PREDECISIONAL DRAFT

Creating an Offshore Wind Industry in the United States: A Strategic Work Plan for the United States Department of Energy

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Wind & Water Power Program

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Executive Summary

Creating an Offshore Wind Industry in the United States: A Strategic Work Plan for the United States Department of Energy was prepared by the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy's (EERE) Wind and Water Power Program to outline the actions that it will pursue to support the development of a world-class offshore wind industry in the United States. The *Strategic Work Plan* is an action document that amplifies and draws conclusions from a companion report, *Large-Scale Offshore Wind Energy for the United States* (Musial 2010). In Fiscal Year (FY) 2011, DOE will initiate a formal activity, titled the Offshore Wind Innovation and Demonstration (OSWInD) Initiative, to promote and accelerate responsible commercial offshore wind development in the U.S., guided by this *Strategic Work Plan*.

Key Points

- Offshore wind energy can help the nation reduce its greenhouse gas emissions, diversify its energy supply, provide cost-competitive electricity to key coastal regions, and stimulate economic revitalization of key sectors of the economy.
- Key barriers to the development and deployment of offshore wind technology include the relatively high cost of energy, technical challenges surrounding installation and grid interconnection, and the untested permitting requirements for siting wind projects in federal and state waters.
- The *Strategic Work Plan* details the OSWInD Initiative, which will guide the national effort to overcome these barriers and to achieve a scenario of 54 gigawatts (GW) of deployed offshore wind generating capacity by 2030, at a cost of energy of 7-9 cents per kilowatt-hour (kWh), with an interim target of 10 GW of capacity deployed by 2020, at a cost of energy of 13 cents per kWh.
- In order to achieve this scenario, the OSWInD Initiative must accomplish two critical objectives: reduce the cost of offshore wind energy and reduce the timeline for deploying offshore wind energy.
- The OSWInD Initiative will initiate or expand a suite of three focus areas – Technology Development, Market Barrier Removal, and Advanced Technology Demonstration Projects – encompassing seven major activities: innovative turbines; marine systems engineering; computational tools and test data; resource planning; siting and permitting; complementary infrastructure; and advanced technology demonstration projects.
- These seven activities will facilitate gigawatt-scale offshore wind power deployment and will augment the nearly $100M allocated to offshore wind research and test facilities through the American Reinvestment and Recovery Act of 2009 (ARRA).

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1. Introduction

Offshore wind energy can help the nation reduce its greenhouse gas emissions, diversify its energy supply, provide cost-competitive electricity to key coastal regions, and stimulate economic revitalization of key sectors of the economy. However, if the nation is to realize these benefits, key barriers to the development and deployment of offshore wind technology must be overcome, including the relatively high cost of energy, technical challenges surrounding installation and grid interconnection, and the untested permitting processes governing deployment in both federal and state waters.

In Fiscal Year (FY) 2011, the United States Department of Energy (DOE) will initiate a formal Offshore Wind Innovation and Demonstration (OSWInD) Initiative to promote and accelerate responsible commercial offshore wind development in the U.S. *Creating an Offshore Wind Industry in the United States: A Strategic Work Plan for the United States Department of Energy* is an action document that will guide this new Initiative as it supports the development of a world-class offshore wind industry in the United States able to achieve 54 gigawatts (GW) of offshore wind deployment at a cost of 7-9 cents per kilowatt-hour (kWh) by the year 2030, with an interim target of 10 GW at 13 cents / kWh by 2020.

To realize these scenarios, the OSWInD Initiative must achieve two critical objectives: reduce the cost of offshore wind energy and reduce the timeline for deploying offshore wind energy. As Figure 1 illustrates, the OSWInD Initiative has developed a strategy that will make measurable gains toward meeting the critical objectives.

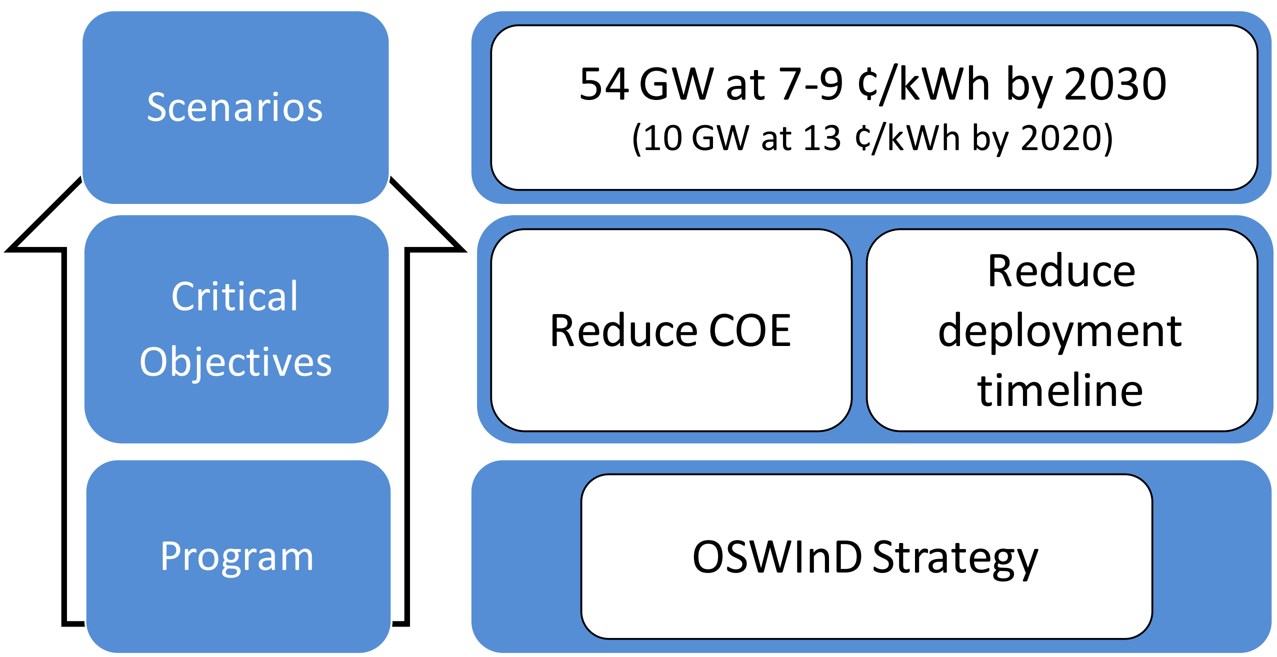


Figure 2. The OSWInD strategy drives toward scenarios through progress on critical objectives

In FY2011, the OSWInD Initiative will initiate or expand a suite of seven major activities, administered through three focus areas, targeted at these critical objectives (see Figure 3). The three focus areas are Technology Development, Market Barrier Removal, and Advanced Technology Demonstration. The seven major activities are Innovative Turbines, Innovative Balance of System, Computational Tools and Test Data, Resource Planning, Siting and Permitting, Complementary Infrastructure, and Advanced Technology Demonstration Projects. Taken together, these efforts will facilitate gigawatt-scale offshore wind deployment and will augment the nearly $80M allocated to offshore wind research and test facilities through the American Reinvestment and Recovery Act of 2009 (ARRA).

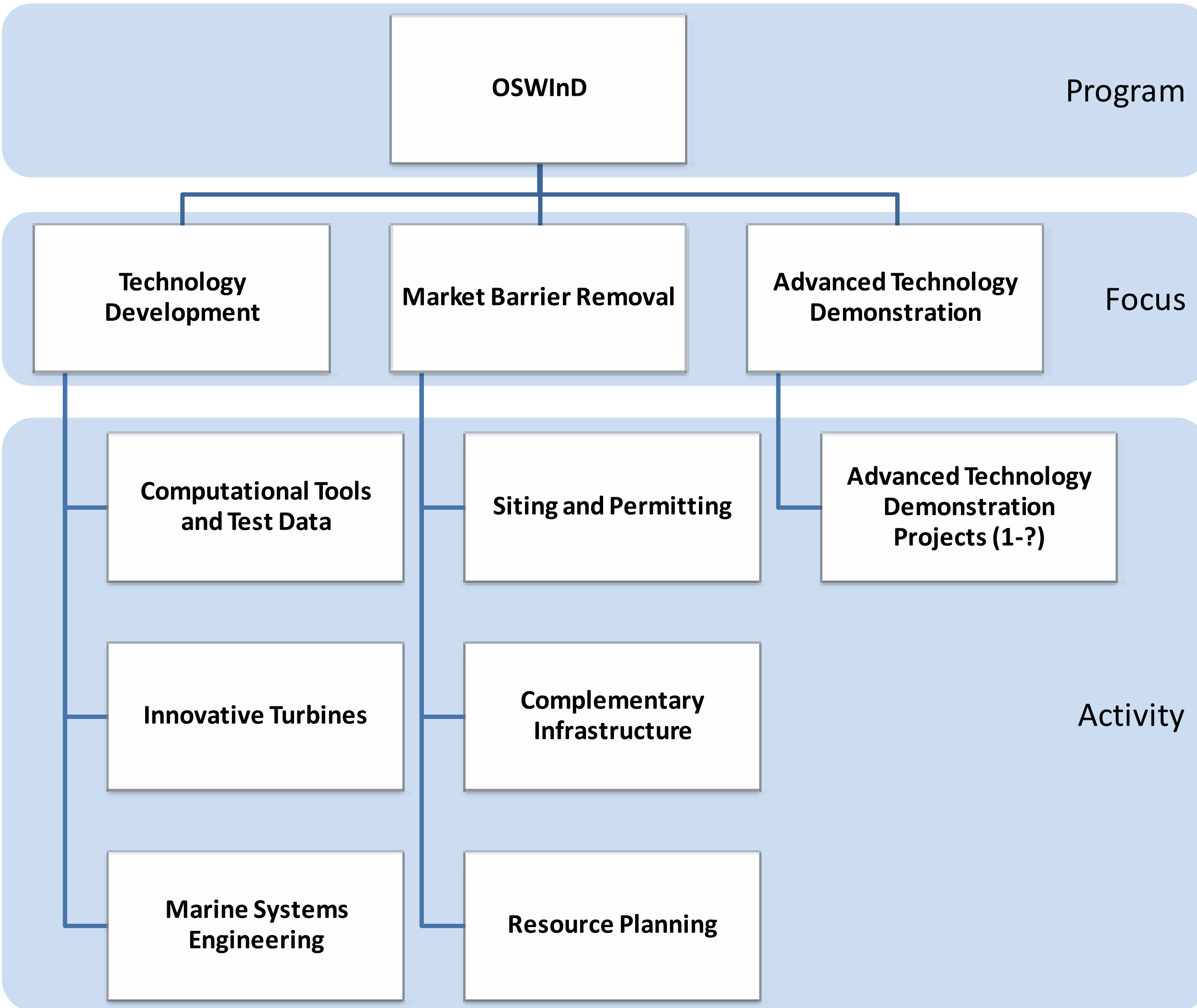


Figure 4. The OSWInD Initiative broken down into focus areas and activities

Section 2 of this document discusses the rationale for a national offshore wind initiative. Section 3 summarizes the key technical and market barriers to the creation of a world-class U.S. offshore wind industry and lays out the assumptions and conclusions that influenced DOE's decision-making for the *Strategic Work Plan*. Section 4 introduces the OSWInD Initiative in more detail and lays out its structure. The appendices augment the information presented in these four sections.

2. Rationale for a National Offshore Wind Program

Increasing the use of renewable energy for electricity generation is crucial to mitigate the risks of climate change and to shift the nation to a long-term low-carbon economy. In the North American Leaders'

Declaration of Climate Change and Clean Energy, the Obama Administration supported the global goal of reducing carbon dioxide (CO_2) emissions by 50% by 2030 and 80% by 2050 (White House 2009[1]). Because offshore wind power generates electricity without emitting CO_2, gigawatt-scale offshore wind deployment could contribute significantly to a national climate change mitigation strategy.

DOE conducted a portfolio benefits analysis to develop a high-level strategy for achieving the Administration's ambitious goals for transforming the nation's energy supply. EERE calculations of potential energy generation sources in the United States indicate that wind power could be deployed more quickly and generate the largest amount of electricity of the renewable energy technologies (see Figure 5 below). Previously, a scenario analyzed in the EERE report *20% Wind Energy by 2030* found that the United States could generate 20% of its electricity from wind energy by 2030, with offshore wind providing 54 GW of capacity (Department of Energy 2008). These scenarios clearly show the potential for wind energy, and offshore wind in particular, to address the daunting challenge of reducing CO_2 emissions in a rapid and cost-effective manner.

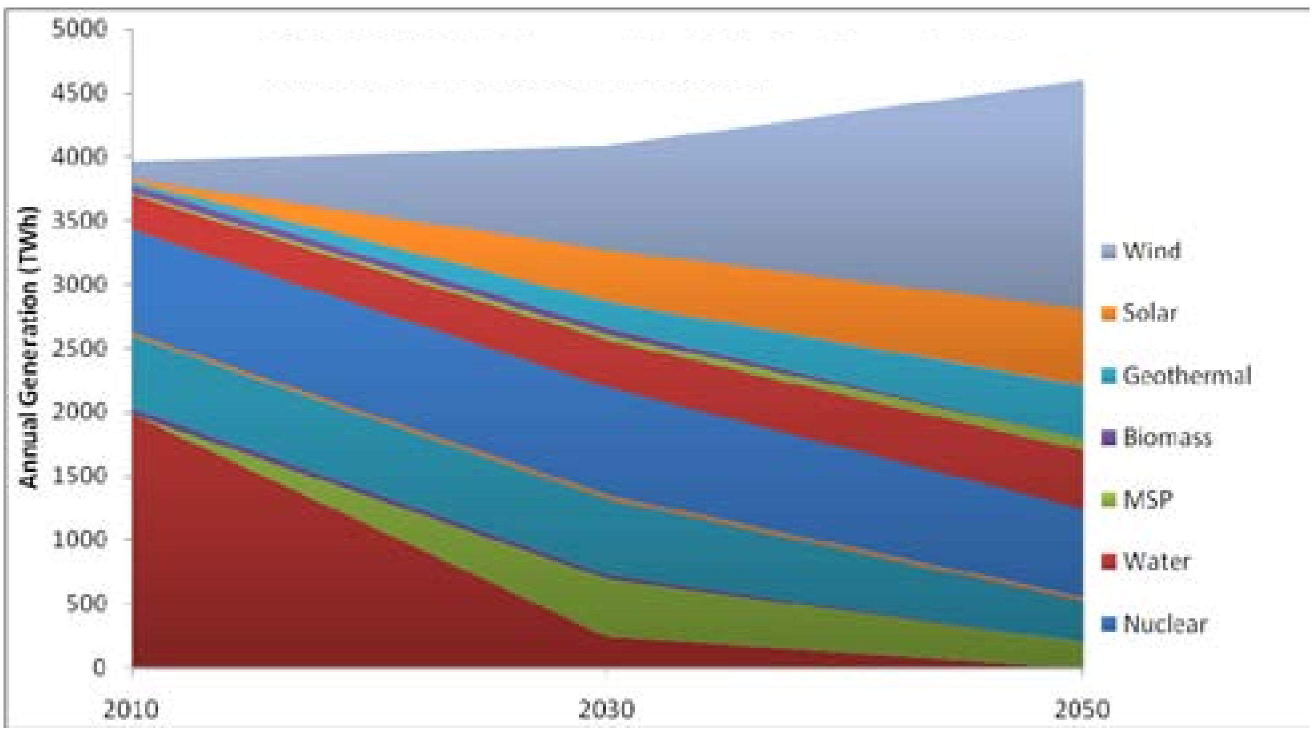


Figure 6. EERE Analysis of Possible Future Electricity Supply Mix (DOE)

2.1 Resource Size

The energy-generating potential of offshore wind is immense due to the lengthy U.S. coastline and the quality of the resource found there (offshore winds blow stronger and more uniformly than on land, resulting in greater potential generation). Offshore wind resource data for the Great Lakes, U.S. coastal waters, and the Outer Continental Shelf, up to 50 nautical miles from shore, indicate that for annual average wind speeds above 7.0 meters per second (m/s), the total *gross resource* of the United States is

[1]www.whitehouse.gov/the_press_office/North-American-Leaders-Declaration-on-Climate-Change-and-Clean-Energy/

4,150 GW, (M. Schwartz June 2010) or approximately three times the generating capacity of the current U.S. electric grid. Of this capacity, 1,070 GW is in water less than 30 meters (m) deep, 630 GW is in water between 30 m and 60 m deep, and 2,450 GW is in water deeper than 60 m (see Figure 7). The scale of this theoretical capacity implies that under reasonable economic scenarios, offshore wind can contribute to the nation's energy mix at significant levels.

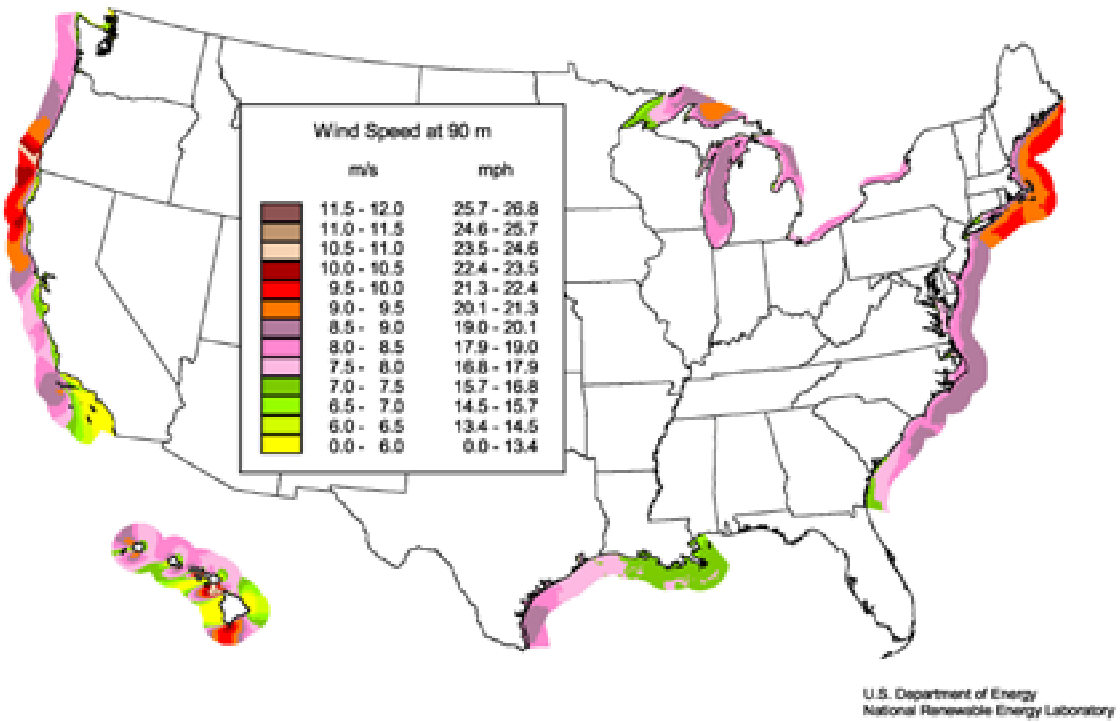


Figure 8. U.S. offshore wind speed estimates at 90-m height

Currently, the vast majority of offshore wind projects are in the European Union (EU), where utility-scale planning for offshore wind has at least a 10-year history. Shallow water technology is proven in Europe, with 39 projects constructed and more than 2,000 megawatts (MW) of capacity installed, although this market is heavily subsidized. The EU and the European Wind Energy Association (EWEA) have established aggressive targets to install 40 GW of offshore wind by 2020 and 150 GW by 2030.

2.2 Benefits to Offshore Wind Deployment

On average, one gigawatt of installed wind power capacity can generate 3.2 million megawatt-hours of electricity annually. Generating the same amount of electricity from fossil fuels would consume 1.2 million tons of coal or 20.9 billion cubic feet of natural gas and 1.3 billion gallons of water and would emit 1.8 million metric tons of carbon dioxide (CO_2). Because offshore winds generally blow more strongly and consistently than onshore winds, offshore wind turbines operate at higher capacity factors[2] than wind turbines installed on land. In addition, daily offshore wind speed profiles tend to correspond well to periods

[2] A measure of the productivity of a power plant, calculated as actual energy produced by a plant over a given period divided by the amount of energy that the plant would produce when generating at maximum capacity during that period.

of high electricity demand by coastal cities, such that the strongest winds (and thus highest potential energy generation) correspond to the periods of greatest electricity demand (Musial 2010).

High electricity costs in coastal regions, more energetic wind regimes offshore, and close proximity of offshore wind resources to major electricity demand centers could allow offshore wind to compete relatively quickly with fossil fuel-based electricity generation in many coastal areas. The 28 coastal and Great Lakes states in the continental United States use 78% of the nation's electricity (Department of Energy 2008) while facing higher retail electricity rates than their inland neighbors (Figure 9). Mid-Atlantic and Northeastern coastal states in particular face a dual problem: high electricity costs and dependence on high-carbon, price-volatile supplies of fossil fuel for generation. In states without substantial land-based renewable resources, offshore wind deployment will be critical to meet their renewable energy standards or goals. In states with high electricity rates, offshore wind energy may quickly become cost-competitive. Finally, the proximity of offshore wind resources to major load centers minimizes the need for new transmission.

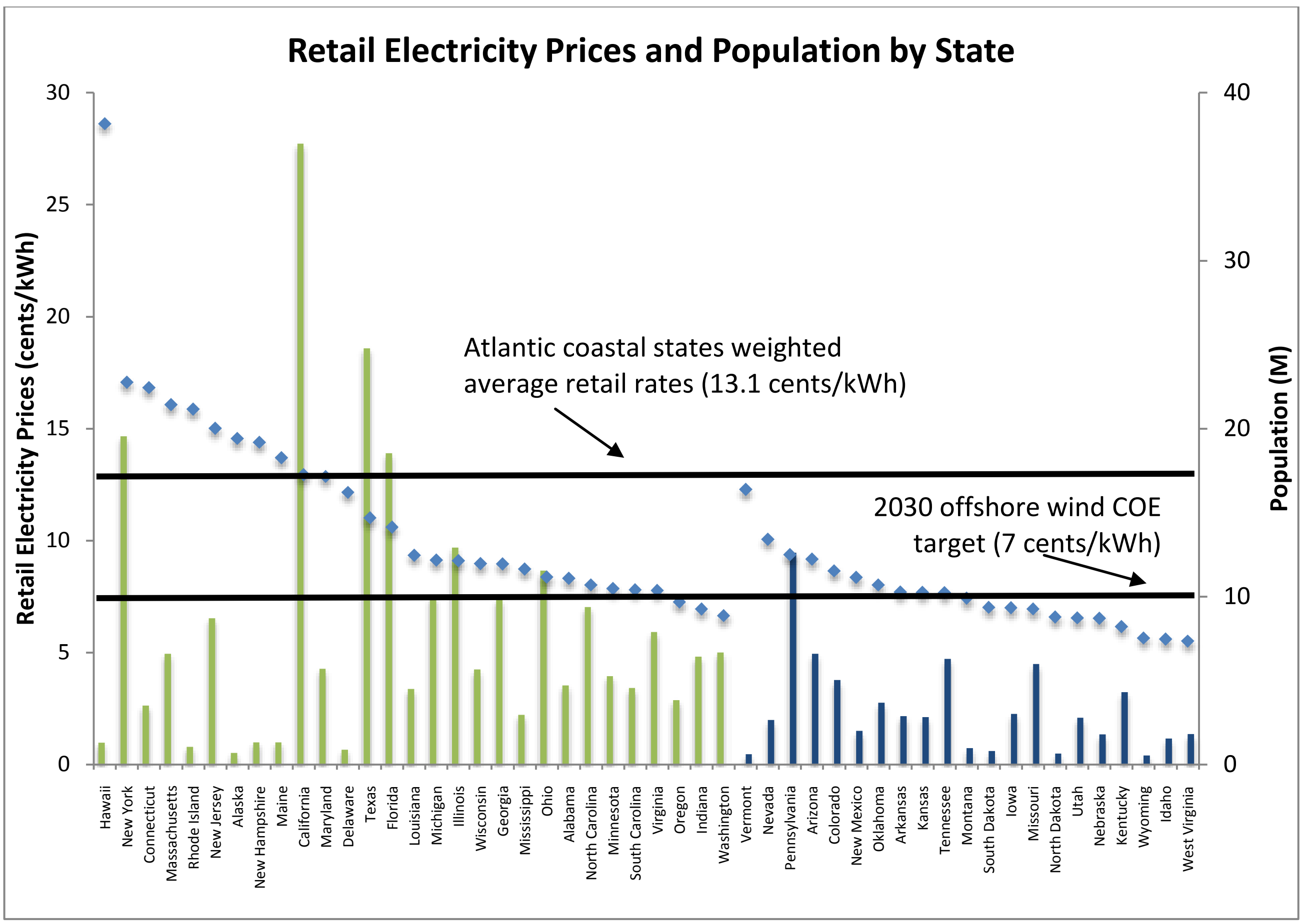


Figure 10. Coastal versus inland state retail[3] electric rates (DOE 2008).

[3] The 2007 national average wholesale electricity price, the average of spot market prices for day-ahead electricity delivery in the NERC regions with wholesale power markets, is 5.72 cents per kWh. However, prices spiked in 2008 and vary by region; for example, New England spot prices averaged $90 / MWh in 2008. (EIA 2010)

Deployment of wind energy along U.S. coasts would also trigger direct and indirect economic benefits. According to NREL's analysis, offshore wind would create approximately 20.7 direct jobs per annual megawatt in the United States. If 54 GW were installed in the United States, more than 43,000 permanent operations and maintenance (O&M) jobs would be created, and more than 1.1 million job-years would be required to manufacture and install the turbines (Musial 2010). Many of these jobs would be located in economically depressed ports and shipyards, which could be revitalized as fabrication and staging areas for the manufacture, installation, and maintenance of offshore wind turbines.

3. Key Barriers to Offshore Wind Deployment

The major barriers to deployment of offshore wind power in U.S. waters include the high costs of offshore wind facilities; the technical challenges and lack of current infrastructure to support the fabrication, installation, interconnection, and maintenance of these systems; and the untested permitting requirements for siting wind projects in federal and state waters.

3.1 High Capital Costs and Cost of Energy

Offshore wind installations have higher capital costs than land-based installations per unit of generating capacity, largely because of turbine upgrades required for operation at sea and increased costs related to turbine foundations, balance-of-system infrastructure, interconnection, and installation. In addition, one-time costs are incurred with the development of the infrastructure to support the offshore industry, such as vessels for turbine installation, port and harbor upgrades, manufacturing facilities, and workforce training programs. NREL reports estimate a current baseline of installed capital costs for offshore wind at $4,250 per kilowatt (kW), based on energy market surveys (Musial 2010). Several important offshore technology issues require research and development in order to achieve competitive market pricing in the long term. These issues include reducing installed capital costs, improving reliability, and increasing energy capture. In the longer term, innovative, comparatively inexpensive foundation designs will be required to harness the massive wind resource located in water more than 60 m in depth.

In addition to elevated capital costs, offshore wind energy currently has a higher cost of energy (COE)[4] than comparable

[4] It is important to note that this Cost of Energy calculation represents the bus-bar cost of offshore wind energy delivered to the terrestrial transmission system and does not include possible additional interconnection or integration costs related to imbalance/integration charges, firming charges, or transmission upgrades needed for interconnection.

technologies. As discussed throughout this *Strategic Work Plan*, a critical objective of the OSWInD Initiative is to lower the offshore wind COE. Since COE is calculated as a unit of currency per unit of energy (typically $/MWh or ¢/kWh), lowering capital costs of a project only applies to the COE by lowering the numerator. To have a significant impact on COE, current COE projections must be cut by over 50%. The OSWInD Initiative will work with all necessary parties to drastically increase the denominator, or the energy generated by a single unit, in addition to lowering in the numerator. Increased energy generation will result from larger, more efficient, more reliable turbines with access to the best wind resource possible.

Achieving COE reduction goals will require substantial improvement in all components of offshore wind project development, capital expenditures, and operational processes (Figure 11).

- *Turbine Capital Cost*: reducing capital and installation costs of all turbine components
- *Balance of Station Capital Cost*: reducing capital and installation costs of foundation structures, cabling, substations and other non-turbine components
- *Operations, Maintenance and Replacement Cost*: reducing scheduled maintenance, improving reliability, and reducing replacement costs for components such as gearboxes, generators and blades.
- *Capacity Factor*: improving overall system performance through improved siting, energy capture and availability
- *Transmission & Grid Integration Cost*: incorporating low cost transmission configurations and wind integration into power management systems
- *Start-up & Permitting Cost*: reducing delays caused by permit approval times
- *Cost of Capital*: reducing financial risks and lowering insurance and warranty premiums as a result of stable and predictable energy output and life-cycle operational time.

3.2 Technical and Infrastructure Challenges

Significant challenges to offshore wind power deployment related to resource characterization, grid interconnection and operation, and infrastructure will need to be overcome. The offshore wind resource is not well-characterized; this significantly increases uncertainty related to potential project power production and turbine and array design considerations, which in turn increase financing costs. The implications for adding large amounts of offshore wind generation to the power system need to be better understood in order to ensure reliable integration and to evaluate the need for additional grid infrastructure such as an offshore transmission backbone. Finally, with current technology, cost-effective installation of offshore wind turbines requires specialized turbine installation vessels, purpose-built portside infrastructure for installation, operations, and maintenance, and robust undersea electricity transmission lines and grid interconnections. These vessels and this infrastructure do not currently exist in the U.S., and legislation such as the Jones Act limits the ability of foreign-flagged vessels of this kind to operate in U.S. waters.

3.3 Permitting Uncertainty

Offshore wind projects face uncertain permitting processes that substantially increase the financial risk faced by potential project developers and financiers and that discourage investment both in projects and in development of supply chain and other supporting infrastructure. Current estimates for project approvals on the Outer Continental Shelf (OCS) range from 7 to 10 years. For the Great Lakes, where eight states and the Canadian province of Ontario claim jurisdiction, numerous competing activities and the lack of an overarching regulatory framework create additional and unique permitting challenges.

Numerous state and federal entities have authority over siting, permitting, and installation of offshore wind facilities; each contributes to the complexity and length of the process. Federal agencies and departments with jurisdiction to regulate and approve offshore wind projects and related infrastructure include the Department of the Interior, through the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE). This agency serves as the lead agency in permitting offshore wind energy on the OCS. Other regulatory bodies include the Army Corps of Engineers (ACOE), which is responsible for permitting any potential obstruction or alteration of U.S. navigable waters, and currently serves as the lead federal agency in permitting offshore wind in state waters, including the Great Lakes; and a host of other federal entities, such as the Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), National Park Service (NPS), National Oceanic Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), Federal Aviation Administration (FAA), Department of Defense (DOD), U.S. Coast Guard (USCG), and the Federal Energy Regulatory Commission (FERC). A number of state and local government entities, as well as numerous other stakeholders, must also be consulted in the permitting process.

DOE's OSWInD Initiative will operate in the context of developing offshore energy collaborations and a changing ocean policy and energy regulatory landscape that presents unique opportunities to work with Federal and state partners. In 2009, BOEMRE issued a Final Renewable Energy Framework detailing regulations for renewable energy development on the Outer Continental Shelf. BOEMRE is also working with the Atlantic Offshore Wind Energy Consortium (AOWEC) to develop means to increase the efficiency of this regulatory process. The Department of the Interior has also recently signed MOUs with several parties, including DOE and many of the Atlantic state governors, articulating a number of potentially synergistic goals for offshore renewable energy, including increasing the efficiency of the regulatory process. Finally, in July 2010 President Obama created a new National Ocean Council chartered to implement the policy recommendations of the Interagency Policy Taskforce, including the development of coastal and marine spatial plans (CMSP) at the regional level. Collectively, these emergent partnerships and policy changes increase the potential and necessity for DOE participation in these issues.

4. DOE Offshore Wind Initiative

DOE, as a non-regulatory agency, is in a unique position to provide national leadership through collaborative barrier-breaking partnerships with other federal agencies, the states, academia, and industry. This section of the *Strategic Work Plan* details a plan to accelerate offshore wind deployment in the United States through targeted technical research and development, partnerships to remove market barriers, and implementation of pioneering demonstration projects. Through such an initiative, DOE can capitalize on its unique position to help eliminate uncertainty, mitigate risks, and facilitate the use of the first installed offshore turbines as testbeds for research and development.

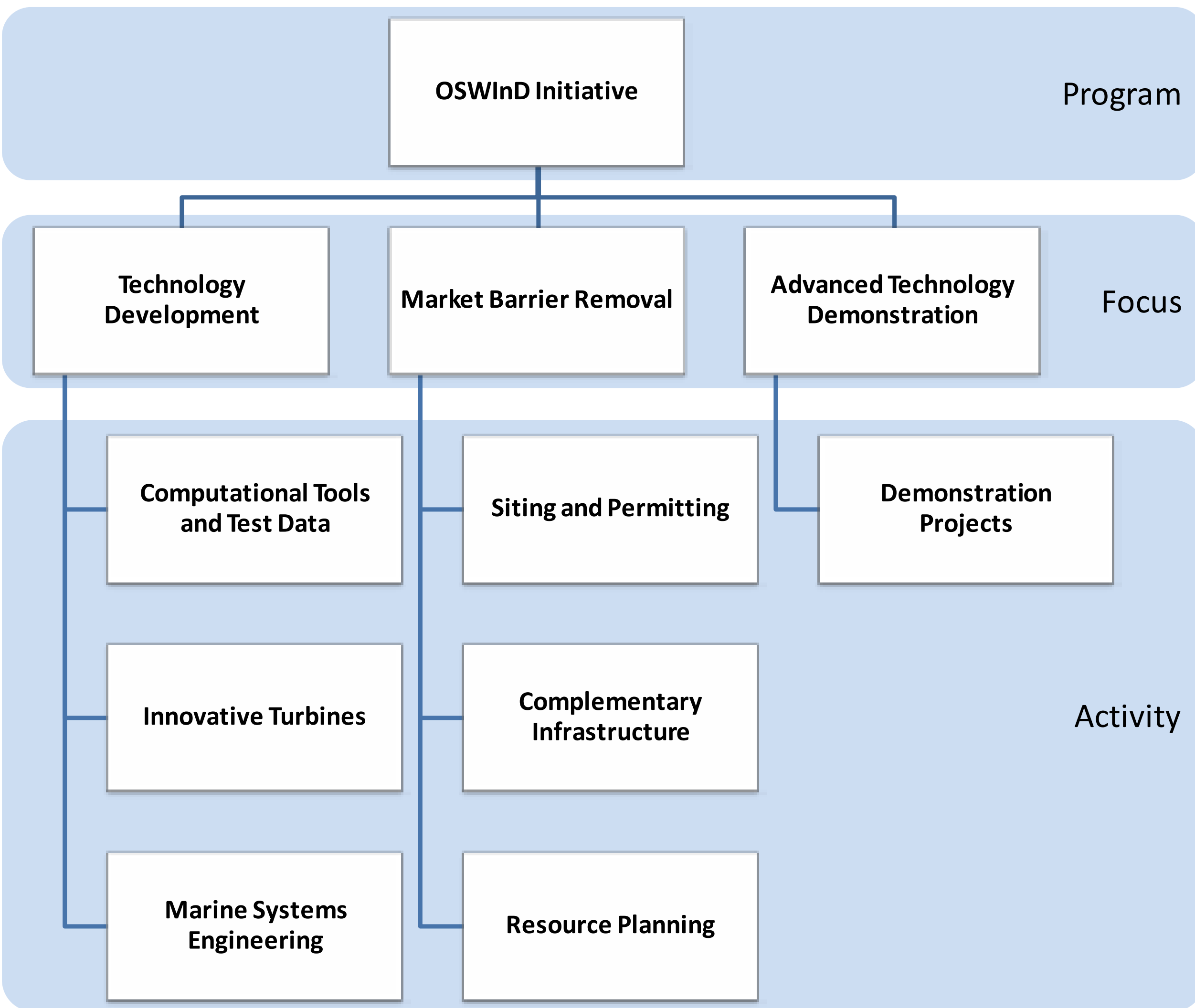


Figure 12. Focus areas, activities, and research areas of the OSWInD Initiative

4.1 OSWInD Strategy

As discussed in Section 2, a common set of challenges and barriers confront the initial U.S. deployment of offshore wind energy and its long term growth into a major industry and significant contributor to the nation's energy needs. The OSWInD strategy considers two critical objectives in attacking these barriers.

Offshore Wind Critical Objectives

- <u>Reduce the cost of energy</u> through technology development to ensure competitiveness with other electrical generation sources;
- <u>Reduce deployment timelines</u> and uncertainties limiting U.S. offshore wind project development.

To meet these objectives, the OSWInD Initiative will undertake a set of seven major activities administered through three focus areas. The activities are further specified into research areas, details, and stages. See Figure 7 for a representation of the Initiative to the research area level and Section 4.2 for an in-depth discussion of the remaining levels. A strategic discussion of the three focus areas concludes Section 4.1.

Technology Development

Currently, more than 2 GW of offshore wind capacity is installed in Europe and about 5 GW of offshore wind is proposed for the United States (Musial 2010), indicating that a certain level of technological readiness already exists, although significant government subsidy will be required to make initial projects economically competitive. A world-class research and development effort is needed to integrate the resources and expertise of the country, in a coordinated investment and information exchange, in order to propel the United States to the leading edge of offshore wind technology. In the short-term, the Technology Development focus area will concentrate primarily on risk reduction to facilitate the initial deployment of offshore wind projects in U.S. waters. Over the long term, the Technology Development focus area will have a primary goal of developing new technologies that lower the cost of energy, sustain the growth of the industry, and make offshore wind cost-competitive without subsidies.

Facilitating deployment of the initial projects in the United States is a top priority in the short-term because these installations will provide experience, generate performance data, and highlight unforeseen issues, all of which will help inform and prioritize the OSWInD Initiative's longer-term technology research and development effort. Design codes, standards development, and performance models are some of the specific technology development activities that will both lay the foundation of a long-term research and development program and reduce risk for developers, regulators, designers, and financiers involved in the first offshore wind installations. Special consideration of technical improvements needed to adapt primarily European technologies to the U.S. offshore environment will also be a priority.

OSWInD's long-term research and development strategy will focus primarily on hardware development to reduce the life-cycle costs of offshore wind energy systems and to expand access to the most promising wind resource areas. More than half of the estimated life-cycle cost of an offshore wind turbine farm is determined by the foundation, electrical infrastructure, installation and logistics, and operations and maintenance costs.

Long-Term Scenarios for Reducing Cost of Energy

Table 10 provides a long term scenario for achieving a \$.07- \$.09/kW Cost of Energy for offshore wind by 2030 through addressing the full range of critical interrelated factors outline below.

I. **Increased system efficiency and decreased capital costs** via (a) development of larger scaled systems and (b) innovative component and overall system designs:
- Installed Capital Cost will need to be reduced by 39% to \$2,600./kW from \$4,259./kW
- Average Turbine rating will need to increase from 3.6 MW to 10.0 MW
- Capacity Factor will need to improve from 39% to 45%.

II. **Decreased operational and replacement costs:**
- Operating costs in a difficult marine environment must be continually reduced to compete with land-based systems
- Fully loaded replacement cost, including the cost of marine transport and component replacement costs, will need to be reduced via higher reliability and innovative, low-maintenance designs.

Year	2010	2015	2020	2025	2030
Component					
Installed Cap Cost/kW	\$ 4,259	\$ 3,900	\$ 3,400	\$ 2,900	\$ 2,600
Fixed Charge Rate	20%	17%	14%	11%	8%
Turbine Rating (MW)	3.6	5.0	6.0	8.0	10.0
Rotor Diameter	107	126	136	156	175
Annual Energy Production / turbine	12276	17905	22029	31040	39381
Capacity Factor	38.93	40.88	43.67	44.29	44.96
Array Losses	10%	9%	8%	7%	7%
Availability	95%	96%	97%	97%	97%
Rotor Cp	0.45	0.46	0.47	0.49	0.49
Drivetrain Efficiency	0.9	0.9	0.95	0.95	0.95
Rated Windspeed (m/s)	12.03	12.03	12.03	12.03	12.03
Average Wind Speed at Hub Heights	8.8	8.91	8.96	9.09	9.17
Wind Shear	0.1	0.1	0.1	0.1	0.1
Hub Height (m)	80	90	95	110	120
Generator	Geared	Geared	DDPM	DDSC	DDSC
Cost of Energy (\$/kWh)	**0.269**	**0.2057**	**0.1486**	**0.1035**	**0.0712**

DDPM: direct-drive permanent magnet; DDSC: direct-drive superconducting.
Reference: From an unpublished National Renewable Energy Laboratory analysis April, 2010.

III. **Decreased financing costs via reduced project risks**:
- Fixed Charge financing rate will need to be reduced from current estimated 20% to target level of 8% via decrease in perceived investor risk. Fixed charge rate includes financing fees, cost of capital/return on equity, fees during construction, insurance and warranty fees.
- Regulatory and permitting approvals will need to be predictable and timely
- Installation construction costs, system performance and maintenance and replacement requirements will need to be stable and predictable.

Successful implementation of this ambitious national research and development initiative will require collaboration with federal and state agencies, universities, international organizations, non-governmental organizations, and complementary industries such as the U.S. offshore oil and gas industry and the

European offshore wind industry. Identifying shared research priorities will be critical to maximizing investment with minimal overlap. Access to shared resources, especially test facilities, will be integral to developing the next generation large offshore wind turbines. As a final step, field testing could be conducted offshore to provide platforms for testing pre-commercial turbines before full deployment and to collect performance data to benefit the entire industry and lead to improved reliability.

Market Barrier Removal

Long-term gigawatt-scale deployment of offshore wind energy in the United States cannot exist within the current landscape in which the regulatory process is still uncertain and the estimated timeline from initial bidding to project approval ranges from 7-10 years (Figure 13). Moreover, the balance of risks and benefits of offshore wind energy development with respect to communities, markets, and the environment is not well-understood; offshore wind resources are poorly characterized; and essential transmission, supply chain, installation and maintenance infrastructure does not yet exist. Absent a clear and shared vision to develop high-quality and more efficient permitting processes, developed in collaboration with key agencies and stakeholders, project development risks will continue to be unmanageable and COE will increase.

The OSWInD Initiative will provide this clear vision for overcoming market barriers through three primary activities:

- *Resource Planning*, which will address wind resource characterization and other data required for coastal and marine spatial planning;
- *Siting and Permitting*, which will address policy and economic analysis, radar interference, regulatory processes, environmental risks, public acceptance, interagency dialogue concerns and risk management;
- *Complementary Infrastructure*, which will address domestic manufacturing and supply chain development, transmission and interconnection planning, and specialized vessels and other installation, operations and maintenance technology.

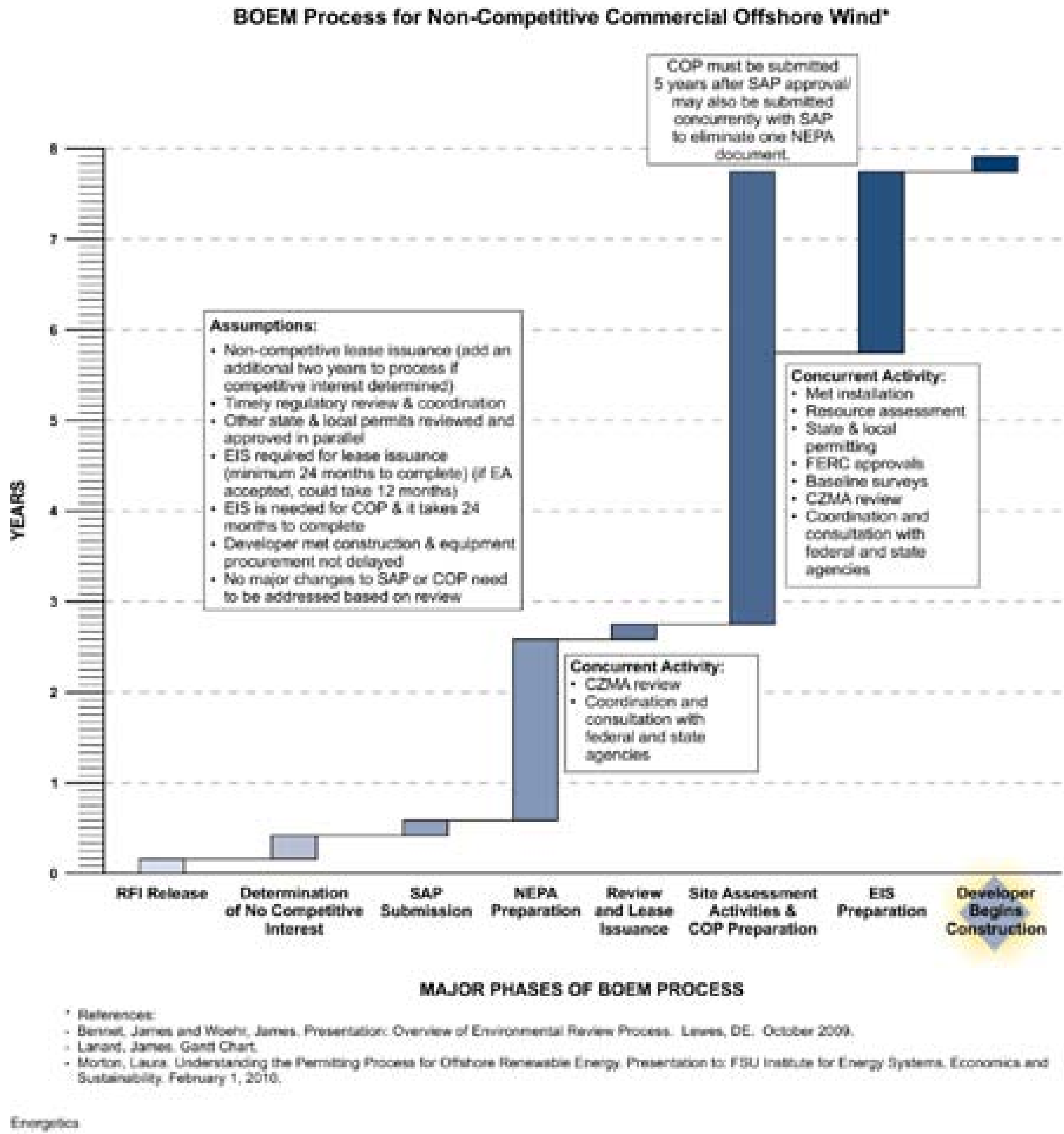


Figure 14. Major phases of the current OSWInD deployment timeline.

Close collaboration among key federal and state agencies, as well as other stakeholders, will be a cornerstone of the Initiative's strategy in this area, which will identify and overcome permitting barriers while maintaining the integrity of these processes and the values they are intended to protect. Responsibility for the barriers facing offshore wind is widely distributed among federal and state agencies, as well as a wide range of stakeholders.

Considering the scale and geographic distribution proposed for offshore wind energy, very little site-specific data exists on external conditions that influence design requirements, energy production, and economic viability. The Initiative will facilitate collaboration between key agencies and research organizations to establish a national data network for characterizing the wind resource and other factors such as wave action and seabed mechanics. These factors are not well documented but must be better understood for accurate marine spatial planning, establishment of prioritized offshore wind zones, and financial due diligence.

Though DOE has no legal authority to mandate the removal of many of the hurdles barring the accelerated gigawatt-scale deployment of offshore wind, the agency is uniquely placed to play a catalytic role in addressing such barriers by bringing depth of knowledge of the technology and the industry, technical and financial resources, as well as a positive history of working across agencies and stakeholders, which will help in identifying administrative efficiency to overcome regulatory barriers. The OSWInD Initiative will engage federal and state regulators, resource management agencies, and outside stakeholders to drive collective action toward the creation of an offshore wind industry, through the establishment of formal working arrangements such as memoranda of understanding with key agencies—for example, the Memorandum of Understanding between DOE and the DOI on the future development of commercial offshore renewable energy projects on the OCS (see BOEMRE MOU and Action Plan text box).

BOEMRE MOU and Action Plan

On June 29, 2010, the Department of the Interior and the Department of Energy signed a new Memorandum of Understanding that will strengthen the working relationship between the two agencies on the future development of commercial offshore renewable energy projects on the OCS. Under the Action Plan developed pursuant to the MOU, the DOE Wind Program and DOI's Bureau of Ocean Energy Management and Regulatory Enforcement (BOEMRE) have committed to improved exchange of data on offshore wind resources and technologies, engage stakeholders on critical barriers, and collaborate on research projects to achieve objectives in five initiatives, including:

- Developing attainable deployment goals for offshore wind on the OCS
- Reducing siting and permitting timelines for project developers
- Improving resource assessment capabilities
- Developing technical standards for the U.S. offshore wind industry
- Reducing public acceptance risk through information exchange and public engagement

Successful implementation of the MOU and the Action Plan will be critical to reducing the deployment barriers identified in this *Strategic Work Plan*.

Safety, domestic economic benefits, cost-effective installation and operations, and practical grid integration processes depend on development of large-scale local, regional and national infrastructure components dedicated to meeting the requirements of the offshore industry. The OSWInD Initiative plans research activities with states, federal agencies and industry to develop optimized, integrated strategies for meeting these needs and funding technical development.

Advanced Technology Demonstration Projects

The OSWInD Initiative will undertake Advanced Technology Demonstration Projects to impact the speed and scale of offshore wind development. Through these demonstration partnerships, DOE will support specific research, engineering and planning activities related to deployment of ground-breaking commercial or research-based offshore wind energy projects. On a cost-share basis, DOE will invest in specific aspects of project development that reduce siting and planning barriers or risks; reduce balance-of-plant infrastructure costs; enable full-scale testing of components, turbines, and arrays; and support initial deployment of innovative technology. By providing funding, technical assistance, and government coordination to accelerate deployment of demonstration projects, DOE can help eliminate uncertainty, mitigate risks, and facilitate the use of the first deployed offshore wind turbines as testbeds for research and development.

Key elements of the Demonstration Project focus area include:

- Multiple partnerships in a well-publicized 5-year effort, awarded through competitive solicitation
- Groundbreaking offshore projects of diverse geographic locations and technical focus areas
- Partnerships with commercial developers, industry, university research consortia, and utilities
- Structure that grows and adapts with industry circumstances and successes
- Parallel DOE effort to utilize BOEMRE research leases for later-stage projects
- Phased 'stage-gate' process through which projects must qualify for next funding phase; Phase 1 activities might focus on factors enabling deployment, facility engineering, and research testing readiness, while Phase 2 activities could include installation and operational testing.

Impact Analysis

The OSWInD Initiative will conduct cost/benefit analysis to help define ongoing program activities and metrics and to provide a context for decision-making. Analysis-based metrics for cost of energy and other factors are critical for reporting progress towards technical objectives and judging the feasibility of new technologies. These analysis activities include a coherent system of metrics to track program impact; analysis of the costs of deployment barriers that will help characterize program performance; and support for the development of analysis tools to assist the Initiative in prioritizing major program research and deployment elements.

COE modeling examines microeconomic cost and supply (e.g. operations and maintenance, installation, turbine subcomponents, etc.), but also considers macroeconomic effects (e.g. commodity prices, exchange rates, public policy, etc.). These activities require substantive knowledge and evaluation tools, some of which remain to be developed. The analysis areas include national energy penetration models such as ReEDs, NEMS, and Markal. These efforts support national-scale initiatives to quantify carbon reductions, and enhance high penetration renewable scenario modeling. They also integrate offshore wind projections with ongoing job models, such as NREL's Jobs and Economic Development Impact (JEDI) model, that are already underway, and include market and policy analysis on offshore wind projects, both in the U.S. and Europe, as appropriate.

The OSWInD Initiative will develop and track metrics for its activities in each of the focus areas listed above to inform decision-making regarding support for technology development and to assess the long range industry impact of DOE investment.

Current Offshore Wind Activities

DOE is currently engaged in several ongoing offshore wind activities. These activities are summarized below and discussed in more detail in Appendix B.

DOE has invested a total of $99.5 million through the American Reinvestment and Recovery Act of 2009 (Recovery Act), FY09 appropriations, and FY10 appropriations into offshore-related activities within the Wind Program. Current offshore wind activities support all three focus areas of the OSWInD Initiative: technology development, market barrier removal, and advanced technology demonstration projects.

Major activities in support of the technology development focus include the large drivetrain testing facility at Clemson University; the large blade test facility at Massachusetts Clean Energy Center; and research conducted at the University of Maine, the University of Delaware, and the University of Toledo. The large drivetrain and large blade test centers provide national infrastructure for full-scale tests of key turbine components. The facilities will enable testing of 15 MW drivetrains and blades up to 90m in length. These facilities are important national investments, as there are currently no facilities in the United States capable of testing the large drivetrains and blades predicted for offshore wind technology deployments. Research conducted by the universities will result in the validation of coupled aeroelastic/hydrodynamic models for floating wind turbine platform deployments; modeling work on two-bladed, downwind floating turbine concepts; feedback to technology developers on corrosion protection and gearbox reliability; and materials innovation using composites for tower and blade structures.

Ongoing market barrier removal activities include environmental research at the University of Maine and Michigan State University; projects addressing marketplace acceptance at the University of Delaware, Sustainable Energy Advantage LLC, the Great Lakes Commission, Princeton Energy Resources International, LLC, and the South Carolina Energy Office; and workforce development work at the University of Massachusetts, University of Maine, University of Toledo, and University of Delaware. The environmental research is investigating avian, bat and marine animal interactions for both the great lakes and the Atlantic seaboard. The market acceptance research is investigating solutions to current barriers for offshore wind deployment. The workforce development activities will result in new curricula specific to offshore wind energy at the community college, university undergraduate, and university graduate levels.

One activity supporting the advanced technology demonstration project focus area is the deployment of a floating platform and turbine. Through the Recovery Act, DOE funds the University of Maine to deploy a 100 kW wind turbine mounted on a floating platform in deep water in the Gulf of Maine. The University of Maine will deploy a turbine and foundation design from three initial concepts that will be tested in a wave tank testing facility. The turbine will be instrumented to gather empirical data that will be used to validate current aero-elastic/hydrodynamic models.

In addition to the activities mentioned above, DOE maintains a core competency of technical experts, distinguished in their fields, throughout the DOE national laboratory complex. These experts support key activities essential to the national agenda. Finally, DOE is actively engaged in interagency collaborations through activities associated with the DOI-DOE MOU and the National Ocean Council, along with other collaborations attempting to address the myriad of regulatory and permitting issues.

4.2 OSWInD Implementation

This section details how each of the focus areas, activities, and research areas will be implemented as the OSWInD Initiative matures.

Focus Area 1: Technology Development

The research efforts in Focus Area 1: Technology Development will be targeted at overcoming technological barriers to achieving the deployment scenario of 54 GW of offshore wind by 2030. The specific activities will focus on improvements to models, design tools, components, turbines and balance-of-system that will lead to a lower cost of energy, reduction in technological risk, and increased access to wind resources. The activities are highly integrated, such that results in one area will be used as inputs to another area, and are ultimately guided by a system-level optimization methodology. The Technology Development focus area is broadly categorized into three main activities: (1.1) Computational Tools and Test Data; (1.2) Innovative Turbines; and (1.3) Marine Systems Engineering.

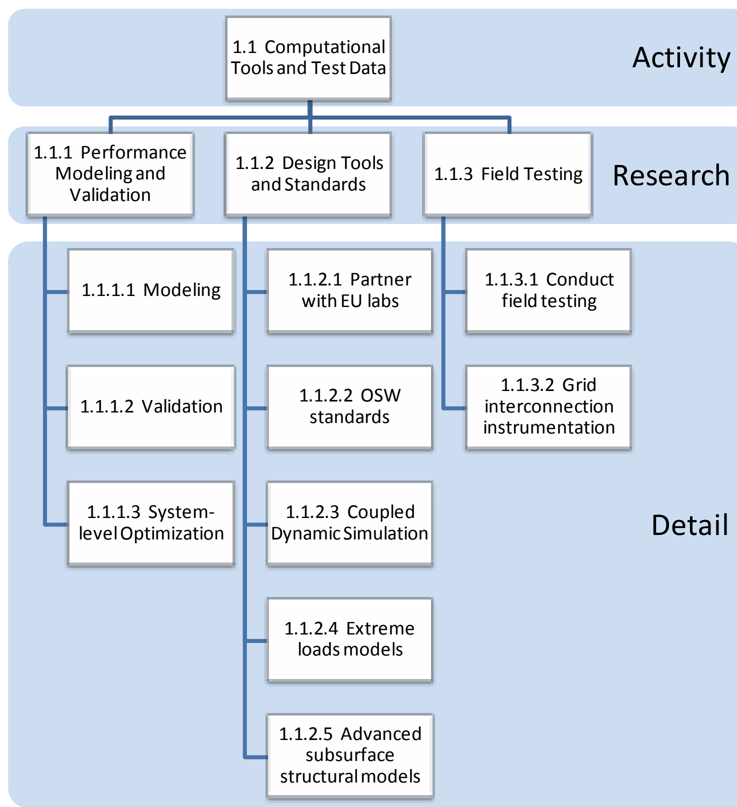


Figure 15. Details and Research Areas for Activity 1.1

Activity 1.1: Computational Tools and Test Data: The development of innovative technology begins with computational tools, which are verified through field tests. Collecting data on current turbine performance and reliability, along with environmental design conditions such as meteorological and oceanographic data and extreme weather events, enables updates and improvements to the design tools. Improved design tools in turn enable the development of new turbines, components and control systems, as well as refinement of economic analysis based on turbine performance models. Current offshore wind turbine technology is largely derived from land-based designs that have been conservatively modified for offshore use. The development of new design tools, standards, and testing methods will lay the foundation for safer, more reliable, cost-effective, and higher performing offshore wind turbines. Financial and regulatory risks are also reduced through the development of validated standards and performance tools, which increase confidence in the long-term performance of offshore wind installations.

Research Area 1.1.1: Performance Modeling and Validation: In assessing the economic feasibility of a project, developers and financiers rely on models that predict the amount of energy a wind project will produce over its lifetime. Accurate project planning and credibility with the financial community require that offshore wind energy production models be developed and validated by existing projects.

The development of a computational model that reliably predicts individual wind turbine performance in large offshore arrays is needed. Once this model is created, it must be validated using field-test data. This capability will allow more reliable power production predictions, thus reducing project performance risk and lowering the cost of capital.

The performance of optimized offshore turbine designs may take advantage of innovations and design opportunities that were previously rejected for land-based turbines. The optimized system may include turbines that cost more per megawatt of generating capacity if these costs are balanced against reduced life-cycle project costs for the offshore system as a whole. Methodologies and computational tools that evaluate proposed improvements to subsystems and measure the impact on the overall system in terms of cost of energy and other relevant metrics need to be developed.

Research Area 1.1.2: Design Tools and Standards: The development of new, accurate computer models is necessary to aid in the development of optimum offshore wind turbine designs. DOE will support development of computational tools needed to address structural design, control systems, aerodynamics, energy production, certification and verification issues, multiple turbine array effects, multiple array impacts on a regional basis, resource characterization, and meteorological and oceanographic phenomena. These tools will address the unique extreme environments in the United States, including hurricanes and ice conditions, to allow deployment in all regions of the country.

Advanced design tools allow the reliable prediction of the behavior of complex ocean environment conditions, and this new capability will permit the rigorous assessment and development of these innovative turbine concepts, components, and foundations. In the longer term, these advanced design tools will be necessary to develop and evaluate the floating platform designs necessary to reach deepwater wind resource locations.

A robust set of standards must be developed for the benefit of designers, developers, regulatory agencies and the industry at large to reduce risk and increase reliability. Partnerships with international and national standards-writing entities will result in access to existing guidelines and standards, which can serve as a baseline for national efforts. It is essential that U.S. standards harmonize with international standards to ensure access to global markets. These standards will lead to increased reliability, lowered risk, and lower cost of capital.

Research Area 1.1.3: Field Testing: The most effective way to establish offshore wind turbine design requirements and confirm performance is through measurements made on actual wind turbines at sea. It will be necessary to instrument and measure multiple turbines to capture regional and technology design differences. DOE and its national laboratories will partner with university research centers and industry in planning a long-term national operational data program.

Field-test data from multiple diverse test sites is essential for computer model validation and to support innovation. This field-test data should include grid interconnection and research instrumentation. Additionally, it is important to collaborate with industry to establish a national or international database of shared operating experience, which can lead to industry-wide understanding of the failures and costs of existing designs to direct and inform future research and development towards the highest impact activities.

Activity 1.2: Innovative Turbines: To lower overall project COE, innovative integrated turbine configurations, encompassing rotor, drivetrain, tower, and controls, are needed to reduce system weight relative to rated capacity, simplify installation processes, drastically reduce maintenance requirements, improve reliability, increase energy capture and, in general, benefit from economies of scale. DOE will form partnerships with research consortia, including industry, to identify, model, and eventually demonstrate candidate system configurations with high potential to impact COE.

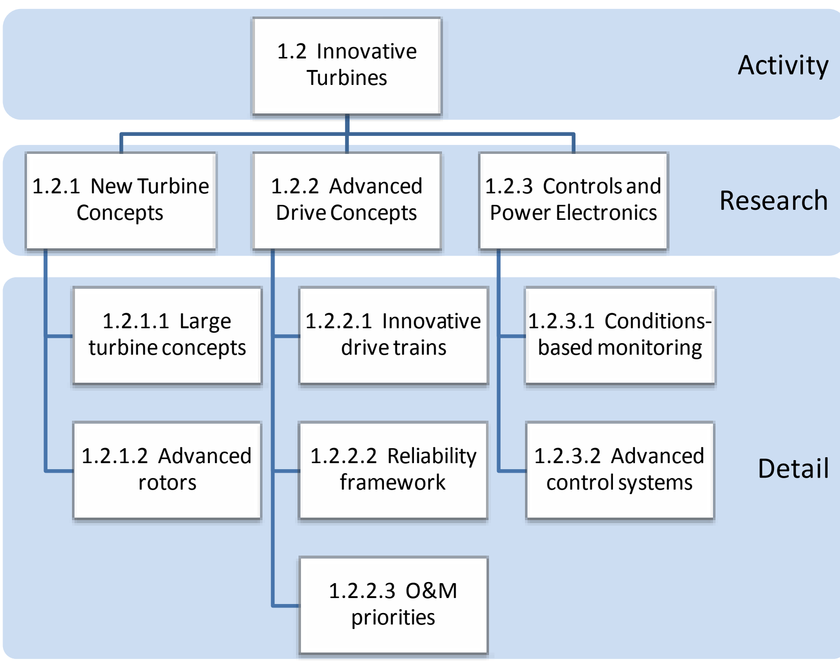


Figure 16. Details and Research Areas for Activity 1.2

Research Area 1.2.1: New Turbine Concepts: It is generally recognized that, in order to generate cost-competitive electricity, larger turbines are needed to overcome the added cost of foundations and other non-turbine capital costs associated with offshore wind turbines. A concept study of a large, efficient and cost-effective turbine system will highlight the research and development areas that will be required to realize a system of that size. This will help direct research and development of advanced components, especially rotors, which will be required to achieve the turbine design requirements. Concepts that achieve major weight reduction will also help enable future floating foundation designs.

Research Area 1.2.2: Advanced Drive Concepts: Innovative turbine drivetrains that have the potential for lower cost of energy, improve reliability, reduce weight and increase energy capture must be developed to enable cost-effective, next-generation turbines. DOE will support pre-prototype studies modeling the integration of superconducting generators, transverse flux topologies, and other enabling technologies into advanced turbine drivetrains. The drivetrain test facilities and, eventually, an offshore test bed will lower the risk for industry to develop these next-generation drive concepts.

Research Area 1.2.3: Controls and Power Electronics: Due to their increased size and cost, offshore turbines offer new possibilities in controls and power electronic sophistication not economically feasible in smaller systems. Research and development leading to advances in condition monitoring systems, control algorithms, blade control strategies, and power conditioning can increase turbine energy production, capacity factor, and component lifetime.

A condition-based monitoring system, consisting of a comprehensive suite of sensors and robust algorithms that detect impending problems before they occur, would improve availability and reliability, lower operating costs, and improve energy capture. These benefits are especially valuable for relatively remote and inaccessible offshore turbines. This comprehensive suite of sensors and robust algorithms can also be combined into control systems that increase hurricane survivability, reduce operational loads, and provide sufficient damping for floating platforms.

Activity 1.3: Marine Systems Engineering: A DOE-sponsored design effort for U.S.-engineered support structures, anchors, and moorings will lead to identification of significant cost-saving opportunities for wind power plants in both shallow water and in deeper water with both fixed-bottom and floating substructures. Engineering trade-off analyses will be followed by detailed design studies and prototype testing. Meanwhile, the development of grid architecture and hardware will be integrated with innovative foundations and turbine concepts into a system-level optimization methodology to produce an optimized next-generation offshore wind turbine technology platform. Such efforts would draw upon the knowledge and expertise of the nation's marine engineering industry.

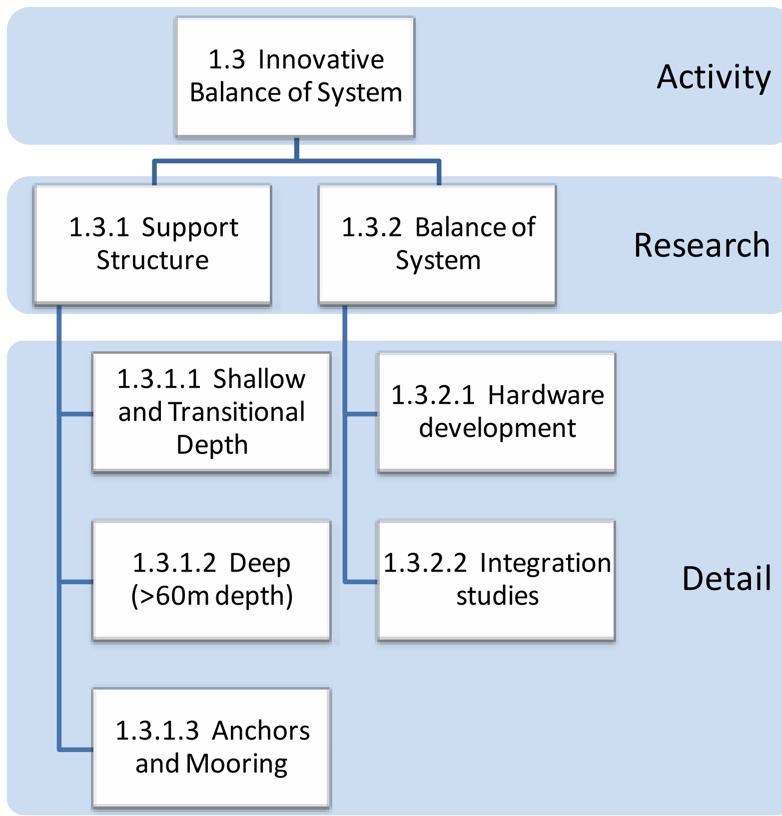
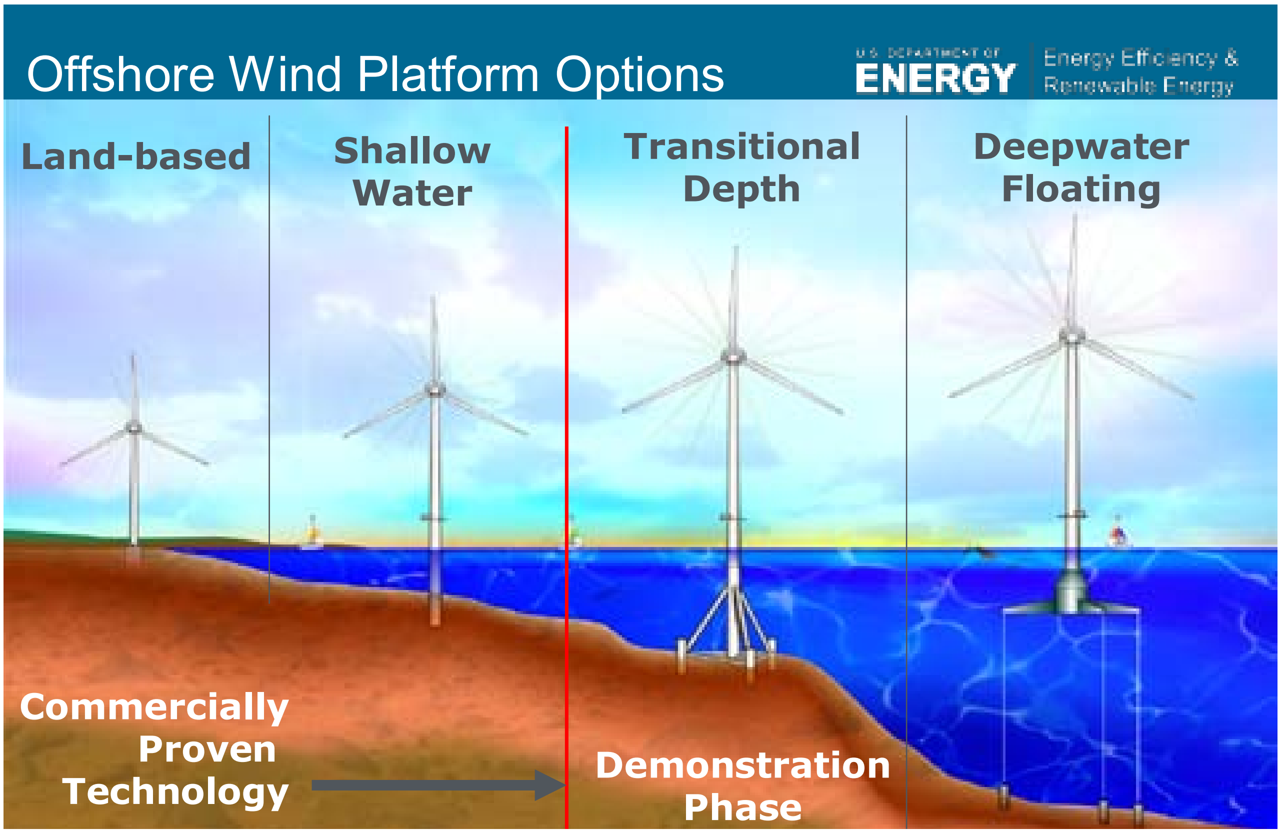


Figure 17. Details and Research Areas for Activity 1.3

Research Area 1.3.1: Support Structure: Innovative shallow, transitional-depth, and deepwater substructure designs that lower capital and installation costs and expand access to available wind resources will be developed. Advanced computational design tools for rigorously analyzing and reliably predicting the behavior of these complex subsurface structures will dramatically decrease the technology adoption timeline and enable focused and cost-effective technology development through design trade-off studies leading to eventual prototype hardware demonstrations. Additionally, innovative anchors and mooring technology for these advanced substructure designs will further reduce cost and risk. Advanced control systems will help reduce loads on foundations and enable the development of floating systems which will require stability control and load minimization. Foundation designs, in tandem with installation strategies, will optimize the time, cost, and complexity of the construction process, which is susceptible to weather, availability of specialized equipment, and variability of seabed conditions.



Research Area 1.3.2: Balance of System: The design of the wind turbine array grid, including inter-turbine connection schemes, substation designs, and longer connections to the main electrical grid, will all need to be optimized in order to make offshore wind developments economical. Design studies for high-voltage direct current transmission, superconducting transmission, and other technologies will be undertaken to evaluate the available options. Concepts and hardware that allow for load balancing, short-term forecasting of wind farm production, and other power grid services will also help make offshore wind more economical and improve offshore wind energy integration with the existing electrical grid infrastructure. Reliability of the substations is also of vital importance, especially as farms grow in size and are installed further from shore.

Table 1. Activity 1.1: Methods and Verification

Activity 1.1: Technology Development – Computational Tools and Test Data							
Research Area	**Title**		**Detail**	**Deliverable**	**Impact**	**Timeline**	**Partners**
1.1.1	**Performance Modeling and Validation**	1	Develop wind turbine & array performance models	Computational models that reliably predict individual turbine and array performance in large offshore farms	Reliable power production predictions reduce project performance risk, lower cost of capital and increase energy capture	Update existing model to beta version incorporating offshore conditions - 1 year	Labs, Academia, NOAA,NCAR, Onshore
		2	Validate performance models with field test data	Validation of above model with field test data	Reliable power production predictions reduce project performance risk, lower cost of capital and increase energy capture	2 years – post installation of turbine.	Labs, wind array operators,
		3	Develop methodologies and computational tools to optimize next generation offshore wind turbines, arrays, O&M strategies, etc at a system-level	Concepts, methods and computational tools to assess impacts of proposed subsystem improvements	Enables optimized designs which ultimately lead to lowest cost of energy	System-level model development - 2 years	Labs, Academia, Industry
1.1.2	**Design Tools and Standards**	1	Partner with European labs to access existing databases	Existing research and operational data from European offshore wind installations	Test data from European installations provides baseline for design tool development	Establish and support Partnerships -1 year Access Data - Ongoing	Labs, European Labs
		2	Develop standards for offshore wind. Harmonize with European standards	Robust suite of design and operation standards for U.S. Offshore Wind Industry	Standards lead to increased reliability, lowered cost, and lower cost of capital	Draft guidelines – 1 year Gap-filling studies – 2 years	Labs, BOEMRE, Offshore wind industry
		3	Coupled Dynamic Computational Model Development	Validated model to evaluate dynamic response on the coupled wind turbine and support structure to wind and wave loading	Allows development of floating platforms and optimization of full turbine systems	2 years – validated code with field test data	Labs, Academia
		4	Develop and validate loads models for extreme environments (hurricanes, ice, etc.)	Validated model that accurately predicts wind turbine loads under extreme environmental conditions	Essential capability to enable deployment in Southeast and Great Lakes and inform standards development	Study on hurricane design loads – 6 months Validation on scale models – 1 year	Labs, Academia, ABS
		5	Advanced design tools for complex subsurface structures	Computational Model that reliably predicts behavior of complex subsurface structures	New capability permits rigorous assessment of innovative structures	2 years after studies on metocean conditions completed	Labs, Academia

Table 2. Activity 1.1 (cont'd): Methods and Verification

Activity 1.1: Technology Development – Computational Tools and Test Data							
Research Area	**Title**		**Detail**	**Deliverable**	**Impact**	**Timeline**	**Partners**
1.1.3	**Field Testing**	1	Implement data gathering campaign and gather test data from multiple field test sites (fixed, floating, regional)	Field test data from diverse sites	Field testing is essential for model validation and to support innovation and technological risk reduction	Instrument - 1 year Data Collection – Ongoing Analysis – 1 year	Labs, Academia, States
		2	Provide grid interconnection and research instrumentation for field test sites	Field test equipment operational at sites identified in above task	Field testing is essential for model validation and to support innovation and technological risk reduction	5 yrs	Demo project awardees, Labs, States

Table 3. Activity 1.2: Innovative Turbines

Activity 1.2: Technology Development - Innovative Turbines							
Research Area	**Title**		**Detail**	**Deliverable**	**Impact**	**Timeline**	**Partners**
1.2.1	**New Turbine Concepts**	1	Large, Cost Effective Turbine Concept Studies	Turbine concepts with full cost analysis, demonstrated engineering feasibility, and tradeoffs for hardware development.	Larger machines are needed to lower balance of station costs that dominate offshore project economics	5 years	Labs, Inventors, Industry, academia
		2	Advanced Rotor Development	New materials, manufacturing methods and design concepts to enable next generation rotor development	Innovations in materials, manufacturing and design lead to load and weight reduction enabling higher energy capture and larger machines	Concept - 1 year Materials and coatings evaluation – 1 year Manufacturing methods – 2 years Blade testing – 2 years	Labs, academia, industry,
1.2.2	**Advanced drive concepts**	1	Evaluate and develop innovative turbine drivetrains with potential for lower cost of energy	Innovative turbine drivetrains demonstrated to improve reliability, lower cost, reduce weight, and increase energy capture	Innovations in the market that increase reliability, lower costs, and increase energy capture	Concept – 1 year Subcomponent testing -1 year Subscale system testing – 1 year Full scale prototype – 2 years	Labs, Inventors, Industry
		2	Develop Reliability Framework and O&M Priorities	Ongoing reliability characterization and analysis reporting	Database that gathers/provides information targeted at improving reliability and asset management	Instrumentation – 6 months Data collection and analysis – 4 years	NL, Industry, Industry, …
1.2.3	**Controls and Power Electronics**	1	Evaluate and develop condition based monitoring systems for offshore systems	A comprehensive suite of sensors and robust algorithms that detect impending problems before they occur	Improved availability and reliability with lower operating costs and improved energy capture	2 yrs	Labs, Academia, industry, Onshore
		2	Evaluate and develop advanced control systems for offshore wind turbines	Control systems that increase hurricane survivability, reduce operational loads, and provide sufficient damping for floating platforms	Increase survivability, increased energy capture, and enables floating platforms	2 yrs after computational tools are available	Labs, Academia, Industry

Table 4. Activity 1.3: Innovative Balance of System

Activity 1.3: Technology Development - Innovative Balance of System							
Research Area	Title		Detail	Deliverable	Impact	Timeline	Partners
1.3.1	Support Structures	1	Evaluate and Develop low cost offshore support structures for a variety of water depths and offshore conditions including floating platforms.	Innovative shallow, transitional and deepwater support structure designs that lower capital and installation costs	Demonstrated and validated innovative support structures that lower cost and expand access to resources	Scale Model design & testing – 2 years Full scale Prototype – 2 years	Labs, Oil and Gas industry, Developers
		2	Evaluate and develop innovative anchors and moorings for floating offshore systems in coordination with water program to reduce cost and risk	Innovative anchor and mooring designs for floating offshore systems that lower cost and risk	Lower cost of energy, increased reliability, and improved investor confidence	Mooring concepts and testing – 2 years Platform integration – 1 year	Labs, Oil and Gas Industry, Coast Guard
1.3.2	Balance of System	1	Offshore Grid Hardware and Integration Studies	Grid architecture and hardware design concepts	Improved array efficiency, feed in to system level optimization	Concept studies and evaluation – 3 years	Labs, Submarine cable industry, consultants
		2	Evaluate and develop grid hardware	New hardware solutions developed based on above designs	Enables larger and more efficient and reliable electrical grids leading to lower COE and O&M costs	Hardware development and testing – 5 years	Labs, Submarine cable industry, consultants

Focus Area 2: Market Barrier Removal

Efforts in the Market Barrier Removal Focus Area will increase the efficiency of the current deployment timeline, summarized in Figure 18 above. The following discussion of activities and research areas will focus on this goal.

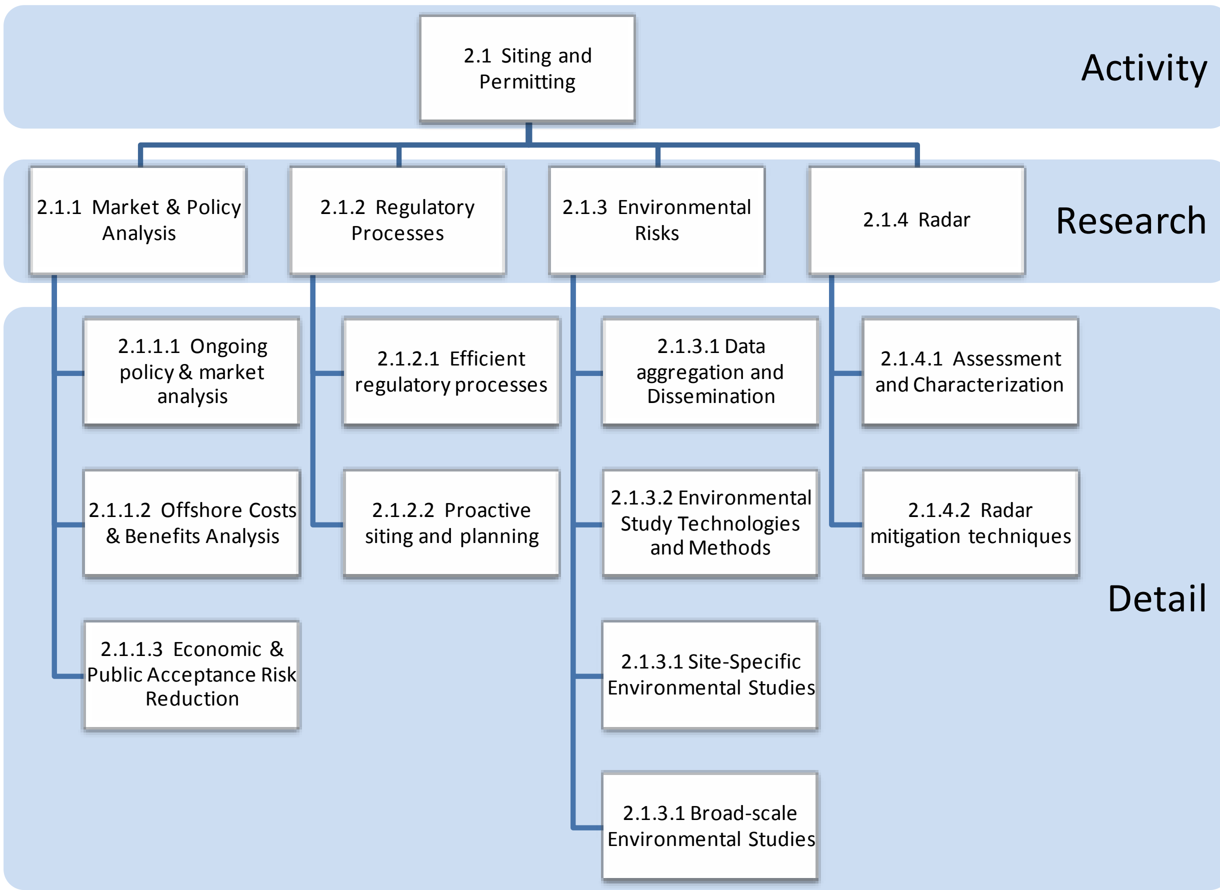


Figure 19. Details and Research Areas for Activity 2.1

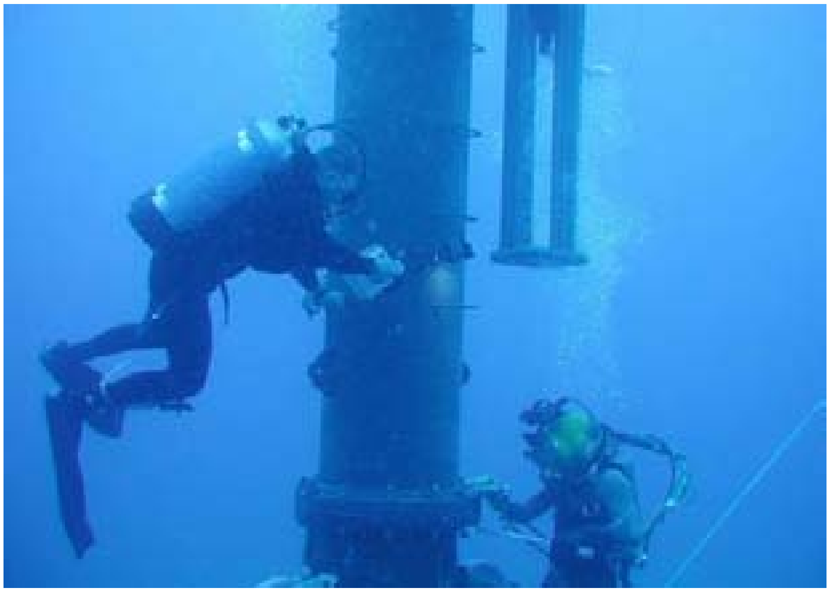
Activity 2.1: Siting and Permitting: In order to meet the Initiative's goals for offshore wind deployment, permitting and siting timelines and costs need to be reduced; key market, socioeconomic, and environmental risks need to be better understood and mitigated; and strategies to build public acceptance of the technology need to be applied to regions with near-term deployment. Concerted federal investment and engagement—coordinated within and across agencies and in close partnership with states, non-governmental organizations, and other stakeholders—will be required to enable both the short- and long-term success of a vibrant offshore wind industry in the United States.

While DOE has no legal authority in the siting or regulation of offshore wind installations, the OSWInD Initiative can make a significant impact in the planning, siting, and permitting processes by partnering with federal, state, and local agencies that regulate and manage these projects in state and federal waters. In addition, strong collaboration with environmental stakeholders can help identify high-priority areas for protection, existing data gaps, and the best manner in which to efficiently incorporate natural resource considerations into the permitting and siting process. By supporting research and analysis to better understand regulatory uncertainties and to identify, reduce, and mitigate key environmental and social science risks and by producing and disseminating critically needed objective information to enable informed decision making by stakeholders, DOE will jumpstart the nascent offshore wind industry.

Efforts in this area will be targeted at overcoming common barriers currently facing offshore investment and deployment. Priority will be given to efforts leveraging DOE investment with initiatives funded by other federal agencies, state and local governments, and the private sector, including utilities. The activities supporting implementation of the DOI-DOE MOU Action Plan referenced above will be critical in these initiatives Research areas will include four broad categories, presented below.

Research Area 2.1.1: Market and Policy Analysis: Development of a utility scale project requires capital investment of hundreds of millions, even billions, of dollars. As experience from land based wind and European offshore wind development have shown, policy options and financial mechanisms can have major impacts on the viability of projects. Credible, objective analysis to inform stakeholders and compare options is often lacking. In the absence of sophisticated and broadly accepted methods of analyzing costs and benefits associated with these investments, there will continue to be a wide variety of often contradictory data and interpretations on both the public value of offshore wind and its financial viability.

Under this research area, DOE will support the development of standardized methods, models and guidelines for the development of credible information on and tools for the evaluation of the costs and benefits of offshore wind. In addition, DOE will support the quantification of relevant positive and negative externalities, such as environmental and socioeconomic impacts, in cost of energy calculations, and will support objective analysis of policy and regulatory options related to offshore wind to enable informed decision-making on relevant questions related to specific projects, the offshore wind industry, and national energy policy.



Public acceptance of offshore wind will also be crucial, both to the deployment of specific projects and the long-term success of the industry. The development of offshore wind could pose risks to competing uses of the ocean space, such as fishing, tourism, and military operations; affected communities and organizations will also have concerns that will need to be addressed. Many of these issues will be site-specific, but many will have common themes that DOE is well-placed to address. To identify and better understand the potential socioeconomic impacts of offshore wind energy and the concerns of key stakeholders and communities, DOE will work with BOEMRE, other interagency partners, and key stakeholders to identify gaps in understanding, followed by targeted research aimed at developing risk mitigation measures and communication strategies to build public acceptance of offshore wind. Increased public acceptance of offshore wind will also be driven by inclusive siting and permitting processes that consider community equities and produce outcomes that show incorporation of public sentiment.

Research Area 2.1.2: Regulatory Processes: Planning an offshore project requires consideration of hundreds of important environmental and potential conflicting-use factors, as well as compliance with a multitude of regulations enforced by agencies with varying levels of jurisdictional authority. The estimated timeline for project approvals ranges from 7 to 10 years and the regulatory processes remain untested, increasing uncertainty and risk for investors.

DOE will work closely with other federal agencies at a staff and policy level to develop recommendations for reasonable and efficient permitting timeframes. DOE will also support efficiency in permitting through the support and development of mechanisms such as standardized protocols for baseline planning surveys and monitoring programs, and the development of adaptive management strategies.

Current government planning for offshore wind investments, particularly at a federal level, has taken a first-come, first-served approach with regard to siting offshore wind projects. This approach may not be optimal for achieving deployment at the speed and scale necessary to meet national objectives. Such an approach, while allowing a greater degree of flexibility to individual developers, misses efficiencies in required baseline data collection, environmental review, and other permitting requirements that could be realized through a more proactive process. Properly designed, a proactive approach to siting and permitting may have the potential to significantly accelerate responsible installation of projects and to reduce the permitting costs and risks associated with offshore wind development.

To facilitate a more robust, broad-based siting strategy, DOE will work with other agencies and stakeholders to identify priority areas for offshore development through mechanisms such as the National Ocean Council's regional coastal and marine spatial planning processes, and will enhance ongoing interagency efforts, including DOE's MOU with DOI, DOI's state offshore wind energy task forces, and DOI's MOU with the Atlantic Offshore Wind Energy Consortium. The ultimate goal of these efforts is to identify priority development zones for near-term, gigawatt-scale deployment, while ensuring that military equities, shipping lanes, environmental sensitivities, commercial fishing, and other issues are taken into account.

Research Area 2.1.3: Environmental Risks: Hundreds of environmental studies have been conducted in Europe in conjunction with offshore wind development. Although the United States can leverage lessons learned from these studies, few studies have been done in U.S. waters. Consequently, major data gaps exist that can delay and add significant risk for both project developers and regulators seeking to install offshore facilities. Filling these gaps requires upfront investments in long-term, expensive research that—while of long-term benefit to the entire industry—has largely fallen to the first generation of individual project developers.

DOE will institute a nationally coordinated effort to gather, analyze, and make public environmental data in order to better inform the public and decision-makers on the extent of potential environmental impacts. This will avoid compelling individual developers to shoulder the high costs of research, and will build the knowledge base. This effort will include joint work with other agencies to coordinate identification of gaps and priority risks, analysis of European studies to identify data and conclusions applicable to the U.S., the aggregation and dissemination of existing environmental data through publicly-available databases, the collection of baseline data to fill key gaps, site-specific efforts such as before-after-control-impact (BACI) studies of relevant marine ecology in key geographic areas, development of tools and technologies for cost-effective pre- and post-construction environmental monitoring and mitigation, and development of broadly acceptable integrated environmental risk assessment and decision-making strategies. These investments will, over time, reduce perception of environmental and statutory risks to the regulatory and resource management agencies involved, reduce environmental requirements on project developers, and increase community acceptance.

Research Area 2.1.4: Radar and Other Technical Challenges: Potential interference of wind turbine arrays with radar signals presents a serious concern for many stakeholders, including commercial aviation and the Departments of Defense and Homeland Security. The Department of Energy is a member of the sub-interagency policy committee on radar. This committee is chaired by the National Security Council and involves representatives from the Department of Defense (DOD), Department of Homeland Security (DHS), Federal Aviation Administration (FAA), NOAA, and the Director of National Intelligence. The committee focuses on identifying and resolving conflicting priorities regarding interaction between wind turbines and radar systems.

Interaction with these key interagency partners will effectively characterize the technical challenges of radar/turbine interaction and develop mitigation options. While many offshore radar issues are similar to those associated with land-based systems, there are also circumstances unique to offshore facilities. Therefore, additional research is needed to complement land-based efforts.

Activities of the OSWInD Initiative will complement, and will be defined by, the collaborative framework established for interagency radar investigations. This framework includes:

- Joint assessment studies to inform research needs;
- Roadmaps that prioritize research and development activities of individual agencies and identify opportunities for joint research projects between agencies;
- Funds for research and development of wind turbine mitigation technologies that can be implemented by the wind industry; and
- Validation of new technologies that can allow development of the nation’s wind resources without jeopardizing national security missions.

A goal of this approach is to dramatically reduce the need for project-by-project technical assistance through broadly accepted technology mitigation measures.

Research supported by the OSWInD Initiative will complement land-based initiatives by identifying offshore specific radar mitigation options for use by the wind industry and radar operators. These efforts will be informed by the experience and investigations carried out in conjunction with the European offshore wind industry, such as tests with integrating supplemental radar systems, and modifications to radar processing software.

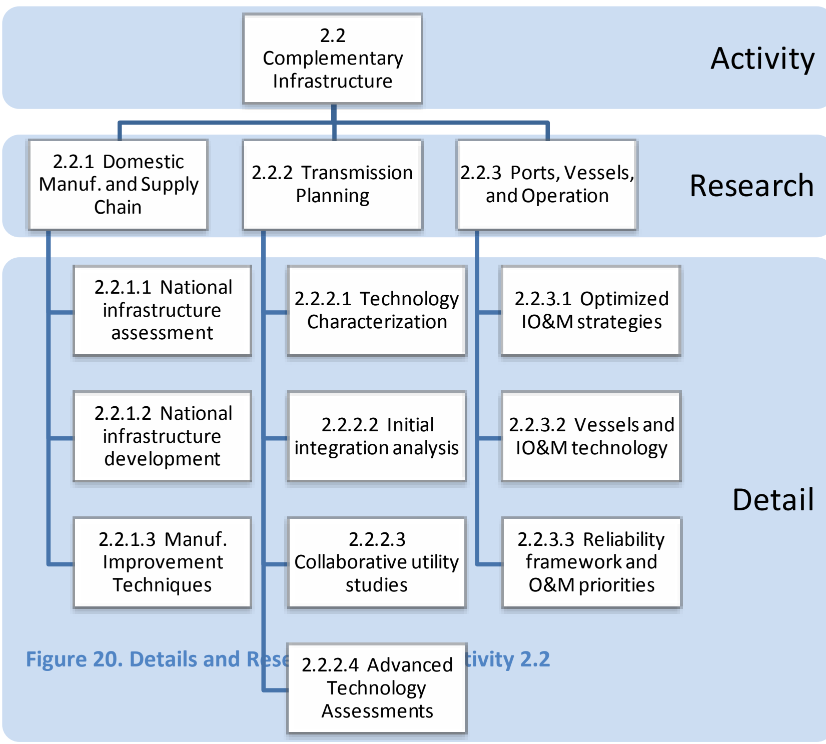


Figure 20. Details and Rese… tivity 2.2

Activity 2.2: Complementary Infrastructure: Research efforts will address infrastructure challenges that, if not adequately resolved on a national level, pose significant restrictions to offshore wind market growth and deployment. Priority will be given to efforts leveraging DOE investment with initiatives funded by other federal agencies, state and local governments, and the private sector, including utilities.

Research Area 2.2.1: Manufacturing and Supply Chain Development: The supply chain is defined as the system of manufacture and/or procurement of components, subcomponents and materials that compose the assembled turbine and completed offshore facility. Domestic infrastructure is critical to the practicality and financial viability of individual offshore projects. Domestic manufacturing and the growth of U.S.-based suppliers is also key to asserting global technical leadership and realizing the full economic benefit of the industry. Specific advantages to the U.S. manufacture of offshore turbines, tower structures, and balance-of-plant components are reduced transportation and transactional costs during installation and operational periods.

In addition to offering financial incentives such as loan guarantees, DOE will provide technical support to companies seeking to supply offshore turbines and components, and to economic development agencies seeking to establish manufacturing facilities in their regions. The goal for this effort is to coordinate, facilitate, and leverage research activities at national laboratories, universities, and other agencies, such as the U.S. Department of Commerce (DOC) to facilitate U.S.-based manufacture, assembly, transport, and operations and maintenance of wind turbine systems and components. Such support includes studies needed to optimize integrated manufacturing and installation strategies; manufacturing process research and development for components such as blades; and analyses of critical material supply and demand factors to be faced by the growing industry.

Research Area 2.2.2: Transmission Planning and Interconnect Strategy: Offshore projects are being planned in close proximity to major urban load centers, requiring interconnection with some of the country's major electricity service providers. Grid interconnection studies are required to ensure that the impacts of large concentrations of offshore wind generation facilities on these transmission networks are properly understood and can be effectively integrated into the day-to-day power management strategies of the utilities, in addition to identifying system upgrades needed for reliable interconnection.

Studies will also assess the value to these utilities of offshore wind energy versus energy from other sources or regions, and the potential value to the East Coast grid of an extended offshore electric delivery network.

The OSWInD Initiative will collaborate with DOE's Office of Electricity Delivery and Energy Reliability (OE) to develop a long-range DOE approach that characterizes and addresses the needs for transmission planning and interconnection strategies specific to offshore wind energy. The following near-term research activities will support OE-led, interconnect-wide transmission planning and address related long-range industry needs and utility challenges:

- Technology/Industry Characterization
- Initial Integration Analysis
- Collaborative Utility Studies
- Advanced Technology Assessments

Research Area 2.2.3: Ports, Vessels and Operations: Offshore wind provides an opportunity for revitalization of a number of U.S. port and heavy industry facilities. Due to the large scale of offshore wind turbine components and tower/foundation structures, it is advantageous to limit or eliminate overland transport from the most effective assembly and installation scenarios. In addition, European experience has clearly indicated that it will be necessary to create a purpose-built installation, operations, and maintenance (IO&M) infrastructure for offshore wind, including specialized vessels and port facilities. To assist industry and regional port facilities in making informed decisions regarding requirements for, and design of, IO&M infrastructure, DOE will participate in collaborative needs and capabilities studies for the benefit of all national regions.

A significant portion of the cost differential between land-based and offshore wind energy systems lies in the transport and installation requirements. European experience indicates that specialized wind system installation vessels, rather than adapted oil and gas vessels, will be required for cost-effective, high-volume installation. DOE will support development of integrated manufacturing, transport, installation, and maintenance strategies leading to specialized vessels, safety systems, and tooling.

Operations and maintenance analysis and planning at the onset of the design and development of offshore wind projects can contribute significantly to reduction of cost of energy by optimizing system reliability and availability. Through maintainability analysis that considers projected component reliability and periods of access limitations, this effort can support accurate energy production estimates as well as provide targeted reliability goals at a component and vessel fleet level. These efforts will include establishment of operations databases and development of advanced O&M strategies based on data analysis targeted at improving asset management.

Activity 2.3: Resource Planning: Accurate field data, mapping, and databases are essential for assessing potential offshore wind project sites and establishing zones of prioritized activity. Although many agencies, universities and other organizations have programs nominally addressing offshore data needs, there has been no national-scale coordination that integrates these efforts to meet an agreed-upon set of data needs for the offshore industry. This OSWInD Initiative activity will ensure a nationally coordinated effort to collect and disseminate data for use in planning individual projects and carrying out critical marine spatial planning activities in support of responsible offshore wind development, such as the National Ocean Council's coastal and marine spatial planning effort.

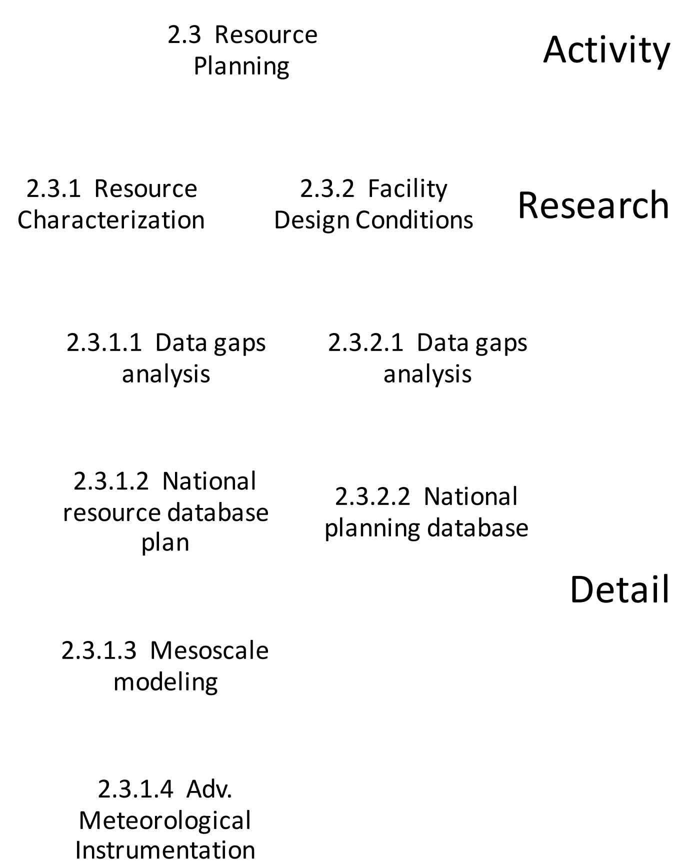


Figure 21. Details and Research Areas for Activity 2.3

Most meteorological, wave, and seabed data used in assessing potential offshore wind sites are based on extrapolations of data from on-shore sites, buoys, or limited surveys. Such projections have not been validated for accuracy. Few wind data have been gathered at actual offshore sites due the cost and lack of practical instrumentation. Similarly, little data exists on seabed conditions, which are required to design foundations and plan cable trenching. These data are critical in assessing the costs, energy production, design requirement and overall economic viability of projects.

DOE will collaborate with other agencies such as DOI, NOAA, and the U.S. Army Corps of Engineers in establishing common databases, ensuring that available data are utilized, supporting new measurement initiatives, and funding development of advanced instrumentation technology.

Research Area 2.3.1: Resource Characterization: DOE's MOUs with DOI and with NOAA establish a framework for effective national collaboration and for defining the highest priority research areas related to the characterization of wind resources. This collaborative framework consists of the following key resource characterization planning activities:

- Engagement of industry experts and formation of an interagency working group;
- Preparation of a data requirements document identifying exactly which data - collected and compiled to specified protocols - are needed by the offshore industry;
- Completion of a gap analysis to determine the relevance of existing data, the best sources of data in the future, required modeling and extrapolation software and recommendations for advanced technology development; and
- Initiation of a long-range implementation plan that acts as a roadmap for the OSWInD Initiative and national partners to coordinate and support the specific activities needed meet stakeholder needs.

Research initiatives to be informed by these planning activities include a resource characterization campaign for the Outer Continental Shelf and Great Lakes; mesoscale atmospheric modeling to predict long range weather trends; analysis of extreme events such as hurricanes; assessment and refinement of advanced instrumentation and methodologies; and joint efforts in establishment of GIS databases and methods.

Research Area 2.3.2: Facility Design Conditions: To support reliable and safe offshore plant design and provide data for emerging marine spatial planning activities, a long-term, concerted effort to collect and disseminate critical field information beyond wind characteristics is needed. These data provide the basis for technical requirements governing structural design and establishes operating parameters for turbines, towers, balance-of-plant structures, and transmission cables. Applying these requirements to facility

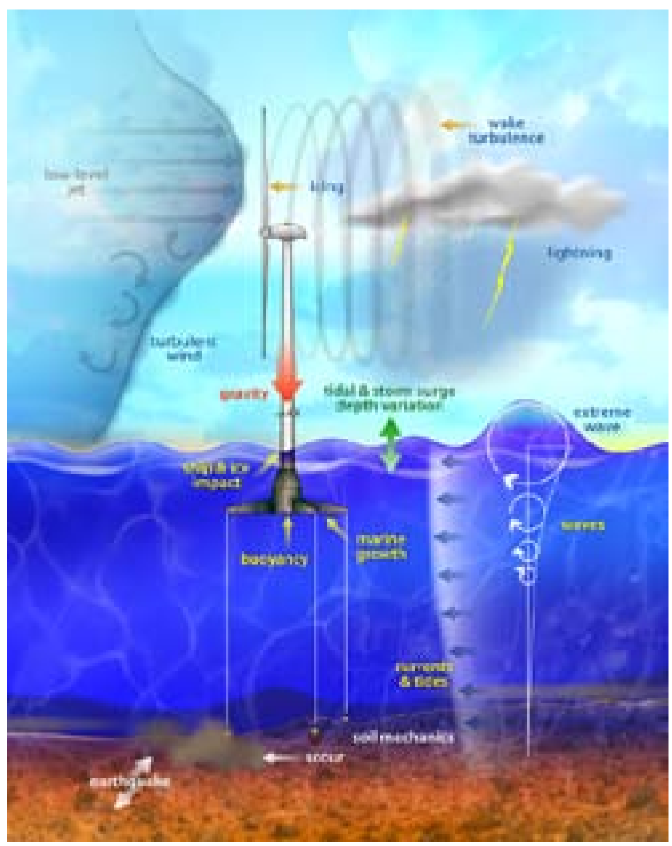


Figure 22. Understanding External Conditions To Define the Design Parameters (DOE)

design will impact determinations of practicality, reliability and economic viability. For instance, information on water depth, current, seabed migration, and wave action is used to study mechanical and structural loading on potential turbine configurations and for assessing impacts of external site-specific conditions, in terms of both survival during extreme loading and long-term fatigue damage and degradation. Other quantifiable factors of the design environment include growth of marine organisms, tidal forces, salinity, and icing, as well as the geotechnical characteristics of the sea or lake bed.

The first steps toward making this design and planning information available are a gap analysis to identify critical non-wind data and assess the best means of collection; and implementation of a plan to establish a national network that provides data and support for the required research and development. These activities will leverage the existing knowledge base of ocean engineering established by the oil and gas industry.

Figure 16 constructs a timeline for the execution of the details and stages of Technology Development and Market Barrier Removal research areas.

Table 5: Details of Activity 2.1

Research Area	Title		Sub-task	Deliverable	Impact	Timeline	Partners
Activity 2.1 - Siting and Permitting							
2.1.1	Market Analysis & Policy	1	Ongoing policy and market analysis	Annual market data report and analysis of emergent policy and economic questions	Reduced information barriers to investment; better decisions by policy makers and other stakeholders	2011: First market report; Ongoing: Policy and market analysis	NREL and other National Labs as required
		2	Offshore Costs & Benefits Analysis	Standard methodologies for project costs & benefits evaluation, including quantification of externalities and COE analysis of non-technology barriers and costs	Allow apples-to-apples comparison of offshore wind with competing generation technologies to enable informed decision making	2011: Methodologies developed; Ongoing: Follow-on work as necessary	National Labs, private sector consultants, universities
		3	Economic and Public Acceptance Risk Reduction	Studies to improve understanding of and mitigation options for key socioeconomic and public acceptance risks; targeted engagement of key stakeholders through publications, electronic media, workshops, etc	Reduced study costs to developers, reduced permitting and NEPA timelines, reduced risks to investors, regulators, improved public acceptance of OSW	2011: Conduct gap analysis 2011: Develop collective research agenda; issue first solicitation for key research 2012-2015: Studies completed, Additional solicitations as funds available	Universities, Labs, NGOs, developers, State and Federal regulatory agencies, other stakeholders
2.1.2	Regulatory Processes	1	Efficient Regulatory Processes	Recommendations to increase efficiency of Federal and State project authorization processes and shorten timelines; standardized protocols for environmental monitoring and mitigation; adaptive management strategies	Decreased timeline and risks associated with siting and permitting to both developers and regulators	2011: Develop recommendations; solicit for standardized protocols 2012-2015: Finalize protocols, conduct follow-up research as necessary	DOI: BOEM, FWS, other DOI agencies; NOAA; State and regional organizations
		2	Proactive Planning and Siting	Coastal and Marine Spatial Planning (CMSP) to identify zones for near-term, GW-scale deployment; improved broad-scale environmental and ocean use data; plan for potential research leases	Accelerated deployment in priority regions; reduced environmental study costs to developers; reduced permitting timelines; reduced long-term risks to investors and regulators	2011: Identify high-potential zones; 2011-2015: Participate in NOC-led CMSP processes; provide technical support as necessary	DOI: BOEM, FWS, other DOI agencies; NOAA; State and regional organizations

Table 6: Details of Activity 2.1 (cont'd)

Activity 2.1 - Siting and Permitting							
Research Area	**Title**		**Sub-task**	**Deliverable**	**Impact**	**Timeline**	**Partners**
2.1.3	Environmental Risks	1	Data aggregation and Dissemination	Offshore wind environmental knowledge management system (KMS)	Maximize leverage of European experience, enable	2011: Development of KMS; 2012: KMS online; 2012-15: maintain and update KMS.	DOE Water Power Program, National Labs, BOEM, NOAA, FWS, European Counterparts
		2	Environmental Study Technologies and Methods	Assessments, technology development, and validation of novel environmental study technologies and methods	Reduced environmental study costs and risks to developers and regulators	2011: Conduct gap analysis and monitoring technology roadmap; issue first solicitation.. 2012-15: Complete initial studies, additional solicitations as funds allow	Developers, universities, labs, NGOs, consultants, Federal and State regulators and resource managers
		3	Site-Specific Environmental Studies	Studies to address key environmental issues facing specific projects in development	Overcome regulatory hurdles faced by specific projects; reduce regulatory burden for projects facing similar questions	2011: Issue first solicitation; 2012-2015	Developers, universities, labs, NGOs, consultants, Federal and State regulators and resource managers
		4	Broad-scale Environmental Studies	Studies to address priority broad-scale environmental data gaps; offshore wind risk evaluation framework	Reduced regulatory and environmental uncertainty for developers, regulators and other stakeholders; decreased requirements and permitting timelines; risk framework will help prioritize areas for investment and separate perceived from real risks.	2011: Joint BAA with BOEM and other agencies; development of offshore wind environmental risk framework. 2012-15: BAA studies compelted; additional BAAs as funds allow	DOE Water Power Program, BOEM, NOAA, Universities, National Labs
2.1.4	Radar	1	Radar Outreach and Mitigation Techniques	Evaluation of potential radar challenges within the OCS and engage key stakeholder to proactively develop mitigation options	Effective mitigation menu for radar and turbine technologies that supports synergistic mission (i.e. energy production and agency mission)	2011: Quantify potential radar challenges. 2012-15: Develop mitigation options, leveraging existing work.	NL, Industry, Universities, DOD, DHS, DOT

Table 7: Details of Activity 2.2

Research Area	Title		Sub-task	Deliverable	Impact	Timeline	Partners
Activity 2.2	**Complementary Infrastructure**						
2.2.1	**Domestic Manufacturing and Supply Chain Development**	1	National Infrastructure Assessment and Development Strategy	Quantify existing and potential infrastructure needs and supplier opportunities as well as critical path to effective growth	Enhanced likelihood of efficient buildup of national scale infrastructure to meet industry needs.	2011 - 2012	NL, Industry, States, Agencies, …
		2	Manufacturing Improvement Techniques	Quantify existing and potential component needs and supplier opportunities. Identify technical pathway for market entry of large offshore components	Manufacturing strategy targeted at the build-out of a robust supply chain	2012 - 2013	NL, Industry, States, Agencies, …
2.2.2	**Transmission Planning & Interconnect Strategies**	1	Technology/Industry Characterization	Provide baseline information on projected scale of offshore wind industry, deployment scenarios, technology and power production characteristics	Primary target for activity: interconnect-wide planning collaboratives	2011	OE, NL, Industry, Utilities, UWIG, …
		2	Initial Integration Analysis	Assess offshore applicability of current wind integration “solution sets”.	Identify gaps and recommend activities to address them in operational integration studies.	2011 - 2012	OE, NL, Industry, Utilities, UWIG, …
		3	Collaborative Utility Studies	Case studies and joint analysis carried out with utilities having large-scale offshore wind development proposed in their service areas.	Activities will be based on integration concerns and technical challenges identified by partner organizations	2011 - 2014	OE, Utilities, UWIG, …
		4	Advanced Technology Assessments	Identify potential advanced marine grid and interface hardware designs such as HVDC offshore 'backbone'; marinized substations; advanced undersea cable concepts; optimized inter-array grids.	Technical analyses will be focused on advancements that lower costs, increase reliability, reduce risks or facilitate acceptance.	2011 - 2015	OE, NL, Industry, Utilities, UWIG, …

Table 8: Details of Activity 2.2 (cont'd)

Research Area	Title		Sub-task	Deliverable	Impact	Timeline	Partners
Activity 2.2	**Complementary Infrastructure**						
2.2.3	**Ports, Vessels and Operations**	1	Optimized IO&M Strategies	Analysis and models to identify the most practical means of reducing cost of energy through IO&M techniques and supporting infrastructure while ensuring safety.	Required for effective decision making by industry	2011 - 2012	NL, Industry, Industry, …
		2	Vessels, Facilities & Technology for Installation, Operations & Maintenance	Stage 1 - Identify needs, solutions, costs and timeframes for development; Stage 2 - Technical and financial support	Enhance efficient buildup of national scale infrastructure to meet industry needs.	Stage 1 - 2011; Stage 2 - 2012-2015	NL, Industry, States, Agencies, …
		3	Develop Reliability Framework and O&M Priorities	Ongoing reliability characterization and analysis reporting. Stage 1 - Plan; Stage 2 - Implementation	Database that gathers/provides information targeted at improving reliability and asset management	Stage 1 - 2011; Stage 2 - 2012-2015	NL, Industry, Industry, …

Table 9: Details of Activity 2.3

Activity 2.3	Resource Planning						
Research Area	Title		Sub-task	Deliverable	Impact	Timeline	Partners
2.3.1	Resource Characterization (Wind)	1	Data Gaps Analysis	Planning report assessing national status and future needs with respect to meeting pre-determined industry and stakeholder data requirements	Required for effective long-range interagency planning and interagency coordination	2011	NL, Industry, Academia, NOAA, NWS, BOEM, NCAR, DoD, NSF…
		2	National Resource Database Plan	Plan to establish network of instrumentation, databases and protocols to meet pre-determined data requirements	Required for effective ongoing characterization of offshore resource and design conditions, including local and regional variations	2011	NL, Industry, Academia, NOAA, NWS, BOEM, NCAR, DoD, NSF…
		3	Refined Mesoscale Modeling & Mapping	Reliable OCS and Great lakes mesoscale models and user tools	Models that provides the information necessary to support technology, siting, and economic decisions	2011 - 2015	NL, Industry, Academia, NOAA, NWS, BOEM, NCAR, DoD, NSF…
		4	Advanced Meteorological Instrumentation, Tools and Methodologies	Evaluation and validation of advanced and applicable technologies (i.e. SODAR, LiDAR, etc.) and related modeling tools	Identification of cost-effective siting tools validated to the satisfaction of structural designers and financial institutions	2011-2015	NL, Industry, Academia, NOAA, NWS, BOEM, NCAR, DoD, NSF…
2.3.2	Facility Design Conditions	1	Data Gaps Analysis	Report identifying critical non-wind data for turbine, foundation and balance of plant design such as water depth, currents, seabed mechanics, wave action, and ice loading and recommend means to collect data for national and regional use	Required to develop a national databases of local and regional design conditions	2011	NL, Industry, Academia, NOAA, NWS, BOEM, NCAR, DoD, NSF…
		2	National Offshore Planning Database	Interagency and multi-organization plan to establish national network to collect and make critical data available	Information feeds into development of priority offshore wind zones and reduction of timelines	2012 - 2013	NL, Industry, Academia, NOAA, NWS, BOEM, NCAR, DoD, NSF…

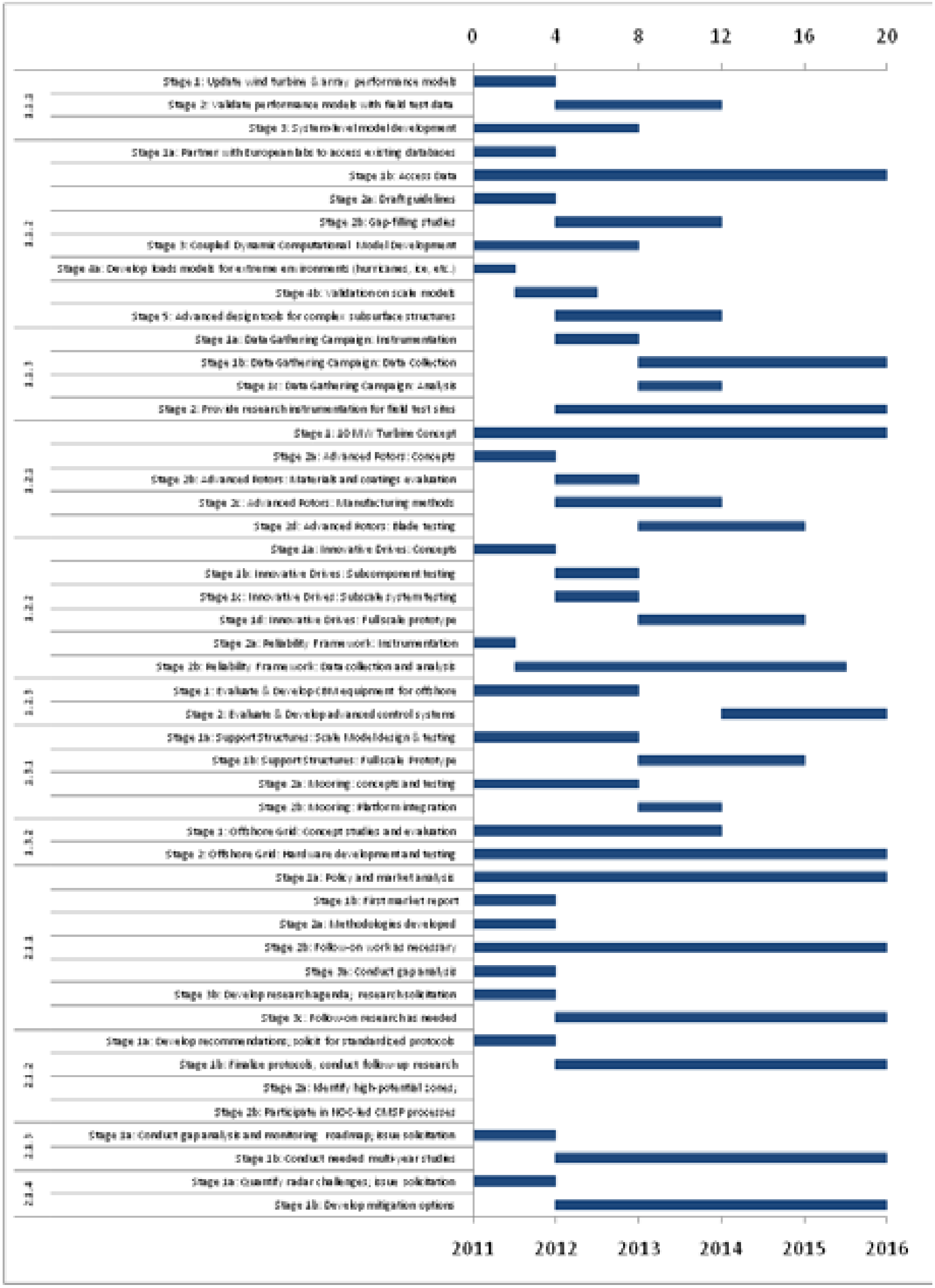


Figure 23. Research Area and Detail Timeline in Quarters and Years

Focus Area 3: Advanced Technology Demonstration Projects

DOE's efforts in the Advanced Technology Demonstration focus area will consist of partnerships with broad consortia to support the development of breakthrough offshore wind energy generation projects. DOE support for these geographically and technologically diverse projects will jumpstart the U.S. offshore wind industry and increase the common knowledge base for all stakeholders.

DOE will fund technical research, engineering, and planning activities that enhance timely project deployment and that use the installed offshore turbines as testbeds for technological research and development. Within each individual partnership, DOE will focus on four major research topics related to the project development process: Planning and Siting; Construction and Installation; Testing and Experimentation; and Reporting and Communications. Use of DOE funds will include, but is not limited to:

- Innovative engineering activities, such as for foundations and electrical systems, facility infrastructure, and installation systems and methods;
- Facilitating field testing through the development of stand-alone testbeds; or the use of instrumented towers, turbines, and foundation structures within a project to gather performance or research and development data; and
- Addressing research gaps related to the marine environment and stakeholder factors including resource assessment, environmental and socio-economic research, and efficiency in permitting, planning and siting processes.

Through cost-sharing initiatives, chosen through competitive solicitations, DOE will partner with one or more commercial offshore wind power developers, research consortia, power producers and/or utilities on pioneering and diverse offshore wind energy generation projects. DOE will seek to partner in demonstration projects that are diversified by geographical region, water depths, and innovative technologies. Consideration will be given to regions or states in which either wind research or commercial leases already have been proposed or have commenced, those in which federal or states have issued public Requests for Information, and/or those where initial environmental studies have been commenced or completed.

A detailed discussion of the deployment timeline for a proposed project is a key consideration when looking at a potential partnership. Projects that do not begin construction by 2015 will not be considered. The deployment timeline discussion should include feasible, innovative, and collaborative solutions to addressing current market barriers to deployment.

Key criteria that DOE will consider in evaluating potential partnerships will include:

- Cost share
- Relative strength of collaborative partnerships
- Demonstrated technical expertise
- Progress to date toward project deployment, particularly in siting and permitting
- How DOE funds/support would accelerate realization of project goals
- How the project success would advance industry knowledge base

- How the project would support innovative research
- Support from State and local communities
- Feasibility of proposed deployment timeline

Successful deployment of advanced technology demonstration projects will make offshore wind cost-competitive with other generation through reduction of uncertainties and refinement of technology. In addition, it will catalyze the nascent commercial offshore wind industry resulting in gigawatt-scale deployment of offshore wind technology.