert Cerrato robert.cerrato@stonybrook.edu		• Radar Science group (you.stonybrook.edu/r adar) a remote sensing group with experience in measurements in urban and coastal areas. • Instrumentation includes fixed and mobile observatories with radar/lidar measurement capabilities, drones and surface flux systems. • A wide array of forward simulators for coupling measurements and high resolution LES models. • Experimental facility to characterize the fatigue behavior of mooring materials; Computational modeling capability to characterize fatigue damage evolution and growth in advanced materials • A variety of emerging field and lab

Stony Brook University Stony Brook, NY *(Continued)*	**Surveys and predictive modeling of marine mammal and seabird abundance and distribution, drone-based assessments of marine mammal body condition** Dr. Lesley Thorne Lesley.thorne@stonybrook.edu **Quantifying and monitoring pelagic marine resources: zooplankton, fish, and marine mammals.** Joseph Warren joe.warren@stonybrook.edu **Multidisciplinary research in environmental assessment and toxicology**. Anne McElroy anne.mcelroy@stonybrook.edu **Energy system modeling, energy economics, energy and environment** Gang He Gang.He@stonybrook.edu		techniques (e.g., fine- scale acoustic telemetry, stable isotopes), modelling (e.g., state-space), and multivariate statistical analyses (e.g., spatial-temporal direct analyses) for marine ecosystem monitoring. • Predictive models of marine mammal abundance, forecasts of marine mammal abundance and distribution in proximity to wind farms • Drone-based estimates of baleen whale body condition reflecting changes to marine habitats and forage fish • R/V Seawolf, an 80 foot ocean going vessel equipped for bottom trawling, ACDP, side scan sonar, berths for 11. Deck and scientific crew have extensive experience sampling in areas of OSW development.

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Texas A&M Univeristy College Station, TX	**Hydrodynamics** Mirjam Furth, furth@tamu.edu Jeffrey Falzarano, jfalzarano@civil.tamu.edu **Structural and fracture mechanics** David Allen, dhallen@tamu.edu Marcelo Paredes, lparedes@exchange.tamu.edu Roger Cordes, rcordes@exchange.tamu.edu **Geotechnical and foundations** Charles Aubeny, caubeny@civil.tamu.edu	TAMU has several faculty focusing on structural and fracture mechanics as well as the hydrodynamics, motion responses and performance of offshore wind farms. There is one faculty member with geotechnical and foundation focus.	• Offshore Technology Research Center, The wave basin is 150 ft long and 100 ft wide, with a depth of 19 ft. • Wind-wave-current flume: 28 m long, 0.8 m wide, and 1.0 m height. • 15-m mobile-bed wave flume • Fleet of research vessels for field measurement campaigns in Gulf of Mexico. • MTS servo-hydraulic loading frame for quasi-static and dynamic testing conditions which includes low and high cycle fatigues and fracture toughness evaluation. • Environmental chamber for low and high-temperature applications ranging from -160 C to 350 C. • Digital Image Correlation (D.I.C.) system for static and dynamic loading regimes to record in real-time full displacement and strain fields under 2D and 3D settings.

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Texas Tech University Lubbock, TX	**Complex Flow Measurements using Radar** Contact: John Schroeder john.schroeder@ttu.edu **Power Performance and Wind Loading Studies** Contact: Delong Zuo delong.zuo@ttu.edu **Hurricane Boundary Layer** Contact: John Schroeder john.schroeder@ttu.edu **Instrument Development/Signal Processing** Contact: Jerry Guynes jerry.guynes@ttu.edu	Texas Tech University (TTU) has performed a number of studies and field campaigns related to the structure of offshore wind and its interaction with wind turbines and/or plants. Whether measurements were acquired using advanced radar systems developed and installed by TTU, or provided by a third party (i.e. collected by an instrumented tower, floating lidar or other technology), TTU maintains expertise to effectively evaluate the measurements, and provide context on the flow structure and its impact on wind turbine performance and loading.	• TTUKa mobile research radars • DOE-X prototype radar • Instrumented field site (low roughness/minimal terrain) for full and research scale testing, includes a 200 m instrumented tower, sodar, vertically pointing and scanning lidar, radar, the Scaled Wind Farm Technology Facility, and other measurement assets

University of Delaware (UD) Center for Research in Wind (CReW), Center for Composite Materials (CCM), and Robotics Discovery Laboratories (RDL) Newark and Lewes, Delaware	**Array performance, control and layout optimization, numerical weather prediction and simulation, and resource assessment** Contact: Cristina Archer, carcher@udel.edu **Geotechnics & site characterization** Contact: John Madsen, jmadsen@udel.edu **Ports, deployment, and installation** Contact: Willett Kempton, willett@udel.edu **Composite materials.** Contact: John Gillespie, gillespi@udel.edu **Tribology** Contact: David Burris dlburris@udel.edu **Under-water and in-air UAVs for monitoring and recording met- ocean conditions** Contact: Matt Oliver, moliver@udel.edu and Art Trembanis art@udel.edu	UD has been bringing an interdisciplinary approach to offshore wind since 2003. UD's team reflects decades of hands-on experience with the offshore wind industry in the US and Europe. UD offers a graduate certificate in wind power science, engineering and policy, runs a skills academy for professionals, and brings a team in mechanical and electrical engineering, materials science, marine geology, meteorology, physical ocean science and engineering, oceanography, marine policy, business, economics, risk management, and wildlife ecology. Under research grants or cooperative agreements UD faculty and researchers have or are investigating and publishing on wakes, wind plant layout optimization, deployment and installation techniques, numerical modeling of wind resources, airborne wind, grid integration, gearbox tribology, geotechnical aspects of and robotics and remote sensing for site characterization (foundations, UXO, fish and endangered species), cost reduction via understanding of public perceptions and tourism impacts, risk analysis, policy and removal of regulatory barriers, marine spatial planning for conflict avoidance, public engagement strategies, and bird and bat assessment.	• 2 MW Gamesa G90 Wind Turbine in Lewes, Delaware, http://www.ceoe.udel.edu/lewesturbine/index.shtml • 915-mHz Wind Profiler, http://www.ceoe.udel.edu/our-people/profiles/carcher/fsmw • Research Vessels, https://www.ceoe.udel.edu/schools-departments/school-of-marine-science-and-policy/marine-operations • Robotics Discovery Laboratories (RDL), http://www.ceoe.udel.edu/schools-departments/school-of-marine-science-and-policy/robotics • Materials Tribology Lab, http://research.me.udel.edu/~dlburris/

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University of Illinois at Urbana-Champaign Urbana, IL	**Flow-structure interaction** Contact: Leonardo P. Chamorro, lpchamo@illinois.edu, Arne Pearlstein, ajp@illinois.edu **Turbulence, aerodynamics and hydrodynamics** Contact: Leonardo P. Chamorro, lpchamo@illinois.edu **Experimental methods** Contact: Leonardo P. Chamorro, lpchamo@illinois.edu **Control systems** Contact: Joseph Bentsman, jbentsma@illinois.edu **Power systems** Contact: Joseph Bentsman, jbentsma@illinois.edu **Mathematical modeling and real- time computation** Contact: Joseph Bentsman, jbentsma@illinois.edu	The University of Illinois has a unique combination of strengths in areas directly applicable to offshore wind energy. These include wind energy systems, modeling and simulation of wind turbines, dynamics and control of mechanical and electromechanical systems, fluid mechanics, structures and materials, control- configured design of offshore wind turbines, failure and reliability analysis, development of control theory and numerical algorithms for the existing and the novel offshore wind-based power generators and wind farms. The University is working on a project to create the world's most efficient, reliable, compact wind energy conversion system. Instead of following the traditional approach of building the electrical generator separately from the power electronics converter and then connecting both to convert the turbine's mechanical power into electrical power, the team applies control co-design methodologies on the generator and converter to substantially reduce the size and weight of the system.	• Combination of national- level wind-tunnels, flumes and large-scale refractive-index- matching (RIM) facilities • State-of-the-art instrumentation very suitable for the study of novel strategies for OWTs. Supporting instrumentation includes time-resolved, 3D particle image velocimetry and 3D particle tracking velocimetry, hotwire anemometry system with automatic 3D traversing, 6-degree-of- freedom load cells, and telemetry. • Computer clusters dedicated to HPC, and data management. • 200 kW drivetrain testbed with state-of-the-art measurement facilities, Fully developed Power Electronics and Electric Machines Laboratory

University of Illinois at Urbana-Champaign Urbana, IL *(Continued)*	**Structures and materials** Contact: Iwona Jasiuk, ijasiuk@illinois.edu **Reduced-order modeling** Contact: Arne Pearlstein, ajp@illinois.edu **Power Takeoff, Electric Machines Power Electronics, and Drives Control** Contact: Arijit Banerjee arijit@illinois.edu		

University of Massachusetts Dartmouth Dartmouth, MA	**Marine environmental and fisheries science.** Contact: Steven Lohrenz (primary) slohrenz@umassd.edu **Ocean physical and environmental modeling.** Contacts: Geoff Cowles gcowles@umassd.edu **Marine renewable energy.** Contact: Dan MacDonald dmacdonald@umassd.edu	The University of Massachusetts Dartmouth is the only four-year doctoral research university in Southeastern Massachusetts and is home to the largest marine science research and academic program in the University of Massachusetts system. The School for Marine Science and Technology (SMAST) has the technology and expertise to analyze the impact of offshore wind installations on the ocean environment, including critical marine habitats. In addition, SMAST has world class expertise in the science of climate change as it relates to the fisheries, ocean temperature and acidification, storm surge, sea level rise and coastal erosion. SMAST and UMass Dartmouth also have extensive computational infrastructure to support state-of-the-art modeling of ocean dynamics and environmental processes. Additionally, researchers in SMAST and the College of Engineering are working on various aspects of marine renewable energy, including the design, modeling, and testing of MRE devices, primarily for small scale applications, materials engineering, underwater sensing and robotics, hydrokinetics, and geotechnics.	• SMAST-East Seawater Laboratory Facility provides highly flexible and configurable capabilities for seawater testing for a variety of applications in a controlled setting. • The SMAST Acoustic/Optic Test Tank is a unique facility built to support the development and testing of sensitive acoustic and optical underwater measurement concepts and devices. • R/V Lucky Lady - 52-foot-long, diesel-powered, coastal research vessel with enclosed cabin, hydro-wire mounted on a side davit and operated by a hydraulic winch for sampling and deploying research equipment, and large work area aft of the pilothouse structure
University of Pittsburgh	**Short-term Wind Forecasting, Wind Farm Modeling**. Contact: Inanc Senocak, senocak@pitt.edu	University of Pittsburgh provides large-eddy simulation capabilities for off-shore and on-shore wind farms with turbine wake modeling. Computations are performed entirely on multiple graphics processing units (GPU) for fast turnaround time. Micro-scale simulations can be informed by weather prediction models through model-chain coupling.	Linux cluster with parallel file storage for accelerated GPU computing.

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University of Minnesota Twin Cities, MN	**Modeling of ocean waves, wind and offshore wind turbines** Contact: Lian Shen shen@umn.edu **Field measurement of wind turbine** Contact: Jiarong Hong jhong@umn.edu Michele Guala mhuala@umn.edu **Laboratory measurement of turbulent boundary layer and wind turbine models** Contact: Michele Guala mhuala@umn.edu **Wind turbine and wind farm control** Contact: Peter Seiler seile017@umn.edu	High-fidelity simulation of ocean wave field, marine wind, and fixed and floating wind turbines; Deterministic prediction of nonlinear wave field evolution; Reduced-order modeling of wind/wave/wind-turbine/wind-farm system In situ measurements of turbine wake flow and structural deformation using novel imaging; Data mining approach for wind field data analysis Laboratory experiments for the scaling of high Reynolds number wall turbulence, organization of large scale motions, and their contribution to turbine performance and wake evolution We have designed, simulated, implemented, and experimentally tested individual blade pitch control for a 2.5MW turbine. We have also designed several other advanced control algorithms for individual turbines and wind farms.	• CFD code “WOW! SAFL!” for wind-ocean- wave-turbine simulation • Eolos Wind Energy Field Station: fully- instrumented 2.5 MW wind turbine and 130 m meteorological tower • St. Anthony Falls Laboratory Atmospheric Wind Tunnel • Control algorithms developed in-house

University of Rhode Island Kingston, RI	**Offshore wind technology** Contact: Prof. M Reza Hashemi reza_hashemi@uri.edu **Environmental Impacts of offshore wind energy:** Contact: Prof. John King jwking@uri.edu **Public acceptance and policy of offshore wind energy** Contacts: Prof. David Bidwell dbidwell@uri.edu	The University of Rhode Island is a leader in coastal and ocean planning because of their expertise in oceanography, sociology, sustainable fisheries, coastal resource management, and ocean engineering. URI researchers have contributed to siting, construction, monitoring, and implementation of the first offshore windfarm in the US, Block Island Wind Farm, through OceanSAMP https://seagrant.gso.uri.edu/oceansamp/ Important areas of expertise: • Macro- and Micro-siting • Underwater acoustics (construction and operation noise, marine mammals monitoring) • Environmental impacts of offshore wind farms (e.g., marine mammals, fish, birds, and other specifies/habitats) • Social acceptance of offshore wind projects • Outreach and public engagement	• URI has several monitoring projects at the first offshore wind farm in the US, Block Island Wind Farm, including structural, environmental, and social aspects. • URI is forming a consortium in offshore renewable energy

University of Texas at Dallas Richardson, Texas	**Rotor and turbine design; Structural Dynamics; offshore wind systems** Contact: Dr. D. Todd Griffith (RDAG Institutional Representative) tgriffith@utdallas.edu **Wind turbine control systems; wind plant control systems; condition monitoring systems** Contact: Dr. Mario Rotea rotea@utdallas.edu **Wind turbine and wind plant modeling: Actuator line and disk, LES.** Contact: Dr. Stefano Leonardi Stefano.Leonardi@utdallas.edu **Wind tunnel testing, LiDAR measurements, Wind plant modeling and design** Contact: Dr. G. Valerio Iungo Valerio.Iungo@utdallas.edu	The following are UT-Dallas capabilities and areas of expertise relevant to offshore wind: Large turbine design, new turbine concepts, offshore wind systems, structural health and prognostics management, and experimental structural measurements. Control systems for load reduction and wind plant/turbine power performance improvement, high-fidelity CFD tools for modeling wind turbine performance and wake impacts in wind farms. Boundary layer wind tunnel for testing sub-scale rotors & wind turbine airfoil aerodynamics. Wind tunnel testing of floating platforms with Hardware-In-the- Loop (HIL) control. Deployable LiDARs to evaluate wind resources, wind farm performance and wake interactions.	• BLAST Wind Tunnel • UTD Mobile LiDAR Station • Energy High-Bay for Large Structural Evaluation • HPC cluster
University of Utah Salt Lake City, Utah	**Numerical Simulations** Contact: Marc Calaf marc.calaf@utah.edu	At the Wind Energy and Turbulence Laboratory, at the Mechanical Engineering Department (University of Utah), we specialize in the development of computational tools (high & low resolution) to model the complex flow in onshore/offshore wind farms.	• Center for High- Performance Computing

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Webb Institute Glen Cove, NY	**Naval Architecture** Contact: Rick Royce rroyce@webb.edu **Marine Engineering** Contact: Matt Werner mwerner@webb.edu **Computational Fluid Dynamics** Contact: Adrian Onas aonas@webb.edu	The Webb curriculum includes Naval Architecture, Marine Engineering and Marine Systems. Each of these focus areas are integral to the development and support of offshore wind energy systems. Our capabilities include: Physical modeling of the environment including waves, currents, and wind in our various laboratories. Modeling of marine systems both through simulation and physical models. Beach access to Long Island Sound.	• Towing tank/wave basin • Wave-maker • Circulating water channel • Wind tunnel • Material and structural testing • Marine engineering laboratory

West Virginia Universirty, Morgantown, WV	**OSW related subject matter expert:** Dr. Onur Avci (Department of Civil and Environmental Engineering). onur.avci@mail.wvu.edu	• Vibration based damage detection and SHM. • Vision-based damage detection and SHM. • Sound-based damage detection and SHM. • Machine Learning, Deep Learning, AI use in SHM and damage detection applications. • Generative models in SHM and damage detection applications. • Use of drones for SHM and damage detection applications (LiDAR, high-speed camera, infrared). • Vibrations serviceability of structural systems.	

Wind Energy Center University of Massachusetts Amherst, Massachusetts	**Array Performance and Control** • **Flow-Induced Vibrations and Fatigue** • **Stability of Off-Shore Wind Turbine Platforms** • **Stability of Wind Turbine Blades** • **Ultrasonic mitigation of bat-wind turbine interactions** **Contact: Yahya Modarres-Sadeghi: modarres@engin.umass.edu** • Optimization Offshore wind turbine control • Dynamics of floating turbines in wind farm arrays • Loads analysis of turbines within wind farm arrays Contact: Matt Lackner lackner@ecs.umass.edu	The Wind Energy Center at UMass Amherst has extensive experience in wind energy in general and offshore wind energy in particular, dating back to the 1970s and continuing up to the present. Recent activity includes: • 10 faculty members across 5 departments • In excess of $10 million in research funding since 2008: NSF, BOEM, GE, DoE, US Fish and Wildlife, MassCEC • Multidisciplinary research and education: Engineering, ecology, public policy, planning • UMass Wind Energy NSF IGERT: 32 PhD fellows ~1/2 female • Wind Energy Engineering certificate program • Fundamentals of wind energy engineering online course • Founding member of North American Academy of Wind Energy, Massachusetts Research Partnership for Offshore Wind and POWER-US **Research capabilities and Personnel** 1. Turbine design and analysis: • Wake modeling and control • Floating platform dynamics: damping and controls • Active, semi-active and passive controls for blades and structures 2. Support structures and foundations: • Soil-structure interaction: monopile reliability and damping *(Continued on next page)*	• Open throat wind tunnel • Re-circulating water tunnel

Wind Energy Center University of Massachusetts Amherst, Massachusetts *(Continued)*	**Cost-Reducing Turbine Support Structures for the US Market** • Offshore structural engineering design • Design for deconstruction and relifing • Offshore structural load estimation • Soil-structure interaction and foundation design • Resiliency to extreme wind/wave loads such as caused by hurricanes Sanjay Arwade arwade@umass.edu Donald Degroot: degroot@umass.edu	• Extreme loads and risk analysis: hurricane wind and wave loads • Novel mooring systems: multiline anchors design and reliability 3. Environmental and ecological modeling and assessment 4. Public policy, acceptance and social impacts 5. Economics 6. Personnel: Sanjay Arwade, Erin Baker, Alison Bates, Don DeGroot, Matthew Lackner, James Manwell, Yahya Modarres- Sadeghi, Krish Thiagarajan Sharman	

Wind Energy Center University of Massachusetts Amherst, Massachusetts *(Continued)*	**Floating Structure Mooring Concepts for Shallow and Deep waters** • Semi-submersible and spar buoy dynamics • Shared anchor concepts • Parameter studies showing depth viability for catenary and other mooring type Contact: Krish Thiagarajan Sharman kthiagarajan@umass.edu **Hurricanes and Winter Storms:** • Hurricane Probabilistic Risk Assessment • Fixed and floating structures • Extreme wave experiments • Extreme wind experiments Contact: Sanjay Arwade arwade@umass.edu		

Wind Energy Center University of Massachusetts Amherst, Massachusetts *(Continued)*	**Offshore wind turbine design standards** **Offshore energy storage** **North American Academy of Wind Energy** **Wind Energy Education** Contact: James Manwell manwell@ecs.umass.edu **Fluid-Structure Interactions** • Flow-Induced Vibrations and Fatigue • Stability of Off-Shore Wind Turbine Platforms • Stability of Wind Turbine Blades • Ultrasonic mitigation of bat-wind turbine interactions Contact: Yahya Modarres-Sadeghi: modarres@engin.umass.edu		

Woods Hole Oceanographic Institution Woods Hole, MA	**In situ and remote sensing, sensor development and testing, coastal ocean and atmospheric processes, turbulence** Contact: Anthony Kirincich (lead member) akirincich@whoi.edu **Marine meteorology and air-sea interaction** Contact: Jim Edson jedson@whoi.edu **High resolution sub-bottom remote sensing** Contact: Dan Lizarralde danl@whoi.edu **Marine Mammal behavior, passive acoustic sensing, sensor development** Contact: Mark Baumgartner mbaumgartner@whoi.edu **Marine Robotics** Contact:Jim Bellingham jbellingham@whoi.edu	The Woods Hole Oceanographic Institution (WHOI) is the world's largest non-profit ocean-themed research institution. WHOI scientists work in a wide range of areas that are critical to the emerging offshore wind energy industry in the U.S., including metocean sensing, advanced atmospheric sensing and numerical modeling, ocean and underwater acoustic sensing, sub-bottom remote sensing, and AUV development and operation. WHOI owns and maintains the Air Sea Interaction Tower (ASIT), a component of the Martha's Vineyard Coastal Observatory, and numerous dockside test facilities for general scientific use. WHOI also maintains a fleet of research vessels, including the coastal research vessel, R/V Tioga.	• The Air-Sea Interaction tower (cabled offshore fixed tower in 17-m water depth) • The Martha's Vineyard Coastal Observatory and Nantucket Test Site • The Center for Marine Robotics • Pressure test facility and sensor test tanks • Port facilities • R/V Tioga coastal research vessel • R/Vs Armstrong and Atlantis • U.S. Navy approved AUV test areas.
Xodus Group Boston, MA	**Floating Offshore Wind Economic Impact Analysis, LCoE/Costing Analysis, Supply Chain and Workforce Analysis, Technology and Innovation Analysis**	Xodus Group is a global energy consultancy and an established industry expert within the offshore wind sector, having performed project work on all related elements such as analyzing, developing, and making recommendations for the development of key supply chain and workforce initiatives.	