U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Wind Energy Technologies Office

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Summary Results
Request for Information on National Offshore Wind Energy R&D Test Facilities

Introduction

On July 30, 2018, the Wind Energy Technologies Office (WETO) of the Department of Energy's Office of Energy Efficiency and Renewable Energy issued a request for information (RFI) on test facilities supporting offshore wind energy research and development. The RFI closed on September 14, 2018.

The stated purpose of the RFI was to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on issues related to national offshore wind test facilities. Through a series of questions, WETO requested information on:

- The facilities in the U.S. that are available for offshore wind-specific experimentation and testing;
- Facilities upgrades or new facilities that are required in the U.S. for offshore wind testing in order to perform cutting edge research and development (R&D); and
- The most pressing R&D-related testing needs that would utilize existing, upgraded, or new U.S. offshore wind-specific test facilities.

This report includes a compilation by WETO, in summary form, of key information received in responses to the RFI. This information has been edited and interpreted by WETO in order to present and utilize it in a common, condensed format.

Responses

WETO received detailed technical responses from twenty-one entities. This group of respondents was made up of:

- 7 from industry, including engineering consultants
- 9 from university-based research centers
- 3 from national laboratories
- 2 from state and national business development organizations

Analysis

WETO created four tables aggregating the information from all the responses into a single summary document with commonality of terms and concepts, avoiding duplication of recommendations and information. These tables are:

1. Testing Needs for Offshore Wind Research and Development

This table introduces the different categories of experimental testing that are needed to further the state of R&D for offshore wind. It identifies the type of testing, type of facilities required to perform the testing, what is being evaluated by the testing, and the rationale for or desired outcome of the testing.

2. U.S. Offshore Wind Energy Test Facility Inventory

   This table is an inventory, based solely on RFI responses, of existing facilities in the U.S. that can support offshore wind testing. This inventory sorts facilities by their capabilities, includes their location, owner/operator, a brief facility description, and the type of offshore wind related testing that could be performed at the facility.

3. Potential Test Facilities Upgrades by Type

   This table identifies types of potential upgrades that could be implemented at existing facilities in the U.S. to broaden their R&D capabilities, along with the rationale for and potential benefits to industry of those upgrades. The table is broken down by facility categories corresponding to those in the U.S. Offshore Wind Energy Test Facility Inventory (Table 2).

4. Potential New Facilities for Offshore Wind Testing in the U.S.

   This table identifies potential new facilities that could be developed in the U.S. to support offshore wind R&D. The broad set of stakeholder responses in this category ranged from hydrodynamic testing at scale, to full-scale testing at sea of turbines and components.

<u>IMPORTANT NOTE</u>: The information in these table is based solely on the RFI responses. No prioritization or assessment of the relative importance of test types or facilities is implied in how the tables are organized and how the information is presented. The information listed regarding existing facilities is abbreviated and has not been verified for accuracy.

TABLE 1 - Testing Needs for Offshore Wind Research and Development

(Based solely on responses to DOE Request for Information 7/30/2018)

No prioritization or assessment of relative importance of test types or facilities is implied in the organization or presentation of information in this table

Test Category	**Applicable Type of Test Facility***	**What is being evaluated?** (examples)	**Rationale/Outcome of Testing** (examples)
Hydrodynamic Performance Modeling of Structures (Testing of small-scale models under simulated conditions)			
	Hydrodynamic (basin or flume)	Support structure - Fixed	Hydrodynamic responses to operational and/or extreme wave conditions currents and other factors in order to perform studies on 3D motions, interaction of multiple devices, directional wave impact forces, scouring potential, stability, vortex-induced motions and vibrations, slamming, run-up, overtopping, optimization, deployment techniques, mooring systems, etc.
		Support structure - Floating	
		Submerged structural components and anchors	
		Support structure with static turbine mounted	
		Transport and tow-out scenarios	
		Design code validation	Comparison of physical model performance under simulated conditions to results from computer models
Coupled Hydrodynamic and Aerodynamic Performance Modeling (Testing of small-scale models under simulated conditions)			
	Hydrodynamic (basin or flume) plus aerodynamic (with wind generation capabilities)	Integrated turbine and structure in simulated operation	Coupled performance under simultaneous wind and wave loading
		Transport and tow-out scenarios	Evaluate behavior of turbine/foundation systems installation scenarios under simulated conditions
		Comparative evaluation of floating offshore wind system (turbine/platform) configurations	Establish key design parameters determining system performance and which configuration characteristics have the most influence on achieving desired results (e.g. decreased operating loads and overall mass)
		Design code validation	Comparison of physical model performance under simulated conditions to computer model results
Aerodynamic Performance Modeling (Testing of small-scale models under simulated conditions)			
	Aerodynamic (boundary layer wind tunnel)	Aerodynamic effects of turbines and support structures above the waterline in wind plant arrays	Develop and validate computer models to optimize the layout of offshore wind plants
Testing of Intermediate-scale Turbines and Structures (e.g. 1/4 scale prototypes)			
	Fixed or floating testbed in sheltered marine or fresh water environment	Turbine/structure/control concepts	Validation of designs, controls, and models in moderate conditions without cost of building and deploying full-scale articles
	Motion-simulation testbed on land	Coupled turbine/structure performance	Characterization of performance variables and design options under controlled conditions

Test Category	Applicable Type of Test Facility*	What is being evaluated? (examples)	Rationale/Outcome of Testing (examples)
Testing of Full-scale Turbines and Components			
	Turbine certification facility	Turbine/tower systems	Performance validation; compliance to type certification requirements; verification of component changes
	Large-scale dynamometer testbed	Turbine drivetrains	Performance validation; accelerated lifetime testing; failure modes analysis
	Large-scale blade test facility	Blades	Structural performance of full-size blades, blade segments, and/or structural elements
	Large-scale bearing test facility	Very large pitch, yaw and mainshaft bearings	Required for turbine certification, improving reliability, and lowering cost of bearing systems for next generation of turbines
	Structural testbed	Support structure and structural components	Load and fatigue tests for evaluating performance of large structural components under offshore wind and sea-state conditions. Test the stiffness, strength, and cyclic performance of component elements and how these are affected by stress levels, cyclic loading, material properties, and structural variables
Geotechnical Modeling (Testing of scale models under simulated conditions)			
	Large soil-structure interaction facility (geotechnical centrifuge and/or shake table)	Support structure - fixed	Fluid soil/structure interaction analysis including scour, stability, verification of uplift capacity and reducing ballast requirements
		Anchors for floating systems	Comparative testing of various configurations under identical simulated conditions
Materials and Coatings Validation			
	Coatings test and verification facility (focused on offshore wind turbine componentry and conditions)	Component coating systems under accelerated conditions	Ensure compliance of coating systems with corrosion, abrasion, and safety protection requirements for offshore structures and turbines, in immersion and above waterline
	Rain erosion test facility	Blades - leading edge and tip erosion	Evaluate leading edge and blade tip material and treatments in a controlled but realistic environment through material modeling, characterization and testing in order to avoid structural degradation and loss of energy production due to surface erosion
	Ice accretion test facility	Blades - ice accretion characteristics and mitigation types	Avoid lost production time and damage due to ice buildup on blades and support structure; test mitigation processes
Atmospheric and Environmental Characterization			
	Meteorological reference site	Remote wind scanning and characterization devices	Testing and validation of innovative, lower cost technologies and methods for wind resource observations and site characterization
	Deployable instrumentation buoys	Performance related site characteristics prior to project development	Data on factors such as wind speed, wind direction, air temperature, humidity, ocean temperature, salinity, current profiles, and wave height and direction used in project design, and for comparison to long term post-construction measurements

Test Category	Applicable Type of Test Facility*	What is being evaluated? (examples)	Rationale/Outcome of Testing (examples)
Marine Sciences and Seawater Testing (Related to offshore wind technology)			
	Marine sciences and seawater laboratory	Offshore-related instruments and underwater vehicles	Evaluate and calibrate instrument packages and remotely-operated or autonomous vehicles for site characterization and environmental and performance monitoring
		Responses of marine organisms to various types of structures, materials, coatings and operating systems used in offshore wind	Conduct behavioral and physiological experiments on marine organisms in order to evaluate responses to different environmental conditions and stimuli
Data Collection at Full-scale Offshore Wind Plants			
	Standard instrumentation package and protocols for in situ monitoring of commercial and demonstration wind plants	Full turbine system performance and environmental conditions over time	Large body of data to compare actual to predicted structural loads, energy production, environmental conditions, etc. in order to inform future designs, operating assumptions, and risk assessments
		Array-level energy losses and control paradigms	Better understanding of the interaction and impacts of multiple-turbine arrays in the marine environment and how losses may be mitigated through advanced controls architecture
	Open water testbed or demonstration project	Performance of individual or multiple prototype or first-of-a-kind systems under research controls and parameters	Characterization of system performance, structural loads and installation/operations process against pre-construction and design assumptions
Computer Simulated Testing, Validation, and Data Archiving			
	High performance computing facility	Relevance and accuracy of computational design tools	Increased confidence in new, complex tools such as coupled aeroelastic hydrodynamic numerical models for floating offshore wind turbines, leading to more optimal designs in terms of performance and cost
		Integrated data protocols and repository to support multi-party and multi-discipline collaboration	Facilitate a network of research entities sharing testing data and outcomes to advance the capabilities and accuracy of all parties' research
	System controls simulator	Coupled turbine and structure controls for floating systems	Modeled validation of advanced wind turbine control strategies for floating wind turbines prior to full-scale deployment

***Not all facilities of a general type can support the all types of tests indicated here. See facility inventory table for greater detail on varying capabilities within the facility types.**

TABLE 2 - U.S. Offshore Wind Energy Test Facility Inventory

(Based solely on responses to DOE Request for Information 7/30/2018)

No assessment of relative merit or suitability for carrying out given types of tests at listed facilities is implied in the organization or presentation of information in this table.

The information listed regarding existing facilities is abbreviated and has not been verified for accuracy.

Upgrades may be required for individual listed facilities to meet specific offshore wind testing requirements.

Facility Type	Facility Name	Location	Owner/ Operator	Brief Facility Description *	Type of Testing that could be Accommodated (facility upgrades may be required)	Website
Hydrodynamic (basin or flume for physical model testing)						
	Large Wave Flume	Corvallis OR	Oregon State	104 m long, 3.7 m wide, and 4.5 m deep, capable of generating periodic and episodic waves	Hydrodynamic performance modeling; design code validation	http://wave.oregonstate.edu/large-wave-flume
	Directional Wave Basin	Corvallis OR	Oregon State	48.8 m long, 26.5 m wide, and 2.2 m deep, capable of generating currents, and periodic and episodic multidirectional waves including tsunamis	Hydrodynamic performance modeling; design code validation	http://wave.oregonstate.edu/directional-wave-basin
	Hydraulics Wave Basin	Coralville IA	U. of Iowa	40 m long, 20 m wide, and 3 m deep, capable of generating periodic and episodic multidirectional waves	Hydrodynamic performance modeling; design code validation	https://www.iihr.uiowa.edu/facilities/annexes-labs-and-shops/hydraulics-wave-basin-facility/
	David Taylor Model Basin (Carderock)	Bethesda MD	U.S. Navy	846 m long x 15.5m wide x 6.7 m deep, capable of generating periodic and episodic waves	Hydrodynamic performance modeling; design code validation	www.navsea.navy.mil/Home/Warfare-Centers/NSWC-Carderock/Resources/News/
Hydrodynamic and Aerodynamic (basin or flume with wind simulation)						
	Alfond Wind/Wave Ocean Engineering Laboratory	Orono ME	U. of Maine	~1:50-scale offshore model testing facility equipped with a high-performance rotatable wind machine over a multidirectional wave basin (30 m x 9 m x 4.5 m)	Coupled hydrodynamic and aerodynamic performance modeling; design code validation	https://composites.umaine.edu/key-services/offshore-model-testing/
	Offshore Technology Research Center Wave Basin	College Station TX	Texas A&M	45.7 m long x 30.5 m wide x 5.8 m deep wave basin with adjustable depth pit (9.1 m x 4.6 m x 16.8 m), current generator, multiple fans for wind simulation	Coupled hydrodynamic and aerodynamic performance modeling; design code validation	https://otrc.tamu.edu/otrc-wave-basin/
	Offshore Technology Research Center Wind/ Wave/ Current Flume	College Station TX	Texas A&M	New (December 2018) flume (25 m long, 0.8 m wide, and 1.0 m high) with wind, wave, and current generators	Coupled hydrodynamic and aerodynamic Performance Modeling (note width limitations for model testing)	Not yet available
Aerodynamic (boundary layer wind tunnel with unique capabilities)						
	Boundary layer wind tunnel	Gainesville FL	U. of Florida	19-foot wide, 10-foot tall, and 130-foot long wind tunnel with continuously adjustable terrain roughness field	Aerodynamic performance modeling (with simulated variations in surface characteristics)	https://multihazard.eng.ufl.edu/experimentation/testing-apparatuses/wind-engineering/boundary-layer-wind-tunnel/
Intermediate-scale Testbed Simulating Offshore Conditions						
	National Wind Technology Test Center	Golden CO	National Renewable Energy Laboratory	Facility includes several test turbines with configuration properties similar to full-scale offshore turbines; frequent extreme wind events; and sophisticated instrumentation to characterize turbine response	Scaled turbine, control system, and tower tests on land	https://www.nrel.gov/nwtc/

Facility Type	Facility Name	Location	Owner/ Operator	Brief Facility Description*	Type of Testing that could be Accommodated (facility upgrades may be required)	Website
	Scaled Wind Farm Technology (SWiFT) facility	Lubbock TX	Sandia National Laboratory	Three turbines with high-resolution atmospheric, turbine, and blade measurements, open-source controller, highly characterized blade design to reduce modeling uncertainty and enable innovative experiments at low cost to qualify new initiatives.	Scaled turbine, control system, and tower tests on land	https://energy.sandia.gov/energy/renewable-energy/wind-power/wind_plant_opt/scaled-wind-farm-technology-swift-facility/
Testing of Full-scale Turbines and/or Components						
	Wind Technology and Testing Center (Blades)	Boston MA	Massachusetts Clean Energy Center	Three test stands; accommodates blades to 90m; static and fatigue testing	Static strength testing and accelerated fatigue testing of turbine blades	https://www.masscec.com/wind-technology-testing-center
	Advanced Structures and Composites Center	Orono ME	U. of Maine	Test stand accommodates blades to 70m; static and fatigue testing	Static strength testing and accelerated fatigue testing of turbine blades	https://composites.umaine.edu/key-services/wind-blade-testing/
	Blade Test Facility	Potsdam NY	Clarkson U.	Test stand accommodates blades to 14m; static and fatigue testing	Scaled testing of blade materials and construction	https://www.clarkson.edu/btf
	National Wind Technology Test Center	Golden CO	National Renewable Energy Laboratory	Two test stands; accommodates blades to 19m; static and fatigue testing; 2.5 MW and 5.0 MW dynamometers with controllable grid interface	Blade sub-component validation tests; lubricant and gearbox component reliability testing	https://www.nrel.gov/nwtc/
	SCE&G Energy Innovation Center	Charleston SC	Clemson U.	15 MW and 7.5 MW dynamometers with off-axis force applicators; max specimen 13m diameter x 20 m length; 15 MW grid simulator for testing electrical characteristics	Complete (full scale) turbine nacelle or drivetrain components	https://clemsonenergy.com/wind-turbine-test-beds/
Full-scale structural testbed (substructures, towers, anchors)						
	Stress Engineering Services	Houston TX	Stress Engineering	130,000 sq. ft. offshore structures test lab with capacity of up to 26.7 MN in tension, 20.9 MN in compression 1356 KN-m bending; internal and external pressure and high and low temperature testing capabilities	Load and fatigue tests for evaluating performance of large structural components under offshore wind and sea-state conditions	https://www.stress.com/capabilities/testing-services/
	Multi-Axial Subassemblage Testing Laboratory (MAST)	Minneapolis MN	University of Minnesota	Structural testbed up to 20 feet x 20 feet in plan and 29 feet high; up to 1320 kips of vertical force and 880 kips of horizontal force in each lateral direction	Load and fatigue tests for evaluating performance of large structural components under offshore wind and sea-state conditions	http://nees.umn.edu/
	Newmark Structural Engineering Laboratory	Urbana IL	U. of Illinois	Structural testbed with three portable 6 degree-of-freedom loading units	Load and fatigue tests for evaluating performance of large structural components under offshore wind and sea-state conditions	https://www.ideals.illinois.edu/handle/2142/3519
Geotechnical Modeling						
	Center for Geotechnical Modeling	Davis CA	U.C. Davis	9 m radius centrifuge able to simulate an area 130 m long by 50 m wide with a soil depth of 50 m; shaking table; payload capacity of 1500 kg	Fluid soil/structure interaction analysis (testing of scale models under simulated conditions)	http://cgm.ucdavis.edu
	Geotechnical Centrifuge Research Center	Troy NY	Rensselaer Polytechnic Institute	3.0 m radius, 100 g-ton centrifuge with shaker	Fluid soil/structure interaction analysis (testing of scale models under simulated conditions)	http://homepages.rpi.edu/~dobryr/centrifuge2.html
	CIEST Geotechnical Centrifuge	Boulder CO	U. of Colorado	5.6 m radius 400 g-ton centrifuge	Fluid soil/structure interaction analysis (testing of scale models under simulated conditions)	https://www.colorado.edu/center/ciest/geotechnical-centrifuge

Facility Type	Facility Name	Location	Owner/ Operator	Brief Facility Description *	Type of Testing that could be Accommodated (facility upgrades may be required)	Website
Materials and Coatings Laboratory						
	Ice Adhesion Testing Facility	Hanover NH	U.S. Army Corps of Engineers	Range of capabilities for specimen testing of the adhesion of ice to various surfaces, and weathering tests to verify the durability of a broad range of coatings	Ensure compliance of coating systems with ice-shedding, corrosion, abrasion, and safety protection requirements	https://www.erdc.usace.army.mil/Media/Fact-Sheets/Fact-Sheet-Article-View/Article/518761/ice-adhesion-testing-facility/
Atmospheric and Environmental Characterization						
	DOE Lidar Research Buoys	Deployable	Pacific Northwest National Laboratory	WindSentinel buoys with motion-compensated LIDAR for measurements of the wind profile to 200m above the sea surface, plus supplemental surface measurements of wind speed, wind direction, air temperature, humidity, ocean temperature, salinity, ocean current profiles, and wave height and direction.	Atmospheric and environmental characterization at specific sites of interest	https://wind.pnnl.gov/lidarbuoyloanprogram.asp
Seawater Testing						
	Marine Sciences Laboratory	Sequim WA	Pacific Northwest National Laboratory	Laboratory facilities and expertise in marine sciences and operations. Marine and hydrokinetic test facility.	Characterization of the offshore environment ; materials and corrosion testing in marine conditions	https://marine.pnnl.gov/
	SMAST-East Seawater Laboratory	New Bedford MA	UMass Dartmouth	Laboratory capabilities to replicate a variety of seawater conditions, including with live organisms	Evaluate test articles in a controlled setting; behavioral and physiological experiments on marine organisms to evaluate responses to environmental conditions and stimuli	https://www.umassd.edu/smast/about/facilities/
	SMAST Acoustic/Optic Test Tank	New Bedford MA	UMass Dartmouth	5.8 m deep 90,000-gallon tank, with more than one-half atmosphere in pressure difference from surface to bottom, supported on an array of neoprene shock absorbers	Testing and calibration of instrumentation packages and/or remotely-operated or autonomous vehicles	http://www.smast.umassd.edu/tank-time/

TABLE 3 - Potential Test Facilities Upgrades by Type

(Based solely on responses to DOE Request for Information 7/30/2018)

No prioritization or assessment of relative importance of upgrades is implied in the organization or presentation of information in this table

See Table 2 for a listing of facilities in each category

Category of Facility	Potential Facility Upgrade*	Rationale for Upgrade	Benefits to Industry
Hydrodynamic Facilities (basin or flume for physical model testing)			
	Enhance depth, current and or bimodal wave simulation capabilities	Truer representation of currents and multidirectional seas impacting turbine support structures; enhance overall calibration capabilities to match design sea state conditions	Greater certainty and risk reduction in design validation, particularly with regard to irregular waves and effects such as wave slamming and run-up
	Add wind simulation capabilities	Truer representation of the coupled dynamics that exist in offshore wind systems between the wind turbine, tower, substructure and moorings	Accelerate the development and validation of numerical tools for efficient analysis and design of offshore wind systems
	Upgrade data acquisition systems, including instrumentation	Ensure that methodology and sampling rates are sufficient to capture the desired results	Greater accuracy and fidelity of data
Hydrodynamic and Aerodynamic Facilities (basin or flume with wind simulation)			
	Enhance wind generation system	More accurate representation of hub height turbulence and shear, and directionality relative to waves; enhance overall wind field calibration capabilities to match design conditions	Greater certainty and risk reduction in design validation
	Enhance sophistication of test models to better replicate operating characteristics of full-scale wind turbine systems	Add simulation of active blade pitch control in order to sustain the target aerodynamic thrust being tested under operational conditions	Greater certainty and risk reduction in design validation
		Add replication of major events such as start-up, emergency stop, and faults to simulate critical design loads	Greater certainty and risk reduction in design validation
		Ensure that Eigen frequencies (flexural properties) of tower and support structure can be replicated in order to avoid resonant structural responses	Greater certainty and risk reduction in design validation

Category of Facility	Potential Facility Upgrade*	Rationale for Upgrade	Benefits to Industry
	Expansion of wind flow instrumentation and visualization techniques to enable more advanced studies of the wind field	Facilitate testing of multiple turbines to understand and quantify wake interaction for floating offshore wind turbines	Improved power production in large arrays
	Upgrade data acquisition systems, including instrumentation	Ensure that methodology and sampling rates are sufficient to capture the desired results	Greater accuracy and fidelity of data
Facilities for Testing of Full-scale Turbines and Components			
	Increase dynamometer capacity to accommodate 12 - 20 MW drive systems	Accommodate next generation(s) of offshore turbines	Risk reduction and design optimization of innovative technologies; development of innovative full turbine testing tools and methods
	Add or increase blade test stand capacity to accommodate 100 to 130m blades for turbines up to 15 MW capacity	Accommodate next generation(s) of offshore turbines; development of new techniques such as dual-axis testing of long blades; and methods of testing segmented blades	Risk reduction and design optimization of innovative technologies; development of innovative full turbine testing tools and methods
	Increase blade test facility capability to carryout validation testing of components of ultra long blades such as spars, studs, laminate structures	Ultra long (>90M) blades will require subsection and materials testing prior to design completion; and to limit time needed on full length test stand	Risk reduction for financing and insurance; increased component life
	Increase bearing test stand capacity to accommodate hub/pitch systems, including bearings, for 10+MW turbines	Enable testing of ultra-large bearings for next generation(s) of offshore turbines	Risk reduction and design optimization of innovative technologies; development of innovative full turbine testing tools and methods
Geotechnical Modeling Facilities			
	Increase the capabilities of facilities for testing soil and structure interaction, such as large-scale centrifuges and shake tables, to match the specific needs of offshore wind structure modeling testing and data processing	Enable large-scale 1-g fatigue and ultimate strength tests on a variety of offshore support structures, and evaluate installation and anchoring approaches	Optimize foundation designs to lower fatigue loads while reducing fabrication and installation costs

Category of Facility	Potential Facility Upgrade*	Rationale for Upgrade	Benefits to Industry
Simulation Testbed for Intermediate-scale Turbines and Structures			
	Create land-based floating wind simulator by adding movable base to intermediate-scale test turbine	Utilize controlled environment to validate simulations of the aerodynamic effects of coupled wind/wave effects, and test control methodologies	Data to help bridge the uncertainty gap between basin-scale models and full-scale prototypes
Seawater Testing Laboratory			
	Add large recirculating flume tank to seawater research facility	Facilitate development and testing of underwater vehicles; observe fish behavior; investigate oceanographic characteristics such as the dynamics of mixing and turbulence	Increase scientific knowledge of the offshore operating environment and enable design and testing of instruments and tools to function in that environment

***Certain facilities listed in Table 2 already have the capabilities that would be gained through the potential upgrades listed here**

TABLE 4 - Potential New Facilities for Offshore Wind Testing in the U.S.
(Based solely on responses to DOE Request for Information 7/30/2018)
No prioritization or assessment of relative importance of new facilities is implied in the organization or presentation of information in this table

Applicable Test Category	New Facility Type	Rationale for Facility	Benefits to Industry
Hydrodynamic Performance Testing of Structures (under simulated conditions)			
	Very large wave flume	Provide capabilities for testing large foundation components under various hydrodynamic conditions and seabed soil types	Aid engineers and developers in the selection of foundation and anchorage types, optimization of designs, validation of models, and testing of structural health monitoring systems
Testing of Intermediate-scale Turbines and Structures (e.g. 1/4 scale prototypes)			
	Intermediate scale floating structures test bed	A fully characterized turbine testbed with grid connection in a sheltered marine environment would allow more accurate assessment of turbine/structure operations and performance and control parameters than at the scale of a wave basin or wind tunnel	Lower risks, uncertainty and costs of design validation compared to transitioning directly from small models to full-scale turbine/platform tests in development of the next generation of turbines and support structures
Testing of Full-scale Turbines and Components			
	Port-side knowledge, innovation, testing and logistics center	Provide state-of-the-art port-side facilities for collaborative testing and validation of offshore wind components, equipment, materials, processes, and logistics. Include capabilities for full-scale tests of large structural members	Shared, mutually beneficial facilities, data and innovations; aid developers in selecting foundation types, and optimizing designs and operating strategies
	Floating offshore wind test center	Testbed for full-scale testing of floating platforms and componentry including dynamic moorings, anchoring systems and cables	Available "suitable for purpose" testing infrastructure, data acquisition systems and protocols. Decrease risk, uncertainty and cost of designs and hardware
		Test site for offshore wind integrated with storage technologies such as ocean-based hydrogen electrolyzers and compressed-air storage and recovery	Enhance the energy export potential of floating offshore wind technology designs
	Full-scale test and certification site for offshore-scale turbines	Full-scale turbine testing and performance validation is required for type certification. Testing at commercial wind project sites is problematic	A U.S. test facility would encourage development of turbines optimized for U.S. conditions and utilizing components from U.S. suppliers
	Large bearing test facility	No U.S. test facilities can accommodate testing of pitch, yaw and main shaft bearings of the scale required for 10 + MW turbines	Risk reduction; increased potential for U.S. supply chain
	Large-scale facility for studying soil-foundation-fluid interaction	Study hydro-geo-structural interactions in large "pit" facility up to 15m deep and 50m in diameter, with a "strong wall" and capacity to hold water for simulation of a subsea environment	Aid developers in the selection of foundation types, optimization of designs, validation of models, testing of structural health monitoring systems and installation strategies
	Subsea electrical cable fatigue testbed	Carry out research on long-term performance of subsea cables and provide test bed for developing cable innovations	Improve cable efficiency and resilience, avoid expensive failures, better understanding of practical operating life
Materials and Coatings Validation			
	Centralized national-scale capabilities for testing coatings to wind industry standards, including accredited leading edge erosion test facility	Current capabilities and knowledge are not centralized or optimized for wind industry requirements. Capabilities are needed to evaluate leading edge and blade tip material and coatings in a controlled environment through material modeling, characterization and testing	Coatings that extend the service life of turbines by resisting corrosion or enhancing the efficiency of blades by resisting ice formation or erosion help avoid degradation of energy output and increases in maintenance costs
	Material characterization and fatigue testing facility	Enable testing of candidate materials in a uniaxial/biaxial testbed with very high-cycle fatigue loading capabilities, within a controlled environment chamber	Existing state-of-the-art and related test practices need to be improved to accommodate the variety of potential new design solutions, and the sensitivity of material performance to structural details

Applicable Test Category	New Facility Type	Rationale for Facility	Benefits to Industry
Atmospheric and Environmental Characterization			
	Add data capture from multiple LIDARs at a commercial offshore wind project	Map wind characteristics, turbine wakes and array-level effects for comparison with pre-installation data and assumptions	Risk reduction, better understanding of offshore wind characteristics and array effects
	Test bed for development and demonstration of Doppler-based remote monitoring technologies	Neutral test site for hub height validation of specific technologies and approaches	Develop innovative methods for wind power resource and site characterization to increase accuracy, reduce siting costs, and inform installation planning
Data Collection at Full-scale Offshore Wind Plants			
	Standardized instrumentation package for data collection at offshore wind sites	A campaign or virtual facility utilizing a common set of instrumentation, software and protocols for a broad set of measurement parameters in order to facilitate gathering of critical data at the first U.S. offshore projects	Field data from the initial U.S. offshore projects, gathered and disseminated in a manner that protects confidentiality while benefiting the entire industry, is critical to risk and cost reduction through verifying design assumptions and better characterizing the operating environment