OCS Study
BOEM 2013-0113

Energy Market and Infrastructure Information for Evaluating Renewable Energy Projects for the Atlantic and Pacific OCS Regions

Volume I: Technical Report

U.S. Department of the Interior
Bureau of Ocean Energy Management
Gulf of Mexico OCS Region

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ABOUT THE COVER

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ABSTRACT

On August 8, 2005, the Energy Policy Act of 2005 (§388) amended the Outer Continental Shelf (OCS) Lands Act to grant the Secretary of the U.S. Department of the Interior (Secretary) discretionary authority to issue leases, easements, or rights-of-way (ROW) for previously unauthorized activities that: (i) produce or support production, transportation, or transmission of energy from sources other than oil and gas; or (ii) use, for energy-related or other authorized marine-related purposes, facilities currently or previously used for activities authorized under the OCS Lands Act. The act also requires the Secretary to share with nearby coastal States a portion of the revenues received by the Federal Government from authorized renewable energy and alternate use projects on certain areas of the OCS.

On March 20, 2006, the Secretary delegated to the Minerals Management Service (later the Bureau of Ocean Energy Management Regulation and Enforcement [BOEMRE], now the Bureau of Ocean Energy Management [BOEM]) the new authority that was conferred by the Energy Policy Act. The MMS published the final rule for "Renewable Energy and Alternative Uses of Existing Facilities on the OCS" in the Federal Register on April 29, 2009.

This report has two objectives: 1) to provide an overview of energy markets and 2) to collect and synthesize information to support socioeconomic portions of environmental assessments and other types of BOEM decision documents related to renewable energy (wind, wave, and current) in the Atlantic and Pacific Outer Continental Shelf regions. The electricity market is very different from the petroleum-based industry that BOEM manages under the OCS Lands Act. The renewable energy projects discussed in this report are the first of their kind to operate in federal waters. These are "frontier" lease areas with no past data on which to base the estimated impacts of future actions.

To provide a context for the study, the report begins with a brief summary of the current status of offshore renewable energy in the United States at the federal and state levels, including legislative activity and proposed projects. Because of the rapid developments in this area (such as the first license issued to the Cape Wind project, on October 6, 2010), this section should be viewed as a "snapshot in time" based on information available in 2010.

This report provides an introduction to electricity generation, transmission, and distribution; trends in the electricity market; factors affecting the delivery of power from an offshore generation site to the onshore electrical grid; the regulatory agencies involved; and the role of renewable portfolio standards, incentives, and power purchase agreements in getting proposed projects into commercial operation. We examine the infrastructure needed for the electricity market, which includes power plants, substations, and transmission lines. Electricity generated in federal waters must transit through state waters and coastal zones in order to reach the onshore electricity grid. Therefore, this report provides a synopsis of factors that might be of concern to each state; this report also describes the areas that each state has identified as suitable for offshore renewable energy projects (if it has done so). We review the technologies that might provide the power and infrastructure needed to build and deploy those technologies (i.e., ports, shipbuilding and repair, vessels, submarine electric cable manufacturing). The report examines the potential community impacts through two case studies—a wave park off the Oregon coast and a wind park off the Massachusetts coast.

The study finds that, at this time, the transmission and integration of offshore renewable energy into the onshore electricity grid is the largest impediment to offshore renewable energy development. The general maritime infrastructure (e.g., ports, shipbuilding and repair, and vessels) required by the offshore renewable energy industry is already available. The extent to which it will be necessary to manufacture specialized installation vessels (as opposed to retrofitting existing vessels) will depend on the pace at which the farms are put into operation. The effects of renewable energy development on jobs in certain areas will depend on whether a sufficient number of projects become close enough to reality that companies are willing to invest in new manufacturing plants (e.g., turbines, marine electric cable, etc.). If this happens, the number of jobs created to support the entire supply chain could be substantial.

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LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ACES	American Clean Energy and Security Act of 2009
ACP	alternative compliance payment
AHT	anchor handling tug
AHTS	anchor handling tug supply vessel
AMI	area of mutual interest
ARRA	American Recovery and Reinvestment Act of 2009
BACT	best available control technology
BART	best available retrofit technology
BOEM	Bureau of Ocean Energy Management
BPA	Bonneville Power Administration
CAA	Clean Air Act
CAFRA	Coastal Area Facility Review Act
CAIR	Clean Air Interstate Rule
CAISO	California ISO
CAMR	Clean Air Mercury Rule
CCC	California Coastal Commission
CEC	California Energy Commission
CLV	cable-laying vessel
CMSP	coastal and marine spatial planning
CO_2	carbon dioxide
CONE	cost of new entry
CPUC	California Public Utilities Commission
CRR	congestion revenue right
CZM	coastal zone management
DEQ	Department of Environmental Quality
DHEC	Department of Health and Environmental Control
DOE	U.S. Department of Energy
DPS	dynamic positioning system
EEA	Massachusetts Executive Office of Energy and Environmental Affairs
EIA	Energy Information Administration
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ERCOT	Electric Reliability Council of Texas
ERG	Eastern Research Group
FCM	forward capacity market
FERC	Federal Energy Regulatory Commission
FRCC	Florida Reliability Coordinating Council
FTR	financial transmission right
GATS	Generation Attribute Tracking System
GHG	greenhouse gas
GIS	geographic information system
GSOE	Garden State Offshore Energy
GW	gigawatt
GWh	gigawatt-hour
HVDC	high-voltage direct current
ICR	installed capacity requirement
IRR	internal rate of return
ISO	independent system operator
ISO-NE	New England ISO
ITC	investment tax credit
JCSP	Joint Coordinated System Plan
kV	kilovolt
LCOE	levelized cost of energy
LINYC	Long Island–New York City Offshore Wind Collaborative
LIPA	Long Island Power Authority
LMP	locational marginal price
LSE	load-serving entity
MAPP	Mid-Atlantic Power Pathway
MARAD	U.S. Maritime Administration
MARCO	Mid-Atlantic Regional Council on the Ocean

MCT	Marine Current Turbines
MD DNR	Maryland Department of Natural Resources
MGGRA	Midwest Greenhouse Gas Reduction Accord
MISO	Midwest ISO
MRTU	Market Redesign and Technology Upgrade
MW	megawatt
MWh	megawatt-hour
NAAQS	National Ambient Air Quality Standards
NAICS	North American Industrial Classification System
NE-GIS	New England Generation Information System
NEPOOL	New England Power Pool
NERC	North American Electric Reliability Corporation
NJBPU	New Jersey Board of Public Utilities
NOAA	National Oceanic and Atmospheric Administration
NO_x	oxides of nitrogen
NPCC	Northeast Power Coordinating Council
NREL	National Renewable Energy Laboratory
NYISO	New York ISO
NYPA	New York Power Authority
NYSERDA	New York State Research and Development Authority
O&M	operating and maintenance
OCS	Outer Continental Shelf
OETF	Ocean Energy Task Force
OPT	Ocean Power Technologies
OPWG	Oregon State Ocean Policy Work Group
OREC	offshore renewable energy credit
OTC	Ozone Transport Commission
OWEG	Ocean Wave Electricity Generation
OWET	Oregon Wave Energy Trust
PG&E	Pacific Gas and Electric
PM	particulate matter
PNGC	Pacific Northwest Generating Cooperative
PPA	power purchasing agreement
PTC	production tax credit
REC	renewable energy credit
RFC	Reliability*First* Corporation
RFP	request for proposals
RGGI	Regional Greenhouse Gas Initiative
RNA	reliability needs assessment
ROV	remotely operated underwater vehicle
RPM	Reliability Pricing Model
RPS	renewable portfolio standard
RSP	regional system plan
RTEP	regional transmission expansion plan
RTO	regional transmission operator
SAMP	Special Area Management Plan
SARA	Scientific Applications and Research Associates, Inc.
SERC	SERC Reliability Corporation
SIP	State Implementation Plans
SO_2	sulfur dioxide
SPP	Southwest Power Pool, Inc.
TCC	transmission congestion contract
TIV	turbine installation vessel
TVA	Tennessee Valley Authority
USOWC	U.S. Offshore Wind Collaborative
WCI	Western Climate Initiative
WECC	Western Electricity Coordinating Council
WREGIS	Western Renewable Generation Information System
XLPE	cross-linked polyethylene

GLOSSARY

Baseload generators	Baseload generators have low operating and maintenance costs and high capacity factors and operate almost continuously regardless of load levels, notwithstanding scheduled or unscheduled shutdowns.
Capacity	A generator's capacity is the maximum amount of electricity it can supply to load, given ambient conditions.
Capacity factor	A measure of relative use, equal to the ratio of the actual energy produced in the year to the energy the unit would have produced at full capacity.
Capital costs	The costs of construction, equipment, and project management required to install an electric generator.
Distribution	Distribution is moving power from the bulk transmission system to retail customers. Distribution is the responsibility of retail electric utilities.
Feed-in tariffs	A feed-in tariff is like a long-term power purchasing agreement, but the rate negotiated is meant to ensure that a wind farm is profitable (as planned).
Intermediate generators	Intermediate sources operate when load is greater than baseload, but has not reached peak load; their average annual capacity factors range from 50% to 60%. Intermediate-load generators are more responsive in their ability to start up or shut down.
Levelized costs	In the electricity market, the term "levelized" means calculating the present value of the total cost of building and operating a generating plant over its economic life and then converting the value to equal annual payments. The costs are adjusted to remove the impact of inflation. In financial terms, a levelized cost is called an annualized real cost.
Load	The electricity that is needed to meet customer demand at any point in the electric system.
Load centers	Concentrated areas of customers.
Megawatt (MW) Megawatt-hour (MWh)	A MWh is a measure of the quantity of electricity supplied or consumed at the rate of 1 MW per hour. While generator capacity is usually expressed in MW, generator output is usually expressed in MWh. A MW is equal to 1,000 kilowatts.
Operating and maintenance costs	The ongoing costs of keeping a generator running.
Peakload generators	Peakload generators (or "peakers") are generally the most expensive generators available (high costs per unit of output), but have the operational flexibility to respond to sudden changes in demand.
Reserve margin	The available extra capacity above peak load.
Transmission	The movement of electricity from the generating source (supply) to load centers (demand).

1 EXECUTIVE SUMMARY

1.1 INTRODUCTION

On August 8, 2005, the Energy Policy Act of 2005 (§388) amended the Outer Continental Shelf (OCS) Lands Act to grant the Secretary of the U.S. Department of the Interior (Secretary) discretionary authority to issue leases, easements, or rights-of-way (ROW) for previously unauthorized activities that: (i) produce or support production, transportation, or transmission of energy from sources other than oil and gas; or (ii) use, for energy-related or other authorized marine-related purposes, facilities currently or previously used for activities authorized under the OCS Lands Act. The act also requires the Secretary to share with nearby coastal States a portion of the revenues received by the Federal Government from authorized renewable energy and alternate use projects on certain areas of the OCS.

On March 20, 2006, the Secretary delegated to the Minerals Management Service (later the Bureau of Ocean Energy Management Regulation and Enforcement [BOEMRE], now the Bureau of Ocean Energy Management [BOEM]) the new authority that was conferred by the Energy Policy Act. The MMS published the final rule for "Renewable Energy and Alternative Uses of Existing Facilities on the OCS" in the Federal Register on April 29, 2009.

Many decisions and developments occurred during the preparation of this report. On October 6, 2010, BOEMRE issued the lease for a commercial offshore wind energy project (Cape Wind, Massachusetts) (USDOI BOEMRE 2010a). Two other offshore wind projects—Deepwater Wind (Rhode Island) and NRG Bluewater Wind (Delaware)—are advancing through the regulatory process. Under its interim policy, on June 23, 2009, MMS issued the first five exploratory leases for placing data collection devices for offshore wind energy projects (USDOI MMS 2009a). We do not anticipate a slowdown in the pace of development in this industry; thus, the reader should consider the report as presenting a "snapshot in time."

This report provides background information on the renewable energy new industry (electricity generation, transmission, and distribution). This report examines factors of transmission from the offshore generation site to the onshore electrical grid; it describes the technologies that might provide the power; and it discusses the infrastructure needed to manufacture, install, and maintain the technologies. Within each topic, this report identifies the differences between the offshore renewable energy industry and the offshore oil and gas industry. Section 1.2 lays out the study objectives and scope for the report. Section 1.3 describes the organization of the rest of Volume 1. (Volume 2 is predominantly graphics.) Section 1.4 summarizes the report findings. Section 1.5 describes the relevant aspects of the maritime infrastructure. Section 1.6 briefly outlines projected community impacts of offshore renewable energy projects.

1.2 STUDY OBJECTIVES AND SCOPE

1.2.1 Study Objectives

BOEM identified two objectives for this study:

- To provide an overview of energy markets and energy infrastructure and to analyze the impacts of likely renewable energy development scenarios.

- To collect and synthesize information to support socioeconomic portions of environmental assessments related to renewable energy.

Broader questions, such as the possible role of renewable energy (both onshore and offshore) in U.S. energy policy, lie outside this study's purview.

1.2.2 Scope

The extent and content of the study are as follows:

- The areas for analysis are the Atlantic and Pacific OCS Regions. There is no discussion of renewable energy projects in the Gulf of Mexico. In order to support the identification of information in support of the socioeconomic portions of environmental assessments, the states of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida are included in the analysis for the Atlantic OCS. Pennsylvania is also included in the infrastructure discussions due to the significance of the port of Philadelphia. For the Pacific OCS Region, the states included in the analysis are Washington, Oregon, and California.

- The focus is on the OCS regions. While each state develops its own Coastal Zone Management plan (CMP), this report identifies specific issues that are likely to affect development in the neighboring federal waters. Efforts in state waters are discussed as they relate to commercial deployment in the OCS; for example, some pilot projects in state waters have the potential for full-scale commercial deployment in federal waters.

- The analysis of energy sources is limited to offshore wind, wave, and ocean current projects. That is, no onshore wind or tidal energy projects are discussed. Technologies applicable to developing both tidal and ocean current projects, however, are included in the analysis.

- The structure and operations of the energy market are extremely complex. As a result, the overview of analysis of the energy markets presented in this study is a broad overview. The goal of this study is to provide a general understanding of the renewable energy industry to a broad audience.

An earlier study, *OCS-Related Infrastructure in the Gulf of Mexico Fact Book* (Louis Berger Group 2004) served as a pattern for the infrastructure aspects of this study. This study analyzes renewable energy infrastructure only as it currently exists. The study does not analyze the infrastructure that may arise from the long-term development of renewable energy sources in the

OCS. These opportunities are amply discussed elsewhere; for example, see USDOE NREL 2010b and 2010d and AWEA 2010. Given the pace of development, much new information will likely have become available by the time this report is finalized. Therefore, some references for potential new information are presented in the bibliography.

1.3 Report Organization

The rest of Volume 1 of this report is organized as follows:

- Chapter 2 presents the status of renewable energy in the OCS at the time the report was written. Section 2.1 covers federal actions (such as the approval of Massachusetts' Cape Wind offshore wind park and five exploratory leases, memoranda of understanding among federal agencies, incentives, and renewable portfolio standards [RPSs]). Section 2.2 gives an overview of the regional policy collaboratives and interstate consistency factors. Section 2.3 describes state RPSs and provides a state-by-state summary of planning activities. Section 2.4 contains a state-by-state discussion of renewable energy projects in state waters (as appropriate) and in neighboring federal waters.

- Chapter 3 is a primer on the electricity market. It begins by describing how electricity is generated, transmitted, and distributed to homes and industries; it also discusses load balancing and pricing considerations. Section 3.2 describes the structure and the regulatory environment of regional electric energy markets, structure, and regulation. Section 3.3 addresses fossil-fueled power plant emission regulations and markets. The final subsection discusses electricity market trends.

- Chapter 4 examines technologies for harvesting energy from offshore wind, waves, and ocean currents. Not all of these technologies might make it to commercial operation, and new technologies, as yet unidentified, might become major contributors to the nation's energy grid. The chapter also examines several studies about the economic viability of offshore renewable energy projects (primarily wind), and summarizes the European experience with offshore energy generation.

- Chapter 5 is organized by state from north to south along the East and West Coasts. It summarizes each state's coastal zone management (CZM) program, highlights issues that might adversely affect the implementation of offshore energy projects, describes areas of environmental or logistical concern, and lists data sources.

- Chapter 6 describes the energy infrastructure—the power stations, substations, and transmission lines—available to accept the energy generated from the offshore projects and the possible effects of the offshore energy on current congestion zones in the grid. It also reviews some studies regarding the costs associated with upgrading the grid to accept the additional electricity.

- Chapter 7 examines the other types of land-based infrastructure available to support offshore energy development. These include ports, shipbuilding and repair facilities, vessels, and businesses that lay submarine cables.

- Chapter 8 is a brief exploration of the manufacturing infrastructure and the primary focus is on wind energy. It reviews turbines, foundations, and cable manufacturing.
- Chapter 9 examines potential community impacts of renewable energy projects in the OCS. Two case studies are presented: a wave energy project on the West Coast and a wind energy project for the East Coast.

Volume 2 consists of appendices, which provide detailed supporting information. The appendices include a description of North American Electric Reliability Corporation entities, figures for state offshore areas of interest, contact information for state CZM officials, and Chapter 6 figures for energy infrastructure.

1.4 Summary of Findings

1.4.1 Regulatory Framework

A number of actions are being taken to foster the development of offshore renewable energy resources at the Federal, State, regional, and local levels. These efforts involve initiatives by government agencies to fund research and develop a regulatory framework that promote renewable energy development. Government bodies have also formed task forces and other regional collaborative efforts to facilitate and improve intergovernmental coordination. Specific actions have also been taken by regulatory agencies to establish renewable energy portfolio requirements and create financial incentives that stimulate renewable energy development. For example, BOEM's (then MMS) responsibility for renewable energy projects in the federal offshore regions began in 2005 with the Energy Policy Act. In 2007, the agency initiated an interim policy to authorize data-gathering activities; in June 2009, Secretary of the Interior Ken Salazar announced the issuance of the first five exploratory leases for renewable wind energy production on the OCS. Four of the leases are off New Jersey; the fifth is off Delaware (USDOI BOEMRE 2009a). On October 6, 2010, BOEMRE issued the lease for a commercial offshore wind energy project (Cape Wind in Massachusetts) (USDOI MMS 2010a), and the agency invited submissions of interest for commercial wind energy projects off Delaware and Maryland describing interest in obtaining one or more commercial leases for the construction of a wind energy project(s) on the OCS offshore Delaware and (USDOI MMS 2010b, USDOI, BOEMRE 2010a).

The Interagency Ocean Policy Task Force, established by President Obama in 2009, consists of representatives from all executive departments and federal agencies. The Task Force was charged with developing recommendations to enhance national stewardship of the ocean, coasts, and Great Lakes and promote the long-term conservation and use of these resources. In 2009, the MMS signed memoranda of understanding with the Federal Energy Regulatory Commission (FERC) and the Department of the Interior's Fish and Wildlife Service that clarifies areas of jurisdiction and cooperation. FERC has issued 11 preliminary permits for wave energy projects, and a 12th project has moved into the licensing stage (FERC 2010a).

Several regional collaboratives are actively focusing on wave, wind, and ocean energy; these include the Oregon Wave Energy Trust, the West Coast Governors Agreement on Ocean Health, the Northeast Regional Council, the Mid-Atlantic Regional Council on the Ocean (MARCO), and the U.S. Offshore Wind Collaborative (USOWC).

As of September 2010, BOEMRE had formed offshore renewable energy task forces with the states of Maine, Rhode Island, Massachusetts, New Jersey, Virginia, Delaware, and Maryland. Task force formation is underway for New York, North Carolina, South Carolina, and Florida (USDOI BOEMRE 2010b). The intergovernmental task forces have been formed to facilitate communication among BOEM and local, state, tribal, and federal stakeholders in each state concerning commercial renewable energy leasing and development on the OCS off their respective coasts.

States along the East and West Coasts are actively supporting the development of offshore wind, current, and wave projects. Much of the impetus for this support comes from the need to meet state goals for obtaining certain percentages of their energy needs from renewable sources. States have been developing renewable energy certificates (RECs) to track the generation from these alternate sources and to provide an additional income source for projects. Some states have issued plans identifying geographically where offshore energy projects are acceptable, such as Massachusetts' Ocean Plan (MA EEA 2009), Rhode Island's Special Area Management Plan (RI CRMC 2010), and Virginia's Coastal Energy Research Consortium report (VCERC 2010a). Some states are developing similar ocean plans (e.g., Maine, Washington, and North Carolina) while others discuss offshore energy projects within their energy plans (e.g., New York, and New Jersey). Some states are beginning to move beyond the planning stage. New York, New Jersey, and Delaware have all requested proposals for new electricity generation from offshore wind. Oregon, Washington, and California are actively pursuing wave projects within their state waters. In all, between 1,300 and 2,800 megawatts (MW) of offshore wind energy and between 370 and 3,555 MW of offshore wave energy have been proposed.

A final aspect of the regulatory framework for developing offshore renewable energy sources concerns financial support, such as the production tax credit (PTC), RECs, and mechanisms to provide stable long-term revenues. Intermittence or lack of financial support may have a major impact on the economic viability of offshore energy projects. One study estimates that total viable projects might be reduced by 25% without revenue from the sale of RECs. If the PTC were not available, the reduction in the number of viable projects might exceed 40% (Weiss et al. 2008).

1.4.2 Energy Infrastructure

Eastern Research Group (ERG) examined the power plants, transmission lines, and substations in the coastal states. ERG identified several factors that might hamper the distribution of electricity from offshore projects to the homes and businesses that use it.

First, depending on the state, there might not be a conveniently located substation to accept the offshore electricity. We examined the number of substations that could accommodate 115 kV or greater power lines within 20 miles of shore. Aggregating over both coasts, there are slightly fewer than 3,000 substations that fit these parameters. South Carolina, for example, has only 17 such substations within 5 miles of the coast.

Second, the electric grid would need expansion to accommodate a substantial proportion of renewable energy generation. Offshore renewable energy generators cannot serve as baseload generators, which operate continuously except during scheduled or unscheduled shutdowns. Renewable energy sources vary uncontrollably. Wind does not blow constantly at one place, and wave and current generation also show temporal and spatial variability. For the same reasons, they cannot serve as peakload generators, which must be able to respond quickly to sudden changes in demand. An offshore renewable energy generator, then, might be considered as an intermediate generator that operates when demand exceeds baseload generation but has not reached peak load. The U.S. Department of Energy (DOE) examined what changes to the grid would be necessary if 20% to 30% of the electricity used in the eastern half of the country were to be generated from wind energy. DOE found that it was technically feasible but would entail a significant expansion of the electrical transmission system. The study noted that wind energy projects might be ready for operation before the necessary grid expansions are constructed (USDOE NREL 2010b).

Third, transmission and integration costs are major components of the overall cost of offshore energy projects. This, coupled with the need to expand the grid, has led governors of 10 East Coast states to propose an offshore transmission "backbone" into which multiple projects could plug (Governors 2009). The aggregation of the energy output from multiple wind farms would result in less fluctuation in the energy level at any point in time and would lower integration costs. The backbone was only in the conceptual stage as of early 2010, but Google and the financial firm Good Energies have expressed interest in investing in a proposed 350-mile transmission backbone (Wald 2010).

1.5 MARITIME INFRASTRUCTURE

This study examined the infrastructure requirements projected by environmental impact statements (EISs) of proposed offshore wind energy projects. In particular, the study investigated ports, shipbuilding and repair facilities, vessels, and submarine electric cable manufacturing and installation capabilities.

1.5.1 Ports

Offshore wind projects do not appear to require large ports for construction. For example, construction and operation of the Cape Wind project will most likely run out of smaller ports. The construction and installation phases of the project will be based in Quonset Point, Rhode Island. Operation and maintenance of the project will be based in New Bedford and Falmouth, Massachusetts. Deepwater Wind has proposed building a manufacturing facility in Quonset Point to support its project off Rhode Island's coast and other East Coast wind farms developed by the company.

The fact that both small and large ports suit the offshore wind industry means that it may have a wider range of useful ports than other offshore industries that require massive ports. Of the 149 largest ports (measured by annual cargo tonnage) in the U.S., 35 are located along the East Coast and 22 are located along the West Coast. In addition to these larger ports, there are 99 other ports that might suit the offshore wind industry.

1.5.2 Shipbuilding and Repair

The shipbuilding industry is dominated by General Dynamics and Northrop Grumman, which operate the "big six" shipyards. Four of these shipyards are on the East and West Coasts. General Dynamics owns Electric Boat in Connecticut, Bath Iron Works in Maine, and NASSCO in California. Northrop Grumman owns Newport News in Virginia. Of the four shipyards, only

NASSCO accepts commercial contracts; the others process military orders (ICAF 2008). Most commercial shipbuilding along the East and West Coasts is handled by 117 smaller shipyards.

This section examines the specific types of vessels that suit offshore energy projects. In the case of Cape Wind, the vessels and equipment specified for use in the project during the construction phase include a hydroplow cable burial machine, an installation barge (100 feet by 400 feet by 24 feet), anchor handling tugs, a cable burial barge, an auxiliary trencher pulling barge (40 feet by 100 feet), and auxiliary vessels, which include a crew boat, two inflatable boats, and several skiffs. Most, if not all, of the specialized vessels used in the construction phase either exist in the Gulf of Mexico to support the offshore oil and gas industry (e.g., anchor handling tugs) or could be modified to support offshore renewable energy installation (e.g., barges and jack-up rigs) (see Kaiser and Snyder 2010). During the operations phase, Cape Wind is expected to require four vessels: a 35- to 45-foot crew boat, a 20- to 25-foot high-speed emergency response boat, and two 65-foot maintenance vessels (USDOI MMS 2009b). If the cost of transporting vessels from the Gulf of Mexico and modifying them becomes excessive, additional vessels may be built.

1.5.3 Vessels

About 315 establishments offer deep sea freight transportation and about 274 establishments offer coastal marine transportation along the East and West Coasts (U.S. Census Bureau 2009a). USDOT MARAD (2009b) identifies U.S.-flagged vessels that meet the domestic manufacturing requirements of the Jones Act. Approximately 38,500 vessels serve the coast and inland waterways, 550 serve offshore oil and gas industry regions, and nearly 100 are classified as ocean vessels.

However, the need for vessels during the operations phase of offshore renewable energy projects appears to be minimal. The Cape Wind EIS mentions four vessels and a staff of 50 people (USDOI MMS 2009b), none of which are for specialized uses. A Bluewater Wind presentation mentions an operations building with four or five boat slips (Bluewater Wind n.d.). It is likely that existing vessels would supply the needs of a wind farm going into operation. As mentioned in the previous section, specialized vessels might travel out of the Gulf of Mexico for short-term construction of a wind farm.

1.5.4 Submarine Electric Cable Manufacture and Installation

We examined two case studies for laying submarine electric cable: the Cross Sound Cable and the Neptune Regional Transmission System. The first project links the New York and New England grids, while the second links the Long Island grid to lower-cost energy sources in Pennsylvania, New Jersey, and Maryland. In both cases, the cable was manufactured in Europe and most of the specialized vessels, which include cable-laying vessels and remotely operated underwater vehicles, were brought over from Europe (ABB 2010; Prysmian 2009b). Unless these industries are confident enough in a multi-year demand for their products and services to invest in U.S. facilities, it is likely that these specialized commodities will continue to be imported.

1.5.5 Other Industries

The offshore renewable energy industry appears to need less support than the offshore oil and gas industry. The former needs none of the specialized service industries supplying the fluids, tools, and supplies for drilling operations; evaluating the oil and gas formations (e.g., mud-logging, measurement-while-drilling, wireline logging, drill stem testing, and cores); running and cementing casing; running production tubing; or fracturing or acidizing the formation. To date no manned offshore renewable energy facilities have been proposed in the U.S. As a result, personnel, supplies, and materials will not need to be frequently taken to and from offshore structures by air or water. There will be no need to construct living quarters for installation, nor will there be a need for catering, laundry, and cleaning services.

1.6 COMMUNITY IMPACTS

Both Cape Wind and Deepwater Wind intend to use Quonset Point, Rhode Island, as a staging point for the manufacture of foundations and assembly of turbines. Should Deepwater Wind's proposal to build a manufacturing area at Quonset Point to supply multiple wind farms come to fruition, an estimated 800 direct jobs would be available to the surrounding communities (RI Office of the Governor 2009a). Otherwise, the estimates range from 391 to 500 jobs during the construction and installation phase and from 50 to 80 jobs during the operating and maintenance (O&M) phase (Cape Wind 2009; Bluewater Wind n.d.). The Reedsport OPT Wave Park estimates approximately 180 full-time jobs over seven months for fabricating the PowerBuoys®, up to 18 jobs created/maintained for assembly and deployment, and eight to 13 jobs for O&M (FERC 2010b). Given the current level of county unemployment in the two areas, the need for this added workforce could be absorbed without difficulty, provided the company offers specialized training for the new industry (if necessary).

Should the number of renewable energy projects that are very likely to go into commercial operation increase to the point to which companies are willing to invest in new manufacturing facilities, the potential benefits to the U.S. could increase dramatically. Not only would there be more direct jobs in the renewable energy sector, there would also be a number of jobs created due to (1) an expanding supply chain and (2) the increased level of overall demand these activities would create.

2 STATUS OF RENEWABLE ENERGY IN THE OCS

2.1 FEDERAL ACTIONS

Federal actions regarding renewable energy projects take place in several forms, including, but not limited to, leases in Outer Continental Shelf (OCS) regions for commercial development or exploration, agreements among federal agencies to cooperate and clarify jurisdictional understandings, agreements with states, and incentives for such developments. These are discussed in more detail in the sections below.

2.1.1 First OCS Lease for Commercial Wind Energy

On October 6, 2010, Secretary of the Interior Ken Salazar signed the nation's first lease for commercial wind energy development on the OCS. The Cape Wind project was first proposed in 2001, before Congress assigned responsibility for renewable energy development in the federal offshore region to the Minerals Management Service (MMS, later BOEMRE, now BOEM). The project area in the 33-year lease comprises approximately 46 square miles on the OCS in Nantucket Sound, offshore from Massachusetts.

2.1.2 First OCS Exploratory Leases for Renewable energy

On June 23, 2009, Secretary of the Interior Ken Salazar announced the issuance of the first five exploratory leases for renewable wind energy production on the OCS. Four of the leases are off New Jersey; the fifth is off Delaware. The leases were developed under an interim policy initiated in 2007 under the authority of the Energy Policy Act of 2005. The leases authorize data-gathering activities, allowing for the construction of meteorological towers or buoys on the OCS from 6 to 18 miles offshore to collect site-specific data on wind speed, intensity, and direction (USDOI MMS 2009a). Table 1 lists the lessees for exploratory data collection, and the lease areas are shown in Figure B-1. Note that all four leases are positioned to send electricity to the Atlantic City area. Acting under the authority granted through the Energy Policy Act of 2005, MMS initiated the Interim Policy in November 2007 in advance of the final regulatory framework, seeking to jumpstart the review and potential authorization of the renewable energy development process.

Table 1
BOEM Exploratory Leases Off the New Jersey Coast

Distance from Shore	Company
15 to 18 miles	Bluewater Wind New Jersey Energy, LLC
6 to 9 miles	Fishermen's Energy of New Jersey, LLC
15 to 18 miles	Deepwater Wind, LLC
12 to 15 miles	Deepwater Wind, LLC

Source: USDOI MMS (2009a).

Bluewater Wind also holds the fifth lease, which is located 14 miles off the Delaware coast (USDOIMMS 2009a).

2.1.3 Requests for Interest

BOEM invites submissions describing interest in obtaining one or more commercial leases for the construction of a wind energy project(s) on the OCS offshore Delaware on April 26, 2010, and offshore Maryland on November 9, 2010. NRG Bluewater and Occidental Development & Equities, LLC, expressed interest in the Delaware region (USDOI MMS 2010b, USDOI, BOEMRE 2010a). Maps of the areas of interest are located in Figures B-2 and B-3.

2.1.4 Memoranda of Understanding Between Federal Government Agencies

In April 2009, the U.S. Department of the Interior (USDOI) and the Federal Energy Regulatory Commission (FERC) signed a memorandum of understanding that clarified jurisdictional authorities of each agency with respect to renewable energy projects in the federal offshore areas. BOEM has exclusive jurisdiction with regard to the production, transportation, or transmission of non-hydrokinetic renewable energy projects on the OCS, such as wind and solar. BOEM has exclusive jurisdiction to issue leases, easements, and rights-of-way regarding OCS lands for hydrokinetic projects. FERC has exclusive jurisdiction to issue licenses and exemptions for hydrokinetic projects located on the OCS. Both agencies agree to work together to develop policies and procedures for hybrid projects (e.g., a wind/wave project) and projects that straddle the state-OCS boundary (USDOI 2009a).

In June 2009, MMS and USDOI signed a memorandum of understanding regarding implementation of Executive Order 13186, “Responsibilities of Federal Agencies to Protect Migratory Birds.” The document identifies specific areas in which cooperation between the parties will substantially contribute to the conservation and management of migratory birds and their habitats (USDOI 2009b).

2.1.5 Participation in State Task Forces

As of September 2010, BOEMRE had formed offshore renewable energy task forces with the states of Maine, Rhode Island, Massachusetts, New Jersey, Virginia, Delaware, and Maryland. Task force formation is underway for New York, North Carolina, South Carolina, and Florida (USDOI BOEMRE 2010b). The intergovernmental task forces have been formed to facilitate communication between BOEMRE and local, state, tribal, and federal stakeholders in each state concerning commercial renewable energy leasing and development on the OCS off their respective coasts.

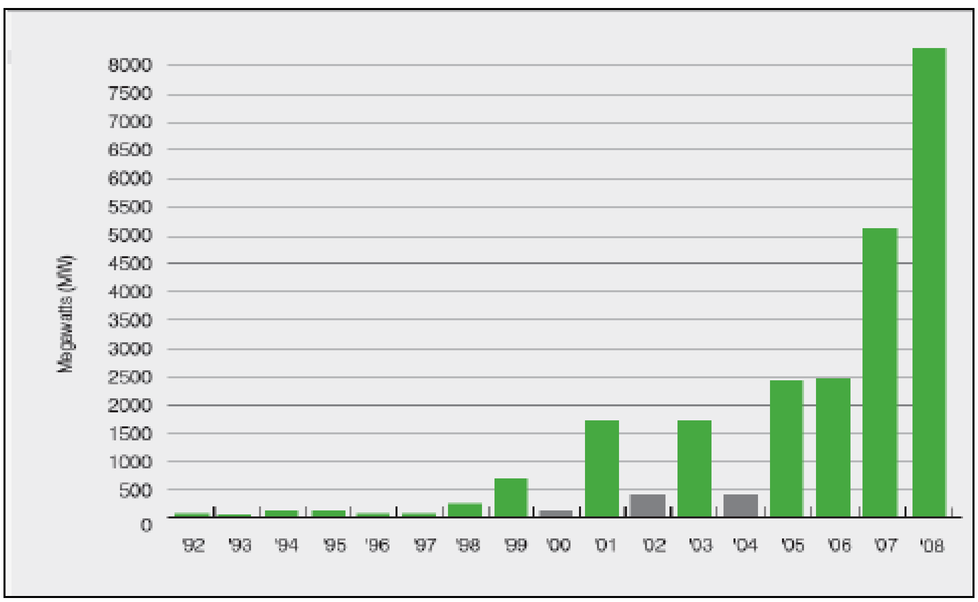
2.1.6. Federal Efforts to Streamline Processes

Relating to offshore energy applications in particular, the Interagency Ocean Policy Task Force was established by President Obama on June 12, 2009. The Task Force was created by a memorandum sent to the heads of all executive departments and federal agencies and was to be led by the Chair of the Council on Environmental Quality. Within 90 days, the Task Force was to develop: recommendations for a national policy for oceans, coasts, and the Great Lakes; a framework to coordinate federal agency efforts to meet policy objectives; and an implementation strategy to meet the objectives of a national policy. Within 180 days the Task Force was to develop a framework for effective coastal and marine spatial planning (CMSP). CMSP identifies areas in the ocean, coastal zones, and Great Lakes that are “most suitable for various types or classes of activities in order to reduce conflicts among uses (and users), reduce environmental impacts, facilitate compatible uses, and preserve critical ecosystems services" (Interagency Ocean Policy Task Force 2009, p. 1). In Germany, for example, an environmental assessment for an offshore wind farm permit would cost approximately $1.5 million to prepare, but because the government has prepared a marine spatial plan that includes "priority areas" for wind farms, costs of preparing an environmental assessment for a proposed offshore wind farm will be reduced or avoided altogether (Interagency Ocean Policy Task Force 2009, p. 3). The *Interim Framework for Effective Coastal and Marine Spatial Planning*, released on December 14, 2009, recommends that CMSP be regional in scope, and developed cooperatively—with substantial stakeholder input—among federal, regional, state, tribal, and local authorities.

2.1.7. Incentives

2.1.7.1 Production Tax Credit

Historically, development of new renewable generation capacity has been hampered by the high capital investment costs required to build these technologies. Under the Energy Policy Act of 1992, Congress created the PTC, which allowed a per-kilowatt-hour income tax credit for electricity generated by qualifying renewable sources. The PTC was designed to provide an incentive for the development of renewable generation, and has been particularly effective in aiding the construction of wind development. The PTC has been allowed to expire and subsequently renewed several times since 1992. Figure 1 shows wind capacity added in the U.S. since 1992, both with and without the PTC.



Source: AWEA (2009).

Figure 1. Annual installed U.S. wind power capacity.

The green bars in Figure 1 show the years in which the federal PTC was available, illustrating a trend of increasing growth over time of installed onshore wind capacity. The gray bars show the years in which the PTC was not available, and the burden that created for wind industry planners and the decline in the amount of wind capacity installed in those years.

The economic recession of 2008 and 2009 created concerns that the amount of financing available for renewable projects would decline, resulting in the development of fewer projects. To address these hurdles, Congress passed legislation providing various financial incentives to lower the cost and encourage development of renewable energy capacity, including projects on the OCS. The American Recovery and Reinvestment Act (ARRA), commonly referred to as the "stimulus package," was signed into law by President Obama on February 17, 2009. Incentives in the final version of the bill that may encourage investment in renewables include:[1]

- An extension of the PTC[2] for wind energy through December 31, 2012, and for marine and hydrokinetic (wave) energy through December 31, 2014.
- The option to claim a 30% investment tax credit (ITC) rather than the PTC for facilities placed into service in 2009 through 2012, which would allow wind facilities to be leased, or subject to sale and leaseback.
- The option to receive an equivalent financial Treasury Department grant in lieu of claiming an ITC. To qualify for this option, a project must have been placed into service in 2009 or 2010, or construction must have begun in 2009 or 2010.
- For capital expenditures incurred in 2009, an extension of bonus depreciation, which allows businesses to write off 50% of the cost of depreciable property in the year it is placed into service and thereby recover the costs of capital expenditures more quickly.
- An additional $1.6 billion of new clean renewable energy bonds to finance facilities generating electricity from wind, marine renewable, biomass, geothermal, small irrigation, hydropower, landfill gas, and trash combustion.
- Allowance for businesses and individuals to qualify for the full ITC even if projects are financed with industrial development bonds or other subsidized energy financing.
- Creation of a loan guarantee program at DOE, funded at $6 billion, applying to "commercial" and "innovative" generation projects, transmission, and manufacturing facilities commencing construction no later than September 30, 2011.
- Provision of $1.25 billion in funding for applied research, development, demonstration, and deployment activities through DOE's Energy Efficiency and Renewable Energy program.
- Provision of $500 million for training to prepare workers for careers in renewable energy and energy efficiency industries.

[1] PL 111-5, American Recovery and Reinvestment Act of 2009.

[2] The federal PTC is a tax credit based on the amount of electricity that is generated by a qualifying facility. For wind, geothermal, and closed-loop biomass, the credit is 2.1¢ per kilowatt-hour; for other eligible technologies, it is 1.0¢ per kilowatt-hour. The PTC generally applies for the first 10 years of operation (N.C. Solar Center and N.C. State University 2009a).

- Provision of $3.1 billion for the State Energy Program, which provides states with discretionary funding that can be used for various energy efficiency and renewable energy purposes.

These ARRA provisions are valid for finite time periods. However, in the future other energy and/or climate change laws will likely extend some or all of these programs, as well as create new financial incentives for the development of renewable energy technologies.

For many renewable developers, the PTC and the ITC are the most attractive incentives offered by the ARRA. The choice between these two options depends on installed project costs and expected capacity factors. Projects with lower installed costs and higher capacity factors favor the PTC, because higher electricity production creates more tax credits and the lower installed costs make those credits more valuable. A study by the U.S. Lawrence Berkeley National Laboratory and the National Renewable Energy Laboratory determines when renewable developers would be more likely to choose either the PTC or the ITC (Bolinger et al. 2009).

Those results are shown in Table 2, where the positive and unshaded region shows those project costs and capacity factors that would favor the ITC, and the negative and shaded region shows those project costs and capacity factors where the PTC provides more value. Projects that have installed costs of $1,500/kW or less get more value from the PTC no matter the capacity factor, whereas projects that cost more than $2,500/kW get more value from the ITC no matter the capacity factor. Capacity factor makes a difference at costs between $1,500/kW and $2,500/kW (Bolinger et al. 2009).

The federal government also encourages the development of renewable energy in other ways. The U.S. Environmental Protection Agency's (EPA's) Green Power Partnership, for example, is a voluntary program designed to increase the use of renewable energy among U.S. organizations, thereby helping to avoid some of the environmental impacts of conventional electricity generation. Participating organizations include local, state, and federal government agencies; manufacturers and retailers; trade associations; colleges and universities; and Fortune 500 companies. EPA helps organizations reduce the transaction cost of purchasing renewable electricity by identifying sources of green power and making that information accessible through a national and state-by-state listing of available green power products. Partners must meet minimum purchase requirements with electricity produced from "new"[3] renewable facilities. Wind, solar, geothermal, qualifying biomass, and low-impact hydropower are the energy sources that currently qualify for the Green Power Partnership.[4]

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[3] "New" facilities are those put into service on or after January 1, 1997.
[4] For more information, see http://www.epa.gov/grnpower/index.htm.

Table 2
Effect of Installed Project Costs and Capacity Factors on Decisions Regarding the Use of the PTC Compared with the ITC

		Total Installed Project Cost ($/kW)										
		$1,500	$1,600	$1,700	$1,800	$1,900	$2,000	$2,100	$2,200	$2,300	$2,400	$2,500
Net Capacity Factor (%)	25%	-1.0%	0.4%	1.7%	2.8%	3.8%	4.7%	5.5%	6.3%	7.0%	7.6%	8.2%
	26%	-1.9%	-0.4%	0.9%	2.0%	3.1%	4.0%	4.9%	5.7%	6.4%	7.0%	7.6%
	27%	-2.8%	-1.3%	0.1%	1.3%	2.4%	3.3%	4.2%	5.0%	5.8%	6.4%	7.1%
	28%	-3.8%	-2.2%	-0.7%	0.5%	1.6%	2.7%	3.6%	4.4%	5.2%	5.9%	6.5%
	29%	-4.7%	-3.0%	-1.5%	-0.2%	0.9%	2.0%	2.9%	3.8%	4.6%	5.3%	6.0%
	30%	-5.6%	-3.9%	-2.4%	-1.0%	0.2%	1.3%	2.3%	3.2%	4.0%	4.7%	5.4%
	31%	-6.5%	-4.7%	-3.2%	-1.8%	-0.5%	0.6%	1.6%	2.5%	3.4%	4.1%	4.9%
	32%	-7.4%	-5.6%	-4.0%	-2.5%	-1.2%	-0.1%	1.0%	1.9%	2.8%	3.6%	4.3%
	33%	-8.3%	-6.4%	-4.8%	-3.3%	-2.0%	-0.8%	0.3%	1.3%	2.2%	3.0%	3.8%
	34%	-9.3%	-7.3%	-5.6%	-4.1%	-2.7%	-1.5%	-0.4%	0.7%	1.6%	2.4%	3.2%
	35%	-10.2%	-8.2%	-6.4%	-4.8%	-3.4%	-2.2%	-1.0%	0.0%	1.0%	1.9%	2.7%
	36%	-11.1%	-9.0%	-7.2%	-5.6%	-4.1%	-2.8%	-1.7%	-0.6%	0.4%	1.3%	2.1%
	37%	-12.0%	-9.9%	-8.0%	-6.4%	-4.9%	-3.5%	-2.3%	-1.2%	-0.2%	0.7%	1.6%
	38%	-12.9%	-10.7%	-8.8%	-7.1%	-5.6%	-4.2%	-3.0%	-1.8%	-0.8%	0.1%	1.0%
	39%	-13.8%	-11.6%	-9.6%	-7.9%	-6.3%	-4.9%	-3.6%	-2.5%	-1.4%	-0.4%	0.5%
	40%	-14.8%	-12.5%	-10.4%	-8.6%	-7.0%	-5.6%	-4.3%	-3.1%	-2.0%	-1.0%	-0.1%
	41%	-15.7%	-13.3%	-11.2%	-9.4%	-7.8%	-6.3%	-4.9%	-3.7%	-2.6%	-1.6%	-0.6%
	42%	-16.6%	-14.2%	-12.1%	-10.2%	-8.5%	-7.0%	-5.6%	-4.3%	-3.2%	-2.2%	-1.2%
	43%	-17.5%	-15.0%	-12.9%	-10.9%	-9.2%	-7.7%	-6.2%	-5.0%	-3.8%	-2.7%	-1.7%
	44%	-18.4%	-15.9%	-13.7%	-11.7%	-9.9%	-8.3%	-6.9%	-5.6%	-4.4%	-3.3%	-2.3%
	45%	-19.3%	-16.8%	-14.5%	-12.5%	-10.7%	-9.0%	-7.6%	-6.2%	-5.0%	-3.9%	-2.8%

Source: Bolinger et al. (2009).

2.1.7.2 Renewable Portfolio Standards

An RPS is a requirement that electricity providers obtain a minimum percentage of their power from renewable sources by a certain date. Technologies that qualify for meeting these standards commonly include wind, tidal, and wave, as well as solar, geothermal, and small hydroelectric resources, although variations in this list occur from jurisdiction to jurisdiction. Some RPS policies establish a "set-aside" or "carve-out," an additional requirement for specific emerging or high-cost resources such as solar photovoltaic energy, to help them achieve greater market saturation and achieve economies of scale. More than half of U.S. states have established RPS policies (FERC 2010c). A number of RPS polices allow the use of RECs for compliance. An

REC is a tradable certificate representing the renewable generation attributes of a unit of electricity (generally in megawatt-hours, or MWh). Thus, RECs represent the environmental attributes of the power produced from renewable energy projects and are sold separately from commodity electricity.

As of November 2010, Congress has established no federal RPS. Section 2.3.1 describes state RPS actions.

2.2 REGIONAL POLICY COLLABORATIVES

2.2.1 West Coast Governors' Agreement on Ocean Health

The West Coast Governors' Agreement on Ocean Health[5] represents a collaboration among the states of Washington, Oregon, and California to protect and manage the ocean and coastal resources along the western coast of the United States. One of the action items described in a May 2008 agreement is to reduce impacts of offshore energy development by opposing all new offshore oil and gas leasing, while evaluating the benefits and impacts of renewable ocean energy development (Office of the Governors 2008, p. 8). While there is a high degree of interest in developing electricity using wave energy and tidal flow along the West Coast, and development and study proposals have been filed with FERC for projects in all three states, no coordinated effort exists "to address the feasibility of energy generation and the potential for environmental impacts on a regional basis." Individual state agencies are working to develop regulatory and permitting frameworks to address the issues related to offshore renewable energy (Office of the Governors 2008, p. 65).

While offshore renewable energy could provide new, reliable sources of energy for the West Coast, the feasibility and environmental impacts of these technologies are not yet fully understood. The West Coast states have agreed to collaborate with the BOEM, Department of Energy, Federal Energy Regulatory Commission, National Oceanographic and Atmospheric Administration (NOAA), and other agencies, to evaluate the potential benefits and impacts of alternative ocean energy projects off the West Coast, as well as develop the long-term regulatory structure for removal or expansion of activities. The collaboration has taken the form of multiple working groups, known as Action Coordination Teams (ACT), that are working together to develop recommendations on how to best implement the actions described in the Agreement. The Renewable Energy ACT, or RE-ACT, developed an Action Plan[6], which includes the development of:

- Information/Data Report
- West Coast Marine Renewable Energy Planning Guidebook
- Cumulative Effects Study Phase I
- Data Management and Communication Mapping and Web Portal
- Standard Monitoring Protocol and Regulatory Agency Exchange
- Renewable Energy Technology Report
- Energy Infrastructure Report

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[5] See http://westcoastoceans.gov/.
[6] See http://westcoastoceans.gov/Docs/Renewable_Ocean_Energy_Final_Work_Plan.pdf.

- Public Education on Regulatory Regimes Report

2.2.2 Oregon Wave Energy Trust

The Oregon Wave Energy Trust[7] (OWET) is a nonprofit public-private partnership funded by the Oregon Innovation Council in 2007. With members from fishing and environmental groups, industry, and government, its mission is to serve as a connector for all stakeholders involved in wave energy project development. OWET's goal is to have ocean wave energy producing 500 MW of power by 2025.

OWET sponsors research in a wide range of areas. Selected completed studies[8] include:

- Advanced Anchoring and Mooring Study
- Sediment Transport Study
- Wave Modeling Results Study
- Baseline Seabird Assessment
- Dungeness Crab and Fish Baseline Study
- Ecological Effects Scientific Workshop
- Marine Mammal Study
- Potential Effects on Marine Mammals Workshop
- Coastal Infrastructure Inventory—Wave Energy Infrastructure Assessment in Oregon
- Utility Market Initiative
- Economic Impact Analysis of Wave Energy
- Human Dimensions of Wave Energy
- Regulatory Requirements Report
- Policy Recommendations Report

The infrastructure report (Lavrakas and Smith 2009) and the economic impact report (ECONorthwest 2009) are most relevant to this study and are discussed in Section 5.16 and Section 9.1, respectively.

2.2.3 Northeast Regional Ocean Council

In 2005, the governors of Maine, New Hampshire, Massachusetts, Rhode Island, and Connecticut formed the Northeast Regional Ocean Council[9] to facilitate a coordinated and collaborative effort to address regional coastal and ocean issues. Federal members of the Council include USDOI, EPA, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Department of Agriculture. In 2007, the Council convened representatives from state and federal agencies, non-governmental organizations, and academic institutions at the region's first Ocean Congress to identify priority issues that demanded a regional response. One focus is on CMSP in a way that incorporates efficiencies for the region (NROC 2010).

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[7] See http://www.oregonwave.org/.
[8] These reports can be found at http://www.oregonwave.org/our-work-overview/completed-projects/..
[9] See http://collaborate.csc.noaa.gov/nroc/default.aspx.

2.2.4 Mid-Atlantic Regional Council on the Ocean

On June 4, 2009, the states of New York, New Jersey, Delaware, Virginia, and Maryland announced the launch of MARCO.[10]. MARCO's purpose is to address the region's ocean issues, such as offshore energy, climate change, water quality, and habitat protection. The agreement calls for the states to collaborate on the development of offshore renewable energy in order to gain greater state influence with the federal government on the management of offshore waters. On July 1, 2009, the coalition issued a Request for Information to developers, equipment manufacturers, and other parties interested in a potential wind energy project. Responses to the Request for Information were due August 31, 2009 (MARCO 2009a, 2009b).

2.2.5 U.S. Offshore Wind Collaborative

The USOWC[11] was formed in 2004, following the Cape Wind proposal, and was made up of the Massachusetts Technology Collaborative, GE Wind Energy, and DOE. The three members brought together a group of stakeholders in Washington D.C. to consider the opportunities and challenges of offshore wind development; this resulted in a September 2005 document titled *Framework for Offshore Wind Energy Development in the United States*. The Massachusetts Technology Collaborative funded a draft *Organizational Business Plan* to consider how to structure a new national collaborative that would aid in building a sustainable offshore wind industry in the United States.[12]

The private and public contexts for the offshore wind industry changed significantly after the publication of this document. Both GE and DOE shifted focus to onshore wind development. At the same time, however, coastal states were implementing policies to plan for wind development and incentivize developers, as federal leasing authority was granted to BOEM for OCS renewables. Research and development in deep-water renewable technology increased, along with investor interest, in the private sector (USOWC 2009, p. 3). With the goal of expanding the organization in time for the federal administration change in January 2009, the Collaborative searched for individuals who had participated in previous stakeholder meetings to join an ad hoc Steering Committee to organize an official launch of the USOWC. The first Steering Committee meeting was held in September 2008. Fourteen states were represented at the meeting, and 24 had responded to a pre-meeting survey about their interest in offshore wind. The USOWC was registered as a nonprofit in Massachusetts on April 28, 2009, and is now applying for federal 501(c)(3) nonprofit status.

Rather than promote competition between offshore wind developers, the USOWC focuses on cooperation and creation of shared manufacturing and maintenance facilities in North America in order to provide a foothold for the offshore wind industry. Its ultimate goal is a network of offshore wind farms along the East Coast, which share shipping ports and are connected by a transmission "spine" (Lehmann 2009a). A group of USOWC states met in New Jersey in October, 2009 for a clean energy summit, exploring ways to share potential infrastructure (like transmission lines) and information about siting, permitting, and turbine construction (Lehmann 2009b). States with access to the OCS are seeking to join together to determine the

[10] See http://www.midatlanticocean.org/.
[11] See http://www.usowc.org/.
[12] See http://www.usowc.org/index.html.

environmental impacts of offshore wind in order to expedite the process of building offshore wind farms so as to meet RPSs (described later in this chapter) and construct the necessary manufacturing plants. Greg Watson, a clean energy consultant for Massachusetts Governor Deval Patrick, stated:

> if there's any way (that) by collaborating and by coming into certain areas with a clear and consistent voice so that perhaps [BOEM] wouldn't have to, on certain issues, consult with every state individually…if we could help them up front by doing that, by coming to some agreement, then maybe that could make that time period a little bit shorter [Lehmann 2009b].

2.2.6 Memoranda of Understanding Between States

2.2.6.1 Massachusetts and Rhode Island

On July 26, 2010, Rhode Island Governor Carcieri and Massachusetts Governor Patrick signed a memorandum of understanding providing that the two states would coordinate and collaborate in the permitting and development of offshore wind projects in a designated area of mutual interest (AMI) in federal waters in Rhode Island Sound. Rhode Island and Massachusetts are both working to develop offshore wind projects in state and federal waters. The memorandum signed by both governors commits their states to coordinate and collaborate in potential development of offshore wind energy in a 400-square-mile AMI beginning 12 miles southwest of Martha's Vineyard and extending 20 miles westward into Rhode Island Sound (Rhode Island 2010). The AMI is shown in Figure B-4.

2.2.6.2 Delaware, Maryland, and Virginia

In November 2009, the states of Maryland and Delaware and the Commonwealth of Virginia signed a memorandum of understanding on three issues. First, they would coordinate potential common electric transmission strategies, seeking to reduce ratepayer costs through regional planning and deployment of transmission services. Second, they would develop strategies to encourage sustainable market demand for offshore wind power, including policies and incentives that could be used across state boundaries. Third, they would work together to foster federal energy and regulatory policies (MD 2009).

2.2.7 Interstate Consistency Reviews

Under the CZMA, coastal states may interact during an interstate consistency review where a federal permitted or lease action with reasonably foreseeable coastal effects for one state will affect uses or resources of another state's coastal zone—see 15 C.F.R. §930.32(a)(1)(3). This mechanism is available for resolving differences, e.g., where the parties cannot reach a mutual understanding regarding development of offshore energy projects in federal waters. As with individual State consistency review, in order for a State to review an renewable energy (or renewable energy) permitted activity via the interstate consistency process, its CMP must list renewable energy activities in its CMP and it must have been approved by NOAA (see 15 CFR 930.53). For renewable energy federal "leasing" activities, BOEM would make a decision on whether a proposed lease activity would have reasonably foreseeable coastal effects on an individual State's enforceable policies before a State would have the authority to review the activity under its CMP.

2.3 STATE ACTIONS

2.3.1 Renewable Portfolio Standard Policies

States have long been involved with enacting policies to encourage the development and use of renewable energy technologies, frequently through RPSs. Some state RPS requirements mandate that a percentage of a utility's power plant capacity come from renewable energy, while others require that a percentage of generation come from renewable sources. Table 3, below, summarizes the RPS policies of the states (and the District of Columbia) bordering the OCS. Policymakers may incentivize the development of a specific technology by providing a "credit multiplier." For example, Delaware law gives the electric utility 350% credit toward meeting the RPS for energy generated by offshore wind facilities constructed by a certain date.

Rather than enact an RPS, the state of Virginia opted to enact a renewable energy portfolio goal, whereby investor-owned utilities are encouraged to obtain a percentage of their power from renewable sources. This is why Virginia is listed with "voluntary goals" in Table 3. Unlike RPSs, renewable energy goals are not legally binding on the electricity provider. Using 2007 as a base year, utilities should achieve the goal of 4% of base year sales coming from renewables between 2010 and 2015, 7% of base year sales between 2016 and 2021, and 12% of base year sales by 2022 (N.C. Solar Center and N.C. State University 2009b). To participate in the renewable program, investor-owned utilities must gain approval from the Virginia State Corporation Commission by demonstrating that they can reasonably expect to meet the 12% target in 2022. The Commission will allow for program cost recovery and an increased rate of return for each goal that participating utilities attain. Resources that can be used to meet the voluntary goal include solar, wind, geothermal, hydro, wave, tidal, and biomass energy; wind and solar power receive double credit toward renewable energy goals.

New Jersey is currently working to implement a system for offshore renewable energy credits (ORECs); New Jersey Governor Chris Christie signed the Offshore Wind Economic Development Act on August 19, 2010, which provides the necessary framework. The law provides for a fixed, long-term offshore wind production payment in the form of an OREC for each MWh produced by qualified offshore wind projects, "address(ing) difficult(ies) developers have had entering long-term PPAs (power purchasing agreements) and securing a reliable REC revenue stream" (Dewey & LeBoeuf 2010; NJ Office of the Governor 2010). Qualified projects are wind generating facilities located in the Atlantic Ocean and connected to the New Jersey electric transmission system with the approval of the New Jersey Board of Public Utilities (NJBPU). Rather than simply requiring that a portion of renewable generation in the state come from offshore wind and letting the market decide the price at which these RECs will be valued, the carve-out actually determines OREC prices in a competitive process in which OREC prices are set on a project-by-project basis after a review of each project's estimated revenues and required returns. Regulations must still be adopted by the NJBPU, which will also be responsible for administration of the program. The agency will review project applications, determine OREC payments, and establish a program that requires electric power suppliers to purchase a percentage of electricity from qualified offshore wind projects equal to a state total of 1,100 MW. Thus, the NJBPU purchases ORECs from each wind project at a fixed price, and sets a purchase obligation for ORECs on New Jersey electric suppliers "in an amount equal to the NJBPU's OREC inventory and at a price set by the NJBPU" (Dewey & LeBoeuf 2010). These fixed OREC prices will provide offshore developers with the predictable revenue stream necessary to secure reasonable long-term project financing.

Table 3
Renewable Portfolio Standards in States With Access to the OCS

State	Renewable Portfolio Standard
Maine	40% by 2017[13]
New Hampshire	23.8% by 2025—16.3% from sources installed after 2006
Massachusetts	15% by 2020 and an additional 1% each year thereafter
Rhode Island	16% by 2020
Connecticut	23% by 2020
New York	24% by 2013
New Jersey	22.5% by 2021 (2.12% from solar; 17.88% from other Class I; 2.5% from Class II or additional Class I renewables)[14]
Delaware	20% by 2019
Maryland	20% Tier 1 by 2022; 2.5% Tier 2 in 2006–2018[15]
District of Columbia	20% by 2020

[13] New renewables include those placed into service after September 1, 2005.
[14] Class I includes solar, wind, wave or tidal, geothermal, landfill gas, anaerobic digestion, fuel cells using renewable fuels, and some biomass. Class II includes hydropower up to 30 MW and resource-recovery facilities.
[15] Tier 1 sources include solar, wind, qualifying biomass, methane, geothermal, ocean, fuel cells, and small hydro plants (less than 30 MW). Tier 2 sources include hydropower other than pump-storage, and waste-to-energy facilities.

State	Renewable Portfolio Standard
Virginia	Voluntary goals of 12% of base year (2007) sales by 2022
North Carolina	12.5% by 2021 for investor-owned utilities; 10% by 2018 for electric cooperatives and municipal utilities
South Carolina	N/A
Georgia	N/A
Florida	N/A[16]
California	33% by 2020
Oregon	25% by 2025 for large utilities; 10% by 2025 for medium utilities; 5% by 2025 for small utilities
Washington	15% from *new* renewable sources by 2020

Source: USDOE EERE (2011).

2.3.2 REC Markets

Two markets exist for RECs: the voluntary market and the compliance market. The voluntary market is made up of individuals, companies, or other organizations that purchase RECs for the purposes of environmental stewardship or responsibility. The compliance market is made up of load-serving entities that are required to comply with state RPS policies. Electricity providers often have options for compliance, including generating their own RECs through investment in renewable energy projects, entering into long-term contracts to purchase RECs and/or renewable energy, or purchasing RECs on the spot market.

There is no single market for RECs and thus no single price. Instead, there are many REC markets, and prices can vary based on location (state or region), compliance year, volume, resource type used to generate the REC, and, in some cases, the availability of other state and federal incentives for renewable energy. Table 4, below, shows a sample of recent prices by state and year for RECs used in Massachusetts, Maryland, New Jersey, and Texas.

Table 4
REC Prices ($/MWh), December 2009

Sec	Term	Bid Price ($/MWh)	Offer Price ($/MWh)
MA REC	2009	$23.00	$29.00
MA REC	2010	$29.00	$33.75

[16] Utility JEA signed a memorandum of understanding committing to 7.5% renewable energy by 2015.

Sec	Term	Bid Price ($/MWh)	Offer Price ($/MWh)
MD Tier 1	2007	—	$0.50
MD Tier 1	2008	$0.50	$0.90
MD Tier 1	2009	$0.75	$1.25
NJ Class 1 REC	2010	$5.50	$7.00
NJ Class 1 REC	2011	$11.00	$13.00
TX REC	2009	$0.85	$1.35
TX REC	2010	$1.30	$2.00

Source: Evolution Markets (2009).

These REC prices are for the same type of resource, i.e. Class I or Tier I, in each state, but as Table 4 indicates, there can be some variability in price from year to year for the same resource in the same state. Prices can also differ significantly between states and regions for similar resource types in the same year. Factors that impact REC prices in different areas are the RPS rules regarding eligible resources and imports of renewables, the quality and quantity of renewable resources available, the degree of difficulty involved in siting and developing new renewable generation, the level of the alternative compliance payment (ACP) and consumer demand for renewable energy (Holt and Bird 2005).

The RPS rules in different states have a significant effect on the REC prices in those states. In Connecticut, for example, there were not enough Class I resources to meet the RPS requirement in 2005 until existing out-of-state biomass facilities were made eligible. RECs had been trading at a price range of $35–$40 as of July 2005, but this new classification led to a flooding of the renewable market from existing Maine biomass, and by the end of 2005 REC prices had dropped to “no bid” at $2.50 per MWh (Evolution Markets 2006). Supply was also tight in Massachusetts in 2005, but with no changes in eligibility rules for renewable resources, suppliers had to purchase electricity and RECs from New York in order to meet the RPS. Average Massachusetts REC prices for 2005 were thus considerably higher, at a cost of $52.80 per MWh (Evolution Markets 2006). REC prices have historically been higher in Massachusetts than in other states, as can be seen in Table 4, due to the fact that renewable resources are not as abundant and siting energy projects is more difficult than in other areas. Texas, on the other hand, has a significant amount of wind resources, and its lower population density makes it easier to site projects, which has caused REC prices in the state to be lower than in other states and regions.

The ability to bank RECs has an effect on prices as well. When Massachusetts first implemented its RPS, RECs had to be surrendered in the year and quarter in which they were generated. This can lead to significant variations in REC prices from quarter to quarter, as renewable generation could vary considerably due to short-term weather events or development of additional resources, and was a contributor to the 2005 REC price of $52.80 mentioned above. Massachusetts has since allowed generators to bank credits for compliance for three years—the year the REC was generated and two years thereafter—which can help smooth the REC price curve over time. While Maryland and New Jersey are both in the PJM region, where prices might be expected to be lower (see below for an explanation of this), New Jersey currently requires that RECs be used in the year in which they were generated[17] while Maryland allows for RECs to have a three-year life. This may account for a portion of the difference in REC prices between the two states.

Rules on the importing of RECs vary from state to state, but often states within a region will allow RECs to be used in any state within that region. Most New England states allow RECs generated within New England to be used for compliance purposes. For example, Connecticut also allows RECs generated in New York, Pennsylvania, New Jersey, Maryland, and Delaware to be used for compliance, provided that these states have an RPS comparable to that of Connecticut, as determined by the Connecticut Public Utilities Commission. Requirements in PJM states are much broader, and most states allow RECs generated within PJM, or sold into PJM, to be used for RPS compliance. Prices in PJM states might therefore be expected to be lower than in New England because RECs from a wider geographic area can be used to meet RPS requirements. States that offer credit multipliers for specific types of renewables could be at risk, given these import rules, because a renewable project outside the state, or even outside the region, could be of a sufficient size to meet the first state's RPS and still generate additional RECs. Delaware, with its credit multiplier of 350% for offshore wind facilities, has eliminated this risk by specifying that credit will be given only to Public Service Commission–regulated electric companies that have put in place contracts for energy and RECs from wind energy installations sited off the Delaware coast.

For suppliers that cannot procure enough RECs to meet RPS requirements, states have set up ACP rates. ACP rates are designed to be higher than the market prices for RECs so that suppliers do make an effort to procure the required amount of renewable energy. The ACP can thus be considered the compliance option "of last resort" under normal market conditions. It can also be considered a hedge against market volatility, providing an alternative to the purchasing of renewable generation and/or RECs if market prices have risen much higher than expected. ACP prices in some states for certain classes of renewables are shown in Table 5, below. Table 5 also shows state REC prices for the states of Massachusetts and New Jersey. State RECs are discussed below. Again, Delaware has taken a unique approach to the ACP mechanism, setting the initial ACP at $25/MWh of shortfall and increasing the penalty in subsequent years for those suppliers who elect to pay it in prior years. After the first year used, the ACP increases to $50/MWh, and after the second year used, it increases to $80/MWh in order to dissuade suppliers from electing to make the ACP payment year after year.

[17] A.B. 3520, enacted in January 2010, allows RECs to be used for compliance during the year in which they were generated, or the following two energy years, but this provision is presumed not to take effect until at least energy year 2011.

Table 5
ACP Prices ($/MWh), February 2010

State and Resource Class	2009	2010
MA Class 1	$60.92	$60.93
MA Class 2 WTE	$10.00	$10.00
MA Class 2	$25.00	$25.00
MA State REC	N/A	$600.00
RI	$60.92	$60.93
NH Class 1	$60.92	$60.93
NH Class 2	$159.98	$160.01
NH Class 3	$29.87	$29.87
NH Class 4	$29.87	$29.87
ME	$60.93	$60.93
MD Tier 1	$20.00	$20.00
MD Tier 2	$15.00	$15.00
NJ State REC	$711.00	$693.00

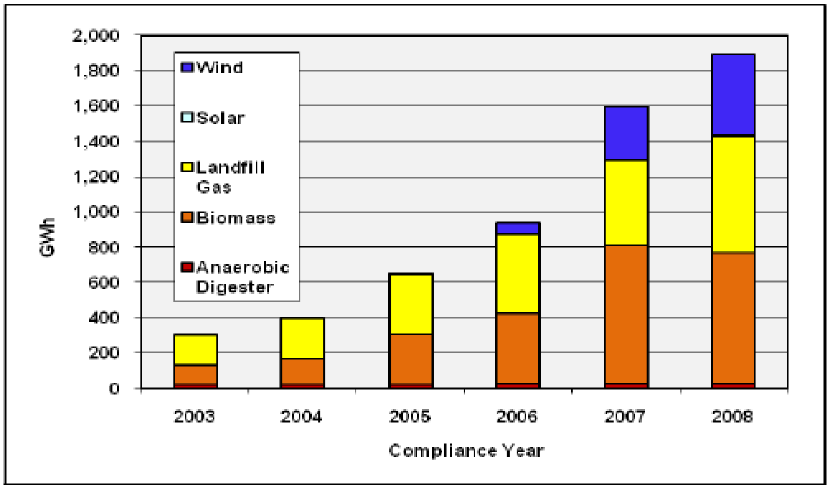
Source: Evolution Markets (2010) and http://www.dsireusa.org.

As discussed previously, Massachusetts is a constrained market, both in terms of its limited supply of renewable resources in-state and also because transmission constraints make it difficult to purchase RECs outside New England for compliance purposes. There were supply shortages in the first four years of the RPS requirements, from 2003 to 2006, but the total supply of Massachusetts RECs for the past two years (2007 and 2008) has exceeded the demand. Nonetheless, three of twenty-six suppliers with RPS obligations in 2008 were unable to acquire sufficient RECs to meet requirements, and had to use the ACP to make up the difference. This difference was less than one-tenth of 1% of the total required RECs. Twenty-one of the suppliers actually banked RECs forward to be used for compliance in 2009 or 2010 (MA DOER 2010).

Figure 2, below, shows those resources that have been used to meet the RPS requirements over the past six years. These are also the technologies that have historically set REC prices and are likely setting those REC prices shown in Table 5. Figure 3 shows the renewable generating technologies that set REC prices in Maryland, in the PJM region, for the year 2008.

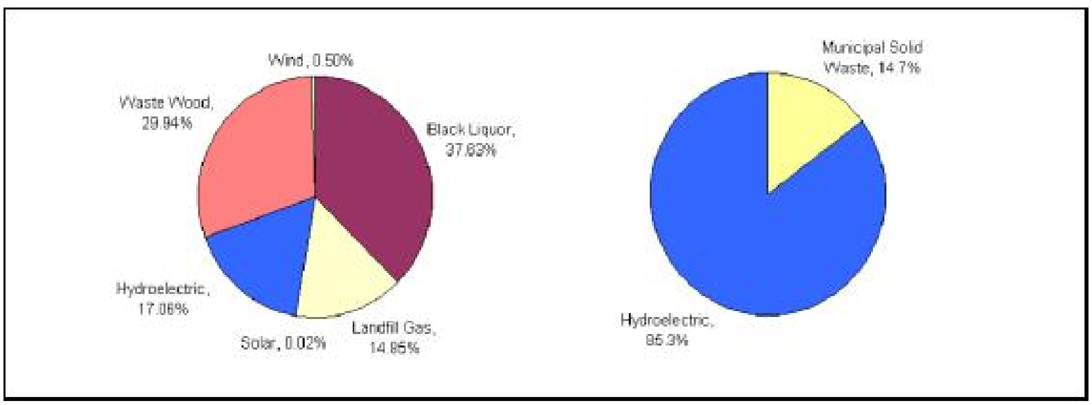
When looking at the renewable resource mix for Massachusetts and Maryland, it is clear that RPS target levels, eligible resources, resource availability, allowances for resource imports, and the level of the ACP have an effect on both REC prices and the mix of renewable resources selected to meet the RPS.

Policymakers have a responsibility to adjust the ACP annually, at a level that incentivizes suppliers to purchase renewable generation and/or RECs, but also to provide a hedge against volatility in market prices. In Massachusetts, the ACP must be adjusted in accordance with the previous year's Consumer Price Index (MA EEA 2010b). To avoid oversupply conditions, policymakers in several states have either reevaluated the RPS targets and adjusted them upward, or created policy carve-outs for specific types of renewable technologies.



Source: MA DOER (2010).

Figure 2. Massachusetts RPS Compliance by Generator Type, 2003–2008.



Source: Public Service Commission of Maryland (2010).

Figure 3. Percentage of Retired Tier 1 and 2 RECs in Maryland by Fuel Source, 2008.

Compliance with the New York State RPS and associated REC market is administered by the New York State Research and Development Authority (NYSERDA). All retail electric customers who pay New York's System Benefits Charge (a charge paid by electric customers through rates, and withheld by suppliers and transferred to NYSERDA to fund public policy initiatives) also pay a volume-based RPS surcharge that funds the RPS program. Using this pool of money, NYSERDA then pays production incentives to renewable energy generators for the RECs associated with their projects. NYSERDA selects generators through competitive procurements and most enter into 10-year contracts. Unlike the RPS requirements in other states, New York has a single buyer of RECs, the budget for purchasing these RECs is predefined, and all renewable projects generating RECs must be located in-state. NYSERDA's program is highly competitive, and all generating technologies must compete against each other for limited RECs. Offshore wind and hydrokinetic generation technologies are not favorably positioned to be competitive under this program structure because there is still an abundance of other less-expensive renewable projects competing for REC dollars from NYSERDA. Including carve-outs for specific technologies or even different resource tiers might provide some opportunities for offshore technologies, but these have yet to be considered in the New York RPS.

2.3.3 State Planning Activities

2.3.3.1 Maine

Governor Baldacci of Maine established the Ocean Energy Task Force (OETF) in November 2008 through Executive Order 20 FY 08/09. The Task Force's primary mission is to recommend strategies to meet or exceed the goals established in the Maine Wind Energy Act, Title 35-A, Section 3404(2)(B), to install at least 2,000 MW of wind capacity by 2015, and to install at least 3,000 MW by 2020, 300 of which could be located in coastal waters (ME 2008). The final report of the OETF indicated strong interest in wind and tidal energy but not in wave energy. According to a study performed by NREL, 82% of Maine's coastal waters have winds that range from outstanding to superb (ME OETF 2009); see Figure B-5. In June 2009, the Maine Legislature passed an act to facilitate testing and demonstration of renewable ocean energy technology (Maine State Legislature 2009).

On December 15, 2009, the Maine Department of Conservation named three ocean energy demonstration sites: Boon Island, Damariscove, and Monhegan Island (ME DOC 2009). The demonstration site areas are shown in Figures B-6 through B-8.

2.3.3.2 New Hampshire

ERG identified no state planning activities for offshore renewable energy as of December 2009. New Hampshire has only an 18-mile coastline, which limits potential areas of interest.

2.3.3.3 Massachusetts

As mentioned in Section 2.2.6 above, in July 2010, Massachusetts and Rhode Island signed a memorandum of understanding to coordinate and collaborate in the permitting and development of offshore wind projects in a designated AMI in federal waters in Rhode Island Sound.

On January 4, 2010, the Massachusetts Executive Office of Energy and Environmental Affairs (EEA) released its final Ocean Plan in accordance with the Ocean Energy Act signed into law on May 28, 2008. The final ocean management plan provides a comprehensive framework for managing, reviewing, and permitting proposed uses of state waters. In two areas comprising just 2% of the planning area, the plan identifies zones suitable for commercial-scale wind energy development. Adjacent to these areas, EEA has identified potentially suitable locations in federal waters for commercial-scale wind energy development. At the Commonwealth's request, the Bureau of Ocean Energy Management has convened a federal-state task force to assist in the planning and regulatory review associated with leasing areas of federal waters for large-scale wind energy development (MA EEA 2009, 2010a).

The Ocean Plan notes that the prospect of commercial-scale wave energy development was limited, although there is a demonstration project in operation on the north shore (MA EEA 2009).

The two designated wind energy areas—off the Elizabeth Islands and south of Nomans Land, off Martha's Vineyard—are shown in MA EEA 2009 Volume 1, Figure 2-18, reproduced here in Figure B-9. The Elizabeth Islands stretch southwest from Falmouth, Massachusetts; their population center is Gosnold. Cuttyhunk Island is the westernmost of the Elizabeth Islands and has fewer than 100 year-round residents. The renewable energy area designated in the plan is approximately 7.5 miles from the closest significant population centers of Aquinnah and Westport. Cuttyhunk residents favor a wind farm (Abel 2009). Nomans Land has no year-round residents and is about 5.5 miles from the nearest population center of Aquinnah (MA EEA 2009).

2.3.3.4 Rhode Island

Rhode Island has undertaken several major special planning actions with respect to ocean energy. As noted above, Massachusetts and Rhode Island signed a memorandum of understanding to coordinate and collaborate in the permitting and development of offshore wind projects in a designated AMI in federal waters in Rhode Island Sound in July 2010.

On October 19, 2010, the Rhode Island Coastal Resources Management Council approved the Ocean Special Area Management Plan (SAMP). The final draft was not yet available as of mid-November; the following discussion is based on the July 2010 draft (RI CRMC 2010). The researchers evaluated several sources of renewable energy including solar, geothermal, ocean thermal energy, wave, tidal, and wind. Of these, only offshore wind appeared to be economically viable on a commercial scale. The SAMP lists coordinates for the area the researchers found suitable for renewable energy projects, called the Ocean Renewable Energy Zone. See Table 6 and Figure B-10 for the coordinates of the Ocean Renewable Energy Zone around Block Island.

Table 6
Coordinates of the Ocean SAMP Renewable Energy Zone

Coordinates of the northern boundary of the Ocean SAMP Renewable Energy Zone	41° 7' 29.208" 41° 7' 25.0212" 41° 10' 7.2042"	-71° 37' 58.26" -71° 31' 46.6032" -71° 30' 7.6788"
Coordinates of the southern boundary of the Ocean SAMP Renewable Energy Zone	41° 6' 50.907" 41° 6' 45.8994" 41° 9' 45.8634"	-71° 39' 12.366" -71° 30' 28.533" -71° 28' 37.4118"

Note: Coordinates in this table differ from Figure B-10, where they are expressed in decimal degrees.

Rhode Island began its investigation of offshore wind power in January 2006, when Governor Donald Carcieri created the Office of Energy Resources and tasked it with performing a wind power siting study to determine if it was possible to get 15% of Rhode Island's electricity from wind power. The results of the study showed that Rhode Island has the potential to generate five times that amount of wind power in an area of almost 100 square miles. Much of that area is in the ocean off the Rhode Island coastline (RI Office of the Governor 2007).

Following the outcome of the wind siting study, the Governor invited representatives from the environmental community, government, and industry to participate in a stakeholder group to discuss the development of an offshore wind farm. The stakeholders identified issues affecting the siting of offshore farms and agreed that next steps include a formal environmental impact analysis and permitting process. According to the report, "Overall, participants in the Stakeholder process expressed their support for the concept of using wind energy to satisfy some portion of Rhode Island's future electricity needs…and their desire to continue participating in future discussions and decision making on this topic" (OER 2008).

In January 2009, Governor Carcieri signed a joint development with Deepwater Wind Rhode Island, LLC, to supply 1.3 million MWh per year. The project has two phases. Phase 1 will be a 20 MW project in state waters, with the exact site selected from locations shown to be acceptable by the SAMP. Phase 2 is a utility-scale project in a separate location within the SAMP, capable of producing 1.3 million MWh per year on submerged federal lands leased from the Minerals Management Service (MMS, later BOEMRE, now BOEM). As part of the agreement, Deepwater Wind will establish a manufacturing facility in Quonset that will manufacture support structures on which the turbine and its tower are based, and will service all of Deepwater Wind's northeast projects. RI estimates that the agreement will create approximately 800 direct jobs with annual wages of $60 million (RI Office of the Governor 2009a). Completion of this offshore wind project would put the state on track to meet its RPS of 20% by 2020—15% of which is expected to be from wind.

On June 26, 2009, Governor Carcieri signed a bill requiring National Grid, Rhode Island's largest utility, to enter into long-term contracts to purchase renewable energy (RI Office of the Governor 2009b). This will allow a long-term contract to purchase power from Deepwater Wind's proposed offshore facility. Deepwater Wind may be more likely to get approval for its wind project with a power purchase agreement in place.

2.3.3.5 Connecticut

ERG identified no offshore renewable energy activities for Connecticut. The state has primarily good offshore wind potential areas, some excellent potential areas, but no outstanding or superb areas (USDOE NREL 2010c).

2.3.3.6 New York

In March 2009, the Long Island Power Authority (LIPA) and Consolidated Edison (Con Edison) released a feasibility study for siting a 350 MW or 700 MW facility off the Long Island coast (Con Edison and LIPA 2009). In July, LIPA, Con Edison, the New York Power Authority (NYPA), the City of New York, NYSERDA, the Port Authority of New York and New Jersey, and the Metropolitan Transportation Authority formed the Long Island–New York City Offshore Wind Collaborative (LINYC) in order to push further for the development of an offshore wind project located 13 miles off the south shore of the Rockaway Peninsula in the Atlantic Ocean (LINYC 2009a). On July 1, the collaborative issued a request for information to which approximately 30 firms responded (LINYC 2009a, 2009b). On December 9, 2009, the collaborative announced that consultants would soon begin pre-development activities. Engineers and scientists are set to begin studying the proposed project site to help guide ocean floor surveying, as well as studying wildlife migration patterns (LIPA 2009). According to its FAQ, LINYC anticipated filing an application for an offshore lease with BOEM and issuing a request for proposals to developers for the development, construction, ownership, and operation of the project in the fall of 2010 (LINYC 2010).

These activities are consistent with the goals for renewable energy in the New York State Energy Plan released in December 2009 (NYS 2009). The offshore wind project is also aligned with New York mayor Michael Bloomberg's goal to reduce greenhouse gas (GHG) emissions in New York City 30% by 2030 (LIPA 2009).

2.3.3.7 New Jersey

Offshore wind development in New Jersey was first attempted in 2003 and 2004, when several private corporations proposed utility-scale wind farms in the OCS between Sandy Hook and Cape May. In December 2004, because the state had not yet developed specific policies for offshore energy installations, acting Governor Richard Codey signed an Executive Order (EO12) establishing a 15-month moratorium on the funding and permitting of offshore wind farms in New Jersey. The order also established the Blue Ribbon Panel on Development of Offshore Wind Turbine Facilities, which sought to evaluate the costs and benefits of developing offshore wind facilities and to submit a report to the Governor with its findings and policy recommendations (NJ 2005). In its final report, the Panel advised that the New Jersey Department of Environmental Protection study the potential environmental effects of offshore wind turbines in order to help inform federal rules regulating the use of the OCS for energy development. The Panel stated that offshore wind facilities "show promise as part of New Jersey's long-term energy solution," and recommended that "New Jersey proceed with a limited test project only, not to exceed 350 MW, to obtain practical knowledge of benefits and impacts resulting from offshore wind turbine facilities" (NJ 2006, p. v.). Finally, the Panel suggested that offshore wind be included in New Jersey's Energy Master Plan (EMP).

Consistent with the Panel's recommendation, the Energy Master Plan was released in October 2008, and it calls for "at least 1,000 MW of offshore wind by 2012, [and] 3,000 MW of offshore wind…by 2020." (NJ 2008a, p. 12). The Plan also established the Offshore Wind Planning Group, tasked with designing a plan for the development of the proposed offshore wind facilities. The Planning Group is made up of the New Jersey Department of Environmental Protection, the New Jersey Board of Public Utilities, the Rate Counsel, and public members. In September 2009, New Jersey released its wind turbine siting report (NJ DEP 2009b).

New Jersey's framework for ORECs, currently under development, establishes a 20-year fixed price for ORECs and requires all electricity load-serving entities to buy a specific number of ORECs depending on their retail sales in New Jersey (NJBPU 2009, p. 3). The framework will create a predictable revenue stream for offshore energy projects and thus facilitate financing for them. New Jersey is also offering rebates for constructing offshore meteorological towers (NJ 2008b).

The NJBPU announced a competitive incentive and financing program to encourage the development of an offshore wind renewable electricity generation pilot project serving the electricity distribution system in New Jersey (NJBPU 2007). Funding comes from the New Jersey Clean Energy Program through the New Jersey Economic Development Authority. Proposals were accepted through January 2008, and GSOE was chosen as the first grant recipient in October 2008 (GSOE 2008). Additionally, the Board began a rebate program for construction of offshore meteorological towers, providing applicants with a rebate of $4 million per tower (NJ 2008b).

On August 19, 2010, the Governor signed an offshore wind economic development act (NJ GOV 2010). The legislation will establish an OREC program (see Section 2.3.1 above) and make available financial assistance and tax credits from existing programs for businesses that construct manufacturing, assemblage, and water access facilities to support the development of qualified offshore wind projects.

2.3.3.8 Delaware

In April 2006, the Delaware General Assembly passed House Bill 6, directing Delmarva Power to contract with new power resources to guarantee a stable process for electricity. Senate Bill 328, signed by the Governor on June 25, 2008, provides a policy incentive. Regulated electric companies (of which there is only one, Delmarva Power and Light) are allowed to receive 350% credit toward Delaware's RPS for energy derived from offshore wind installations sited off the coast on or before May 31, 2017. This 350% multiplier is available for the life of the offshore wind contracts (Delaware State Senate 2008).

While it does not present any specific policies for offshore renewable energy development, the Delaware Energy Plan for 2009 to 2014 (released on March 26, 2009) does highlight the potential for offshore wind energy in the state. According to the Plan, Delaware has the potential for 6,200 MW of offshore wind energy if fully developed; however, development of this resource is contingent on considerable investment, upgrades in transmission, and a means to overcome the reliability concerns arising from the intermittency of wind. Delaware is well-positioned to take advantage of offshore wind resources due to its large potential, its long coastline and protected ports, one deepwater port, strong support from the public, and an underutilized manufacturing base. As the Plan states, "the expansion of wind generation makes sense for the electricity sector to stabilize prices and reduce our high carbon risk profile" (Governor's Energy Advisory Council 2009, p. 78).

Delaware is also working to modernize the process for its Integrated Resource Plans, by which electric utilities evaluate different options for meeting future electricity demand and select the optimal mix of resources that minimizes the cost of electricity supply. The state will require that utilities include externality costs when determining their resource mix, taking into account health and environmental costs of different generating technologies. This will increase the cost of fossil-fired generation, helping move it closer to renewable technologies in terms of costs in the near term.

2.3.3.9 Maryland

The Maryland Energy Administration issued a "request for expression of information and interest" to engage business and industry leaders with expertise in the installation and development of offshore wind energy. This request reaches out to U.S. and European developers to begin a constructive dialogue on strategies for facilitating a long-term offshore wind energy strategy for Maryland. Expressions of interest were due to the Maryland Energy Administration at the end of March 2010 (MEA 2010).

Maryland offers a state PTC of $0.0085/kWh, up to a total of $2.5 million over a five-year period, for wind and other resources that are operational before 2011 (MEA 2006).

2.3.3.10 Virginia

The Virginia legislature created the Virginia Coastal Energy Research Consortium (VCERC) in 2007 with the purpose of developing coastal energy technologies (VCERC 2010a). VCERC's report, released on April 20, 2010, noted that the region encompassing state waters is dominated by Class 4 winds while Atlantic federal waters off the Virginia coast are dominated by Class 5 and Class 6 winds.[18] The consortium developed a geospatial database with more than 25 layers. Avoiding conflicting uses, VCERC identified 25 OCS lease blocks of entirely Class 6 winds beyond 12 nautical miles offshore (the approximate visual horizon), in water depths less than 30 meters (suitable for commercially available monopile foundations), which could support approximately 3,200 MW of offshore wind farm capacity. VCERC estimated that, assuming an array efficiency of 89%, these 25 lease blocks could generate 11 million MWh per year—approximately 10% of Virginia's annual electricity consumption (VCERC 2010b).

VCERC also notes that these 25 OCS lease blocks lie beyond the 6-nautical-mile-boundary for federal–state revenue sharing and recommends that a different determinant be used to qualify states for federal revenue sharing of lease and royalty payments, which would require a new act of Congress (VCERC 2010b).

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[18] Class 4: 7.0 to 7.5 meters per second mean wind speed (400–500 watts per square meter mean power density) (good); Class 5: 7.5 to 8.0 meters per second mean wind speed (500–600 watts per square meter mean power density) (excellent); Class 6: 8.0 to 8.8 meters per second mean wind speed (600–800 watts per square meter mean power density) (outstanding) (VCERC 2010b).

The Virginia Department of Mines, Minerals, and Energy released its 2007 Energy Plan, which identified offshore wind as having the potential to supply 28,000 MW to the state (VA DMME 2007). The Department and James Madison University has established the Virginia Wind Energy Collaborative, which educates citizens and county decision-makers about the benefits of wind power, as well as the possible impacts and how they can be mitigated (NASEO 2009).

2.3.3.11 North Carolina

The University of North Carolina at Chapel Hill conducted a nine-month study on the feasibility of installing wind turbines in Pamlico Sound, Albemarle Sound, and the ocean waters off the North Carolina coastline (UNC 2009a). The study found potential areas in the eastern portion of Pamlico Sound and off the coast. A map overlaying the various constraints for the North Carolina region is shown as Figure B-11. A presentation on the study stated that the state could generate 55,000 MW if it developed all usable potential offshore wind sites. (This is approximately 130% of North Carolina's energy consumption in 2007.) Developing the resources on 45 OCS blocks could supply 20% of the state's 2007 consumption. The presentation also reports an NREL study of the economic impact of installing 10,440 MW by 2030, and found the total direct and indirect impact to be 45,000 temporary jobs in construction, 9,100 permanent jobs in operation, and $22.2 billion to local economies (UNC 2009b).

In April 2009, North Carolina issued a report *(Developing a Management Strategy for North Carolina's Coastal Ocean)* whose second chapter is devoted to ocean-based renewable energy, including wind, wave, current, and tidal. The report notes that there are overlapping jurisdictions among the Coastal Resources Commission, Utilities Commission, and Environmental Management Commission, and recommends that the state determine which commission has primary jurisdiction. The report also identified two policies that could limit the development of offshore wind energy. First, offshore wind turbines are not considered water-dependent structures and thus would need a variance to be installed and operate in a public trust area (Ocean Policy Steering Committee 2009). Second, current rules do not permit transmission lines to cut through the beach and dunes (CRC regulation 15A NCAC 07H .0309).

2.3.3.12 South Carolina

On January 1, 2010, the South Carolina Wind Energy Production Farms Feasibility Study Committee issued its report in response to South Carolina Act 318 of 2008. The Committee's recommendations include (Wind Energy Production Farms Feasibility Study Committee 2010):

- Establishing a target of 40 to 80 MW generation from offshore wind by 2013 and 1,000 MW by 2018.
- Developing a marine spatial plan for the state's offshore waters.
- Establishing a leasing framework for offshore energy projects.
- Negotiating with Santee Energy (a state-owned utility) to develop two test towers and purchase electricity from an offshore wind demonstration project.
- Establishing a program to provide "revenue certainty" for offshore wind projects.

Data collection is underway at transects off North Myrtle Beach and Winyah Bay (CCU 2010).

2.3.3.13 Georgia

Georgia has no significant policies designed to promote offshore renewable technologies at this time. Southern Power Company partnered with Georgia Institute of Technology to evaluate the feasibility of offshore wind power. As a result, Southern Power deemed offshore wind power unworkable as of 2008 (Southern Company 2008). Figure B-12 shows the limited wind resources off the Georgia coast.

2.3.3.14 Florida

The Florida Renewable Energy Production Tax Credit Program established a corporate renewable energy production tax credit equal to \$0.01/kWh of electricity produced and sold to an unrelated party. The tax credit is designed to encourage the development and expansion of renewable energy facilities, and applies to wind and ocean energy technologies, among others (NASEO 2009).

2.3.3.15 Washington

The Washington Governor's Office established the State Ocean Policy Work Group (OPWG) in 2005 to summarize the status of Washington's ocean resources and their value to the state, and to provide recommendations for improving protection and management of the state's ocean resources. The OPWG recommended that state agencies coordinate on the scientific, technical, legal, and policy issues relating to renewable energy (WA Dept. of Ecology 2010).

On the basis of this recommendation, the State Ocean Caucus was created. The Caucus gives a number of state agencies a way to work together to prioritize activities related to the ocean environment. The Caucus has developed a detailed work plan (WA 2009) designed to carry out the recommendations of the OPWG. With respect to ocean energy, the work plan activities include:

- Combining and improving data and information on renewable energy technologies.
- Developing an understanding of regional siting criteria for projects.
- Assessing the feasibility of comprehensive planning for renewable ocean energy.
- Examining marine spatial planning efforts by other states.
- Understanding and seeking the basic data that would support planning by assessing marine resources and other uses.

Work is under way at this time.

2.3.3.16 Oregon

In March 2008, FERC and the state of Oregon signed a memorandum of understanding with respect to wave energy projects. FERC issues permits for wave energy projects within Oregon's territorial sea. FERC acknowledges Oregon's authority over such wave energy projects through the CZM Act, the Clean Water Act, and the National Historic Preservation Act. One intention of the memorandum of understanding is to ensure coordinated review of proposed wave energy projects. The memorandum mentions Oregon's intent to develop a comprehensive plan for siting wave energy projects. If such a plan is filed with FERC, FERC will consider whether proposed projects are consistent with the plan in its decision to issue or not to issue a preliminary permit (FERC 2008).

See Section 2.2.2 above for a discussion of the research supported by the Oregon Wave Energy Trust.

2.3.3.17 California

The California Ocean Resources Management Act of 1990 created the Ocean Resources Management Program to coordinate the policies of state departments with jurisdiction over ocean and coastal resources (California Ocean Resources Management Program 2010). The program produced an ocean management plan in 2004, but that plan does not discuss ocean renewable energy sources (California Ocean Resources Management Program 2004). The Program website does not list any updates to the plan.

California Ocean Protection Act of 2004 created the California Ocean Protection Council, whose charge is to, among other duties, (1) continue to serve as a facilitator between the state agencies, federal agencies, local organizations, and West Coast states; (2) address future research needs and leverage research dollars; and (3) develop state policies. The Council has a marine renewable energy workgroup and might sponsor inter-agency workshops in the future to develop statewide regulatory guidance for testing and developing pilot hydrokinetic energy projects (California Ocean Protection Council 2010).

2.4 PROJECTS

This section provides a state-by-state discussion of the wind, wave, and ocean current commercial and research projects. Each state's section mentions the energy types that are under consideration in that state. Some states have primarily offshore wind, while others focus on wave energy. Ocean current energy, for the most part, is in the research and development stage rather than the project planning phase.

2.4.1 Maine

In October 2009, DOE made an award to a consortium led by the University of Maine to investigate deep-water offshore wind energy generation and to design and deploy 10- and 100-kW prototypes to be mounted on floating offshore foundations. The first prototypes are scheduled to be in the water as early as the spring of 2011. Principle Power is a member of the consortium and hopes to test its WindFloat technology (McGlinchey 2009; Principle Power 2010a).

In January 2010, the National Institute of Standards and Technology announced a $12.4 million grant for the Advanced Nanocomposites in Renewable Energy Laboratory, located at the University of Maine in Orono as part of the Advanced Structures and Composites Center. The lab is scheduled to be completed in spring 2011. It will be the only facility in the United States to have complete development capabilities for designing, prototyping, and testing large structural hybrid composite and nanocomposite components for the deep water offshore wind energy industry (NIST 2010).

On December 15, 2009, the Maine Department of Conservation named three ocean energy demonstration sites: Boon Island, Damariscove, and Monhegan Island (ME DOC 2009). The demonstration site areas are shown in Figures B-6 through B-8.

2.4.2 New Hampshire

In November 2009, the University of New Hampshire's Center for Ocean Renewable Energy (CORE) announced that it was receiving $700,000 in stimulus funds to deploy and test a deepwater wind power turbine in the Gulf of Maine. The floating tower will be moored to the seabed (CORE 2009). CORE has a full-scale wave energy test site at the University of New Hampshire's Atlantic Marine Aquaculture site in 170 feet (52 meters) of water, approximately 6 miles from the New Hampshire coast (CORE 2010).

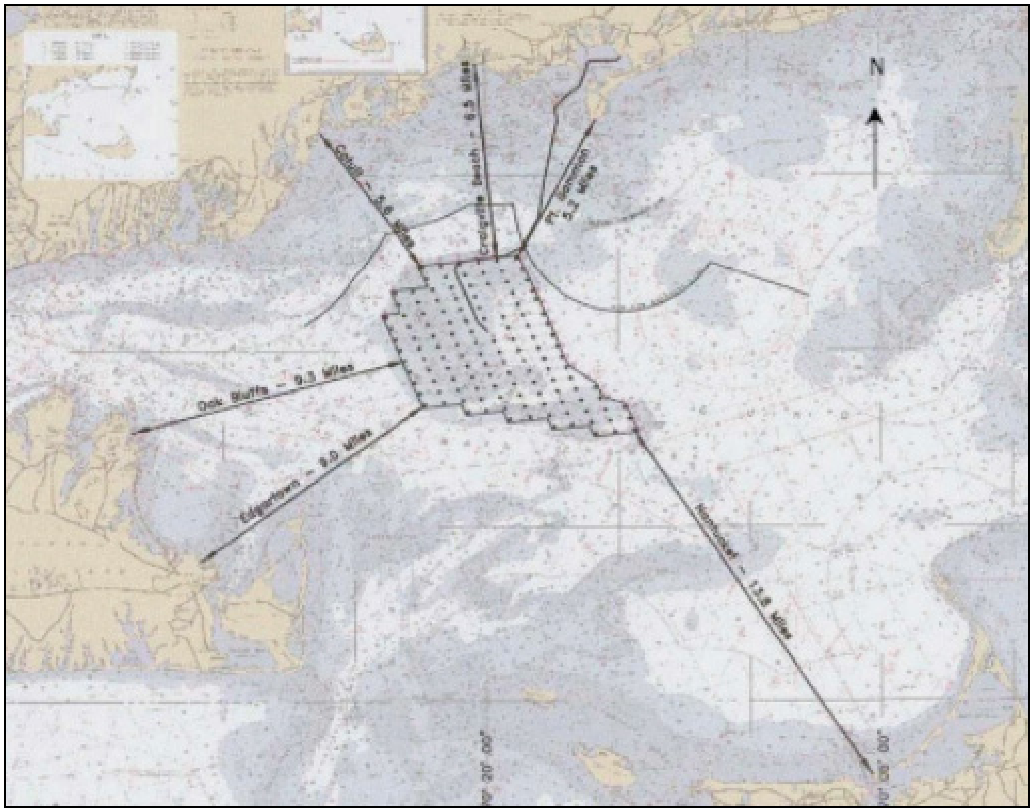
2.4.3 Massachusetts

2.4.3.1 Cape Wind

Energy Management, Inc. first proposed the Cape Wind project in 2001. The U.S. Army Corps of Engineers assumed the lead federal regulatory role under the River and Harbors Act, and issued a draft EIS in November 2004. In 2005, Congress expressly authorized MMS to regulate and approve offshore wind facilities in the OCS. MMS published the Cape Wind draft EIS in January 2008 and the final EIS on January 16, 2009. On December 1, 2009, National Grid entered into a memorandum of understanding with Cape Wind and the Massachusetts Department of Energy Resources, which sets a proposed timetable and method by which National Grid will solicit a proposal from Cape Wind and potentially execute a long-term contract for energy, capacity, RECs, and related products from Cape Wind's offshore wind facility (MA DPU 2009a). National Grid and Cape Wind reached an agreement on a long-term power purchase agreement within 60 days of the execution of the memorandum (MA DPU 2009b; Ailworth 2009). The presence of a long-term purchasing agreement is a key factor in the economic viability of such power projects.

On January 4, 2010, the National Park Service determined that Nantucket Sound was eligible for listing in the National Register of Historic Places. On February 2, 2010, U.S. Interior Secretary Ken Salazar met members of the Mashpee Wampanoag tribe and discussed their concerns about the project (Daley 2010; USDOI MMS 2010a; USDOI NPS 2010; Rodgers and Olmstead 2008).

On October 4, 2010, BOEMRE issued a license to Cape Wind (USDOI MMS 2010a). Figure 4 illustrates the layout and orientation of the planned wind turbine array. The site is located in Nantucket Sound, south of Cape Cod, northeast of Martha's Vineyard, and northwest of Nantucket (Rodgers and Olmstead 2008). The wind farm would consist of 130 Siemens wind turbines, each capable of producing 3.6 MW, for a total delivered electricity capacity of about 450 MW.[19] Each turbine would have a maximum height of 440 feet with a rotor diameter (i.e., tip-to-tip measurement of the blades) of 364 feet. The turbines would be supported on monopile foundations at an average water depth of 30 feet. Within the wind farm array, the turbines would be linked by strings of transmission cables to a central electrical service platform. At the platform, the voltage would be stepped up from 33 to 115 kilovolts (kV) for transmission through two transmission circuits to the NStar grid approximately 12.5 miles away. Both sets of cables would be buried to a depth of 6 feet through jet plow embedment (USDOI MMS 2009b; Cape Wind 2010).



Source: Rodgers and Olmstead (2008).

Figure 4. Cape Wind proposed layout.

Cape Wind identified Quonset, Rhode Island, as the planned onshore staging area (Cape Wind 2009). Unlike Deepwater Wind in its proposal to Rhode Island (see Section 2.4.4.1), Cape Wind did not commit to establishing a manufacturing center at Quonset.

[19] Line losses account for the difference between the possible capacity (i.e., 130 turbines at 3.6 MW is 468 MW) and what could be delivered to the grid.

Cape Wind places the total capital cost of the wind farm at $700 million. The company estimates that construction and installation activities would entail an estimated 391 jobs during the 27-month period. Approximately 316 jobs would likely be in Quonset, Rhode Island, for manufacturing and assembly activities and 75 jobs would be in construction and installation jobs in Barnstable, Massachusetts. The work force would be drawn from both Massachusetts and Rhode Island, with an estimated 135 and 256 jobs, respectively (Cape Wind 2009).

Cape Wind estimates that each turbine would require five days of maintenance per year—two days of planned or preventive maintenance and three days of unplanned or forced outage emergency maintenance. For 130 turbines and five maintenance days per turbine, between two and three crews are needed to cover the 650 work days. Annual maintenance is estimated to entail 50 jobs. The crew boat(s) are assumed to travel out of Falmouth, while a maintenance support vessel is assumed to travel from New Bedford (Cape Wind 2009).

2.4.3.2 Wave

Grays Harbor had applied to FERC for a wave energy site located 12 to 23 miles southeast of Nantucket Island. FERC dismissed the application in April 2009 (Grays Harbor 2009a).

2.4.3.3 Research Facilities

The University of Massachusetts at Dartmouth houses the New England Marine Renewable Energy Consortium. Its mission is to foster the development of ocean-based renewable energy projects (e.g., wave, tidal, current, and wind projects); it is currently developing a test site in Muskeget Channel between Martha's Vineyard and Nantucket (Boyd 2008).

In May 2009, DOE provided $25 million in funding for the Massachusetts-NREL Wind Technology Testing Center, to be located in Charlestown, Massachusetts. The application was submitted in 2006 and the project was selected in 2007; the funding was awarded in May 2009. The center, which opened in May 2011, is the first commercial large blade test facility in the nation—it will allow for testing of blades longer than 50 meters (164 feet), which currently can be done in Europe but not in the United States (USDOE 2009b; MTC 2010b; MACEC 2011).

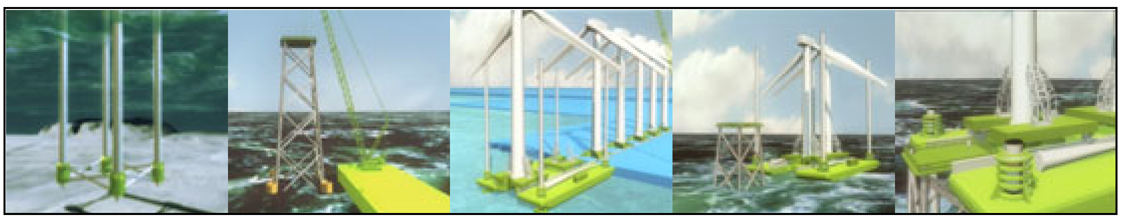
2.4.4 Rhode Island

2.4.4.1 Deepwater Wind Block Island and Rhode Island Sound Projects

Deepwater Wind's proposed Rhode Island wind farm continues to move forward. In January 2009, Governor Carcieri signed a joint development with Deepwater Wind Rhode Island, LLC, to supply 1.3 million MWh per year, with the final site selection dependent on the outcome of the SAMP process. On June 26, 2009, Governor Carcieri signed a bill requiring National Grid, Rhode Island's largest utility, to enter into long-term power purchase agreements for renewable energy (RI Office of the Governor 2009a, 2009b). In December 2009, Deepwater Wind and National Grid signed a long-term power purchase agreement (RI EDC 2009). In August 2010, the Rhode Island Public Utilities Commission approved a power purchase plan for the Block Island Project.

Deepwater Wind's proposal has two phases. Phase 1—called the Block Island Project—will be an eight-turbine, 20 MW project in state waters (at a site chosen from locations shown to be acceptable by the SAMP). Phase 2—called the Rhode Island Sound Project—is a utility-scale project in a separate location within the SAMP, capable of producing 1.3 million MWh per year on submerged lands leased from the Federal government. This would be about 100 turbines located about 15 miles from the nearest landfall (Isensee 2009; RI Office of the Governor 2009b).

Deepwater Wind uses a jacket design to support a wind turbine, a technology the company describes as standard in the oil and gas industry. The jacket design permits installations in water depths up to 150 feet; the company notes that monopile designs (e.g., in the proposed Delaware Bluewater project) become costly in water depths exceeding 70 feet. Figure 5 illustrates the Deepwater Wind jacket technology and installation. From left to right, pin piles are sunk into the seabed, a conventional barge carries the jacket to the site where it is cemented to the piles, turbines are assembled on shore and loaded onto an installation barge which transports the turbine to the jacket, and the barge "floats" the turbine over the jacket for connection to the jacket (Deepwater Wind 2010a).



Source: Deepwater Wind (2010a).

Figure 5. Deepwater Wind offshore jacket and turbine installation.

Deepwater Wind does not identify its turbine manufacturers. The website says only that the company "works only with world-class marinized turbine suppliers" (Deepwater Wind 2010a), which, in 2010, likely means Siemens or Vestas.

Deepwater Wind was one of seven proposals submitted to the Rhode Island Wind Energy Proposal Evaluation Team. Job creation was one of the evaluation factors, and Deepwater Wind agreed to establish a manufacturing facility in Quonset that will manufacture support structures (for turbines and their towers) that will service all of Deepwater Wind's northeast projects. Rhode Island estimates that the agreement will create approximately 600 to 800 direct jobs, with annual wages of $60 million (QDC 2009; RI Office of the Governor 2009a).

2.4.4.2 Blue H USA Project

On August 21, 2009, Blue H USA, LLC, submitted an application to the Army Corps of Engineers to install a deepwater floating offshore wind platform in federal waters. The platform would be located on the OCS, approximately 23 miles southwest of Martha's Vineyard. The Army Corps ruled that the application was complete and it was opened to public comment between September 15 and October 15, 2009 (Blue H 2009a). The objective of the platform is to address the suitability of the location for utility-scale operations. The platform will be installed at a water depth of 51 meters (167 feet). The offshore Vineyard site was selected because it is an area without a great deal of boat traffic and it does not sustain a fishery. The Army Corps has made a preliminary determination that the project would not substantially affect fish habitat

(Sigelman 2009). The test is structured to demonstrate the viability of deepwater offshore wind power, and will contain data collection equipment but no wind turbine. Blue H stated that the temporary facility was not subject to Federal lease requirements because of its temporary nature, pursuant to a MMS policy dated February 10, 2009, that eased offshore energy development. As such, Blue H USA considered its application to the Army Corps to supersede its previous Nomination for Lease submission to MMS in March 2008 (Blue H 2009b).[20]

2.4.4.3 Wave

Grays Harbor had applied to FERC for a wave energy site south of Block Island, approximately 12 to 25 miles offshore. FERC dismissed the application in April 2009 (Grays Harbor 2009a).

2.4.5 Connecticut

According to DOE's Wind and Hydropower Technologies Program, the state of Connecticut has no operating or planned projects (USDOE 2010). However, a Connecticut-based company—COWI USA—had been selected by Santee Cooper, South Carolina's state-owned electric and water utility, as the prime consultant for the first phase of constructing an ocean-based anemometer tower, part of the Palmetto Wind Research Project and a key step in researching the viability of a proposed offshore wind farm in South Carolina. COWI A/S—based in Lyngby, Denmark, and one of the most successful offshore wind farm foundation design firms in the world—will provide technical expertise to the team on all phases of the project (COWI 2009).

2.4.6 New York

2.4.6.1 Long Island–New York City Offshore Wind Project

In June 2010, the NYPA Trustees—representing the Long Island–New York City Offshore Wind Collaborative—announced that they have authorized the application for a lease from BOEMRE for lands beneath the Atlantic Ocean for development of the Long Island–New York City Offshore Wind Project. The wind project site occupies approximately 64,500 acres of underwater land and is approximately 13 to 15 miles offshore of Long Island. The Collaborative is evaluating the feasibility of developing between 350 and 700 MW of offshore wind power by 2016 (NYPA 2010). In March 2009, New York's LIPA and Con Edison released a feasibility study for siting such a facility off the Long Island coast (Con Edison and LIPA 2009). On July 1, 2009, New York issued a request for information to which approximately 30 firms responded (LINYC 2009a, 2009b).

Deepwater Wind's website shows a project off the Long Island coast but says only "details to come" (Deepwater Wind 2010b).

[20] In 2008, Blue H proposed building a 120-turbine wind farm capable of generating 429 MW of power in the waters off Martha's Vineyard and New Bedford. The company has taken the formal application to MMS off the table for the present (Blue H 2009b).

2.4.6.2 Wave

Grays Harbor had applied to FERC for a wave energy site located off Long Island (east of Jones Island and south off the Hamptons), approximately 12 to 25 miles offshore. FERC dismissed the application in April 2009 (Grays Harbor 2009a).

2.4.7 New Jersey

2.4.7.1 Wind

New Jersey's Energy Master Plan Implementation Strategy calls for 1,000 MW of offshore wind capacity installed by 2012 and 3,000 MW installed by 2020 (NJ 2008b). Multiple wind farms are likely to be necessary to meet these goals. Several offshore wind energy projects are in the proposal stage.

Deepwater Wind

The Company has partnered with Public Service Enterprise Group Renewable Generation to form Garden State Offshore Energy (GSOE) as a joint venture. As mentioned in Section 2.3.3.7, the New Jersey Board of Public Utilities selected GSOE for a $4 million grant. The completion of the project is dependent on receipt of all required permits, ongoing analysis of environmental impacts, wind quality studies, energy markets, financing, and other conditions. These factors could affect the decision to proceed, as well as final location, design, and construction schedules. Deepwater Wind's acquisition of two leases in the OCS for the purpose of installing a meteorological tower and collecting data is a step in this process. GSOE is proposing to construct 96 wind turbines (350 MW) in a rectangular grid between 16 and 20 miles off the coast of Cape May, New Jersey (see Figure B-1). Deepwater Wind's intent is to have the wind turbines be only slightly visible from shore. If construction goes according to schedule, the development could begin generating electricity in 2012 and be fully operational in 2013 (GSOE 2008; Stein and Peters 2008).

Fishermen's Energy

Fishermen's Energy is a company that was founded in 2007 by Northeast commercial fishing companies. Like Deepwater Wind, it submitted a proposal to the NJBPU on March 4, 2008. The project is expected to occur in two phases. Phase I will be located in 692 acres of state waters 3 miles off the coast of Atlantic City. Eight 2.5 MW turbines would be oriented to produce 20 MW for interconnection with the PJM transmission grid; power would be sold to rural customers in New Jersey. Phase II is anticipated to be located in about 20,000 acres within federal waters 7 miles off the coast. Sixty-six turbines would produce about 330 MW. It is expected that power would be sold to municipal, commercial, industrial, and other customers in New Jersey. The company expects that the two phases will cost a total of $1.5 billion. Fishermen's Energy has taken this phased approach because it is consistent with the Blue Ribbon Panel directive for a pilot project. In addition, the approach allows time for finalization of the federal regulatory programs and for continued work toward commercializing offshore wind technologies.

In June 2009, Fishermen's Energy was awarded one of the four leases in OCS waters off the New Jersey coast (USDOI MMS 2009a) (see Figure B-1). In October 2009, the company won a $4 million grant from the state of New Jersey to build a meteorological tower. Fisherman's Energy launched a monitoring buoy in April 2010 as part of a preconstruction monitoring program. Depending on the permitting process, Fishermen's Energy is hoping to begin construction in 2012 (Chernova 2009; Fishermen's Energy 2010a, 2010b).

Bluewater Wind

Bluewater Wind was acquired by NRG Energy in November 2009 (NRG Energy 2009a). Bluewater Wind has received a $4 million state grant from New Jersey for an offshore meteorological tower and hopes to develop a 350 MW wind project at its preferred site, approximately 16 miles off the coast of Atlantic City (Barron 2008, 2009a, 2009b; Chernova 2009). MMS awarded Bluewater Wind a lease off New Jersey in April 2009 (USDOI MMS 2009a) (see Figure B-1).

2.4.7.2 Wave

Grays Harbor had applied to FERC for a wave energy site due east of Atlantic City, approximately 12 to 25 miles offshore. FERC dismissed the application in April 2009 (Grays Harbor 2009a).

Ocean Power Technologies (OPT) conducted a 24-month demonstration test of its prototype wave energy buoy. The deployment site was in the Atlantic Ocean, approximately 5 miles offshore from Tuckerton, New Jersey. This site is near the northeast corner of the Long-Term Ecosystem Observatory, which is part of the Coastal Ocean Observation Laboratory. The work was supported by the NJBPU. No power was transferred to the mainland (OPT 2010a). OPT does not appear to have applied to FERC for a preliminary permit in waters off New Jersey.

2.4.8 Delaware

2.4.8.1 Bluewater Wind

Bluewater Wind holds one of the first five exploratory leases issued by MMS on June 23, 2009, to authorize data-gathering activities and allow for the construction of meteorological towers on the OCS (NRG Energy 2009; USDOIMMS 2009a). Prior to the lease award, Bluewater Wind LLC submitted a proposal to Delmarva Power to construct an offshore wind facility with up to 150 turbines supplying between 230 and 400 MW. In July 2008, Delmarva Power executed a 25-year power purchase agreement with Bluewater Wind for 200 MW (DE NREC 2009). The range in capacity is explained by Figure B-13, which shows two wind farm regions separated by a shipping lane. Figure B-14 depicts the location of the OCS lease (Bluewater Wind 2010 and n.d.; USDOIMMS 2009a). The Bluewater Wind website has visualizations that show how the proposed projects would look from shore (Bluewater Wind 2010).

A presentation by Bluewater Wind estimates that the economic impacts during the construction phase would be a minimum of $800 million, up to 500 local jobs, $38.5 million in transmission line upgrades, and $7.2 million in direct impacts for the Port of Wilmington (due, in part, to a 25- to 30-acre site for a laydown area for towers, nacelles, foundations, and blades). The estimated economic impacts during O&M are reported as up to 80 jobs. About four or five boat slips would be involved, and the O&M area would be staffed 24 hours per day, seven days a week (Bluewater Wind n.d.). Bluewater Wind's website mentions that wind turbines need minimal upkeep, estimated as typically less than 48 hours per year (Bluewater Wind 2010). About 48 hours per year for each of 150 wind turbines is about 7,200 hours of maintenance per year. However, each maintenance hour could involve one or two vessel operators, plus two maintenance personnel, plus travel time to and from the wind tower, plus the need for 24/7 staffing.

2.4.8.2 Academic Program

The University of Delaware now offers a multidisciplinary offshore wind program in the College of Earth, Ocean, and Environment, which is part of the University's Center for Carbon-free Power Integration. Class offerings include "Offshore Wind Power: Science, Engineering, and Policy," where student reports range from an evaluation of wind and ocean current energy sources for Florida to the effects of offshore wind energy on beach tourism and surveying Delaware residents about their preferences for offshore wind power. A proposed Wind Energy Certificate program is undergoing internal review, with courses on wind power engineering, offshore wind power, composites manufacturing, fluid mechanics measurements, waves in the marine environment, electric power and renewable energy systems, and electric power distribution design (UD 2010).

2.4.9 Maryland

In December 2009, the state of Maryland signed a power purchase agreement with Bluewater Wind to supply up to 55 MW of wind power (NRG Energy 2009b). Presumably the power will be generated from the proposed wind farm described in Section 2.4.8.1.

2.4.10 Virginia

As mentioned in Section 2.3.3.10, VCERC identified 25 OCS blocks that are suitable for the development of offshore wind energy (VCERC 2010b) and are superior to any areas in state waters. The BOEM website mentions the agency has received two unsolicited applications for offshore wind projects off Virginia.

2.4.11 North Carolina

In October 2009, Duke Energy signed an agreement with the University of North Carolina at Chapel Hill to place up to three wind turbines in Pamlico Sound as a demonstration project (Duke Energy 2009). The South Carolina report on ocean energy lists the North Carolina project as 10 MW (Wind Energy Production Farms Feasibility Study Committee 2010).

2.4.12 South Carolina

South Carolina's focus appears to be on offshore wind energy development in state waters rather than the neighboring OCS region. Palmetto Wind is a collaborative project by Clemson University's Restoration Institute, Santee Cooper, Coastal Carolina University, and the South Carolina Energy Office. Activities include gathering data for an analysis of wind, wave, and tidal energy off the coast using six buoys and two land-based stations that will measure wind speed, direction, and frequency up to 6 miles from shore. The transects are off North Myrtle Beach and Winyah Bay, with the instruments located at 1.5, 3, and 6 miles from the beach (Wind

Energy Production Farms Feasibility Study Committee 2010; Restoration Institute n.d.; CCU 2010).

On August 6, 2010, Savannah National Research Laboratory deployed a monitoring device that uses sound to measure wind speeds (Bartleme 2010). Bartleme also reports that Clemson University's Restoration Institute will break ground this fall on a $100 million turbine test lab at the old Charleston Navy base.

2.4.13 Georgia

ERG identified no commercial or research projects on offshore renewable energy as of 2010.

2.4.14 Florida

On August 2, 2010, DOE designated the Center for Ocean Energy Technology at Florida Atlantic University as a national center for ocean energy research and development. The new Southeast National Marine Renewable Energy Center at Florida Atlantic University will work to advance the operational readiness of ocean energy technologies (FAU 2010). About two years ago, Florida Atlantic University's Center for Ocean Energy Technology deployed four Doppler current meters off the east coast of Florida, ranging from approximately 4.9 miles to 22.3 miles from Dania Beach at depths from 725 feet to 2,116 feet. The current meters will gather baseline information to characterize the spatial and temporal variability of the Gulf Stream, a preliminary step to evaluating this renewable energy source (FAU 2009).

In 2010, BOEMRE (now BOEM) worked with three potential ocean current energy generation developers. The projects in question fell under BOEMRE's Interim Policy. These were not commercial and were limited in scope (USDOI BOEMRE 2010e).

2.4.15 Washington

In February 2009, Finavera Renewables, Inc. surrendered its license for the wave energy project in Makah Bay (Finavera 2009a).

On September 21, 2010, FERC cancelled the preliminary permit (P-13058) for Grays Harbor Ocean Energy, LLC, that was issued in July 2008 (FERC 2010d).

2.4.16 Oregon

2.4.16.1 Wind

In November 2008, Principle Power, Inc., signed a memorandum of agreement with the Tillamook People's Utility District for the development of a floating wind farm off the coast of Tillamook County, Oregon. The memorandum stated that the location would be selected with the participation of local stakeholders (Principle Power 2008). Elsewhere, Principle Power noted that it was in discussions with the People's Utility District about a power purchasing agreement (Barron 2008b). Principle Power's website described the wind farm as located "about 10 miles from port" (Principle Power 2010b). Although this may have referred to a site within the state waters, it more likely to referred to a site in the OCS. BOEMRE (2010c) mentioned that it received expressions of interest in renewable energy projects on the OCS off Washington, Oregon, and California (both deepwater wind and wave projects).

Development of the farm would occur in two phases. The first phase would include installation of a 5 MW floating turbine to ensure the viability, reliability, and economics of the WindFloat technology. This technology is discussed in more detail in Section 4.1.1 below.[21] The second phase would be expected to begin in 2012 and would expand capacity of the system to the full nameplate capacity of 150 MW (Principle Power 2010b). Turbines could be assembled on land, towed the 10 miles or more offshore, and anchored to the seabed by six mooring lines. The electricity that the turbines produce would flow into an interconnected grid, and then would be delivered to shore via a single seabed cable, the cost of which would be approximately $1 million per mile (Hill 2008).

2.4.16.2 Wave

OPT made two filings to FERC in early 2010 regarding its Reedsport site. On January 29, OPT filed for a final license for a 1.5 MW Reedsport OPT Wave Park (FERC 2010a, 2010b). On February 1, OPT filed for a preliminary permit to secure and retain priority for its original application for the expansion of the 1.5 MW project to a 50 MW project in adjacent waters using OPT's PowerBuoy technology (FERC 2010e). Figure B-15 shows the proposed project location (OPT 2010b).

On August 10, 2010 FERC issues a second preliminary permit to Oregon Wave Energy Partners for the Coos Bay site to be located approximately 2.7 miles off the coast of Oregon, west of the towns of Coos Bay and North Bend. The planned size of this park is up to 100 MW. Like the Reedsport site, it will use OPT's PowerBuoy technology, possibly up to 200 buoys having an installed capacity of 100 MW, an approximately 3.4-mile-long subsea transmission cable, and an approximately 200-yard-long, 13.8-kilovolt transmission line connecting to an existing substation (FERC 2010f). Figure B-16 shows the proposed project location (OPT 2010c).

On June 18, 2010, FERC issued a notice of surrender for the preliminary permit for Project No. 13047 issued to the Tillamook Intergovernmental Development Entity (FERC 2010g).

[21] The former founder of AquaEnergy is one of the founders of Principle Power.

2.4.17 California

FERC lists nine wave energy projects in its preliminary permit database as of October 2010 (FERC 2010a). These are listed in Table 7.

Table 7
FERC Preliminary Permits for Wave Energy Projects in California

FERC Docket No.	Project Name	Permittee
P- 12779	Pacific Gas and Electric (PG&E) Humboldt WaveConnect	PG&E
P- 13052	Green Wave San Luis Obispo	Green Wave Energy Solutions, LLC
P- 13053	Green Wave Mendocino	Green Wave Energy Solutions, LLC
P- 13376	Del Mar Landing	Sonoma County Water Agency
P- 13377	Fort Ross (South)	Sonoma County Water Agency
P- 13378	Fort Ross (North)	Sonoma County Water Agency
P- 13498	SWAVE Catalina Green Wave	SARA, Inc.
P- 13461	Central Coast WaveConnect	PG&E
P- 13679	San Onofre OWEG Electricity Farm Project	JD Products, LLC

Source: FERC (2010c).

PG&E intends to test up to four different wave energy technologies at its WaveConnect project off Humboldt County. The study site is an approximately 18-square-statute-mile rectangle located between 2 and 3 nautical miles off the coast. PG&E formed the Humboldt Working Group to work with local stakeholders and regulatory agencies to reduce the study area to approximately 1 square nautical mile. Figure B-17 shows the proposed project location (PG&E 2010a).

In December 2009, PG&E applied for a preliminary permit for a wave energy project off the central coast of California. The proposed site is off the coast of Vandenberg Air Force Base and the subsea transmission cables would connect to the grid on the base. Figure B-18 shows the proposed project location (PG&E 2010b).

FERC issued a preliminary permit to Green Wave Energy Solutions, LLC, for a wave energy project off the Mendocino County coast on May 1, 2009, and a second preliminary permit for a project off the San Luis Obispo coast on May 7, 2009. The permit for the San Luis Obispo project limited the site to within state waters. On May 28, Fishermen Interested in Safe Hydrokinetics and other petitioners sought a rehearing of the permit order. FERC denied the rehearing. Each project would have had 100 MW installed capacity. The application did not specify which wave energy technology would be used (FERC 2009a, 2009b). On September 23, 2010, FERC cancelled both permits (FERC 2010h). However, the projects are still shown on the November 2010 map and included in the count on the map, so they are included in this discussion.

In July 2009, FERC issued the Sonoma County Water Agency preliminary permits for three areas (see Figures B-19 to B-21). The Agency intends to study the feasibility of developing 2 to 5 MW of wave power at each location and to assess the potential for expansion to over 40 MW at each of the three sites (SCWA 2009).

In September 2009, FERC issued a preliminary permit to Scientific Applications & Research Associates, Inc. (SARA, Inc.) which proposed to study the feasibility of the SWAVE Catalina Green Wave Energy Project, located in the Pacific Ocean approximately 0.75 miles off the west coast of Santa Catalina Island, on submerged lands of the state of California. In the permit, FERC notes concerns and comments submitted by the National Oceanic and Atmospheric Administration's National Marine Fisheries Service regarding essential fish habitats, threatened and endangered species or their critical habitats, and the possible need for SARA to obtain a permit under the Marine Mammal Protection Act. FERC further notes that such questions would be addressed during a licensing process, while the purpose of a preliminary permit is to provide "first-to-file" status for the filer and permit the conduct of investigations to determine the feasibility of the project. SARA has developed and patented a magnetohydrodynamics generator and is currently looking for investors (FERC 2009c; SARA 2010).

On October 29, 2010, FERC issued a preliminary permit to JD Products, LLC, to study the feasibility of the proposed San Onofre OWEG (Ocean Wave Electricity Generation) Electricity Farm Project. OWEG is described in more detail in Section 4. The proposed farm would consist of more than 11,000 OWEG units with an estimated installed capacity of 3,186 MW. The project site is located next to the San Onofre Nuclear Power Plant in San Onofre, California. The nuclear power plant has smart grid transmission lines of 500 kV and 230 kV currently in use. The project plan calls for a 2,640-foot 500 kV transmission line that interconnects with the San Onofre substation (FERC 2010i).

2.4.18 Summary

Sections 2.4.18.1 through 2.4.18.3 summarize the status of wind, wave, and ocean current projects, respectively. As can be seen from the sections above, projects under consideration can be dropped at any point in time. Additionally, the date when a project might begin commercial operation depends on the timing of the regulatory process. Due to these uncertainties, ERG did not develop specific project timelines. Where possible, the summaries are presented on a "near-term" and "mid-term" basis with the understanding that not all projects listed might reach commercial operation.

2.4.18.1 Wind

Table 8 summarizes some of the characteristics for three projects described in the previous sections that are farthest along the regulatory process. Together, they might generate about 1,300 MW. Table 9 lists other wind projects that are either being requested by states or listed on company websites, as well as companies holding one of the five leases issued by MMS in 2009. The upper bound total capacity of the projects listed in Table 9 is nearly 2,800 MW.

Table 8
Proposed Wind Project Characteristics—Near-Term

	Project		
Developer	Bluewater Wind	Deepwater Wind	Cape Wind
State	Delaware	Rhode Island	Massachusetts
Distance From Shore	13 miles	15 miles	5.6 miles
Waters	OCS	State/OCS	OCS
Number of Turbines	150	5 to 8 in state waters; 100 in federal waters	130
Design	Monopile	Jacket	Monopile
Capacity	450 MW	28 MW (state) 385 MW (federal)	450 MW
Proposed Installation Date	2010–2013	2013 (state) 2015 (federal)	27 months after approval
PPA	Yes	Yes	Yes
Installation	At least $800 million, 500 jobs	$1.5 billion	$700 million, 391 jobs
O&M	Up to 80 jobs	N/A	$16 million 50 jobs

Table 9
Potential Wind Project Characteristics—Mid-Term

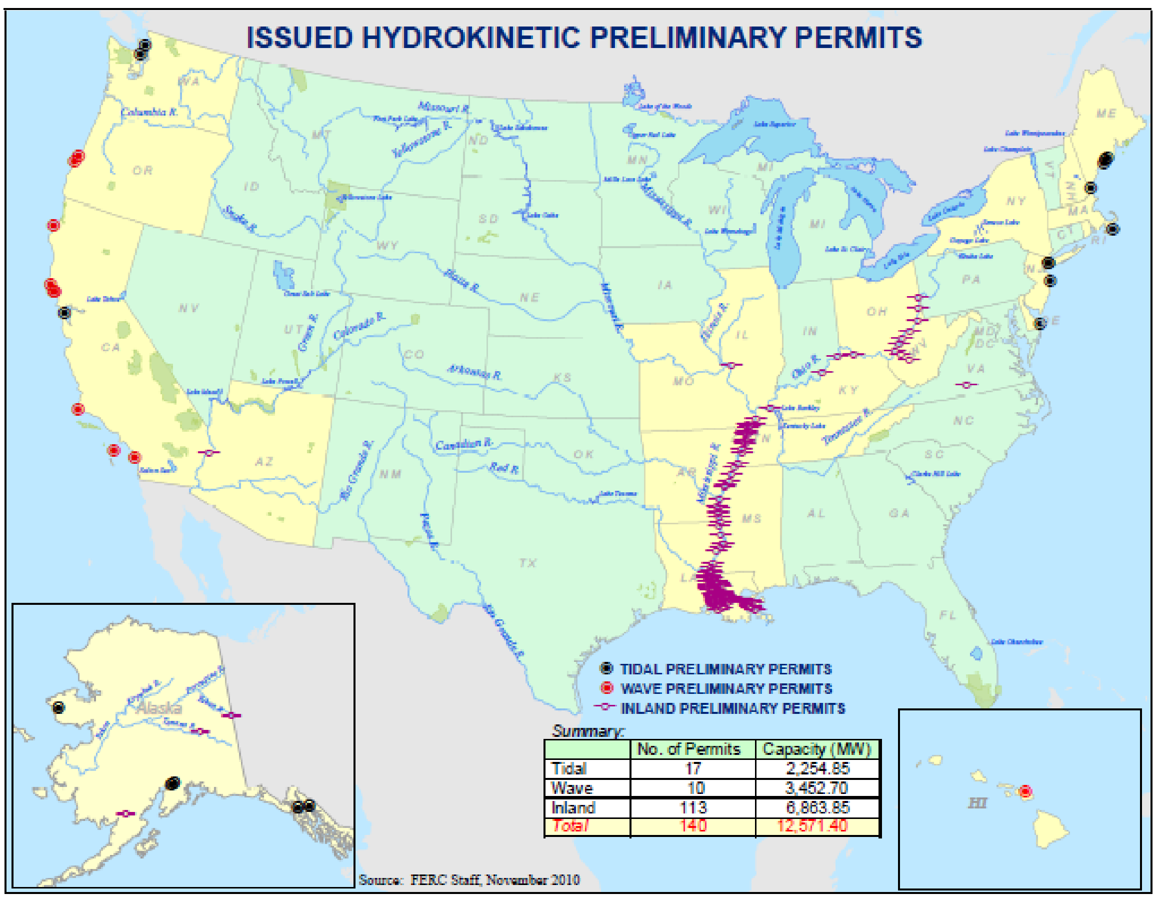
Developer	State	Waters	Capacity (MW)
Blue H (withdrawn as of February 2010)	RI	OCS	429
LIPA/Con Ed Long Island Offshore Wind Park	NY	OCS	350 or 700
Deepwater Wind Garden State Offshore Energy	NJ	OCS	345
Bluewater Wind New Jersey Energy, LLC	NJ	OCS	350
Wind Fishermen's Energy of New Jersey, LLC	NJ	State/OCS	20 (state) 330 (OCS)
Bluewater Wind	DE	OCS	230 to 450
State	MD	State	Proposals received March 2010; no decision as of November 2010
Tillamook Wind Farm	OR	OCS	5 (test phase); 150 (full scale)

Note: Not all projects listed might come into commercial operation.

2.4.18.2 West Coast Wave Projects

Figure 6 shows the location of preliminary permits for hydrokinetic projects issued by FERC as of October 2010. Wave projects are located along the West Coast. Table 10 lists 12 projects because the Reedsport OPT Wave Park in Oregon has moved to the licensing stage and the San Onofre project is pending. When looking at Figure 6 and Table 10, the reader should remember that it is possible, if not likely, that some of these projects will not be completed. As noted above, Finavera Energy surrendered its wave energy projects to FERC (Finavera 2009a).

The projects use a range of technologies. The Greenwave projects propose using either the OPT or Pelamis technology (FERC 2009c, 2009e). These technologies are described in more detail in Section 4.1, but the OPT technology is a point-absorbing buoy that uses the up-and-down motion of the water while the Pelamis technology is an attenuator—a string of cylindrical sections that resist the wave motion between the joints. The OPT and SARA projects would use the company-specific technologies, i.e., the OPT point-absorbing buoy or a magnetohydrodynamics generator, respectively (FERC 2009e, 2010f, 2010g; see Section 4.1). The Sonoma County Water Agency and WaveConnect projects do not specify a final technology (SCWA 2009; PG&E 2010a, 2010b). The Tillamook project would use a floating turbine (Principle Power 2008).



Source: FERC (2010a).

Figure 6. FERC-issued permits for hydrokinetic projects.

Table 10
Hydrokinetic Projects

Docket No.	Project Name	Permittee	State	Auth MW	Waters
P- 12779	PG&E Humboldt WaveConnect	PG&E	CA	40	State
P- 13052	Green Wave San Luis Obispo	Green Wave Energy Solutions, LLC	CA	100	State
P- 13053	Green Wave Mendocino	Green Wave Energy Solutions, LLC	CA	100	State
P- 13376	Del Mar Landing	Sonoma County Water Agency	CA	5	State
P- 13377	Fort Ross (South)	Sonoma County Water Agency	CA	5	State
P- 13378	Fort Ross (North)	Sonoma County Water Agency	CA	5	State
P- 13498	SWAVE Catalina Green Wave	SARA, Inc.	CA	6	State
P- 13461	Central Coast WaveConnect	PG&E	CA	100	State
P- 13679	San Onofre OWEG Electricity Farm Project	JD Products, LLC	CA	3,186	State
P- 12749	Coos Bay OPT Wave Park	Oregon Wave Energy Park Partners	OR	100	State
P- 13058	Grays Harbor Ocean Energy	Grays Harbor Ocean Energy Co. LLC	WA	6	State
P- 12713	Reedsport OPT Wave Park	Reedsport OPT Wave Park, LLC	OR	1.5	State

Note: Not all projects listed might come into commercial operation.
Source: FERC (2010a).

2.4.18.3 Current

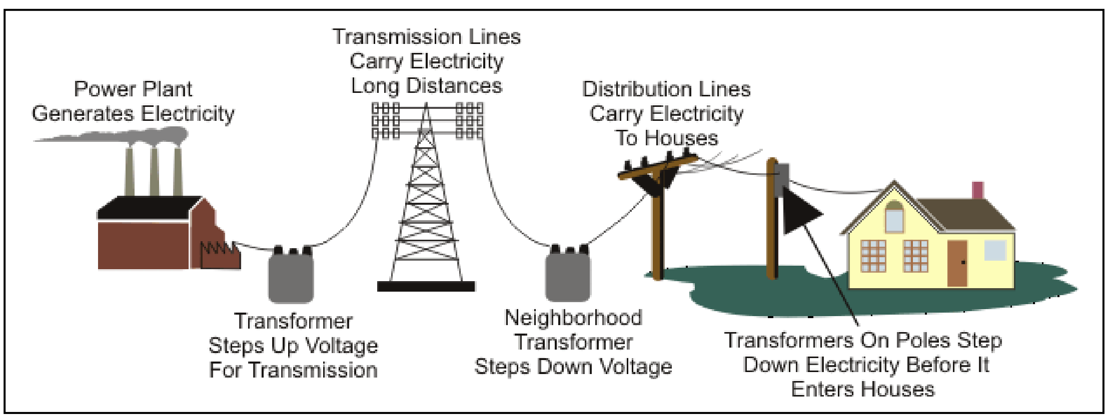
FERC has issued no preliminary permits for ocean current projects as of December 2010.

3 ELECTRICAL ENERGY MARKET: A PRIMER

Approximately 42% of the population of the U.S. lives in the coastal zone.[22] The proximity of offshore renewable energy sources to centers of electricity demand is a critical aspect of utility planning. Electricity is produced on all scales, ranging from home solar panels that meet part of one household's needs to multi-unit central generating stations that supply electricity to half a million households. Distance from the generating source to the consumer can range from a few feet to a thousand miles or more. For example, a renewable energy generating station might be located several miles offshore and provide electricity for major cities along the coast. Regardless of their scale, all electricity production feeds into the same power system and shares the same physical components. A better understanding of these components and of the relationship among them and proximity of offshore renewable energy sources to onshore electricity centers will provide a basis for utility planning. This chapter provides an overview of the major components of the electric industry and how they will impact the development of renewable offshore resources.[23]

3.1 BASICS OF ELECTRICITY

The major physical components of the U.S. electric power system are generation, transmission, and distribution. Electricity is a secondary energy source, produced by electric generators that transform energy from primary sources. These primary sources include wind, water, coal, natural gas, nuclear fission, and sunlight. After the electricity is generated, the transmission system transfers it from the offshore generator to onshore local distribution systems. Transmission systems can carry over long distances. Finally, local distribution systems deliver the electricity to end-users, including industrial, commercial, governmental, and residential consumers.



Source: USDOE (n.d.).

Figure 7. Basic schematic of the electricity system.

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[22] The definition of "coastal zone county" may vary from state to state. For, example, all of Florida is defined as a coastal zone. Coastal zone counties make up about 20% of the land area of the U.S. (including Alaska and Hawaii). For more information, see "NOAA's Coastal and Ocean Resource Economics" (NOAA 2009).
[23] See USDOE EIA (2009a) for an overview of U.S. electricity statistics. See also Steinhurst (2008).

Figure 7 illustrates how electricity is generated and transmitted to end-users. At the left of the figure is a generating station that produces electricity from a primary fuel such as wind, coal, or gas. The step-up transformer increases the voltage of the generated power for transmission.[24] The electricity then flows along transmission lines until the power is "stepped down" by another transformer and distributed to homes and businesses for end-users to consume.

The direct storage of electric energy is quite difficult and expensive, and at present only a small amount of electricity can be stored for later use.[25] As a result, resource planners must ensure that capacity, which is the amount of generation and transmission resources available, suffices to meet the instantaneous needs of customers at all times.[26] The electricity that is needed to meet customer demand at any point in the electric system is known as "load." Load centers are concentrated areas of customers. Load fluctuates over the course of the year and the course of the day, and is said to "peak" when system demand is at its highest point. For example, in many regions of the country, annual peak load occurs in the summer due to increased use of air conditioners. In these areas, the hourly peak load is often in the mid- to later afternoon (USDOE n.d.).

Since the 1970s, the electric industry has undergone successive waves of change that have altered the organization, ownership, and regulation of generation, transmission, and distribution.[27] Currently, electricity is provided to retail customers by utilities that either own generation or have arrangements with generating plants. In many regions of the country, and in most of the OCS-situated regions, regional transmission operators (RTOs) or independent system operators (ISOs) provide transmission services. Prior to the formation of RTOs and ISOs, vertically integrated electric utilities owned and provided transmission services, and in the areas of the country where RTOs and ISOs do not exist, those utilities retain responsibility for transmission in their areas.

Figure 8 is a map of the RTO and ISO regions of North America. The RTO and ISO regions that border the OCS are the New England ISO (ISO-NE), the New York ISO (NYISO), the PJM Interconnection (PJM), and the California ISO (CAISO). RTOs and ISOs are regulated by FERC. The roles of utilities, RTOs, ISOs, and FERC are discussed in more detail later in this chapter and in Section 3.2.

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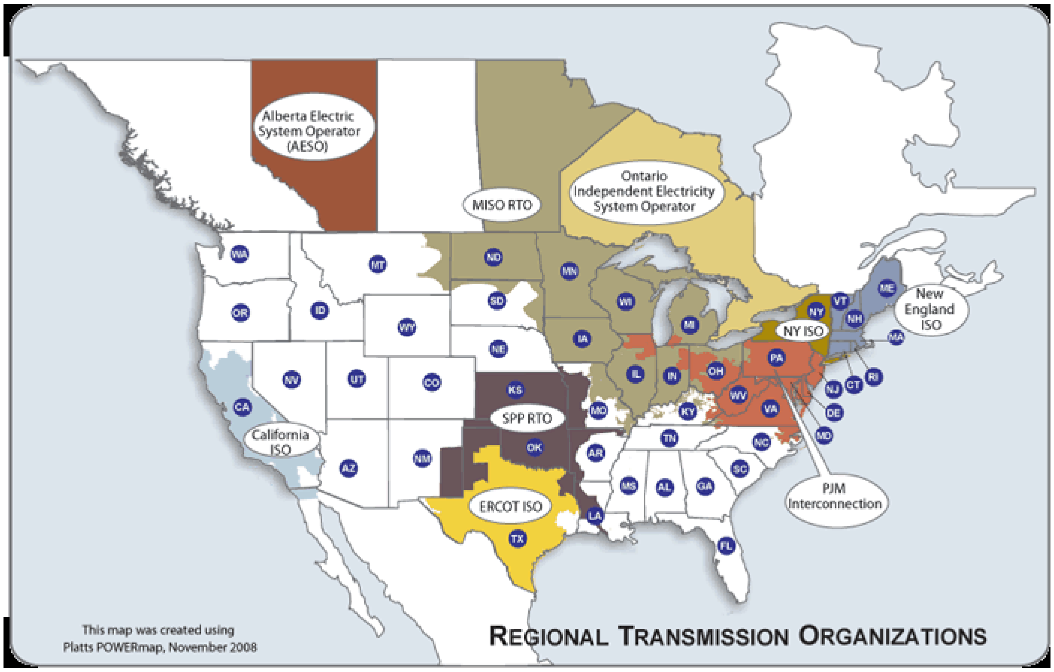
[24] Voltage is a measure of electromotive force or the pressure of electricity, measured in volts (abbreviation: V). Most transmission takes the form of alternating current at voltages from a thousand to around 750,000. Electricity can be moved long distances more efficiently using high voltage.

[25] Some examples of large-scale electricity storage are pumped storage facilities where water is pumped to a reservoir during periods of low usage and then released during periods of high demand. Recently there has been discussion of the use of large numbers of hybrid vehicle batteries as a form of electrical energy storage.

[26] Capacity is usually measured in kilowatts (kW—one thousand watts), megawatts (MW—one million watts) or gigawatts (GW—one billion watts).

[27] For an overview of the evolution of electric industry structure, see *The Electric Industry at a Glance* (Steinhurst 2008).



Source: FERC (2009a).

Figure 8. RTO and ISO regions of North America.

3.1.1 Electricity Generation

An electric power generator uses a turbine or similar machine to convert mechanical energy to electric energy. The energy from a primary source, such as coal, nuclear fuel, moving water, oil, gas, or wind, rotates the turbine, which moves an electromagnet through a series of wire coils, generating an electric current. The small currents from each wire coil in the generator are added together to form one large current that flows from the electric power station through transmission and distribution lines to consumers.

Electric generators take many forms and use a variety of primary fuels. A common set of metrics can be used to compare the attributes of generators across technologies, including generator capacity, capacity factor, capital costs, and O&M costs. A generator's capacity is the maximum amount of electricity it can supply to load, given ambient conditions. Capacity factor is a measure of relative utilization and is equal to the ratio of the actual energy produced in the year to the energy the unit would have produced at full capacity.[28] Capital costs are the costs of construction, equipment, and project management required to install an electric generator. O&M costs are the ongoing costs of keeping a generator running. O&M costs may be fixed costs that do not change based on the output of the plant, as opposed to scheduled maintenance, and variable costs that can fluctuate based on unit output. Fixed costs are typically expressed in dollars per megawatt-year or per kilowatt-year, and dollars per MWh or per kWh are used for

[28] The capacity factor ratio will always be between 0 and 1, since all electric generating units will have some downtime for maintenance.

variable costs.[29] The cost of fuel for the electric generator is usually considered a variable cost, but it may be zero for many renewable energy projects, such as wind generators.

These generator characteristics determine which generators are used to provide energy at a given time. The generators that are available to supply energy to a regional electricity grid are often categorized as baseload, intermediate, or peaking resources. Baseload generators have low O&M costs and high capacity factors and operate almost continuously regardless of load levels, notwithstanding scheduled or unscheduled shutdowns. Intermediate resources operate when load is greater than baseload, but has not reached peak load; their average annual capacity factors range from 50% to 60%. Intermediate-load generators are more responsive in their ability to start up or shut down. Peakload generators (or "peakers") are generally the most expensive generators available (high costs per unit of output), but have the operational flexibility to respond to sudden changes in demand. Because baseload plants are designed for maximum efficiency and output, these resources are therefore more expensive to build but have lower variable costs. In contrast, intermediate and peaking resources sacrifice some efficiency (resulting in higher variable costs) in exchange for lower capital costs.

Figure 9 illustrates the fundamental pattern of load over a 24-hour period, and how baseload, intermediate, and peaking resources are used to meet that load. Offshore renewable energy resources do not easily lend themselves to the traditional characterization of resources as baseload, intermediate, or peaking. In the case of wind farms, which depend on an uncontrollable phenomenon (wind), energy does not produce a steady stream of energy, nor can it be guaranteed to be available at a specific time. Wind and other renewables are therefore considered to be "intermittent resources." Wave and current projects might provide a more stable energy source than wind farms and resemble a baseload resource, but the technology is too new to have data that support this position.

3.1.1.1 Electricity Consumption Trends in the United States

Annual growth in electricity consumption has slowed in the United States. Data from the Energy Information Administration (EIA) show that national electricity sales decreased by 4% in 2009 compared to sales in 2008; however, EIA attributes this negative growth to the economic downturn and expects positive growth of 1.6% in 2010. Areas expected to show the strongest growth in 2010 are the West North Central (3.9%) and East South Central (3.8%) census regions. Regions along the OCS are expected to show growth rates ranging from 0.11% in the Pacific Contiguous region to 1.9% in the Mid-Atlantic (USDOE EIA 2009b, Table 7b). The national reserve margin (the available extra capacity above peak load) has remained steady at about 16% since the mid-1990s.[30]

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[29] A megawatt-hour (abbreviation MWh) is a measure of the quantity of electricity supplied or consumed at the rate of one megawatt per hour. While generator capacity is usually expressed in megawatts, generator output is usually expressed in megawatt-hours.

[30] The summertime balance is often singled out in discussions about load and generating capacity balance, because the summer surpluses are narrower in most parts of the United States as a result of increased demand, specifically the large increase in the usage of air conditioning.

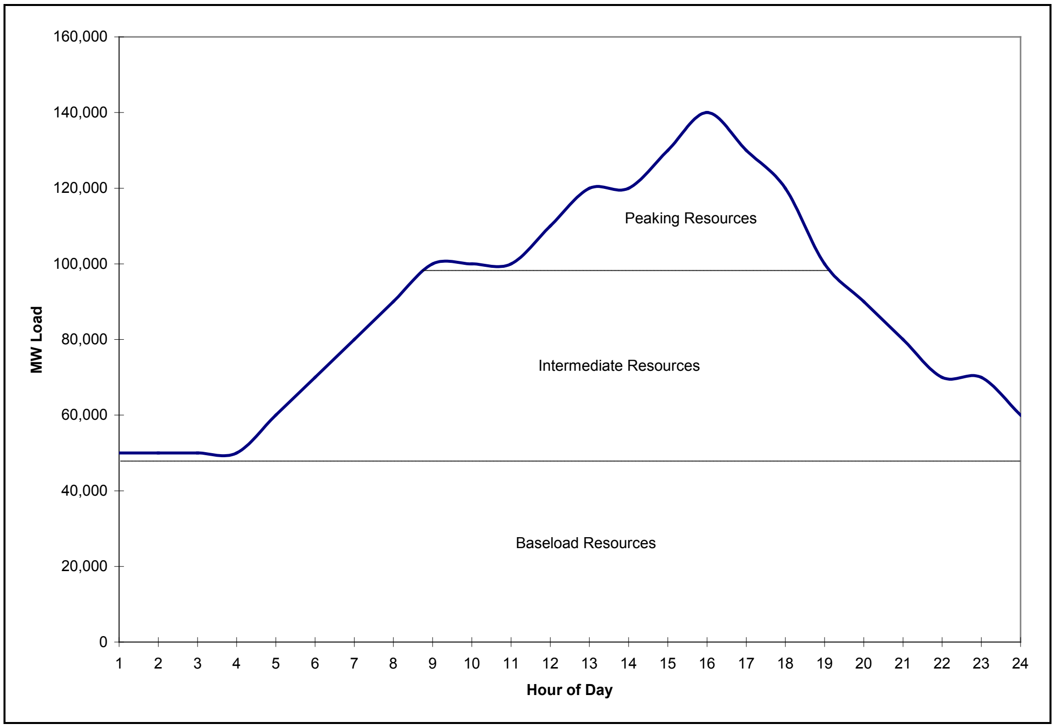
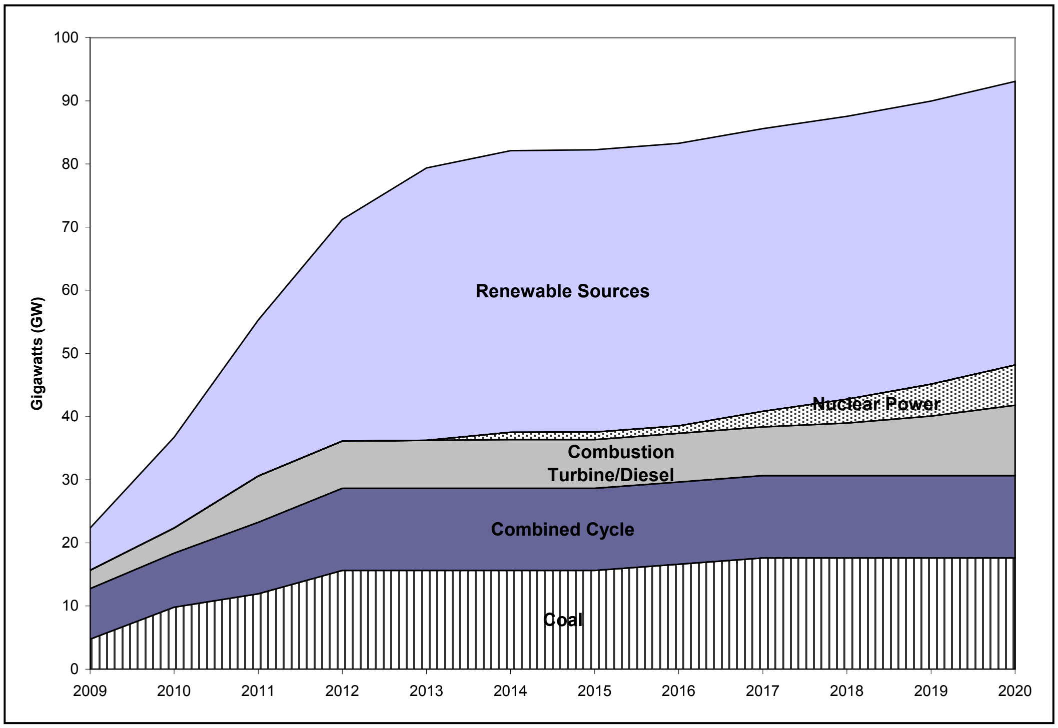


Figure 9. Typical diurnal load cycle.

The need to develop new, cleaner resources to replace retiring sources is at least as important as the need to develop resources to meet any increased demand. Approximately 58% of electricity generation capacity in the United States was operational before 1980, and 27% of generators are at least 35 years old. This suggests that the development of new projects within OCS regions may be necessary if only to replace energy output from aging plants and outdated technologies that may be rendered less economical due to new regulatory requirements for pollution control. These regulatory requirements and their implications for the economics of generating technologies are discussed in Section 3.3.

On April 22, 2009, President Obama issued a policy statement declaring that the United States should lead the development of renewable electricity generation. He announced the establishment, through the Department of the Interior, of a program to authorize the leasing of federal waters for offshore wind and ocean technologies (White House 2009). As shown in Figure 10, EIA projects that low-carbon resources, such as the types of renewable generation projects that may be developed within the state waters and federal OCS regions, will be the predominant sources of electricity generation growth. Drivers for this shift toward renewable technologies include federal tax incentives and state energy programs. In addition to these drivers, the rising prices of fossil fuels will increase the cost-competitiveness of renewable and nuclear capacity. Likewise, apprehension of new increased limits on GHG emissions will likely reduce the competitiveness of coal (USDOE EIA 2009c, p. 72). See Section 3.4 for additional details.



Source: USDOE EIA (2009c).

Figure 10. EIA-forecasted capacity additions by type.

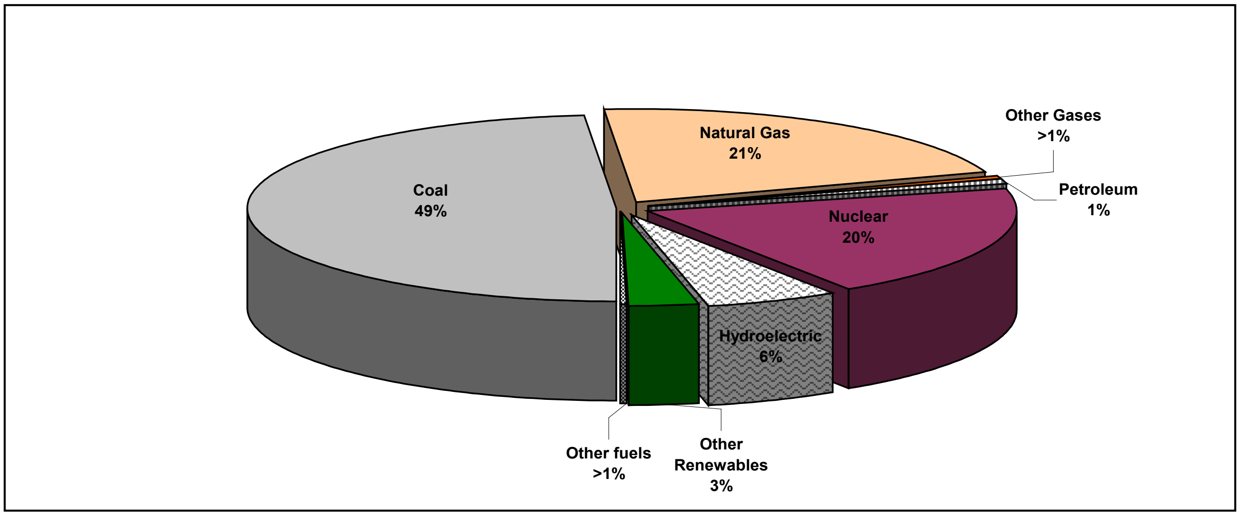
3.1.1.2 Generation Fuel Types

As mentioned above, electric generators use a variety of fuels as the primary energy source to produce electricity.[31] Energy sources for electricity generation can be categorized as:

- Renewables, including the sun, biomass, rivers, ocean currents, geothermal sources, wind, tides, and wave energy.
- Fossil fuels, including natural gas, petroleum, and coal.
- Nuclear fission.

Figure 11 below shows the share of U.S. electricity generation from each fuel type in 2008.

[31] Section 3.1.1.2 is an overview of the major fuel sources in the United States. Detailed information about the individual fuel sources is available through the Department of Energy's (DOE's) Energy Information Administration (EIA) website at http://www.eia.doe.gov.



Notes: Percentages may not sum to 100% due to rounding.
Source: USDOE EIA (2009b).

Figure 11. U.S. electricity generation by type, 2008.

Fossil fuels, also known as hydrocarbon fuels, are formed by the decay of organic material in the Earth's crust. About 70% of U.S. electric generation derives from fossil fuels (natural gas, oil, coal), and about 50% derives from coal alone. Coal is a relatively abundant and inexpensive source of energy in the U.S. It is often relied upon for baseload generation. Electric generation from fossil fuels can produce harmful pollutants such as nitrous oxide, sulfur dioxide, and mercury, and also releases carbon dioxide and other GHGs into the atmosphere.

After coal, natural gas and nuclear power plants provide most of the remaining electric capacity in the U.S. In recent years, growth in the electric industry has been dominated by new natural gas plants. Natural gas plants have lower capital costs than coal-fired plants, but they are subject to highly volatile fuel prices and are therefore often run as intermediate or peakload generators. There are two primary types of new natural gas plants: combined cycle and combustion turbine. Combined cycle units have both combustion and steam turbines, which lead to increased plant efficiency and greater output. These plants are often used as intermediate units, though they can sometimes serve baseloads. Combustion turbines are less efficient and are typically operated as peaking units, and these units are the most likely to be used to follow intermittent renewable resources. Natural gas is a fossil fuel like coal, but gas-fired plants are less polluting than coal-fired plants. GHG emissions by fuel type are discussed more completely in Section 3.3.

Nuclear generation provides about 20% of the electricity in the United States. Given their low variable costs, nuclear generators usually supply baseload electricity. Nuclear plants are very expensive to build, and though they do not directly emit GHGs,[32] environmental and safety concerns regarding siting and radioactive waste disposal remain.

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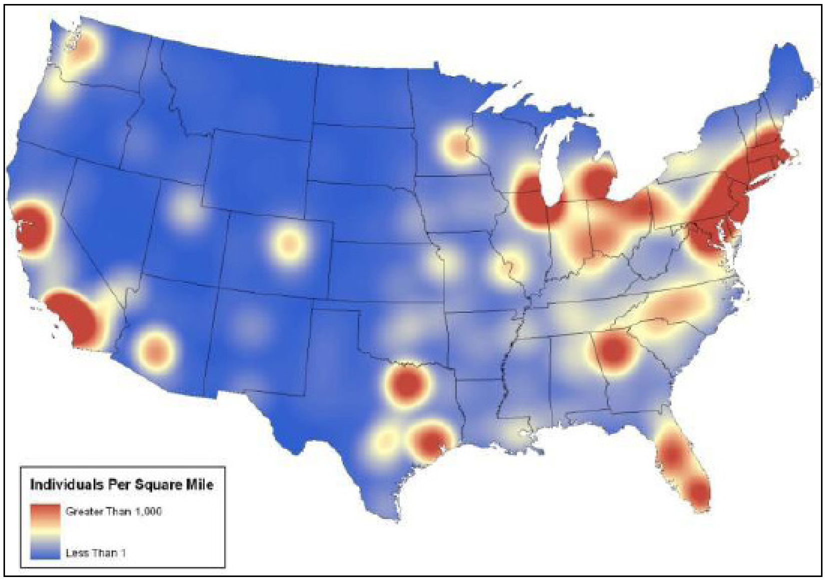
[32] GHGs are emitted over the course of the nuclear fuel cycle involving the extraction and processing of nuclear fuels for "consumption" in nuclear power stations.

Renewable energy sources provide a relatively low share of the nation's electricity. Hydroelectric generation provides 6% of the country's electricity. Half of the hydropower in the U.S. is generated in three states: Washington, Oregon, and California. Though a non-polluting source of energy from the standpoint of air emissions, hydropower generation is associated with other environmental impacts. For example, it reduces downstream flows, which can affect fisheries habitat, wildlife (including endangered species), agriculture, and water quality.

Other renewable energy sources combined supply approximately 3% of the country's electricity. While onshore wind generation has grown exponentially, it still accounts for less than 1% of the country's generation. There are two challenges facing wind-based energy generators. First, it is only useful when other types of electricity generation are present in an electricity system. That is, its presence in a system depends on the use of other energy sources in that system; since its output is variable, other forms of electricity generation are required to balance out the supply and demand of the system. Second, wind is also considered to be a "location-constrained" resource: the areas that are most suitable for wind generation are often far from load centers and may require new transmission infrastructure to deliver the electricity to consumers.

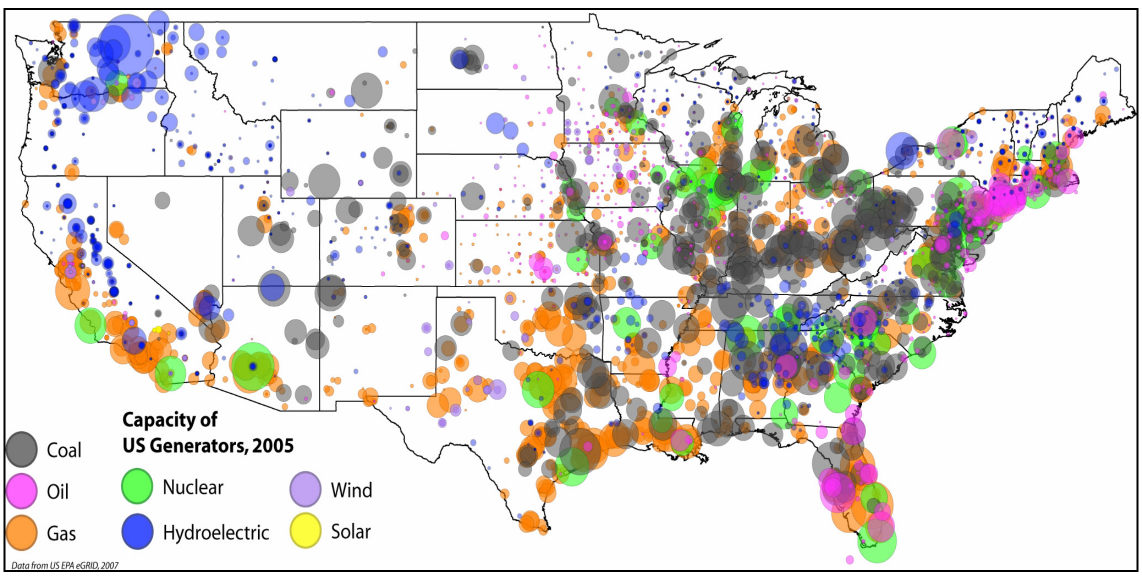
Currently no offshore generation projects are in operation in the United States, but offshore wind generating plants and wave parks have been proposed for development off the Atlantic and Pacific coasts; these are discussed in Section 2.4. Figure 12 shows the population centers of the U.S. Figure 13 illustrates the locations and approximate sizes of power plants across the United States as of 2005.[33] The figure shows a large number of natural gas and oil power plants along the eastern seaboard, illustrating a greater reliance on gas and oil resources in the ISO-NE and NYISO regions. The string of coal-fired power plants through the Midwest illustrates the dependence on coal resources in the Midwest ISO (MISO) region. On the West Coast, gas plants and hydro plants dominate, and reliance on seasonal hydropower in this region can cause generation and pricing issues depending on the time of year. The large-scale correlation of population centers and energy generators is apparent.

[33] On Figure 13, "Wind" refers to onshore generating capacity only.



Source: AWS Truewind (2009).

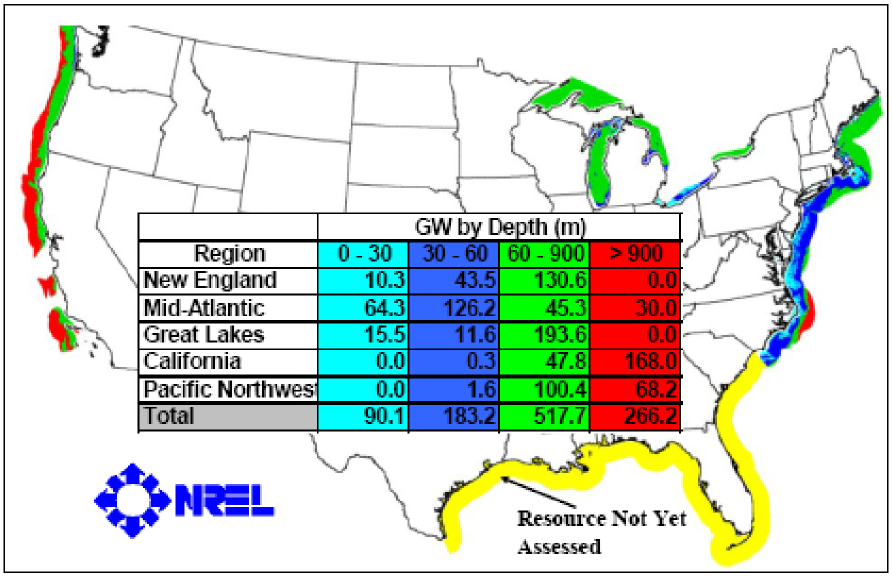
Figure 12. Population density of the contiguous United States (2005).



Source: EPA (2007).

Figure 13. Distribution of U.S. electric generation by fuel source.

Figure 14 shows NREL's estimate of domestic offshore wind energy potential. The general correspondence of population density, substantial electrical generation capacity, and potential offshore wind seen in certain regions (e.g., southern California and the Massachusetts-Virginia areas) indicate offshore wind's potential usefulness as a variable output generator. However, to become a reality, new transmission infrastructure might need to be developed to get the energy from the OCS to the customer (see Section 6 for more details).



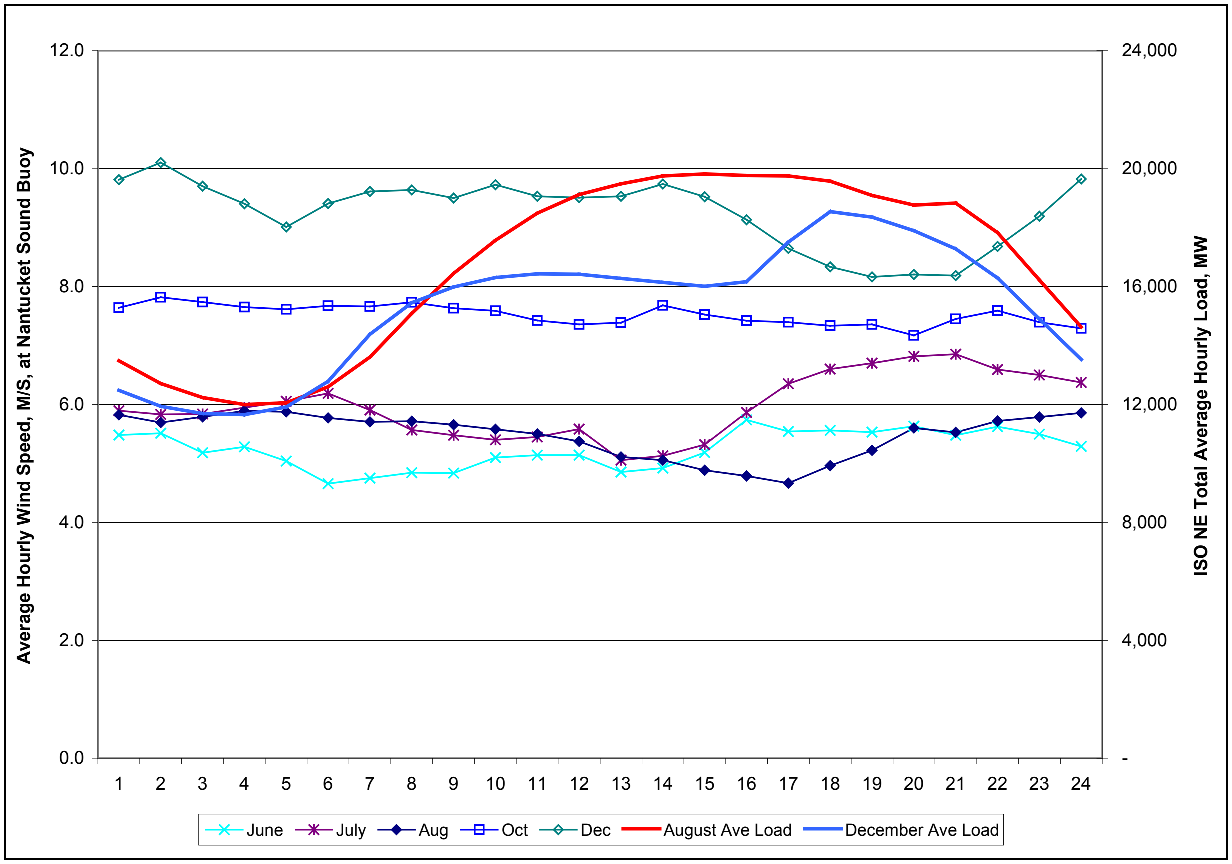
Region	GW by Depth (m) 0 - 30	30 - 60	60 - 900	> 900
New England	10.3	43.5	130.6	0.0
Mid-Atlantic	64.3	126.2	45.3	30.0
Great Lakes	15.5	11.6	193.6	0.0
California	0.0	0.3	47.8	168.0
Pacific Northwest	0.0	1.6	100.4	68.2
Total	90.1	183.2	517.7	266.2

Source: USDOE NREL (2007).

Figure 14. U.S. offshore wind energy potential.

Seasonality and time-of-day are important when considering the amount of electricity that can be contributed by intermittent resources, especially offshore wind. Figure 15 compares average daily wind speeds found in Nantucket Sound (i.e., the approximate location for the Cape Wind project) for various months of the year[34] to average daily summer and winter peak electricity loads in New England in 2009. This figure shows wind speeds for summer, winter, and shoulder months, and illustrates the relatively steady wind speed over the course of a day, which translates to reasonably stable electricity output by wind turbines in this location. Seasonally, the greatest wind speeds occur in the winter months, followed by the shoulder months, with the lowest speeds in the summer months.

[34] Note that these wind speeds were measured at buoy height, not at anticipated turbine hub height, and are likely to be lower than those speeds measured at turbine heights of 50 to 80 meters or more.



Source: Load data—ISO-NE hourly historical data, entire control area.
Wind speed data—2009 NOAA Station 44020 (LLNR 13665), Nantucket.

Figure 15. Nantucket Sound wind speeds, by selected month, and New England average hourly load, August and December (2009).

Daily and seasonal wind speed patterns vary from region to region, as do electricity load patterns. It is important for wind developers to compare these elements on a project-by-project basis in order to be able to fully consider the effects of offshore electricity production on regional electric grids.

3.1.2 Transmission and Distribution of Electricity

Transmission can be summarized as the movement of electricity from the generating source to load centers, from supply to demand. As mentioned in Section 3.1, RTOs and ISOs control transmission in the regions that border the OCS. When electricity reaches the load center, distribution utilities take responsibility. Distribution encompasses all aspects of the retail delivery of electricity to consumers. One analogy would be to consider transmission as the highway that electricity travels and distribution as the connecting surface roads.

Physically, transmission and distribution systems involve substations, transformers, poles, wires, meters, and other equipment. There are over 150,000 miles of transmission lines in the United States (USDOE 2009a). The U.S. transmission system is composed of three major electrically interconnected grids, each spanning many states: the Eastern Interconnection, the Western Interconnection, and the Texas Interconnection (operated by Electric Reliability Council of Texas).

3.1.2.1 Transmission

The League of Women Voters of California (2009) noted that "Transmission availability significantly impacts the market price of power. Inadequate power lines between an area and the best sources of power often require older, more expensive—but closer, or otherwise better situated—generators to come on line to meet the demand. This leads to significant price rises "in the "congested" areas often seen in coastal regions with high populations, such as New York City, the mid-Atlantic coast, and southern California. The report also notes, "Resolving such transmission problems is likely to be a long-term effort. New generation can be put online in as little as two years, but the lead time to acquire sites, obtain permits, and build major new transmission lines has historically been on the order of 10 to 15 years" (League of Women Voters of California 2009). Section 3.2 contains a discussion of transmission structures and prices.

FERC is an independent agency that regulates the interstate transmission of electricity, natural gas, and oil.[35] Among other things, FERC regulates transmission and ensures the reliability of high-voltage interstate transmission systems. In 1996, FERC Orders 888 and 889 set out the principle of open access to the grid for any generator requiring transmission. Order 888 required transmission owners to make transmission service available to other utilities, independent generators, municipal and rural cooperatives, and power marketers. FERC Order 889 mandated that providers of transmission service create Web-based, public information systems, so that a vertically integrated owner of transmission could not use its knowledge of capacity availability in favor of its own generators. The new open access to the power grid allowed for the development of wholesale power markets in which all of those entities could participate.

3.1.2.2 Distribution

The function of the distribution system is to move power from the bulk transmission system[36] to retail customers. Distribution is the responsibility of retail electric utilities.

The function of distribution is both physical and commercial. The physical aspect consists of the construction and operation of the poles, wires, customer meters, and other equipment needed for retail delivery. The commercial aspects include metering accounts, initial handling of complaints, billing, and the like. The same distribution utility usually performs both functions.

In addition to delivering electricity to retail customers, distribution and sub-transmission systems also interconnect small generators, allowing them to sell their output to utilities or other wholesale market participants. Future OCS wave, current, or wind projects might include small generators and tie into the grid at the distribution level. When this is the case, OCS generators

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[35] FERC's website is located at http://www.ferc.gov/.

[36] "Sub-transmission" is a term used in some jurisdictions for facilities that are physically similar to bulk transmission but that move power within a given utility's service territory, either to different regions of that utility's territory or to smaller utilities embedded in its territory.

will work with local utilities that conduct or participate in long-range planning and engineering studies to ensure the adequacy and stability of the distribution grid. FERC has set interconnection standards for small generators that prevent the utility that owns the distribution system from favoring its own generators over those of its competitors.

3.1.2.3 Power Generation and OCS Resources

New offshore energy projects, regardless of technology—offshore wind, ocean wave, or ocean current—will need to compete with existing sources of electricity generation. Table 11 summarizes the existing generating capacity and predominant fuel types in the four RTO regions along the OCS.

Table 11
Total Capacity and Predominant Fuels in Coastal RTO Regions

	New England	New York	PJM Region	California
Capacity (MW)	32,000	28,000	182,000	60,000
Predominant Fuels	Gas	Gas/oil	Coal	Gas
Secondary Fuels	Hydro	Hydro	Nuclear	Hydro
	Nuclear	Nuclear	Gas/oil	Nuclear

As with the country as a whole, fossil fuel generation dominates capacity in the East Coast and West Coast states. Hydropower plants are also important sources, and nuclear power also plays a role in each region.

New offshore energy generation (wave, ocean current, or wind) on the OCS would impact the electricity market in nearby regions by changing the generation supply curve. Figure 16 is a generic representation of the supply curve for electricity in a coastal RTO region. The supply curve is made up of the baseload, intermediate, and peaking units discussed above and shown in Figure 9. These units are dispatched sequentially, beginning with the units that have the lowest operating costs, until enough power is generated to meet demand at any given hour in a day. This process is known as economic dispatch modeling, and is designed to allocate the electricity demand between the available generating units such that the cost of operation is minimized. In the RTO regions along the OCS (New England, New York, PJM, and California), "spot" market electricity is sold in single-clearing price markets, meaning that the "marginal," or next least expensive generator needed to meet load, sets the price for all the generation in the region.[37] The vertical line represents the demand for electricity at a given hour. Baseload generators producing electricity on the left hand side of the curve are thus "price takers," receiving the price set by more expensive intermediate and peakload generators that supply incremental electricity as demand increases.

The demand curve shifts to the left or right depending on both the season and the time of day. Electricity demand tends to be higher in summer and winter months, and lower in the fall and

[37] When transmission constraints bind in these regions, the price of electricity is determined by more than one "marginal" producer.

spring. Over the course of a day, the demand curve would be farther to the left, for example, during non-peak hours when electricity demand is low, e.g., overnight. The curve would shift to the right in the mornings and early evenings, during peak hours, when consumers are turning on lights and appliances and electricity demand is higher. Because many renewables are intermittent resources, their generation output does not always coincide with times of peak demand.

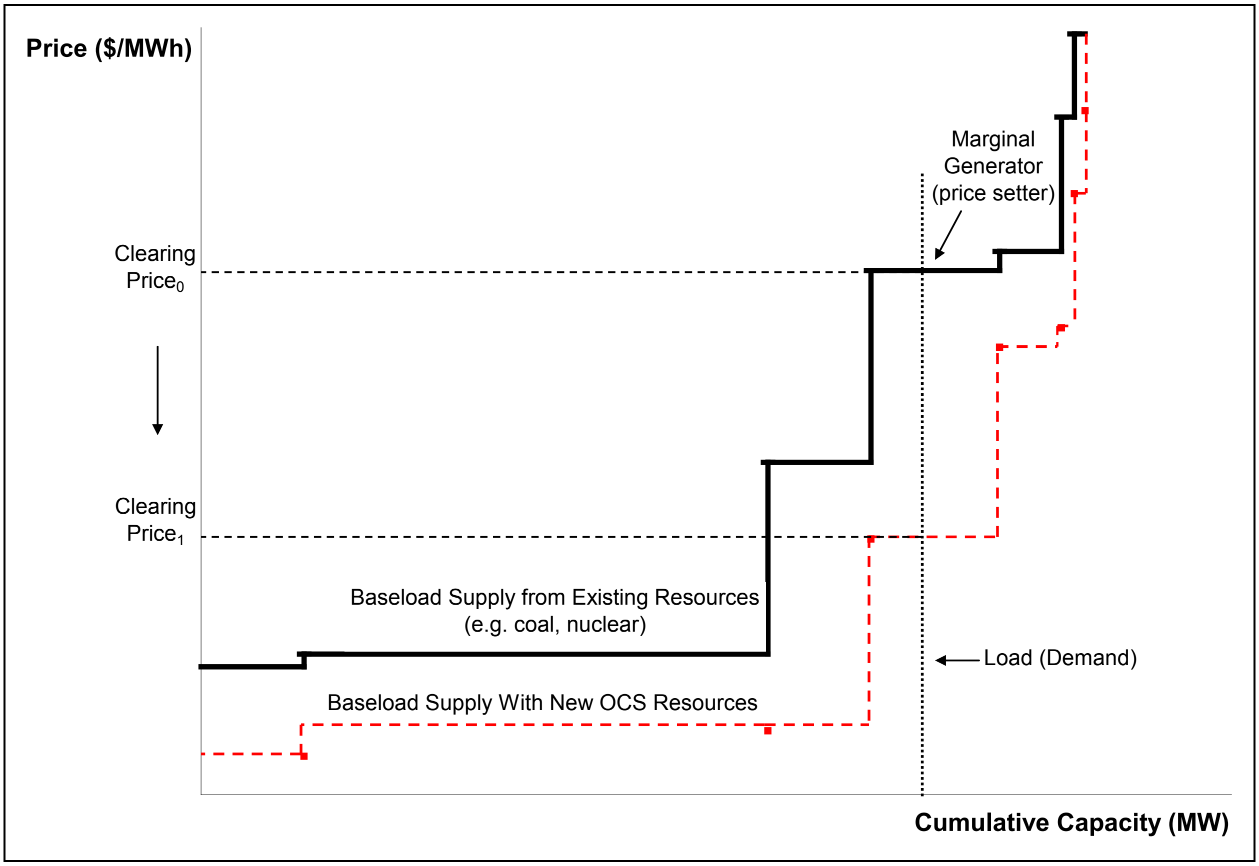

Figure 16. Generic single-clearing price market supply curve.

Hydropower resources in the West, for example, have important seasonal variations in output that can drastically affect electricity prices. Spring run-off in the Pacific Northwest can often depress electricity prices, as it shifts the supply curve for baseload resources to the right. In times of drought in the summer, supply of hydro resources is constricted, leading to higher electricity prices (left shift of supply curve). Wind often has significant hourly variation, typically blowing harder overnight, and at these times of low electricity demand this increased amount of low-cost wind could economically result in a reduction of baseload coal generation output, particularly in those transition months between peak and non-peak seasons. It is even possible for electricity prices to become negative, which typically happens overnight when demand is low, and suppliers prefer to pay buyers to consume power in order to avoid curtailing electric output (Hartley 2010).

New OCS renewable resources will have lower variable costs than the existing coal and nuclear baseload generators in these regions because they will have zero fuel costs and zero costs to control SO_x, NO_x, and CO emissions (see Figure 25 in Section 3.3 below). As these new resources are added to the market, the supply curve for electricity will shift to the right, lowering the clearing price for spot market generation (see Figure 16).

New OCS projects should not be influenced directly by the retail distribution of electricity; however, transmission issues will be important. Offshore renewable energy projects on the OCS will be located near areas where transmission is constrained and where existing lines and facilities will have limitations. Population growth or other heightened demand augments the constraints on the regional transmission system. In such regions, additional generation from offshore resources could ease congestion on the system by enabling electricity to flow into the load centers while avoiding existing transmission constraints. Thus, new generation offshore may allow the postponement of upgrades to existing onshore transmission lines and the associated costs. New offshore generation may also allow for greater flexibility in the scheduling of transmission system maintenance, since it can lessen the demands on existing inland transmission lines.

3.1.3 Summary

Development of new generation resources on the OCS would provide opportunities to reduce electricity prices and improve grid reliability in densely populated areas along the east and west coasts of the U.S. As existing fossil-fuel-fired and nuclear plants retire in New England, the Mid-Atlantic, and California, new generation sources will be needed to replace them. Given the low variable costs associated with operating offshore renewable resources, their addition to wholesale electricity markets in these regions would lower the overall clearing price for electricity by reducing the need for generation from the most inefficient and most costly fossil resources (NYSERDA 2009a). Furthermore, the volatility of fuel prices and uncertainty about future restrictions on GHG emissions has made investment in renewable generation increasingly cost-competitive with fossil-fuel-fired generation. However, the variable output of renewable resources such as wind generation, requires the presence of other supply- and/or demand-side resources in the system to balance supply and demand.

Unlike most onshore wind resources, offshore resources are in close proximity to congested coastal load centers, and could ease constraints on existing transmission lines, improving reliability and allowing the postponement of costly infrastructure upgrades. The development of new offshore generation will require transmission lines to carry electricity from the generators to the onshore grid systems. There is a possibility that additional onshore transmission facilities will be required to balance and transmit the electricity generated in the OCS.

3.2. Regional Electric Energy Markets, Structure, and Regulation

3.2.1 Overview and Summary

Successful development of utility-scale, grid-connected[38] offshore energy resources in OCS waters requires a comprehensive understanding of the applicable regulatory and market-based structures that affect new generation supply connection, operation, and overall economic feasibility. At a high level, these institutional structures include:

- Federal regulatory oversight (FERC).[39]
- Technical reliability oversight (the North American Electric Reliability Corporation [NERC] and NERC subregional entities).
- Regional energy and capacity markets (e.g., PJM, New York, New England, and California wholesale spot electricity markets) and related renewable energy credit (REC) markets.
- Regional market operators and reliability overseers (e.g., regional transmission organizations).
- State regulatory authorities (e.g., public utility commissions and environmental agencies).
- Non-RTO utilities with transmission planning and operation oversight.

The presence of these institutional structures affects resource development in OCS waters, primarily because these structures shape the overall wholesale- and retail-level playing field for electricity generation provision and pricing, and thus affect the revenue streams an OCS resource development could expect.

After briefly defining what these structures are, this section explains their fundamental purpose and describes their influence on the outcome of potential OCS resource development. Appendix A contains details about NERC regional reliability entities.

FERC. The Federal Energy Regulatory Commission is the overarching entity with regulatory responsibilities that will influence OCS development outcomes. FERC regulates both monopoly-based transmission provision and competitive-market-based wholesale electric markets. OCS resources generally will need to access this transmission to deliver supply, and OCS resource developers will need to understand the workings of these markets in order to estimate revenues from the sale of OCS resource output. See Section 2.1.4 above for a

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[38] It is possible that some smaller-scale OCS resources will not require connection to the transmission grid, but rather will be connected at distribution or local sub-transmission voltages. These projects will still need to understand at least the wholesale market structures, if only because pricing for the output of smaller resources may be tied to this market. State-level regulation and local distribution connection protocols would then have a greater influence on these projects than transmission level issues and federal regulation.

[39] There are other federal regulatory impacts on energy resources in OCS waters—for example, the BOEM role as the lead agency for OCS resource leasing and easements. This section focuses on the technical, market, and regulatory aspects of electric power system institutional structures and does not address other federal regulatory requirements such as those set by BOEM or EPA.

discussion of the memorandum of understanding between MMS and FERC regarding hydrokinetic projects on the OCS (USDOI 2009a). FERC has jurisdiction over hydrokinetic projects on the OCS, and will issue licenses for projects only after MMS (later BOEMRE, now BOEM) has issued a lease, easement, or right-of-way for the site. The two agencies share responsibility for inspecting projects and ensuring compliance.

NERC and NERC subregional reliability entities. Technical reliability of the grid is ensured through reliability standards[40] developed by NERC and its subregional entities, and approved by FERC. These standards are comprehensive and cover a very broad range of technical issues. At their core, they serve primarily to ensure that day-to-day and long-term reliability is ensured, that equipment is not operated beyond rated values, and that worker safety is ensured. The standards apply to all states except for Alaska and Hawaii.[41] NERC reliability standards must be approved by FERC.

Regional electricity markets and regional transmission system organizations. Regional wholesale energy and capacity markets are the vehicle through which most generation supply is priced and sold in areas proximate to OCS offshore waters. These markets are generally overseen and operated by RTOs, whose responsibilities include delivery of such supply across the transmission grid to the distribution companies that ultimately provide power to most customers. RTOs consist of highly skilled personnel, technically sophisticated monitoring and control equipment, and authority to implement these markets and oversee technical operation of the grid. RTO institutional presence has come to dominate the wholesale provision and delivery of electricity over the past 10 to 15 years.

State regulatory authorities. Pursuant to state law, state regulatory authorities[42] retain considerable authority over the extent of development of renewable resources and the wholesale-level procurement of electric utilities, in addition to oversight of resource decisions for those utilities that remain vertically integrated and regulated. There are three facets of state regulation, including RPSs, "standard offer service" procurement policies for non-vertically integrated utilities, and resource procurement decisions for vertically integrated utilities. These facets can dramatically influence prospects for development of offshore OCS resources. In Delaware, New Jersey, and Rhode Island offshore wind development has made considerable strides as a result of

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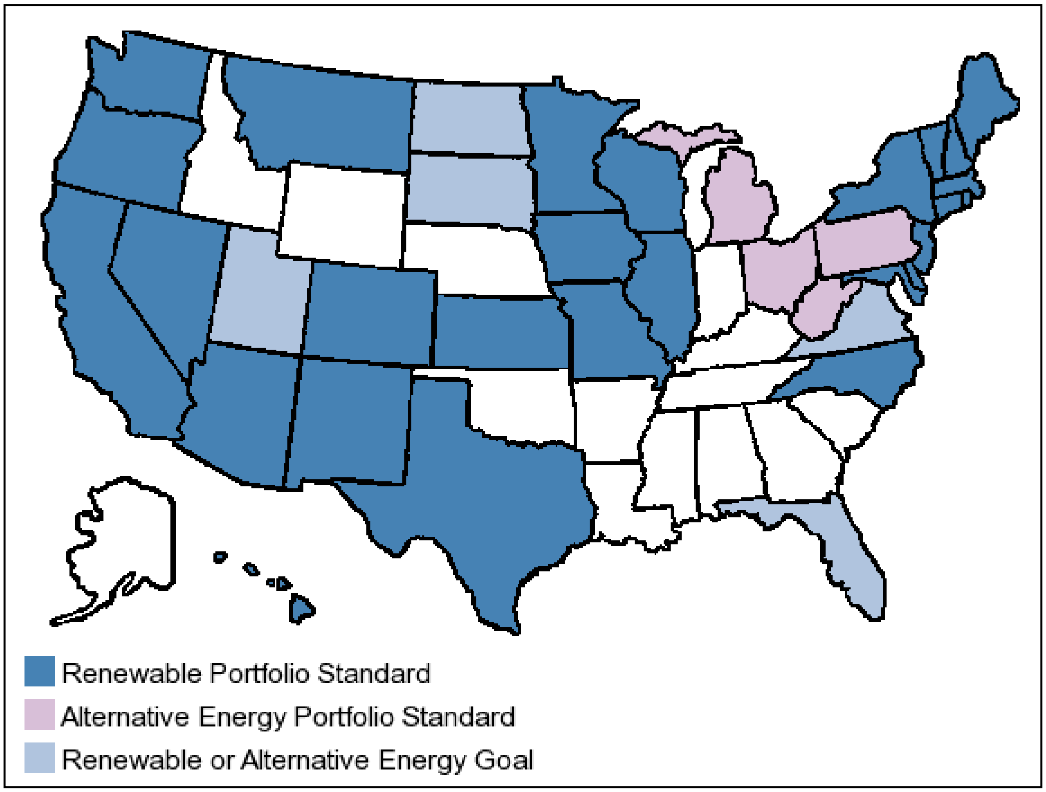
[40] Reliability standards are mandatory planning and operational practices approved by FERC pursuant to federal law and implemented by transmission owners and regional transmission system operators. They serve to ensure safe and reliable electric grid operation. They apply to the planning and operation of the bulk power system, defined by law as generation and high-voltage transmission systems. The standards codify good utility practices that relate to balancing customer demand with generation supplies, planning for new transmission facilities, emergency operations, real-time transmission operations, system restoration and blackstart, voltage control, cyber security, vegetation management, facility ratings, disturbance reporting, connecting facilities to the grid, certifying system operators, and personnel training. See NERC (2009a).

[41] Mandatory electric utility reliability standards do not apply to these states; however, electric utilities do follow "good utility practices," which are the fundamentals upon which modern reliability standards are based. While limited electric transmission is in place in Alaska and Hawaii, the degree of transmission interconnection is much less than exists for the 48 lower-continental U.S. More information concerning Alaskan electricity systems is available at http://www.alaskapower.org/ak-energy-system.htm. More information on Hawaiian systems can be found at http://www.heco.com.

[42] This chapter does not address local regulatory authority issues.

the existence of RPSs and regulatory oversight of wholesale procurement by local utilities. Figure 17 depicts the status of renewable and renewable energy portfolio standards. See Section 3.4 for a larger discussion of state planning with respect to CZM and renewable energy sites. See Section 3.3 for a discussion of the Regional Greenhouse Gas Initiative (RGGI), a 10-state cooperative for a market-based effort to reduce GHG emissions in the northeastern and mid-Atlantic states via cap-and-trade.



Source: Pew Center on Global Climate Change. With permission.

Figure 17. State renewable and renewable energy portfolio standards.

Non-RTO utility regions. The Pacific Northwest and Southeast regions of the United States contain OCS resources whose interconnection to the grid would be overseen by the traditional utilities in those regions, and not pursuant to RTO tariffs and protocols. In these regions, wholesale energy and capacity market dynamics and transmission regulation are different than in RTO regions.

Table 12 summarizes each of the market structures described above and discusses their influence on development and operations of electric generators and transmission operators.

Table 12
Summary of Electric Power Sector Regulatory and Market Structures and Their Influence on OCS Resource Development

	Influence on OCS Resource Development	Influence on OCS Resource Operations
FERC	• Granting licenses and exemptions for the construction and operation of hydrokinetic projects on the OCS • Approval of RTO tariffs and protocols that affect both market structures and the revenue streams for the output of generation projects • Approval of reliability standards that can affect transmission and generation equipment requirements for developers	• Ongoing regulation of transmission and wholesale sales of electricity • Inspection and environmental oversight of hydropower projects • Monitoring of wholesale power markets and enforcement of rules
NERC and Regional Reliability Entities	• Indirect effects due to the development, monitoring, and enforcement of reliability standards • Indirect effects due to the market impacts associated with reliability assessment and resource adequacy planning	• Indirect. Compliance with reliability standards developed by NERC and implemented by regional security coordinators
Regional Markets	• Price patterns, marginal fuels, existence of RPSs, and generation and load balances affect the need for new OCS renewable resources	• Market pricing patterns influence choices for planned maintenance outages. Possible effect on whether to provide energy or ancillary service capacity during day-to-day operations for advanced turbine designs
RTOs	• Transmission interconnection study and cost protocols	• Generation dispatch and curtailment (balancing authority) • Administration and monitoring of wholesale power markets
State Legislative Authorities	• Transmission siting (if applicable) • RPSs and other incentives for renewables • Climate change policy/regulation	• Minimal
State Public Service Commissions	• RPSs, RECs, and other incentives for renewables • Approve PPAs between utilities and developers of OCS resources for electricity output	• May administer programs for long-term, fixed renewable payments (REC payments) to developers for specific resources
Non-RTO Utilities	• Transmission interconnection study and cost protocols • PPAs	• Generation dispatch and curtailment (balancing authority)

3.2.2 Federal Energy Regulatory Commission

FERC's responsibilities include regulating the transmission and wholesale sales of electricity in interstate commerce and ensuring the reliability of high-voltage interstate transmission systems. In addition to other functions, FERC administers accounting and financial reporting regulations for regulated companies, monitors and investigates energy markets, and enforces its market rules with civil penalties and other means. FERC also has a specific role in hydroelectric projects, including the licensing and inspection of private, municipal, and state hydroelectric projects, and oversight of environmental matters related to these projects.

FERC's influence over development of electrical generation in OCS waters resides mainly in four overlapping areas: 1) oversight and approval of RTO tariffs, policies, and procedures affecting use of regional networked transmission systems; 2) transmission system regulation; 3) wholesale electricity market regulation; and 4) oversight of reliability standards development and enforcement. This influence is depicted in a diagram (Figure 18) of how OCS development and operation are affected by FERC oversight responsibilities and the related roles of RTOs, regional markets, state regulatory authorities, and non-RTO region utilities.

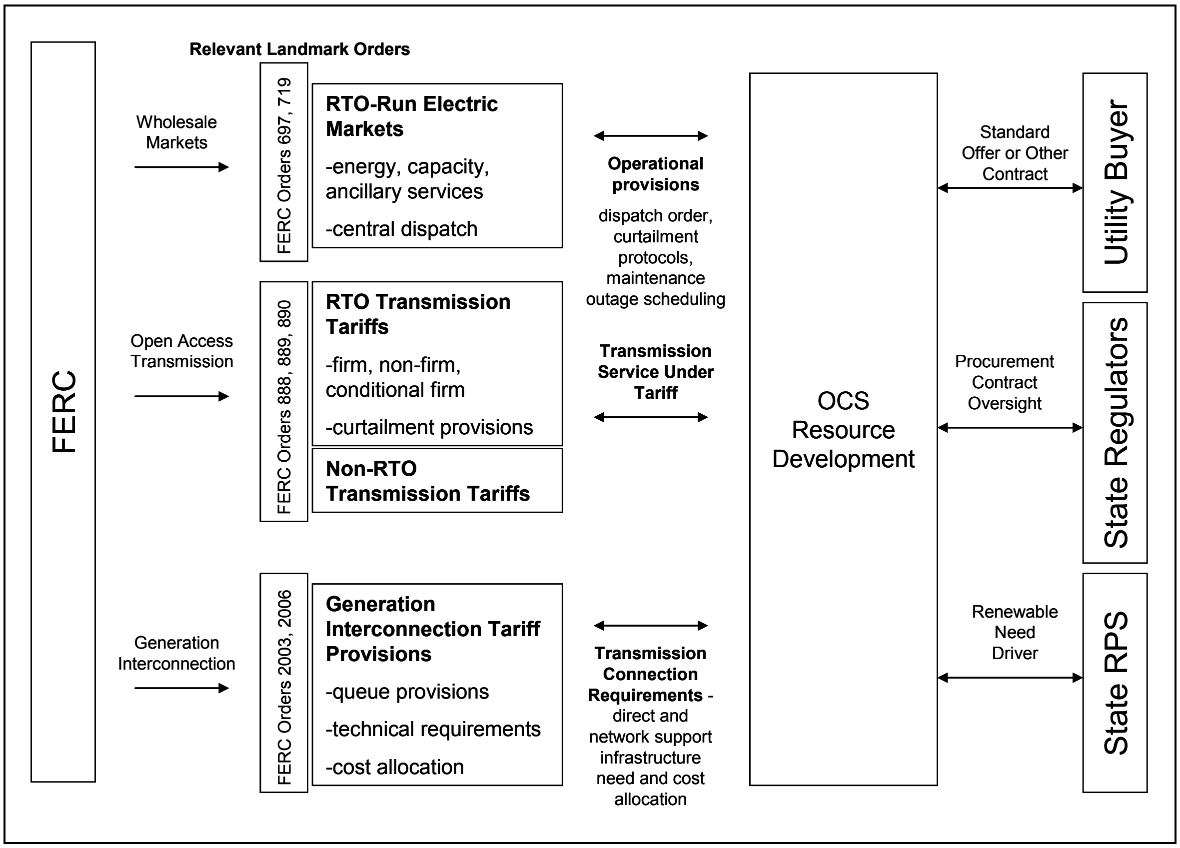


Figure 18. Electric power industry institutional structures and effect on OCS resource development and operation.

Much of the potential wind, wave, and current resources in the Atlantic and Pacific OCS regions are adjacent to areas with RTO oversight of transmission and wholesale markets. RTOs are also generally the reliability coordinators which implement reliability standards in these areas,[43] and they administer structured electricity markets. For these reasons, much of the focus of this chapter is on the policies in place at RTOs that affect the interconnection and operation of new resources. For the OCS waters that are not proximate to an RTO—those in the Southeast and the Pacific Northwest—FERC's responsibilities in regulating transmission, overseeing wholesale

[43] California is the exception. The Western Electricity Coordinating Council is the reliability coordinator for all of the West, as will be described.

markets, and ensuring reliability are equally applicable as in RTO regions, but the mechanisms differ somewhat because the oversight is focused on individual electric utilities.

3.2.3 NERC and Regional Reliability Entities

NERC is a nonprofit, self-regulating organization that seeks to maintain and improve the reliability of North America's bulk power system by developing and enforcing reliability standards, monitoring the bulk power system, and assessing and reporting on future transmission and generation adequacy.[44] NERC oversees the reliability of a bulk power system that provides electricity to 334 million people. This bulk power system has a total electricity demand of 830,000 MW (NERC 2010a) and accounts for virtually all of the electricity supplied in the U.S., Canada, and a portion of Baja California, Mexico (NERC 2008). NERC is subject to oversight by governmental authorities in the U.S. and Canada. In particular, all U.S. reliability standards promulgated by NERC and its regional reliability entities must be approved by FERC per federal law, the 2005 Energy Policy Act.

The influence of NERC and subregional reliability organizations on OCS resource development is generally indirect. The reliability oversight that NERC and its regional entities provide is made manifest through transmission system and market system planning and operation protocols in place at both RTOs and non-RTO transmission operators in regions proximate to OCS waters. This section briefly describes the main activities of NERC and the regional reliability organizations.

Appendix A provides additional detail on the structure of NERC's regional reliability entities. Table 13 lists the states along the East and West Coasts along with each state's associated regional reliability entity.

Much of the reliability "infrastructure" that is developed through NERC and regional entities is implemented by reliability coordinators. In eastern OCS-proximate areas, these coordinators are the RTOs. In the West, the Western Electricity Coordinating Council (WECC) is the reliability coordinator. The initial effect of reliability infrastructure on OCS resource development is to influence the initial requirements for transmission interconnection and provide minimum technical specifications for generation equipment, such as reactive power support, supervisory control and data acquisition elements, and generators' ability to stay online during certain transmission system events. Ongoing operational requirements that affect OCS resources include both system-wide requirements, such as operating reserve amounts, and more resource-specific requirements such as voltage level at interconnection points.

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[44] NERC's role in assessing and reporting on future transmission and generation adequacy does not include projections or conclusions regarding expected electricity prices or the efficiency of the electricity markets within its footprint. NERC also offers education and certification programs to industry personnel (NERC 2008).

Table 13
Regional Reliability Entities for Atlantic and Pacific States

State	Regional Reliability Entity
East Coast	
Maine	Northeast Power Coordinating Council (NPCC)
New Hampshire	NPCC
Massachusetts	NPCC
Rhode Island	NPCC
Connecticut	NPCC
New York	NPCC
New Jersey	Reliability*First* Corporation (RFC)
Delaware	RFC
Maryland	RFC
Virginia	RFC and SERC Reliability Corporation
North Carolina	SERC Reliability Corporation
South Carolina	SERC Reliability Corporation
Georgia	SERC Reliability Corporation
Florida	Florida Reliability Coordinating Council (FRCC)
West Coast	
Washington	Western Electricity Coordinating Council (WECC)
Oregon	WECC
California	WECC

NERC assesses and reports on electricity system reliability and adequacy in eight regions, represented by regional reliability entities with formally delegated enforcement authority (NERC 2010b).[45] Figure 19 shows the North American interconnections and the footprints of NERC and its regional reliability entities. The WECC is the reliability council for the Western Interconnection. The six regional reliability entities within the Eastern Interconnection are:

- Florida Reliability Coordinating Council (FRCC)
- Midwest Reliability Organization (MRO)
- Northeast Power Coordinating Council, Inc. (NPCC)
- Reliability*First* Corporation (RFC)
- SERC Reliability Corporation
- Southwest Power Pool, Inc. (SPP)

The Electric Reliability Council of Texas, or ERCOT, is the reliability entity for the Texas Interconnection.

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[45] Electric systems in Alaska and Hawaii are not subject to oversight by NERC.

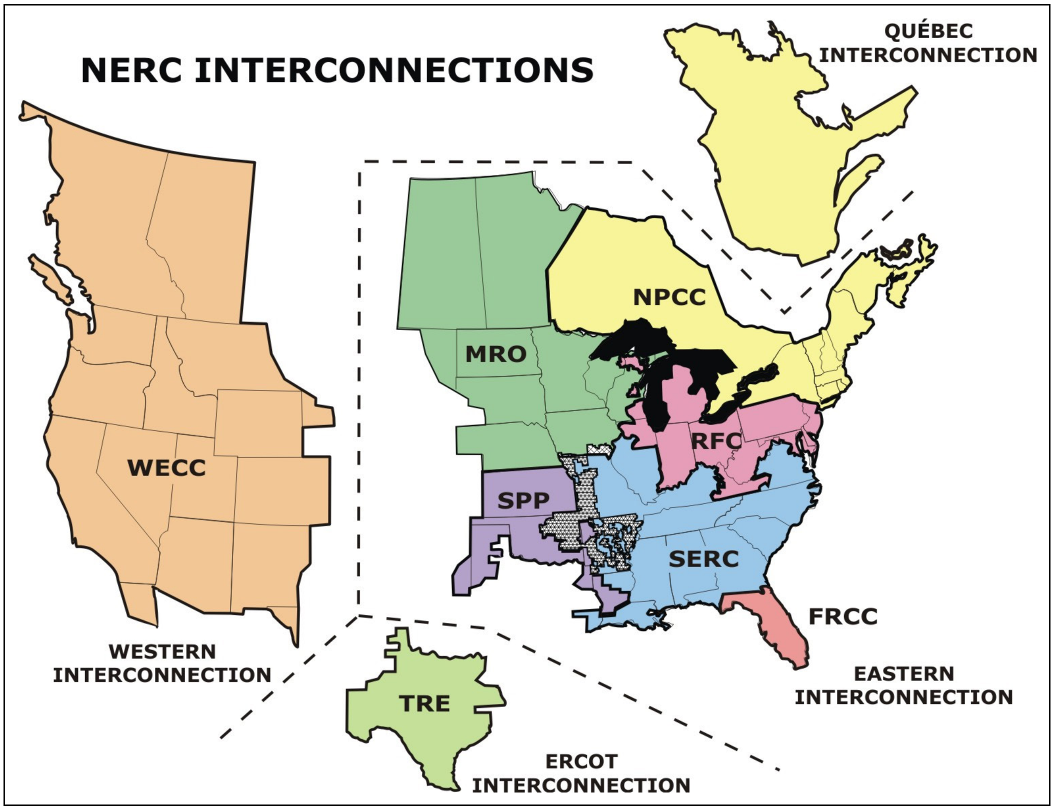

Figure 19. NERC interconnections and regional reliability entities.

NERC's reliability standards define the reliability requirements for power systems planning and operations in a number of areas, including resource and demand balancing, critical infrastructure protection and emergency operations, facilities design and maintenance, interchange and interconnection coordination, communications, and transmission operations and planning, among others. NERC standards apply for all grid-connected generation plants in aggregate greater than 75 MW, whether onshore or offshore. The standards are mandatory and enforceable in the United States.[46] Every year, NERC revises its Reliability Standards Development Plan to identify and prioritize standards for development over the immediate three-year horizon.

NERC is currently assessing its standards to identify gaps that might need to be filled to ensure system reliability given the large increases in new interconnected variable resources—including wind, solar, ocean, and some forms of hydro—that are expected to come online in the next few years. A recent report identified standards for review and possible action in several categories, including modeling, data and analysis, communications, facilities design, interconnecting and maintenance, and transmission planning (NERC 2009b). New or modified standards and guidelines resulting from these reviews would certainly affect the development of OCS resources, e.g., by encouraging or requiring installation and operation of forecasting systems for variable generation output.

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[46] NERC standards are also mandatory in the Canadian provinces of Ontario and New Brunswick. NERC is seeking similar policies in the other Canadian provinces and formal recognition in Mexico (NERC 2010c).

NERC and the regional entities engage in compliance monitoring and enforcement efforts to ensure adherence to the approved reliability standards. In order to deter new or further violations, NERC can issue remedial action directives for either confirmed or alleged violations. An entity found in violation of any mandatory standard must submit and execute a NERC-approved mitigation plan. Subject to NERC oversight, regional entities are responsible for monitoring compliance within their boundaries, ensuring mitigation of violations, and assessing penalties and sanctions for failure to comply (NERC 2010d). Regional entities can also adopt and enforce regional reliability standards approved by NERC and either FERC (in the U.S.) or other applicable authorities (in Canada and Mexico).[47]

NERC conducts periodic, independent assessments of long-term (10 years) and short-term (winter and summer) reliability based on data from the regional entities. The most recent such assessment forecasts that high levels of new variable resources (such as offshore wind and ocean capacity) will be added to the bulk power system in the next decade, a departure from historical trends.[48] Given the expected increase in variable resources, NERC issued a special report on the shortcomings of traditional methods for system planning, design, and operations. The report (NERC 2009b) finds that

> high levels of variable generation will require significant transmission additions and reinforcements to move wind, solar, and ocean power from their source points to demand centers and provide other needed reliability services, such as greater access to ramping and ancillary services.

The report encourages policymakers to address transmission siting and permitting issues, as well as other obstacles hindering transmission development. The extent to which these issues are addressed in coastal areas will affect the development of OCS resources, for example, by facilitating the development of an increase in transmission capacity to bring power from wind-rich areas off OCS coastal areas to nearby load centers.

The regional reliability entities address reliability planning at regional levels, and allow for region-specific attributes of the electric power system to be accommodated in reliability planning.

3.2.4 Regional Electricity Markets and RTOs

Structured, regional electricity markets exist along the northeastern, mid-Atlantic, and western parts of the country bordering much of the OCS waters. Structured markets are the spot (i.e., short-term) electric energy and capacity markets operated by RTOs as well as RTO markets for ancillary services.

The NPCC subregion reliability coordinators New York ISO and ISO-NE (both of which are RTOs) operate these markets. The PJM RTO is the RFC reliability coordinator for the OCS-

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47 Regional reliability standards can also be developed and revised through a NERC-approved development procedure (NERC 2010e).

48 These resources differ from conventional resources in terms of their variability (i.e., the extent to which plant output fluctuates on all time scales based on changes in the availability of fuel, such as wind, sunlight, and moving water) and uncertainty (reflecting the predictability of the magnitude and timing of generation output).

proximate region bordering the mid-Atlantic coast and operates the PJM electricity market, and CAISO (an independent entity treated in the same manner as an RTO) covers much of the Pacific coast and operates the CAISO markets. This section summarizes RTO markets and operations; Section 3.4 presents summary statistics on key aspects of RTO operation in these regions.

The OCS regions off Oregon and Washington do not border an RTO-overseen structured market, nor does the southeastern portion of the United States. In those regions, the wholesale electricity markets are formed by bilateral trade. However, the Pacific Northwest region does have extensive electrical transmission interconnection to California and thus the CAISO markets influence the prices and quantities of generation resource development in that region. There are interconnections between the southeastern United States and the nearest RTO—PJM—but the extent of electrical transfer capability and ease of electric market transaction execution is much less than between the Pacific Northwest and the CAISO region.[49] Also, the Pacific Northwest and southeastern United States historically have exhibited lower electricity prices than those in California, the mid-Atlantic region, "downstate" New York, and New England. Lastly, while RPSs exist in OCS-bordering states whose transmission infrastructure is overseen by RTOs (and also in Oregon and Washington), the OCS-bordering southeastern U.S. states (Florida, Georgia, and South Carolina) do not have RPSs.

Thus, a substantial majority of OCS waters resource development is likely to occur proximate to regions with RTOs because of the three drivers of 1) higher electricity prices,[50] 2) the existence of renewable energy portfolio standards, and 3) state initiatives to support development of renewable resources on the OCS.

Transparent market data and the separation of generation from transmission and distribution functions—core attributes of the electricity market in RTO regions—will facilitate merchant development[51] of OCS resources in areas with electricity markets, although proposals for offshore resource development in RTO regions have largely gone hand-in-hand with state policies encouraging their development.

3.2.4.1 RTO Region Electricity Markets Summary

In 1996, FERC Orders 888 and 889 established open access to the grid for any generator requiring transmission. These orders paved the way for the development of wholesale power markets and supported the development of ISOs and, with successive orders, RTOs. Since then, ISOs and RTOs have become dominant electric industry operatives. (Figure 8, in Section 3.1, shows a map of the territories of the ISOs and RTOs in the United States.) Simultaneously, and intentionally, these FERC Orders led to a greatly expanded merchant generation market in the United States.

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[49] OCS water resources off the Florida and Georgia and South Carolina coasts, for example, do not have direct transmission path access to the PJM market interface at its southeastern border with North Carolina utilities.

[50] The higher prices are due primarily to the greater use of natural gas for marginal generation in these RTO regions, a large number of areas of concentrated populations and electric loads, and transmission constraints.

[51] The term "merchant development" usually refers to private investment in a generating resource, and has been interpreted to mean dependence on structured electricity markets for revenue streams. However, the term could also be applied to a private development that secures a long-term contract for electrical output.

ISOs and RTOs have several key roles and responsibilities in operating, monitoring, and planning the power system. First, they manage the bulk electric power system through central dispatch, ensuring that the regional grid operates reliably and cost-efficiently. Second, they ensure nondiscriminatory access to transmission. To this end, they process transmission and generation interconnection requests by running load flow studies to show how and where a new interconnected resource would impact the grid, what reinforcements would be required to address any weaknesses, and who would pay for the reinforcements. In addition to RTO/ISO review and approval processes, state and local authorities have separate review processes for transmission and generation siting. (State and local permitting requirements are not discussed here.) Both state and local government permitting policy and RTO/ISO cost allocation decisions will be a key driver for offshore generation capacity expansion.

Third, ISOs and RTOs manage reliability and transmission planning processes, serve as reliability coordinators for NERC, and are responsible for meeting FERC planning principles. They determine the bulk system needs for general reliability and either identify preexisting transmission or plan new transmission to meet those needs. For example, the California Energy Commission (CEC) established an initiative to identify, conduct detailed studies, and allocate costs for the transmission projects that are needed in order for the state to meet its renewable energy goals. In addition to transmission planning, most ISOs and RTOs also conduct long-term generation resource planning.

Fourth, ISOs and RTOs provide information on wholesale market prices and the state of the power system to facilitate market monitoring and market rules enforcement, policy development, and investment in generation, transmission, and demand-side management resources. ISOs and RTOs do special studies in support of policymaking, such as determining long-range transmission options to allow for large increases in wind resource development (on and off shore) 10 to 15 years in the future to meet a state-level RPS.

Last but not least, ISOs and RTOs run competitive wholesale spot markets. The wholesale markets run by ISOs and RTOs generally include the following products:

- Electric energy markets feature real-time prices, generally in five-minute intervals. Day-ahead markets supplement the real-time markets and lessen the need to call upon expensive standby generation at the last minute to fill supply gaps. Pricing is location-based, generally at the node level.

- Ancillary services ensure reliability and support the transmission of electricity from generation sites to customer loads. They include load regulation, spinning reserve, non-spinning reserve, replacement reserve, and voltage support. ISOs and RTOs operate markets for some or all of these products.

- Capacity markets are intended to help the grid operator ensure that sufficient generating capacity will be available to meet high peak loads by compensating generators for siting units in an area.

The prices of the products that OCS renewable resources can supply, plus the value of RECs (discussed in Section 2.3.2), determine the revenue potential for offshore resources. Renewable resources qualify to supply energy products, although payments for underdeliveries or overdeliveries have been substantial in the past. Wind forecasting systems, which are under development or in discussion in all ISOs, are critical for minimizing over- and under-commitment (Lasher 2008). Typically variable energy resources receive compensation for capacity consistent with their contribution to the system during peak times. Wind resources to date often supply only energy and limited levels of accredited capacity, and have not supplied ancillary services. Systems incorporating larger amounts of wind resources may need additional ancillary services to support the reliability of the grid, depending on the extent of forecasting accuracy and other attributes of the regional load and generation balance. The economics of developing renewable generation capacity on the OCS will depend in part on RTO/ISO rules regarding payments and charges for all of these products.

Typically, only a small fraction of energy is transacted in spot markets. A large portion of power is supplied through bilateral trades. Data on bilateral transactions are generally not available, so it is difficult to determine to what extent bilateral prices follow, anticipate, or index spot prices. This question is particularly important for OCS resources, since many offshore resources will likely need bilateral contracts to obtain up-front financing; indeed, OCS region offshore wind projects that are furthest advanced have secured or are in the process of securing long-term contracts from local utilities.[52]

In ISOs/RTOs, transmission use is based on its highest value as reflected in the generation offer prices and load bid prices in wholesale energy markets. Transmission is not physically scheduled by energy suppliers or consumers (except at the ISO/RTO borders), unlike in other areas. Instead, ISOs and RTOs run markets for financial transmission rights (FTRs). FTRs are financial instruments that entitle the holder to revenues (or charges) based on differences in energy prices across a transmission path, thereby allowing market participants to hedge against the congestion costs associated with their energy deliveries. Physical transmission constraints are observed through the security-constrained dispatch process used by all ISOs and RTOs, although the specifics of its implementation vary by ISO/RTO.

3.2.4.2 Impact on OCS Resource Opportunities of RTO Policies on Transmission Interconnection, RTO Market Protocols, and RTO Wind Integration Efforts

The way in which electric systems are planned, operated, and regulated will affect the profitability, feasibility, and overall attractiveness of investment in a potential OCS resource. For example, the duration, costs, and other requirements of generation interconnection permitting can make a project economically unfeasible, especially if initial investment costs are high, as is the case with OCS resources. In general, transmission expansion planning[53] can focus on upgrading facilities within load centers on the coasts—possibly making interconnection for OCS resources more feasible—or it can emphasize importing power from other regions, e.g., from the coal-rich interior. The structure for compensating generators that cannot precisely schedule

[52] Namely, the offshore wind projects noted elsewhere in this report planned for interconnection in coastal regions in Delaware, Rhode Island, Massachusetts, and New Jersey.
[53] Each of the three eastern RTOs conducts transmission expansion planning.

output, such as wind and wave resources, varies from region to region.[54] Beyond compensation for energy or capacity, integration of intermittent wind resources can be facilitated using wind forecasting systems.

RTO polices on transmission interconnection requirements and costs can have an effect on OCS resource location decisions. While all of the RTOs must comply with FERC policies on interconnection requirements as established in FERC Orders,[55] each region does have different policies on determining need for and allocation of the cost of transmission reinforcement required when an OCS resource is connected to the transmission grid. For example, interconnecting generators usually have to support the reinforcement of the transmission grid to ensure reliability at locations beyond the direct interconnection point of the OCS resource to the grid. However, the detailed methods used to analyze such cost responsibilities vary across the RTOs. Also, physical infrastructure differences may result in interconnection cost obligations that vary dramatically.[56]

The types of required transmission upgrades encountered by OCS resource developers through their participation in RTO interconnection studies include, for example, reinforcement of transmission paths that would carry OCS energy resource output beyond the point of direct interconnection to the grid (i.e., inland from the coast). For example, an OCS resource might connect to the grid through two 115 kV cables that run from the OCS resource collection point (e.g., on a platform in the ocean) to the nearest 115 kV substation on land and connected to the regional grid. Since the local network of 115 kV or higher-voltage lines (e.g., 138 kV or 230 kV) in the vicinity of the OCS resource connection point may not have been designed to deliver a large source of supply, but instead represented the tail end of the local transmission system delivering to load, it may not be appropriately sized to safely and reliably carry the output of the OCS resource.

[54] Technologies for curtailing or ramping wind output are becoming more common. For example, many turbines are now capable of adjusting the pitch of the turbine blades in real-time to modify output (NERC 2009b).

[55] The applicable landmark FERC Orders include Orders 2003, 2003-A, and 2003-B for large generators (more than 20 MW).

[56] For example, comparing two potential offshore projects in New England and PJM shows how costs may vary. For PJM, New Jersey, the total network and direct interconnection costs for a 350 MW offshore wind facility at the Lewis substation are over $260 million, though direct interconnection costs are estimated at just $2.5 million. For ISO-NE, Massachusetts total connection costs for a 462 MW offshore project are $28.5 million.

This impact on the local grid where the OCS resource connects is usually modeled (as part of the RTO interconnection process) at successive points on the transmission grid beyond the supply interconnection point, to see just how far "into the grid" a transmission upgrade might be needed. Depending on the size of the OCS resource and the particulars of the local grid connection point, the upgrades may be relatively minor (such as re-conductoring a single circuit) or relatively major (supplementing the local grid with a new transmission line and installing another transformer to move OCS resource supply out of the local area and onto the regional grid). Such upgrades could be required because of thermal limitations inherent in the transmission lines and transformers of the local grid, or perhaps due to power quality (e.g., voltage) issues that arise under certain OCS resource output levels (e.g., even if the conductors could thermally handle the OCS resource output, the local system voltage may drop too far below required minimum values).

The interconnection process was laid out by FERC Order 2000 and subsequent orders, although ISOs and RTOs generally have more flexibility to customize the terms, conditions, and pricing associated with the process to meet their regional needs. Under the Order, the interconnection process consists of three studies, to be completed within up to six months of the developer signing each succeeding study agreement with the transmission owner and transmission organization.[57] The order also specifies that the developer can take no more than seven years from the interconnection request to the project in-service date, unless the developer can demonstrate that engineering, permitting and construction of the project will take longer, but not to exceed 10 years.

All three northeastern US RTOs (PJM, NY, NE) and the California ISO use the spot energy market pricing system known as locational marginal pricing (LMP) for both day-ahead and real-time electric spot markets. LMP is a system of energy market pricing that combines 1) a single-clearing-price market structure for supply and demand with 2) security-constrained economic dispatch that directly incorporates the effect of transmission constraints into the dispatch and the underlying price (LMP) paid for energy received or supplied at each electrical node in the system. This system of pricing results in an optimal (i.e., most efficient) generation dispatch of a defined electric system by minimizing the total production costs of meeting load at any point in time while respecting the ability of the transmission system to deliver energy reliably. The effect

[57] The three studies (FERC 2003) are 1) the Interconnection Feasibility Study, a preliminary evaluation of the feasibility of the proposed interconnection, using power flow and short-circuit analyses (to be completed within 45 calendar days from the date of signing of an Interconnection Feasibility Study Agreement) (study requires a $10,000 deposit); 2) the Interconnection System Impact Study, a comprehensive evaluation of the impact of the proposed interconnection on the reliability of the transmission provider's transmission system and affected systems, using a stability analysis, power flow, and short-circuit analyses (to be completed within 60 calendar days from the date of signing of an Interconnection System Impact Study Agreement) (study requires a $50,000 deposit); and 3) the Interconnection Facilities Study, which determines a list of facilities (including the transmission provider's interconnection facilities and network upgrades as identified in the Interconnection System Impact Study), the cost of those facilities, and the time required to interconnect the generating facility with the transmission provider's transmission system (to be completed within 90 to 180 calendar days from the date of signing of an Interconnection Facilities Study Agreement) (study requires a $100,000 deposit or an estimated monthly cost developed by the transmission provider for conducting the Interconnection Facilities Study). There is a fourth, optional Interconnection Study or sensitivity analysis of various assumptions specified by the interconnection customer to identify any network upgrades that may be required to provide transmission delivery service over alternative transmission paths for the electricity produced by the generating facility (study requires a $10,000 deposit).

of such pricing systems is to internalize the costs of transmission congestion through the spot price of energy. Descriptive materials abound for this system of pricing. For example, the PJM RTO provides extensive training material on its LMP markets in publicly available postings (see extensive PJM training materials at http://www.pjm.com/training/training-material.aspx).

The effect of the existence of LMP market structures on OCS resource development is to first provide a transparent means of understanding how energy market prices are developed in the regional markets into which OCS resources would be connected. Second, LMP markets and the attendant RTO protocols offer opportunities to OCS developers to ensure access to relatively high-priced coastal electricity markets with minimal potential curtailment of OCS resource output as long as sufficient transmission interconnection is completed at the time of resource development. LMPs are computed based on the offer or bid price of the most-expensive resource required to meet demand at any point in time. All load will pay the LMP at its delivery location, and all supply receives the LMP at the point of delivery of energy. Bilateral contracting provisions can help ensure greater pricing certainty between buyer and seller.

In a constrained transmission system, LMPs between nodes by definition will differ depending on whether a region has excess generation (with transmission bottlenecks preventing its delivery) or requires more expensive local generation to ensure reliable service. When prices differ, transmission "congestion" is present.[58] In the northeastern RTOs, this construct usually manifests itself through the need to occasionally dispatch higher-running-priced gas- or oil-fired resources close-in to load centers, to complement less-expensive remotely sourced generation from coal or hydro facilities (whose running costs are lower). More generally, if insufficient transmission exists to deliver wind resource energy from a remote area into a load center, the prices (LMPs) in the area with "excess" generation will be relatively low, while the load area will require the use of more expensive generation to meet local needs (since the transmission system would be incapable of delivering all required energy into this area) and will have relatively higher prices (LMPs). In the extreme, LMPs could be less than zero if generation were not willing to back down enough to balance the system—and thus would have to pay to have their generation absorbed by the system. Some generation sources—nuclear, or baseload coal—are sometimes willing to pay to stay turned on at least to a minimum level, to avoid restart-related costs. This willingness to pay to maintain minimum operation levels has resulted in negative LMPs during some time periods in some localized, inland regions with excess supply.

Generally, OCS resource areas will not be faced with this price effect if sufficient transmission is built at the outset to both interconnect the resource to the grid, and bolster the local grid to allow OCS resource flow even in the event of a transmission system element outage. Even in the event that insufficient transmission is available to handle the full output of the OCS resource, the result is likely to be curtailment of output of the resource, rather than a negative LMP outcome. Contractual provisions between the buyer of OCS resource energy and the seller determine which party would bear attendant curtailment risk.

[58] Prices can also differ due to transmission system loss effects. This is a different price effect than the congestion price effect.

Coupled to the LMP-based energy market pricing structure is the presence of financial transmission rights (FTRs) that serve as financial "hedges" against the impacts of congestion.[59] These rights can be thought of as the financial equivalent to a physical transmission access right. FTRs exist to allow a market entity to transfer energy from one region to another, even in the presence of a congested grid, and generally be held harmless against the "costs" of that congestion, or the fact that the LMP may differ by a certain amount. In a system with FTRs, load in a congested coastal area may be able to buy a remotely dispatched resource and not suffer the financial consequences of delivering this resource from a low-priced zone into a high-priced zone. In other words, the holder of an FTR does not have to pay a toll across the congested highway other than what was paid to obtain the FTR. FTRs are generally sold at auction by system operators, although many are effectively allocated to load based on historical patterns of energy use, purchase of the output of remote resources, and payment for the underlying transmission system that allowed remote generation to be delivered to load centers.

FTRs vary in value depending on their term, the period in which they apply (e.g., off-peak or on-peak periods) and perhaps most importantly the geographical or electrical locations to which they are attributed. FTRs are "point-to-point" in nature, meaning that they hedge congestion costs from one node (or from one region) into another node (or into another region). FTRs that are held for delivery into New York City from upstate New York, or into eastern PJM from western PJM, or into the Boston region from northern Maine are currently representative of the relatively higher-value FTRs that exist in each of these northeastern RTO systems. These examples are broadly illustrative of "source to sink" paths that reflect generation-rich, low-load "remote" regions (e.g., Maine, western PJM, upstate New York) and load-dense, generation-short, "local" load areas. If the transmission systems between these respective points are bolstered, or if generation supply located closer-in to coastal load areas is increased, then the value of these FTRs would be relatively lower—i.e., the degree of congestion between the remote regions and the coastal regions would be less if either transmission increases or supply resource shifts towards load areas were to occur. OCS resources with sufficient transmission built to access the local coastal load regions would reflect an injection of supply resource into or close to the electrical heart of load centers on the coast—traditionally the highest-priced markets that exist in the lower 48 states.

An FTR's value is usually expressed as an energy "hedge" term, such as $/MWh. For example, a locational marginal price difference between two zones may average $5/MWh during on-peak periods of the summer months. An FTR associated with those zones and for that time period could be said to have a value of $5/MWh. This number represents the average of the LMP price differential between the two points in the day-ahead LMP market of interest. An FTR has a literal settlement value that is equal to the price difference between two points, not including any transmission loss component that may exist.

In each RTO, at any given point in time, controllers generally balance the system by using supply resources to meet load—and they use an economic dispatch priority to do so. This means

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[59] Detailed descriptive information on FTRs and related annual revenue rights is publicly available. See, for example, PJM's FTR training materials at http://www.pjm.com/sitecore/content/Globals/Training/Courses/ip-arr-ftr-annual.aspx.

that at any given time, one or more resources are "on the margin," used to meet the need for the last MWh of output to meet demand. Generally, this marginal resource is the most expensive resource underutilization. If an OCS resource were available to deliver energy into the grid, its output would generally first displace the most expensive resource that would otherwise be used to keep supply and load in balance. This concept results in a single resource or set of resources that at any given time are "marginal" in nature, and whose displacement is expected when an OCS resource with little or no variable operating costs comes online. The reason more than one resource may be needed as the "marginal supply" is the presence of transmission constraints. A transmission constraint effectively separates the system into pieces whose supply and demand must be balanced within each piece, and it usually requires multiple resources to do so. Marginal resources are usually fueled by natural gas, oil, or coal, as nuclear, hydro, and renewable resources usually have much lower (or even zero) operating costs. A set of marginal resources could include a combination of fuels. For example, if major west-to-east transmission paths are full in the PJM system, a coal unit may be on the margin in the western portion of the system, while a natural gas or oil unit is simultaneously on the margin in the eastern part.

Ancillary service costs are currently borne by load in the RTO regions of interest. Ancillary services are provided by capacity resources available to ramp up or down according to a dispatch directive, to assist in balancing supply with demand. As increased levels of variable output or intermittent resources are integrated onto the system, the need for ancillary services will likely change, increasing in some hours as the variability of the output is added to the variability of load. While discussions of cost allocation for added ancillary service requirements have taken place in many regions, at this point RTO tariffs do not include provisions to assign such costs directly to wind resources, for example.

In some RTOs, wind resources can participate in ancillary services markets if they meet the RTO's requirements.

Capacity markets have common structures across the eastern RTOs. PJM, NYISO, and ISO-NE all allow self-supply of capacity or capacity procurement via bilateral transactions, and all have periodic auctions. For these RTOs, the value of capacity to the purchaser (i.e., the demand by load-serving entities in order to fulfill their reserve requirements) is linked to the cost of new entry (or CONE, generally defined as the cost of bringing a new peaking resource online), although how the CONE figures into the procurement differs somewhat. For example, ISO-NE uses the CONE for the floor price at the auction.[60] Wind resources are generally permitted to participate in capacity markets, although they are generally only credited with historical output during peak hours. Unlike these eastern RTOs, California does not have a capacity market (Fink et al. 2009).

[60] The starting price in ISO-NE's Forward Capacity Market auction was initially set at two times the CONE, but in an order on April 23, 2010, FERC approved ISO-NE's proposal to decouple the auction starting price from the CONE. The price floor for the auction, currently based on the CONE, is still under consideration (FERC 2010c).

3.2.5 ISO Details

3.2.5.1 ISO-NE

ISO-NE's reliability region covers Connecticut, Maine,[61] Massachusetts, New Hampshire, Rhode Island, and Vermont. Its power system includes a projected 33,995 MW of generation and demand response capacity, total electricity demand of 27,875 MW at the summer peak, and 131,315 gigawatt-hours (GWh) of annual energy for 2009/2010. The ISO forecasts energy to grow at a moderate pace, 0.9% annually from 2009 to 2018. With massive investment in natural gas resources over the past decade, these generators are on the margin most of the time.

Resource Adequacy, Reliability, and Transmission Planning

ISO-NE analyzes and reports on the reliability and efficiency of proposed changes to New England's transmission system. Each year, ISO-NE produces a regional system plan (RSP) that determines resources and transmission facilities needed to maintain reliable and economic operation of New England's bulk electric power system over a 10-year horizon. RPSs summarize load and energy forecasts, resource adequacy studies, and transmission plans. System studies ensure that the reliability criteria of the bulk power system are met, evaluate system additions/alternatives to mitigate reliability criteria violations found, evaluate proposed interconnection of new generation and transmission, and support the regional system planning process (ISO-NE 2008a).

Transmission and Generation Interconnection

In ISO-NE, the generation interconnection process requires action by the ISO and its board, the transmission owner, and the generation developer. Interconnection requests are not grouped for simultaneous analysis. The steps generally involve:

- Completion of a system impact study by the ISO.
- ISO and transmission owner review of construction schedule, dispatch and bid modeling, and interconnection, metering, substation, and generator configuration.
- Review and approval by the New England Power Pool (NEPOOL) Committee.
- Execution of a generator agreement on dispatch protocol.
- Assignment of costs, maintenance, and operating responsibility for dispatch control equipment.
- ISO review of the site survey and generator definition.
- Transmission owner review of the transmission definition.

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[61] The transmission system and electric power markets in northern Maine, including Aroostook and Washington counties, are served by the Northern Maine Independent System Administrator, Inc., which has a load of approximately 130 MW (NMISA 2010). New Brunswick System Operator is the NERC reliability coordinator for NMISA (NERC 2008).

- Installation of communications equipment by the ISO.

- Testing and release of generation asset for commercial operations (ISO-NE 2005a).

With respect to transmission expansion, RSPs specify the characteristics of the physical solutions that can meet the system's economic and reliability needs and identify potential market solutions (ISO-NE 2008b). Any entity may undertake the design, construction, and interconnection of an elective transmission upgrade if it submits an application, completes any ISO-required studies, and obtains approval for the proposed upgrade (ISO-NE 2010a, Section II.47). The RSP also identifies a regulated transmission solution as a backstop measure in case market responses fail to meet transmission infrastructure requirements or the identified overall and area-specific system needs (ISO-NE 2008b).

Markets

The ISO operates day-ahead and real-time locational energy markets, which coordinate commitment and production from the region's generation and demand resources. LMPs are calculated for nodes, load zones (eight in total) and a hub (the Mass hub). Wind resources can submit a bid curve or self-schedule into the day-ahead market. Resources with a capacity supply obligation must offer or self-schedule into the real-time market. Energy imbalances between the real-time and day-ahead schedules are settled at the real-time LMP (Fink et al. 2009).

The installed capacity requirement (ICR) is the minimum amount of capacity needed to meet the reliability requirements defined for the New England control area—i.e., non-interruptible customers are disconnected no more than one day in 10 years. Through the monthly forward capacity market (FCM), capacity is procured three years forward on a locational basis. The FCM is intended to facilitate the entry of new supply and demand resources, but both new and existing resources can participate. The first auction was conducted successfully in February 2008 to meet the capacity requirements for June 2010 through May 2011 (Potomac Economics 2008a). The second auction produced an excess of capacity above the net ICR (Bacon 2009). The auction uses a single-price, descending clock auction. As the price ticks down, bidders remove themselves from the auction. Prices drop until the point at which lowering the price further would cause the supply to no longer meet installed capacity requirement. Wind resources can participate in the market as a capacity resource, valued based on median historical seasonal output during specific hours (Fink et al. 2009).

Market-based ancillary services include operating reserves and regulation.

- *Forward reserves.* At semi-annual auctions, 10-minute non-spinning reserves are procured for all of New England, and 30-minute operating reserves are procured for these reserve zones: all of New England, Boston, Connecticut, Southwest Connecticut, and the rest of the system (Potomac Economics 2007).

- *Real-time reserves.* Market clearing prices are calculated in real time for Boston/northeastern Massachusetts, southwest Connecticut, and the rest of Connecticut.[62]

- *Regulation.* ISO-NE designates generators to provide regulation service and calculates an hourly clearing price based on submitted offers for the generators providing this service in that hour (ISO-NE 2010b). Compensation to generators that provide regulation includes a regulation capacity payment, a service payment, and unit-specific opportunity cost payments (ISO-NE 2008c).

Wind is not eligible to participate in ancillary services markets (Fink et al. 2009).

Outside the energy markets, net commitment-period compensation is made to resources whose hourly commitment and dispatch by ISO-NE resulted in a shortfall between the resources' three-part offered value in the energy and regulation markets and the revenue earned from single-part clearing price paid for output over the course of the day. These reliability costs fall into four categories:

- *Voltage*—compensation for resources operated by ISO-NE to provide voltage control in specific locations.

- *Distribution/special constraint resource*—compensation for units dispatched at the request of local transmission providers to manage constraints on the distribution system.

- *Second contingency*—compensation for resources providing adequate capacity in constrained areas to respond to a local second contingency.

- *First contingency/"economic"*—compensation for eligible resources that are not providing second contingency, voltage, or distribution requirements. These resources may have been providing first contingency coverage system-wide or locally (Likover 2009).

ISO-NE operates annual and monthly auctions for FTRs. FTRs can be traded in a secondary market. The revenues from the auction of FTRs are allocated to load-serving entities (LSEs) and transmission customers.

Integrating Wind Resources

To minimize the additional ancillary services needed to follow load when large amounts of wind capacity is on the system, ISO-NE is investigating immediate-term and short- to medium-term wind power forecasting. A December 2008 RFP for such a study sought recommendations for technologies and forecast responsibility (centralized vendor, ISO-NE, or wind plant operator), among other things (ISO-NE 2008d).

[62] Reserve prices are calculated using the energy offer prices and reserve-constraint penalty factors when applicable; there are no real-time reserve offers (ISO-NE 2008c).

3.2.5.2 NYISO

NYISO is the ISO for the state of New York. For 2010, it has total resource capacity of 41,841 MW and a projected peak load of 33,025 MW. Annual energy was projected to grow by 0.78% per year through 2020, starting from a projected 160,358 GWh in 2010. Natural gas was the marginal fuel (NYISO 2010a).

Resource Adequacy, Reliability and Transmission Planning

NYISO conducts a comprehensive system planning process, consisting of local planning, reliability planning, and economic planning. The process starts with a local transmission owner planning process that gives stakeholders the opportunity to participate in the transmission owner's local planning efforts. Results of local planning efforts are fed into a two-part reliability planning process, beginning with a reliability needs assessment (RNA). The RNA is a reliability assessment of resource adequacy and transmission security of New York's power system over a 10-year planning horizon. In the second part of the reliability planning process, the ISO requests market-based and regulated backstop and alternative solutions to the needs identified in the RNA. Solutions can include generation, transmission, demand response, or some combination of these. NYISO develops a comprehensive reliability plan based on its technical and reliability assessments of the proposed solutions. This plan becomes a starting point for economic planning, consisting of congestion studies developed with market participant input and additional studies (NYISO 2009a [Table 3-7], 2010a).

Transmission and Generation Interconnection

In NYISO, as with other ISOs, developers of large generation (more than 20 MW) and merchant transmission are responsible for submitting an interconnection request to ISO, designating a point of interconnection, providing data, and making deposits with the ISO for completion of necessary studies. In coordination with the connecting transmission owner and owners of affected systems, NYISO completes a feasibility study (if required), a system reliability impact study, and an interconnection facilities study. The developer, connecting transmission owner, and NYISO negotiate, execute, and file the large generator interconnection agreement with FERC. The interconnection process in NYISO differs from some of the other ISOs' processes in that it groups interconnection requests into a class year for a combined interconnection facilities study. Under this process, the cost of system upgrade facilities, which are required to reliably interconnect the new facilities, is allocated among a class year of developers (NYISO 2004, 2006).

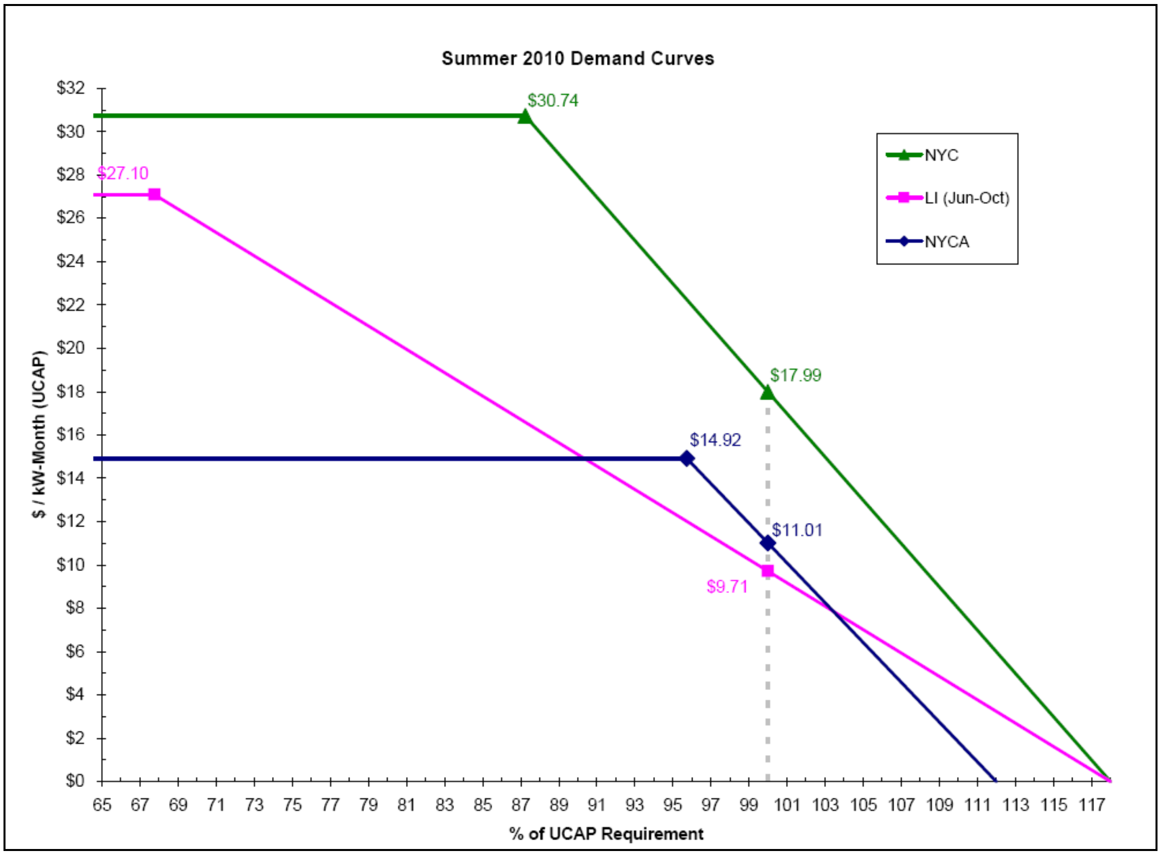
Customers exploring a transmission expansion submit a request to the ISO for either a system impact study (in-depth, identifying specific transmission reinforcement options) or a reinforcement options study (high-level, exploratory).

Markets

NYISO operates locational day-ahead and real-time wholesale markets. Day-ahead location-based marginal prices are determined on an hourly basis for the state's 11 zones and for the four neighboring areas (New England, Hydro Quebec, Ontario Hydro, and PJM). Real-time market location-based marginal prices are calculated at five-minute intervals (NYISO 2010b). For the real-time market, wind resources are required to bid a price curve that can include negative prices. A price curve is optional for participating in the day-ahead market. If wind is scheduled day-ahead, it is required to buy out shortfalls in its output at the real-time market price. However, if system operations are unconstrained, up to 3,300 MW is exempt from under-generation penalties (Fink et al. 2009).

Unforced capacity (reflecting the probability that a resource will be available to serve load, taking into account forced outages) can be sold into the ICAP Spot Market Auction or through bilateral contracts. The price of unforced capacity in the auction is determined by ICAP demand curves. The demand curve is administratively constructed and has been set for the 2008/2009, 2009/2010, and 2010/2011 capability years. NYISO established three ICAP demand curves: one each for the locational unforced capacity obligations for New York City and Long Island, and one to determine the total unforced capacity obligations for all LSEs serving load in the New York Control Area. The demand curve is based on three points, including a reference point defined by the localized levelized[63] cost to develop a peaking unit for the y-coordinate and 100% of that area's capacity requirement for the x-coordinate. A second point is where ICAP supply equals the minimum installed capacity requirement, and the price is 1.5 times the reference point price. Above the minimum installed capacity requirement, the curve declines to the zero crossing point, where supply equals 118% of the reserve requirement for New York City and Long Island and 112% of the reserve requirement for the New York Control Area (NYISO 2008a [Section 5.5], 2009b). Figure 20, below, shows the maximum clearing prices for the summer 2010 capability period (NYISO 2010c).

[63] In discussions of the electricity market, "levelizing" means calculating the present value of the total cost of building and operating a generating plant over its economic life and then converting the value to equal annual payments. The costs are adjusted to remove the impact of inflation. In financial terms, a levelized cost is called an annualized real cost.



Source: NYISO (2010c).

Figure 20. NYISO UCAP demand curves, summer 2010.

Wind is defined as an intermittent power resource in NYISO's tariff. It can supply unforced capacity based on NYISO's calculations for the summer and winter capability periods, which determine the amount of capacity it can reliably provide during system peak load hours.[64]

Market-based ancillary services include regulation and operating reserve and energy imbalance. Regulation service, 10-minute spinning, 10-minute non-synchronous, and 30-minute operating reserves are available from an hourly market for two separate zones (east and west). Cost-based ancillary services include scheduling, system control and dispatch, voltage control, and black start. Voltage support payments are made annually to all qualified suppliers for the entire New York Control Area based on installed capacity. Generators who provide black start services consistent with NYISO system restoration planning are paid for the actual costs of providing those services (NYISO 2009b, Schedules 2 through 5). Wind is not precluded from participating in the ancillary services markets, but it must meet the eligibility requirements for the specific market (Fink et al., 2009).

The NYISO conducts periodic auctions where one-month, six-month, and annual transmission congestion contracts (TCCs) are bought or sold. A TCC allows energy market participants to

[64] Wind capacity is rated based on its capacity factor between 2 p.m. and 6 p.m. from June through August and 4 p.m. through 8 p.m. from December through February (Fink et al. 2009).

hedge transmission price fluctuations. The holder of a TCC has the right to collect or the obligation to pay congestion rents in the day-ahead energy market between specific points of injection and withdrawal on the transmission system (NYISO 2010d).

Integrating Wind Resources

NYISO has recently implemented an array of wind-related initiatives:

- Established a centralized wind forecasting system in 2008, which uses frequent meteorological updates from wind power projects to predict their energy production for use by NYISO's electricity dispatching systems (NYISO 2010e).

- In 2009, implemented full integration of wind resources with economic dispatch of electricity. Wind plants are now part of security-constrained economic dispatch (the operation of generation facilities to produce energy at the lowest cost to reliably serve consumers, recognizing any operational limits of generation and transmission facilities), and NYISO system operators can now dispatch wind plants down to a lower output if needed to maintain system security (NYISO 2010e).

- Conducted a wind generation study, which determined that NYISO's systems and procedures (which includes the security-constrained economic dispatch and the practices that have been adopted to accommodate wind resources) will allow for the integration of up to eight GW of installed wind plants without any adverse reliability impacts, assuming that a sufficient resource base is maintained to support the wind. The eight GW of wind would supply in excess of 10% of the system's energy requirement and over 20% of the expected 2018 peak load on a nameplate capacity basis. The study further found that the average regulation requirement will need to increase by approximately 9% for every 1,000 MW increase in wind generation between the 4,250 MW and 8,000 MW level of installed wind (NYISO 2010e).

- Developed and implemented new market rules to expand the use of new energy storage technologies, such as flywheels and advanced battery systems that complement renewable energy resources such as wind generation (NYISO 2010e).

3.2.5.3 PJM

PJM's footprint includes all or most of Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, Virginia, West Virginia, and Ohio, as well as parts of Illinois, Michigan, Indiana, Kentucky, North Carolina, and Tennessee.

Resource Adequacy, Reliability and Transmission Planning

PJM's Regional Transmission Expansion Plan (RTEP) identifies transmission overloads, voltage limitations, and other reliability standards violations over a 15-year time horizon and puts forth transmission system upgrades and enhancements to mitigate those constraints. Approval of the RTEP by the PJM governing board binds transmission-owning utilities to construct the upgrades and new transmission laid out in the plan. Although some RTEP upgrades are economic in the sense that they relieve congestion and lower costs for electricity consumers, the vast majority of approved upgrades are required to meet reliability standards (PJM 2008a).

The RTEP approach integrates transmission with generation and load response projects. The RTEP is a coordinated and open planning process at the regional and local level. Mid-Atlantic, Western, and Southern Sub-Regional RTEP Committees participate in the review of proposed upgrades of more concern locally, starting from the initial stages in which assumptions are set through review of the planning analyses, violations, and alternative transmission expansions. The RTEP planning studies include all generation with a completed system impact study (PJM 2008b).

Transmission and Generation Interconnection

Like the other ISOs, PJM conducts a feasibility study, system impact study, and interconnection facilities study based on the generation or transmission developer's submission of data and deposits. Interconnection requests are grouped based on when they are submitted, four times per year. Wind facilities are subject to additional requirements. For example, interconnection requests for wind facilities must include site plans or specify that minimum acreage requirements have been met (PJM 2009a).

Markets

PJM operates markets for day-ahead and real-time energy, day-ahead scheduling reserves, capacity (the Reliability Pricing Model or RPM), synchronized reserves, regulation services, and FTRs.

In the day-ahead energy market, LMPs are calculated for each location (node) on the system for every hour of the following day based on generation offers, demand bids, and scheduled bilateral transactions. Real-time energy market LMPs are calculated at five-minute intervals and reflect actual grid operating conditions (PJM 2010a). How wind generators participate in the energy market depends on whether it is a capacity resource (i.e., whether the generator can be used by loadserving entities to meet capacity obligations). If a wind resource is a capacity resource, it is required to offer into the day-ahead energy market; other wind resources are allowed but not required to offer into the day-ahead energy market. A wind resource that only participates in the real-time market receives the real-time energy market price. If self-scheduled wind generators produce more or less energy than scheduled the previous day, they incur balancing charges, although differentials less than 5% or 5 MW incur no deviation charges. Wind resources that are not self-scheduled are assessed deviation charges based on how closely they follow PJM's dispatch signals (Fink et al. 2009).

Through the annual RPM auctions, LSEs can fulfill any capacity obligations that they have not committed to supply themselves or through bilateral contracts. Base residual auctions are held for the procurement of unit-specific resource commitments that are required to satisfy the region's unforced capacity obligation, after accounting for self-supply, interruptible load, and existing capacity obligations, for a future delivery year three years in the future.[65] Residual auctions are held 23, 13, and four months in advance of the delivery year in order to account for changes in the need for capacity after the base residual auction (PJM 2007). Both existing generation and new sources of capacity are eligible, including generating plants, demand

[65] Unforced capacity is installed capacity that is not on average experiencing a forced outage or forced derating. It is rated at summer conditions (PJM 2008e).

response, and transmission facilities. Capacity prices are set based on supply bids and downward-sloping, administratively determined demand curves that assign value to additional capacity above the target installed reserve margins for the PJM region as a whole and for its constrained subregions (called locational deliverability areas). A backstop mechanism is designed to ensure that sufficient resources will be available to preserve system reliability, should the RPM auctions fail to produce sufficient capacity (PJM 2009b). As described in manual M-21, PJM has a specific procedure to determine an appropriate capacity value for wind generator output (PJM 2009a).

The day-ahead scheduling reserve market is an offer-based forward market for supplemental, 30-minute reserves on the PJM system (PJM 2010b). To the extent that this market does not meet the requirement for day-ahead scheduling reserves, PJM schedules additional operating reserves (PJM 2008c).

PJM operates two ancillary services markets. Synchronized reserves provide electricity to meet unexpected needs on short notice, and regulation services correct for short-term changes in electricity use. Market prices for these services are calculated on an hourly basis. PJM determines which market resources supply these services using simultaneous optimization of energy, regulation, and synchronized reserves (PJM 2009c). Black start service is providing electricity to restore the system if the entire grid loses power; it is not market-based. If it can meet the requirements, wind can participate in ancillary service markets (Fink et al. 2009).

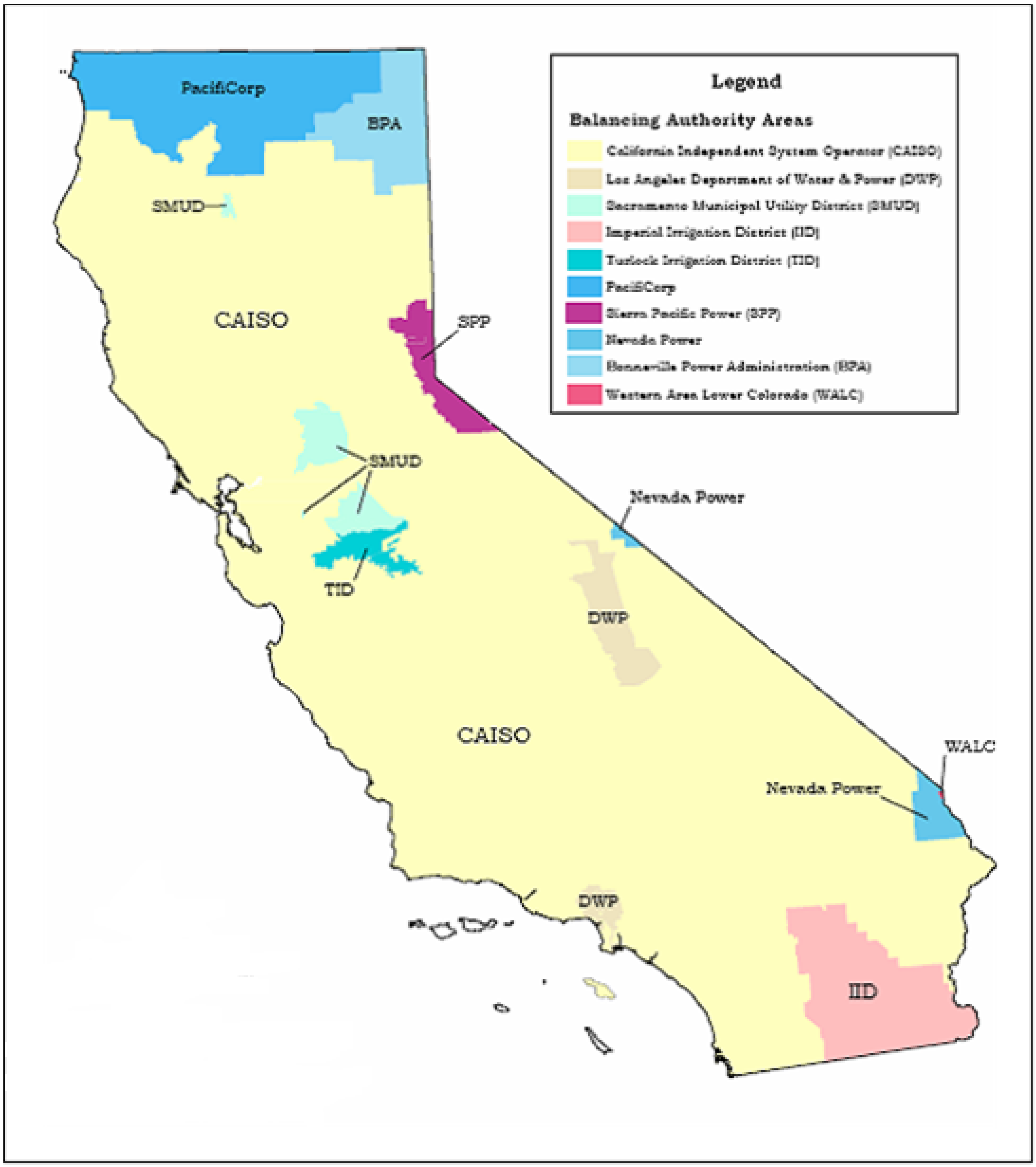
PJM operates a market for FTRs, financial instruments that entitle the holder to receive compensation for transmission congestion charges that arise in the day-ahead energy market as a result of the dispatch of more expensive generation to relieve the congestion. PJM holds monthly, long-term, and annual auctions for FTRs. FTRs are available for points to and from individual buses, hubs, zones, and aggregate or interface buses at the monthly auctions; FTR sources and destination points are more limited in the long-term and annual FTR auctions (PJM 2008d).

Integrating Wind Resources

A PJM stakeholder group has been working on the wind power data requirements needed to produce accurate wind forecasts. PJM recently selected Energy and Meteo Systems from Germany to provide wind forecasting services (PJM 2009d).

3.2.5.4 CAISO

CAISO includes most of California and northern Baja California (Mexico). The footprint consists of the former control areas of the three IOUs (PG&E, San Diego Gas and Electric, and Southern California Edison) and service areas of some of the municipal utility districts. Sacramento (Sacramento Municipal Utility District) and Los Angeles (Los Angeles Department of Water and Power) are their own control areas. Figure 21 shows the California balancing authorities.



Source: California Energy Commission. http://www.energy.ca.gov/maps/ISO_NON-ISO_SERVICE_AREAS.PDF.

Figure 21. California balancing authorities.

As of 2006, the CAISO system included 56,347 MW of capacity and produced 177,757 GWh of energy. The CEC forecasts energy to grow 1.25% annually from 2008 to 2018 statewide, although per capita growth is expected to be much lower. The marginal fuel for the CAISO system is natural gas. CAISO's planning processes, market structure, and wind integration efforts are described below.

Resource Adequacy, Reliability and Transmission Planning

Unlike ISO-NE, NYISO, and PJM, CAISO does not serve as reliability coordinator for NERC. As of January 1, 2009, the WECC assumed that role for the entire Western Interconnection. Planning reserve margins are set by the California Public Utilities Commission (CPUC) or the relevant regulatory authority, although LSEs are required to provide monthly and annual resource adequacy plans to the ISO (CAISO 2010a, Sections 40.2–40.4, p. 463B). As of 2007, the CAISO does set and enforce requirements for the minimum amount of local capacity area resources that must be available to the CAISO within each local capacity area (CAISO 2009a). Although the ISO prepares a 12-month forecast of weekly generation capacity and peak demand on an annual basis (CAISO 2010a, Section 42.1), the CEC is the primary energy policy and planning agency with responsibility for forecasting future energy needs and licensing of thermal power plants.

CAISO conducts transmission planning processes, including a comprehensive transmission plan focusing on expansion of the transmission system to support long-term power supply arrangements, long-term transmission rights, and the larger regional bilateral market. This plan includes project-specific reports and specific resource adequacy studies for transmission-dependent local areas. Regional transmission focuses on long-term planning (three to 15 years) and short-term planning (zero to three years) (CAISO 2010b). The CEC takes an active role in addressing transmission planning and permitting issues, especially as they may affect attainment of the state's GHG reduction goals (CAISO 2010c).

Transmission and Generation Interconnection

Using a serial study approach, CAISO experienced a substantial backlog of generation interconnection requests, many of them renewables. Requiring roughly six months to completely study a project all the way through the facilities study analysis, CAISO would have needed over three years to process all of the projects in the queue as of April 2008 (Porter et al. 2009). In July 2008, CAISO proposed reforms to the generator interconnection process to improve study efficiency, increase CAISO's confidence in commercial viability of projects being studied, and give project developers greater certainty about the timing of interconnection studies and their share of interconnection costs. In September 2008, FERC conditionally approved these proposed changes. The reforms address the backlog in interconnection requests and other procedural flaws in the interconnection application process by:

- Increasing the financial commitment necessary.
- Studying projects with related system impacts in groups.
- Providing for pro rata allocation of transmission upgrades across grouped projects.

The CAISO proposal intends to complete the first set of interconnection cluster studies by the second quarter of 2010, which will help clear much of the backlog (CPUC 2008). In terms of interconnecting a merchant transmission facility (for which the project sponsor does not seek a regulated rate of recovery), the ISO and affected participating transmission owners perform technical studies to determine whether and how the project can be safely and reliably integrated with the ISO balancing authority area. Further, detailed facilities studies are performed by the owners of the existing transmission facilities to which the new project would interconnect. Studies are performed at the expense of the project sponsor (CAISO 2009b).

Markets

CAISO operates a locational real-time energy market and, since implementation of the Market Redesign and Technology Upgrade (MRTU), a locational day-ahead energy market. An integrated forward market, including day-ahead energy, ancillary services (electricity reserves), and transmission management, was established to improve the efficiency of resource management and reduce opportunity for market manipulation (FERC 2006).

For the energy markets, LMPs are calculated for nodes and aggregated pricing nodes, including load aggregation points and hubs (CAISO 2009c). Before MRTU, there was no organized day-ahead market in California, and consequently all day-ahead scheduling was based on bilateral contracts and supply resources directly owned or controlled by LSEs. The high level of forward scheduling is partly due to a CAISO Tariff requirement that day-ahead schedules equal at least 95% of hourly forecast demand, and partly to CPUC procurement guidelines that encourage LSEs to forward-contract for most or all of their projected energy needs. Wind energy is scheduled hour-ahead as a price-taker in the real time market. Imbalance settlements are determined based on participation in the wind forecasting system: if participating, hourly deviations are settled at a monthly weighted market-clearing price; if not, then the wind generator is subject to 10-minute imbalance energy charges (Fink et al. 2009).

Ancillary services products that are procured in the CAISO markets include:

- Regulation up: The ability of a resource to increase its actual operating level in response to a signal from the system operator to maintain grid reliability.
- Regulation down: The ability of a resource to decrease its actual operating level in response to a signal from the system operator to maintain grid reliability.
- Spinning reserve: The additional generating capacity that is available by increasing the power output of generators that are already connected to the power system.
- Non-spinning reserve: The additional generating capacity that is not currently connected to the system but can be brought online after a short delay.

Regulation up and regulation down are distinct capacity products, with separately stated requirements and market clearing prices in each settlement period (CAISO 2010a). Ancillary services requirements, procurement, and pricing are expressed by Ancillary Services Region. Ancillary Services Regions include the expanded system, system, and eight subregions, created in anticipation of congestion on Path 15 and Path 26 (CAISO 2009c). Wind generators participating in the Participating Intermittent Resource Program (discussed below) are specifically excluded from taking part in the ancillary services market (Fink et al. 2009).

With MRTU, congestion revenue rights (CRRs) were created to reserve and allocate space on the transmission wires. CRR terms are monthly, seasonal (January–March, April–June, July–September, and October–December), long-term (10 years), or merchant transmission (30 years or life of facility). CRRs can be obtained from ISO allocation, annual and monthly auctions, and bilateral trades (CAISO 2010d).

Integrating Wind Resources

The Participating Intermittent Resource Program Initiative seeks to shed light on the cost drivers for wind resources, and on whether improving the forecast accuracy can significantly reduce cost impacts. The ISO is proposing changes to its Eligible Intermittent Resources Protocol to increase availability of site-specific and precise real-time data, for developing more accurate real-time production forecasts. The proposed modifications are:

- Expanding the equipment installation and data communication requirement.
- Lowering the forced outage threshold reporting requirement (CAISO 2010e).

For example, the WECC has initiated the development of generic wind turbine models to facilitate the development and implementation of solutions to regional reliability and market challenges posed by renewable energy integration (WECC 2009).

As discussed, RTO market protocols vary, but in general the effect on new resources can be seen in the way in which electricity output is priced in each of the energy, capacity, and ancillary service market structures in each RTO. All of the RTOs use a form of LMP in their energy markets. The level of these prices stems from the fundamental market factors—supply and demand quantities, loading patterns, and fuel used—but it is predominately the fuel of the marginal generator or generators that determines the price in each market. Capacity market structures in place at each RTO vary, but in the three eastern RTOs, the structures have similar foundations tied to the costs of a new fossil-fuel-fired peaking generator. Ancillary service markets structures are also similar across the eastern RTOs.

RTO wind integration efforts have only recently begun to accelerate, as new wind resources make up a large fraction of the generation interconnection queues in all the RTO regions, and existing installed wind levels are increasing. At this point, wind integration costs are less of a factor for OCS resource development because all operating reserve requirement costs are allocated to load, not to generators, in the eastern RTOs.

3.2.5.5 Highlighted Opportunities for OCS Resources in Eastern RTO-Operated Market Areas

In this section we focus on OCS resource opportunities proximate to the three eastern RTO regions since these are the areas that have already seen the greatest level of commercial interest in OCS resource development. We present information illustrating the nature of RTO activities that provide support for eventual development of such resources. Section 2.4 describes the specific projects currently being considered in the states within the three northeastern and mid-Atlantic RTOs.

New England. ISO-NE has prepared a draft economic study of the potential for the region to absorb as much as 12,000 MW of wind power (the size of installed electric generation capacity in New England is roughly 34,000 MW) (ISO-NE 2009a). One of the planning scenarios in this report considers as much as 4,000 MW coming from offshore wind resources, split approximately equally off the waters of Rhode Island, Massachusetts, and Maine. The report outlines a series of transmission reinforcement requirements associated with this level of offshore wind, and provides an approximation of the costs of this transmission. The report indicates that OCS resource developers generally would be responsible for providing 115-kilovolt cable interconnections from the resource to the land grid. ISO-NE is also in the process of completing a wind integration study,[66] which follows a study completed in 2007 (Levitan and Associates 2007) for ISO-NE on the potential for onshore and offshore wind resources.

All of the New England states have RPSs, and New England wholesale market prices have been among the highest in the United States due to the extensive reliance on natural gas for electric power generation. In part as a result of these drivers, offshore wind development projects have been proposed and are in various stages of contract and permit development in Rhode Island and Massachusetts.

New York. In 2004, the New York State Energy Research and Development Authority (NYSERDA) sponsored a wind integration study that illustrated the New York region's ability to integrate up to 3,300 MW of wind generation (GE Energy and Energy Consulting 2005). That study considered integration of offshore resources in the downstate New York area. In 2009, Con Edison and the Long Island Power Authority announced a joint effort to consider an offshore wind facility of 350 MW, potentially expanding to 700 MW and eventually 1,400 MW (Con Edison and LIPA 2009). This project would interconnect into one of the highest-priced electricity market regions in the United States. In April 2009, the New York Power Authority announced plans to consider proposals for offshore wind on Lake Ontario (NYPA 2009). NYISO has taken explicit steps to help integrate wind resources into the grid,[67] and these steps will be to the benefit of OCS resources that seek to be connected to the New York grid. For example, the following illustrates some of the wind integration measures overseen by NYISO:

- Prepared formats and protocols for individual wind power operators to report to NYISO (NYISO 2008f).
- Developed a Web-based tool to forecast wind power production.[68]
- Continued efforts to fully integrate wind power (NYISO 2009f).
- Continued development of tools to support integration of wind power into their system (NYISO 2009g).

PJM. The PJM RTO has conducted feasibility studies for transmission interconnection for potential offshore wind projects off the coasts of New Jersey and Delaware.[69] The potential construction of a new 500-kilovolt line (the Mid-Atlantic Power Pathway, or MAPP) that would extend closer to the Atlantic coast (at the planned terminus at Indian River, Delaware) than any

[66] The first part of this study is complete. The remaining portions will be completed during 2010.
[67] For example, see NYISO's "Integration of Wind" white paper (NYISO 2008b).
[68] See NYISO (2008c), Figure 4-1.
[69] Multiple studies have been conducted. They are available at http://www.pjm.com/planning/generation-interconnection/generation-queue-active.aspx.

other 500-kilovolt line in PJM offers an opportunity for OCS resources to interconnect to the high-transfer capability "backbone" grid of PJM. The eastern PJM market area, like downstate New York, experiences some of the highest wholesale electricity prices in the nation. Delaware, New Jersey, Pennsylvania, Maryland, the District of Columbia, and Virginia all have RPSs in place.

3.2.5.6 State Regulatory Authorities and OCS Waters Development

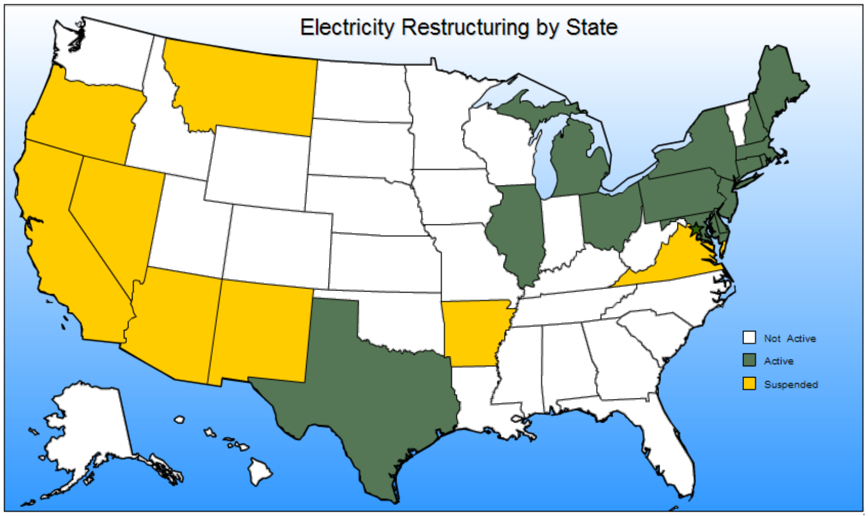
Section 3.2 focuses on regional electricity markets; state regulatory entities may take actions somewhat independent of regional competitive wholesale markets and the presence of an RTO. State actions are discussed in Section 2.3 above, while specific projects are described in Section 2.4.

3.2.5.7 Non-RTO Utility Regions

Non-RTO utility regions in the United States are composed primarily of vertically integrated utilities and wholesale-level cooperative arrangements (such as is seen in the Pacific Northwest, where federal power from the Columbia River system is delivered to various utilities at regulated rates). Vertically integrated utilities are the primary model for generation, distribution, and transmission of power supply for end use customers in most areas of the country. Frequently, the same entities that own and operate the transmission and distribution systems also generate some or all of the power needed to meet their customers' electric load. These entities can take the form of for-profit investor-owned utilities, municipal utilities, and electric cooperatives. Some vertically integrated utilities do purchase generation from other entities, such as federal power authorities or the owners (or co-owners) of qualifying facilities. The service territory for one such federal power authority, the Bonneville Power Administration (BPA), covers much of the Pacific Northwest, including Washington and Oregon, the states that border the OCS.[70,71] The generation, transmission, and distribution rates of vertically integrated utilities are generally regulated by state public utility commissions (also called public service commissions, corporation commissions, departments of utility control, etc.). Figure 22 shows the states that have replaced the monopoly system of electric utilities with competing retail suppliers.

[70] In addition to Washington and Oregon, BPA's service territory includes Idaho, western Montana, and small contiguous portions of California, Nevada, Utah, Wyoming, and eastern Montana (BPA 2008).

[71] State power authorities also exist in areas with deregulated electricity markets, including, for example, the New York Power Authority and the Long Island Power Authority in the NYISO region.



Source: USDOE EIA.
http://www.eia.doe.gov/cneaf/electricity/page/restructuring/restructure_elect.html.

Figure 22. Status of electricity restructuring by state.

Per FERC Order 888, merchant generators can access transmission lines and potentially sell power to an incumbent utility. However, with a few exceptions, vertically integrated utilities are not obligated to purchase power from other entities, and, having less experience doing so than merchant generators or other entities, may not be able to develop renewable resources as quickly or cost-effectively. Moreover, the price of power in the regions that are rate-regulated tends to be low. For example, the southeastern United States has access to plentiful low-cost coal resources, and the Pacific Northwest has an abundance of cheap hydroelectric power. Without legislative or regulatory prompting, these areas are much less likely to invest in currently expensive OCS resources. Moreover, in the Southeast, the potential for renewable resources is much less than in the high-priced Northeast and Mid-Atlantic, where proposals for the development of offshore wind and wave resources are currently being discussed. Population centers in the Southeast (with the exception of Florida) are also located further inland (see Figure 12) and would benefit less from development of renewables on the OCS. In the Northwest, state RPSs and the Western Climate Initiative have spurred interest in renewable resource development on the OCS. (See Sections 3.2 and 3.3 for more detail on policies affecting alternative resource development and on specific proposals to develop renewable energy resources on the OCS.)

3.3 Federal and State Fossil-Fueled Power Plant Emission Regulations and Markets

Section 3.2 described a number of state and federal policies that require or directly incentivize the development of renewable energy projects including wind, wave, and tidal resources. This section focuses on policies that indirectly support energy resources that produce low or no air emissions by establishing and regulating the societal, environmental, and economic costs of air emissions. These policies require that conventional fossil-burning energy resources internalize the cost of air emissions by installing and operating mitigation technologies, by paying another entity to reduce its emissions, or by paying non-compliance penalties. This increases the cost of fossil-fired generation vis-à-vis clean renewable resources and makes the latter more competitive. Increasingly strict environmental regulations may encourage significant development of renewable energy resources on the OCS in the near future.

Existing policies on power plant emissions regulate sulfur dioxide (SO_2), particulate matter (PM, further classified as $PM_{2.5}$ and PM_{10} according to the diameter of the particulate in microns), oxides of nitrogen (NO_x), mercury, and secondary pollutants that form from direct emissions, including ozone (O_3). As explained below, climate protection policies focused on GHG emissions, including carbon dioxide (CO_2), would almost certainly have a far greater impact on the cost of fossil-fired generation resources than existing air quality and emissions policies. New restrictions on CO_2 emissions, combined with more stringent future regulation of SO_2, NO_x, and mercury, may all contribute to the narrowing of the cost differential between conventional forms of generation and renewable energy technologies.

3.3.1 Basic Concepts of Emission Regulation and Trading

Existing air quality regulations in the United States focus on the source of air emissions, such as power plants, or on the concentrations of pollution in the ambient air.

U.S. regulations on emissions sources have included both command-and-control and emission trading programs. Under command-and-control regulations, policymakers mandate that entities use certain technologies that reduce the amount of pollution discharged into the environment. Emission trading programs ("cap-and-trade" programs) are market-based alternatives to the traditional command-and-control approach to environmental policymaking. Cap-and-trade programs are designed to be both efficient and cost-effective. They set a limit (cap) on the amount of a specific pollutant that can be emitted by the sources covered under the program. Those sources are then issued allowances, or emissions permits, that allow them to emit a certain amount of the covered pollutant. The initial supply of allowances may be given away, auctioned off, or some combination of the two. In most programs, one allowance typically represents one ton of a pollutant. The total number of allowances in the program cannot exceed the emissions limit set by a governing body or agency. Allowances, like any other commodity, may be bought, sold, traded, or saved for future years. Sources that emit less of a pollutant than the number of allowances they hold may sell them to sources that emit more. In this way, sources that can reduce emissions at a cost lower than the price of an allowance will do so, and sources that find it more expensive to reduce emissions can then purchase these extra allowances at a lower cost.

Generally speaking, any factor that restricts the supply of emissions allowances or causes an increase in the consumption of allowances will lead to an increase in the price of an emissions allowance. In the short-term, allowance price fluctuations are driven by factors that affect electricity production. Prices can be expected to be higher in the summer and winter months, when power plants must produce more electricity and therefore emit greater quantities of air pollutants. The composition of the electricity being produced at any given time will also have an effect on emissions allowance prices. The availability of baseload nuclear and hydro and other renewables, as well as availability of gas-fired resources, will affect the share of energy production coming from coal-fired units, and also the price of associated emissions. Factors affecting emissions allowance prices in the long term include the availability and cost of low-emissions and emissions control technologies, the tightening of emissions regulations over time, the ability to bank allowances for compliance in a future year, and the availability of low-cost offset projects, both domestically and internationally (in the case of carbon dioxide allowances).

In contrast to direct regulation of emission sources, air quality regulations have focused on the concentrations of pollution in the ambient air. The 1970 Clean Air Act (CAA) established two types of National Ambient Air Quality Standards (NAAQS), primary and secondary standards. Primary standards seek to protect human health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. NAAQS are discussed later in this section under "Regulations of Other Power Plant Emissions."

3.3.2 New England Generation Information System, PJM Generation Attribute Tracking System, Western Renewable Generation Information System

The New England Generation Information System (NE-GIS), an accounting system adopted in 2002 and maintained by NEPOOL, tracks the attributes of each MWh of power produced. Similarly, the Generation Attribute Tracking System (GATS) is a software system designed in 2005, used in Delaware, Maryland, New Jersey, Washington D.C., Pennsylvania, and Ohio for tracking purposes.[72] The Western Renewable Generation Information System (WREGIS) is an independent tracking system/database for renewable energy that serves the same purpose as NE-GIS and PJM GATS for the region covered by the Western Electricity Coordinating Council.[73] RECs are issued to document the attributes of each MWh of power produced, including type of generation technology, date of operation, fuel sources, and different emissions. Electricity suppliers use the certificates to differentiate their products for customers for the purpose of ensuring compliance of the state and regional RPS and emissions standards, and to provide the information needed for energy disclosure labels. The NE-GIS is the most comprehensive system of its kind in the United States: it labels each unit of power, whereas the others give certificates only to the renewable energy. The certificates-based tracking systems support a robust market for renewable and environmentally preferred electricity generation sources.[74]

3.3.3 Climate Change Policy

3.3.3.1 Proposed Federal Legislation

In 1992 an international treaty known as the United Nations Framework Convention on Climate Change was developed with the objective of stabilizing GHG concentrations at a level that would prevent dangerous changes to the global climate system. The Kyoto Protocol of 1997 established a binding global commitment to the reduction of emissions of GHGs for all countries choosing to ratify the treaty.

The United States was not among these countries and has not yet capped its own national emissions of GHGs. Should the United States adopt its own legislation that restricts GHG emissions, it might take the form of a cap-and-trade program. In recent years there have been

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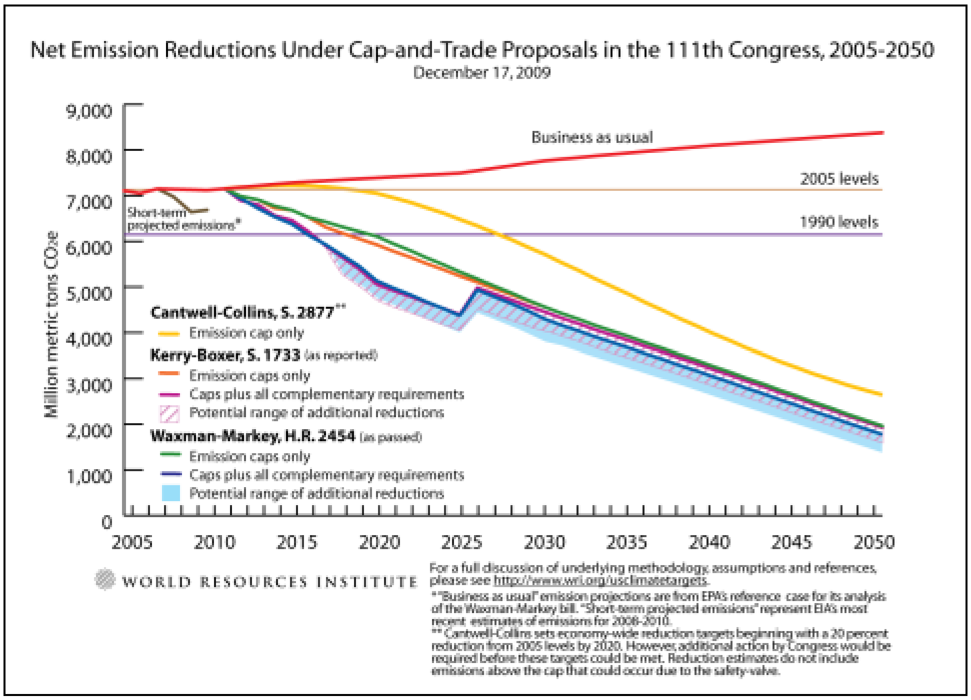
[72] For more information, see http://www.pjm-eis.com/gats/about-gats.html.
[73] For more information, see http://www.wregis.org/about.php.
[74] For more information, see http://www.masstech.org/cleanenergy/policy/rec.htm.

several proposed bills for the regulation of GHGs in the United States, all of which have included emissions trading programs with caps that decrease over time. Figure 23 below shows the emissions trajectories that would be mandated by the legislation that came before the 111th Congress. The Waxman-Markey bill, passed by the House of Representatives as the American Clean Energy and Security Act of 2009, would require emissions reductions of 17% below 2005 levels by 2020 and 83% by 2050. A portion of allowances would be given to utilities for free, and the remaining portion would be auctioned. The Kerry-Boxer bill had a stricter short-term emissions target, with a goal of a 20% reduction below 2005 levels by 2020 and 83% by 2050. A proposal from the Obama administration included a cap-and-trade program and aimed to reduce GHGs by 80% by 2050. These targets reflect scientific consensus of the reductions, which are necessary to stabilize atmospheric CO_2 concentrations at levels that may avoid the most dangerous impacts of climate change.



Source: World Resources Institute.

Figure 23. Emissions reductions that would be required under climate change bills introduced in the 111th U.S. Congress.

Various government agencies have performed analyses which model the impact of these policy proposals by examining various possible scenarios. These scenarios reflect a wide range of assumptions concerning important inputs, such as the "business-as-usual" emissions forecasts, the reduction targets in each proposal, whether complementary policies such as aggressive investments in energy efficiency and renewable energy are implemented independently of the emissions allowance market, the policy implementation timeline, program flexibility regarding emissions offsets (perhaps international) and allowance banking, assumptions about technological progress and the cost of alternatives, and the presence or absence of a "safety valve" price, a market stability reserve that holds 3.5 billion allowances that will be released if a strategic reserve trigger price is reached. Depending on the scenario, a wide range of allowance prices is possible, from a low of $10/ton to a high of $50/ton at program inception in 2012, and reaching anywhere from $23/ton to $180/ton in 2030.[75]

Regulation of GHGs need not result from new federal legislation. On April 2, 2007, in *Massachusetts v. EPA,* the Supreme Court found that GHGs are subject to EPA regulation under the existing CAA. It was the Court's finding that the EPA Administrator determines whether or not emissions of GHGs are a danger to public health or welfare. This Endangerment Finding was issued on December 7, 2009, allowing EPA to finalize emissions standards on light-duty vehicles proposed earlier that year (EPA 2009a). While President Obama and EPA Administrator Lisa Jackson have both stated that they support a legislative solution to the climate change issue, the Endangerment Finding allows EPA to regulate GHGs under the CAA should legislation not be passed (EPA 2009b). EPA is currently using the Endangerment Finding to develop the first-ever GHG standards for heavy-duty vehicles and to further develop the standards for light-duty vehicles. While it has the authority to do so, the Agency has announced no plans, to date, to use the Endangerment Finding to regulate GHGs from electric power generation.

EPA has also issued a Mandatory Reporting of Greenhouse Gases Rule, which requires the reporting of emission data from large sources and suppliers (emitting 25,000 metric tons or more per year of GHGs) in the United States. The intent of the rule is to collect accurate and timely data on emissions that can be used to inform future policy decisions. The final rule was signed by the Administrator on September 22, 2009, and was effective as of December 29, 2009 (EPA 2009c). Finally, EPA has proposed a rule regarding the injection of CO_2 into the ground for the purpose of sequestration and the permitting required to do so (EPA 2008). Carbon sequestration is viewed as being critical to keeping coal plants in operation, but carries significant costs. Many coal-producing states are developing their own carbon sequestration rules.

3.3.3.2 Effect of Proposed Federal Regulation on Electricity Costs

Figure 24 and 25 below represent the cost of electricity, for existing and new generation plants, given an assumed CO_2 price of $39 (2008$) per ton, levelized over the period 2015 through 2034.[76] This allowance price represents the mid-range CO_2 price projected by Synapse Energy Economics in 2008 (Schlissel et al. 2008). Both figures use assumed fuel price projections. The second figure includes estimated capital costs for construction. The first, Figure 24, does not include capital costs, because the existing U.S. power plants are of varying ages and exhibit a

[75] Modeling data taken from EIA at http://www.eia.doe.gov/neic/press/press321.html, and from EPA at http://epa.gov/climatechange/economics/economicanalyses.html. Dollar values were converted and are presented in 2009$ per short ton of CO_2 equivalent.

[76] Levelized costs represent the entire cost of an electric generating system over its lifetime, and includes capital costs, O&M costs, fuel costs, and environmental costs. Levelized costs are typically calculated over a 20- or 40-year lifetime and are represented in dollars per MWh (or some other unit of output), and are thus useful for comparing operating costs of various different types of electric generation technologies. In order to calculate levelized costs, annual costs are summed and then discounted over the relevant time period in order to arrive at the net present value of the generating technology. This total net present value is then converted into a stream of payments, which are equal in all years, over that same time period.

wide range of construction costs that are not relevant to production cost and related impacts of climate change regulation. [77]

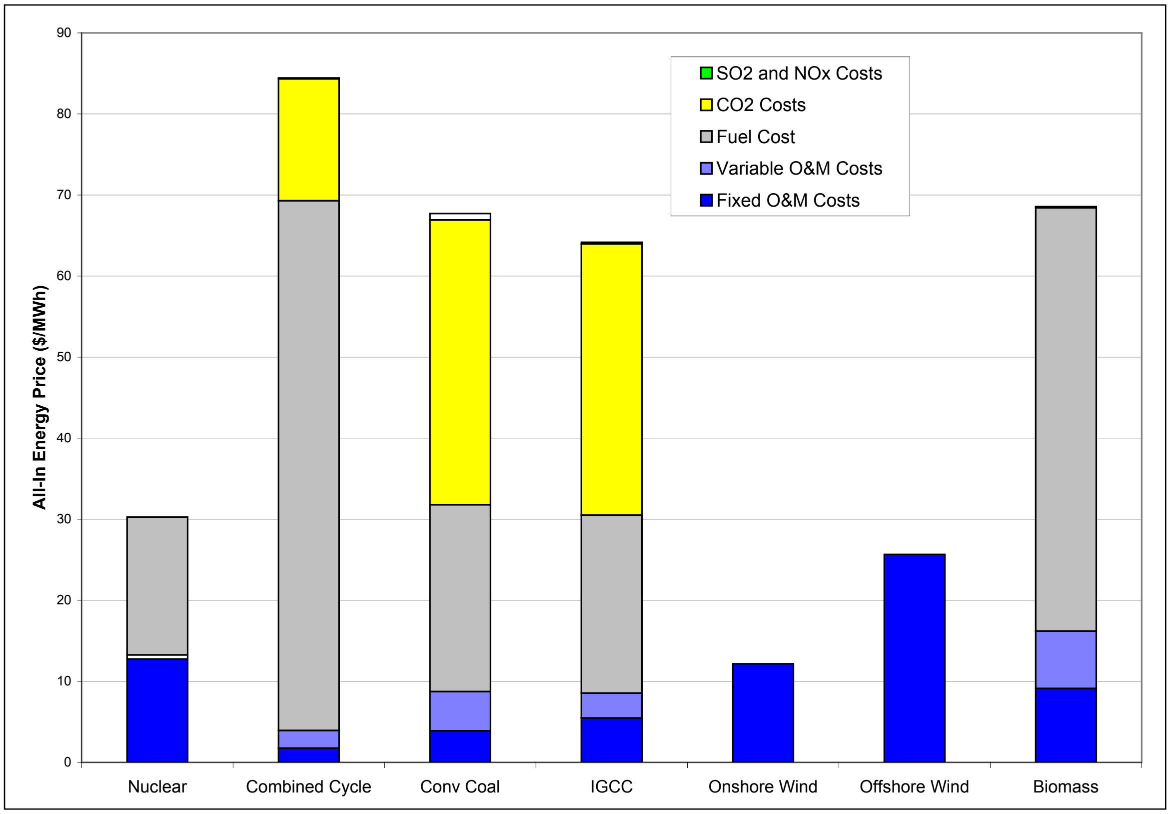


Figure 24. Levelized costs of electricity production from existing power plants, excluding sunk capital costs and including projected costs of carbon.

[77] Costs of compliance with emissions regulations are taken from EPA's IPM analysis of CAIR, and include a SO_2 price of $1,000/ton and a NO_x price of $1,481/ton. Fixed and variable costs are taken from DOE EIA 2009d, Table 8.2. Assumed capacity factors were as follows: 85% for nuclear, 80% for combined cycle, 85% for conventional coal, 85% for integrated gasification combined cycle, 30% for onshore wind, 42% for offshore wind, and 85% for biomass. Assumed heat rates were as follows (Btu/kWh): 10,000 for nuclear, 6,998 for combined cycle, 9,200 for conventional coal, 8,765 for integrated gasification combined cycle, and 8,706 for biomass. Assumed levelized fuel costs were taken from Hornby et al., and were as follows (2008$/mmBtu): $1.70 for uranium, $9.34 for natural gas, $2.51 for coal, and $6.00 for biomass. Wind costs (onshore and offshore) include the PTC but do not include firming of power to account for differences in estimated capacity factors across units. In order to convert fuel costs to $/MWh, the levelized fuel cost (in $/mmBtu) was multiplied by the assumed plant heat rate (in Btu/kWh), and the product was divided by 1,000 (the number of kWh in 1 MWh). In order to convert emissions costs into $/MWh, the emissions rate for a pollutant (in lbs/mmBtu) was multiplied by the emissions cost (in $/ton), and the product was multiplied by the assumed heat rate, which was then divided by 1,000 (the number of kWh in 1 MWh) and divided again by 2,000 (the number of lbs in 1 ton). Fixed O&M was given by the EIA in $/kW-year. This value was divided by the product of the unit capacity factor and 8.76 (which is the number of hours in a year divided by 1,000) in order to determine fixed O&M costs in $/MWh.

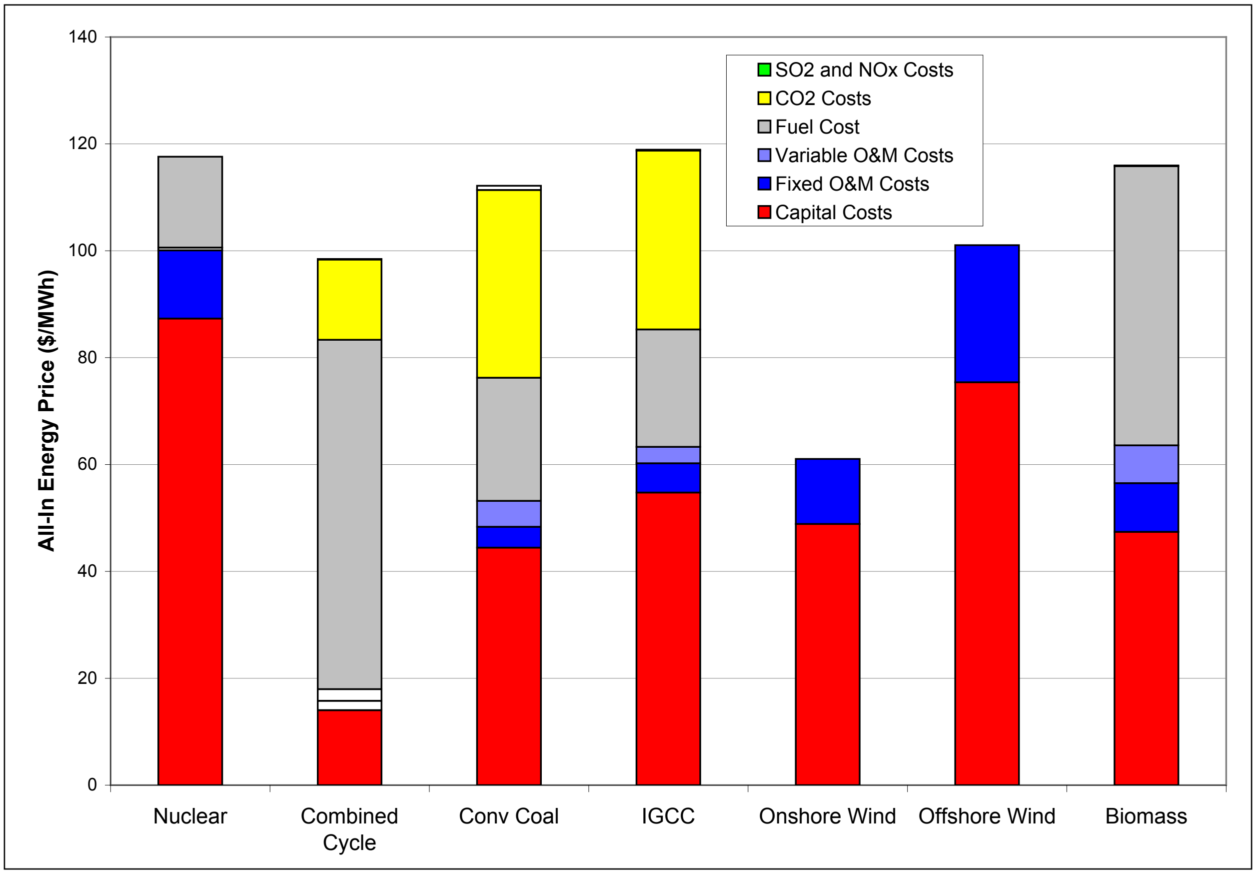


Figure 25. Levelized costs of electricity production from new power plants, including capital costs of construction.

The graphs illustrate, in an aggregate fashion, the relative economics of operation for existing plants and the economic choice when considering new electric generation construction. Prices on GHG emissions will impact owners, operators, and prospective operators of traditional fossil-fueled electric generating units. Costs of operating these plants will increase as companies buy allowances and invest in the technologies that reduce emissions. As operating costs of fossil technologies rise, renewable technologies will become more competitive.

Changes to the input assumptions shown in the figures above would change the relative economics of the generating technologies. Changes in costs for natural gas, coal, or biomass fuels would make thermal generation look more or less attractive, depending on the direction of the shift in fuel costs. More stringent emissions regulations, whether for CO_2, SO_2, or NO_x, could add to the emissions allowance costs, or it could add to both capital and O&M costs in the form of emissions control technologies, as units must install these technologies and then operate them to achieve emissions reductions. Changes in the operating efficiency of generating units, whether in heat rates for thermal units or capacity factors for wind units, would lower the O&M

costs for the units and would make these technologies more cost-effective when compared to the others in these figures. Environmental regulations, fuel prices, and technological improvement trends will affect all of the units in these figures in different ways, making offshore wind look more or less attractive depending on the ways in which these variables change over time.

3.3.3.3 Existing and Proposed Regional Policies

States have formed groups that seek to implement regional cap-and-trade programs aimed at reducing CO_2 emissions. The program of the Western Climate Initiative (WCI) is still being developed and would not begin until 2012. The Regional Greenhouse Gas Initiative (RGGI) of the eastern states began in 2009.

California was the first entity to commit to a cap-and-trade program for GHGs in the United States. In 2006 the Legislature passed (and Governor Schwarzenegger signed) AB 32, the Global Warming Solutions Act of 2006. AB 32 set into law the GHG reduction goal of reaching 1990 levels by 2020, and reducing emissions 80% below 1990 levels by 2050. The California Air Resources Board has developed a Scoping Plan, which identifies a cap-and-trade program as one of the main strategies California will use to meet these reduction targets. The Board must adopt cap-and-trade regulation by January 1, 2011, and the program must begin in 2012. California is working with the WCI to design a regional cap-and-trade program in order to achieve regional reductions at a lower cost than that which could be realized through a California-only program.[78]

Both the WCI and the RGGI are described below. The Emission Trading Scheme of 2005 operated by the European Union is also described below.

Western Climate Initiative

The WCI is a consortium of seven U.S. state governors and four Canadian province premiers that came together in 2007 to identify, evaluate, and implement ways to reduce GHGs in the western region. The participating U.S. states are California, Oregon, Washington, Utah, New Mexico, Arizona, and Montana, and the participating Canadian provinces are British Columbia, Manitoba, Ontario, and Québec. Together, the states represent 20% of the U.S. economy and the provinces make up 70% of the Canadian economy. Six other U.S. states, one Canadian province, and six states in Mexico are Observers to the WCI.

The WCI focuses on a market-based cap-and-trade system, recommending a program that is designed to reduce emissions of GHGs by 15% below 2005 levels by 2020. The proposed program would cover 90% of the region's emissions, and would include those from electricity generation, industry, transportation, and commercial and residential fuel use, making it "the most comprehensive carbon-reduction strategy designed to date" (WCI 2008). Rather than having an annual limit on emissions, the WCI proposes three-year compliance periods, at the end of which participating sources must surrender enough allowances to cover emissions occurring within each period. Similar to the U.S. Acid Rain Program (discussed below), the WCI's cap-and-trade

[78] See the California Air Resources Board's Web page on cap-and-trade at http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm. See also the AB 32 Scoping Plan at http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm.

program would be implemented in two phases. The first phase will begin on January 1, 2012, and will include emissions from electric generators, industrial combustion at large sources, and industrial process emissions. The second phase, beginning in 2015, will incorporate emissions from transportation fuels and industrial, commercial, and residential fuels that are not otherwise covered.

Midwest Greenhouse Gas Reduction Accord (MGGRA)

The MGGRA was signed in November 2007 as part of the Midwestern Governors Association Energy Security and Climate Change Summit. The Accord commits the participating jurisdictions to reduce GHGs through a regional cap-and-trade program and other complementary policy measures. Current members of the MGGRA include Iowa, Illinois, Kansas, Michigan, Minnesota, Wisconsin, and the Canadian province of Manitoba. Observers include Indiana, Ohio, South Dakota, and the province of Ontario. In early 2008 an Advisory Group was formed, which included representatives from state and provincial governments, business and industry, agriculture, environmental groups, and academia. This Advisory Group was given the task of making recommendations for emissions reduction targets and the cap-and-trade program design. Draft recommendations were issued by the Advisory Group in June 2009, and a draft Model Rule was released on October 21, 2009.

The Midwestern cap-and-trade program, consistent with proposed federal legislation, would be designed to reduce GHG emissions 20% below 2005 levels by 2020 and 80% below 2005 levels by 2050. Regulated sources under the program would include electric generators, electric importers, fuel suppliers, and industrial sources emitting 25,000 metric tons or more of GHGs annually. GHG allowances would be allocated to participating entities by the regulatory agency having jurisdiction over a particular state or province, with an award for early reduction allowances. Allowance allocation among sectors will be determined by each sector's proportion of emissions in 2010 and 2011. The Model Rule also contains provisions for allowance banking and offset projects (MGGRA Advisory Group 2009). Allowance banking allows entities that do not use the entirety of their purchased allowances in a given year to hold them for use in future years; offsets allow entities to substitute allowances for a reduction in emissions from another source.

Regional Greenhouse Gas Initiative

RGGI is the first mandatory cap-and-trade program for CO_2 in the United States. RGGI is a regional trading program for the following participating states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. After jointly drafting a Model Rule to provide the coordinating framework for RGGI, each state has passed its own laws, rules, or regulations to cap the emissions of CO_2 from its electric power plants; created CO_2 allowances; and participated in auctions of those allowances. Though issued by individual states, plants covered under the program will be able to use an allowance from any of the participating states to be considered in compliance. The emissions cap set by the states will remain constant through 2014, stabilizing emissions at current levels before mandating a decline of 2.5% each year from 2015 to 2018, for a total reduction of 10%.

Electric generating units greater than 25 MW are subject to the RGGI program and are required to hold allowances for any CO_2 emissions. Rather than giving away allowances, the participating states chose to auction allowances in several phases. Although the memorandum of understanding between the participating states only requires that 25% of each state's allowances be auctioned, all states have agreed to auction all or nearly all of their allowances and allocate the proceeds toward supporting consumer benefit programs (RGGI 2007, p. 4). Allowance auctions have been and will be held quarterly, with the first auction occurring on September 25, 2008. In the first two auctions, only allowances with a vintage year of 2009 were auctioned.[79] Beginning in the third auction, a percentage of allowances with a vintage year of 2012 were auctioned as well. Results of the six auctions held to date are shown in Table 14 below.

Table 14
Results of RGGI Auctions to Date

Auction	Date	Vintage Year	Allowances Sold at Auction	Number of Participants	Allowance Clearing Price	Total Proceeds
1	9/25/2008	2009	12,565,387	59	$3.07	$38,575,738
2	12/17/2008	2009	31,505,898	69	$3.38	$106,489,935
3	3/18/2009	2009 2012	31,513,765 2,175,513	50 20	$3.51 $3.05	$117,248,630
4	6/17/2009	2009 2012	30,887,620 2,172,540	54 13	$3.23 $2.06	$104,242,445
5	9/9/2009	2009 2012	28,408,945 2,172,540	46 12	$2.19 $1.87	$55,278,239
6	12/2/2009	2009 2012	28,591,698 1,599,000	62 8	$2.05 $1.86	$61,587,121

Source: Potomac Economics (2008b, 2008c, 2009a, 2009b, 2009c, 2009d).

States will use the proceeds from these auctions to invest in energy efficiency, renewable energy, and other clean energy technologies. Five of the OCS states participating in RGGI passed enabling legislation specifically mandating that a portion of auction proceeds go to renewable energy technologies, possibly including those that may be located offshore.[80] Table 15 shows the percentage of funds OCS states have allocated to programs that include offshore renewables, and the corresponding amount of money earned from the RGGI auctions.

[79] Allowances of a particular "vintage year" may be used in that year, or they may be banked for compliance in future years. Allowances may not be used for compliance in years prior to the vintage date. An allowance with a vintage year of 2010 may not be used for compliance in 2009 but could be used in 2011, for example.

[80] Maine, Rhode Island, and New Hampshire have designated that all RGGI funds go toward energy efficiency programs. Massachusetts plans to use RGGI funds to support some renewables on municipally owned lands. Vermont is not an OCS state.

Table 15
RGGI Funds in OCS States Allocated to Programs That Include Offshore Renewables

State	Program	Percentage of Funds Allocated for Programs	Total State Proceeds for Programs
Connecticut	Clean Energy Fund	23%	$6,103,955
Delaware	GHG reduction projects	10%	$1,149,905
Maryland	Grants for renewable energy	N/A	$193,000 allocated to date
New Jersey	New Jersey Economic Development Authority	60%	$33,213,668
New York	Electric power supply and delivery	19.7%	$35,593,707
	Multi-sector programs	16.8%	$30,354,025

Source: RGGI (n.d.).

In Connecticut, the Clean Energy Fund encourages the development of clean energy technologies and the use of energy from those sources, which include wave, tidal, ocean thermal, and wind (Connecticut Clean Energy Fund 2008, p. 2). Under the Greenhouse Gas Reduction Projects program in Delaware, projects must result in quantifiable and verifiable GHG reductions and are selected for funding after a competitive proposal process. Maryland's renewable energy grant program authorizes grants to projects that increase generation of electricity from Tier 1 renewable resources located within the state, including wind and ocean resources. New Jersey contributes funds to the NJ Economic Development Authority, which gives interest-free project loans and grants for end-use energy efficiency, combined heat and power, and renewable energy in the commercial, institutional and industrial sectors (NJ EDA n.d.). Awards can be up to $5 million, and funds have already been granted to offshore wind energy projects in the state, as described in Section 3.3. Finally, New York devotes funds to two programs that could finance renewable projects. The first is the Electric Power Supply and Delivery Program, which has three parts:

- The advanced renewable energy part of the program supports activities that help introduce promising renewable technologies (e.g., advanced biomass, tidal, and offshore wind) to the market.

- The advanced power delivery part of the program supports, in part, the demonstration of advanced technologies that promote the widespread adoption of renewable resources and their interconnection to the transmission system.

- The third part of the program deals with carbon capture and storage technologies.

The second New York program allocates funds to multi-sector GHG reduction initiatives (NYSERDA 2009b).

In the short term, it is possible that construction of renewable energy facilities, including those offshore, will increase if funds from the RGGI auction go toward the development of renewable energy infrastructure. However, fossil-fueled electric generators are still allowed to emit CO_2, and additional renewable generation may make it easier and less costly for them to meet the emissions cap. As electricity from renewable energy flows into the grid, less electricity from fossil sources may be needed, avoiding CO_2 emissions and reducing the demand for allowances (RGGI 2007, p. 5). In that way, renewable energy generation can help industry meet the emissions cap at a potentially lower cost, and effectively balance the CO_2 and REC markets over time.

Some states have adopted a rule in which allowances may be retired through voluntary purchases of renewable energy. Many utilities offer programs by which customers may sign up to receive all or a portion of their electricity from renewable sources. Provided this energy is not used to meet a state RPS, allowances may be retired in an amount equivalent to the avoided emission from these voluntary purchases (RGGI 2007, p. 6). The RGGI Model Rule also contains a banking provision, whereby utilities that do not use the entirety of their purchased allowances in a given year may hold them for use in future years, which may help to ensure stability in allowance prices.

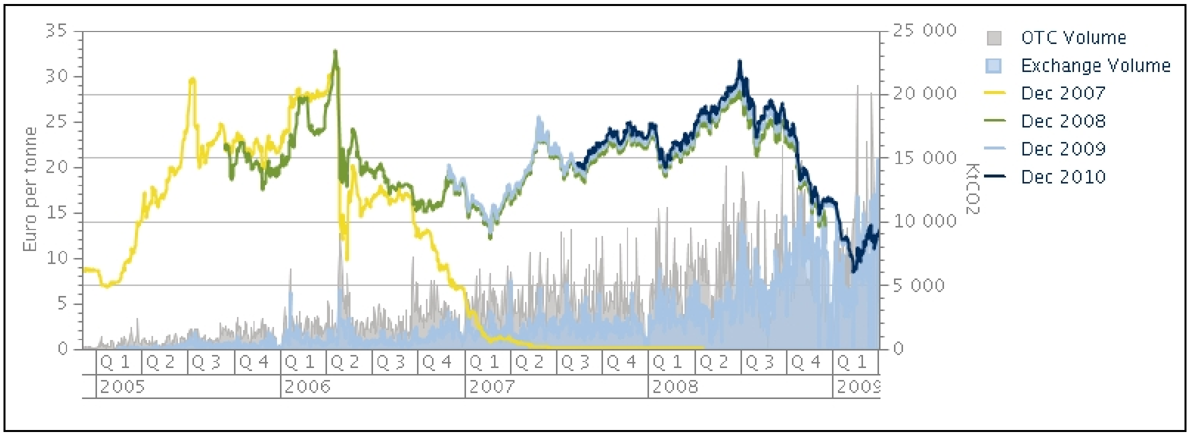
European Union Emissions Trading System (EU ETS)

ERG also examined European policies that indirectly support energy resources, such as offshore wind, current, and wave, that produce low or no air emissions. In this case, setting emission reduction targets, allocating allowances, and establishing a trading system for the allowances are all EU ETS actions that indirectly support energy resources that release minimal air emissions. As such, the EU ETS provides a case study for how such markets operate and an estimate of the cost of CO_2 emissions.

The EU ETS began operating in January 2005. Designed to help EU member countries meet their emissions reduction targets under the Kyoto Protocol, the EU ETS is the world's largest emissions trading scheme, encompassing many sectors and multiple countries. Emissions sources in the trading scheme include combustion plants, oil refineries, coke ovens, iron and steel plants, and factories making cement, glass, lime, brick, ceramics, pulp, and paper, which together make up almost half of the CO_2 emissions in Europe (European Commission 2005).

The European Commission (EC) has, in the past, allocated allowances to member nations under National Allocation Plans, which countries would then allocate to companies covered by the ETS. The member nations, therefore, would make the decisions regarding the number of allowances to be allocated in each trading period, as well as the number that each entity covered by the ETS will receive. Trading has occurred in three phases: the first phase ran from 2005 to 2007, the second runs from 2008 to 2012, and the third will begin in 2013. When making the allocations, the EC has refrained from setting cost controls on allowances; price is a function of supply and demand, and the ETS is designed to facilitate the achievement of emissions reductions at least cost.

At program inception in 2005, prices for CO_2 allowances were approximately €9/tonne, but they shot up quickly over the next six months to reach approximately €30/tonne in the third quarter of 2005. However, allowance prices plunged at the end of 2006 and 2008, as shown in Figure 26.



Source: PointCarbon (2010).

Figure 26. Historical allowance prices under the EU ETS (euros/tonne).

According to some sources, this plunge in prices was the result of too many free allowances, which took away the financial incentive to reduce emissions.[81] In order to remedy this situation, the EC has mandated that in 2013 electricity companies will have to begin buying all of their allowances at auction, and other industries like oil refineries and airlines will gradually purchase allowances over time, beginning at 20% in 2013 and scaling up to 100% by 2020 (Scott 2008).

Prices over the duration of the program's life have been erratic, but at most points in time have been at least five times higher than the price of RGGI allowances at just over $3/ton.[82] At the program's inception in 2005, when prices were at one of their lowest points, EU ETS allowances were priced three times higher than RGGI allowances.

A European Wind Energy Association study found that the current ETS design has failed to encourage clean technology investment. This study found that, in the absence of a very high price of CO_2 (€40 per tonne), mechanisms such as the policies discussed in Section 3.2 are necessary to support wind energy resources. Countries leading in new installed renewable capacity in 2006 (Germany, Spain, France, Portugal, UK, Italy) were found to have higher levels of direct support for renewables than other European countries (Rodrigues 2008). These findings suggest that the implementation of a carbon policy such as the EU ETS can be one element in the promotion of offshore renewables, but not the only element.

[81] There is some question as to whether the RPS policies of certain countries are resulting in an aggregate oversupply of CO_2 reductions and therefore lowering the emissions allowance price. European countries' renewable standards average to a requirement of 20% by 2020. As countries are just beginning on the path to this goal, any evidence of these policies suppressing historical CO_2 prices has not yet been published. In an analysis of future interactions between state RPS policies and federal GHG legislation in the United States, however, results showed that the addition of an RPS and energy efficiency savings to a base GHG cap results in a reduction of CO_2 allowance prices. This reduction occurs because compliance costs are shared by various policies, and some costs are shifted to REC prices. The effect is more pronounced for an RPS policy of 25% by 2020 than for lower RPS levels. See Bird et al. 2010.

[82] One short ton (RGGI) is equivalent to 0.90718474 tonnes (EU ETS).

The U.S. Government Accountability Office (GAO) was asked to investigate the effects of the EU ETS and examine the lessons learned from the program within the context of the proposals in Congress to regulate GHG emissions. When emissions data were released in the EU in 2006, it was found that the emissions cap far exceeded the demand for allowances. Like the European Wind Energy Association, the GAO determined that the effect on technology investment in the first phase of the trading system was minimal because the trading phase was too short to affect investment, and the price collapse of allowances reduced any incentive for investment in clean energy technologies. The GAO found that: 1) accurate baseline emissions data are essential to setting an effective emissions cap, 2) the time period covered by a trading program should be long enough to actually influence technology decisions made by industry, and 3) the way in which allowances are allocated has an important effect on government and industry. When allowances are allocated for free, the result is a transfer of wealth to those entities regulated by the trading program, while an allowance auction results in revenues to the government that can be used to encourage clean energy development or subsidize those entities that have a difficult time meeting program caps (GAO 2008).

3.3.4 Regulations of Other Power Plant Emissions

Regulations currently exist for a number of pollutants emitted by fossil-fired power plants, including SO_2, PM, NO_x, mercury, and secondary pollutants that form from direct emissions, such as O_3. These regulations include the NAAQS, Acid Rain Program, NO_x State Implementation Plan (SIP) Call/Budget Trading Program, Clean Air Interstate Rule (CAIR), and Regional Haze Rule. In addition, EPA is developing new standards for mercury emissions to replace its 2005 Clean Air Mercury Rule (CAMR). Each of these regulations is described in greater detail later in this section.

Air quality regulations tend to differ between the western and eastern parts of the country, with emphasis on SO_2 in the west and on NO_x in the east, due to its contribution to widespread non-attainment of the NAAQS for ozone.

As noted in the previous section, regulation of CO_2 emissions from the power sector as part of congressional efforts to establish a national cap-and-trade program is possible. A cap-and-trade system for CO_2 would apply to the same sources that are currently subject to regulations of other pollutants. Although the impact on electricity prices from the cost of CO_2 allowances would most likely far outstrip the cost of complying with regulations of other pollutants, the latter constitute real cost components that fossil-fired generators face but renewable energy resources do not. Moreover, all major regulated pollutants must be considered with respect to power plant operating costs, as the costs of compliance with CO_2 and other power plant emissions regulations are highly interrelated.[83]

[83] Fuel switching, some post-combustion controls, and process changes can simultaneously reduce emissions of more than one pollutant. For example, coal gasification allows for carbon capture and sequestration, as well as the capability to achieve extremely low SO_x, NO_x, and particulate emissions. Burtraw et al. (2005) mention that earlier EPA studies found that pollution control strategies to reduce emissions of NO_x, SO_2, CO_2, and mercury are highly interrelated, and that the costs of control strategies are highly interdependent.

3.3.4.1 NAAQS

EPA has established NAAQS for nitrogen dioxide, O_3 (which is regulated in part through limits on NO_x emissions), $PM_{2.5}$, PM_{10}, and SO_2.[84] NAAQS standards are based on health and environmental effects of exposure to these pollutants. EPA is required to reevaluate these standards every five years to reflect changes in scientific knowledge. The NAAQS are ambient standards, although amendments to the CAA in 1977 added a market-based element allowing limited trading through emission offsets (Burtraw et al. 2005). Under this provision, an increase in a qualified air pollutant can be offset with a reduction of the pollutant from some other stack at the same plant, from another plant owned by the same company, or from sources owned by another company in the area. Existing major permitted facilities in non-attainment regions create offsets by permanently curtailing operations, voluntarily controlling emissions above and beyond what is required, or shutting down.

The EPA oversees implementation of the CAA, although most states have authority to administer the federal laws within their borders. States implement NAAQS through SIPs, subject to EPA review and approval. The cost for an individual fossil-fired generator to comply with NAAQS will depend on the form of regulation under the applicable SIP.

3.3.4.2 Acid Rain Program

The U.S. Acid Rain Program was created under Title IV of the 1990 Amendments to the CAA in response to the nation's growing problem of ecosystem acidification resulting from the emission of large amounts of SO_2 into the atmosphere. The Acid Rain Program set a cap on the total emissions of SO_2 from regulated entities and established a system of tradable emissions allowances to assist these entities in meeting this cap. An entity holding one emissions allowance may emit one ton of SO_2 during a particular year or any future year.

The program is administered by EPA and has proceeded in two phases. Phase I began in 1995 with the allocation of emission allowances to 263 Eastern and Midwestern electricity generating units at 110 higher-emitting, mostly coal-burning power plants. Allowances were allocated based on an emission rate of 2.5 pounds of SO_2/mmBtu of heat input, multiplied by the unit's baseline heat input in mmBtu. The baseline heat input was established for each unit by averaging its annual level of fossil fuel consumption from 1985 through 1987.[85] Additional allowances could be obtained in three ways. First, regulated units could receive additional allowances if they installed technologies to remove at least 90% of the unit's emissions, or by making required reductions at other units that already had this type of technology. Second, allowances may be awarded to those units that achieve emissions reductions through renewable energy generation or customer-oriented conservation measures. Finally, allowances can be purchased through an annual auction held by the EPA, or on the open market. Units that began operation after December 31, 1995, did not receive any emissions allowances and were required to purchase all allowances.

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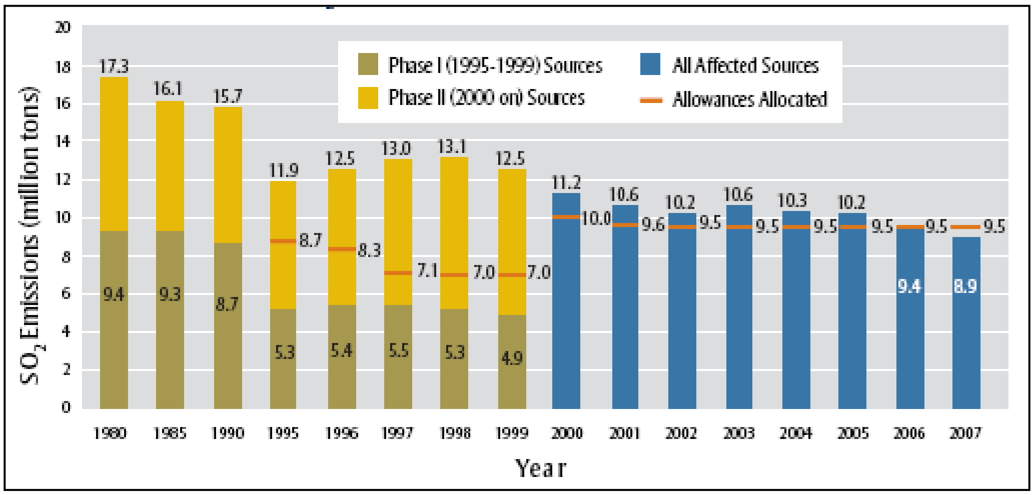
[84] Carbon monoxide and lead are also subject to NAAQS, but these pollutants are less of an economic concern for power plants than the other criteria pollutants.
[85] Various units in Illinois, Indiana, and Ohio were allocated additional allowances from 1995 to 1999.

Phase II of the Acid Rain Program began in 2000, expanding the trading program to include cleaner coal, oil, and gas units with more than 25 MW of generating capacity. Allowance allocation was tightened to an emissions rate of 1.2 pounds of SO_2/mmBtu of heat input, multiplied by the unit's baseline heat input. The allowance allocation will tighten again in 2010 to allow only 8.95 million tons of SO_2 emissions—approximately half of the emissions in 1980.

Since 1990, the Acid Rain Program has led to a 43% decrease in emissions of SO_2, and EPA has documented a corresponding improvement in environmental conditions (EPA 2009d). Acid deposition is declining, and there has been an improvement in the surface water quality of many lakes and streams. The annual allowance allocation and SO_2 emissions are shown in Figure 27, below:



Source: EPA (2009d).

Figure 27. Historical emissions of SO_2 in the United States.

Chestnut and Mills (2005) re-examined the benefits associated with the Acid Rain Program, taking into account the contribution of SO_2 and NO_x emissions to the formation of fine particulate (PM2.5), and evidence of the harmful human health effects of PM2.5 that had emerged since 1990. They estimated the benefits of the emissions reductions associated with the 2010 emissions cap.[86] In addition to the environmental benefits resulting from the decrease in emissions, the public health benefits of the emissions reductions program in 2010 are estimated at $122 billion[87] and outweigh the $3 billion in program costs by a ratio of more than 40:1 (Chestnut and Mills 2005).

In all likelihood, regulation of CO_2 emissions from the power sector will have a significantly greater impact on electricity prices than the cost of SO_2 allowances. In making some fossil-fired units uneconomic to run during some hours, CO_2 regulation would tend to reduce demand for SO_2 allowances (and NO_x allowances, discussed in the following section) and thereby drive down their prices.

[86] SO_2 emissions in 2007 were 8.9 million tons, which is below the 2010 emissions cap.
[87] Costs and benefits are in 2000 dollars.

3.3.4.3 NO_x Trading Program

The cap-and-trade approach is also used to reduce emissions of NO_x in the northeastern and mid-Atlantic states. When combined with volatile organic compounds, NO_x reacts with sunlight to form ground-level ozone (smog), particularly in the summer months. Many states did not meet the NAAQS for ozone during these months. States expressed concern that emissions from upwind areas must be dealt with in order for them to meet their own pollution requirements. The Ozone Transport Commission (OTC) was formed under the 1990 CAA Amendments to help states meet the air quality standard for ground-level ozone. In collaboration with EPA, these states developed their own cap-and-trade program—the OTC NO_x Budget Program—which was the first of its kind to be formed by a group of states rather than being carried out on a national level. The program applied to electric power generators of 15 MW or more and large industrial boilers from several industries during ozone season, from May 1 to September 30. From 1999 to 2002, emissions of NO_x were reduced from 473,000 tons to 193,000 tons—or by approximately 60%.

Despite the efforts of the OTC, ozone remained a problem in downwind states, and in 2003 the NO_x Budget Trading Program was replaced by the NO_x SIP Call, administered by EPA. The SIP Call extended the emissions reduction goals to additional states as well as the District of Columbia. The single emissions cap on NO_x was divided among the states based on energy use of the emitters. States were then required to reduce seasonal NO_x emissions below their individual budgets, but were allowed to develop their own compliance strategies. EPA gave states the option of a cap-and-trade program covering electric generators of 25 MW or more[88] and large industrial sources, and all of the affected states chose to participate to some degree. States allocate allowances to sources within their borders, and typically only allocate allowances for a specific number of years (three to five). In comparison, the Acid Rain Program allocates allowances in perpetuity. Virginia and Kentucky chose to set aside a portion of allowances for auction rather than allocate them to emitters. The banking of allowances for future years is allowed in the NO_x program as well as in the Acid Rain Program, but the NO_x program requires that a certain percentage of banked allowances must be given for compliance at a ratio of 2:1 when the regional bank of allowances grows to more than 10% of the region's budget.

The NO_x cap-and-trade program has proven to be an effective policy for emissions reductions. In 2006, the program counted 19 states and the District of Columbia as participants in the program, and they had achieved emissions reductions of 60% (730,000 tons) since 2000. Of those areas that were out of attainment for ozone in 2004, 80% now have air quality that is better than that called for by the NAAQS (Napolitano et al. 2007).

3.3.4.4 CAIR

In 2005 EPA finalized the CAIR, which is designed to result in even deeper cuts in emissions of SO_2 and NO_x. CAIR covers 28 eastern states and the District of Columbia, and each state may choose whether to achieve the new reductions through participation in EPA's two-phase cap-and-trade program or through measures of the state's choosing. Under EPA's program, the cap

[88] States were given the option of including smaller sources in the trading program, and many of the states that had participated in the OTC NO_x program chose to include those sources between 15 MW and 25 MW.

for SO_2 would decline by 45% to 3.9 million tons in 2010 and again by 57% to 2.7 million tons in 2015. The cap for NO_x would decline to 1.6 million tons in 2009 and again to 1.3 million tons in 2015.

Of the states bordering the OCS, CAIR would apply to New York, New Jersey, the District of Columbia, Delaware, Maryland, Virginia, North Carolina, South Carolina, and Florida for their contribution to ground-level ozone and fine particles in downwind states. Massachusetts and Connecticut would only be subject to CAIR's requirements for states contributing to ozone air pollution in downwind states—NO_x are the precursors to ozone—while CAIR would cover Georgia and Texas for precursors of particulates (SO_2 and NO_x).

CAIR supplants the NO_x SIP Call *trading* program, although the NO_x SIP Call *emission reduction requirements* remain in place. NO_x SIP Call states have the option of including all NO_x SIP Call trading sources in the CAIR ozone-season NO_x program at their NO_x SIP Call levels. In states subject to CAIR's SO_2 requirements, CAIR would achieve SO_2 emission reductions by requiring CAIR sources to retire acid rain allowances at a ratio greater than one.[89] Retirement ratios do not apply to Title IV sources outside the CAIR region (Murray 2005).

As a hypothetical, Table 16 shows EPA's 2005 projections of the operating cost (including the cost of complying with CAIR) of a typical waste coal combustion unit once CAIR is enacted.

Table 16
Operating Costs of a Circulating Fluidized Bed Combusting Waste Coal Unit[90]

Components of Operating Costs	Cost to Operate 2010 ($/MWh)	Cost to Operate 2015 ($/MWh)
Variable O&M	$2.11	$2.11
Fixed O&M	$5.31	$5.31
Fuel cost	$7.28	$7.20
SO2 allowance cost	$1.53	$2.17
NOx allowance cost	$0.77	$0.95
Total operating cost	$17.00	$17.74

Source: EPA (2006).

On December 23, 2008, the D.C. Circuit Court remanded CAIR without vacatur while EPA revises the rule to correct its flaws and to be consistent with Court opinion handed down on July 11, 2008. Uncertainty over the initial Court vacation of CAIR, and the December Court remand back to EPA, have caused SO_2 and NO_x allowance prices to tumble to historically low levels. Moreover, the price of SO_2 (and NO_x) emissions allowances would be interdependent with CO_2 allowances under a national cap-and-trade program, and the CO_2 program is likely to have a significantly greater impact on electricity prices than the cost of SO_2 and NO_x allowances. Thus,

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89 A generating unit would be required to retire 1.5 allowances for every ton of SO_2 emitted, for example.

90 This table assumes a capacity factor of 85%, a heat rate of 10.2 MMBtu/MWh, an SO_2 allowance cost of $700/ton in 2010 and $1,000/ton in 2015, and a NO_x allowance price of $1,206/ton in 2013 and $1,481/ton in 2015. This analysis did not include a cost for mercury or CO_2. The allowance costs present in this analysis are consistent with those in Figures 25 and 26. Engineering assumptions in this table come from Black & Veatch as presented by EPA.

the projected cost impacts under CAIR shown in Table 16 are higher than currently anticipated costs given today's regulatory outlook.

3.3.4.5 Regional Haze Rule

EPA's 1999 Regional Haze rule requires states, in coordination with federal agencies, to develop and implement air quality protection plans to reduce the ambient pollutants that impair visibility in 156 national parks and wilderness areas. Power plant emissions and secondary pollutants that contribute to haze include $PM_{2.5}$, SO_2, NO_x, and ozone, among others.

Under the Regional Haze rule, states must identify major stationary sources of air pollution that require emission controls, known as best available retrofit technology, or BART (ERG 2005, executive summary). In an October 2006 final rule, EPA revised provisions of the Regional Haze regulations to give states or tribal governments flexibility in how BART could be applied. The revised rule allows for BART requirements to be satisfied if an alternative emissions trading program meets or exceeds the visibility benefits that would result from BART. Based on a determination that CAIR controls are "better than BART," EPA ruled that states adopting the CAIR cap-and-trade program for SO_2 and NO_x are allowed to apply CAIR controls as a substitute for controls required under BART.

In January 2009, EPA issued a finding that 34 states had failed to submit SIPs that satisfy the basic program requirements of the 1999 regional haze rule. Of the 34 states identified, those bordering the Atlantic and Pacific OCS include California, Connecticut, the District of Columbia, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Oregon, Rhode Island, Virginia, and Washington. Any state that has not completed an approved plan of its own by January 15, 2011, will be subject to the basic program requirements of a Federal Implementation Plan (EPA 2009e). A Federal Implementation Plan simply creates a compliance plan for a state in the absence of a SIP, and a state may at any time issue a SIP that is designed to meet emissions reductions requirements and displace the federal plan.

Under its New Source Review rules, EPA has made a proposal that would protect small businesses and farms from expensive regulation compliance under the Prevention of Significant Deterioration and Title V programs of the CAA, from September 30, 2009. This proposal would phase in the threshold requirements for GHG emissions control for the sake of administrative feasibility, and in order to shield smaller entities from paralyzing costs associated with regulation.[91]

3.3.4.6 Mercury Best Available Control Technology (BACT) Requirements

On March 15, 2005, EPA issued the final CAMR, establishing the first limit on mercury air emissions by power plants and creating a market-based cap-and-trade program to reduce utility emissions of mercury nationwide. In order to implement a cap-and-trade program, the proposed CAMR would have effectively moved mercury from Section 112 to Section 111 of the CAA, and therefore mercury emissions would be not subject to BACT standards. The D.C. Circuit Court,

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[91] See the proposed rule: "Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule," available at http://www.epa.gov/NSR/actions.html#sep09.

however, issued a judgment that vacated the CAMR on February 8, 2008.[92] The basis of the court's decision was that mercury was listed as a hazardous air pollutant under Section 112 of the CAA, and was therefore subject to BACT requirements. On February 6, 2009, the Department of Justice on behalf of EPA requested that the U.S. Supreme Court dismiss EPA's request to appeal the D.C. Circuit of Appeals decision, thus leaving mercury subject to CAA Section 112 and BACT requirements.[93] EPA has indicated its intent to develop emissions standards for power plants under the Section 112 of the CAA.[94]

While the CAMR required approximately 70% mercury control at power plants, regulations in some states are requiring 90%–95% mercury capture beginning in 2012. These state regulations will provide an important benchmark for future federal mercury regulations.

The costs of mercury control would depend on the stringency of the emissions standards. Sources subject to the mercury emissions standard would also be regulated under other air emissions rules (for CO_2, NO_x, SO_2, and PM). Some facilities will achieve co-benefit reductions, i.e., reducing mercury emissions by reducing SO_2 and NO_x emissions in compliance with other regulations. In any event, mercury standards should significantly reduce the cost differential between coal and renewable resources.

3.3.4.7 Clean Air Act (CAA) General Conformity Rule

The CAA, Section 176(c)(1), requires that the federal government not engage in, support, or provide financial assistance for licensing, permitting, or approving any activity not conforming to an approved CAA implementation plan. Massachusetts and Rhode Island are non-attainment areas for ozone. As a result, the Cape Wind project needed a conformity determination to address offshore emissions from survey vessels, transport vessels, barges, tugboats, cranes, pile drivers, and crew boats and onshore emissions associated with the construction of the 115 kV cable (e.g., excavators, backhoes, trenchers, dump trucks, drill rigs, cranes, and graders). Estimated emissions for Massachusetts are below the 100 tons/year threshold for conformity. Estimated emissions for Rhode Island are above the threshold and MMS stipulated that Cape Wind purchase the needed emission offsets (USDOI MMS 2009d).

3.3.5 Summary: Impact of Air Regulations on OCS Resources

Fossil-fuel-fired electric generating plants in the United States are subject to numerous state and federal regulations concerning the emissions of pollutants that affect air quality. In the near future, if these regulations become increasingly stringent, and if new regulations to set limits on GHG emissions are implemented, then these new GHG regulations are likely to have greater cost implications for conventional electric generating plants than existing or pending regulations on other pollutants. However, a power plant's cost of compliance with GHG regulations will be closely interrelated with the compliance costs of other air quality regulations, as steps taken to reduce GHG emissions may also reduce other types of emissions.

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[92] See http://pacer.cadc.uscourts.gov/docs/common/opinions/200802/05-1097a.pdf.
[93] See http://www.epa.gov/air/mercuryrule/pdfs/certpetition_withdrawal.pdf.
[94] See http://www.epa.gov/hg/.

Offshore wind, wave, and tidal resources do not emit GHGs or other regulated air pollutants. However, emissions during the construction and operation phases (from vessels and onshore activities) might trigger the need for a conformity determination and/or the purchase of emission offsets. See Section 3.3.4.7 above.

Increases in costs to fossil fuel plants resulting from air quality and climate protection regulations could make OCS resources more cost-competitive from an operations standpoint. It is important to note, however, that while increased costs from GHG cap-and-trade programs act as one catalyst for the development of renewable generation, additional policies that directly promote renewable energy, such as RPSs, are necessary to fully incentivize renewable energy projects.

Furthermore, increases in renewable resource capacity could make the renewable sector less competitive over time. In one possible scenario, as the amount of renewable generation increases, a portion of generation from fossil units may be displaced. If this scenario occurs, then emissions of GHGs are likely to decline. A decline in emissions would lessen the demand for emissions allowances, thereby causing allowance prices to decrease. Figure 26 shows that if environmental costs declined, the levelized costs of coal and integrated gasification combined cycle technologies would be even with, or even smaller than, offshore wind technologies. Therefore, if capital costs for generating technologies remain the same, or change at the same rate over time, a decline in environmental costs could stall the development of offshore renewables as it causes fossil technologies to become competitive once again. A decrease in capital costs for renewable technologies or a tightening of a cap on GHG emissions would help the competitiveness of renewable technologies in this situation.

3.4 ELECTRICITY MARKET TRENDS

New renewable energy resources on the OCS will be connected to existing onshore power systems, whether they are operated by RTO/ISOs with wholesale electricity markets or by vertically integrated utilities. This section provides an overview of key statistics and trends of the electricity markets along the northeast and west coasts of the country. These factors are important to the development of renewable energy resources on the OCS. In particular, this section examines system size, fuel mix, market prices, bilateral contracts, imports and exports, transmission trends, and data reporting for the major markets bordering the OCS, including New England (ISO-NE), New York (NYISO), the mid-Atlantic region and adjacent states to its west (PJM), and California (CAISO).

Data availability on CAISO is more limited than for the other RTOs. Where data are not available for the CAISO area, data are provided for the entire state of California instead (and are identified as such).

3.4.1 Size of the System

Forecasting errors and variability in the output of renewable energy resources can pose a challenge for the efficient operation of the power system, though system operators are well-trained in adjusting system output to accommodate load variation. System operators accommodate deviations in actual variable-resource power output from forecasted output by routinely adjusting operations of other resources on the grid whenever the actual load deviates from the forecasted load. That is, the output of renewable energy sources is only one of several sources of uncertainty that the system operator needs to address in order to balance the actual load. If variable-output resources generate less than forecasted levels, one or more conventional unit(s) may need to be called upon to make up the difference.

The impact of variable-output resources on the system varies depending on the time frame under consideration. Traditional fossil resources are "committed" (turned on and ramped up) from 10 minutes to 48 hours ahead of their need to provide output to the system. The extent to which traditional units must be committed in advance (to cover possible shortfalls from variable-output resources) depends on how accurate forecasters can be over the advance time frames considered. Hour-to-hour variations in output that exceed the forecasted (and thus scheduled) output can require dispatch of "load-following" resources.[95] Minute-to-minute variability in renewable energy resource output may contribute toward required dispatch of regulation resources.[96]

There is concern that the variability of intermittent resources may increase the operating costs of electric systems. Variations in output from renewable resources like wind might force conventional resources also to vary their output in order to maintain system balance which, in turn, might cause these power plants to deviate from the operating levels that minimize the operating costs for the entire electric system. The U.S. National Renewable Energy Laboratory (NREL) did a survey of the results obtained from utilities and other entities that have done studies in order to determine the effect of integrating wind and other variable resources on their system costs (USDOE NREL 2004). For the purposes of the survey, entities examined increases in system costs during three time frames. The "regulation" time frame spans a horizon of one minute to one hour in one- to five-second increments. The "load-following" time frame spans a horizon of one hour to several hours in five- to 10-minute increments. The "unit-commitment" time frame spans a horizon of one day to one week with one-hour time increments. The results of the NREL survey are presented in Table 17, below.

These results show that lower wind penetration rates lead to smaller increases in system costs, while the impact is higher at higher wind penetrations. Research still needs to be done in several areas, however, which include gaining a better understanding of how the system costs increase with greater renewable penetration, determining the difference in system costs for utilities and market-based costs, correlating load with errors in the forecasting of wind output, conducting sensitivity studies on varying generation portfolios and fuel cost mixes, and determining the impacts of transmission congestion (USDOE NREL 2004).

The impacts of real-time variability and day-ahead forecasting errors tend to be lower when there is a larger pool of resources from which to draw (ISO/RTO Council 2007). In a larger system, the central dispatch has more flexibility to accommodate variability in the output of renewable energy resources, and costs to maintain required operating reserves for the system will tend to be

[95] A load-following resource is a generation supply or demand response that can predictably vary its output in time frames ranging from minutes to hours. These resources ramp up or down to accommodate the intra-day patterns of demand.
[96] Regulation services allow the system operator to automatically increase or decrease a generator's level of output to control frequency and to maintain proper power flows into and out of the control area. In the context of variable-output resources such as wind, regulation is used to adjust the net (load minus wind) variation.

proportionately lower than they would be in a small system.[97] To a limited extent, resources within an RTO can be supplemented with imports, and excess energy can be exported to other systems to maintain reliability. Some areas, such as California, import a significant portion of their energy needs.

Table 17
Summary of Cost of Ancillary Services Necessary to Accommodate Variable Electric Generating Resources

Study	Relative Wind Penetration (%)	Regulation ($/MWh)	Load Following ($/MWh)	Unit Commitment ($/MWh)	Total ($/MWh)
UWIG/Xcel	3.5	0	0.41	1.44	1.85
PacifiCorp	20	0	2.5	3	5.5
Bonneville	7	0.19	0.28	1.00–1.80	1.47–2.27
Hirst	0.06–0.12	0.05–0.30	0.70–2.80	N/A	N/A
We Energies I	4	1.12	0.09	0.69	1.9
We Energies II	29	1.02	0.15	1.75	2.92
Great River I	4.3				3.19
Great River II	16.6				4.53
CA RPS Phase I	4	0.17	N/A	N/A	N/A

Source: USDOE NREL (2004).

The tables below show current and projected load, generation, and capacity of the markets bordering the OCS, as an indication of the size of these ISO/RTOs and their rate of growth.

Table 18 lists summer and winter peak demand in each of the four OCS-region RTOs. For California, the entire state values are listed (including non-RTO entities such as the Los Angeles Department of Water and Power). For PJM, the entire RTO is listed, as is the subregion known as the "mid-Atlantic" area. The mid-Atlantic region, along with the Virginia territory in PJM, consists of the service territories most proximate (of the PJM region) to OCS waters.

Table 18
OCS Region RTO Size—Energy and Peak Demand

	CAISO/California	ISO-NE	NYISO	PJM
Summer Peak Load, Current and Projected (GW)	*CA/Mex U.S. NERC subregion* 2009: 61.2 2018: 66.2[98]	2009: 27.9 2018: 31.0[99]	2009: 34.1 2018: 35.7[100]	*PJM RTO*[101] 2009: 134.4 2019: 158.6 *PJM Mid-Atlantic* 2009: 59.6 2019: 69.5

[97] Currently, operating reserve costs for both regulation resources and other spinning and non-spinning reserves are generally charged to load, not to generation resources.
[98] NERC (2009c), p. 166.
[99] ISO-NE (2009b).
[100] NYISO (2009a), Table 3-7.
[101] Forecasts incorporate all load in the PJM Control Area, including members and non-members; they do not include any load reductions due to load management, voltage reductions, or voluntary curtailments (PJM 2009e).

	CAISO/California	ISO-NE	NYISO	PJM
Winter Peak Load, Current and Projected (GW)	*Statewide* Winter peak is roughly 68% of summer peak[102]	2009/2010: 22.1 2018/2019: 22.9[103]	2009/2010: 25.6 2018/2019: 28.3[104]	*PJM RTO* 2009/2010: 112.7 2018/2019: 127.4 *PJM Mid-Atlantic* 2009/2010: 46.5 2018/2019: 52.3
Annual Energy, Current and Projected (GWh)	*CAISO*[105,106] 2006: 177,757 *CA/Mex U.S. NERC subregion*[107] 2009: 296,368 2018: 330,919	2009/2010: 131,315 2018/2019: 142,125[108]	2009: 164,568 2018: 172,939[109]	*PJM RTO* 2009: 712,236 2019: 837,907 *PJM Mid-Atlantic* 2009: 291,660 2019: 340,696

All four of these RTO regions have sizable peak demand and annual energy requirements that could readily absorb considerable amounts of OCS offshore resource output. Projected growth rate patterns (Table 19, below) illustrate projected increases in demand. Because integration cost drivers include the relative penetration of a given quantity of offshore resources into the overall regional resource base, increases in demand and in supply reserve requirements will reduce integration costs for those resources.

Table 19
OCS Region RTO Projected Growth Rates

	CAISO/California	ISO-NE	NYISO	PJM
Annual Growth Rate: Energy	*CA/Mex U.S. NERC subregion*: 2009–2018: 1.2%[110]	2009–2018: 0.9%[111]	2009–2018: 0.8%[112]	2009–2019: 1.6%[113]
Annual Growth Rate: Peak Load	*CA/Mex U.S. NERC subregion* 2009–2018: 0.9%[114]	2008–2017, summer: 1.2% (NERC LTRA)	2008–2017, summer: 0.9% (NERC LTRA)	2009–2019, summer: 1.7% 2009–2019, winter: 1.2%

Table 20 lists the level of capacity resources in each region. The total quantity of resources reflects inclusion of generating reserve requirements (i.e., not all generation will always be available to meet peak load) and thus is seen to be higher than peak loads shown in Table 18.

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[102] NERC (2009c), pp. 394, 395 (CA-MX U.S. region, 2009 and 2009/2010).
[103] ISO-NE (2009b).
[104] NYISO (2008d), Table 1-1.
[105] FERC (2007).
[106] California ISO uses the CEC's demand forecasts in its transmission planning (CAISO 2009d).
[107] NERC (2009c), p. 166.
[108] ISO-NE (2009b).
[109] Includes generation and demand-side resources (NYISO 2009e).
[110] NERC (2009c), p. 166.
[111] ISO-NE (2009b).
[112] NYISO (2009a), Table B-4.
[113] Forecasts incorporate all load in the PJM Control Area, including members and non-members; they do not include any load reductions due to load management, voltage reductions, or voluntary curtailments (PJM 2009e).
[114] CEC (2009a).

Table 20
OCS Region RTO Installed Resource Capacity

	CAISO/California	ISO-NE	NYISO	PJM
Capacity, Current and Projected (GW)	*CAISO* 2008: 55.1 GW[115] *CA/Mex U.S. NERC subregion* 2009: 70.0 GW 2018: 113.3 GW (generation)[116]	2009/2010: 34.0 GW 2018/2019: 34.7 GW (generation and demand response)	2009: 42.1 GW 2018: 42.5 GW[117,118] (generation and demand response)	2008: 164.9 GW (generation)

Table 21 lists the reserve margin requirements for each region. Reserve margin is defined as the amount of capacity required above peak load amounts to maintain reliability, as a percentage of the peak load (i.e., reserve margin = [total capacity – peak load]/peak load).

Table 21
OCS Region RTO Capacity Requirements—Reserve Margin

	CAISO/California	ISO-NE	NYISO	PJM
Capacity Require-ments	15.3%[119,120] 2009, U.S. portion of California-Mexico (building block planning reserve margin—not mandatory). Local regulatory authorities have responsibility and discretion in setting the planning reserve margin for load-serving entities; default is ≥15% of forecasted monthly peak hour demand.	14.1% Local sourcing requirements apply to Boston/northeast Massachusetts and Connecticut. Maine is subject to a maximum capacity limit.[121]	16.5% 2009–2010 capability year, New York Control Area: locational capacity requirements apply to New York City and Long Island.[122]	15%[123] Pro rata allocation of the "obligation" is based on PJM unforced capacity requirement for the region.

[115] ISO/RTO Council (2009).
[116] USDOE EIA (2009e).
[117] The 2009 RNA Base Case model of the New York bulk power system does not include all projects currently listed on NYISO's interconnection queue or those shown in the 2008 Gold Book. It includes only those which meet the screening requirements for inclusion. The following new and proposed facilities and updates to the forecasts in the Gold Book, based on new information developed before the start date of the RNA studies, are included in the base case (NYISO 2009a, Table 3-7): TO projects on non-bulk power facilities; facilities that have accepted their Attachment S cost allocations and are in service or under construction as of June 1, 2008; transmission upgrades related to any projects and facilities that are included in the RNA Base Case, as defined above; TO plans identified in 2008 CRP and the 2008 Gold Book as firm plans; facility reratings and uprates; scheduled retirements; updated forecasts of Special Case Resources and the impacts of the New York State Public Service Commission EEPS Order, as developed and reviewed at the ESPWG; and external system modeling.
[118] NYISO (2009a), Table 3-7.
[119] NERC (2009d), p. 118.
[120] If a local regulatory authority does not adopt a specific power reserve margin, the default provision for the reserve margin requirement of an LSE is at least 15% of the applicable month's forecasted peak hour demand.

Table 22 summarizes the total "queued" generation, or generation interconnection requests awaiting study by the RTO for connection to the grid. These requests are not indicative of what will be constructed in the region, but rather represent the level of commercial interest expressed by generation developers considering a supply investment. Historically, the actual level of generation that is built in an RTO area is considerably lower than the sum of all interconnection requests. The levels indicated include some OCS resources that are under study by RTOs, including resource options off the coasts of New York, New Jersey, Delaware, Rhode Island, and Massachusetts. The table also contains the formally announced generation retirements in each region, which are relatively minimal.

Table 22
OCS Region RTO Generation Interconnection and Retirement Requests

	CAISO/California	ISO-NE	NYISO	PJM
Generation Inter-Connection Requests (Summer Rating) [124]	66,870 MW	18,096 MW	18,913 MW	33,713 MW
Retirements	Planned retirements in 2009: 26 MW[125] Local capacity requirement analyses, currently under development, may set retirement dates for some plants using once-through cooling (OTC) consistent with pending state water resources policy.[126] Under a low retirement scenario, 4,928 MW of OTC capacity is projected to retire by 2018.[127]	No resource capacity retirements/ deactivations are assumed for 2009–2013.[128]	Forecasted retirements to 2018: 1,272 MW[129]	Generator deactivation requests through February 2010: 2,882 MW http://www.pjm.com/planning/generation-retirements.aspx

Table 23 summarizes the importing and exporting trends at each of the OCS region RTOs. California relies on considerable energy from both the Pacific Northwest and the Southwest

[121] ISO-NE and NYISO (2009).
[122] State of New York Public Service Commission (2009); NYISO (2009f).
[123] NERC (2009d), p. 118.
[124] CAISO queue data are as of July 2009. ISO-NE queue data are current through October 1, 2009. NYISO queue data are current through September 30, 2009. The PJM queue data are as of October 30, 2009.
[125] CAISO (2009e).
[126] CEC (2009b).
[127] McCann and Welch (2009).
[128] ISO–NE (2008e).
[129] NYISO (2009a).

Desert region, and also has a direct connection to a large Utah coal plant. PJM exports both to New York, from its eastern border, and to Midwestern states from its western borders. The eastern region of PJM—near OCS waters—is a net importer of energy from the western part of PJM, which is predominately a nuclear and coal-fired generation region. One observation of PJM flow trends is that even though the RTO as a whole is a net exporter, OCS resources would tie into its easternmost regions, which have the highest locational energy prices, and thus would serve to displace the most expensive sources of energy that are currently used in the region.

The New England region is a net importer of energy, from Canada. In particular, a large (1,400 MW[130]) DC tie line between Québec and Massachusetts allows for significant annual energy imports. New York is also a net importer, since its downstate region benefits from connections to New England and PJM, and there exists a large interconnection from Hydro Québec to the northern part of the state. On the margin, generation is less expensive in those adjacent regions than in the dense New York City load area. PJM has considerable low-cost generation in its western regions and thus is able to export surplus energy to upper Midwest regions. It also exports to New York from its eastern border. The economics of these exports are driven by the high market costs for power in the New York City region.

Table 23
OCS Region RTO Import and Export Trends

	CAISO/California	ISO-NE	NYISO	PJM
Imports and Exports	Load-serving entities within CAISO rely on imports for approximately one-fourth of their annual energy needs.[131]	On net, New England imports power from Canada and exports to New York. Overall it is a net importer. In 2008 imports totaled 9,311 GWh, a 54.3% increase from 2007.	In 2007, New York was a net importer from each of the four adjacent control areas: New England, PJM, Ontario, and Québec.	Total net exports in the real-time market in 2008 were 12,124 GWh, a decrease from 2007. 42% of these exports were to New York. In the day-ahead market, total net exports were 20,783 GWh, mostly to Iowa, Wisconsin, and Indiana.[132]

The RTO systems discussed in this primer have the highest loads, the greatest need for electricity resources, and the highest wholesale electricity prices in the summer. The coincidence of generation with load is important for the economics of a project, to the extent that the generator owner's revenues track prices in the wholesale market. This coincidence is also important for power system operators, because other energy resources must be called on to follow load if variable resources do not produce electricity when it is needed.

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[130] The HQ tie line has a higher thermal rating, but can only be operated at a maximum for 1,400 MW for other reasons.
[131] FERC (2010j).
[132] Monitoring Analytics (2009), Volume II.

3.4.2 Fuel Mix

In addition to the size of the system, the ease of integrating new variable resources will depend on the makeup and overall flexibility, or maneuverability, of existing resources. This flexibility can be thought of as the ability of generation units to "ramp up" or "ramp down" quickly, in response to dispatchers' signals. This is required to maintain a reliable system and a set frequency on the grid. For larger RTO systems, the aggregate capability of hundreds of generation supply sources allows for greater flexibility and lower integration costs, relative to much smaller systems that do not have a centralized dispatch over tens of thousands of MW of generation.

Certain energy resources, such as some types of hydroelectric and natural gas generation, can be very good resources for "following" the profile of demand net of variable generation output (net demand); i.e., these resources can adjust output to meet the fluctuations in net load that occur throughout the day. The availability of such load-following generation resources can allow greater amounts of new variable-output resources to be integrated into a system without eroding system reliability. If there are too few such units, then additional capacity might be required as the penetration of variable-output resources grows. Because of the fact that a greater percentage of variable resources can require "following resource" additions to a system, integrating a new variable resource project into a system in which variable resources account for 30% (or more) of existing total capacity may be more expensive than adding the same project to a system in which variable resources account for 10% (or less) of capacity.

Tables 24 and 25 illustrate the range of fuel mixes present in each of the four OCS region RTOs. Table 24 below illustrates which fuels are most often "on the margin" in each of the RTO regions. A fuel that is "on the margin" in a RTO region is the fuel for the generation resources most often on the economic margin—i.e., the most costly to operate but representing the last increment of physical supply necessary to keep the supply in balance with the load. In any region, more than one fuel could be on the margin if transmission constraints do not allow the least expensive resources to operate. This is often the case in PJM, for example: the most expensive of western PJM coal generation, and the most expensive of eastern PJM region natural gas (or sometimes oil-fired) plants are required to operate to maintain reliability—thus both coal and natural gas are marginal fuels. The marginal fuel may vary during peak and non-peak hours, depending on the types of resources in a region. During non-peak hours, the marginal fuel might be set by an intermediate, or even baseload, generating unit, while the marginal fuel during peak hours is likely to be set by peaking units in the region.

The important similarity across all four of the RTO regions is the presence of natural gas as the marginal fuel. This means that spot market prices in each of these regions could be expected to be broadly in range of each other, depending on the exact mix of generation unit types and associated efficiencies of those units. It also means that OCS resources, when they come online, will likely displace natural-gas-fired (or sometimes oil-fired) resources on the margin first, which are the most expensive units to operate.

Table 24
Generation Fuel Most Often Setting Electricity Market Prices[133]

	California ISO	ISO-NE	NYISO	PJM
Marginal Fuel	Natural gas	Natural gas	Natural gas	Coal and natural gas

Tables 25 and 26 show the predominance of natural-gas-fired power (as a dominant energy provider in Table 25 and as a capacity resource in Table 26) in California, New England, and New York. Notably, while gas is used to provide capacity in PJM, its use as an energy resource there is much more limited. This illustrates that PJM currently relies heavily on nuclear and coal-fired energy but retains significant gas-fired assets to use for load-following and peaking purposes. Any PJM-region OCS energy would first displace a portion of the gas currently used during peaking periods, but it may also displace coal-fired power during off-peak times when it is more likely that gas- and oil-fired resources would be used less.

Table 25
Current Generation by Fuel

	California (Statewide)	ISO-NE	NYISO	PJM
Year	2008	2008	2008	2008
Total	208,519 GWh	124,749 GWh[134]	144,619 GWh	735,244 GWh
Coal	18.2%	14.9%	13%	55.0%
Gas	45.7%	40.9%	Gas: 12% Gas and oil: 23%	7.3%
Oil	—	1.5%	<1%	0.3%
Nuclear	14.5%	28.5%	30%	34.6%
Hydro	Large: 11.0% Small: 1.4%	6.8%	18%	1.7%
Wind	2.4%	Included in other	<1%	0.5%
Other	Biomass: 2.1% Geothermal: 4.5% Solar: 0.2%[135]	Pumped storage: 1.3% Renewables: 6.0%[136]	Pumped storage: 1% Other: 2%[137]	Solid waste: 0.7%[138]

[133] FERC (2009b).
[134] ISO-NE (2010d).
[135] CEC (2009c), Table 2.
[136] ISO-NE (2009c).
[137] NERC (2009c).
[138] Monitoring Analytics (2009), Volume I.

Table 26
Current Capacity by Fuel

	California (Statewide)	ISO-NE	NYISO	PJM
Year	2008	2009	Summer 2009	Year end 2008
Total	63.4 GW	31.4 GW	39.2 GW	164.9 GW
Coal	1%	8.7%	7%	40.7%
Gas	60%	39.0%	Gas: 17% Gas and oil: 37%	29.3%
Oil	1%	23.8%	9%	6.5%
Nuclear	7%	14.7%	14%	18.5%
Hydro	22%	5.2%	11%	4.5%
Wind	Included in other	Included in other	Wind: <1%	Wind: 0.1%
Other	9%[139]	8.6% (including pumped storage)	Pumped storage: 4% Other: 0.9%[140]	Solid waste: 0.4%[141]

Table 27 lists the makeup of the fuel sources for all generation requests currently in each RTO's interconnection queue, including multiple OCS wind resources in the "wind" category. It shows the dominance of gas and wind in the interconnection queue. The nuclear requests stem from a small handful of large plant interconnection studies. The OCS wind entries in Table 27 include projects discussed in Sections 2.4 and 3.4.4.4 of this report.

Table 27
Generation Interconnection Request Capacity by Fuel (Total MW and Share by Fuel)[142]

	California	ISO-NE	NYISO	PJM—Mid-Atlantic/APS[143]	PJM RTO
Total MW	66,870	18,096	18,913	17,329	33,713
OCS Wind ICAP MW[144]	0	876	1,961	1,496	1,496
Coal	—	9%	—	1%	10%
Gas	34%	Gas: 10% Gas and oil, kerosene, jet fuel: 26%	Gas: 37% Gas and oil: 3%	66%	52%
Oil	—	Oil, kerosene: 2%	—	5%	3%

139 Navigant Consulting (2009).
140 NERC (2009c).
141 Monitoring Analytics (2009), Volume I.
142 CAISO queue data are as of July 2009. ISO-NE queue data are current through October 1, 2009. NYISO queue data are current through September 30, 2009. The PJM queue data are as of October 30, 2009.
143 Mid-Atlantic/APS data are provided because this region would most likely absorb the output of an offshore wind facility. (This region of PJM includes the service territories of APS, RECO, JCPL, PSEG, AEC, DPL, PECO, PENELEC, PPL, Met Ed, BGE, and Pepco.)
144 OCS wind entries are based on interconnection queue listings for PJM, New York, New England, and CAISO and refer to the total installed capacity, not the capacity ratings, for resource adequacy purposes. The percentage entries for wind in total refer to the capacity value of the installed wind resource.

	California	ISO-NE	NYISO	PJM—Mid-Atlantic/APS[143]	PJM RTO
Nuclear	—	7%	10%	19%	11%
Hydro	1%	23%	—	1%	1%
Wind	19%	20%	38%	5%	20%
Other and Other Renewables	Solar: 45% Geothermal: 1%	Wood waste solids: 2%	Energy storage, flywheel, methane, solar, wood: 1% Load: 1% PS: 11%	Biomass, methane, solar, wood, and other: 3%	Biomass, methane, solar, wood, and other: 3%

Table 28 presents a distribution of the possible in-service dates for generation currently in the interconnection queues of the RTOs. Most of the queued generation would be in service prior to 2015. This shows that RTO queues are focused mostly on nearer-term generation investment, as is understandable given the market-based nature of most new generation in the RTO regions.

Table 28
Generation Interconnection Requests, Total and by Proposed In-Service Date (MW)[145]

	California	ISO-NE	NYISO	PJM—Mid-Atlantic/APS	PJM RTO
Total MW, All Years	66,870	18,096	18,913	17,329	33,713
2009–2011	29,867	8,446	8,827	5,928	15,287
2012–2014	33,901	9,650	6,898	8,944	14,101
2015 and After	3,100	0	3,161	2,458	4,285
TBD or Not Reported	0	0	26	0	40

The generation queue can provide a rough idea of future fuel mix, but on its own it does not indicate future total system capacity. Demand resource capacity is accounted for separately. Also, many of the projects in the generation queue will not materialize. When developing forecasts and plans, RTOs will take into account historical attrition rates for generation proposals as well as new demand-side resources. The rate of attrition is often very high; in PJM, for example, 72% of proposed MW and 44% of proposed projects have dropped off of the queue since 1997 (PJM 2009f). The relatively high attrition rate can be ascribed to the fact that historically there has been a relatively low monetary requirement for entering the queue—payment for a system feasibility study. The queue can be thought of as a broad indicator of commercial interest in developing generation supply, rather than as an expression of what supply is likely to be built.

Current generation interconnection queues for the ISOs and RTOs bordering the OCS can be found on the following Web pages:

- California, CAISO: http://www.caiso.com/docs/2002/06/11/2002061110300427214.html.
- California, statewide: http://www.energy.ca.gov/sitingcases/all_projects.html.

145 CAISO queue data are as of July 2009. ISO-NE queue data are current through October 1, 2009. NYISO queue data are current through September 30, 2009. The PJM queue data are as of October 30, 2009.

- ISO-NE: http://www.iso-ne.com/genrtion_resrcs/nwgen_inter/status/index.html.

- NYISO: http://www.nyiso.com/public/webdocs/services/planning/nyiso_interconnection_queue/nyiso_interconnection_queue.xls.

- PJM: http://www.pjm.com/planning/generation-interconnection.aspx.

Regional load forecasts, combined with the required reserve margins necessary to maintain system reliability, are the primary drivers of decisions on whether or not new capacity is necessary in a given area. Decisions about the type of generation capacity to build depend on a variety of factors that have been mentioned previously in this report, such as unit capital costs, fixed and variable operating costs, fuel costs, unit efficiency, environmental regulations and their associated costs, state and federal environmental goals, incentives for new resource technologies, etc. Regional interconnection queues are the best way to determine how power developers view each of these factors, and which types of generating resource they think will be the most economical in the near-term future. It is practically impossible to make an accurate forecast of the resources that could be expected to be added over the long term.[146]

3.4.3 Prices

The development of OCS renewable resources in areas with an RTO is contingent on the prices the developers receive for generation, capacity, ancillary services, and renewable energy credits. Electricity generated by an renewable energy resource in these areas can be sold on the spot market, sold through bilateral contracts, or used internally. Typically, most energy is self-supplied or sold through power purchase agreements or other contracts because of the risk of the price volatility commonly seen in spot markets. Nevertheless, a developer will look at projected and historical market prices of generation (on-peak and off-peak, which can be important given the particular generation profile of the variable energy resource in question), capacity, and ancillary services in order to estimate revenues if selling directly into the spot market or to determine the opportunity cost of entering into a bilateral contract or using the energy internally. Electricity markets provide transparency, which facilitates determining the value of generation investments early in the development process (ISO/RTO Council 2007).

As of the launch of CAISO's day-ahead market in 2009, all of the wholesale electricity markets bordering the OCS have both day-ahead and real-time markets. Real-time markets allow market participants to cover unforecasted generation shortfalls or excesses, and they exhibit a much higher level of volatility than day-ahead markets. Exposure to high volatility in the real-time market underscores the importance of accurate forecasting for variable energy resources. On

[146] EIA's Annual Energy Outlook does make an attempt to make long-term forecasts of resource additions by region. These forecasts were determined to be of limited use here, as they are similar for all regions and do not seem to reflect events that are actually expected to occur in the market. For example, EIA adds renewable resources between 2010 and 2014, after which very few are added. EIA retires some oil and gas combustion turbine units, but neither retires nor adds any significant amounts of coal generation. Finally, EIA adds large amounts of gas combustion turbine and combined cycle units in mid-years, but these units cannot and should not be expected to make up the bulk of the resource additions through the year 2035.

average, electricity prices in the day-ahead and real-time markets should be roughly the same, with a small premium on day-ahead prices reflecting the value of their stability.

Table 29 illustrates the broad pricing patterns in 2007 and 2008 applicable to the key regions in which OCS Atlantic offshore wind resources would connect to the grid. Prices in 2009 were lower due to lower natural gas prices—annual averages are not yet available. In the PJM-RTO region, coal- and gas-fired generation is typically on the margin,[147] and thus electricity prices reflect the prices of these fuels. In all of the other regions, listed prices are mainly if not solely set by natural-gas- and/or oil-fired generating units and thus closely track gas and oil prices.[148] As the table shows, eastern PJM prices in Delaware and New Jersey (where potential OCS wind resources would connect) are higher than the broader PJM RTO prices. New York City and Long Island prices are the highest, and New England hub prices also reflect natural gas price setting in that region. These listed regions alone represent the price data for what arguably will be the first group of potential large-scale OCS resources, i.e., the projects at various stages of development in New Jersey, Delaware, Long Island/New York City, Rhode Island, and Massachusetts.

Table 29
Summary Price Trends for Eastern OCS Market Regions—Real-Time Energy Market Price Simple Annual Average ($/MWh)

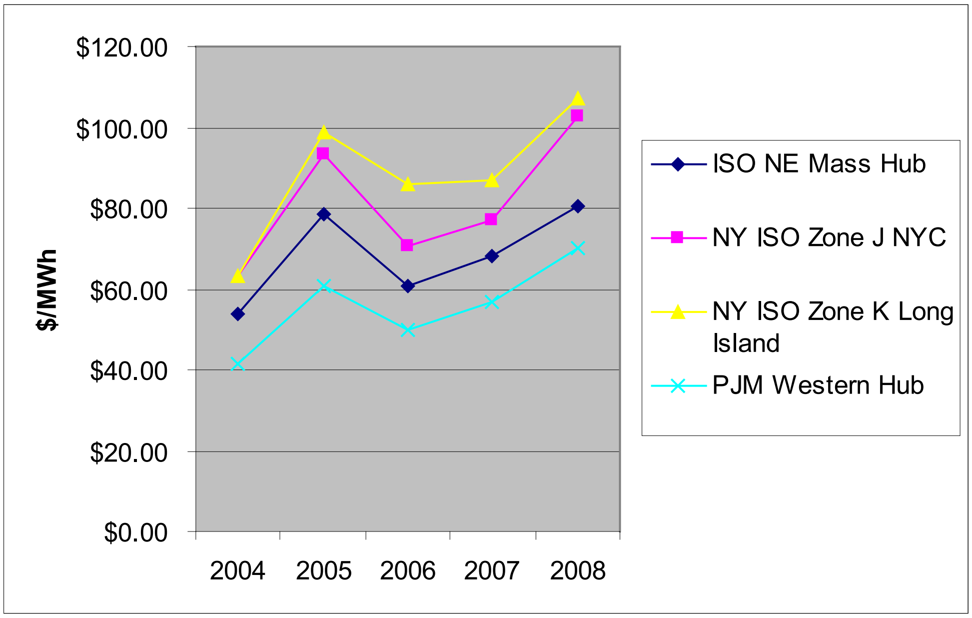
Region	2007	2008
PJM: RTO-wide	57.58	66.40
PJM: Delmarva	64.15	77.20
PJM: New Jersey (south)	65.02	80.70
ISO-NE: Hub	66.72	80.56
NY: RTO	70.84	83.17
NY: Long Island, Zone K	92.74	104.22
NY: NYC Zone J	81.87	102.95

Sources: Monitoring Analytics (2009); ISO-NE (2009d); Potomac Economics (2009e).

Figure 28 shows historical average wholesale electricity prices in the day-ahead markets for key eastern locations in each of the ISOs/RTOs bordering the Atlantic OCS for 2004–2008.

[147] The generating unit(s) on the margin in a wholesale electricity market is the next least expensive generator needed to meet load.

[148] In competitive markets, the marginal generating unit receives a price equal to or slightly above its bid price, which is tied to actual operating costs. Marginal costs for these units are often estimated as equal to a heat rate value multiplied by the cost of fuel (gas or oil) in dollars per MMBtu. It is for this reason that electricity prices are tied to gas and oil prices in these regions.



Sources: FERC (2009b); ISO-NE (2005b, 2006, 2007, 2008c, 2009d); Potomac Economics (2009e).

Figure 28. Annual average day-ahead spot electricity price, eastern RTOs, 2004–2008.

Tables 30 through 32 provide overview statistics on energy, futures, and capacity prices and contracts in the RTOs/ISOs bordering the OCS.

Table 30
ISO/RTO Energy Prices, 2008

	CAISO	ISO-NE	NYISO	PJM
All Hours Annual Average Spot Electricity Prices, 2008 ($/MWh)	Real-time[149] *NP-15 $64* *SP-15 $70*	Day-ahead *Mass. Hub*: $80.43[150] Real-time *Mass. Hub*: $80.56[151]	Day-ahead *Zone J NYC*: $102.52 *Zone K Long Island*: $107.02[152]	Day-ahead *Western Hub*: $69.88[153] Real-time *Western Hub*: $68.52 *Eastern Hub:* $77.15 *NJ Hub:* $79.02
On-Peak Annual Average Spot Electricity Prices, 2008 ($/MWh)	Real-time *NP-15:* $80.14 *SP-15*: $79.36[154]	Real-time *Mass. Hub:* $91.55	Day-ahead *Zone J NYC*: $112.63	Real-time (load-weighted) *RTO wide* $83.90

[149] CAISO (2009e), Table 3.4, p. 3.4. Values estimated from graph.
[150] FERC (2010k).
[151] ISO-NE (2008c).
[152] FERC (2010l).
[153] FERC (2010m).

	CAISO	ISO-NE	NYISO	PJM
Off-Peak Annual Average Spot Electricity Prices, 2008 ($/MWh)				Real-time (load-weighted)[155] *RTO-wide* $57.55

Table 31
ISO/RTO Futures Prices

	CAISO	ISO-NE	NYISO	PJM
NYMEX Near-Term Monthly Electricity Futures[156]	N/A	Internal Hub LMP Swap Peak: Jul 2010: 67.29 Jul 2011: 72.00 Off Peak: Jan 2010: 57.22 Jan 2011: 68.00	Zone J LBMP Swap Peak: Jul 2010: 96.17 Jul 2011: 104.75 Off Peak: Jan 2010: 61.82 Jan 2011: 61.13	Western Hub Swap Peak: Jul 2010: 70.95 Jul 2011: 76.10 Off Peak: Jan 2010: 45.05 Jan 2011: 51.50 Eastern Hub Swap Peak: Jul 2010: 81.95 Off Peak: Jan 2010: 50.18 Jan 2011: 62.75
NYMEX Mid-Term Annual Electricity Futures[157]	N/A	Internal Hub LMP Swap Futures Peak: 2012: 73.48 2013: 75.67 2014: 77.84 Off Peak: 2012: 57.46 2013: 58.75 2014: 59.98	Zone J LBMP Swap Peak: 2012: 91.97 Off Peak: 2012: N/A	Western Hub Peak: 2012: 64.75 Off Peak: 2012: 43.81 Eastern Hub Peak: N/A Off Peak: N/A

As seen in Table 31, on-peak prices are always higher than off-peak prices, on average, across all of the RTOs. Prices also differ by location within RTOs; for example, eastern PJM prices have always been significantly higher than interior, western PJM prices, and the "downstate" New York zones are pricier than upstate zones. The locational aspect of pricing generally bodes well for mid-Atlantic region OCS resources, as their logical points of interconnection are at coastal areas with the highest relative average energy prices seen in most of the nation.

Table 31 lists futures prices for electricity for the RTO regions. Generally, futures prices will follow the natural gas price futures since price formation in the RTO markets is tied to natural gas price trends. The table shows that summer futures are higher than winter futures, and that

[154] FERC (2010j).
[155] Monitoring Analytics (2009), Volume II, p. 450.
[156] NYMEX OTC electricity futures, October 27, 2009.
[157] NYMEX OTC electricity futures, October 27, 2009.

on-peak futures are higher than off-peak futures prices, reflecting the market's understanding that lower load leads to lower clearing prices in these regions.

Table 32 below shows the historical capacity prices for the eastern regions. California does not have a structured, "spot" capacity market like the other regions. Each of these regions has a similar form of a locational, forward generation capacity market. New York City and eastern PJM regions generally exhibit higher locational capacity prices due to transmission constraints in these regions.

Table 32
ISO/RTO Capacity Prices

	CAISO	ISO-NE	NYISO	PJM
Historical Capacity Prices	N/A	FCM transition payment rates, $/kW-month: Through May 2008: $3.05 June 2008: $3.75 2010/2011 capacity commitment period, $/kW-month: $3.60	Six-month strip auction, $/kW-month *Rest of State :* May–Oct 07: $2.25 Nov 07–Apr 08: $1.91 May–Oct 08: $2.67 Nov 07–Apr 09: $1.77 *NYC*: May–Oct 07: $12.37 Nov 07–Apr 08: $5.32 May–Oct 08: $6.50 Nov 07–Apr 09: $2.79 *LI* May–Oct 07: $3.75 Nov 07–Apr 08: $0 May–Oct 08: $2.80 Nov 07–Apr 09: $1.77[158]	Base residual auction, $/MW-day *RTO:* 07/08: $40.80 08/09: $111.92 09/10: $102.04 10/11: $174.29 11/12: $110.00 *MAAC+APS:* 09/10: 191.32[159]

Prices of generation in California, ISO-NE, and NYISO are largely determined by the price of natural gas, because gas is frequently on the margin in these areas. To a lesser extent, the price of gas also influences the price of these products in PJM, although PJM is also heavily influenced by coal prices. Compared to prices in the northeast and west, electricity prices in the rest of the country reflect heavy influence by coal and much less influence by gas.

The "market-implied average heat rate," defined as the price of electricity divided by the price of gas, is particularly useful in regions where gas-fired generation is on the margin for a significant portion of the time. The market-implied heat rate suggests the aggregate average efficiency of units that are run at the margin during peak periods in those regions. A typical simple cycle gas-fired generator, much less efficient than an average combined cycle unit, will have a heat rate of about 10,000 Btu/kWh. A market heat rate above 10,000 Btu/kWh suggests greater utilization of inefficient older or peaking units and that market prices include a scarcity premium. A market heat rate below this level indicates greater levels of more efficient, combined cycle generation

158 NYISO (2009g).
159 Monitoring Analytics (2009).

assets or newer peaking gas turbine assets. This is relevant for variable-output resources that require some following capacity. Table 33 shows the current implied heat rates for the ISOs/RTOs bordering the OCS. As expected, based on the higher prices seen in the New York City region, the high heat rate illustrates that OCS resources connecting into this market area are likely to see the highest level of market energy revenues.

Table 33
Market-Implied Average Heat Rates

	CAISO/California	ISO-NE	NYISO	PJM
Summer Implied Heat Rate, Jun–Aug 2008[160]	Southern California (SP-15): 10,193 Btu/kWh	Massachusetts Hub: 9,799 Btu/kWh[161]	New York City: 13,170 Btu/kWh	PJM Western Hub: 9,845 Btu/kWh

A large portion of generation is supplied through bilateral contracts, often in the form of off-take arrangements.[162] Bilateral contract prices reflect the parties' expectations about the future price of energy; sometimes contract prices are explicitly tied to the market price of electricity at the time that the contract is signed or indexed to current prices. Data on bilateral transactions are generally not available, however, so it is difficult to determine to what extent bilateral contract prices follow, anticipate, or index to spot prices. The development of capital-intensive offshore renewable energy resources often hinges on the developer's ability to secure a bilateral contract to provide a predictable stream of revenues, thereby reducing risk and facilitating the developer's ability to obtain financing. Table 34 describes the nature of bilateral trading activity in each region.

Table 34
ISO/RTO Bilateral Contracting

	CAISO	ISO-NE	NYISO	PJM
Bilateral Contracts (%)	The CAISO Tariff required that at least 95% of hourly forecast demand must be scheduled one day ahead. Before the day-ahead market was created, all day-ahead scheduling was based on bilateral contracts and self-supply.	75% of electricity trading is covered under bilateral contracts. 25% is traded in the real-time market.[163]	Bilateral forward contracts outside the NYISO: 50% (day-ahead market: 45%–50%; real-time: <5%).	In 2008, 14.6% of real-time load was supplied by bilateral contracts, 20.1% by spot market purchases, and 65.2% by self-supply.[164]

160 FERC (2009b).
161 See also ISO-NE (2008c).
162 An off-take agreement is a contractual arrangement wherein a buyer agrees to purchase/sell portions of a producer's future production; an off-take agreement can facilitate financing for the construction of a project, because the terms of sale and demand for future output are secured (Investopedia 2010).
163 ISO-NE (2010d).
164 Monitoring Analytics (2009), Volume I.

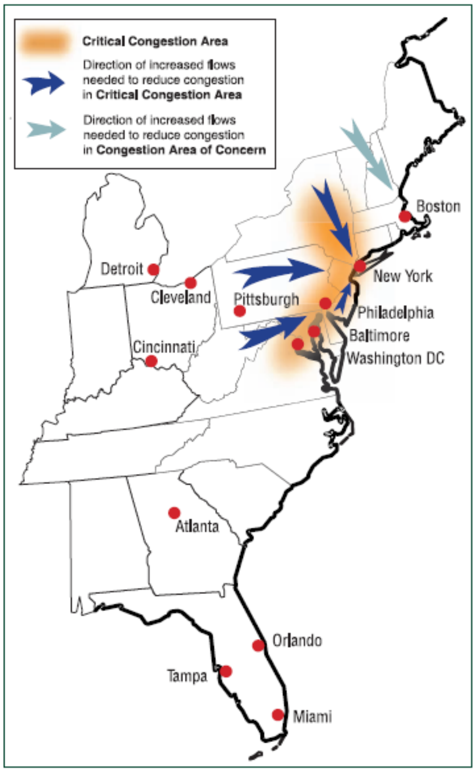
Like generation, capacity and ancillary services can be used internally, sold via bilateral contracts, or offered on the spot market. Typically, variable energy resources receive compensation for capacity consistent with their contribution to the system during peak times. Renewable resources often do not qualify to supply ancillary services, and indeed wind resources will generally need additional or modified ancillary services to support the reliability of the grid. The economics of developing renewable generation capacity on the OCS will depend in part on RTO/ISO rules regarding payments and charges for all of these products.

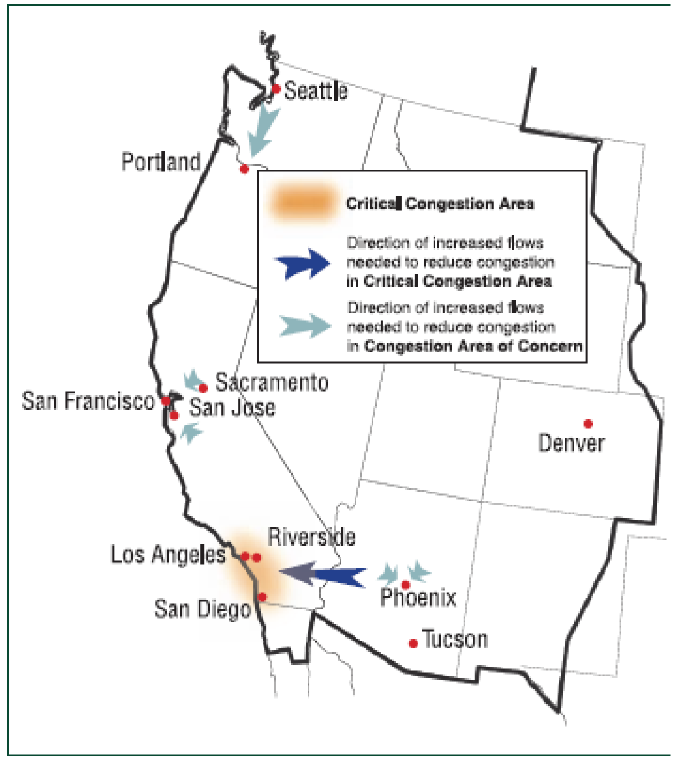
3.4.4 Transmission

Planned transmission expansions can focus on upgrading facilities within load centers on the coasts—possibly making interconnection for OCS resources more feasible—or they can emphasize importing power from other regions, e.g., from coal and wind generation in the Midwest. Transmission planning can also seek to alleviate "locationally constrained" alternative resources by creating renewable energy zones and encouraging development of transmission to these zones. Emphasis on developing transmission from the interior, the costs of which would be shared by a large number of transmission customers—and potentially subsidized by taxpayers—will reduce the competitiveness of off-shore wind. In contrast, developers and owners of offshore generation would bear all of the costs of the transmission assets needed to bring electric output to shore, absent the development of an offshore transmission "backbone" to facilitate interconnection of renewable energy resources there.

3.4.4.1 National Electric Transmission Congestion Study

In 2006, DOE published the national electric transmission congestion study (USDOE 2006). Figure 29 shows electric transmission areas of critical congestion and areas where DOE identified concern about congestion. The proposed and potential wind projects along the East Coast are located where they would most effectively lower congestion in the critical areas, which will also lessen the need for electricity imports from Canada. Likewise, the proposed and potential wave projects along the West Coast would mitigate areas of concern and critical congestion. They could also reduce the need for electricity imports from Canada.





Source: USDOE (2006).

Figure 29. Critical transmission congestion areas (2006).

3.4.4.2 Interregional Transmission Planning

Interregional efforts to engage in transmission and generation system planning are seeking ways to accommodate large amounts of renewable resources, primarily land-based wind. The Joint Coordinated System Plan (JCSP) is an initiative of many of the major transmission operators in the Eastern Interconnection, including the MISO, SPP, PJM, the Tennessee Valley Authority (TVA), MAPP, and several key members of SERC. ISO-NE and NYISO withdrew from authorship of the JCSP'08 study prior to its release, because of the lack of ongoing activities and initiatives in the region (ISO-NE and NYISO 2009). ISO-NE and NYISO cited strong policymaker support for offshore wind projects in New York and New England as a reason for withdrawal from authorship (ISO-NE and NYISO 2009).

The modeling for JCSP'08 considered a scenario in which, by 2024, 20% of energy would come from the highest-capacity onshore wind resources, primarily located in the Midwest; it examined the associated transmission requirements to deliver to loads throughout the Eastern Interconnection. The 20% Wind Scenario is contrasted with a "base" case that assumed incremental wind development would only address existing RPS requirements. Figure 30 shows the transmission lines that JCSP'08 finds would be needed to bring inexpensive coal and wind power from the interior to the East Coast under the 20% Wind Scenario.

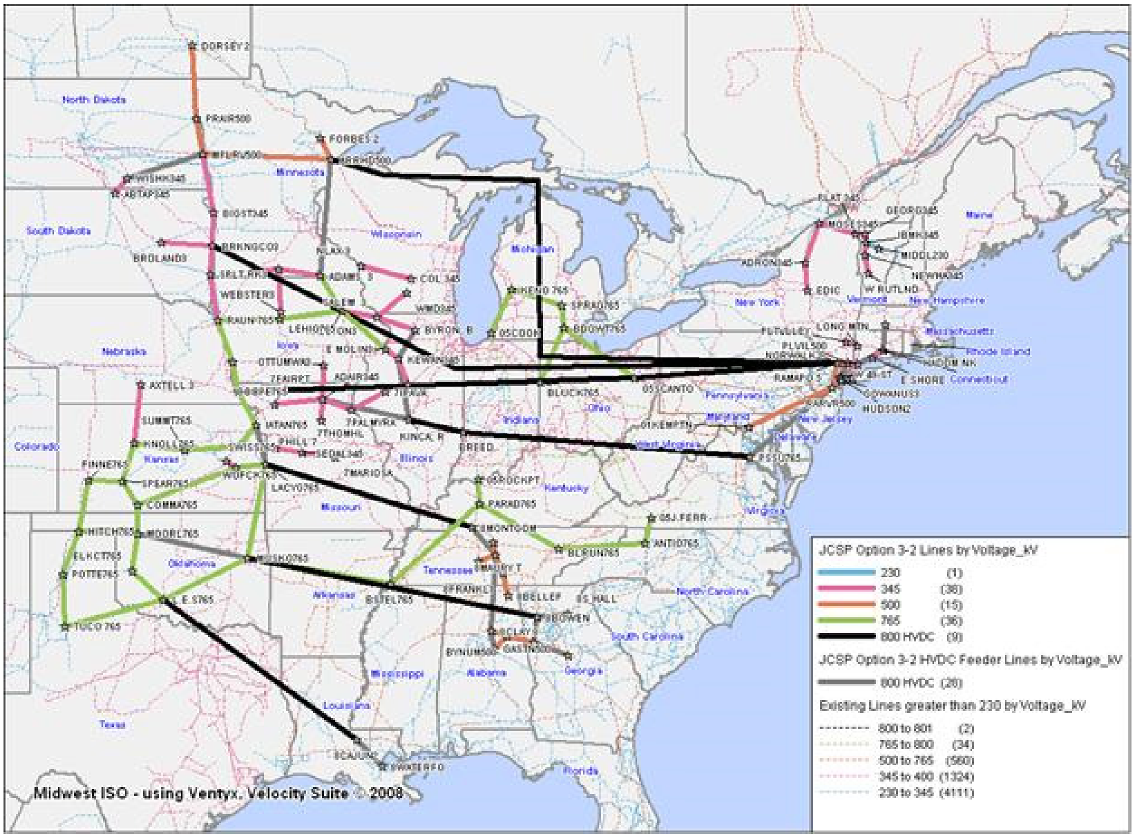


Figure 30. Needed transmission lines per JCSP'08, 20% Wind Scenario.

Development of offshore wind resources was not modeled in the JCSP'08 report. Future modeling may look at sourcing more wind nearer to eastern load centers, allowing comparison of the costs of using capital-intensive offshore wind plus lower-quality onshore wind (which would require more wind turbines) against a reduction in the costs of Midwest to East transmission investment (JCSP 2008).

There are two federal legislative proposals that would designate national transmission corridors between Midwestern load centers and Eastern load centers. The House Energy Bill would give FERC "backstop" authority to override states' permitting decisions on transmission proposals in the Western Interconnection, but not in the East. The Senate version would grant FERC backstop authority to issue certificates for a "high-priority national transmission project" in both the East and the West if a state either fails to site the line or denies the project's application within a one-year window.[165] These legislations may negatively affect renewable energy development. Several East Coast companies, among them PJM, Midwest ISO, ISO-NE, NYISO, SERC, Duke Energy, Entergy Corp., Florida Power & Light, Progress Energy, the Tennessee Valley Authority, Southern Co., and Ontario's Independent Electricity System Operator, have launched an initiative to develop a bottom-up planning approach to preempt these legislations

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[165] High-priority national transmission projects are projects that operate above 300 kV (or that connect renewable energy projects directly to such a line) and are included in a region-wide transmission plan (Jones Day 2009).

(Behr 2009), which would include interconnection-wide top-down grid planning that would accommodate large amounts of renewable energy.

An offshore transmission network connecting multiple wind projects would reduce variability and the costs associated with that variability. Although an offshore transmission network is technically feasible, the high costs of interconnecting offshore projects may far outweigh the benefits of avoided operating reserves and more renewable generation.

3.4.4.3 Intraregional Transmission Planning and Development

More information on major transmission projects is publicly available today than earlier in this decade, thanks in part to the emphasis on transparency in FERC Order 890. This transparency allows better market assessment of transmission concerns, allowing the market to respond to these needs more efficiently. Transmission trends and developments for each ISO are summarized in Table 35 and discussed in the following subsections.

Table 35
Transmission Trends

	CAISO/California	ISO-NE	NYISO	PJM
Trans-mission Trends	Emphasis is on bringing renewable energies (wind, solar, geothermal) and lower-cost generation from inland or out of state to load centers on the West Coast.	A few major 345 kV backbone projects seek to ensure load pocket (southwest Connecticut, Boston) reliability. Peak load trends and demand-side investments may defer need for major 345 kV projects under consideration to ensure bulk system reliability. Various merchant or reliability proposals for new transmission would bring wind and low-cost resources from north to south or from offshore resources to load.	Emphasis is on bringing generation to major load centers in downstate New York; load growth and scheduled power plant retirements will further tax system. Transmission reinforcements may be needed to support wind capacity interconnection in northern and western New York. Proposals are under consideration for major transmission interconnection of offshore New York City/Long Island wind farm(s).	Several "backbone" projects will transport cheaper coal-or wind-based power from the West to critically congested load centers in the East. Major increases in demand response resources present in the capacity market will impact the longer-term needs of bulk system upgrades. Interconnection studies have been completed for a number of potential offshore wind projects.

3.4.4.4 Eastern Wind Integration and Transmission Study

DOE commissioned the Eastern Wind Integration and Transmission Study through NREL (USDOE NREL 2010b). The study was designed to identify and address issues associated with meeting a goal of generating 20% to 30% of the electricity consumed in the Eastern Interconnection by 2030. (The Eastern Interconnection is roughly the eastern half of the United States minus Texas; see Figure 19 in Section 3.2.3.)

An earlier NREL study identified about 1,325 separate wind energy facilities, with a combined capacity of nearly 700 GW, for the eastern United States. The database includes both onshore and offshore locations and most of the facilities are hypothetical. (For the purpose of this report, offshore wind is located in water up to 30 meters deep in the Great Lakes and off the East Coast.) The split between onshore and offshore capacity is 580 GW onshore and 100 GW offshore. There is no information on how much of the 100 GW offshore wind capacity is estimated to come from the Great Lakes region. Using this database, the Eastern Wind Integration and Transmission Study developed four scenarios:

- *Scenario 1, 20% penetration—high capacity factor, onshore.* Uses high-quality wind resources in the Great Plains, with other development in the eastern United States where good wind resources exist. This scenario features only onshore wind development.

- *Scenario 2, 20% penetration—hybrid with offshore.* Some wind generation in the Great Plains is moved east. Some East Coast offshore development is included.

- *Scenario 3, 20% penetration—local with aggressive offshore.* More wind generation is moved east toward load centers, necessitating broader use of offshore resources. The offshore wind assumptions represent an uppermost limit of what could be developed by 2024 under an aggressive technology-push scenario.

- *Scenario 4, 30% penetration—aggressive on- and offshore.* Meeting the 30% energy penetration level uses a substantial amount of the higher-quality wind resource in the NREL database. A large amount of offshore generation is needed to reach the target energy level.

Table 36 compares these four scenarios. MISO/MAPP, SPP, and TVA are located in the interior and can develop only the onshore wind resources in their areas. PJM is the region with the largest potential for offshore wind, with nearly 55 GW in Scenario 4. This is five times larger than ISO-NE under the same scenario. (Under Scenario 2, both regions develop 5 GW capacity in offshore wind energy.) SERC develops 4 GW wind energy capacity under Scenarios 2 through 4. NYISO develops between 2.6 and 9.3 GW, depending on the scenario.

Table 36
Total and Offshore Wind Scenarios

	Scenario 1 20% High Capacity Factor, Onshore		Scenario 2 20% Hybrid With Offshore		Scenario 3 20% Local, Aggressive Offshore		Scenario 4 30% Aggressive On- and Offshore	
Region	TOTAL (MW)	Offshore (MW)	TOTAL (MW)	Offshore (MW)	TOTAL (MW)	Offshore (MW)	TOTAL (MW)	Offshore (MW)
MISO/MAPP	94,808		69,444		46,255		95,046	
SPP	91,843		86,666		50,958		94,576	
TVA	1,247		1,247		1,247		1,247	
SERC	1,009		5,009	4,000	5,009	4,000	5,009	4,000
PJM	22,669		33,192	5,000	78,736	39,780	93,736	54,780
NYISO	7,742		16,507	2,620	23,167	9,280	23,167	9,280
ISO-NE	4,291		13,837	5,000	24,927	11,040	24,927	11,040
Total	223,609	0	225,902	16,620	230,299	64,100	337,708	79,100

Source: USDOE NREL (2010b).

In general, the study found that 20% to 30% of the electrical energy requirements could be met by wind by 2040, but only with significant expansion of the transmission infrastructure. Because it takes longer to build new transmission capacity than it does to build a wind farm, early planning for expanding the transmission system is a high priority. In particular, long-distance and high-capacity transmission makes a substantial difference in regions' abilities to integrate wind energy while balancing their load requirements. USDOE NREL (2010b) found that Scenario 1, which does not include offshore wind energy, has the highest estimated total cost for transmission improvements—approximately 22,697 miles of new extra-high-voltage transmission line at a cost of $93 billion (US$2009). Scenario 3 has the lowest estimated transmission costs—approximately 17,050 miles of new extra-high-voltage transmission line at a cost of $65 billion (US$2009). Under Scenario 3, more wind generation moves to the East and reduces the need for high-voltage transmission lines.

Table 37 lists the levelized cost of energy (LCOE) for onshore and offshore wind based on the wind database. The study notes that offshore wind has more effect on locational marginal prices in eastern load centers because of its proximity to large load centers otherwise served by generation with higher costs.

Table 37
LCOE Economic Cost Assumptions (US$2009)

Assumption	Onshore	Offshore
Fixed charge rate (%)	$11.92	$11.92
Capital cost ($/kW)	$1,875	$3,700
Fixed O&M ($/kW/yr)	$11.50	$15.00
Variable O&M ($/MWh)	$4.79	$14.50

Source: USDOE NREL (2010b).

3.4.4.5 Offshore Energy Projects, Integration Into the Electric Power Grid, Associated Expansion of Transmission Assets

This section examines what might happen if and when the first wave of offshore wind projects become reality. There are currently eight offshore wind resource projects totaling 3,078 MW of installed capacity at various stages of development in the Northeastern and mid-Atlantic regions of the United States (see Table 38).

The projects themselves have been described in Section 2.4 of this report. They will be interconnected via submarine transmission cables at 115 kV, 138 kV, and 230 kV voltage levels to eight separate transmission substations that are part of the networked electric grid and are located close to the coast in Delaware, New Jersey, New York, Rhode Island, and Massachusetts. The requirements for interconnection were specified by the respective RTOs in each of the three regions, pursuant to current FERC-approved tariff and interconnection protocols.

If the projects come to fruition, all but one would be located in OCS waters. (There is a 29 MW Rhode Island "pilot" project in state waters.) While none is under construction yet, detailed transmission interconnection studies have been conducted for all of the projects, and contracts have been signed or contract negotiations are underway for the energy and capacity output of some of the projects. All are planned for in-service operation no later than 2015, and all will contribute toward meeting state RPSs for electricity. While additional transmission interconnection studies are underway or may be required to finalize transmission connection facility details, there is sufficient information to describe how these projects would be interconnected to the grid.

In addition to transmission interconnection requirements, the operators of the transmission system in each of the respective regions—namely, PJM, NYISO, and ISO-NE—will need to take other action in order to fully integrate these projects into the electric power system. These actions would focus on considering the effect of the wind farms on operational requirements for capacity and ancillary services, and energy dispatch effects, in operational time frames from a few days ahead to real-time. Generally, the operators' actions would not be dissimilar to ongoing operator procedures for handling the presence of existing variable output resources (primarily wind) connected to the grid. These grid operators oversee installed capacity and loads that total (for the three RTOs) well over 100,000 MW, so the offshore resources in aggregate represent a relatively small fraction of supply resources.

Table 39 lists the transmission interconnection details associated with each of the eight projects. Generally, the transmission expansion requirements associated with this “first wave” of projects are well understood, and do not pose any particular problems or challenges that utility companies and RTOs do not already address as part of their planning for and operation of the transmission grid.

Table 38
Summary Attributes for Grid Integration of Eastern OCS Region Offshore Resource Projects

Project	State	Utility Territory/ RTO	Lead Developer/ Partner	Installed Capacity	Estimated In-Service Date	Connection Point—Substation	Comments
Cape Wind	MA	NSTAR/ ISO-NE	Energy Management, Inc.	468 MW	2012	Barnstable 115 kV	BOEM issued the license in October 2010.
RI Offshore Wind Farm—Newport	RI	National Grid/ISO-NE	Deepwater Wind	385 MW	Within three years of approval by BOEM	West Kingston 115 kV	Interconnection study underway.
RI Offshore Wind Farm—Block Island Pilot	RI	National Grid/ISO-NE	Deepwater Wind	29 MW	2012	Block Island and Narragansett 34.5 kV	Connected to sub-transmission system. Located in state waters. Contract pending at RI PUC proceeding.
Garden State Offshore Energy (T146)	NJ	Atlantic City Electric/ PJM	Deepwater Wind/ PSEG Renewable Generation	346 MW	2014	BL England 138 kV	All three proposals are pursuant to state of New Jersey RFPs promoting development of offshore wind clean energy. Policy proposal for offshore renewable energy credits structure.
FERN Blueribbon Wind Farm 2 (U1-056)	NJ	Atlantic City Electric/ PJM	Fisherman's Energy	350 MW	2015	Lewis 138 kV	
NJ Offshore Wind Farm (T84)	NJ	Atlantic City Electric/ PJM	Bluewater Wind/ NRG	350 MW	2014	Dennis 230 kV	
DE Offshore Wind Farm (R36)	DE	Delmarva Power and Light/PJM	Bluewater Wind/ NRG	450 MW	2012	Indian River 230 kV	Approved contract with Delmarva Power.
LIPA/Con Edison Offshore Wind Farm	NY	Con Edison/ LIPA	Con Edison/ Long Island Power Authority	700 MW	2015	Far Rockaway 138 kV	Additional 700 MW under consideration also.
Total				3,078 MW			

Table 39
Summary Transmission Requirements to Date for Eastern OCS Offshore Resource Project Integration

Project	Description of Transmission Interconnection Requirements	Substation Point of Intercon-nection (POI)	Description of Connection From Land Substation to Wind Farm	Estimated Integration Costs[166] $Millions Total	Direct	Indirect
Cape Wind	A 115/33 kV gas-insulated substation electric service platform in Nantucket Sound, consisting of six 115 kV circuit breakers and four transformers. Installation of two 115 kV cables connecting the substation to the Barnstable substation. Reconductoring of the Brook Street-Kingston #117 line and the Kingston-Auburn #191 line.	Barnstable	Two 115 kV cables	$29	$17	$12
RI Offshore Wind Farm	Unknown at this time.	West Kingston	115 kV cable(s)	National Grid cost analysis expected in March 2010.		
RI New Shoreham (Block Island) Pilot	Block Island currently does not have 34.5 kV; it is limited to distribution circuit voltages. New sub-transmission station required.	Block Island	One 34.5 kV cable	~$60 million for cable system from Block Island to mainland (34.5 kV).		
Garden State Offshore Energy (T146)	The three New Jersey wind farms connect to the Atlantic City Electric system; the Delaware wind farm connects to the Delmarva Power system via submarine cables. Circuit breakers must separate each cable from the POI. The available interconnection reports do not specify collector station and transformer arrangements at sea; the developer must provide all such equipment and metering/telemetry pursuant to PJM protocols. Several 230 kV and 138 kV circuits and related equipment must be upgraded: the circuits must be rebuilt (to double circuit configuration) and/or reconductored. Line terminal and circuit breaker upgrades are also required. Costs are shared across contributing newly connecting generators and will be finalized in the Interconnection Service and Construction Agreements between the generators and PJM. Estimates shown are from system impact (New Jersey) and facilities (Delaware) studies. Final requirements, costs, and cost responsibility have not yet been determined.	BL England	Two 138 kV cables	$70	$4	$66
FERN Blueribbon Wind Farm 2 (U1-056)		Lewis	One 138 kV cable	$58	$2	$56
NJ Offshore Wind Farm (T84)		Dennis/ Corson	One 230 kV cable	$78	$3	$75
DE Offshore Wind Farm (R36)		Indian River	One 230 kV cable	$22	$22	—
LIPA/Con Edison Offshore Wind Farm	A new transmission line from an on-shore receiver station to a new substation in the vicinity of Eastern Queens, combined with a connection to the LIPA transmission system near the Rockaways. Existing transmission lines between LIPA and Con Edison would be reconfigured at the new station.	Far Rockaway	Multiple 138 kV cables	$821	Total costs listed as stage 1 ($415) plus stage 2 ($406); includes direct and indirect costs.	

[166] Costs exclude developer costs of at-sea platform and collector systems, and cable costs to POI. Estimated costs based on system impact study or facilities study, or feasibility study (New York). A portion of the total costs in PJM may be allocated to other users. New Jersey wind farm costs overlap, as similar ACE system upgrades are required for each of the resources. Costs in PJM exclude additional reactive support and/or stability impact costs, if any; these are to be determined at later stages of study. The New York offshore wind farm includes significant costs to upgrade the Long Island/eastern New York City grid; further studies could assign some of these costs to other parties, and/or allow future additional offshore wind to be supported.

The offshore wind farms will use at-sea platforms to serve as "collector points" for the output of the ocean-based arrays of wind turbines. Sub-sea collection systems using sub-transmission voltage level submarine cables (analogous to onshore wind farm collector systems) will bring the output to this collection point platform. Those platforms will generally contain step-up transformation to deliver higher-voltage supply to the submarine cables that will transmit the power to the onshore transmission grid. On shore, incremental transmission substation expansion will be required to accept the injection of the wind farms' output. In some cases, a new onshore substation will be constructed.

In addition to these "direct" connection requirements, a number of "indirect" upgrades are required for local 115 kV, 138 kV, and/or 230 kV system elements in the region. These upgrades consist of reconductoring or rebuilding existing circuits to sufficiently handle increased electricity flow, either under normal circumstances or under "contingency" circumstances (e.g., a transmission line is hit by lightning and switches out of service). Under such conditions, the transmission grid must be able to carry power from all generating resources (including the wind farms) to all load. The interconnection studies carried out by RTOs under FERC-approved protocols analyze these situations and determine what additional transmission elements are required to ensure such reliability. In addition to circuit reinforcement or reconstruction, additions or upgrades of other transmission elements such as circuit breakers or reactive power support is sometimes required. The feasibility studies, the system impact studies, and the facilities studies undertaken by the RTOs contain descriptions, explanations, and cost estimates of the requirements.

In total, the upgrades required to bring these eight projects online were initially estimated (as part of initial feasibility studies) as totaling more than one billion dollars and included major 230 kV and 500 kV circuit upgrades, mainly in the PJM system. More detailed system impact studies, conducted later, indicated costs an order of magnitude lower, consisting primarily of local 115, 138, and 230 kV system upgrades (except for New York). The actual cost responsibility for these upgrades is still to be determined, but costs will be shared and thus actual integration costs will be lower for some projects, especially in PJM. This amount will not be known with any precision until the final interconnection service agreements are developed and signed by the RTOs and the wind farm developers.

Once operational, the RTOs will operate the regional grids using dispatch and unit commitment protocols, likely similar to current protocols but more evolved than them. PJM and NYISO both use centralized wind forecasting systems already. It would be expected, considering the additional planned wind (both onshore and offshore) in New England, that ISO-NE would also migrate to use of such a system. At the present time, it is not known with any certainty if ancillary service requirements will change due to the wind projects, but given the relatively low total penetration of wind resource onto these grids by 2015, changes to such requirements would be expected to be minimal and would not change the overall nature of system operations.

3.4.5 ISO-NE

Load growth in some northern and interior areas in New England has caused reversals in power flows, which historically went from north to south but are now moving from south to north during a significant number of hours each year (ISO-NE 2008b).

A number of needed transmission upgrades to service these growing loads, in various stages of development, have been identified in the ISO-NE region (ISO-NE 2008b):

- SWCT Phases 1 (in service) and 2 (under construction).
- NSTAR 345 kV Project Phases I (in service) and II (under construction).
- Northwestern Vermont (in service and under construction).
- The Monadnock area of southeastern Vermont, southwestern New Hampshire, and north-central Massachusetts.
- New England East–West Solution (under study), with projects in Rhode Island, western Massachusetts, and central Connecticut.
- Southeastern Massachusetts (under construction).
- The Maine Power Reliability Program (under study).
- The 1385 Replacement (under construction).
- The Vermont Southern Loop (under study).

Various merchant or reliability proposals for new transmission to handle new wind capacity or to leverage high prices in load pockets have been made. These include 1) from Quebec to southern New Hampshire, 2) from Maine to southern New Hampshire, and 3) from possible offshore wind sites in Maine.

Notably, transmission needs for two prominent OCS projects—Cape Wind in Massachusetts and the Deepwater proposal in Rhode Island—are relatively minor (115 kV) compared with some of the larger-scale 345 kV projects recently in service or planned for the region, as noted in Table 35.

3.4.6 NYISO

NYISO has dominant flows from the north and west to constrained areas downstate, including Long Island and New York City. NYISO is studying possible increases in the need for transmission reinforcements to support burgeoning wind capacity and interconnection proposals, many of which seek to interconnect in concentrated clusters in northern and western New York. NYISO has noted that "these regions are supported by an existing transmission network that will not be capable of delivering all the potential wind output to the load centers in the southeastern regions of the state" (NYISO 2008b). An initial study has been performed for interconnecting 700 MW (and potentially 1,400 MW) of offshore Long Island wind to the Long Island/New York City transmission grid. The study concluded that an interconnection of up to 700 MW of offshore wind at the desired location would be feasible with upgrades to the transmission systems of both LIPA and Con Edison.

Several proposals to lay transmission cables under the Hudson River would increase the capacity of the existing interface between New Jersey and New York City. A proposal for a new 345 kV cable from Westchester, New York, into New York City would likewise relieve some congestion into the city (NYISO 2009f). The additions of the Cross Sound Cable from Long Island to Connecticut in 2005 and the Neptune Cable between Long Island and New Jersey in July 2007 have increased downstate New York's access to resources located in adjacent regions by nearly 1,000 MW. Downstate load growth and scheduled power plant retirements will further tax the transmission network. Several transmission proposals that would address the projected reliability needs for New York City are moving forward. These include:

- New transmission cables under the Hudson River, connecting New Jersey and New York City.
- A new 345 kV cable from Westchester to the Bronx, by 2010 (NYISO 2010d).

3.4.7 PJM

In 2006, FERC ruled that the costs for transmission projects 500 kV and above be socialized among all PJM zones. Numerous 500 and 765 kV extra-high-voltage "backbone" projects at various stages of approval make up the bulk of planned transmission expenditures over the next three to 10 years. These projects will increase capacity from western PJM to load centers in the east and will help to reduce price differentials between the east and the west portions of PJM. However, they will also allow for significantly increased coal-fired generation onto the PJM grid. These "backbone" transmission projects include:

- The Trans-Allegheny Interstate Line (TrAIL) project to relieve projected overloads in the Washington, D.C., area.
- The Susquehanna-Lackawanna-Roseland line to import electricity into New Jersey from Pennsylvania.
- The Potomac-Appalachian Transmission Highline project to relieve congestion in the Washington, D.C., and Baltimore areas.
- The MAPP from Virginia to New Jersey via Delaware, to bring additional power supply to the Delmarva Peninsula region. Notably, this project could bring a larger "backbone" interconnection to the coast for increases in offshore wind from Delaware and New Jersey.

Studies for offshore wind interconnections to the PJM grid have been performed. Generally, these studies indicate relatively straightforward 138 kV and 115 kV connections to the backbone grid for offshore wind projects.

3.4.8 California and CAISO

Southern California has been identified as a Critical Congestion Area (a region where it is critically important to remedy existing or growing congestion problems), and the San Francisco Bay Area is a Congestion Area of Concern (an area where a large-scale congestion problem exists or may be emerging, but the magnitude of the problem and transmission expansion and other solutions require further study). Aside from transmission projects to relieve this congestion, a number of proposals would bring renewable energies (wind, solar, geothermal) to load centers on the West Coast:

- Southern California Edison's Devers–Palo Verde 2 will increase capacity to import low-cost power from Arizona into the Los Angeles Basin by 1,200 MW. Its projected online date was summer 2009, though regulatory delays continue to burden the project.
- San Diego Gas and Electric's Sunrise Powerlink would reduce system congestion and its resultant costs and interconnect renewable resources and lower-cost out of state generation with the San Diego area, if approved by CPUC.
- Tehachapi Renewable Transmission projects would provide 4,500 MW of capacity from the wind-rich Tehachapi resource area into the Los Angeles Basin. Segments 1 to 3 (750 MW) have been approved; 4 to 11 are pending approval.
- Green Path (a joint venture of the Los Angeles Department of Water and Power, Imperial Irrigation District, and Southern California Public Power Authority) would provide access to renewables and increase transfer capacity into the San Diego and Los Angeles regions.
- The San Joaquin Cross Valley Loop 220 kV Transmission Line Project would deliver additional power from hydroelectric facilities in the Sierra Nevadas to Tulare County, California (CPUC 2010; CEC 2007).

It is notable that a study of wind potential off the shore of California found that the northern part of the state has the best wind resources at 80 meters high but the least transmission capacity (Dvorak et al. 2007). The major transmission projects listed above would likely compete with transmission projects that would facilitate OCS resource development for priority and funding.

3.4.9 Data Tracking

ISOs and RTOs often administer systems for tracking generation, generation attributes, and/or RECs. These systems provide the basis for renewable energy attribute trading and for compliance with state RPSs and emissions programs.

- *New England.* The NE-GIS, launched by NEPOOL in July 2002, tracks the generation attributes, emissions, and outputs of all generators in New England and facilitates the trading of RECs for states with renewable energy portfolio standards (NYISO 2010e).
- *PJM.* Based the NE-GIS, PJM's Generation Attribute Tracking System creates generator-specific electronic certificates for compliance with state policies or documenting green power claims. This system tracks MWh produced, emissions data (primarily from EPA and supplemented from other sources), fuel source, location, state program qualification, and ownership of attributes (PJM 2005).
- *New York.* NYISO is working with market participants to determine the suitability of adapting the NE-GIS to New York markets (NYISO 2010e).

- *WECC region/California.* The WREGIS is an independent system for tracking renewable energy, developed through collaboration among the Western Governors' Association, the Western Regional Air Partnership, and the California Energy Commission. WREGIS tracks renewable energy generation from units that register in the system using verifiable data and creates RECs for this generation (WREGIS 2009).

4 OFFSHORE ENERGY SYSTEMS

Section 4.1 provides an overview of different offshore energy systems—a snapshot of technologies as of November 2010. (Note that not all technologies described in Section 4.1 may progress to the commercial stage, and new technologies, not public at this time, might be successful.) Section 4.2 briefly summarizes the economics of offshore energy systems, particularly with respect to U.S. operations. Section 4.3 is a brief overview of the European experience with offshore energy.

4.1 TECHNOLOGIES

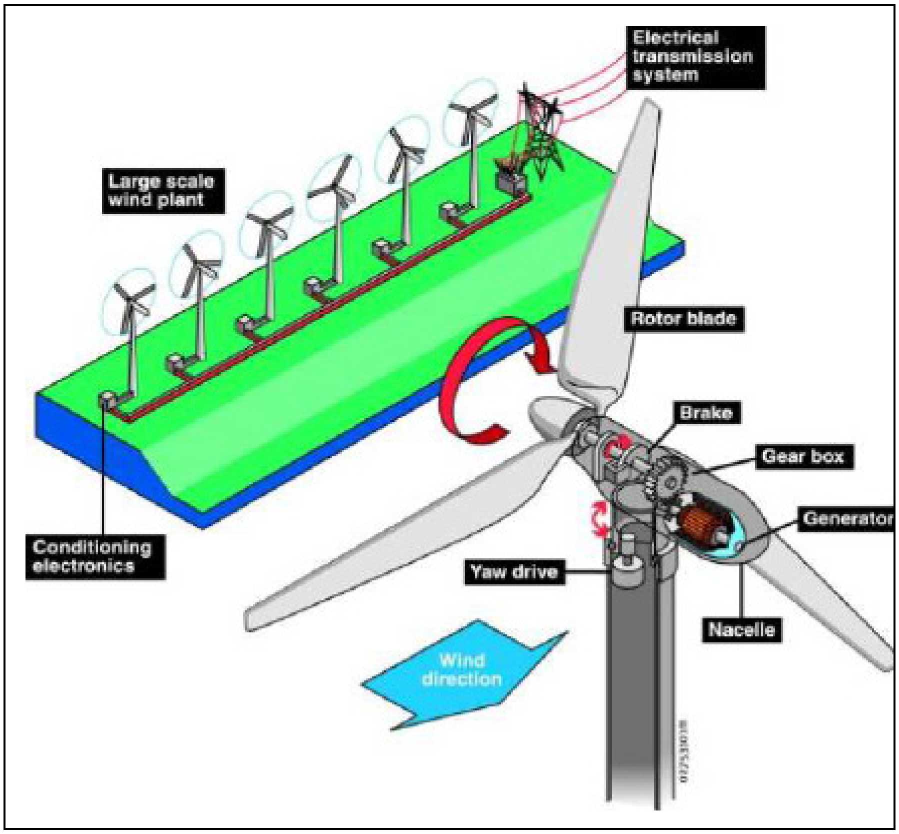
4.1.1 Offshore Wind Energy

As of November 2010, there are no operating offshore wind installations in the United States, whereas there is more than 25,000 MW installed capacity for onshore wind (AWEA 2009a). Part of the effort within this report is to differentiate the infrastructure available for offshore development rather than onshore development. Offshore turbines tend to be larger (2.5 MW to 5 MW) than onshore turbines (1.5 MW; see AWEA 2009a). The turbines must also be adapted to withstand corrosion from salty ocean water. In addition to turbine size, major differences between onshore and offshore wind farms rest in the turbine foundations and the turbine installation process. Offshore wind offers several advantages, such as steadier winds and higher wind speeds (AWEA 2009b). As discussed in Chapter 3, offshore wind has the potential to supply energy to coastal load centers while mitigating some of the congestion in the grid.

4.1.1.1 Turbines

As a result of the rapid growth in the wind industry in recent years, components of utility-scale wind turbines, e.g., blades and nacelles, have become standardized. A utility-scale turbine consists of a generator housed in a nacelle casing and propelled by two or three blades, as shown in Figure 31, below. Offshore turbines must endure increased pressure from the wind and waves, and are therefore designed to be larger in size.

Offshore wind turbines have more intricate electrical systems than land-based turbines and exist in a highly corrosive environment. This has led to the creation of a number of different models of offshore turbines. Siemens, Vestas, and AREVA are some of the more successful developers of offshore wind turbines. Traditional wind turbines have three blades; however, some turbine manufacturers are making two-bladed turbines for offshore purposes. Two-bladed turbines rotate at faster speeds and are much lighter than three-bladed turbines. Because offshore turbines have greater capacity than land-based turbines, the size of turbine components may present a particular challenge. For large systems, blades may be as long as 65 meters (about 213 feet) with towers 100 meters (328 feet) high or higher. Transporting component parts to dock facilities, onto ships, and into place at sea will require significant onshore planning and infrastructure.



Source: USDOE NREL (2006).

Figure 31. Diagram of wind turbine components.

4.1.1.2 Foundations

Turbine foundations will vary based on water depth. NREL has classified offshore ocean depths in the following way:

- *Shore*—on or near shore, with structures minimally exposed to seawater.
- *Shallow*—0 to 30 meters.
- *Mid-depth or transitional depth*—30 to 60 meters.
- *Deepwater*—more than 60 meters (Musial et al. 2006).

Foundation technologies for shallower waters are essentially marine versions of onshore designs, with updated electrical and corrosion systems. As water depth increases, however, additional resources are needed for turbine foundations and the design becomes increasingly complex. Because wind potential is greater in deeper waters, the offshore wind industry is moving farther from shore, and the bulk of current research in foundation technologies is in the area of deepwater turbine substructures.

Fixed foundational structures are currently being used for wind turbines in shallow and traditional waters. These types of structures include the following:

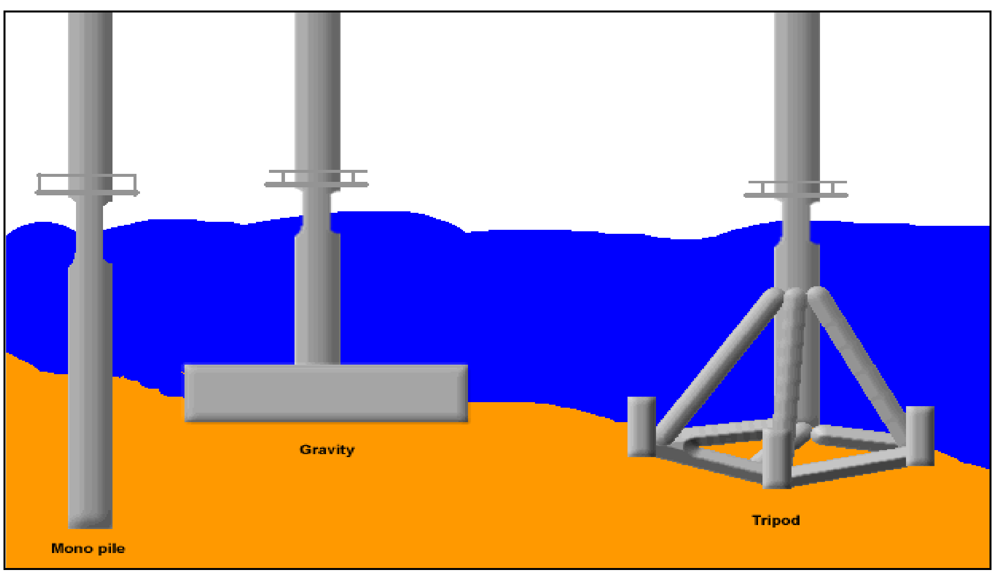
- Monopile structures consist of a steel cylinder, or pile, that is hammered approximately 32 to 64 feet into the sea floor—deep enough to stand upright against the wind and waves. The turbine is then attached to the pile. Monopiles are best suited for shallow waters and are favored for their simplistic design, their minimal impact on the seafloor, and the ease of transition from onshore to offshore applications. They are not suited for sea beds with large boulders, and require heavy duty piling equipment for siting.

- A gravity foundation is made up of a large, flat base that rests on the sea bed and is typically constructed from either concrete or steel. The size of the base depends on the wave and ground conditions in the area; for the foundation to be correctly sited, the sea bed must undergo significant preparation to ensure a level substrate.

- A tripod foundation is made up of a single steel piling driven into the sea floor, similar to a monopile, but also supported by three steel pilings in a triangular formation. This technology has been adopted from technologies used by the oil and gas industry and is best used in depths less than 50 meters.

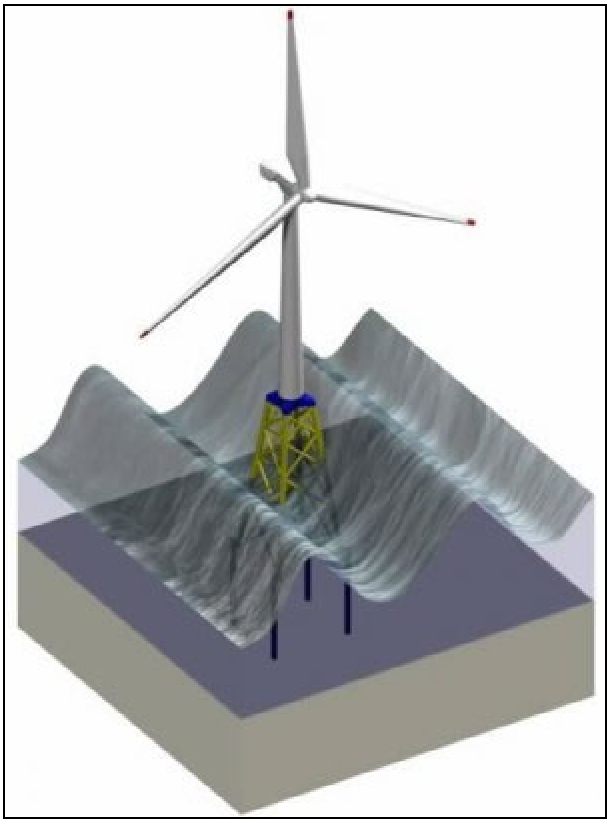
- A jacket foundation is connected to the sea floor by four steel pilings and a series of structural frames called trusses, resembling a lattice tower. A full-height jacket foundation extends from the sea bed all the way to the nacelle of the wind turbine, while a submerged design uses the jacket structure only below the surface of the ocean. At the surface, the jacket serves as a base to which a monopile tower attaches.

Figure 32 shows examples of monopile, gravity, and tripod foundations. Figure 33 shows a jacket structure that will be used in offshore wind projects in Rhode Island and New Jersey.



Source: OffshoreWind.biz (2009).

Figure 32. Monopile, gravity, and tripod foundations.



Source: OffshoreWind.biz (2009).

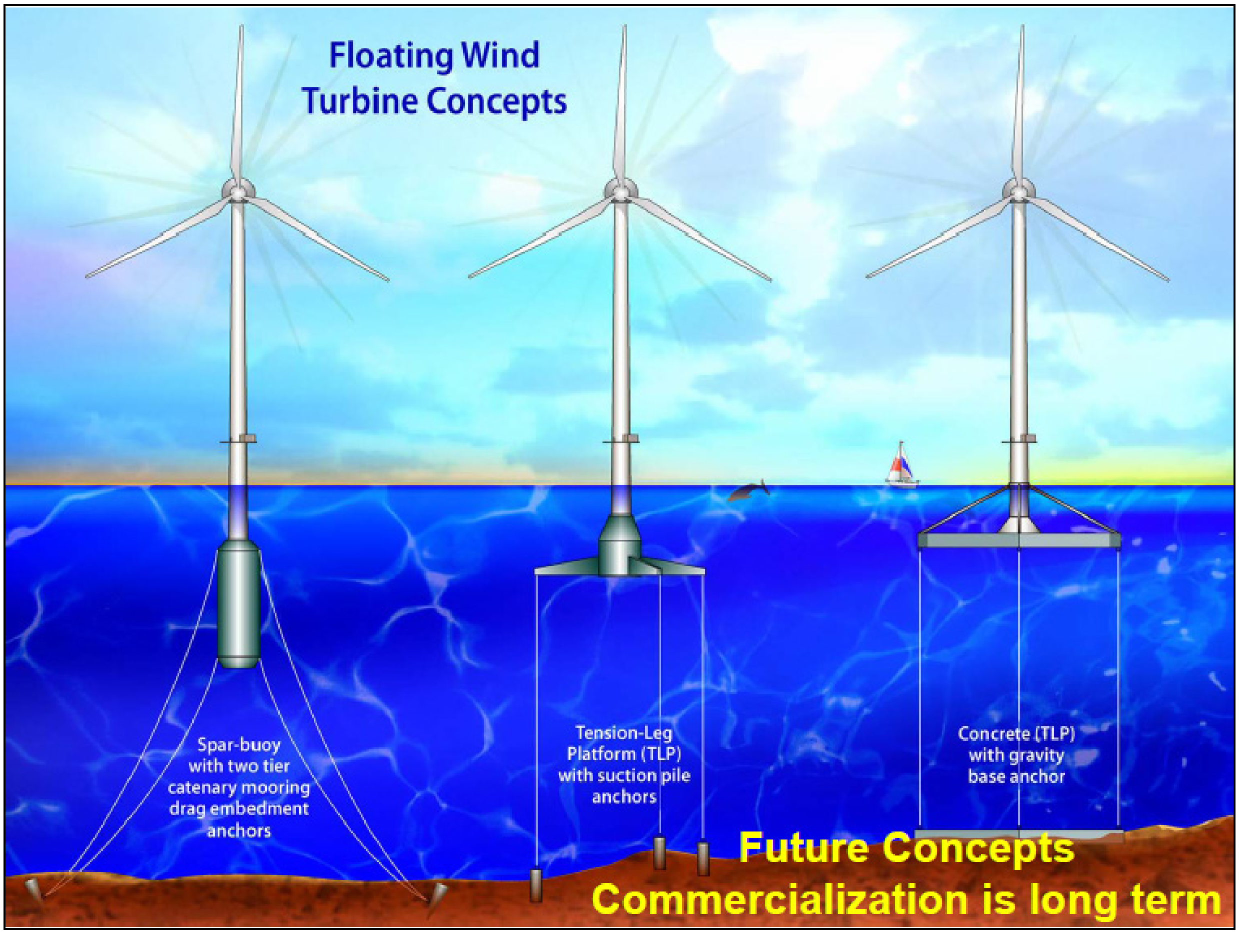
Figure 33. Jacket foundation.

At some water depth, fixed foundational structures are no longer feasible to support wind turbines. Deepwater turbines will require floating foundational structures, which are not yet ready for commercialization—but are necessary for large-scale development in the United States, as much of the OCS resources are in waters much deeper than those in Europe where commercial wind facilities are currently sited. Floating structures must provide enough buoyancy to support the weight of a turbine while also suppressing the motion of the ocean (Musial et al. 2006). Based on oil and gas platforms, they can use various combinations of platform types and mooring systems. Some examples (shown in Figure 34) are spar-buoy systems, suction bucket foundations, and tension-legged platforms.

- A spar-buoy system consists of a tall, thin buoy that floats upright in the water and is filled with water and rocks to provide stability. The buoy extends below the surface of the water and is attached to the sea floor by three anchor wires. Siemens, StatoilHydro, and SWAY AS are using spar-buoy systems.

- Suction bucket foundations use cylinders shaped like upturned buckets, open at the bottom but sealed at the top. Once a cylinder is lowered to its final position on the sea floor, the water trapped inside is pumped out, creating a vacuum that sucks the foundation into its final position. Suction bucket foundations are still in preliminary development.

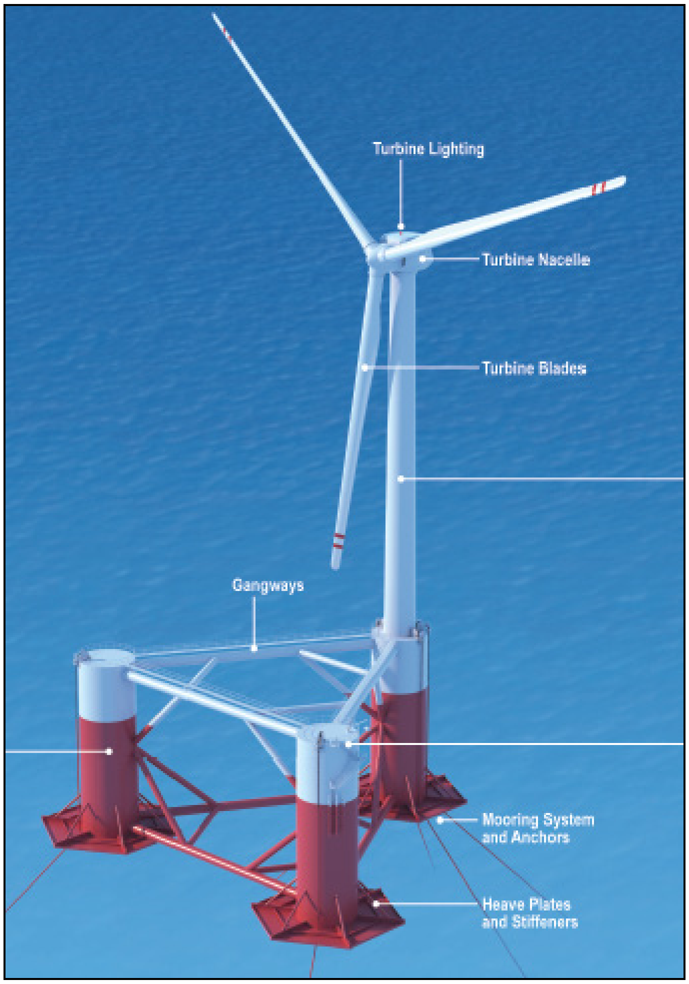
- A semi-submerged tension-legged platform is held by chains to a counterweight on the sea floor.



Source: USDOE NREL (2006).

Figure 34. Floating wind turbine designs.

A recent design developed by Marine Innovation & Technology and used by Principle Power uses a three-column stabilization system ballasted with water to improve the stability of the structure. The turbine tower is set within one of the columns. Figure 35 shows a schematic for this system, which is called WindFloat. This technology is proposed for the Tillamook Offshore Wind Energy Demonstration Project, described in Section 2.4.



Source: Marine Innovation & Technology (2009).

Figure 35. WindFloat foundation.

4.1.2 Wave Energy[167]

Wave energy devices may float on the surface of the ocean or be fastened to the ocean floor, and typically use turbines through which water flows to create electric power. These reports identify four categories of wave energy technology:

- Point absorbers capture energy from the rise and fall of waves. Typically, point absorbers consist of a float with a stationary connection to the seabed. When a wave rises, the float moves upward relative to the connection. As the wave reaches its lowest point, the float moves downward relative to the connection. The motion of the float relative to the stationary connection either produces electricity directly or uses a pressure differential produced in long tubes when waves swell up and down. Point absorbers are being used by AWS Ocean Energy, Renewable Energy Holdings, Finavera Renewables, and Ocean Power Technologies.

[167] As well as the other sources cited, this section draws heavily on USDOE EERE (2009a) and USDOIMMS (2006).

- Attenuators float on the ocean surface, using multiple methods to capture energy from waves. One particular design employs articulated segments to ride wave crests and produce pressure; another uses the tendency of waves to pull and push objects together as they roll. Attenuators tend to be large devices with multiple collection points per unit. Pelamis Wave Power is the primary company using attenuator designs.

- Overtopping terminators create an elevation differential between sea level and a pool of water. Waves are concentrated through funneling mechanisms (systems designed to increase wave height) toward a central reservoir. Waves above the reservoir height spill over the top of the device into a storage pool isolated from the ocean. The pool, elevated above sea level, is connected to a turbine through which water returns back to the ocean. Voith Hydro (a wholly owned subsidiary of Siemens), Aquamarine Power, and Wave Dragon are pilot-testing overtopping terminator energy designs.

- Oscillating water column terminators capture water through an opening in a partially submerged platform and allow that water to rise in an air column. The air is then compressed, which drives a turbine to generate electricity. Voith Hydro and Ocean Linx are developing these technologies.

Figure 36, taken directly from USDOE EERE 2009a, shows several different wave technologies. It describes these technologies, the companies developing them, projects using them, and test results.

Although Finavera's AquaBuOY is listed, the company announced that it was dropping its wave energy projects to focus on wind energy and surrendered its ocean energy permits to FERC in February 2009 (Finavera 2009).[168] Pelamis' majority owner, Australia's Babcock & Brown Ltd., went into bankruptcy in March 2009 (Williams 2009). The Pelamis website mentions that it has raised £40 million from multiple investors and has secured £4.8 million of funding from the UK government's Marine Renewable Proving Fund (PWP 2010a, 2010b).

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168 In 2006, Finavera purchased AquaEnergy, which had developed the AquaBuOY. Finavera constructed an AquaBuOY wave energy converter and deployed it off the coast of Newport, Oregon, in September 2007. These tests were completed in October 2007. In the period ending September 30, 2008, Finavera reported that it had retrieved the AquaBuOY from the seabed where it had lain since October 2007 and that retrieval costs had been covered by insurance. Finavera also reported that the California Public Utility Commission denied Pacific Gas & Electric's application for a power purchase agreement with Finavera for an ocean wave project. In the financial statements for the period ending December 21, 2008, Finavera wrote down the AquaBuOY investment to $1 and PricewaterhouseCoopers issued notice that there was considerable doubt that Finavera could continue as a "going concern." In subsequent reports, Finavera says it has ended all wave energy projects to focus on wind energy projects (Finavera 2007, 2008a, 2008b, 2008c, 2009a, 2009b, 2010).

Company: AWS Ocean Energy **Product Name:** Archimedes Waveswing **Product Website:** http://www.awsocean.com	**Technology - Point Absorber:** Developed in 2004, this device is a buoy moored to the seabed. Waves move over a submerged air-filled upper casing and push against the fixed cylinder. Air inside the cylinder is compressed, serving as a point absorber. The compressed air drives a hydraulic system and generator set to convert the wave energy to electricity.	**Projects:** Pilot power plant installed off the coast of Portugal in 2004. Power plant in Portugal was designed to test technology at full scale but was not designed as a long-term demonstrator. Pre-commercial 250 kW device is planned for testing during 2009 and 2010 at Orkney's European Marine Energy Center (EMEC) in Scotland.	**Test Performance:** Pilot plant delivered wave power to the Portuguese grid at predicted levels (250 kW). Pre-commercial 250 kW prototype to be tested in Scotland (EMEC). The technology is scalable and the commercial system will be in excess of 1 MW.	 *Figure 5: Archimedes Waveswing* *Courtesy of AWS Ocean Energy*
Company: Renewable Energy Holdings **Product Name:** CETO **Product Website:** http://www.ceto.com.au/	**Technology - Point Absorber:** Moored to the seabed and completely submerged, movement produces high-pressure sea water that is delivered to shore through pipes. The high-pressure sea water can be desalinated with reverse osmosis and used to drive the on-shore hydro-turbine. There is no need for underwater cabling or high voltage transmission. CETO will operate in waters between 15-50 meters below breaking waves.	**Projects:** First CETO wave energy conversion device was tested in Western Australia in January 2008.	**Test Performance:** Produced sustained high-pressure sea water greater than 1,000 pounds per square inch (psi) during testing. CETO is the only wave energy technology that produces fresh water directly from sea water. Commercially availability expected in 2009.	 *Figure 6: CETO* *Courtesy of Renewable Energy Holdings*

Source: USDOE EERE (2009a).

Figure 36. Wave energy technologies.

Company: Pelamis Wave Power (PWP)* **Product Name:** Pelamis **Product Website:** http://www.pelamis wave.com *Formerly Ocean Power Delivery	**Technology - Attenuator:** Semi-submerged structure composed of cylindrical sections linked by hydraulic joints. Ram pumps resist wave motion in the joints that in turn pump high-pressure oil through motors. The hydraulic motors drive generators to produce electricity. Each device is 140 meters long and 3.5 meters in diameter with three wave energy conversion modules.	**Projects:** PWP is working on three full scale trials with the initial one deployed in Portugal summer 2008: 2.25 MW Agucadoura wave project off the coast of Portugal for Enersis and Babcock & Brown. 3 MW project under development off the coast of Orkney for Scottish Power Renewables. 5 MW wave station for Cornwall, United Kingdom, as part of the Cornwall Wave Hub.	**Test Performance:** The multiple PWP units in Agucadoura make up the world's first multi-unit commercial wave farm tied to Portuguese grid. Each Pelamis is capable of generating 750 kW with an expected average of 25-40% of this power being continuously generated. **Cost:** Estimated (2004) $2 million to $3 million per device.	 *Figure 7: Pelamis* *Courtesy of Pelamis Wave Power*
Company: Finavera Renewables* **Product Name:** AquaBuoy **Product Website:** http://www.finavera.com *Formerly AquaEnergy	**Technology - Point Absorber:** A moored buoy floats on the surface of the waves. As the buoy moves up and down, sea water inside a 25-meter (82-foot) tube drives a piston that then drives a hose pump. Sea water inside the elongated hose becomes pressurized and is released to drive the Pelton turbine. Underwater transmission lines transmit electric energy to shore. The AquaBuoy must be deployed where water depth is greater than 50 meters (164 feet).	**Projects:** 1 MW project in Makah Bay, Washington, pending a FERC environmental impact study. 2 MW project with 200 MW planned for Figueira de Foz, Portugal. 5 MW wave energy device off Ucluelet, British Columbia, granted an investigative permit. 20 MW wave energy project off Western Cape, South Africa. 200 MW wave park under development in Coos Bay, Oregon. FERC granted a preliminary permit for this project.	**Test Performance:** Each 40-ton AquaBuoy is rated for up to 250 kW. Unfortunately, the prototype device failed before power tests were complete, springing a leak that caused the pump to malfunction after only one month of deployment. The AquaBuoy sank off the coast of Oregon. The test was intended to measure power output of the AquaBuoy 2.0. No reports from this test have been released. **Cost:** The cost for the project in Makah Bay, Washington, including grid connection cable and four AquaBuoys, was $3 million (2004).	 *Figure 8: AquaBuoy* *Courtesy of Finavera Renewables*

Source: USDOE EERE (2009a).

Figure 36. Wave energy technologies (continued).

Company: Ocean Power Technologies **Product Name:** PowerBuoys **Product Website:** http://www.ocean powertechnologies.com	**Technology - Point Absorber:** Converts wave motion into electricity with a moored buoy that floats freely up and down in the water. A structure with a piston moves as the PowerBuoy bobs in the waves. This movement drives a turbine and electric generator.	**Projects:** 1 MW wave park deployed for the U.S. Navy in Oahu, Hawaii. 5 MW wave station for Cornwall, United Kingdom, as part of the Cornwall Wave Hub. 1.25 MW commercial wave power station off the Spanish coast. Agreement signed with Iberdrola. Still in development. 100 MW project in Coos Bay, Oregon. Application filed with FERC for permits. 2 MW to 50 MW wave park near Reedsport, Oregon. Agreement signed with Pacific Northwest Generating Cooperative (PNGC) Power.	**Test Performance:** PowerBuoys installed in Hawaii and New Jersey rated at 40 kW each. Operational 2005 in Atlantic City, New Jersey. Demonstrated feasibility of wave power in New Jersey. Testing and grid connection deployed for the U.S. Navy in Kaneohe Bay, Hawaii. Completed extensive environmental assessment. Demonstrated wave power for use at US Navy bases, worldwide.	 *Figure 9: PowerBuoy* *Courtesy of Ocean Power Technologies, Inc.*
Company: Voith Hydro* **Product Name:** Limpet **Product Website:** http://www.voith siemens.com *Wavegen is a wholly-owned subsidiary of Voith Siemens Hydro Power Generation	**Technology - Overtopping Terminator:** Secured on shore, the Limpet is an inclined Oscillating Water Column (OWC). An air chamber captures wave energy from an opening in the bottom. Water compresses the air as it moves up the column, which turns a turbine at the top. The turbine spins the same direction no matter the air direction.	**Projects:** The Limpet prototype has been installed since 2000 on the island of Islay in Scotland.	**Test Performance:** The Limpet on Islay has three chambers that generate a combined average of 100 kW. Typical ratings for shore wave energy stations are 100 kW to 500 kW per unit.	 *Figure 10: Limpet* *Courtesy of Voith Hydro*

Source: USDOE EERE (2009a).

Figure 36. Wave energy technologies (continued).

Company: Aquamarine Power **Product Name:** Oyster **Product Website:** http://www.aquamarine power.com/	**Technology - Overtopping Terminator:** Uses the movement of a flap (12 meters by 18 meters). When waves come in and out to drive an oscillating wave surge converter, or pump, the pump delivers high-pressure water to drive a typical hydroelectric generator located on shore.	**Projects:** Pilot testing started in 2008 off the Orkney coast in Scotland.	**Test Performance:** Each Oyster can produce 300 kW to 600 kW peak energy depending on location.	 *Figure 11: Oyster* *Courtesy of Aquamarine Power*
Company: Wave Dragon **Product Name:** Wave Dragon **Product Website:** http://www.wavedragon.net	**Technology - Overtopping Terminator:** Captures waves in its long wings and focuses the water over the top to form a reservoir above sea level. Released water is forced through hydro-turbines that generate electricity. The reservoir contains 1,500 to 14,000 cubic-meters of water. Device width is up to 390 meters.	**Projects:** Prototype deployed in 2003 off the coast of Nissum Bredning, Denmark, that has so far generated electricity for more than 20,000 hours. 7 MW device to be deployed in 2011 off Pembrokeshire, Wales, to be tested 3 to 5 years.	**Test Performance:** Rated generated power is between 1.5 MW and 12 MW depending on wave climate. **Cost:** Estimated (2004) $10 million to $12 million for the 4 MW device.	 *Figure 12: Wave Dragon* *Courtesy of Wave Dragon*

Source: USDOE EERE (2009a).

Figure 36. Wave energy technologies (continued).

Company: Oceanlinx* **Product Name:** Oscillating Water Column (OWC) **Product Website:** http://www.oceanlinx.com *Formerly Energetech	**Technology – OWC Terminator:** Oceanlinx patented oscillating water column (OWC) technology. As waves pass the Oceanlinx device, water enters from beneath the column and compresses the air inside the chamber. This compressed air drives the turbine located in a narrow tapered part of the column. The Oceanlinx OWC can be deployed on the shoreline or in water depths of up to 50 meters.	**Projects:** 450 kW prototype power purchase agreement with Integral Energy in Port Kembla, New South Wales, Australia. 5 MW facility letter of intent signed with Cornwall, United Kingdom, as part of the Cornwall Wave Hub. 1.5 MW signed memorandum of understanding with Rhode Island. 2.7 MW wave generator memorandum of understanding signed with Hawaii. 1.5 MW under contract with GPP, Namibia.	**Test Performance:** Each OWC produces 100 kW to 1.5 MW depending on wave climate. **Cost:** Estimated (2004) $2.5 million to $3 million	 *Figure 13: Oscillating Water Column Courtesy of Oceanlinx*

Source: USDOE EERE (2009a).

Figure 36. Wave energy technologies (continued).

New ocean wave energy technologies are still being invented. In September 2009, FERC issued a preliminary permit to SARA, which developed and patented a magnetohydrodynamics generator for wave energy and is currently looking for investors. FERC issued a preliminary permit for the SWAVE Catalina Green Wave Energy Project, located in the Pacific Ocean approximately 0.75 miles off the west coast of Santa Catalina Island (FERC 2009g; SARA 2010).

In February 2010, FERC received an application for the San Onofre ocean wave energy project from JD Products, Inc. The permit describes an electrical generating unit consisting of four 5-foot-diameter wheels, a conveyor belt (16 feet long by 6 feet wide), eight "water buckets," and one electrical generation box. Each bucket has a one-sided swinging door attached to the back. The eight buckets are attached to the conveyor belt such that three are on top, three are on the bottom, and one is on either side. As a wave moves from left to right, it pushes against the (closed) door and moves the conveyor belt to the right. If a wave moves in the other direction, the door opens and lets the water pass through the bucket. Thus, the conveyor belt moves only in one direction. As the belt moves, it rotates wheels and the rotational energy is stored in a flywheel that generates the electricity. The public copy of the plan did not contain an illustration of the device. The application calls for nearly 11,500 units with a capacity of 3,198 MW (FERC 2010i).

4.1.3 Ocean Current Energy

Energy can be generated from the movement of water in the form of tides or currents, just as it can be captured from the movement of air in the atmosphere. Devices similar to wind turbines can be placed into tidal or ocean currents to generate energy, which can then be brought to shore. Water-based energy systems operate on the same principles as wind turbines: a bladed system is placed in the water and energy is generated from the moving water stream. As a result, many tidal systems are conceived as dual-role devices, systems able to operate in tidal and ocean current regimes. So, although the OCS does not contain tidal systems, the technologies that exist for capturing tidal energy are directly applicable to capturing ocean current energy.

Based on USDOE EERE 2009a and USDOIMMS 2006, there are three technologies that are designed to capture ocean current energy:

- Horizontal axis systems resemble current utility-scale wind turbines. Such a system often has a three-bladed turbine mounted on a tower, which is then anchored to the seabed. Frequently towers are allowed to protrude above the water surface, allowing the turbine to be lifted out of the water for maintenance rather than requiring specialized underwater repair. These systems are referred to as horizontal axis systems because the turbine's axis of rotation is parallel to the direction of fluid flow.

- Conversely, a vertical axis system's axis of rotation is perpendicular to the direction of flow. Such a system typically has a series of blades parallel to a central shaft. The blades are mounted several feet away from the shaft and are connected to the shaft via supports. The shaft then connects to a generator. Numerous variations of vertical axis systems are available, including blade curvature, direction of rotation, and funneling mechanisms.

- Floating systems, though they may employ either horizontal or vertical turbine systems, differ in the fact that the turbine is not fixed to the seabed. This allows turbines to be placed in the region of the water column with the greatest velocity rather than being limited by the foundation type. Also, floating systems allow for the capture of deeper resources. Floating systems must be tethered to the seafloor to remain in position, but the turbine elevation may vary.

FERC has issued no preliminary permits for ocean current projects (FERC 2010a). However, several companies are active in tidal energy generation elsewhere in the world. Marine Current Turbines (MCT) uses a vertical axial system (called SeaGen) that resembles an underwater wind farm. Projects include a 300 kW unit installed off the coast of Devon, UK, in 2003 and still in operation; a 10.5 MW farm off the coast of Anglesy, Wales, planned for 2011/2012; and several tidal projects. The MCT website lists no projects in the United States (MCT 2010). Lunar Energy Limited and Clean Current Power house their turbines in symmetrically curved ducts that are narrower in the center to draw the current through with accelerated energy. Lunar Energy has an 8 MW farm off the cost of Wales that is expected to be completed in 2011. Clean Current Power is a Canadian company with projects in British Columbia and the Bay of Fundy. OpenHydro uses a slow-moving rotor in its design and has projects installed off Scotland, in the English Channel, and in Nova Scotia's Bay of Fundy. Blue Energy uses a horizontal axis technology developed in collaboration with the University of British Columbia. Verdant Power currently has a six-turbine farm in New York City's East River with plans to expand (USDOE EERE 2009a).

4.1.4 Ocean Thermal Energy

Ocean thermal energy results from the uneven heating of the ocean. The surface ocean is heated by the sun, but sunlight can only penetrate so far. Wind mixes newly warmed water into the depths of the oceans, but there is a point at which the mixing stops and a temperature gradient develops, known as the thermocline. Temperatures above the thermocline tend to be homogeneous with surface temperatures, while temperatures below the thermocline fall quickly with depth. The tendency of water to separate into warm and cold components reinforces the stratification developed through solar heating. The ocean temperature profile that results is generally predictable and stable from year to year and allows for the generation of energy through one of two processes:

- In the closed cycle method, a fluid such as ammonia is pumped through a heat exchanger and vaporized, with the resulting steam spinning a turbine. The cold water found at greater depths in the ocean condenses the vapor back to a fluid, and it returns to the heat exchanger.

- The open cycle system uses warm surface water, which is pressurized in a vacuum chamber and converted to steam to spin the turbine. The steam is again condensed using the colder ocean water found at lower depths (MTC 2010a; USDOE EERE 2009a).

Of wave, current, and thermal energy technologies, thermal is the least advanced in terms of its development. Deep Ocean Power Philippines Inc. is the only company yet identified to embark on a commercial project[169] and the project depends on the extreme temperature differences between the surface waters and very cold deep shelf waters (Remo 2009). In the United States, NREL states that it is no longer interested in pursuing this form of energy conversion (USDOE NREL 2010a). Therefore, this report does not discuss ocean thermal energy further.

4.2 Economics and Offshore Wind Deployment

This section reviews three recent studies focusing on the economic deployment of offshore energy and the social costs and benefits of such deployment.

4.2.1 Ecological and Economic Cost-Benefit Analysis of Offshore Wind Energy

Snyder and Kaiser (2009a) have compiled cost data from nearly 20 public sources, primarily on European wind farms. Costs for offshore wind farms range from $1,462/kW to $3,125/kW. The authors note that the cost of building and installing the foundations is about 20% of the overall capital cost while turbine installation costs represent about an additional 20% of the overall cost. The researchers developed several multiple regression models of capital costs. The three best models incorporated variables for total capacity, turbine size, water depth, distance to shore, and the year in which the farm was constructed. Water depth and construction year were not significant in any of the models, which might reflect the limited range in water depth in the data set (1 to 21 meters) more than anything else.

Snyder and Kaiser (2009a) note that offshore wind is not currently cost-competitive with onshore wind or conventional electricity. However, multiple factors could shift the comparison. For example, revenue is determined by energy costs at the local level and a wind farm might have a second revenue stream by selling RECs. Proper siting could make a difference in the economic viability of a wind farm.[170]

4.2.2 Fiscal Cost-Benefit Analysis to Support the Rulemaking Process for 30 CFR 285

MMS developed a series of financial and economic models for a fiscal cost-benefit analysis in support of the rulemaking process for 30 CFR 285, which governs renewable energy production and alternate uses of existing facilities in the OCS (Weiss et al. 2008). The study developed three model wind farms with capacities of 150 MW, 500 MW, and 1,000 MW, a size range comparable to that shown in Tables 8 and 9 in this analysis.[171] The model wave farm had a total rated capacity of 90 MW and was based on Pelamis technology. Weiss et al. assumed a premium on early project costs, since first units often are more expensive than initially planned. Over time, however, capital costs were assumed to drop by 18%.[172] Due to the absence of data, ocean current projects were assumed to have the same costs as wave energy projects.

The study then developed an initial forecast of 76 projects in the Atlantic, Gulf of Mexico, and Pacific regions that would be operational by 2027. These break down into 39 wind farms along

[169] Makai Ocean Engineering, located in Hawaii, conducted research and testing in the past but appears to have no current projects (Makai Ocean Engineering 2010).

[170] Snyder and Kaiser do not appear to have examined the potential impact of a PTC on economic viability.

[171] For wind energy, the periods are 2008–2011, 2012–2015, 2016–2019, and 2020–2027.

[172] For wave energy, the periods are 2009–2011, 2012–2015, 2016–2019, 2020–2023, and 2024–2027.

the Atlantic coast, three wind farms in the Gulf of Mexico, 10 wind farms off the California coast, and 11 ocean current energy projects off the Florida coast. All projects were in federal OCS waters.

The study examined four scenarios: a baseline with no payments to MMS and low, medium, and high scenarios with different rental payments and/or an annual operating fee during construction and operating phases. They also classified projects by their internal rates of return (IRR). Projects with IRRs less than 5% were assumed to be proposed but not to enter the pre-development phase (i.e., no federal revenues). Projects with IRRs equal to or greater than 5% but less than 11% were assumed to undergo some pre-development activity, but it was assumed that construction and operations would not occur. For projects with IRRs equal to or greater than 11%, all phases and revenues were included in the calculations.

Findings for the baseline scenario included:

- 58 of 76 projects might be considered viable under the baseline, low payment, and intermediate payment scenarios.

- Nine of the 18 projects that might not be considered viable are the wave energy projects in the Pacific region. The model assumed low electricity prices due to the availability of large onshore hydroelectric resources. The other nine projects were wind farms in the Atlantic, Pacific, and Gulf of Mexico regions.

- All 15 ocean current projects were considered viable due, primarily, to the high capacity factor (nearly double that for wind or wave).

The study performed sensitivity analyses on the impacts of RECs and the PTC. These financial incentives are very important to project viability. The study reported that:

- Total viable projects might be reduced by 25% without revenue from REC sales.

- If the PTC is not available, the reduction in viable projects might exceed 40%.

4.2.3 Assessing the Costs and Benefits of Electricity Generation Using Renewable energy Resources on the Outer Continental Shelf

Weiss et al. (2007) examined potential benefits and social welfare costs associated with renewable energy projects in the OCS. The study developed profiles for three renewable energy projects: a 360 MW wind farm located off the mid-Atlantic coast, a 90 MW wave energy project located off the Oregon coast, and a 20 MW ocean current project located off the Florida coast between Miami and West Palm Beach. All projects were located in federal waters. Similar profiles were developed for fossil fuel, nuclear, and conventional hydrokinetic power generation. Weiss et al. then identified the categories of benefits and costs from a social welfare perspective with a focus on “externalities” that were not reflected in the market price of electricity. These included, but are not limited to, carbon emissions during the operations phase and ecological impacts during the construction phase. The study compared the relative costs and benefits of the offshore renewable energy displacing onshore generation. Noting that the actual displacement of onshore generation reflects transmission constraints, when the energy was being generated, and fluctuations in fossil fuel prices, the study examined simplified scenarios of offshore energy displacing coal-fired generation or a mix of generation sources resembling the market region into which the offshore generation would supply. The information on the energy infrastructure provided in Chapter 6 (and to MMS in geographic information system [GIS] format) would help the agency refine these analyses.

4.3 EUROPEAN EXPERIENCE

Michel et al. (2007), Kaiser et al. (2008), and Snyder and Kaiser (2009b) provide in-depth comparisons between Europe and the United States in the development of offshore wind, which are summarized here. The studies list 32 operational wind farms with a total of 1,488 MW capacity. The United Kingdom has the most capacity and the largest number of wind farms (598 MW in nine farms). Denmark is second, with 425 MW capacity in eight wind farms. Denmark installed the first wind farm in 1991. Until 2007, none of the farms were located more than 20 kilometers from shore. Now there are three farms (one each in the United Kingdom, Netherlands, and Belgium) between 20 and 30 kilometers offshore. Thus, there appears to be a difference between Europe and the United States on the acceptability of seeing the wind turbines from shore.

Other differences noted in the studies include:

- In Europe, developers started with test projects (10 to 50 MW), then proceeded to 100 to 200 MW farms, and now consider projects with 400 to 1,000 MW capacity. The U.S. is beginning with full-scale commercial projects.

- The slower pace of European development meant that there was time for developing the infrastructure as well as experience. The United States is now highlighting the need for transmission upgrades and expansion to support large-scale development of wind energy (USDOE NREL 2010b).

- In Europe, developers of offshore wind projects are among the largest energy companies. In the United States, development is being spearheaded by relatively small companies that do not have the institutional knowledge gained by the European companies over the past 20 years.

The most noticeable difference between Western Europe and the United States are national financial incentives for renewable energy (Snyder and Kaiser 2009b). Every nation in Western Europe is party to the Kyoto Protocol. In order to meet their mandated goals for producing energy from renewable sources, the nations have developed financial incentives, including:

- *Feed-in tariffs.* A feed-in tariff is similar to a long-term power purchasing agreement but the rate negotiated is meant to ensure that a wind farm is profitable (as planned). Denmark, Germany, and the Netherlands have feed-in tariffs.

- *Tax exemptions.* Several European nations have carbon taxes from which renewable energy generators are exempt.

- *Grants.* The United Kingdom gives grants to apply against the capital costs of building an offshore wind farm.

On a national level, the United States has a PTC but it has expired three times in the last 10 years. Snyder and Kaiser also note that DOE started a program guaranteeing up to 80% of total project costs for renewable energy projects. This will ease financing for such projects, but these are guarantees and not grants.

On a state level, 25 states have RPSs (discussed in more detail in Section 3.2). Utilities that cannot generate a particular percentage of electricity from renewable sources must either buy RECs to make up the difference or face financial penalties. The importance of PTC and RECs to offshore energy projects is discussed in Section 4.2.3 above.

5 STATE COASTAL ZONE MANAGEMENT AND OTHER POLICIES

Each State's federally-approved Coastal Zone Management Plan (CMP) seeks to identify the best way toward sustainable use of the coastal region's resources and uses. It can range from shoreline management and the mitigation of coastal erosion to balancing broader goals: environmental protection, pollution control, economic development, shipping and port management, coastal erosion, flooding, defense requirements, and non-consumptive uses such as tourism. These uses are laid out in a State's enforceable policies. Federal authority for managing the nation's coastal zones was established by the Coastal Zone Management Act (CZMA), which takes a holistic approach to managing coastal resources that behave as systems that interact with each other. Each coastal state develops its own CMP, which needs federal approval in order to qualify for federal funding for the development and administration of the plan.

This study focuses on renewable energy development in the federal waters of the OCS. However, no such development project will be able to connect to the onshore electricity grid without crossing through state waters and coastal zones. The CZMA requires state review of any federal action that would affect land and water use of the coastal zone regardless of its location within State waters or beyond on the Outer Continental Shelf. Even if all turbines are located outside state waters, states might require permits for cable crossings if a proposed energy project has "reasonably foreseeable coastal effects." In order for a State to review an renewable energy (or renewable energy) permitted activity, its CMP must list renewable energy activities in its CMP and it must have been approved by NOAA (see 15 CFR 930.53). For renewable energy federal "leasing" activities, BOEM would make a decision on whether a proposed lease activity would have reasonably foreseeable coastal effects on an individual State's enforceable policies before a State would have the authority to review the activity under its CMP.

This section also reviews additional planning and mechanisms developed by states for administering their coastal and marine resources. For example, several states are taking proactive regulatory steps to develop marine spatial plans that would identify areas suitable for renewable energy development, which would also help the states meet their renewable portfolio standards (see Section 2.3.1). Marine spatial planning is a process that involves all stakeholders that use the ocean, e.g., fisherman, surfers, shippers, recreators, industry, and energy generators, to make informed and coordinated decisions on how to use the ocean. The approach has several attributes:

- It balances competing objectives (e.g., governmental, industrial, economic, social, and ecological).
- It has a spatial focus. GIS tools are used to map the area with different layers corresponding to different attributes of interest (e.g., shipping lanes).
- It is integrated; that is, interdependencies and interrelationships are specifically identified and addressed during the process.

On the federal level, BOEM is creating a multi-purpose marine cadastre (a detailed registry of property ownership and other characteristics). An online interactive map viewer, available at http://www.BOEM.gov/offshore/mapping/, has integrated submerged lands information consisting of legal, property ownership, physical, biological, and cultural information from multiple agencies and states in a common reference framework.

The following sections discuss CZM and marine planning policies state by state from north to south on the East and West Coasts. Each section briefly describes CZM policies, environmental or logistical areas of concern, and availability of GIS or other mapping data.

Figures and maps for each state are located in Appendix B. State contacts are listed in Appendix C.

5.1 MAINE

5.1.1 CMP Enforceable Policies Related to Renewable Energy

The Maine Coastal Program is led by the State Planning Office and consists of a network of 19 state laws. Five state agencies work with local governments and others to implement the program. Maine's coastal zone extends to the inland boundary of all towns bordering tidal waters and includes all coastal islands.

The Maine Coastal Polices Act (38 MRSA section 1801) outlines the policies of the Maine Coastal Program. Each policy is enforceable and has a basis in state environmental and land use laws. A number of state laws articulate Maine's support for renewable energy development. In reviewing applications for offshore energy facilities for federal consistency, state and local land use and environmental laws and regulations require consideration of potential adverse effects due to construction and operation of submerged utility lines and other land- and water-based energy-related infrastructure. The applicability of these authorities depends on the nature, scale, and location of the proposed development. Maine has produced a guidebook for federal consistency (ME Coast 2006).

5.1.2 Environmental or Logistical Areas of Concern

Given its interests in commercial fisheries and other natural resources issues of a regional nature, the state would have an interest in ensuring appropriate review of federal activities on OCS areas in the Gulf of Maine (including Georges Bank), particularly those proximate to Maine's coastal waters (CTC 2009). Other areas of interest include eelgrass beds, shellfish beds, and essential wildlife habitats for roseate terns, piping plovers, and least terns.

5.1.3 Data Availability

Maine's Department of Marine Resources provides maps of eelgrass beds, shellfish distributions, and aquaculture sites at http://www.maine.gov/dmr/maps/mapindex.html. The Maine Office of GIS provides Shapefiles for shorebird and seabird nesting habitats at http://megis.maine.gov/catalog/catalog.asp?state=2&extent=cover#shorebird.

5.2 New Hampshire

5.2.1 CMP Enforceable Policies Related to Renewable Energy

The New Hampshire Coastal Program is administered by the Department of Environmental Services. New Hampshire Coastal Program enforceable policy #12 addresses siting of energy facilities and states that national interest will be considered, siting will not interfere with orderly development of the region, and siting will not have unreasonable adverse impact on coastal aesthetics, natural resources, or public health and safety. The New Hampshire Site Evaluation Committee is responsible for reviewing, approving, monitoring, planning, siting, construction, and operation of energy facilities in New Hampshire (NH DES n.d.).

5.2.2 Environmental or Logistical Areas of Concern

The New Hampshire coastline is highly developed, with the highest residential development densities occurring in the towns of Hampton and Seabrook and extensive commercial development in Hampton. Six state parks are located along the coastline from Hampton to Rye. There is a large estuary in Hampton and Seabrook, sensitive sand dune habitat in Hampton and Seabrook, and numerous saltmarsh complexes along the entire coastline. In addition, Hampton, Seabrook, and Rye Harbors support commercial and recreational fishing and boating activities. Finally, a large area of critical cod spawning habitat is located off New Hampshire's coast. All of these factors may make difficulties for connecting energy facilities on the OCS to upland areas (CTC 2009).

5.2.3 Data Availability

Hard-copy maps of salt marshes and state parks along the sea coast are available from various state offices (CTC 2009).

5.3 Massachusetts

5.3.1 CMP Enforceable Policies Related to Renewable Energy

The Massachusetts coastal program is implemented through several agencies within the Executive Office of Energy and Environmental Affairs (EEA; see http://www.mass.gov/envir/), with the Massachusetts Office of Coastal Zone Management serving as the lead policy and technical assistance agency. The Massachusetts coastal zone is a defined area extending landward 100 feet from certain specified roads or transportation lines and seaward to the extent of the Commonwealth's territorial sea (generally, but not always, 3 miles from shore), plus all of Barnstable County and the Islands (MA EEA 2010c).

The current Massachusetts CMP establishes enforceable program policies. Energy generating facilities are considered dependent on the coast if they use ocean thermal, wave, or tidal power. Alternative locations are to be considered when siting such energy facilities (MA EEA 2002).

5.3.2 Environmental or Logistical Areas of Concern

Appendix G to the current Massachusetts CMP (MA EEA 2002) shows areas of critical environmental concern, also shown in Figure B-22.

In May 2008, Governor Patrick signed the Oceans Act of 2008, which required the Commonwealth to develop an ocean management plan by the end of 2009 (MA EEA 2009). The final ocean management plan provides a comprehensive framework for managing, reviewing, and permitting proposed uses of state waters. In two areas making up just 2% of the planning area, the plan identifies zones suitable for commercial-scale wind energy development. Adjacent to these areas, EEA has identified potentially suitable locations in federal waters for commercial-scale wind energy development. These are shown in Figure B-9 (MA EEA 2009, 2010a). Figure B-9 also shows two areas for tidal energy projects.

5.3.3 Data Availability

The Massachusetts Ocean Resource Information System, is an online mapping tool created by Massachusetts Office of Coastal Zone Management and the [Massachusetts Office of Geographic and Environmental Information](#) (MassGIS). The tool can be used to search and display spatial data pertaining to the Massachusetts coastal zone. Users can interactively view various data layers (e.g., tide gauge stations, marine protected areas, access points, eelgrass beds, etc.) over a backdrop of aerial photographs, political boundaries, natural resources, human uses, bathymetry, and other data. Users can quickly create and share maps and download the actual data for use in a GIS at http://www.mass.gov/czm/mapping/index.htm. Massachusetts' seafloor mapping program data are available in GIS and PDF formats at
http://www.mass.gov/czm/seafloor/index.htm (MA EEA 2010b).

5.4 RHODE ISLAND

5.4.1 CMP Enforceable Policies Related to Renewable Energy

Rhode Island's coastal zone encompasses the entire state, although the inland extent of the Coastal Program's regulatory authority is generally 200 feet inland from any coastal feature. The Coastal Resources Management Council oversees the program under the Coastal Resources Management Act of 1971 (RI CRMC 2010).

5.4.2 Environmental or Logistical Areas of Concern

Rhode Island is using a Special Area Management Plan (SAMP) to streamline the federal National Environmental Policy Act process for offshore renewable energy. The Tier 1 screening process rules out areas with hard constraints, e.g., shipping lanes or inadequate wind energy. Figures B-23 through B-26 are some of the maps generated through the Tier 1 process. Figure B-23 shows areas that are unacceptable for development because they are airport buffers, coastal buffers, navigation lanes, or other regulated areas. Figure B-24 presents vessel counts in 1-mile-square blocks during the September 2007 to July 2008 period. Figure B-25 shows the developable bathymetry at various depths minus the exclusion areas shown in Figure B-23. Figure B-26 is a visual analysis (e.g., bands marking five different distances from shore/populated areas) with cut-outs marking the high-traffic areas shown in Figure B-24 and the exclusion areas from Figure B-23. The Tier 2 evaluation weights use compatibility and conflicts, e.g., commercial and recreational fishing. Figure B-10 shows the overlay of commercial and recreational fishing areas in the SAMP area.

In July 2010, the Rhode Island Coastal Resources Management Council released a draft Ocean SAMP (see RI CRMC 2010). Through a process of elimination for competing activities, the researchers identified an area around Block Island deemed suitable for commercial offshore wind energy development. The coordinates for this Ocean Renewable Energy Zone are given in Table 6 (in Section 2.3 above) and Figure B-10.

5.4.3 Data Availability

Data supporting the draft SAMP are available as paper maps, Web maps, and GIS data at the Narragansett Bay.org website: http://www.narrbay.org/d_projects/OceanSAMP/gis.htm.

5.5 Connecticut

5.5.1 CMP Enforceable Policies Related to Renewable Energy

Connecticut has a two-tiered coastal zone. The first-tier "Coastal Boundary" generally extends inland 1,000 feet from the shore. The second-tier "Coastal Area" includes all of the state's 36 coastal municipalities. All property within the two boundaries is subject to program consistency (CTC 2009).

Connecticut's CMP is led by the Office of Long Island Sound Programs within the Department of Environmental Protection. The Connecticut Coastal Management Act Chapter 444, Sections 22a-90 to 22a-112, contains coastal resource policies, coastal use policies, and a defined "adverse impacts section" pertaining to protection of the natural resources as they might be affected by OCS development. The Act also contains policies related to energy facilities, national interest facilities (including energy development), and fuel, chemical, and hazardous materials, all of which would require that energy-related activities be conducted in a manner consistent with necessary and appropriate protection of coastal resource and uses. The Act's Policy 51 says that there is a continuing need in Connecticut for economic development, including the development and use of renewable energy resources to assist industrial and commercial businesses in meeting their energy requirements. Connecticut has a coastal management manual that provides guidance to local governments for their local development ordinances and permitting (CT DEP 2010a).

5.5.2 Environmental or Logistical Areas of Concern

Sensitive resources and protected habitats exist along the Connecticut shore, and have previously been the source of concern and conflict related to proposed installation of cables and pipelines associated with conventional, non-renewable energy development. These resources include, but are not limited to, shellfish beds, eelgrass beds, intertidal flats, and other significant subtidal habitat. Any potential adverse impacts to these resources related to proposed renewable energy development would raise similar concerns.

5.5.3 Data Availability

GIS data for shellfish beds, eelgrass beds, tidal wetlands, and other areas of concern are available from the Department of Environmental Protection (CT DEP 2010b).

5.6 New York

5.6.1 CMP Enforceable Policies Related to Renewable Energy

The New York Department of State, through the Division of Coastal Resources, is the lead agency responsible for administering the coastal program. As of December 2010, the agency is amending its CMP to appropriately site offshore wind energy facilities and provide greater protection of ocean habitats (NYS 2010). In New York, Executive Law Article 42 ("Waterfront Revitalization of Coastal Areas and Inland Waterways") and the State CMP approved by NOAA's Office of Coastal Resource Management provide the authority and mechanism to undertake planning for coastal resources. Policies 27 and 29 in the Coastal Management Program address energy facility siting and energy resources development. Policy 27 concerns decisions on the siting and construction of major energy facilities in the coastal areas, which will be based on public energy needs, compatibility of such facilities with the environment, and facilities' need for a shorefront location. Policy 29 encourages the development of energy resources on the OCS, in Lake Erie, and in other water bodies while ensuring the environmental safety of such activities (NYS 2001). New York's coastal area has been divided into four geographic regions: Long Island, New York City, Hudson Valley, and the Great Lakes; see Figure B-27. Note that New York considers its coastal area to extend up to Albany (Division of Coastal Resources 2010).

On December 12, 2009, the state asked MMS to form a task force to facilitate coordination and consultation among federal, state, local, and tribal governments on renewable energy leasing proposals on the OCS offshore of New York (Congdon 2009).

5.6.2 Environmental or Logistical Areas of Concern

Environmental or logistical areas of concern are being identified through the process of amending New York State's CMP (NYS 2010).

5.6.3 Data Availability

ERG assumes data will become available as New York State completes its amendment to the state CMP (see NYS 2010) and as the Long Island-New York City Offshore Wind Collaborative completes and publishes environmental assessments for a potential offshore wind project located 12 miles off the south shore of the Rockaway Peninsula (LINYC 2009a).

5.7 New Jersey

5.7.1 CMP Enforceable Policies Related to Renewable Energy

New Jersey does not have a comprehensive ocean management plan in place, but it is developing the components for one (NJ DEP 2002). The New Jersey Coastal Management Program is composed of a network of offices within the New Jersey Department of Environmental Protection that serve distinct functions but share responsibilities for managing New Jersey's coast. Through the CMP, the Department manages the state's diverse coastal area, which includes portions of eight counties and 126 municipalities. New Jersey's coastal zone boundary has four distinct regions. From the New York border to the Raritan Bay, the boundary extends landward from mean high water to the first road or property line. From the Raritan Bay south along the Atlantic shoreline and up to the Delaware Memorial Bridge, the boundary extends from half a mile to 24 miles inland (1,376 square miles of land area). From the Delaware Memorial Bridge northward up the Delaware River to Trenton, the boundary extends landward to the first road inclusive of all wetlands. The fourth boundary serves a 31-mile-square area in the northeast corner of the state, bordering the Hudson River (NJ DEP 2009a).

In New Jersey, enforceable coastal policies are contained in the CZM rules (N.J.A.C. 7:7E) and the Coastal Permit Program rules (N.J.A.C. 7:7). Two major state laws are implemented through the CZM rules: 1) the Waterfront Development Law, N.J.S.A. 12:5-3 and 2) the Coastal Area Facility Review Act (CAFRA) (N.J.S.A. 13:19). The Waterfront Development Law authorizes the New Jersey Department of Environmental Protection to regulate the construction or alteration of a dock, wharf, pier, bulkhead, bridge, pipeline, cable or other similar development on or adjacent to tidal waterways throughout the state (NJ DEP 2009a).

The CAFRA applies to projects near coastal waters in the southern part of the state. The CAFRA area begins where the Cheesequake Creek enters Raritan Bay in Old Bridge, Middlesex County. It extends south along the coast around Cape May, and north along the Delaware Bay ending at Kilcohook National Wildlife Refuge in Salem County. The inland limit of the CAFRA area is an irregular line that follows public roads, railroad tracks, and other features. The width of the CAFRA area varies from a few thousand feet to 24 miles. The law divides the CAFRA area into zones, and regulates different types of development in each zone (NJ DEP 2009a).

5.7.2 Environmental or Logistical Areas of Concern

In September 2009, the New Jersey Department of Environmental Protection released the *Large Scale Wind Turbine Siting Map Report* (NJ DEP 2009b). This report identifies areas where wind turbines 200 feet or greater in height or having a cumulative rotor swept area of greater than 4,000 square feet are unacceptable due to operational impacts on birds and bats. These areas are shown in Figure B-28. While the study prohibits onshore, not offshore, wind turbines, the sensitive areas still need to be considered during the activities to bring the electric transmission cables onshore.

The OCS areas for which MMS issued limited leases are shown in Figure B-1.

5.7.3 Data Availability

New Jersey's Department of Environmental Protection undertook baseline studies to determine the current distribution and usage of this area by ecological resources. The scope of work includes the collection of data on the distribution, abundance, and migratory patterns of avian, marine mammal, sea turtle, and other species in the study area over an 18-month period. The interim report was published in March 2009 (NJ DEP 2009c). The New Jersey Ocean Atlas, shown in Figure B-29, shows telecommunication cables, sand resources, sand resource study areas, artificial reefs, shipwrecks, and dump sites, all of which would factor into siting offshore energy facilities (NJ DEP n.d.).

5.8 DELAWARE

5.8.1 CMP Enforceable Policies Related to Renewable Energy

Delaware's CMP lead agency is the Division of Soil and Water Conservation, Department of Natural Resources and Environmental Control. As a networked program, Delaware's program is administered through a number of agencies, including the Divisions of Water Resources, Fish and Wildlife, Parks and Recreation, Air and Waste Management, and the Department's own Office of the Secretary. Due to its small size, the whole state of Delaware is considered coastal, but the coastal zone is divided into two tiers, the "coastal strip" and the rest of the state. The "coastal strip" is defined as all that area of the state—whether land, water, or subaqueous land—between the territorial limits of Delaware in the Delaware River, Delaware Bay, and Atlantic Ocean, and a line formed by certain Delaware highways and roads as defined in Section 7002 of the Delaware Coastal Zone Act, Title 7 Delaware Code, Chapter 70. The coastal strip, averaging 4 miles in width, receives special zoning protection from industrial development, while the second tier only falls under general program provisions (DCMP 2004).

Heavy industry uses of any kind not in operation on June 28, 1971, are prohibited in the coastal strip and no permits may be issued. "Heavy industry use" means a use characteristically involving more than 20 acres and employing equipment that has the potential to pollute when equipment malfunctions or human error occurs. The Coastal Management Plan permits power plants inland and in the coastal zone provided that state and local standards are met. Finally, "expenditures for construction of sewage treatment and *transmission facilities* [emphasis added] should be based on careful analysis of alternatives, consideration of the impacts on growth patterns with particular consideration given to the risks of over-extension and over-design..." (DCMP 2004).

Coastal Technology Corporation' discussions with Bluewater Wind revealed no major environmental or safety constraints associated with installation and operation of transmission lines in the intertidal zone or along the shoreline. The state is concerned that trenching to bring the transmision lines from the OCS to an onshore electric substation might negatively impact the integrity of the dune system, but directional boring techniques may eliminate those concerns (CTC 2009).

5.8.2 Environmental or Logistical Areas of Concern

Habitats for rare, endangered, and threatened species occur along Delaware's coastline. While strict environmental windows and other management techniques can be used to prevent irreparable damage, these issues must be addressed in more detail (CTC 2009).

5.8.3 Data Availability

ERG assumes data will become available through Bluewater Wind's exploratory lease (USDOIMMS 2009a).

5.9 MARYLAND

5.9.1 CMP Enforceable Policies Related to Renewable Energy

Maryland's CMP, established by executive order and approved in 1978, is a networked program of state laws and policies designed to protect coastal and marine resources. Maryland's coastal zone includes 16 counties and Baltimore City, encompassing two-thirds of the state's land. Maryland has 4,360 miles of coastline along the Chesapeake Bay, coastal bays, and Atlantic Ocean.

The Department of Natural Resources (MD DNR) is the lead agency for the CMP. MD DNR is currently undertaking a comprehensive review of all of the related laws, regulations, and policies with the guidance of other Maryland agencies and programs as well as the Environmental Law Institute to determine if they are adequate to address the siting and potential impacts of renewable energy (MD DNR 2010). In 2006, MD DNR released *Toward a Vision for Maryland's Ocean,* which addresses many components of managing its ocean resources, including wind power (MD DNR 2006).

Within MD DNR, the Coastal Zone Management Division of the Watershed Services Unit leads the CMP program. The MD DNR has a guide to the federal consistency process (MD DNR 2004). The federal consistency requirements are carried out by the Coastal Zone Consistency Division in the Wetlands and Waterways Program of the Water Management Administration in the Maryland Department of the Environment. Although the Water Management Administration is responsible for the official federal consistency decision, the decision is often based upon the findings of agencies within CMP program network, depending upon the nature of the proposed activity. It should be noted that the Critical Area Commission for the Chesapeake and Atlantic Coastal Bays makes the consistency decision for these geographic areas. Any differences in position among state permitting and/or review agencies are resolved before the official federal consistency decision is forwarded to the federal permitting agency. When a state permit is required, the permit decision constitutes the consistency decision if the state permit review addresses all of the CMP program issues of concern.

5.9.2 Environmental or Logistical Areas of Concern

Maryland's Atlantic coast includes Fenwick Island (a developed residential and resort beach) and Assateague Island (a National Seashore and a State Park). Tourism and fishing are the primary economic ties to the ocean (CTC 2009).

5.9.3 Data Availability

Maryland's coastal atlas is available to the public at http://dnr.maryland.gov/ccp/coastalatlas/.

5.10 VIRGINIA

5.10.1 CMP Enforceable Policies Related to Renewable Energy

Virginia has a networked program, which includes the laws and policies of six agencies. The Department of Environmental Quality (DEQ) serves as the lead agency. Virginia's coastal zone includes the state's 29 coastal counties and encompasses salt marshes, wetlands, beaches, transition and inter-tidal areas, and islands. One of the goals of the existing program is to promote "renewable energy production and provide for appropriate extraction of energy and mineral resources consistent with proper environmental practices" (VA DEQ 2010a, 2010b). Virginia's DEQ website lists core enforceable policies, including energy development policies, beach crossing policies, and wetland policies. Currently no enforceable policy exists for birds, though state endangered species laws would be applicable (VA DEQ 2010a, 2010b).

5.10.2 Environmental or Logistical Areas of Concern

The whole barrier island/lagoon system along Virginia's eastern shore is sensitive. The Virginia Department of Conservation and Recreation lists natural area preserves along the coast (VA DCR 2010) as well as a UN Biosphere Reserve (UNESCO 2010). This area also contains resting stops for birds on long-distance migrations. The Virginia Energy Plan states that sensitive areas unsuitable for development must be excluded from offshore wind potential sites (VA DMME 2007). CTC (2009) mentions that this is likely to exclude turbines out to 6 nautical miles (i.e., most of Chesapeake Bay), and include only 67% of the area from 6 to 20 nautical miles offshore and 33% from 20 to 50 nautical miles offshore because of potential ocean use conflicts.

The Virginia Coastal Energy Research Consortium (VCERC) released its report on April 20, 2010, in which it noted that the region encompassing state waters are dominated by Class 4 winds while Atlantic federal waters off the Virginia coast are dominated by Class 5 and Class 6 winds. The consortium developed a geospatial database with more than 25 layers, including restrictions necessitated by military activities. Avoiding conflicting uses, VCERC identified 25 OCS lease blocks of entirely Class 6 winds beyond 12 nautical miles offshore (the approximate visual horizon), in water depths less than 30 meters (suitable for commercially available monopile foundations), which could support approximately 3,200 MW of offshore wind farm capacity (VCERC 2010b). The OCS blocks are shown in Figure B-30.

5.10.3 Data Availability

The Virginia DEQ maintains "Coastal GEMS," an online portal to coastal data and maps, including shellfish sites, wetlands, dunes, essential wildlife habitat, and other parameters (VA DEQ 2010c).

James Madison University conducted the GIS mapping for VCERC (http://www.cisat.jmu.edu/cees/windpowerva/vcerc/index.html), but ERG could not find a publicly accessible version of the data.

5.11 North Carolina

5.11.1 CMP Enforceable Policies Related to Renewable Energy

The lead agency for coastal management in North Carolina is the Division of Coastal Management within the Department of Environment and Natural Resources. North Carolina's coastal zone includes 20 coastal counties of which the Atlantic Ocean or a coastal sound adjoins, intersects, or binds in whole or in part. In general, permits must not violate water quality standards, must minimize impact to habitat, and must not adversely affect state historic/cultural resources such as famous lighthouses.

Two policies could limit the development of renewable energy off the North Carolina coast. The first policy affects only wind energy. In 2005, the North Carolina Coastal Resources Commission declared that wind turbines were not water-dependent structures. Coastal and ocean waters are public trust areas, and non-water-dependent uses are generally not permitted in public trust areas. Wind turbines do not need water to perform their function while wave, current, and tidal energy generation do need water. Thus, the hydrokinetic forms of energy generation would not require a variance (Ocean Policy Steering Committee 2009).

The second policy affects all ocean-based energy projects. At this time, the Coastal Area Management Act prohibits almost all forms of "development" seaward of beach dunes and vegetation line. Transmission lines from offshore generators would have to cut through the beach and dunes, and this activity is not permitted under current rules (CRC regulation 15A NCAC 07H .0309; NC 2009; Kalo and Schiavinato 2009).

The Coastal Area Management Act rules and policies require that each local county complete a local land use plan consistent with the coastal management plan. The state may not issue a permit for something inconsistent with a local plan once it has approved that plan. Local authority stops at the high water line. The State Energy Office has developed a model wind ordinance for local governments.

5.11.2 Environmental or Logistical Areas of Concern

A University of North Carolina at Chapel Hill study examined the feasibility of installing wind turbines in Pamlico Sound, Albemarle Sound, and the ocean waters off North Carolina coastline (UNC 2009a). The study found potential areas in the eastern portion of Pamlico Sound and off the coast. A map overlaying the various constraints for the North Carolina region is shown in Figure B-31.

5.11.3 Data Availability

Maps are available at http://www.climate.unc.edu/coastal-wind/maps.

5.12 South Carolina

5.12.1 CMP Enforceable Policies Related to Renewable Energy

The South Carolina Department of Health and Environmental Control (DHEC) is the coastal management agency in South Carolina. DHEC has direct permitting authority over any developments or alterations to marine and intertidal waters up to the 3-mile state boundary and authority under the "federal consistency provision" of the CZM Act to certify federally conducted, supported, or permitted activities that might impact state waters. DHEC has established an Ocean Policy Workgroup with representatives from federal and state agencies and academic institutions that will meet with experts and stakeholders on various issues. The May 2010 meeting minutes mention a draft ocean plan for February 2011 (SC DHEC 2010a).

Like North Carolina, South Carolina prohibits non-water-dependent energy and energy-related facilities along the shorefront, unless no feasible alternative is available, or unless there is an overriding public interest and environmental impacts are minimized. Adverse environmental impacts from the installation of submerged cables, pipelines, and transmission lines should be minimized through a variety of measures. In addition, state policy is to minimize adverse environmental impacts from the installation of submerged cables, pipelines, and transmission lines (SC DHEC 2006).

5.12.2 Environmental or Logistical Areas of Concern

The Ocean Planning Workgroup is working on a report and mapping effort scheduled for late 2011 (SC DHEC 2010b).

5.12.3 Data Availability

South Carolina has a portal for retrieving natural resource data in GIS format at https://www.dnr.sc.gov/pls/gisdata/download_data.login.

5.13 GEORGIA

5.13.1 CMP Enforceable Policies Related to Renewable Energy

The Georgia Coastal Management Act authorized the creation of the Georgia Coastal Program; Georgia's Department of Natural Resources, Coastal Resources Division, serves as the program's lead agency. The Coastal Program was built on existing state resource laws and established a network among state agencies to improve coastal resource management. The boundary includes the state's six coastal counties and five "inland tier" counties: Chatham, Effingham, Bryan, Liberty, McIntosh, Long, Glynn, Wayne, Brantley, Camden, and Charlton. A chain of eight main groups of barrier islands, stretching over 100 miles from northernmost Tybee Island near the South Carolina border south to Cumberland Island near the Florida border, buffers the marshes and mainland from the forces of the Atlantic Ocean (CTC 2009).

Georgia identified several policies pertaining to OCS energy policy in its comments to MMS: the Coastal Marshlands Protection Act of 1970 (O.C.G.A. §12-5-280 et seq.), the Shore Protection Act (O.C.G.A. §12-5-230 et seq.), the Coastal Management Act (O.C.G.A. §12-5-320 et seq.), the Georgia Natural Areas Act (O.C.G.A. §12-3-90 et seq.), the Protection of Tidewaters Act (O.C.G.A. §52-1-1 et seq.), the Georgia Endangered Wildlife Act of 1973 (O.C.G.A. §27-3-130 et seq.), the Georgia Air Quality Control Act (O.C.G.A. §12-9-1 et seq.), the Georgia Water Quality Control Act (O.C.G.A. §12-5-20 et seq.), the Georgia Erosion and Sedimentation Act (O.C.G.A. §12-7-1 et seq.), Georgia's Submerged Cultural Resources Act (O.C.G.A. §12-3-90 et seq.), and associated regulation for all the above statutes (CTC 2009).

5.13.2 Environmental or Logistical Areas of Concern

In 2008, Southern Power Company deemed offshore wind power as unworkable (Southern Company 2008). As a result, no environmental or logistical areas of concern for offshore wind, wave, or current energy projects have been identified.

5.13.3 Data Availability

ERG did not identify any relevant data sources; see also Section 5.13.2.

5.14 FLORIDA

5.14.1 CMP Enforceable Policies Related to Renewable Energy

The Florida CMP is composed of a network of eight state agencies and five water management districts, together enforcing 24 separate statutes. The Florida Department of Environmental Protection serves as the lead agency. The Florida coastal zone is the entire state, but coastal cities and counties that include or are contiguous to state water bodies where marine species of vegetation constitute the dominant plant community must develop a coastal zone protection element (see Florida Statutes, Title XXVII, Chapter 380.24). Florida's seaward boundary is 3 marine leagues (9 nautical miles) in the Gulf of Mexico and 3 nautical miles in the Atlantic.

Florida has two CMP policies that could affect the development of offshore renewable energy sources. The first, issued in 1988, identifies incompatible uses for natural resource lands. The definition of "natural resource lands" includes state-owned beaches, wildlife management areas, state parks, state recreation areas, state preserves, state sanctuaries, state wilderness areas, and state forests (FL 1988). The second, issued in 1996, applies only to linear facilities, including electric transmission and distribution facilities, telecommunications transmission and distribution facilities, pipeline transmission and distribution facilities, and public transportation corridors. This policy calls for owners and operators of linear facilities "*to avoid location on natural resource lands* [emphasis added] unless no other practical and prudent alternative is available and all steps to minimize impacts as set forth…" [in the policy are implemented] (FL 1996).

5.14.2 Environmental or Logistical Areas of Concern

USDOE NREL (2010d) mentions Florida as having "virtually no potential" for offshore wind energy. As a result no environmental or logistical areas of concern have been identified.

5.14.3 Data Availability

Because of the unlikelihood for offshore wind energy development (see USDOE NREL 2010d), no data have been developed. The technologies for wave and current energy in the OCS abutting Florida have not yet progressed to the data collection stage.

5.15 WASHINGTON

5.15.1 CMP Enforceable Policies Related to Renewable Energy

The primary authority for the Washington CMP is the Shoreline Management Act of 1971 (State Law—Revised Code of Washington 90.58 RCW), which requires local governments to develop and implement Shoreline Master Programs that regulate streams, lakes over 20 acres, and marine waterfronts. The Washington Department of Ecology co-administers the Shoreline Management Act with local governments and provides federal consistency determinations under the CZM Act. The Washington coastal zone includes the state's 15 coastal counties that front saltwater: Clallam, Grays Harbor, Island, Jefferson, King, Kitsap, Mason, Pacific, Pierce, San Juan, Skagit, Snohomish, Thurston, Wahkiakum, and Whatcom (WA 1971).

Through the Ocean Resources Management Act, the state expressed an interest in the management of ocean resources in federal waters (from 3 to 200 nautical miles offshore). The act also mandates that the state "participate in Federal Ocean and marine resource decisions to the fullest extent possible." Section 10 of the act specifically addresses ocean energy production (e.g., wave, current, or water temperature differential). The three enforceable policies under Section 10 are (WA 2003):

> (a) Energy-producing uses should be located, constructed, and operated in a manner that has no detrimental effects on beach accretion or erosion and wave processes.
>
> (b) An assessment should be made of the effect of energy producing uses on upwelling, and other oceanographic and ecosystem processes.
>
> (c) Associated energy distribution facilities and lines should be located in existing utility rights of way and corridors whenever feasible, rather than creating new corridors that would be detrimental to the aesthetic qualities of the shoreline area.

The Energy Facility Site Evaluation Council consists of all natural resource agencies and a governor's representative, and it provides a streamlined approval process for energy projects in the state. This does not include hydroelectric projects or small-scale projects (under 350 MW). Renewable energy projects of any size can opt into the process. In April 2009, the Council withdrew its proposal to develop renewable energy facility siting standards, thus leaving decisions to be made on a case-by-case basis (WA EFSEC 2009).

5.15.2 Environmental or Logistical Areas of Concern

The outer Washington marine shoreline is generally a sensitive wilderness-type environment with a number of state parks, a National Marine Sanctuary, and a national park. Counties and cities are responsible for adopting shoreline master programs under the Washington coastal management program. Sensitivity of resources and shorelines is determined at the local level.

5.15.3 Data Availability

The Washington State Department of Ecology maintains a searchable coastal atlas (WA Dept. of Ecology 2010).

5.16 OREGON

5.16.1 CMP Enforceable Policies Related to Renewable Energy

On March 26, 2008, the Governor of Oregon issued Executive Order 08-07 directing state agencies to protect coastal communities when siting marine reserves and wave energy projects (OR Office of the Governor 2008). In 2009, Oregon developed Part Five of its Territorial Sea Plan, which describes the process for making decisions concerning the development of renewable energy facilities (e.g., wind, wave, current, thermal) in the state territorial sea. It lays out the information needed in the application, and the formation of a joint agency review team for projects in state waters. In Oregon's Plan, the text refers to a map in Appendix C that supposedly shows the area(s) suitable for renewal energy, but only Appendices A and B are included in the PDF file of Oregon's Plan (OR 2009).

5.16.2 Environmental or Logistical Areas of Concern

High-value fishery areas such as crabbing, high-value biological habitats, navigation lanes, whale migration, and other factors are to be addressed in amendments to the Territorial Sea Plan.

5.16.3 Data Availability

Oregon's Coastal Atlas, with data available in GIS format, is located at http://www.coastalatlas.net/index.php.

The Oregon Wave Energy Trust is producing a series of reports supporting wave energy development (see http://www.oregonwave.org/our-work-overview/completed-projects/ and Section 2.2.2), but no marine spatial planning database is available.

5.17 CALIFORNIA

5.17.1 CMP Enforceable Policies Related to Renewable Energy

The California Coastal Commission (CCC) is an independent, quasi-judicial state agency established by the legislature through the California Coastal Act of 1976. It is one of three agencies that administer the federal CZM Act in California. The San Francisco Bay Conservation and Development Commission oversees development in San Francisco Bay, while the California Coastal Conservancy purchases, protects, restores, and enhances coastal resources, and provides access to the shore. California's coastal management program is carried out through a partnership between state and local governments. Implementation of Coastal Act policies is accomplished primarily through the preparation of local coastal programs that are required to be completed by each of the 15 counties and 60 cities located in whole or in part in the coastal zone (CCC 2010; NOAA 2010).

5.17.2 Environmental or Logistical Areas of Concern

The factors that determine areas of concern include commercial or recreational fishing, marine reserves, marine sanctuaries, kelp beds, hard bottom habitat, essential fish habitats, marine mammals and critical habitats. Section 2.4.17 and Figures B-17 to B-21 list and illustrate the regions proposed for nine wave projects in state waters.

5.17.3 Data Availability

The state does not have a single data source that lists or maps all areas of interest (Center for Ocean Solutions et al. 2009).

6 ENERGY INFRASTRUCTURE

Section 3.1 provides an overview of the electricity power generation system; this chapter briefly describes three major energy infrastructure components: power plants, substations, and transmission lines (Sections 6.1 through 6.3, respectively). The data are drawn from Platts GIS layers for the North American electric power industry, dated August 2009 (Platts 2009). Appendix D contains a map for each state discussed in this section as well as the District of Columbia, with power plants, substations, and transmission lines.

Figures D-1 through D-18 are state-by-state maps showing power plants, substations, and transmission lines.[173] Figures D-19 through D-38 show substations capable of handling 115 kV lines and higher voltages within 20 miles of the coast (see discussion on substations in Section 6.2). Figures D-39 and D-40 show transmission line constraints for the East and West Coasts, respectively (see Section 6.3).

6.1 POWER PLANTS

Figures 37 and 38 show the distribution of power plants along the East and West Coasts, respectively.[174,175] The Platts data contain all power generation plants—both commercial and non-commercial—including waste-to-energy, landfill gas, biomass, hydro, solar, wind, and other energy sources.[176] For example, paper companies will burn wood waste or "black liquor" from pulping operations to provide heat and energy for the manufacturing operations. Any manufacturing plant that generates some or all of its energy would be in the database even if it is not a commercial entity that sells power. These plants appear in the GIS data as power plants with no transmission lines because the generated energy is not transmitted to the grid.

The approximately 2,872 operating power plants shown in these figures are categorized in Table 40. Separate counts are provided for gas, oil, coal, nuclear, and "other." Nearly half (47%) of the operating plants fall into this "other" category, for the reasons given in the preceding paragraph. Gas fuels about 35% of all plants, oil fuels about 10% of all plants, coal fuels about 7% of all plants, and the remaining 1% of all plants use nuclear fuel. Note the relatively heavy use of coal by plants in Pennsylvania, Virginia, and North Carolina.

Offshore energy projects might supply increased demand, replace the capacity of older power plants, or displace conventional generation sources. The energy mix displaced by a particular wind farm might be highly dependent on location, fuel type, generation type (base, intermittent, or peaking), transmission congestion, and a host of other factors. Thus a detailed discussion of the displaced or replaced power mix would be premature at this time.

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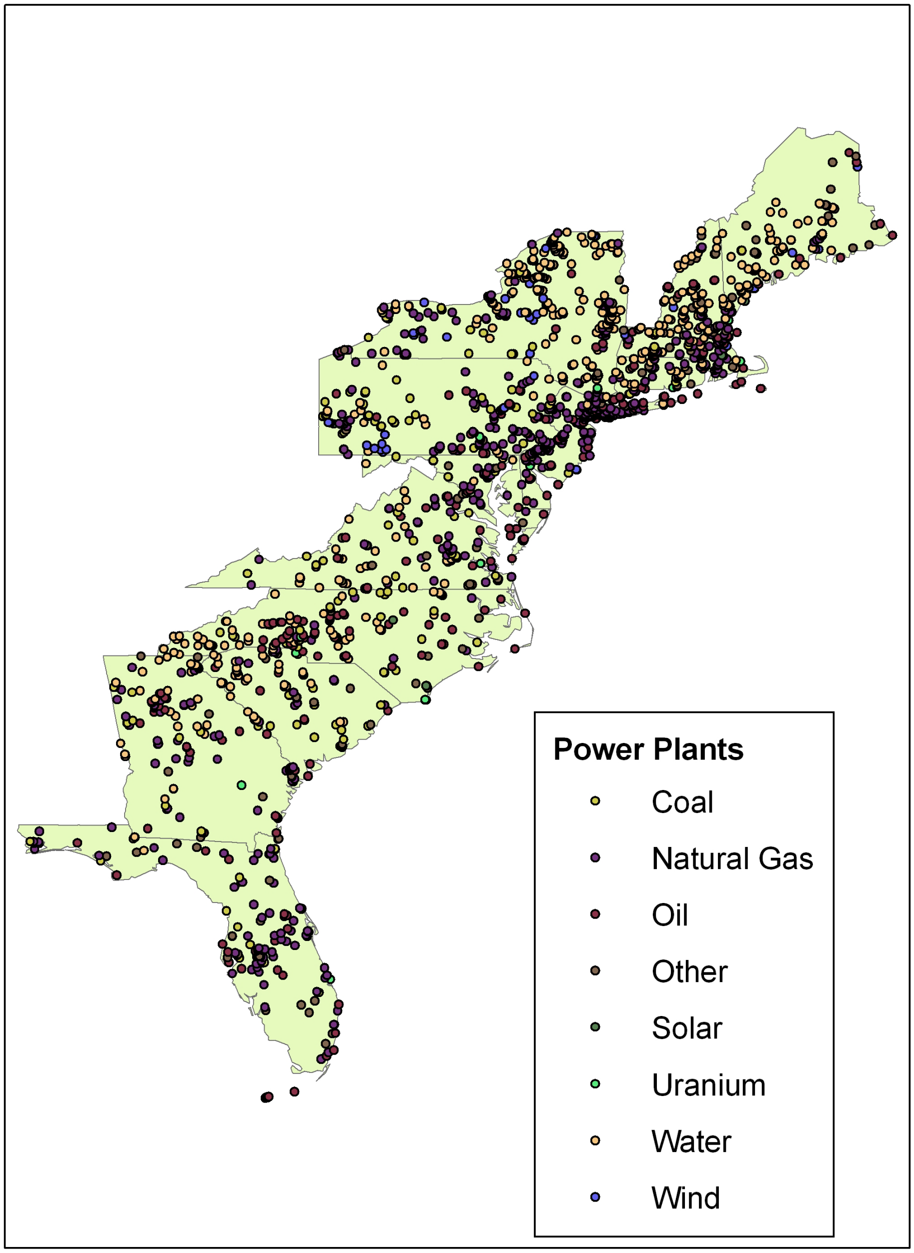
[173] In some figures, the reader will see substations with no transmission lines. ERG checked the identity of several examples and found them to be wind turbines or photovoltaic systems serving small businesses, such as a ski resort. These systems need to invert the electricity from DC to AC and adjust the voltage from the generation rate to the consuming rate, and so they appear as stand-alone substations.

[174] Pennsylvania is within the Mid-Atlantic Area National Corridor congestion area, so it is included in the maps for Chapter 6.

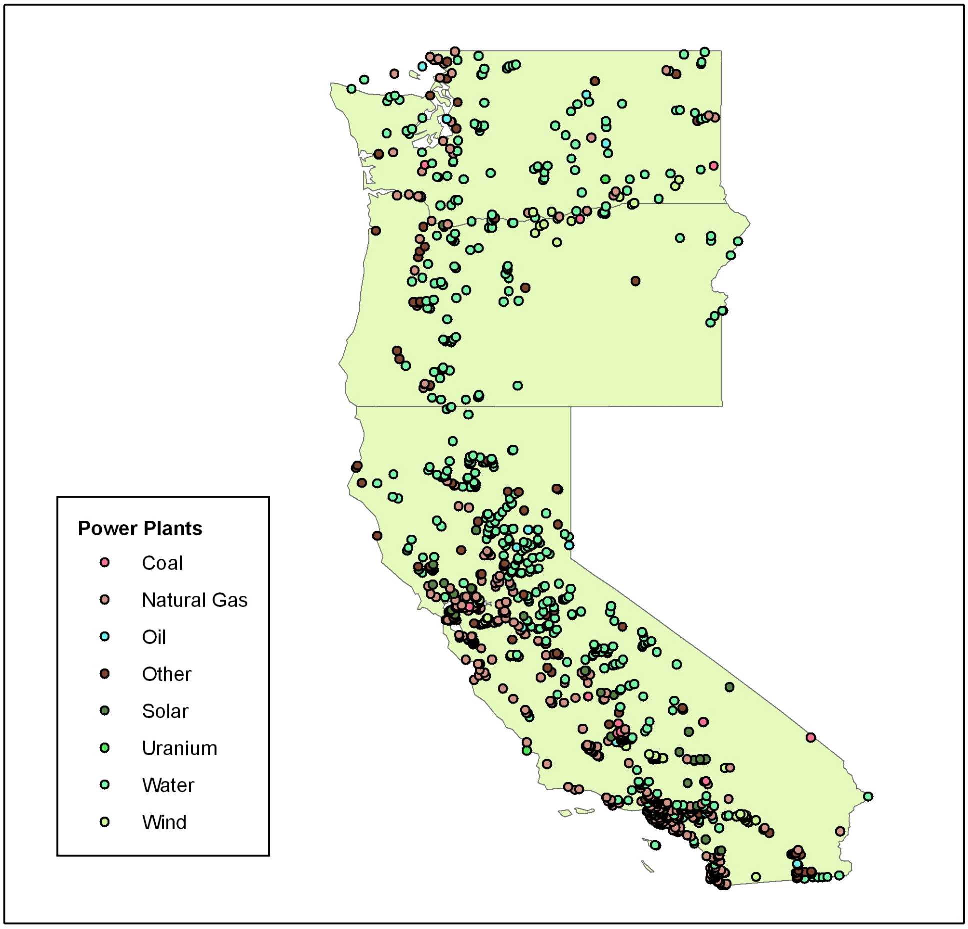
[175] Figure 14 in Section 3.1.1.2 shows a national view, with the commercial power plants' capacities indicated by circle size.

[176] For this analysis, the non-conventional energy sources listed here are combined into a single "other" category.



Source: Platts (2009).

Figure 37. East Coast power plants.



Source: Platts (2009).

Figure 38. West Coast power plants.

Table 40
Power Plants by State

State	Total	Operating	Not Operating	Operating				
				Gas	Oil	Coal	Nuclear	Other
California	1341	847	494	367	13	17	2	448
Connecticut	97	60	37	17	12	3	1	27
District of Columbia	4	2	2	0	2	0	0	0
Delaware	23	17	6	7	8	2	0	0
Florida	214	126	88	72	23	17	2	12
Georgia	184	130	54	44	31	18	3	34
Massachusetts	199	137	62	50	27	6	1	53
Maryland	59	42	17	18	8	5	1	10
Maine	161	122	39	7	7	1	0	107
North Carolina	197	145	52	19	46	29	3	48
New Hampshire	112	101	11	8	7	1	1	84
New Jersey	139	102	37	76	12	5	0	9
New York	549	370	179	116	26	14	2	212
Oregon	185	109	76	20	0	2	0	87
Pennsylvania	280	190	90	75	30	40	5	40
Rhode Island	21	13	8	6	2	0	0	5
South Carolina	113	85	28	18	11	14	5	37
Virginia	186	133	53	48	26	28	2	29
Washington	218	141	77	25	3	2	1	110

Source: Platts (2009).

6.2 SUBSTATIONS

Substations serve several functions. They are locations where:

- Electrical voltage coming in from one transmission line is stepped up or down before being carried by another transmission line,
- Various lines connect to maintain reliability of supply, and
- One transmission line "taps" into another.

These substations can be located on the surface within fenced enclosures, within special-purpose buildings, on rooftops (in urban environments), or underground.

For this project, substations serve as places where offshore energy could join the onshore grid. For this project, ERG restricted the Platts data set to substations capable of handling at least a 115 kV line within 20 miles of the coast. The count of stations includes substations that are otherwise identified as being seaward of the coastline. Some of these are underwater, such as those along the Neptune Cable (between Long Island and New Jersey), while others are on barrier islands or in the Florida Keys. The 20-mile band for each state is shown in D-19 through D-38. Pennsylvania's image is shaped by its border with Delaware and the upper reaches of Delaware Bay and Chesapeake Bay.

Table 41 cross-tabulates the number of substations with at least 115 kV lines within 20 miles of the coastline. The counts are given within 5-mile bands, e.g., 0 to 5 miles, between 5 and 10 miles, between 10 and 15 miles, and between 15 and 20 miles. Within each 5-mile band, the substations are divided into four voltage categories (i.e., 115 kV, 116 to 140 kV [to capture 138 kV lines], 141 to 299 kV [to capture 220 kV lines], and lines with capacities of 300 kV and greater). The number of potential substations into which an offshore energy project could plug is relatively sparse; there are slightly fewer than 3,000 substations that fit these characteristics for both the Atlantic and Pacific OCS regions.

Table 42 takes the number of substations within 5 miles of the coast and calculates the number of substations per mile of coast. The National Atlas of the United States (USDOI 2009c) reports two measurements. These measurements were made from small-scale maps, the coastline was generalized, and large sounds and bays were included. Shoreline of the outer coast, offshore islands, sounds, and bays was included, as well as the tidal portion of rivers and creeks. (The term "coastline" is used to describe the general outline of the seacoast; "shoreline" is used to describe a more detailed measure of the seacoast.)

On the basis of Table 42, an offshore energy project in South Carolina might have the most difficult time finding an existing substation for connecting to the grid. South Carolina has only 17 substations within 5 miles of its coastline that can handle at least 115 kV, implying an average access of one per 11 miles of coastline. Maine and Oregon have the next sparsest access to appropriate substations within 5 miles of the coast, averaging about one per every 8 miles. If the shoreline is a more accurate measure of the difficulty of getting to a substation, the problem increases by more than one order of magnitude.

In other words, the nexus where the offshore energy meets the onshore grid might be one of the more problematic areas for actualizing an energy project. To get access to the onshore grid, the nearest substation might not be close to the offshore facility (thus entailing additional material and installation costs as well as possible additional permitting costs) and the substation might need upgrading or expansion to accommodate the additional electricity supply.

Table 41
Substations by State and Maximum Voltage

State	Substations by Maximum Voltage (kV) by Distance From Shore															
	5 Miles or Less				Between 5 and 10 Miles				Between 10 and 15 Miles				Between 15 and 20 Miles			
	115	116–140	141–299	300+	115	116–140	141–299	300+	115	116–140	141–299	300+	115	116–140	141–299	300+
CA	187	0	87	15	93	0	44	5	32	0	37	1	42	0	60	15
CT	55	1	0	18	20	0	0	3	8	0	0	6	22	0	0	9
DC	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
DE	0	21	5	1	0	12	2	1	0	8	0	1	0	1	0	0
FL	35	147	77	2	3	35	52	4	0	11	27	2	3	1	14	2
GA	34	0	6	0	13	0	3	0	14	0	5	0	7	0	1	3
MA	35	0	0	30	24	0	1	11	31	0	0	9	16	0	1	6
MD	28	4	12	1	19	7	4	4	17	2	9	0	13	0	13	3
ME	15	0	0	12	17	0	0	7	7	0	0	6	17	0	0	7
NC	27	0	35	0	12	0	16	0	7	0	7	0	5	0	5	0
NH	7	0	0	5	1	0	0	1	3	0	0	0	1	0	0	1
NJ	0	19	42	10	1	7	28	4	0	7	27	0	0	4	14	3
NY	0	71	0	44	0	17	0	22	0	1	0	4	0	3	0	1
OR	26	0	12	0	17	0	7	0	1	0	2	0	5	0	2	1
PA	0	0	0	0	0	0	2	1	0	1	7	0	0	1	6	3
RI	22	0	0	5	13	0	0	3	5	0	0	0	3	0	0	3
SC	13	0	4	0	7	0	8	0	2	0	3	0	4	0	3	0
VA	53	1	47	4	11	1	33	4	4	0	15	4	27	0	20	1
WA	176	0	15	3	53	0	16	5	49	0	14	4	36	0	4	2

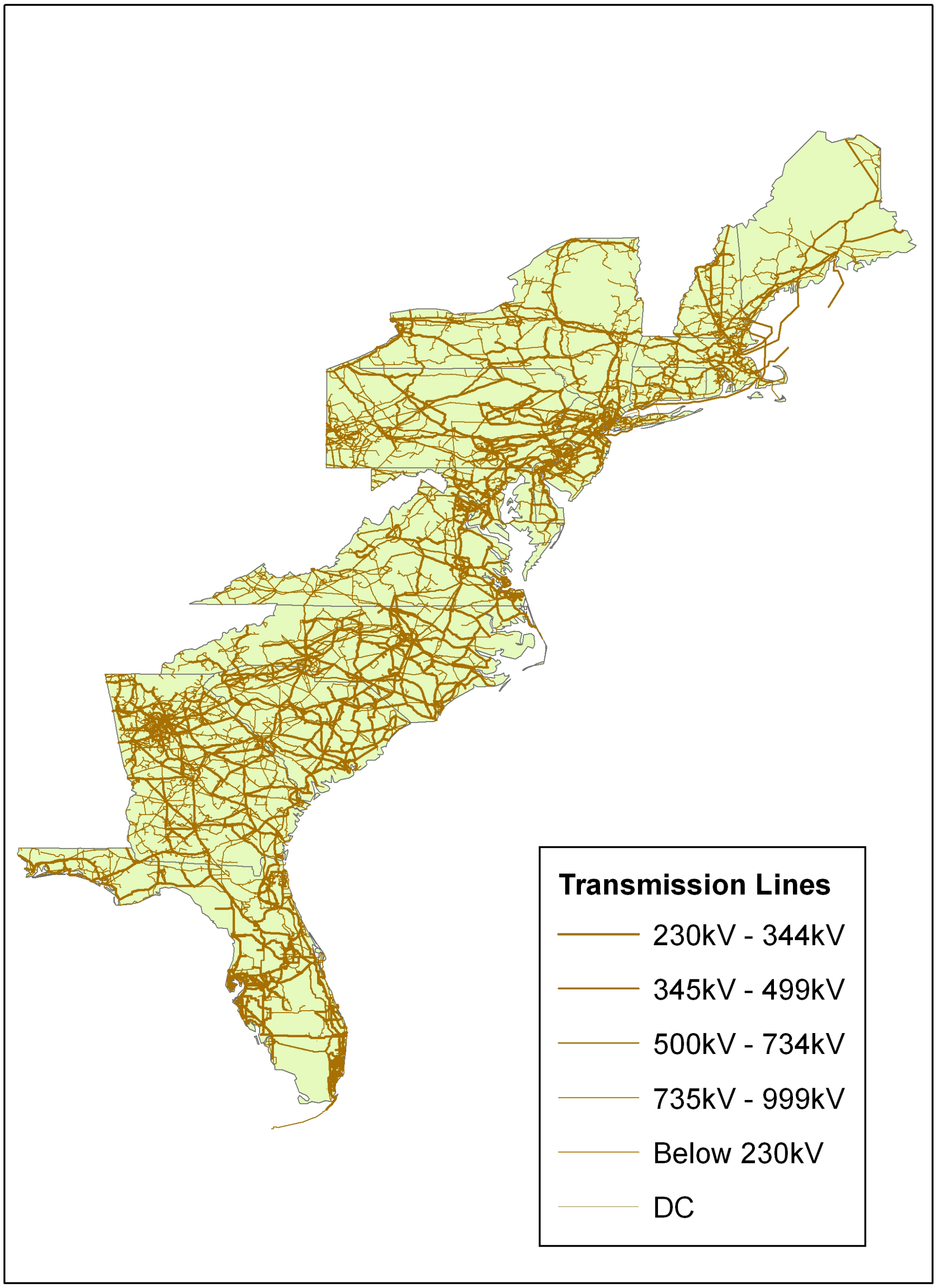
Source: Platts (2009).

Table 42
Number of Miles per Substation Within 5 Miles of Coast

State	Within 5 Miles of Coast	Statute Miles		Miles per Substation	
		Coastline	Shoreline	Coastline	Shoreline
California	289	840	3,427	2.9	11.9
Connecticut	74	na	618	na	8.4
Delaware	27	28	381	1.0	14.1
Florida	261	1,350	8,426	5.2	32.3
Georgia	40	100	2,344	2.5	58.6
Massachusetts	65	192	1,519	3.0	23.4
Maryland	45	31	3,190	0.7	70.9
Maine	27	228	3,478	8.4	128.8
North Carolina	62	301	3,375	4.9	54.4
New Hampshire	12	13	131	1.1	10.9
New Jersey	71	130	1,792	1.8	25.2
New York	115	127	1,850	1.1	16.1
Oregon	38	296	17,410	7.8	458.2
Rhode Island	27	40	384	1.5	14.2
South Carolina	17	187	2,876	11.0	169.2
Virginia	105	112	3,315	1.1	31.6
Washington	194	157	3,026	0.8	15.6

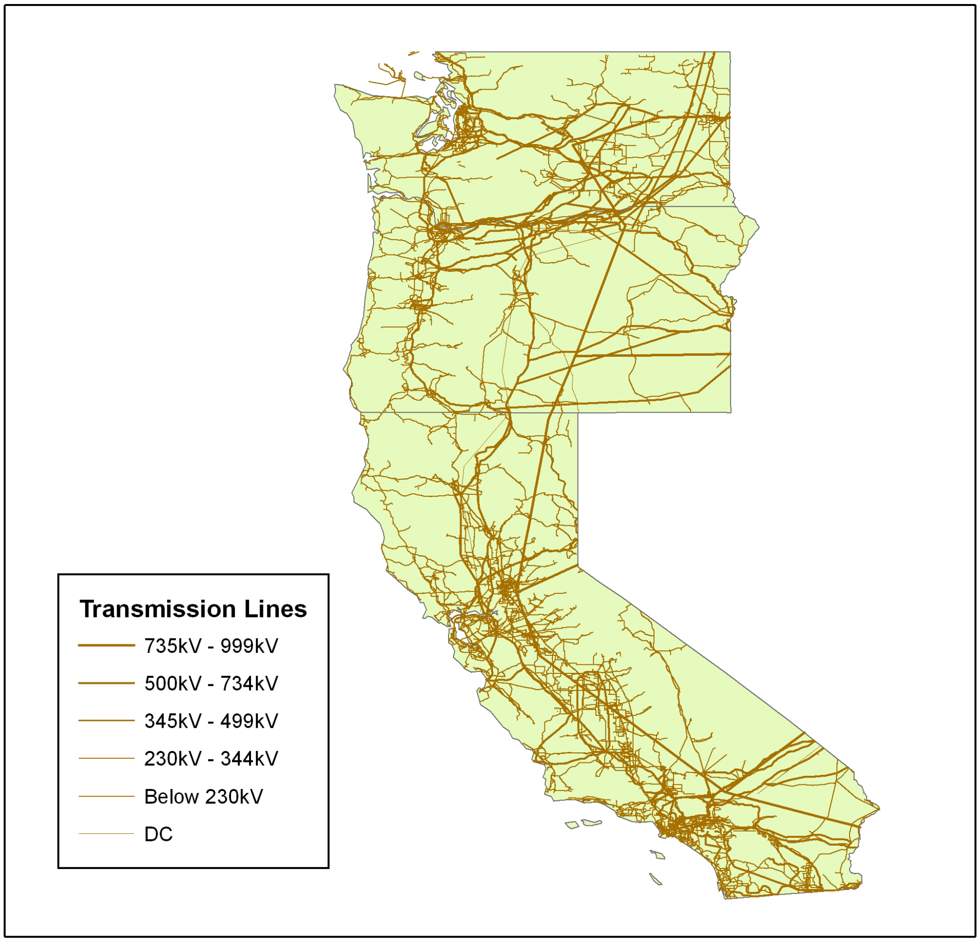
6.3 TRANSMISSION LINES

Figures 39 and 40 show the transmission line systems for the East and West Coasts, respectively, while Table 43 lists the number of transmission line segments by state and maximum voltage level. For this study, the available capacity of these lines is an important factor for offshore energy generation. Section 3.2 discusses financial instruments such as financial transmission rights. These entitle the holder to revenues (or charges) based on differences in energy prices across a transmission path, thereby allowing market participants to hedge against the congestion costs associated with their energy deliveries. In other areas, congestion revenue rights were created to reserve and allocate space on the transmission wires.



Source: Platts (2009).

Figure 39. East Coast transmission line system.



Source: Platts (2009).

Figure 40. West Coast transmission line system.

Table 43
Transmission Lines by State and Maximum Voltage

State	Total	Maximum Voltage					
		DC	<230 kV	230–344 kV	345–499 kV	500–734 kV	735–999 kV
California	7,049	6	6,268	682	5	83	5
Delaware	122	0	98	16	0	8	0
Florida	1,880	0	1,300	556	0	24	0
Georgia	3,656	0	3,243	378	0	35	0
Massachusetts	574	3	476	12	83	0	0
Maryland	408	0	274	96	1	33	4
Maine	231	1	200	0	30	0	0
North Carolina	1,078	0	745	318	0	15	0
New Hampshire	555	4	522	10	19	0	0
New Jersey	680	0	443	202	14	20	1
New York	1,539	3	1,349	48	128	2	9
Oregon	1,465	4	1,203	154	4	97	3
Pennsylvania	1,108	0	772	228	40	64	4
Rhode Island	137	0	127	0	10	0	0
South Carolina	557	0	374	176	0	7	0
Virginia	1,094	0	762	266	3	52	11
Washington	1,830	1	1,455	235	23	114	2

Source: Platts (2009).

6.3.1 Congestion Areas

The growing demand for electricity and the subsequent congestion of the transmission system has been a concern at the national level for several years. The Energy Policy Act of 2005 directed DOE to conduct a nationwide study of electric transmission congestion (USDOE 2006). The resulting study identified two areas of critical congestion; these are shown in Section 3.4.4.1, Figure 29. The congested transmission lines are shown in Figures D-39 and D-40. The first critical area runs from the New York City metropolitan area to northern Virginia. The second critical area is in southern California in the Los Angeles–Riverside–San Diego region. As DOE 2006 notes, transmission congestion always has a cost—because when constraints prevent delivery of energy from less expensive sources, energy that is deliverable from more expensive sources must be used instead. Section 3.1.2 observes that the offshore wind farms proposed in the Northeast are positioned to potentially relieve some of the congestion constraints in the region.

6.3.2 Integrating Offshore Wind Energy into the Electrical Grid

DOE recently completed a study to identify and address issues associated with meeting a goal of generating 20% to 30% of the electricity consumed in the Eastern Interconnection by 2030 from renewable sources (USDOE NREL 2010b). The report is discussed in detail in Section 3.4.4.3. Offshore wind energy is considered in three of the four scenarios examined. Scenario 3 represents an uppermost limit of offshore wind energy developed by 2024 under an aggressive technology-push scenario. DOE also developed a reference scenario to approximate the current state of wind development plus some expected level of near-term development guided by interconnection queues and state RPSs. Only about 6% of the total 2024 projected load requirement was supplied by onshore and offshore wind in DOE's reference scenario.

Table 44 lists the estimated costs for expanding the electric transmission infrastructure. An estimated $31 billion in transmission line expansion is needed for the reference scenario. Scenario 1—with no offshore wind—has the highest cost at $93.1 billion. In contrast, Scenario 3 requires about one-third less investment—i.e., it has the lowest cost, $64.9 billion. The costs for additional 345 kV (single and double circuits), 500 kV (single and double circuits), and 765 kV transmission lines are the same for all four scenarios. A small difference is seen in the need for 400 kV lines; Scenario 3 is estimated at $1.9 billion while the comparable costs for Scenarios 1, 2, and 4 are $1.5 billion. The largest difference is in the estimated mileage (and, therefore, cost) for 800 kV DC transmission lines. Scenario 3 is estimated to require 4,747 miles at a cost of $22.9 billion while the other scenarios require between 8,352 and 11,102 miles at costs between $40.2 billion and $53.4 billion. By using offshore wind, the generating capacity is located much closer to the demand areas, thus obviating the need for high-voltage lines to transport power from the Midwest to the East Coast.

Table 44
DOE Estimated Costs for Integrating Wind Into the Eastern Transmission System

Transmission Lines	Cost (Millions, $2024)				
	Reference	Scenario 1 20% High Capacity Factor, Onshore	Scenario 2 20% Hybrid With Offshore	Scenario 3 20% Local, Aggressive Offshore	Scenario 4 30% Aggressive On- and Offshore
345 kV	$5,607	$3,569	$3,569	$3,569	$3,569
345 kV AC (double circuit)	$880	$743	$743	$743	$743
500 kV	$1,367	$2,916	$2,916	$2,916	$2,916
500 kV AC (double circuit)	$1,900	$935	$935	$935	$935
765 kV	$10,790	$30,033	$30,033	$30,033	$30,033
400 kV DC	$1,383	$1,539	$1,539	$1,898	$1,539
800 kV DC	$9,243	$53,445	$40,206	$22,852	$50,898
Total	$31,170	$93,179	$79,941	$64,865	$92,551

Source: USDOE NREL (2010b).

One option not considered in DOE NREL 2010b is the installation of a marine transmission cable. Several East Coast governors have sent letters to FERC asking about installing a transmission "backbone" that would link all offshore energy projects. This would make it possible to transport the energy from wherever the wind is blowing to states where demand exceeds supply. Because the electricity that is available for transmission is a mix from multiple sources, the intermittency associated with wind power would be mitigated to some degree. While this sounds like a good idea, such an infrastructure project would cross state boundaries, affect different developers, and connect different regional power grids. It is uncertain whether such a complex project could be organized and completed in time to be available for the first wind farms to use. If these projects have already made the investment to transmit the energy to shore and connect to the onshore grid, it is uncertain how they would benefit from joining the backbone later—so timing has a major impact on the viability of such a backbone (Nathans 2009; DE Office of the Governor 2010).

In July 2009, the American Wind Energy Association released its report card on meeting a national goal of generating 20% of electricity from wind power by 2030 (AWEA 2010). While technology development rated an A-minus and manufacturing rated a B-plus, transmission and integration rated only a C-minus. That is, transmission and integration is seen as the weakest point in the process of developing wind power (both onshore and offshore).

7 OCS INFRASTRUCTURE

Offshore renewable energy projects will draw on the existing infrastructure of maritime assets to construct, operate, and maintain their sites. As the industry grows, it will also change the existing infrastructure, as entrepreneurs respond to the growing demand for certain types of assets and (perhaps) reduced demand for other assets. This chapter discusses aspects of the existing marine infrastructure likely to be drawn on as offshore renewable energy sites are developed. In particular, it focuses on ports, shipping, ship construction and repair, and the equipment necessary to lay subsea power cables.

Alternative offshore energy is a nascent industry in the U.S. Because there are no existing commercial-scale offshore energy projects in U.S. waters, it is difficult to project the impact of industry growth on the future development of U.S. coastal areas. However, based primarily on European experience, it seems doubtful that—at least in the near future—renewable energy will result in wholesale development of specialized industrial complexes like those in the Gulf of Mexico to support offshore oil and gas drilling and production. The scale of resources required by offshore renewable energy appears to be orders of magnitude smaller than those for oil and gas: a sizable wind farm of 100 turbines or more might need less than 100,000 square meters of dock space to fabricate structures, two or three sizeable vessels on relatively short-term charter to install the turbines, and a few smaller ships to perform routine maintenance. This is in marked contrast to the requirements of fabricating platforms weighing tens of thousands of tons: such a platform must be continuously supplied with drilling mud, drilling pipe, fuel, and a myriad of other supplies for the live-on-board crew for months while drilling offshore; its drilling rig must be replaced with a production platform (also requiring fabrication), and the supply platform and crew must be maintained for years; and finally the entire structure must be decommissioned at the end of the well life. Although this might understate the requirements of supporting multiple offshore wind farms that might eventually reach thousands of structures, the scale appears to be so different that it is difficult to imagine offshore energy dominating an entire region as offshore oil and gas dominates the Gulf of Mexico.

Section 7.1 discusses the nation's large and smaller ports, their role in the development of offshore renewable energy projects, and port governance. Section 7.2 addresses waterborne transportation, including a fleet profile and regulations such as the Jones Act. Section 7.3 focuses on shipyards and shipbuilding, while Section 7.4 describes the submarine cable laying and production industry.

7.1 PORTS

Ports are an important part of the support infrastructure for renewable energy projects, serving as points of debarkation for construction and maintenance workers and providing storage and loading for parts and materials. Based on information currently available, renewable energy projects should largely be able to rely on existing port infrastructure—in contrast to the offshore oil and gas industry, which requires ports with services tailored to its specific needs (Louis Berger Group 2004). During construction, they should place relatively few demands on existing infrastructure insofar as they require few deep-draft berths, and relatively small dockage, storage space, staging and loading areas. After construction is complete, they should place even fewer demands on infrastructure.

There are approximately 360 ports in the United States, including more than 150 deep-draft seaports along the Atlantic, Pacific, Gulf and Great Lakes coasts, as well as in Alaska, Hawaii, Puerto Rico, Guam, and the U.S. Virgin Islands (AAPA 2010). Ports may accommodate a variety of vessels, including recreational watercraft, barges, ferries, and ocean-going cargo and passenger ships. Deep-draft ports accommodate large ocean-going vessels (AAPA 2008a), while ports on inland rivers have depths of 14 feet or less and accommodate smaller vessels (USDOT MARAD 1999). Many ports offer terminal facilities for the transfer of cargo between ships, barges, trucks, and railroads, as well as for ferry and cruise passengers. There are more than 1,900 deep-draft terminals and 1,800 inland river terminals in the United States (USDOT MARAD 1999). Ports on the coasts and inland waterways provide about 3,200 berths for deep-draft ships (AAPA 2008a). Berths are the locations where vessels dock, and may be specialized to handle passengers or certain types of cargo.

The ownership and operation of port facilities may encompass a broad spectrum of activities. Some port authorities also oversee airports, bridges, tunnels, commuter rail systems, inland river or shallow draft barge terminals, industrial parks, Foreign Trade Zones, world trade centers, terminal or short-line railroads, shipyards, dredging, marinas, and other public recreational facilities (AAPA 2010).

U.S. ports and waterways handle more than 2 billion tons of domestic and import/export cargo annually covering a wide range of commodities, including renewable energy equipment (AAPA 2010). For instance, the Albany Port District Commission (2010) reports having received more than 1,600 windmill blades, enough to build 500 windmills (presumably for installation on land).

Ports vary widely in their size and cargo-handling capacity, with a handful of major ports handling most of the cargo flowing into and out of the United States. Over 85% of U.S. containerized freight flows through 10 ports: Los Angeles, Long Beach, New York/New Jersey, Savannah, Hampton Roads, Oakland, Charleston, Houston, Seattle, and Tacoma. There are also numerous small and medium-sized ports that serve local communities or have developed specialized cargo handling capabilities (USDOT MARAD 2009a).

Section 7.1.1 reviews what might be required of ports to support renewable energy development in the OCS. Section 7.1.2 contains an industry profile for large and smaller ports. Section 7.1.3 discusses navigation and navigable channels, commercial vessel and crew standards, safety monitoring and assessment, environmental protection, and security.

7.1.1 Ports' Role in Renewable Energy Projects

Renewable energy projects that could be sited offshore on the East and West Coasts include wind turbines, wave turbines, and Tidal In Stream Energy Conversion (TISEC) devices. Wave turbines are typically anchored to the sea floor and make use of waves on the surface of the water, while TISEC devices are moved by underwater tidal currents (USDOIMMS 2009b).

Compared to offshore oil and gas drilling operations, renewable energy projects are anticipated to require less intensive use of ports and less specialized infrastructure. Oil and gas drilling relies heavily on ports with services tailored to its specific needs, including frequent delivery and pick-up of personnel, supplies, and delivery of materials to and from offshore platforms; a specialized fleet of at least 29 types of vessels; shipyard and repair facilities to tend to those vessels; large fabrication facilities for drilling platforms; supply bases to provide equipment and materials; and crew services such as catering, laundry, and cleaning (Louis Berger Group 2004) . For example, Port Fourchon is one of the primary port facilities serving the oil and gas industry, with over 50% of current or pending deep water oil and gas projects using or planning to use Port Fourchon (Greater LaFourche Port Commission 2010). Port Fourchon has become highly specialized in servicing the oil and gas industry. Of the 25 million tons of cargo handled at Port Fourchon in 2007, over 95% was oil and gas related (Greater LaFourche Port Commission 2010).

By contrast, renewable energy projects require far fewer personnel and specialized vessels, and as a result may not require particularly large or specialized ports. For example, most of the criteria for site selection of wind energy projects are not related to port infrastructure. These criteria include average wind speeds, water depth, and geologic framework; proximity to flight paths, shipping lanes, and fishing grounds (especially those where bottom trawling is used); the presence of nearby military facilities or sonar testing grounds; the existence of shipwrecks; the locations of protected environmental areas; and the capacity of the utility transmission infrastructure (UNC 2009a; ME DOC 2009).[177]

Once other criteria are satisfied, the site chosen need not even be close to major ports. In the case of Cape Wind, the final EIS indicates that no major port facilities, which handle large deep-draft vessels, or which engage in commercial cargo trade, are near the proposed project site (USDOIMMS 2009b). This may in fact be an asset, as it means that the project will not affect existing deep-draft ship traffic.

Nonetheless, ports serve as embarkation points for the vessels used to construct and operate renewable energy projects. In the case of wind energy projects, a staging area is required to receive, store, and assemble equipment such as turbines and the foundations that support them. Wave projects, such as that proposed off Reedsport, Oregon, do not need staging and assembly areas; the buoys would be transported from the place of manufacture to the port and loaded onto barges for deployment (Northwest Renewable News 2009a). In addition, ports providing drydock and shipyard facilities for the vessels used in the installation and maintenance of the project should be accessible (Westgate and DeJong 2005). In the case of Cape Wind, the vessels and equipment specified for use in the project include (USDOIMMS 2009b):

- A hydroplow cable burial machine.
- An installation barge (100 feet by 400 feet by 24 feet).
- Anchor handling tugs.
- A cable burial barge.
- An auxiliary trencher pulling barge (40 feet by 100 feet).

[177] ERG was not able to locate criteria specific to wave energy projects, other than that the harbors used should be "suitable" (Grays Harbor 2010c).

- Auxiliary vessels (crew boat, two inflatable boats, several skiffs).

Most of these vessels are used only during construction. Once installed, the Cape Wind project is expected to require a 35- to 45-foot crew boat, a 20- to 25-foot high-speed emergency response boat, and two 65-foot maintenance vessels. A single port need not accommodate all these vessels; in the case of Cape Wind one port would be used for installation and construction vessels, another for maintenance vessels, and a third for crew vessels. Crew vessels can be based in small harbors close to the project, while large vessels require larger ports suitable for vessels with deeper drafts. Normal service and maintenance expected for Cape Wind includes one crew vessel trip and one maintenance support vessel trip per working day, so dock space would be leased year-round (USDOIMMS 2009b).

At this time, offshore renewable energy projects in the United States are designed to operate without onsite operators, so extensive support services for personnel would not be required. In the case of Cape Wind, the construction phase is the most labor-intensive, projected to require 316 manufacturing and assembly workers and an additional 75 full-time workers. Routine O&M is anticipated to require only 50 workers, with most of these at an onshore monitoring facility. Routine service and maintenance of the turbines may only require three to four crew members making day trips to the turbines (USDOIMMS 2009b). The Reedsport OPT Wave Park projects the need for one supervisor, five operations personnel, and two technical/maintenance personnel, i.e., a total of eight positions with the potential of an additional five temporary positions to support major overhauls (FERC 2010e).

7.1.1.1 Cape Wind and Deepwater Port Profiles

The characteristics of the ports that will be used in the Cape Wind project and proposed for the Deepwater project suggest what sort of port infrastructure is required for renewable energy projects. In the case of Cape Wind, the wind turbine blades would be fabricated and assembled in Quonset Point, Rhode Island; maintenance vessels would depart from New Bedford, Massachusetts; and operations and maintenance workers would board work boats in Falmouth, Massachusetts (USDOIMMS 2009b). The following subsections summarize the infrastructure available at each of these sites to characterize what might be expected for other renewable energy port requirements.

Quonset Point

Although Quonset Point handles only 132,277 tons of cargo per year, Cape Wind considers it equipped to handle the construction, staging, assembly, and loading of supplies for the project (USDOIMMS 2009b). Its 30- to 35-foot channel depth is also judged to be sufficient for large vessels to dock in the area (AAPA 2009; USDOIMMS 2009b). It is also home to an industrial park and Deepwater Wind, a renewable energy company that plans to use Quonset as a base for manufacturing, assembly, and launching of wind turbines (QDC 2009) for a proposed wind farm off the coast of Block Island, Rhode Island, and other potential sites (Kuffner 2009). However, although Quonset Point provides piers and a channel for deep-draft ships, it offers no other support services (NOAA 2011b).

New Bedford

New Bedford is an altogether more substantial port, which handles 628,000 tons of cargo annually and has a 30-foot channel depth (AAPA 2009); one of its terminals would provide dock space for two 65-foot maintenance vessels, warehousing for tools and parts, and parking for crew members (USDOIMMS 2009b). The New Bedford waterfront has seven piers and wharves that have at least 25 feet of depth alongside and range from 400 feet to 1,600 feet long, most of which are used by the fishing industry. Cargo in the port is usually handled by ship's tackle, with a 250-ton floating "A" frame derrick available for heavy lifts by prior arrangement. Available supplies include gasoline, diesel fuel, water, provisions, and marine supplies. There are several facilities nearby that can make hull, engine, and electronic repairs; storage facilities are also available (NOAA 2011b).

Falmouth

Falmouth would be used to carry construction workers and approximately 50 O&M workers to the wind farms on 35- to 45-foot-long crew boats (USDOIMMS 2009b). A 20- to 25-foot-long emergency response boat would also be kept at Falmouth (USDOIMMS 2009b). Falmouth is not included in the AAPA (2008b, 2009) list, but it is a point of embarkation for passenger/vehicle/cargo ferries to the islands of Nantucket and Martha's Vineyard, as well as recreational and private and commercial fishing vessels (USDOIMMS 2009b). Falmouth Harbor has an anchorage for vessels in 24 to 36 feet of water about 0.8 miles from shore, while smaller vessels can anchor closer to the shore in 15 to 18 feet of water (NOAA 2011b). Falmouth Inner Harbor is a dredged basin about 0.7 miles long and less than 0.1 mile wide, on the north side of Falmouth Harbor. In March 2004, the entrance channel to the Inner Harbor was 7.1 feet deep and the Inner Harbor itself was 6.2 feet deep. There are several small-craft facilities and a yacht club in Falmouth Inner Harbor (NOAA 2011b).

ERG was unable to find specifications for the infrastructure needs by other projected offshore renewable energy projects in the United States. There is little reason to believe, however, that requirements will differ substantially from those of Cape Wind and Deepwater Wind. Offshore wind farms built in Europe appear to have used vessels of reasonably similar size for installation as Cape Wind anticipates using, and in similar numbers (A2SEA 2010; Axelsson 2008; Gerdes et al. 2006; Nitschke et al. 2006; Sorensen et al. 2002). Furthermore, the European wind farms were constructed further offshore (Gerdes et al. 2006). Although there is a trend in Europe toward the use of specialized ships for installation (Hogue 2009; Baird Maritime 2010), the first turbine installation vessel (TIV) completed is about 428 feet long with a beam of 124 feet, and therefore is not significantly larger than the installation barge specified by Cape Wind (400 feet by 100 feet).[178]

[178] To the extent that future U.S. wind farms are further offshore than Cape Wind (several European wind farms are 20 to 45 kilometers offshore [Gerdes et al. 2006]; Deepwater Wind is planning to build 15 to 25 miles off the coast of Rhode Island [Scharfenberg 2009]), it is probable that maintenance vessels larger than those specified by Cape Wind will be necessary. These may well require larger ports than Falmouth. However, we were unable to find information on the size of the maintenance vessels used in Europe.

7.1.1.2 Ports of Wilmington, Camden, and Paulsboro

An October 2010 article at OffshoreWind.biz reports that NRG Bluewater Wind and the Port of Wilmington, Delaware, are planning a $66 million staging area for assembling wind turbines and foundation and have applied for a $22 million TIGER grant from the U.S. Department of Transportation. The project is estimated to create 770 jobs during construction and 750 during operation. Fisherman's Energy is reported to be considering the Port of Camden as a staging area for its project in New Jersey state waters and the Port of Paulsboro for its larger project (OffshoreWind.biz 2010).

7.1.2 Industry Profile

Ports in the United States vary widely in size and capability. The largest have multiple terminals and berths, and handle millions of tons of cargo per year, while others are primarily used by smaller vessels or are only used intermittently. In contrast to offshore oil and gas operations, renewable energy projects require fewer vessels and personnel, and thus are able to use smaller ports for at least some of their aspects. The subsections below discuss large and small ports.

7.1.2.1 Large Ports

Table 45 presents summary data on major U.S. East and West Coast ports. Of the 149 largest U.S. ports in 2008 as measured by annual cargo tonnage, 35 are located on the East Coast and 22 are located on the West Coast; the remaining 92 ports on the list are located on the Gulf of Mexico, Great Lakes, Alaska, Hawaii, Puerto Rico, and the inland waterways. Two East Coast ports (Port of New York and New Jersey and Hampton Roads, Virginia) and one West Coast port (Long Beach, California) are ranked among the 10 largest U.S. ports by tonnage; an additional five ports on both coasts are ranked among the 25 largest.

Table 45 also provides data (where available) on:

- Tonnage as an indicator of a port's size and cargo-handling capabilities.
- Channel depth, which potentially limits the type of ships that can use the port.
- Number of terminals and berths, an indicator of port size and shore facilities.
- Access to rail, road, and airport infrastructure.

All ports listed in this table are deep-draft ports with a channel depth of at least 30 feet, and thus should be able to accommodate the type of vessels required for offshore wind farms (AAPA 2008b, 2009). Based on the information described above concerning Cape Wind's plans and European operations, deep-channel ports are likely to be needed primarily during the construction. Following the table, Figures 41 and 42 show the listed ports' locations.

Table 45
Major U.S. East and West Coast Ports

City	State	Rank (Annual Cargo Tonn.)	Annual Cargo Tonn.[179]	Main Channel Depth (ft.)[180]	Cargo Terminals[181]	Berths[182]	Access via:[183]		
							Rail	Road	Air
Humboldt Bay	CA	N/A	989,406[184]	38 (MLLW)	5	6			
Long Beach	CA	4	80,205,281	76	18	62	x		
Los Angeles	CA	12	59,788,339	53	27[185]	38			
Oakland	CA	39	17,809,805	50	9	20[186]			x
Port Hueneme	CA	131	1,300,714	35 (MLLW)	2	5	x		
Redwood City	CA	124	1,675,392	30	1	3	x	x	
Richmond	CA	30	26,357,184	38	7	11	x		
Sacramento	CA	149	824,693	30	1	5	x		
San Diego	CA	116	1,891,343	41 (MLLW)	2	14	x		
San Francisco	CA	126	1,385,851	55	5	8	x		
Stockton	CA	119	1,772,031	35 (MLLW)	1	20			
Bridgeport	CT	72	5,840,506	35[187]	2[188]	3[189]	x	x	
New Haven	CT	54	9,663,115	36-39(MLW)[190]	1[191]	3[192]			
Stamford	CT	138	1,064,122	ND	ND	ND			
New Castle	DE	64	6,867,709	ND	ND	ND	x		
Wilmington	DE	80	3,979,109	35-38(MLW)	1	7			
Jacksonville	FL	36	21,049,729	41	3	13	x	x	
Miami	FL	65	6,825,685	42	3	ND			

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179 AAPA (2008b), unless otherwise specified.
180 AAPA (2009).
181 AAPA (2009).
182 AAPA (2009).
183 AAPA (2009).
184 AAPA (2009).
185 Port of Los Angeles (2010).
186 Port of Oakland (2010).
187 ConnDOT (2005a).
188 ConnDOT (2005a).
189 ConnDOT (2005a).
190 ConnDOT (2005b).
191 ConnDOT (2005b).
192 ConnDOT (2005b).

Table 45
Major U.S. East and West Coast Ports (continued)

City	State	Rank (Annual Cargo Tonn.)	Annual Cargo Tonn.[193]	Main Channel Depth (ft.)[194]	Cargo Terminals[195]	Berths	Access via:[196]		
							Rail	Road	Air
Palm Beach	FL	106	2,377,226	33	1	ND	x	x	
Port Canaveral	FL	104	2,431,427	39 (MLW)	11	11			
Port Everglades	FL	35	21,652,027	47 (MLW)	3	ND			
Brunswick	GA	103	2,444,155	36 (MLW)	3	6	x	x	
Savannah	GA	22	35,393,680	42 (48 Future)	2	18	x	x	
Boston	MA	37	21,035,413	40 (MLW)	3	4			x
Fall River	MA	84	3,655,429	36	1	2			
New Bedford	MA	N/A	628,000[197]	30 (MLLW)	4	ND	x	x	x
Baltimore	MD	17	43,412,662	50	15	43	x	x	
Portland	ME	34	22,124,178	ND	ND	ND			
Searsport	ME	117	1,856,286	ND	ND	ND			
Morehead City	NC	89	3,300,143	45 (MLLW)	1	9			
Wilmington	NC	63	6,872,424	42 MLLW)	1	9			
Portsmouth	NH	34	3,832,513	35 (MLW)	1	2			
Camden	NJ	70	6,262,945	40 (MLW)	4[198]	ND	x		
Paulsboro	NJ	20	36,351,709	ND	ND	ND			
Trenton	NJ	127	1,384,119	ND	ND	ND			
Albany	NY	60	7,556,190	32 (MLW)	1	5			
Hempstead	NY	145	963,559	ND	ND	ND			
Port Jefferson	NY	132	1,270,840	ND	ND	ND			
New York/ New Jersey	NY/ NJ	3	153,480,226	40-45	6	26	x		x
Coos Bay	OR	121	1,732,595	37-47 (MLLW)	7	8	x		
Portland	OR	29	26,668,489	40-55	4	16	x		x
Chester	PA	79	4,121,776	ND	ND	ND			
Marcus Hook	PA	32	24,670,971	ND	ND	ND			
Philadelphia	PA	24	32,282,853	40 (45 Future)	6	18	x	x	
Davisville	RI	N/A	132,277[199]	30-35	1	6			x
Providence	RI	57	8,518,360	40[200]	1[201]	6[202]			

[193] AAPA (2008b), unless otherwise specified.
[194] AAPA (2009).
[195] AAPA (2009).
[196] AAPA (2009).
[197] AAPA (2009).
[198] South Jersey Port Corporation (2010).
[199] AAPA (2009).

City	State	Rank (Annual Cargo Tonn.)	Annual Cargo Tonn.[193]	Main Channel Depth (ft.)[194]	Cargo Termina[195]	Berths	Access via:[196]		
							Rail	Road	Air
Charleston	SC	38	20,936,313	45-47 (MLW)	6	21	x		
Hampton Roads	VA	10	67,195,766	50	4	18	x		

[200] ProvPort (2009).
[201] ProvPort (2009).
[202] ProvPort (2009).

Table 45
Major U.S. East and West Coast Ports (continued)

City	State	Rank (Annual Cargo Tonn.)	Annual Cargo Tonn.[203]	Main Channel Depth (ft.)[204]	Cargo Terminals[205]	Berth	Access via:[206]		
							Road	Rail	Air
Hopewell	VA	143	1,009,863	ND	ND	ND			
Richmond	VA	130	1,317,960	25	1	3	x	x	x
Anacortes	WA	47	11,468,133	44 (MLW)	1[207]	3[208]	x	x	x
Bellingham	WA	N/A	0[209]	30-32	1	3	x		x
Everett	WA	95	2,836,565	40	3	7	x		
Grays Harbor	WA	123	1,678,204	36 (MLLW)	4	5	x		x
Kalama	WA	45	12,934,895	43	3	3	x		
Longview	WA	71	5,867,131	40	1[210]	9[211]	x		
Olympia	WA	140	1,025,597	30 (MLLW)	1	3	x	x	x
Port Angeles	WA	133	1,244,714	40 (MLLW)	2	4			
Seattle	WA	31	26,168,818	50	9	34			x
Tacoma	WA	28	27,165,629	51 (MLLW)	6	11	x	x	
Vancouver	WA	58	7,936,612	40 (MLW)	4	10	x		

ND: No data.
N/A: Not applicable; not one of the 149 largest U.S. ports based on AAPA 2008b.
Channel depth measured as mean low water (MLW), average low tide, or mean lower low water (MLLW), the average of the lower of the two low tides.

Primary data source: AAPA (2008b), supplemented with four deep water ports identified from AAPA (2009).

[203] AAPA (2008b), unless otherwise specified.
[204] AAPA (2009).
[205] AAPA (2009).
[206] AAPA (2009).
[207] Port of Anacortes (2008).
[208] Port of Anacortes (2008).
[209] AAPA (2009) reports no current cargo, but cargo in the recent past.
[210] Port of Longview (2010).
[211] Port of Longview (2010).

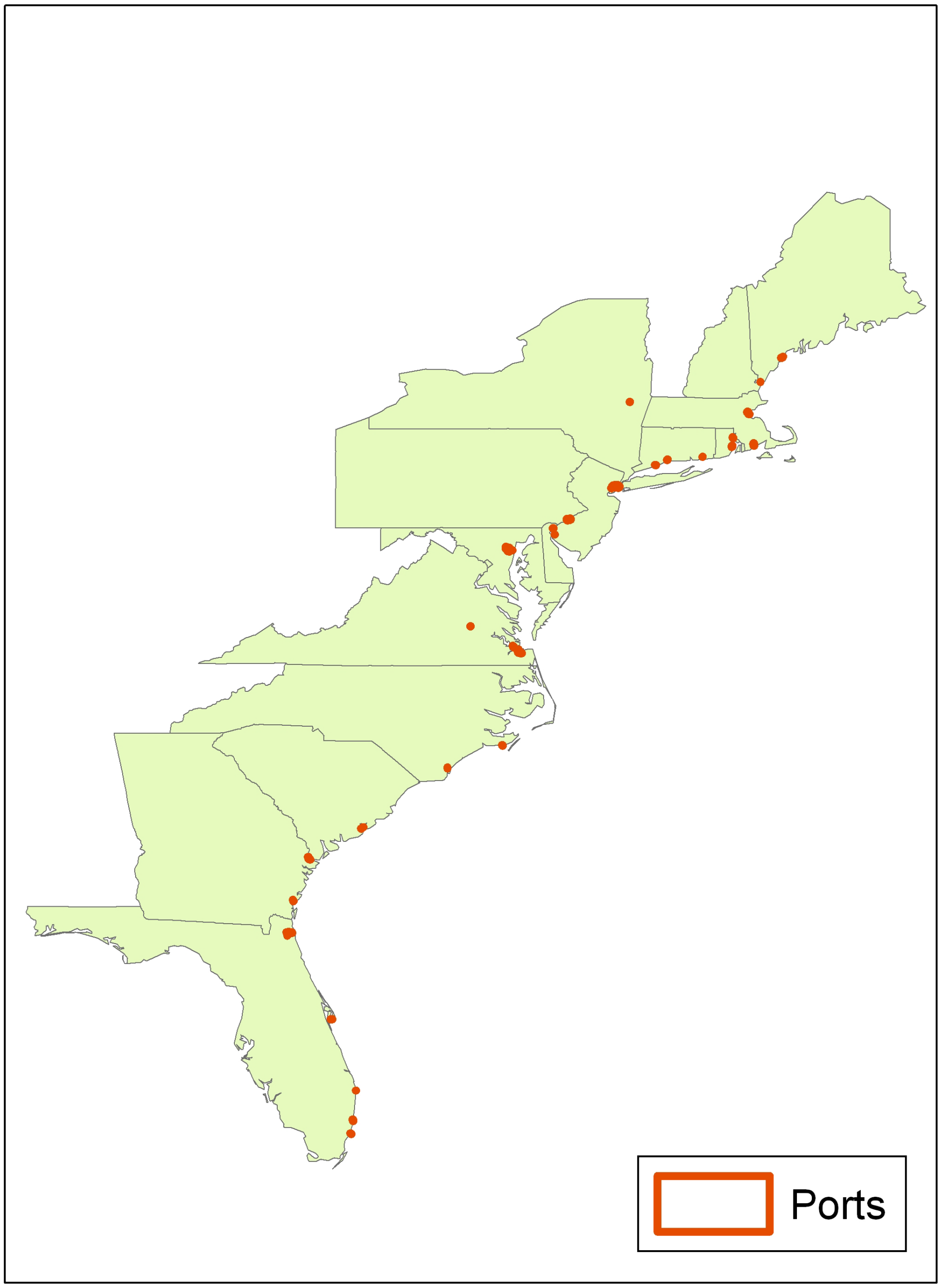

Figure 41.Locations of major East Coast ports.

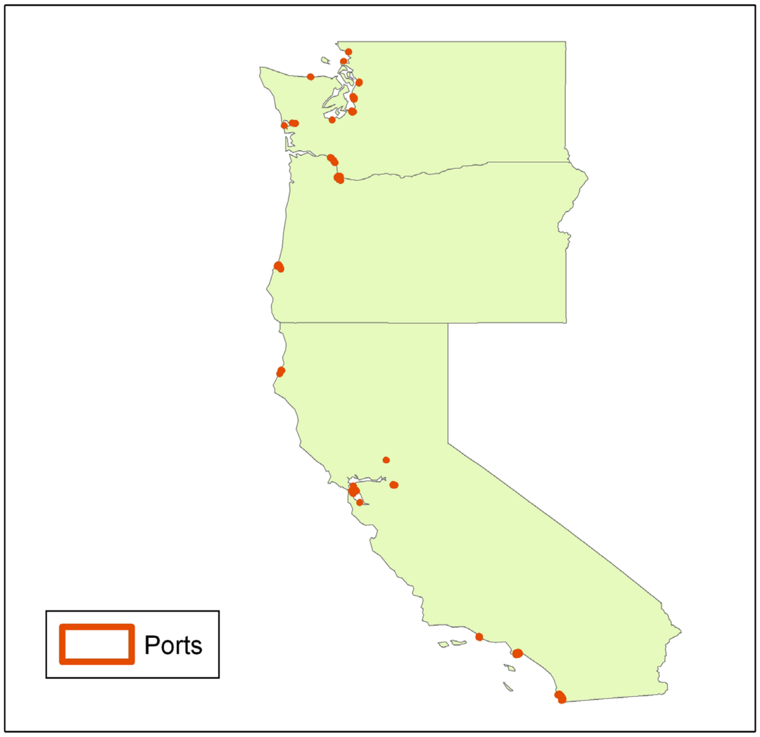

Figure 42. Locations of major West Coast ports.

7.1.2.2 *Smaller Ports*

Generalizing from the plans published by Cape Wind and Deepwater Wind, renewable energy projects are not limited to using large ports, especially after installation is complete. Thus, many smaller ports that could be used as bases for offshore wind projects are not captured in the American Association of Port Authorities list of ports (AAPA 2008b, 2009). ERG used several sources to identify smaller ports including: NOAA's (2006) list of fishing communities, NOAA's Coast Pilot (2011a-e), www.marinasdirectory.org, www.worldportsource.com, www.sailorschoice.com, www.sail-the-net.com, www.ports.com, www.gaports.com, www.portofgraysharbor.com, www.marinalife.com, www.icwfacilitiesguide.com, as well as websites for individual marinas. Whether a port is considered potentially suitable for supporting offshore wind development and operation depends, in part, whether the dock length and dock-side water depth are sufficient to accommodate the necessary vessels and whether there is sufficient infrastructure to support vessel operations. Cape Wind documentation identifies a 65-ft maintenance vessel (USDOIMMS 2009b). Research vessels might be necessary in the beginning phases to install meteorological towers. Stony Brook University's research vessel, the RV Seawolf, has a length of 80 feet and a draft of 11 feet (Stony Brook University 2011). ERG used a criterion of at least 2,000 people in the nearby community as a proxy for sufficient infrastructure as reported in the 2010 Census (US Census Bureau 2011). Thus, any of the 99 ports listed on Table 46 has at least 80 feet in dockspace, 11 feet dockside depth, and a neighboring population of at 2,000 individuals

Table 46
Smaller U.S. East and West Coast Ports

California			
Eureka	Santa Barbara	Santa Cruz	Ventura
Connecticut			
Darien	New London	Norwich	
Delaware			
Delaware City			
Florida			
Fernandina Beach	Fort Pierce	Key West	Saint Augustine
Fort Lauderdale			
Georgia			
Port Wentworth	Saint Mary's	Thunderbolt	
Massachusetts			
Barnstable	Falmouth	Lynn	Plymouth
Beverly	Gloucester	Nahant	Sandwich
Cohasset	Hull	Newburyport	Woods Hole
Maryland			
Annapolis	Cambridge	Crisfield-Somers Cove	
Maine			
Bar Harbor	Camden	Kittery	South Thomaston
Belfast	Cape Porpoise	New Harbor	Southwest Harbor
Boothbay Harbor	Cutler	Northeast Harbor	Stonington
Bucks Harbor	Eastport	Port Clyde	Tenants Harbor
Bucksport	Harpswell	Rockland	
North Carolina			
Beaufort	Elizabeth City		
New Jersey			
Atlantic City	Deepwater Point	Gloucester	Wildwood
Cape May	Elizabeth	Perth Amboy	
New York			
Greenport	Northport	Port Chester	Yonkers
Montauk			

Table 46
Smaller U.S. East and West Coast Ports (continued)

Oregon			
Astoria	Charleston	North Bend	Reedsport
Brookings			

Rhode Island			
Block Island	Point Judith/South Kingston	Portsmouth	Quonset Point
Newport			

South Carolina			
Beaufort	Hilton Head Island	North Charleston	Wadmalaws Island
Georgetown	Isle of Palms	Port Royal	

Virginia			
Alexandria	Newport News	Port Cape Charles	Portsmouth
Hopewell	Norfolk		

Washington			
Aberdeen	Everett	La Conner	Raymond
Blaine	Friday Harbor	Neah Bay	Sequim
Edmonds	Ilwaco	Port Townsend	Westport

Source: NOAA (2006), NOAA Coast Pilots (2011a-e), www.marinasdirectory.org, www.worldportsource.com, www.sailorschoice.com, www.sail-the-net.com, www.ports.com, www.gaports.com, www.portofgraysharbor.com, www.marinalife.com, and www.icwfacilitiesguide.com.

An additional determinant in a port's suitability as a base for renewable energy projects is its proximity to the site. Labor time is a significant component of maintenance costs, and thus worker transit time by boat can become very costly.

7.1.3 Port Governance

This section discusses the agencies that have authority over port operations. Port governance consists of both public and private entities. Port authorities are usually agencies of state or local governments that are established by enactments or grants of authority by the state legislature (USDOT MARAD 2009a).

The federal government does not directly control ports or port authorities, but port activities are subject to federal law and jurisdiction regarding security, safety, environmental protection, customs, and immigration. The U.S. Constitution specifically grants federal jurisdiction over navigable waters of the United States, including deep-draft channels and harbors. Eighteen federal departments and agencies play a role in the marine transportation system, with no single entity designated as the lead agency (USDOT MARAD 2009a). The primary agencies regulating ports and their functions are discussed below.

7.1.3.1 Navigation and Navigable Channels

The Coast Guard places and maintains 50,000 navigation aids, such as buoys, beacons, and radio towers, as well as maintaining aids to longer distance navigation such as LORAN (Long Range Navigation) and DGPS (Differential Global Positioning System) (TRB 2004).

The Ports and Waterways Safety Act of 1972 and the Port and Tanker Safety Act of 1978 authorize the Coast Guard to establish vessel traffic management schemes for U.S. harbors. The Coast Guard carries out these duties by establishing navigation rules and monitoring vessels of a certain size and function to report their location. The Coast Guard uses the latter to provide traffic information and advice on routing (TRB 2004).

NOAA's National Ocean Service surveys and charts U.S. coastal waters and the Great Lakes. NOAA's Physical Oceanographic Real-Time System (PORTS) tool provides mariners with real-time water level, current, and other oceanographic and meteorological information. Port authorities and similar entities pay to install and operate the tool (TRB 2004).

The U.S. Army Corps of Engineers surveys inland rivers and is the primary agency responsible for ensuring the navigability of inland river, coastal, and harbor channels. The Corps also maintains infrastructure such as breakwaters and jetties in ocean harbors and ensures that deep-draft channels are of sufficient width and depth (TRB 2004).

The Coast Guard is responsible for ice breaking in channels and harbors (TRB 2004).

7.1.3.2 Commercial Vessel and Crew Standards

The Coast Guard has numerous regulations governing vessel construction, equipment, seaworthiness, pilotage, fire protection, life-saving equipment, and crew member qualifications (TRB 2004). As such, the Coast Guard will have jurisdiction over matters of navigation and vessel safety, safe access for vessel routes, as well as participate in the NEPA review (USCG 2007).

The U.S. Maritime Administration (MARAD) participates in crew training by supporting and administering the U.S. Merchant Marine Academy and state maritime academies (TRB 2004). Thus, the Administration has a role in ensuring properly-trained crews for offshore energy installation and maintenance operations.

7.1.3.3 Safety Monitoring and Assessment

The Coast Guard collects data on marine incidents. The National Transportation Safety Board also investigates some incidents, focusing on those that resulted in or could have resulted in loss of life, those involving environmental damage, or those involving non-maritime modes of transportation. The Board's recommendations after an investigation are often evaluated and implemented by the Coast Guard (TRB 2004).

7.1.3.4 Environmental Protection

The Coast Guard has the lead role in ensuring that navigation activity is environmentally compatible and issues regulations intended to reduce marine pollution. The Oil Pollution Act of 1990 gave the Coast Guard responsibility for administering the Oil Spill Liability Trust Fund, as well as new responsibilities for environmental protection. The Coast Guard operates the

National Response Center, which helps coordinate pollution response, as well as the National Strike Force, which performs pollution response in conjunction with other agencies. The Coast Guard is responsible for issuing oil spill cleanup and liability regulations and ensuring that the responsible parties pay for cleanup (TRB 2004).

NOAA provides technical and environmental guidance to the states, local governments, and port authorities who operate ports. NOAA's data on tides, currents, weather, and waves inform oil and chemical spill response and restoration. NOAA also oversees fisheries, and the possible impacts on fisheries from activities such as dredging, filling, and placing structures in marshes must be assessed by NOAA (TRB 2004).

NOAA and the Coast Guard work together in developing ballast water management programs to prevent the harmful spread of invasive species (TRB 2004).

The Army Corps of Engineers reviews the environmental impacts of its own actions, as well as conducting environmental reviews for agencies dealing with wetlands (TRB 2004).

The U.S. Environmental Protection Agency (EPA) administers and enforces most Federal environmental statutes, such as the Clean Water Act and the Endangered Species Act. The Clean Water Act regulates water pollution of navigable waters.

7.1.3.5 Security

The Maritime Transportation Security Act of 2002 directs the Coast Guard to work with the Transportation Security Administration to limit access to security-sensitive areas through background checks and use of ID cards, and establishes a grant program for port authorities, terminal operators, and state and local agencies to increase security. In implementing the Act, the Coast Guard is required to assess threats and vulnerabilities at ports (TRB 2004).

The Coast Guard was transferred to the Department of Homeland Security in 2003, where it works with the Transportation Safety Administration and the Bureau of Customs and Border Protection on security initiatives (TRB 2004).

7.2 WATERBORNE TRANSPORTATION

Water transportation is vital to the development of the renewable energy industry. It provides the vessels necessary to carry needed cargo and personnel out to offshore areas for the installation and maintenance of renewable energy infrastructure. The relevant sectors of the water transportation industry are summarized by two North American Industrial Classification System (NAICS) codes: Deep Sea Freight Transportation (NAICS 483111) and Coastal and Great Lakes Freight Transportation (NAICS 483113). Other related industries, including Port and Harbor Services (NAICS 48831), Navigational Services to Shipping (NAICS 48833), Other Support Activities for Water Transportation (NAICS 48839), and Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing (NAICS 532411), primarily provide supporting services to the shipping industry, and were not included in this report.[212]

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[212] Because offshore renewable energy developers might charter or lease vessels during installation or for ongoing maintenance, the Commercial Air, Rail, and Water Transportation Equipment Rental and Leasing (NAICS 532411)

Section 7.2.1 is a general profile for the waterborne transportation industry. Section 7.2.2 provides a general fleet profile while Section 7.2.3 describes the Jones Act and environmental regulations. (See Section 8.3 for a discussion of specialized vessels for the offshore energy industry and potential competition for those vessels by other industries.)

7.2.1 Waterborne Transportation Profile

The U.S. waterborne transportation industry carried 2.3 billion metric tons of cargo in 2008, 60% of which was accounted for by foreign trade. Of the remainder, 8% (182 million tons) was carried by coastal shipping, while 25% was carried on inland waterways. Coastal shipping is dominated by the carriage of petroleum products; tankers carrying crude oil from Alaska to West Coast ports are considered coastal shipping (USDOT MARAD 2009b).

There were 336 deep sea freight transportation establishments and 496 coastal and Great Lakes freight transportation establishments as of 2007 (U.S. Census Bureau 2009a). The former pertains to establishments shipping across the sea, while the latter pertains to establishments shipping between U.S. ports. Almost all deep sea freight establishments were located on the East and West Coasts (94%), although only about half of all coastal and Great Lakes freight transportation establishments were located there (55%). Table 47 presents the employment, annual payroll, and number of establishments by size for the deep sea and the coastal and Great Lakes transportation industries.

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sector could be relevant to this report. However, maritime equipment rental and leasing composes a small fraction of that industry, and is combined with data on rental and leasing for auto, truck, rail, and air transportation—all of which are very different from water transportation—and therefore the data were considered too unrepresentative for inclusion.

Table 47
U.S. Maritime Freight Transportation by Region, 2007

Location	State	Employment	Annual Payroll	Total Establish-ments	Number of Establishments by Employment Size								
					1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1,000+
Deep Sea Freight Transportation													
East Coast	CT	228	48,110	14	3	6	2	2	1	0	0	0	0
	DC	N/A	N/A	1	1	0	0	0	0	0	0	0	0
	GA	132	10,090	13	7	4	0	2	0	0	0	0	0
	MA	N/A	N/A	12	6	1	2	1	1	0	1	0	0
	MD	244	14,905	14	7	3	1	2	0	1	0	0	0
	NC	N/A	510	6	6	0	0	0	0	0	0	0	0
	NH	N/A	N/A	1	1	0	0	0	0	0	0	0	0
	NJ	566	44,133	31	13	5	5	4	2	2	0	0	0
	NY	N/A	65,632	34	13	6	3	9	1	2	0	0	0
	PA	N/A	1,131	6	5	1	0	0	0	0	0	0	0
	RI	N/A	N/A	2	2	0	0	0	0	0	0	0	0
	SC	67	3,419	6	4	1	0	0	1	0	0	0	0
	VA	1,611	148,502	20	7	3	2	4	3	0	0	0	1
East Coast/ Gulf of Mexico	FL[213]	3,190	208,144	69	34	7	6	6	5	9	1	1	0
West Coast	CA	1,643	116,628	51	23	6	10	5	4	2	0	1	0
	OR	N/A	N/A	5	2	2	0	0	0	1	0	0	0
	WA	227	19,692	30	22	0	6	1	1	0	0	0	0
Grand total		N/A	N/A	315	156	45	37	36	19	17	2	2	1
Coastal and Great Lakes Freight Transportation													
East Coast	CT	N/A	N/A	4	2	1	1	0	0	0	0	0	0
	DE	N/A	N/A	3	2	0	0	0	1	0	0	0	0
	GA	33	1,883	6	5	0	0	1	0	0	0	0	0
	MA	283	18,620	14	6	3	1	2	2	0	0	0	0
	MD	N/A	N/A	8	4	2	0	1	0	1	0	0	0
	ME	N/A	N/A	3	1	1	1	0	0	0	0	0	0
	NC	54	2,061	6	2	2	1	1	0	0	0	0	0
	NH	N/A	N/A	1	1	0	0	0	0	0	0	0	0
	NJ	778	56,017	23	10	3	6	2	0	1	1	0	0
	NY	1,746	125,570	50	24	11	4	5	1	2	3	0	0
	PA	278	17,956	9	3	1	2	1	1	1	0	0	0
	RI	N/A	N/A	1	0	0	1	0	0	0	0	0	0
	SC	60	2,352	5	2	1	0	2	0	0	0	0	0
	VA	565	30,704	15	5	3	1	1	3	2	0	0	0
East Coast/ Gulf of Mexico	FL	1,242	94,429	47	18	5	12	7	2	2	1	0	0

[213] ERG could not distinguish between Florida establishments on the East Coast and those on the Gulf of Mexico.

Location	State	Employment	Annual Payroll	Total Establish-ments	Number of Establishments by Employment Size								
					1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1,000+
West Coast	CA	N/A	N/A	29	12	3	5	3	2	2	1	1	0
	OR	476	25,206	13	7	1	2	1	0	1	1	0	0
	WA	1,903	136,543	37	10	7	4	6	2	6	2	0	0
Grand total		N/A	N/A	274	114	44	41	33	14	18	9	1	0

Source: U.S. Census Bureau (2009a).

7.2.2 Fleet Profile

The water transportation industry operates multiple types of vessels. The industry's primary purpose is the transportation of products between ports; most of the vessels can be categorized as self-propelled or as barges, by the type of product carried (dry or liquid; bulk or break bulk), and by method of loading (e.g., containerized or roll-on/roll-off). These categories may or may not be mutually exclusive. Table 48 defines the categories.

Table 48
Major Vessel Types

Type	Definition
Self-propelled	Vessels with on-board propulsion systems powered by either steam or diesel.
Barges	Vessels that rely on another vessel for propulsion (e.g., tugboats, pushboats); may also be classified as tank, dry bulk, container, or roll-on/roll-off barges. In addition to transporting cargo and equipment, flat or deck barges are frequently used as floating work platforms for marine construction projects and may be used by offshore renewable energy developers.
Tugboats	Small vessels powered with very large engines used to push or tow non-self-propelled vessels, such as barges, and so are required any time a barge is moved for either transportation or marine construction.
General cargo	Vessels that are traditional multipurpose freighters that carry non-uniform items packaged as single parcels or assembled together on pallet boards (break bulk). Cargo is typically lifted on and off the vessels using a crane and wire or rope slings.
Bulk carriers	Vessels that carry homogenous unpacked cargo, usually in shipload lots.
Dry bulk carriers	Vessels that carry dry bulk commodities such as grain or ore.
Tankers	Vessels that carry liquid bulk commodities, such as oil or petroleum products; specialized tankers carry liquefied natural gas (LNG) or liquefied petroleum gas (LPG).
Intermodal	Vessels including container vessels and roll-on/roll-off vessels.
Container	Vessels designed to carry cargo in standard-size preloaded containers that permit rapid loading and unloading and efficient transportation of the cargo to and from port.
Roll-on/roll-off	Vessels onto which and off of which cars can be driven.
Offshore supply vessels	Vessels designed to maximize carrying capacity, carrying workers and equipment needed to supply offshore oil and gas drilling and production platforms.

Source: EPA (1997); USDOT MARAD (2009b).

Table 49 presents a general overview of the entire U.S. privately owned fleet. MARAD categorizes vessels by whether they ply ocean, Great Lakes, or coastal waters (except offshore supply vessels, for which that distinction is not made.) The coastal transportation fleet is dominated by tugs and barges.

Table 49
U.S. Privately Owned Fleet, 2008

Fleet	Ships
Ocean	
Tankers	234
Gas tankers	20
Dry bulk	174
Container	102
Roll-on/roll-off	58
Combo	2
General	38
Subtotal, ocean	*628*
Great Lakes	
Dry bulk ("lakers")	47
Offshore Supply	
Offshore supply vessels	689
Coastal	
Tugs	5,707
Dry barges	27,577
Tank barges	4,607
Ferries	611
Subtotal, coastal	*38,502*
Total	39,866

Source: USDOT MARAD (2009b).

Table 50 indicates the number of vessels that meet the requirements of the Merchant Marine Act of 1920, also known as the Jones Act. See Section 7.2.3.1 for a discussion of the Jones Act and the possible implications for installing offshore energy projects.

Table 50
U.S. Privately Owned Fleet by Segment, 2008

Fleet	Ocean	Great Lakes	Coastal and Waterways	Offshore
Total U.S. owned	628	47	38,502	689
Foreign flag[214]	437	0	0	138
U.S. flag	191	47	38,502	551
Jones Act	*98*	*47*	*38,502*	*551*
Other	*93*	*0*	*0*	*0*

Source: USDOT MARAD (2009b).

7.2.3 Water Transportation Regulations

There is a substantial amount of regulation pertaining to the water transportation industry. The following section briefly covers several of the major acts relating to the sector, considering both those that do and those that do not pertain to the environment.

7.2.3.1 Non-Environmental Regulations

The Merchant Marine Act of 1920, also known as the Jones Act, was designed to ensure the continued existence of the U.S. shipbuilding industry, as well as a cadre of trained merchant seamen as necessary for national security. The Jones Act requires that any vessels that sail between U.S. ports must be owned by U.S. citizens, sail under the U.S. flag, and be operated by crews of U.S. citizens (ICAF 2008; USDOT MARAD 2010). Vessels in three categories meet Jones Act requirements: 1) U.S.-built and U.S.-flagged, 2) reconstructed in the U.S. and U.S.-flagged, or 3) foreign-built but forfeited under violation of U.S. law and now U.S.-flagged. Along with the Byrnes-Tollefson Amendment—which requires that vessels for the U.S. armed forces must be built in U.S. shipyards—the Jones Act guarantees that at least a minimal level of ship construction will occur in the U.S. and therefore ensure the existence of domestic shipbuilding. USDOE NREL (2010d) mentions that the effect for offshore wind development is that only vessels qualified under the Jones Act will be able to transport, construct, install, and maintain offshore wind turbines.

The act also mandates that workers on U.S.-flagged vessels be entitled to compensation until they recover, called "maintenance and cure," in the event of injury due to employer negligence or a vessel's lack of seaworthiness (TrueSpring 2008). Seamen covered by this act may not also claim eligibility for compensation under the Longshoremen's and Harbor Workers' Act.

[214] By registering a vessel under a "flag of convenience" rather than under the flag of the nationality of ownership, ship owners can usually reduce operating costs and pay lower taxes (USDOT MARAD 2006).

7.2.3.2 Environmental Regulations

The CAA General Conformity Rule, Section 176(c)(1), results in the need to examine whether emissions from the activities involved in construction, installation, and operation of an offshore energy facility will occur in a non-attainment area. If so, the emissions need to be estimated and addressed; see Section 3.3.4.7 above. For example,MMS stipulated that Cape Wind purchase emission offsets (USDOIMMS 2009d).

The Ocean Dumping Act further strengthens dumping prohibitions by explicitly forbidding dumping of waste and other materials in U.S. waters, and requires permits for those who wish to dump provided that there is no notable danger in doing so. Disposal is required to occur at least 106 miles offshore (EPA 1997).

The Clean Water Act also has a set of wastewater permit requirements, and instituted a requirement that facilities have contingency plans on-hand to document the location of storage vessels, types of containment, emergency response equipment to a leak, and procedures for contacting the appropriate regulatory authorities (EPA 1997).

Although the Resource Conservation and Recovery Act addresses the generation, transportation, treatment, storage, and disposal of hazardous waste, these provisions apply to the facilities housing the vessels, not the vessels themselves, meaning that bilge water and used oil are considered to be exempt for the vessels. However, this is subject to debate as the matter has been discussed within EPA previously (EPA 1997).

The Comprehensive Environmental Response, Compensation, and Liability Act authorized EPA to coerce parties responsible for hazardous substances entering the environment to rectify any damages they produce (potentially including water transportation), or to reimburse EPA for any cleanup that needs to be performed. The Emergency Planning and Community Right-to-Know Act complemented this, requiring that any facilities responsible for certain hazards inform the legislatively designated responsible bodies for addressing said scenarios (EPA 1997).

The Hazardous Materials Transportation Act regulates the manner in which some materials are transported, requiring additional paperwork, potentially specialized training, and a government-specified number of personnel to be on hand (EPA 1997).

7.3 SHIPYARDS AND SHIPBUILDING

The shipbuilding industry is essential to the development of the offshore renewable energy industry. It manufactures the vessels necessary for bringing parts and personnel out to sea for the installation and maintenance of renewable energy infrastructure. U.S. Economic Census data on the shipbuilding industry are found in two NAICS sectors: Shipbuilding and Repairing (NAICS 336611) and Boat Building (NAICS 336612). The former consists of establishments operating a shipyard for building purposes other than personal or recreational use, while the latter focuses on fulfilling the same purposes. Since both the offshore renewable energy and petroleum industries are commercial enterprises and use the same types of vessels, this report focuses on NAICS 336611.

7.3.1 Number and Location of Shipyards and Establishments

The exact number of U.S. shipyards varies according to source and their criteria for defining a shipyard. The Census Bureau found 656 establishments belonging to NAICS 336611 (U.S. Census Bureau 2009b). EPA found 346 shipyards classified in NAICS 336611 as of 2006 (EPA 2007), while an independently maintained shipyard directory is consistent with the EPA estimate, listing 343 shipyards (Colton 2010). The latter tally explicitly excludes establishments that act as maintenance departments for a parent company, establishments with no waterfront operations, and establishments that only manufacture pleasure craft and/or non-commercial fishing vessels.[215,216]

Of the 343 shipyards found in the directory, 137 are located in an East Coast or West Coast state. However, of the 26 facilities listed in Florida, ERG found that only 10 were located in East Coast towns, reducing the number of facilities actually located on the coasts to 121. The state-by-state count of shipyards can be found under Table 51, while the shipyard directory for East Coast and West Coast sites can be found in Appendix E. Table 51 also provides establishment counts from County Business Patterns—including facilities that do not appear to directly perform ship construction—to provide a sense of overall industry size.

Table 51
Shipyard Count by Region, 2007–2010

Region	State	Shipyards	Census Establishments
East Coast	CT	4	10
	DE	N/A	1
	GA	2	5
	MA	5	13
	MD	3	22
	ME	5	16
	NC	2	9
	NH	N/A	4
	NJ	3	13
	NY	7	22
	PA	6	4
	RI	4	6
	SC	3	6
	VA	10	37
East Coast/Gulf of	FL[217]	26	86

[215] In addition, several of the entries in the directory have multiple listings with one address, indicating different facilities for different vessel-sizes.

[216] The industry maintains 100% coverage and product specialization ratios, indicating that the establishments included in NAICS 336611 are dedicated strictly to shipbuilding and repair, and that only they perform these services (U.S. Census Bureau 2009b). Thus, the difference between Census and other source establishment counts is primarily due to the inclusion of office and other support establishments, and that Census might count a single physical location as multiple establishments.

[217] Ten shipyards in the Shipbuilding History database appear to be on the East Coast; however, ERG was unable to distinguish between Florida's East Coast and Gulf of Mexico locations in the Census data.

Region	State	Shipyards	Census Establishments
Mexico			
West Coast	CA OR WA	14 13 30	64 16 66
Relevant total		137	400

Source: Colton (2010); U.S. Census Bureau (2009a).

7.3.1.1 Shipyard Types

MARAD provides more detailed information about the largest and most important shipyard and repair facilities, along with those it designates as medium or small. A major shipyard and repair facility is considered to be "one that is open and has the capability to construct, drydock, and/or topside repair vessels with a minimum length overall of 122 meters [400 feet], provided that the water depth in the channel to the facility is at least 3.7 meters." In general, shipyards with building positions also provide repair services (USDOT MARAD 2004).

Further distinctions between types are defined in Table 52. MARAD conducts an annual survey of major shipyards that can be used to classify ship construction and repair facilities based on the definitions in Table 52.

Table 52
Privately Owned Shipyard Facility Types

Type	Definition
Major Shipyard Facility Types	
Active shipbuilding yard	Has at least one shipbuilding position capable of accommodating a vessel 122 meters (400 feet) in length or over; no dimensional obstructions in the waterway leading to open water (i.e., locks, bridges); water depth in the channel to the facility is at least 3.7 meters.
Other shipyard with build positions	Has at least one building position capable of accommodating a vessel 122 meters in length or over, but has not constructed a naval ship or major oceangoing merchant vessel in the past two years; may not be capable of ship construction without significant capital investments.
Repair yard with drydock facility	Has at least one drydocking facility that can accommodate vessels 122 meters in length and over; water depth in the channel to the facility is at least 3.7 meters; may also be capable of constructing a vessel less than 122 meters in length overall.
Topside repair facility	Has berth/pier space for topside repair of ships 122 meters in length and over; water depth in the channel to the facility is at least 3.7 meters; may also have drydocks and/or construction capability for vessels less than 122 meters in length.

Type	Definition
Medium and Small Shipyard Facility Types	
Boatbuilding and repair company	Capable of building and/or repairing maritime vessels less than 122 meters in length.
Vessel repair company	Only provides repair services, either with drydocking or topside repair, to maritime vessels less than 122 meters.
Fabricator/ manufacturer of maritime vessels	Builds small commercial craft less than 76 meters (250 feet).
Barge building and repair company	Builds or repairs barges.
Recreational craft building/repair company	Builds and repairs recreational craft such as yachts.

Source: USDOT MARAD (2004).

For the 85 privately owned major shipyards identified, MARAD has produced a regional count for each major shipyard subcategory; these can be found in Table 53.

Table 53
Privately Owned Major Shipyards by Type and Region, 2004

Region	Active Shipbuilding Yards	Other Shipyards with Building Positions	Repair Yards with Drydock Facilities	Topside Repair Yards	Total
East Coast	4	1	12	12	29
West Coast	1	2	6	6	15
Gulf of Mexico	4	7	6	14	31
All other regions	0	5	3	2	10
Total	9	15	27	34	85

Source: USDOT MARAD (2004).

Additionally, facilities can be differentiated by the types of docks they use. "Ships can be either wet-docked or drydocked. A wet-dock or berth is a pier or a wet slip position that a ship can dock next to and tie up. A ship that has its entire hull exposed to the atmosphere is said to be drydocked" (EPA 1997). Ships routinely need access to a drydock for maintenance, removal of marine growth, cleaning, painting, and significant repairs. Lesser repairs may be performed while a ship is still in the water. Table 54 describes the classification of dock facilities.

Table 54
Types of Ship Construction and Repair Positions

Type	Definition
Building ways	Building ways are used only for building ships and releasing them into the adjacent waters.[218]
Graving docks	Graving docks are artificial rectangular bays where water can be let in and pumped out. Ships are floated into the dock area when the dock is full of water. Water-tight gates are closed behind the ship and the water is pumped from inside the dock area to the outside adjacent waters. Graving docks may be used for ship repair or construction.
Floating drydocks	Floating drydocks are floating vessels secured to land that can be lowered under the water's surface in order to raise ships above the water surface. The drydock is submerged by filling ballast tanks with water, ships are floated into and positioned within the dock, and the ballast tanks are pumped out, which raises the dock and the ship above the water surface. Floating drydocks are used for ship repair and—more rarely—ship construction.
Marine railways	Marine railways have the ability to retrieve and launch ships. A marine railway essentially consists of a rail-car platform and a set of railroad tracks. The rails are secured to an inclined slab that runs the full length of the way and into the water to a depth necessary for docking ships. A motor and pulley system is located at the head of the railway to pull the rail-car platform and ship from the water. Marine railways are used for repairs to smaller ships.

Source: NSRP (1993) as referenced by EPA (1997).

For the 85 major shipyards included in Table 52, MARAD also produced a tally of the number of docks they operate by type. A regional count of these types can be found in Table 55.

[218] This document does distinguish different types of facilities that are only used for ship construction (e.g., land levels versus more traditional shipways).

Table 55
Privately Owned Major Shipyard Build and Repair Positions by Region, 2004

Region	Shipbuilding Ways	Graving Docks	Floating Docks	Marine Railways	Total
East Coast	16	21	11	2	50
West Coast	5	1	13	0	19
Gulf of Mexico	24	4	16	0	48
All other regions	3	6	4	0	13
Total	48	32	44	2	126

Source: USDOT MARAD (2004).

Some vessels used to install wind farms, such as the purpose-built TIV *Resolution,* exceed 122 meters (400 feet) in length (Ship-Technology 2010), and would have to be built in a major shipyard. However, many other vessels (such as smaller lift boats and vessels used for wind farm maintenance) do not exceed that length and could be built in smaller shipyards.

As befits its reliance on customers supporting the offshore petroleum industry, construction of offshore support vessels appears to occur primarily in the Gulf of Mexico. ERG found that five companies have delivered liftboats to this industry since 2007; all of those companies are located exclusively on the Gulf of Mexico (Liftboats.com 2010). Data were not available to determine the location of anchor handling tug suppliers, but it is presumed they are generally located on the Gulf of Mexico, as well.

7.3.1.2 Dominant Shipyards

The shipbuilding industry is heavily dependent upon the U.S. military, which constitutes approximately 70% of market demand (ICAF 2009), with the remainder belonging to the commercial sector. Although there are nearly 600 establishments primarily engaged in shipbuilding and repair (U.S. Census Bureau 2009b), the industry is dominated by two firms (General Dynamics and Northrop Grumman) which operate the "big six" shipyards (ICAF 2008). Three of these shipyards are located on the East Coast, while one is located on the West Coast. Of these:

- Bath Iron Works, Bath, Maine, is also owned by General Dynamics. Although traditionally a major builder of merchant ships, it has not built one since 1982, instead specializing in the construction of cruisers and destroyers for the U.S. Navy.

- Electric Boat, Groton, Connecticut, is owned by General Dynamics. It specializes in the construction of nuclear-powered submarines for the U.S. Navy.

- Newport News, Newport News, Virginia, is owned by Northrop Grumman. It no longer appears to build merchant vessels, but does provide repair services for them (10-K 2010).

- NASSCO, San Diego, California, is owned by General Dynamics. It builds both commercial and U.S. Navy vessels.

The two remaining "big six" shipyards are on the Gulf Coast.

7.3.1.3 Employment

The Economic Census also provides data on shipyard employment by establishment size. Although the caveats discussed above concerning establishment counts still apply, these data provide a useful characterization of the distribution of shipyard and repair facilities by size and location. Table 56 presents the number of shipyard establishments by size and location for the East and West Coasts.

Table 56
Shipyard Establishments by Number of Employees and State, 2007

Region	State	Employees	Annual Payroll ($1,000)	Total Establishments	Number of Establishments by Employment at Site: 1 to 4	5 to 9	10 to 19	20 to 49	50 to 99	100 to 249	250 to 499	500 to 999	1000+
East Coast	CT	N/A	N/A	10	2	3	2	0	1	1	0	0	1
	DE	N/A	N/A	1	0	1	0	0	0	0	0	0	0
	GA	N/A	N/A	5	3	0	0	1	0	1	0	0	0
	MA	311	15,950	13	6	2	2	1	0	2	0	0	0
	MD	245	10,649	22	9	2	6	5	0	0	0	0	0
	ME	N/A	N/A	16	6	2	2	2	3	0	0	0	1
	NC	N/A	2,063	9	6	2	0	1	0	0	0	0	0
	NH	N/A	N/A	4	1	1	0	1	0	1	0	0	0
	NJ	1,604	65,831	13	4	2	2	3	0	1	0	0	1
	NY	N/A	20,597	22	7	3	6	5	0	1	0	0	0
	PA	N/A	N/A	4	0	0	0	0	1	2	0	1	0
	RI	N/A	N/A	6	0	1	1	3	0	1	0	0	0
	SC	N/A	N/A	6	1	1	1	1	0	1	1	0	0
	VA	N/A	N/A	37	4	7	4	4	8	3	5	1	1
East Coast/ Gulf of Mexico	FL[219]	2,678	127,400	86	46	11	12	8	2	4	2	1	0
West Coast	CA	7,092	353,944	64	25	11	8	8	5	4	1	1	1
	OR	590	24,821	16	2	4	3	4	2	1	0	0	0
	WA	4,033	213,785	66	20	11	10	10	2	9	3	1	0
Grand total		N/A	N/A	400	142	64	59	57	24	32	12	5	5

Source: U.S. Census Bureau (2009a).

Additionally, MARAD published Bureau of Labor Statistics employment figures for privately owned U.S. shipyards. Although not strictly comparable to the 2007 Economic Census figures due to differences in definition and base year, these data (Table 57) emphasize the significance of the four shipyards on the East Coast and West Coast owned by General Dynamics and Northrop Grumman, which account for 40% of shipyard employment. Average hourly wage for these employees was $18.46 in 2004 (USDOT MARAD 2004).

[219] ERG was unable to distinguish between Florida establishments located on the East Coast and those on the Gulf of Mexico.

Table 57
Employment at Private Shipyards by Region, 2004

Category	Shipyard	Employment[220]
Atlantic coast	Bath Iron Works	6,500
	Electric Boat	9,700
	Newport News	18,800
Pacific coast	NASSCO	4,000
Subtotal, four shipyards		39,000
% of all private shipyards total		40%
All other private shipyards		58,800
% of all private shipyards total		60%
All private shipyards		97,800

Source: USDOT MARAD (2004); Colton (2010).

Although complete regional employment distributions are not available, MARAD's employment figures for production workers (i.e., excluding office and support staff) at the 85 shipyards it designates as major may be representative of overall patterns. MARAD estimated that 43% and 14% of major shipyard production workers are employed on the East Coast and West Coast, respectively; 39% are employed in Gulf Coast shipyards.

7.3.2 Fabrication Sites

The offshore oil and gas industry has developed a significant infrastructure that specializes in the fabrication of offshore drilling rigs and production platforms. The structures built for this industry may have to stand in water up to 1,700 feet deep, have 100,000 square feet or more of main deck area, or support a floating weight of tens of thousands of tons (Louis Berger Group 2004; Offshore Technology 2010). A 2001 inventory of the oil platform fabrication industry found 43 facilities, many of which specialize in production of components for the platform, with a handful of larger facilities constructing the largest components. Five of these facilities exceed 400 acres in size, and nine exceed 150 acres; however, 31 facilities (72%) are smaller than 100 acres (Louis Berger Group 2004).

Offshore wind farms also require fabrication sites to construct foundations and supporting structures, assemble the turbine and blades, and load vessels to take the components to the offshore site (Gerdes et al. 2006). However, the scale of fabrication is substantially smaller than for offshore oil and gas platforms. A study of four installations in Europe found that sites ranged from 15,000 square meters (about 3.7 acres) to fabricate 80 turbines for the Horns Rev wind farm to 64,000 square meters (15.8 acres) for the 72 turbines of the Nysted wind farm (Gerdes et al.

[220] Employment in the four shipyards specified by name was reported directly by the shipyard to MARAD; overall total employment was estimated by the Bureau of Labor Statistics, and therefore may not be completely consistent.

2006).[221] In Quonset Point, Rhode Island, Deepwater Wind has leased 117 acres (473,000 square meters) in order to fabricate structures for three different offshore wind sites, including a planned five-to-eight turbine pilot site near Block Island, a planned 117 turbine site 15 to 25 miles off the coast of Rhode Island, and a third site off of the coast of New Jersey (Scharfenberg 2009). The Reedsport OPT project also describes the buoys to be manufactured at a site away from the coast and then deployed by barge (Sibley 2009).

7.3.3 Shipbuilding Regulations

Numerous non-environmental regulations and environmental regulations affect the shipbuilding industry. Non-environmental regulations that affect the industry pertain to vessel origins, labor standards, and shipyard grants. Many of these were found through MARAD's *Compilation of Maritime Laws* and MMS's 2004 infrastructure report.

7.3.3.1 Non-Environmental Regulations

The Jones Act and its effects on U.S. ships and shipyards are discussed in Section 7.2.3.1 above.

The Longshoremen's and Harbor Workers' Compensation Act (codified under Chapter 18 of 33 USC) mandates the continued reception of a worker's regular salary and medical benefits for workers involved in the "loading, unloading, repairing or building of a vessel" (TrueSpring 2008). It also provides the authority for 29 CFR 1915, which establishes labor standards pertaining to the welding, cutting, and heating of materials; working surfaces and areas; and the securing of ship systems when construction is being performed around vital systems. Eligible workers are restricted to longshoremen, not seamen, and workers may not claim benefits under both the Longshoremen's and Harbor Workers' Compensation Act and the Jones Act.

Provisions from other acts provide grants to the industry. For example, the National Defense Authorization Act of 2006 (specifically 46 USC 54101) gave MARAD the ability to make grants to small shipyards (defined as having 600 or fewer employees) for capital improvements. Additionally, the Consolidated Appropriations Act of 2008 (Public Law 110-161) provided further grant money to small shipyards, facilitating the improvement of infrastructure affecting the quality of domestic ship construction. The federal government further supports the industry via the Tariff Act of 1930 (more commonly known as the Smoot-Hawley Tariff Act, embodied in 19 USC 1466), which places a 50% tax on the cost of all repair work done on domestic vessels at foreign establishments. The list of fiscal year 2010 grants to small shipyards does not specifically identify any of the improvements to support offshore energy development (USDOT MARAD 2010).

7.3.3.2 Environmental Regulations

A series of environmental regulations also affect the industry. The Oil Pollution Act of 1990 (specifically 46 USC 3703a) imposes some additional manufacturing costs on the industry for oil tankers by mandating that they have a double-layered hull to prevent hull ruptures and possible

[221] The planners for the Horns Rev project apparently badly underestimated the necessary site size. The original site was 5,000 square meters; it was later expanded to 15,000 square meters, although 25,000 square meters would have been preferred (Gerdes et al. 2006).

spills from ruptures. The Resource Conservation and Recovery Act's Subtitle C imposes restrictions on solid wastes that shipyards may generate during machining, metalworking, cleaning, degreasing, plating, surface finishing, preparation, painting, or coating (Louis Berger Group 2004). The CAA mandates that shipyards adhere to a set of volatile organic compound limits (Louis Berger Group 2004) that apply to the emission of 10 or more tons of any one hazardous air pollutant, and any shipyard that emits more than 25 tons of total hazardous air pollutants. The Clean Water Act is analogous, mandating that shipyards must purchase permits to discharge their wastewater into navigable waters, with a special set of restrictions and permit application requirements applying to storm water (Louis Berger Group 2004). The Comprehensive Environmental Response, Compensation, and Liability Act provides the legal framework for Superfund sites to clean up hazardous waste sites, some of which consist of chemical compounds produced by shipyards (Louis Berger Group 2004).

7.4 Submarine Cable Laying and Production Industry

Power from offshore wind turbines is transmitted to the main grid through high-voltage submarine cables that are buried under the ocean floor, creating a link between the point of power production and consumption. The installation of these cables is carried out by specialized submarine cable layers that dig under the sea floor and lay cable over vast stretches of ocean. As larger and larger wind farms are planned, they tend to be placed further and further out to shore. This means that the connecting submarine power cable must be longer and capable of handling higher voltages than ever before.

In terms of the geographical focus of the industry, almost all companies with experience in offshore wind projects are based in Europe, because most of the projects have been developed and completed off European coastlines. However, significant subsea cable projects have been completed for the oil and electric power transmission industries in the U.S.; see the case studies in Section 7.4.3 below.

7.4.1 Issues Associated With Undersea Cable Laying

A key decision that must be made in siting a wind farm is how far offshore to place the generation equipment. In shallower waters, a shorter cable is needed, less precision is required for surveying and designing installed equipment, and smaller, less costly vessels can be used. Smaller cable-laying vessels (CLVs) generally cost $35,000 to $65,000 per day plus fuel, which costs $15,000 to $25,000 per day on average. However, the permitting process is much more complicated in these areas because there is greater risk of human contact and environmental damage. In deeper environments, the reverse is true; permits are easier to obtain but operating in deep waters requires careful planning and execution that can be costly (Axelsson 2008).

Wind farms tend to be located in areas that are difficult to access due to high winds and rough seas and therefore maintenance tends to be expensive. Additionally, if cable is not installed correctly in the first place it can result in significant costs down the line. Ian Gaitch, Director of Global Marine Energy at Global Marine Systems, was quoted as saying, "A lot of the work on the market lately has been remedial work. There are a number of sites around Europe where cables have not been installed as they should have been" (Stancich 2010). This has reduced the profitability of offshore wind. Part of the problem is inherent in the installation process, which requires long periods of fair weather to install a long cable; if bad weather occurs, the cable-layer will have to cut the cable and return later to complete the job. This practice can increase the risk of installation problems. Also, although this is less of an issue with deeply buried power cable than with telecommunications cable, there is always the risk that an unsuspecting commercial vessel will disturb subsea cable as it anchors or trawls for fish (Stancich 2010).

In the event that a cable needs repair, there may be a considerable amount of downtime before it can be completed. Global Marine Services operates a fleet of specialized vessels strategically positioned around the globe to respond to damaged telecommunications cables, but does not use the same system for power cables. If a repair is necessary in the near term, marine assets and crews must be contracted out; given the time needed to assemble crews and repair vessels, this could mean a three-month repair time. With a specialized vessel system placed in strategic locations, that time could be reduced to four weeks (Stancich 2010).

7.4.2 Cable Technology

In terms of options for the types of cable technology, both DC and AC submarine cable systems exist in the market. Because wind turbines generate power as AC and the onshore transmission grid is AC, the most obvious choice for cable type is an AC connection system. In today's market, the most advanced and cost-effective AC technology for this type of interconnection is solid dielectric (also called extruded dielectric or polymeric insulated) cable, usually with cross-linked polyethylene (XLPE) insulation (Mar Athanasius College of Engineering 2009). These systems have been used for most wind farms that are in operation. Nexans, a French company, installed its 170 kV XLPE AC submarine cable for the Horns Rev wind farm off the coast of Denmark in 2009.

In contrast, high-voltage direct current (HVDC) transmission systems are less common for wind farms but are used for grid interconnectors that are created to stabilize electricity supply. DC systems are more economical over long distances due to their lower demand for reactive power for energy transmission, but they require expensive converter stations at each end in order to convert the current from DC to AC (Rudervall et al. 2000). Therefore, as wind farms become larger and farther out to sea, DC systems become more attractive as the longer distances favor lower power losses, and the larger scale means the high fixed costs of the converter stations will be spread over more power generation, resulting in lower average costs (Mar Athanasius College of Engineering 2009). Additionally, DC systems can carry more power per conductor (per cable) and offer supply stability advantages, since they allow power transmission between unsynchronized AC distribution systems. The two leading versions of HVDC cable in the market today are the HVDC Light technology (developed by the ABB Group, a Swiss technology firm) and HVDC PLUS (developed by Siemens).

7.4.3 Case Studies

Two significant underwater power cables have been laid in U.S. waters in the last eight years. These two projects may be representative of what might be involved in laying the cable for a substantial offshore wind farm.

7.4.3.1 The Cross Sound Cable

The Cross Sound Cable is an HVDC transmission interconnector (40 kilometers, or about 25 miles, long) that links the New England and New York electricity grids. It runs between New

Haven, Connecticut, and Long Island and is an essential component of the growing but capacity-constrained New York and New England electricity markets (Babcock & Brown Infrastructure 2006). Commissioned in 2002 and operating since 2005, it can transmit up to 330 MW continuously in either direction. The interconnector was installed in order to improve the reliability of power in the Connecticut and New England energy grids and in order to allow increased sharing of power plant capacity, thereby reducing the capacity each must have for a particular winter or summer (ABB 2009).

The project was initiated by TransÉnergie U.S. Ltd., which is headquartered in Westborough, Massachusetts, and is a U.S. subsidiary of Montreal-based Hydro-Quebec. It was privately developed, placing the entire financial burden on TransÉnergie and its investors. TransÉnergie subcontracted the cable portion of the project out to ABB Power Technologies, a Swedish subsidiary of the ABB Group, which manufactured and installed its patented HVDC Light cable system. The cable was manufactured in Karlskrona, Sweden, and then transported to the United States to be installed. ABB mobilized a variety of marine assets for the installation, including a specialized CLV called *Sea Spider* (now called *TEAM Oman*) to lay the HVDC cable precisely on the ocean floor. Next, a remotely operated underwater vehicle (ROV) called the Smartjet plow fluidized the seabed with pressurized water to create a narrow trench, allowing the cable to rest 6 feet under the seabed (ABB 2010). Reportedly, six days after the cable was installed, the seabed had returned to its natural state as the cable was covered over (ABB 2010).

Of course, high-voltage submarine interconnectors tend to be much longer and capable of higher voltages than subsea cables typical of offshore wind projects. For example, the Cape Wind project plans to have a 115 kV submarine power cable system that will stretch 12.5 miles.

7.4.3.2 The Neptune Regional Transmission System

The Neptune Regional Transmission System is a 65-mile, 660 MW electric transmission cable system that links Long Island's grid to lower-cost energy sources in New Jersey, Pennsylvania, and 11 other states in the mid-Atlantic and Ohio River Valley regions. Siemens Power Transmission and Distribution, Inc., a wholly owned U.S. subsidiary of Siemens AG, supplied the HVDC conversion and control technology required for the AC-DC conversion stations at each end of the cable. Prysmian Cables and Systems was subcontracted by Siemens to supply and install the principal submarine transmission line, consisting of a bundle of three cables—a 500 kV HVDC cable, a fiber optic cable, and a medium-voltage metallic return cable. Additionally, Prysmian provided a 0.5-mile-long 230 kV AC (XLPE) cable system at the Sayreville converter station and a similar 2-mile-long 345 kV cable system in order to link the Duffy Avenue converter station to the Long Island Power Authority (LIPA) Newbridge Road interconnection installations. Both the submarine and the land cables of the HVDC system were manufactured by Prysmian in Arco Felice (near Naples), Italy; the two AC cables were produced in Gron, France, and Delft, The Netherlands (Prysmian 2009a).

Construction of the cable system began in fall of 2005 and was completed one month ahead of schedule in June 2007. In terms of marine assets employed, Prysmian's *C/S Giulio Verne,* an advanced and versatile CLV, was the principal operating asset and was responsible for transporting the cable from Arco Felice to New York. The vessel is equipped with a 7,000-ton turntable for carrying high-voltage cables and has a capstan crank with a pulling tension of 55 tons. Additionally, its dynamic positioning system (DPS) allows the vessel to follow a predetermined route with extremely high accuracy. Supporting the *Giulio Verne* were several other marine assets, including the *Prysmian I* barge, trenching and embedding ROVs, and a team of divers for shallower operations (Prysmian 2007).

7.4.4 Major Companies

The industry is composed of a variety of companies performing specialized functions:

- Manufacturing the advanced AC and HVDC cable systems.
- Providing marine assets to perform the physical installations.
- Ancillary services such as project management, system engineering, and associated planning, coordination, and operations activities.

In some cases, a single large corporation carries out all these tasks; in others the tasks are subcontracted.

As of early 2010, nearly all major high-voltage cable manufacturing companies were based in Europe. Furthermore, because the cable tends to be loaded onto the main CLV during the manufacturing process, European firms also dominated the cable-laying services market. This is especially true on projects oriented toward wind farms, where Europe has taken the lead.

However, the cable-laying industry has been in existence for decades and similar firms do exist in the U.S. to assist the oil and gas and the telecommunications industries with their offshore projects. Although these other industries are still the biggest consumers of cable-laying services, the same methodologies that are used on their projects can be transferred to wind farms and other marine renewable energy projects (Axelsson 2008).

- *Global Marine Systems Limited.* Based in the United Kingdom, Global Marine Systems is a subsea marine engineering services provider for the international energy market. With over 600 employees, they operate across all major sectors, including the oil and gas, offshore, and renewable energy markets. Their capabilities include subsea cable installation, surveying/route engineering, ROV operation, project coordination, communications, and logistics. The company has a fleet of multi-role large CLVs positioned around the globe—for example, *The Cable Innovator,* a 477-foot CLV that is equipped with an ROV, a 21-wheel pair linear cable engine, and DPS, and can operate continuously for 45 to 60 days (Global Marine Systems 2010). During the summer of 2002, Global Marine Systems was contracted to lay and bury all power cables within the Horns Rev wind farm site off the coast of Denmark. At the time, Horns Rev was the largest wind farm in operation, requiring 160 cable connections for its 80 turbines.

- *Van Oord.* Based in the Netherlands, Van Oord is an international marine contractor that works on dredging, offshore, and marine engineering projects around the world. In 2008, Van Oord teamed with Evelop, a division of the Dutch sustainable energy company Econcern, to plan and build four offshore wind farms in Western Europe. The first project will be the 330 MW Belwind project off the coast of Belgium, for which Van Oord will be responsible for the installation of foundations and electrical cabling. Three wind farms off the German coast—Gode Wind, OWP West, and Albatros—are the next projects planned by Evelop and Van Oord.

- *The ABB Group*. This Swiss technology firm is the world's biggest supplier of electrical systems to the wind energy industry. It developed and manufactured the advanced HVDC Light cable system that was installed in the Cross Sound Cable project, as well as the NorNed Interconnector currently being installed for the BorWin1 wind farm off the coast of Germany. When completed, BorWin1 will be the world's largest wind farm and will mark the first time that HVDC technology will be used to connect a wind farm to the main power grid.

- *Nexans*. Nexans is a French company expert in cables and cabling systems that was in charge of installing the subsea cable for the Horns Rev 2 wind farm. They installed 70 kilometers of medium voltage cable to connect 91 turbines, as well as a 42-kilometer high-voltage AC XLPE 170 kV power cable to connect the wind farm to the mainland at Henne Strand—the world's longest cable of this type. The cables were buried at water depths of 9 to 18 meters (Nexans 2010a). Nexans' contract was reported to be worth €30 million (Nexans 2010b). One of their most impressive assets is the *C/S Nexans Skagerrak* CLV. This CLV is 378 feet long; it has a 7,000-ton, 26-meter wide cable turntable, a computer-based laying control system, and DPS, and can also deploy Nexans' specialist Capjet ROV trenching systems for cable burial operations (Offshore Shipping Online 2006). It was reportedly involved in laying ABB's 576-kilometer-long NorNed Interconnector.

- *Siemens Power Transmission and Distribution, Inc.* This division of Siemens AG is a leading supplier of high- and medium-voltage power delivery equipment and energy management and information systems. While the parent company has extensive wind farm experience on projects such as Horns Rev 2, Siemens Power Transmission and Distribution is also experienced on HVDC projects such as the Neptune Regional Transmission System described above.

- *Prysmian Cables and Systems.* Formerly Pirelli Cavi e Sistemi S.p.A., this corporation is a large Italian cable and cable systems manufacturing firm with subsidiaries in 38 countries, 53 plants in 21 countries, seven research and development centers, and over 12,000 employees. In 2005, they manufactured and installed a 65-kilometer HVDC cable system for the Neptune RTS project described above. In 2010, Prysmian was awarded a €18 million (about $24.46 million in 2010 U.S. dollars) contract by the Danish utility DONG Energy to supply a complete 132 kV export cable system for the 51 turbines in the second phase of the Walney Offshore Wind Farm project in the Irish Sea. This project is expected to be completed by summer 2011 (Prysmian 2009b).

- *Parker Scanrope.* A Norwegian subsidiary of Parker Hannifin Corporation, Parker Scanrope manufactures cable products for the world's energy industry as well as large steel and synthetic mooring lines and other specialized rope products for the offshore industry. In 2009, it won a purchase order from Van Oord Dredging and Marine Contractors to supply array cables worth more than €7.8 million ($11.1 million in 2010 U.S. dollars) for phase 1 of the Belwind wind farm offshore of Belgium. The first-phase array cables include 50 kilometers of submarine cable and associated services and will connect 55 turbines being installed in the first phase.

8 MANUFACTURING INFRASTRUCTURE

For any of the proposed wind projects to become reality, three questions must be answered:

- Who will supply the turbines and where will they be built?
- Who will install the structures?
- Who will supply the marine electrical cables and where will they be built?

Because there are no existing offshore wind energy projects in the U.S., there is no existing domestically owned manufacturing infrastructure for this industry. This chapter reviews the major players in each area and speculates what conditions might need to occur for these goods and services to be offered domestically.

8.1 TURBINES

Three manufacturers with significant experience with offshore wind turbines have manufacturing plants in the U.S. None of these domestic plants currently produce wind turbines suitable for offshore sites. Offshore wind turbines differ from onshore turbines in a number of ways. The main conceptual difference is that components of offshore turbines must be more robust and have significantly improved corrosion protection to operate in the harsh salt water environment (Nitschke et al. 2006). However, the economics of offshore wind energy impose additional design constraints on wind turbines. Because offshore maintenance can be five times costlier than onshore maintenance, reliability and minimal routine maintenance are at a premium. Also, to spread the substantially higher fixed costs associated with foundations and cabling over as large an output as possible, offshore wind farm developers will use larger individual wind turbines than they would for onshore sites (Gerdes et al. 2006; Musial et al. 2006).

It is unclear how difficult it would be to produce components for offshore wind turbines in any of these manufacturers' facilities. Presumably facilities producing wind turbines for onshore use can be converted to also produce offshore turbines. The production of turbine blades, however, might be more difficult. For example, Siemens produces 148-foot blades for onshore turbines in its Fort Madison, Iowa, plant; blades for offshore turbines might reach lengths of nearly 200 feet.

GE Wind is the dominant manufacturer of wind turbines supplying the U.S. market (USDOE EERE 2008, 2009b). The total number of GE facilities producing wind turbine components in the U.S. cannot be determined with certainty. In 2008, GE had announced plans to build at least three additional U.S. facilities. By 2009, GE had ceased development of its 3.6 MW geared offshore turbines, stating an intention to focus on the onshore wind energy market (Galbraith 2009). Since halting development of its offshore turbine, GE has purchased a Norwegian manufacturer of offshore wind turbines, ScanWind (LaMonica 2009). ScanWind is a leader in the development of direct drive turbines. A direct drive turbine would avoid gearbox failure, which has been identified as a major reliability problem in the geared turbines used in the vast majority of wind applications (USDOE NREL 2009).

Siemens AG, headquartered in Germany, claims to be the fifth-largest wind turbine manufacturer in the world and the largest manufacturer of offshore wind turbines. To serve the U.S. market, Siemens opened a wind turbine blade manufacturing facility employing approximately 260 workers in Fort Madison, Iowa, in 2007 at a cost of $28 million. The facility manufactures 148-foot blades for its 2.3 MW turbines (Siemens 2007). Siemens opened a second manufacturing facility for wind turbine gear drives in Elkin, Illinois, in 2009 at a cost of about $20 million; this plant employs about 350 workers (Siemens 2009). In 2009 Siemens broke ground on a $50 million wind turbine manufacturing plant in Hutchinson, Kansas, that is expected to employ about 400 people. Cape Wind announced its decision to use Siemens wind turbines in 2010 (Cape Wind 2010).

Vestas Wind Systems A/S of Denmark claims to be the largest manufacturer of wind turbines and the second largest manufacturer of offshore wind turbines in the world. Vestas has three manufacturing locations in Colorado: two in Brighton that manufacture turbine blades and nacelles and a third in Winsor that also manufactures turbine blades. As of December 2009, these facilities employed about 735 workers, with an additional 1,400 sales and service staff elsewhere in the U.S. and Canada (Vestas 2009).

While it is clear that companies like GE, Siemens, and Vestas are willing to invest in manufacturing facilities for onshore wind, it is less clear that they are willing to invest in manufacturing facilities for offshore wind. These same companies will probably need to see more offshore wind projects in development, before they begin to invest in offshore wind manufacturing facilities. A *New York Times* article about manufacturing offshore wind turbines in the U.S. states that manufacturers would need to see the equivalent of five or six Cape Wind projects in the pipeline before they would be willing to invest in new manufacturing sites (Lehmann 2009c). A recent study comparing Europe and the U.S. in offshore wind development is neutral on whether turbines for U.S. offshore wind projects would be manufactured in the U.S. (Snyder and Kaiser 2009b). There has been nothing to indicate that European production is so backlogged as to cause significant delay or that shipping costs to the U.S. would be prohibitive.

8.2 MARINE CABLES

Wright et al. (2002) note the lack of a domestic manufacturer of medium- and high-voltage insulated submarine cables. Because of the close ties between cable manufacture and the CLVs needed for offshore wind farm installation, discussion of European manufacture of submarine cables is included in Section 7.4.

8.3 SPECIALIZED VESSELS FOR OFFSHORE RENEWABLE ENERGY

Section 8.3.1 describes the types of vessels that might be used in the installation and operation of offshore energy projects. Section 8.3.2 discusses the possibility of competition for the vessels with other industries.

8.3.1 Specialized Vessels

Routine maintenance of offshore renewable energy sites may not require highly specialized vessels; Cape Wind, for example, does not expect to routinely need maintenance vessels more than 65 feet long, and the types of craft proposed, such as crew boats, should be readily available (USDOIMMS 2009b).

8.3.1.1 Tugs and Barges

Installation of offshore wind farms might require specialized construction vessels. Such vessels have been designed and built in Europe, but they are similar to those already used for the construction of offshore oil and gas drilling and production platforms. Most offshore wind farms installed to date in Europe have used vessels of the latter type; the design and construction of purpose-built vessels is a relatively new development. Descriptions of wave energy projects, such as that off Reedsport, Oregon, mention deploying the units by barge (FERC 2010e).

As previously mentioned, tugs and barges will likely be used in the construction of offshore renewable energy projects. The backbone of almost any maritime construction project, a barge can be used like a flatbed truck to move material to and from shore and the worksite. Pile-driving equipment and cranes may also be temporarily or permanently mounted on barges (Herman and Kooijman 2002). Finally, they can be used for near-shore installation of cables. The size of the tug used in conjunction with barges will depend on a number of factors. If barges are only to be used for transportation of equipment, tugs may be fairly standard. If the site is further offshore, or equipment such as pile-drivers or cranes are mounted on barges, the tug might need to be more robust and sophisticated, such as the anchor handling tugs (AHTs) used in the offshore petroleum industry. AHTs and the hybrid anchor handling tug supply (AHTS) vessels are workhorses, accounting for over 50% of all tug and supply vessels and 32% of all offshore support vessels used in that industry (Clarkson Research Services 2006a, 2006b).[222] There are no publicly available estimates of the U.S. AHT and AHTS fleet currently available.

8.3.1.2 Heavy Lift Ships

Heavy-lift-capable vessels are necessary for the handling and installing of foundations, support structures, and turbine and blade assemblies, as well as supporting electrical equipment such as transformers. In Europe, jack-up lift rigs have generally been used to provide the required lifting capability, although heavy lift cranes have also been used (Herman and Kooijman 2002). The jack-up legs provide stability during the installation process. Jack-up rigs may be mounted on barges or be self-propelled, in which case they are called liftboats. Liftboats are widely used in the offshore petroleum industry.

At least 229 liftboats appear to be available for charter worldwide.[223] Of these, 216 are owned in the United States, with 205 listed as currently operating in the Gulf of Mexico and one operating in New England. However, many of these vessels are relatively small (Liftboats.com 2010). The exact capabilities required for use in constructing offshore wind farms will vary with site conditions (e.g., water depth, distance from shore) and turbine specifications (e.g., type of supporting structure, height above water, size and weight of turbine assembly), but a review of the vessels used in Europe suggests these specifications: two cranes, one with 25 metric tons

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[222] Clarkson Research Services publishes the dominant industry guides to these vessels. Their two most relevant publications for offshore construction vessels are *Anchor Handling Tugs and Supply Vessels of the World,* 13th edition, and *A–Z of Offshore Support Vessels of the World,* 5th edition.

[223] The database from which this information was drawn depends on listing by the owner. At a minimum, it does not appear to include the liftboats known to have been used by the contractors installing the Horn Rev offshore wind farm. Also, it lists liftboats available for charter, which presumably excludes liftboats owned and operated solely "in-house." Therefore we assume this voluntary listing represents an underestimate of total operating liftboats.

capacity and one with 80 to 100 metric tons capacity, and 800 square meters of deck space (A2SEA 2010; Axelsson 2008). Only 22 of the liftboats in the database (all U.S.-owned) meet these requirements; all can work in water up to 125 feet deep and 19 can work in water up to 150 feet deep, although liftboats that can work in water exceeding 200 feet are under construction (Liftboats.com 2010).

In 2003, the first specialized TIV was completed. The 14,900-gross-ton vessel is almost 430 feet long, with a beam of about 125 feet. It has six jack-up legs, can work in water 150 feet deep, and has two cranes (one of which has a capacity of 300 metric tons) as well as an ROV (Ship-Technology 2010). Although plans for future TIVs were delayed by the economic downturn, it appears that at least five of these specialized vessels have been ordered for delivery in 2011 and 2012 (Williams 2010; Windpower Monthly 2010; Offshore Wind 2010). Furthermore, the Community of European Shipyards' Associations and the European Wind Energy Association predict that 10 newbuilds will be required for projected growth in offshore wind beyond 2020 (Baird Maritime 2010). A U.S. Department of Transportation grant was sought to subsidize the building of three TIVs at the Aker Philadelphia Shipyard, but funding was not forthcoming and plans for construction of U.S. TIVs appear to be on hold (Marine Log 2010).

Kaiser and Snyder (2010) provide additional information about liftboats, jackup barges, self-propelled installation vessels (SPIV), or heavy lift vessels for the offshore renewable energy industry. Table 6.2 in the report crosstabulates vessel type by the likelihood of being used to install foundations, turbines, cables, or substations.

8.3.1.3 Cable-Laying Vessels

CLVs are needed to lay and bury the power cables necessary for inter-field connection and power transport to shore. They have a specific application design, and only a handful exist. CLVs are generally large ships of 110 meters (350 feet) or larger. It may be possible to procure the necessary cable machinery or use a contractor that has a portable set of cable machinery for mobilization onto an existing vessel. But handling machinery for cable installations is not easily or readily available to the industry as stand-alone equipment (Axelsson 2008).

Kaiser and Snyder (2010) review multiple methods of installing cable for offshore wind farms. These range from using a remote-operated vessel to plow and lay the cable, to trenching first and then laying the cable, to laying the cable first and trenching later. Factors affecting the method used include soil type, depth of burial, or need for scour protection. Horizontal drilling is discussed as a viable method of getting a cable to an onshore substation with minimal disturbance of delicate transition zones.

8.3.1.4 Sub-Sea-Capable Vessels

Sub-sea-capable vessels use ROVs or divers to perform deep sea trenching and inspection services of the subsea infrastructure. Cable burial or protection can take place either during installation or post-lay. The in situ method uses a cable burial plow; post-lay involves an ROV with a cable jetting tool. Burial plows are large pieces of equipment (9 meters long, 18 metric tons) requiring large handling equipment for launch and recovery. Plows are not easily mobilized to a vessel of opportunity. Divers may be used for depths from 20 to 50 meters in near-shore cable installation activities such as cable landing services, post-lay inspection, and installation of cable protection in environmentally sensitive areas, where burial may be prohibited (Axelsson 2008). While the three major vessel types described above are primarily needed for installation, it may be necessary to perform periodic inspection of undersea infrastructure, thus creating a longer-term demand for these vessels.

8.3.2 Potential Conflicting Demands of the Offshore Energy Industry With Other Industries for Vessels

There is a debate concerning the availability of vessels to install future offshore wind farms in the U.S. For example, USDOE NREL (2010d) cites a position from the American Wind Energy Association that the availability of suitable vessels may be a short-term barrier to development; Peter Mandelstam, CEO of Bluewater Wind, identifies vessels as a "choke point," and that it would likely be cost-prohibitive to convert vessels from the oil and gas industry (Jesmer 2009).[224] Other sources, such as Yanchunas (2010), indicate the likelihood that early efforts will use vessels from the offshore oil and gas industry. Part of the debate stems from a difference in perspective. As explained in the introduction, this report focuses on "what is" rather than "what might be." "What is" is that there are no dedicated wind farm installation vessels available in the States due to the requirements of the Jones Act (see next section). "What might be" might involve multiple wind farms and wave farms along the Atlantic and Pacific coasts—see Tables 8 and 9 in Section 2.4.18.1, as well as USDOE NREL 2010b and 2010d. Should all the opportunities discussed in USDOE NREL 2010d come to rapid fruition, there might be a short-term peak in demand for such vessels.

Essentially all offshore wind vessel types described in this section are used in the offshore petroleum industry; some newly developed vessels, like the TIV, which are particular to offshore wind, are essentially specialized versions of other vessels that are used in the offshore petroleum industry. Offshore wind is in direct competition with offshore petroleum for the use of these vessels. Until offshore wind becomes a sizable industry with some continuity of demand, the supply and demand for these types of offshore support vessels, and therefore the price of chartering such vessels, is likely to be determined by the offshore petroleum industry. Vessel day rates will generally fluctuate with the price of oil. For example, in 2008, when oil prices exceeded \$130 per barrel, the oil and gas industry was expanding the exploration for and development of new fields and the infrastructure to produce and transport oil, which resulted in rates in excess of \$100,000 per day for offshore support vessels (Axelsson 2008). By July 2009, demand slowed, which, by some estimates, dropped the day rate by half (Sanchez 2009). With the 2010 *Deepwater Horizon* blowout and associated moratorium on deepwater drilling, demand slowed even further. Thus, at this time, the competition between the offshore oil industry and the offshore energy industry is at a low point compared to 2008. A developer for a commercial database on heavy lift vessels observed that in Europe many of the offshore wind projects have been undertaken using retrofitted barges (Bodle 2010); that is, it is possible for Jones Act vessels in the United States to be used this way.[225]

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[224] ERG has not been able to find detailed information on what would be involved in the conversion, and thus cannot compare conversions and new-built vessels.

[225] A reviewer raised questions about the ability of retrofitted vessels to handle Atlantic conditions. In May 2008, a 25-year-old liftboat was researching bird migration off the Delaware coast for Bluewater Wind when the engine

For wave and ocean current projects, ERG found either no reference to the vessel type used to install the units or a reference to barges. Table 49 above lists over 27,000 dry barges, a number from which ERG infers a reasonable supply.

ERG did not consider there to be potential conflicts in demand for vessels between the commercial fishing industry and the offshore energy industry. Fishing vessels frequently have wells to store fish and gear to handle nets or lines. Thus, vessels suitable for offshore energy projects would not be suitable for commercial fishing. Nor did ERG anticipate much competition for dock space at ports during the construction or operating phases, either because of use of otherwise unused facilities or the small number of vessels, respectively. During the construction phase when specialized vessels would be needed, both Deepwater Wind and Cape Wind identified an otherwise unused facility at Quonset Point, North Kingston, Rhode Island, as the debarkation point. Deepwater Wind envisioned the Quonset Point location would serve all Deepwater Wind offshore wind farms in the Northeast. During the operating phase, the small number of vessels (four to five) and the relatively small vessel size (under 65 feet) are unlikely to lead to unsustainable demands for dock space. If necessary, the vessels could be moored except for loading and unloading and the harbormaster would coordinate such matters.

8.4 GROWING DOMESTIC INDUSTRIES

Companies are hesitant to make long-term investments in new technologies, such as building manufacturing facilities, until they are confident that there will be a long-term market for their products (Lehmann 2009c; Ling 2010). While it is not clear just how many offshore wind farms might be necessary to create the critical mass that triggers new investment, it is clear that a substantial long-term commitment to offshore energy is needed before a domestic industry grows to serve it.

To have a critical mass of projects, offshore wind energy must be competitive with onshore energy sources (including onshore wind). Weiss et al. (2008) note that without the PTC, a significant percentage of offshore wind projects—perhaps more than 40%—would not be viable. The same study notes that the sale of RECs made the difference between viability and non-viability for up to one-quarter of the projects. Snyder and Kaiser (2009b) note that the PTC has expired three times in the last 10 years; the intermittent nature of a PTC is likely to make a company pause before committing to a project that depends on it for its economic success. Snyder and Kaiser also note that onshore wind projects are now able to compete with coal- and natural-gas-fired power but that offshore wind is still too new an industry to compete with conventional sources. It is possible that—as the offshore wind industry climbs the learning curve—costs might become more competitive with onshore energy sources. Musial and Butterfield (2004), for example, cite estimates that unit costs decline by 18% for each doubling of capacity as new technologies are introduced.

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failed and the vessel broke apart in a storm (Saxton 2008). Such tragedies are not unknown in the water transportation industry, and this does not necessarily indicate that retrofitted Gulf of Mexico vessels are not capable of handling Atlantic conditions.

European nations have undertaken long-term support for offshore wind generation (Section 4.3). While individual states have taken action, no guaranteed long-term support at the national level is in place at this time (Sections 2.1 and 4.3). Some proponents for a climate bill argue that, without a price on carbon to internalize the cost of carbon emissions, there will be no economic parity between fossil-fuel-based electrical generation and non-fossil-fuel sources (Ling 2010).

There has been some support on the federal level. For example, in May 2009, DOE provided $25 million in funding for the Massachusetts-NREL Wind Technology Testing Center to be located in Charlestown, Massachusetts. The center will be the first commercial large blade test facility in the nation; it will allow for testing of blades longer than 50 meters (164 feet), which currently can be done in Europe but not in the United States (USDOE 2009b; MTC 2010b). A third-party testing center for blades is a basic part of a system to ensure the quality and specifications of offshore wind system components.

Future support might include a marine transmission line to act as a "backbone" linking multiple offshore wind farms to the onshore grid (see Sections 3.4.4 and 6.3). Ten East Coast governors made recommendations to Congress to enact legislation that would promote renewable energy resources. One recommendation is the establishment of an offshore wind transmission regime, in particular a transmission "backbone" to facilitate the interconnection of offshore energy generation to onshore load centers. The governors note that this effort would involve MMS (later BOEMRE, now BOEM), DOE, and FERC (Governors 2009). One advantage of a marine transmission backbone is that, because it would collect electricity from multiple windfarms, it would smooth out some of the "lumpiness" associated with offshore wind energy (since calms in one offshore area may be offset by wind blowing in another offshore area). A second advantage is that, from the standpoint of the developer, it could result in lower transmission costs for each wind farm due to the socialization of costs (DE Office of the Governor 2010; Nathans 2009). The backbone was only in the conceptual stage as of early 2010; however, in October 2010, Google and the financial firm Good Energies have expressed an interest in offshore wind transmission and have invested in a proposed 350-mile transmission backbone (Wald 2010).

9 COMMUNITY IMPACTS

9.1 INTRODUCTION

There is more than one approach to estimating community impacts. There are *direct impacts,* which are the jobs and spending associated with the project itself (e.g., building a PowerBuoy). There are *indirect impacts* that occur when the supply chain is refilled (e.g., the steel mill needs to manufacture more steel to replace that used in the PowerBuoy). Finally, there are *induced impacts* caused by household spending of the wages earned by the employees.

The total impacts (i.e., the sum of direct, indirect, and induced impacts) can be several times higher than just the direct impacts. A study sponsored by OWET estimated the Oregon coast might see 45 jobs from a research and development project, 802 jobs from a 500 MW wave farm, and about 2,700 jobs if 2,500 MW of equipment were manufactured in Oregon and exported elsewhere. However, for the 500 MW wave farm, the report estimates about 361 direct jobs with the additional 441 jobs resulting from indirect and induced effects (ECONorthwest 2009). The larger the region, the larger the proportion of the spending that remains within that region. Thus, the 2,700 jobs associated with the 2,500 MW scenario increases to slightly more than 6,000 jobs when the entire state of Oregon is considered (ECONorthwest 2009). For the operating phase, the number of estimated jobs is 91; 264; or 11,113 depending on whether the scenario is a research and development, commercial wave farm, or industrial manufacturing. The number of direct industrial manufacturing jobs is 5,058, which is based on the assumption that 100 percent of the engineering services, platework and structural steel manufacturing, and wave power generation module manufacturing take place within Oregon (ECONorthwest 2009).

USDOE NREL (2010d) estimates that, if 54 GW of offshore wind energy is installed, it could support 43,000 O&M jobs with an additional 1.1 million job-years needed in the manufacturing and construction phases. These estimates, in addition to being total impact values for the nation, assume a new industry developing in the United States to support a substantial portion of the supply chain.

Because there are specialized models, such as IMPLAN, that estimate indirect and induced effects, this study focuses on the number of direct jobs associated with typical offshore renewable energy projects. This means that the number of jobs and the concomitant impacts are likely to be smaller than those discussed in other reports.

9.1.1 How Projects Might Impact Local Communities

Offshore renewable energy projects have two phases that can potentially affect coastal communities. The first is the *construction phase,* when the turbines (or other generators) and their supports are manufactured, assembled, transported, and installed. This is typically a short period (e.g., six months to a couple of years) with a higher level of employment. How much impact this has on the coastal community depends on the proportion of the goods and services that are area supplied locally. The turbines, for example, might be made locally or imported from another region, state, or country. The supporting structures, such as bases for the wind turbines, could be made locally for an imported turbine. The assembly area is likely but not necessarily to be located on the coast. The installation vessels might be brought in from the Gulf of Mexico or be locally modified barges. CLVs and the associated cables might be imported (see Section 7.4.3).

The second phase is the *operating phase*. This phase involves fewer employees than the construction phase, but the jobs last for many years over the project lifetime. Vessels and employees are more likely to be drawn from the neighboring community.

9.1.2 Case Study Approach

ERG selected a case study approach to provide community descriptions for locations where socioeconomic impacts from the development of offshore renewable energy projects might occur. Accordingly, Section 9.2 describes a West Coast wave project, while Section 9.3 describes some of the New England communities that might be affected by the Cape Wind and Block Island projects. The community descriptions are modeled after those developed for MMS in *Benefits and Burdens of OCS Activities on States, Labor Market Areas, Coastal Counties, and Selected Communities* (Petterson et al. 2008). The county or parish is the smallest unit considered in the report. This report examines the county and communities within the county that might be affected. Each case study begins with a basic introduction to location, industries, and population centers. Descriptive statistics are provided for population, employment, income/poverty/unemployment rates, education, and health and welfare. The final subsection in the case study describes the renewable energy project proposed for the region. Section 9.4 extrapolates the findings to other areas.

9.2 WEST COAST WAVE PROJECT

The OPT Wave Park near Reedsport, Oregon will likely be the first wave park to be developed in the U.S. (Section 2.4.16.2). Much of the business and commercial impact of the project will be focused in Reedsport, with socioeconomic community impacts felt in Douglas County, Oregon.

Douglas County borders Lane County to the north, Klamath County to the east, Jackson County and Josephine County to the south, Coos County West and Curry County to the southwest, and the Pacific Ocean to the west. Twelve towns constitute Douglas County: Canyonville, Drain, Elkton, Glendale, Myrtle Creek, Oakland, Reedsport, Riddle, Roseburg, Sutherlin, Winston, and Yoncalla. There are also numerous unincorporated communities and census-designated places.

Economic activity in Douglas County has been historically focused on the forest products industry, agriculture, orchards, and livestock, but has moved into industries expected in small-town areas (U.S. Census Bureau 2000).[226]

For the most part, the towns in Douglas County are small, rural towns with populations less than 2,000 (some even less than 1,000) and, at most, around 1 square mile of land. Employment in Douglas County is focused in four industries: 1) manufacturing; 2) retail trade; 3) arts, entertainment, recreation, accommodation, and food services; and 4) education, health, and social services (U.S. Census Bureau 2000).

9.2.1 Population Centers

There are five larger towns: Myrtle Creek, population 3,419; Reedsport, population 4,378; Winston, population 4,613; Sutherlin, population 8,085; and Roseburg, the largest town, with 20,017 people and about 10 square miles of land (U.S. Census Bureau 2000).

Reedsport was established on the estuary of the Umpqua River in 1852. According to the U.S. Census Bureau, the total area of Reedsport is 2.3 miles and the population is 4,378, with 1,627 people in the labor force. The timber industry has historically provided significant employment in the city; since its recent collapse, the economy has seen an increase in tourism because of its fishing and sand dunes.

Employment in Reedsport is focused in management, professional, and related occupations; service occupations; sales and office occupations; government work; and construction, extraction, and maintenance occupations. The wave park is predicted to add jobs to the Reedsport economy during the construction, deployment, maintenance, and monitoring phases. OPT is planning to use local labor as much as possible, taking advantage of a labor force that already understands the Oregon ocean environment (Harshman 2009).

OPT recently reached a settlement agreement for the project in August. It has declared its intent to contract with Oregon Iron Works, where the first buoy is being manufactured. Oregon Iron Works, in turn, intends to contract with American Bridge for the project, although no official information on contracts is currently available from the companies (Harshman 2009; Northwest Renewable News 2009a; Renewable Energy World 2010).

9.2.2 Population

In 2000, the total population of Douglas County was 100,399; for Reedsport it was 4,378. Table 58 presents the population distribution. A significant portion of the population is over 60: 23.1% in Douglas County as a whole, and 32.3% in Reedsport. The median age in Douglas County is 41.2 years, compared to a median age in Reedsport of 47.1 years (U.S. Census Bureau 2000). Both Douglas County and Reedsport are fairly evenly split between male and female population:

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[226] The most recent U.S. Census data available for Reedsport are from 2000. For this reason, ERG used 2000 data for both Reedsport and Douglas County.

Douglas County is 49.2% male and 50.8% female, while Reedsport is 48.3% male and 51.7% female.[227]

Table 58
Reedsport and Douglas County, Oregon: Age/Sex Distribution, 2000

Parameter	Count		Percent	
	Douglas County	Reedsport	Douglas County	Reedsport
Total population	100,399	4,378		
Age distribution and sex				
Under 5 years	5,629	210	5.6	4.8
5 to 9 years	6,387	247	6.4	5.6
10 to 14 years	7,429	295	7.4	6.7
15 to 19 years	7,219	259	7.2	5.9
20 to 24 years	4,971	171	5.0	3.9
25 to 34 years	10,122	366	10.1	8.4
35 to 44 years	14,199	505	14.1	11.5
45 to 54 years	15,267	622	15.2	14.2
55 to 59 years	6,004	291	6.0	6.6
60 to 64 years	5,284	267	5.3	6.1
65 to 74 years	9,644	590	9.6	13.5
75 to 84 years	6,306	433	6.3	9.9
85 years and over	1,938	122	1.9	2.8
Male	49,389	2,113	49.2	48.3
Female	51,010	2,265	50.8	51.7

Source: U.S. Census Bureau (2000).

Table 59 summarizes the racial makeup of the county and community. Both Douglas County and Reedsport are predominantly white: 96.5% and 96.1%, respectively. Douglas County is 0.4% black or African American, 3.4% American Indian and Alaska Native, 1.0% Asian, 0.2% Native Hawaiian and other Pacific Islander, and 1.4% some other race. Similarly, Reedsport is 0.3% Black or African American, 2.9% American Indian and Alaska Native, 0.8% Asian, 0.1% Native Hawaiian and other Pacific Islander, and 2.3% some other race.

[227] The 2000 U.S. Census does not provide the margin of error for these percentages.

Table 59
Reedsport and Douglas County, Oregon: Race, 2000

Parameter	Count		Percent	
	Douglas County	Reedsport	Douglas County	Reedsport
Total population	103,945	4,378		
White	96,845	4,207	96.5	96.1
Black or African American	359	11	0.4	0.3
American Indian and Alaska Native	3,368	125	3.4	2.9
Asian	1,041	33	1.0	0.8
Native Hawaiian and other Pacific Islander	233	3	0.2	0.1
Some other race	1,410	102	1.4	2.3

Note: Respondents could check more than category.
Source: U.S. Census Bureau (2000).

9.2.3 Employment

Table 60 shows employment by industry in both Douglas County as a whole and Reedsport. Employment patterns show some differences between the two areas: the highest percentage of the employed population of Douglas County works in management, professional, and related occupations (25.5%), while the highest percentage of the employed population of Reedsport works in service occupations (27.3%). The next highest percentages of the employed population work in sales and office occupations (23.2%) and management, professional, and related occupations (24.7%) for Douglas County and Reedsport, respectively. Production, transportation, and material moving occupations account for 20.5% of employment in Douglas County; sales and office occupations account for 20.4% of employment in Reedsport. Douglas County's three smallest industries by employment are service occupations (still with 18.2% of employment); construction, extraction, maintenance, and repair occupations (9.8%); and lastly farming, fishing, and forestry (only 2.8% of employment). In Reedsport, the three smallest industries by percentage of employment are construction, extraction, maintenance, and repair occupations (13.9%); production, transportation, and material moving occupations (11.3%); and lastly farming, fishing, and forestry (2.4% of employment).

Table 60
Reedsport and Douglas County, Oregon: Occupation, 2000

Parameter	Count		Percent	
	Douglas County	Reedsport	Douglas County	Reedsport
Civilian-employed population 16 years and over	41,670	1,464		
Management, professional, and related occupations	10,634	362	25.5	24.7
Service occupations	7,574	399	18.2	27.3
Sales and office occupations	9,670	299	23.2	20.4
Farming, fishing, and forestry occupations	1,182	35	2.8	2.4
Construction, extraction, maintenance, and repair occupations	4,075	204	9.8	13.9
Production, transportation, and material moving occupations	8,535	165	20.5	11.3

Source: U.S. Census Bureau (2000).

Table 61 re-summarizes employment data for Douglas County and Reedsport by occupation. The highest percentage of the employed population in both Douglas County and Reedsport is in educational services, health care, and social assistance, with 20.9% and 19.3%, respectively. The second most populated industry for Douglas County is manufacturing, with 17.1% of the work force; in Reedsport it is arts, entertainment, recreation, accommodation, and food services, also with 17.1% of the work force. In Douglas County, retail trade and arts, entertainment, recreation, accommodation, and food services each claim close to 10% of employment, while other occupations (in order from most to least populated: construction; agriculture, forestry, fishing and hunting, and mining; other services except public administration; transportation, warehousing, and utilities; professional, scientific, management, administrative, and waste management services; public administration; finance, insurance, real estate, rental, and leasing; wholesale trade; information) claim around 5% or less. In Reedsport, retail trade claims 14.7% of employment and construction claims 11.2%; professional, scientific, management, administrative, and waste management services claim 7.8%; and other occupations claim roughly 5% or less (in order from highest to least populated: transportation, warehousing, and utilities; manufacturing; agriculture, forestry, fishing and hunting, and mining; public administration; other services except public administration; information; finance, insurance, real estate, rental and leasing; wholesale trade).

Table 61
Reedsport and Douglas County, Oregon: Occupation, 2000

Parameter	Count		Percent	
	Douglas County	Reedsport	Douglas County	Reedsport
Civilian-employed population 16 years and over	41,670	1,464		
Agriculture, forestry, fishing and hunting, and mining	2,255	65	5.4	4.4
Construction	2,807	164	6.7	11.2
Manufacturing	7,146	71	17.1	4.8
Wholesale trade	1,519	14	3.6	1.0
Retail trade	4,990	215	12.0	14.7
Transportation, warehousing, and utilities	1,999	96	4.8	6.6
Information	732	46	1.8	3.1
Finance, insurance, real estate, rental and leasing	1,576	28	3.8	1.9
Professional, scientific, management, administrative, and waste management services	1,978	114	4.7	7.8
Educational services, health care, and social assistance	8,706	283	20.9	19.3
Arts, entertainment, recreation, accommodation, and food services	3,837	250	9.2	17.1
Other services, except public administration	2,160	54	5.2	3.7
Public administration	1,965	64	4.7	4.4

Source: U.S. Census Bureau (2000).

9.2.4 Income, Poverty, and Unemployment Rates

Table 62 shows the median income and poverty level statistics for Douglas County and Reedsport. The median household income in 2000 was $33,223 for Douglas County and $26,054 for Reedsport. The median family incomes for Douglas County and Reedsport were $39,364 and $33,689, respectively. The percentage of families living below the poverty level is 9.6% for Douglas County and 11.7% for Reedsport.

Table 62
Median Income and Poverty Level Statistics: Douglas County and Reedsport, Oregon, 2000

Parameter	Count/Percentage	
	Douglas County	Reedsport
Median household income (dollars)	$33,223	$26,054
Median family income (dollars)	$39,364	$33,689
Percentage of families whose income in the past 12 months is below the poverty level	9.6%	11.7%

Source: U.S. Census Bureau (2000).

Unemployment in Douglas County shows seasonal peaks during winter months, and is lowest in the summer months (see Figure 43). The economic downturn of 2008 is reflected in the peak unemployment rate of around 17.5% in January 2009. The unemployment rate was dropping after the beginning of 2009, but was on the rise again at the end of the year to around 14.7%, following the same pattern seen at the end of the previous years. Based on the population figure for Douglas County, this means almost 15,000 people were unemployed at the end of 2009, so the possibility of thousands of jobs eventually seen directly and indirectly from the wave park would add significantly to the employment in Douglas County.

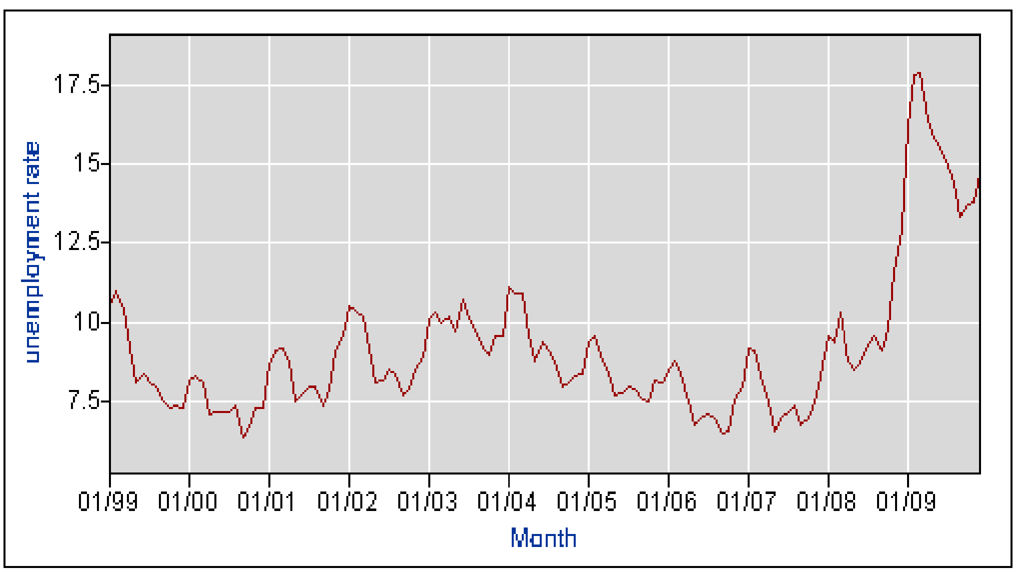


Figure 43. Unemployment rate for 1999–2009, Douglas County, Oregon.

9.2.5 Education

Table 63 summarizes the education levels attained by the population of Douglas County and Reedsport. Over 80% of both populations have a high school degree or higher, and 13.3% of people in Douglas County and 14.1% of people in Reedsport have a bachelor's degree or higher.

Table 63
Education Levels in Douglas County and Reedsport, 2000

Parameter	Count		Percent	
	Douglas County	Reedsport	Douglas County	Reedsport
Population 25 years and over	68,783	3,218		
Less than 9th grade	3,216	208	4.7	6.5
9th to 12th grade, no diploma	9,869	406	14.3	12.6
High school graduate (includes equivalency)	23,836	974	34.7	30.3
Some college, no degree	18,276	1,003	26.6	31.2
Associate's degree	4,441	172	6.5	5.3
Bachelor's degree	5,754	292	8.4	9.1
Graduate or professional degree	3391	163	4.9	5.1
Percent high school graduate or higher			81.0	80.9
Percent bachelor's degree or higher			13.3	14.1

Source: U.S. Census Bureau (2000).

9.2.6 Health and Welfare

Douglas County's childhood poverty rate was 20.7% in 2008, and shows a decreasing trend from the previous years. The Head Start Act (42 U.S.C. 9801) promotes the school readiness of low-income children by enhancing their cognitive, social, and emotional development. In 2009, 93% of the children participated in Head Start programs, up from 58% in 2006. The high school dropout rate was 2.3% in 2008. Abuse and neglect victims among children numbered at 4.8 per thousand in 2008 (Annie E. Casey Foundation 2009).

9.2.7 Potential Impacts

OPT plans to build the wave park 2.5 miles offshore, in the Pacific Ocean near Reedsport, and connect to the Bonneville Power Administration's substation in Gardiner (Northwest Renewable News 2009b). The owner is OPT Wave Energy Partners, LLC, with the project shareholders PNGC (Pacific Northwest Generating Cooperative) Power, Douglas Electric Cooperative, and Bonneville Power Administration.

OPT seeks to cooperate and collaborate with all stakeholders, as the project has both environmental and economic ramifications for the area (OPT 2010b). Environmental concerns are mainly for marine wildlife. There are specific concerns for whales, the effect of the electromagnetic fields on marine life, sea lions, sea birds, and the fishing and crabbing industries (Newman 2010; Harshman 2009). OPT reached a settlement agreement in August 2010 with federal and state agencies, fishermen, and tribal officials for the wave energy park off the coast of Reedsport (Powers 2010; Renewable Energy World 2010).

City officials are currently seeking federal funding for job training programs and efforts to secure local labor for the project. Reedsport drafted an urban renewal plan in 2007, outlining the current state of the economy in Reedsport, its weaknesses, and where expansion was possible/needed for economic vitality in the area. The key relevant points of this plan include interest in having businesses in the area expand and an interest in having new businesses build in empty or underutilized space. The plan cites vacant land and buildings and underused properties as key reasons for low economic activity, and the plan lays out efforts to use funds and programs to facilitate expansion of existing businesses and attract new businesses to the area, including financial incentives and tax relief.

The Reedsport urban renewal plan's economic goals include the use of funds and programs to facilitate the expansion of existing businesses and attract new businesses. The plan outline notes that American Bridge has been a source of job growth and manufacturing wages for Reedsport and that OPT plans to contract with Oregon Iron Works, which, in turn, plans to subcontract with American Bridge (which will continue job growth). The development of the wave park would definitely include development of office space and commercial property, both for project activities and to meet the resulting economic needs (City of Reedsport 2007).

This urban renewal plan and the positive interest that it generates pave the way for the wave park to be beneficial both to the Douglas County community and to OPT in its business endeavors. The executive chairman of OPT is expecting jobs created immediately at Oregon Iron Works (in Clackamas, Oregon) in manufacturing, as well as other jobs in the surrounding coastal communities in assembly, installation, and maintenance over the lifetime of the buoys. A Coos Bay company—Sause Bros.—will be in charge of transporting and deploying the buoys by barge.

In addition to the direct economic impacts of new business and employment, Reedsport and Douglas County would capture much of the commercial growth and activity resulting from economic stimulus. The plan shows that tourism grew over 25% between 1996 and 2004, indicating commercial expansion in food services, accommodation, retail services, and other industries that would also continue to expand as an indirect effect of the wave park in the area. This kind of growth can also be seen in the growing employment of American Bridge.

To date, funding has gone to OPT from the U.S. Department of Energy—$2.4 million in the recent settlement, matched 20% by Ocean Wave Energy Trust—and PNGC Power, the local public electric power cooperative (Oregon Iron Works, Inc. 2010). Also expected are federal tax credits, State of Oregon Business Energy Tax Credits, and other company investments, like that by PNGC, which may purchase some of the electricity generated by the project (Northwest Renewable News 2009a; OPT 2010b).

Two estimates exist for the number of jobs supported by the Reedsport Wave Park. Northwest Renewable News (2009a) reports that the wave park will create or sustain an estimated 30 jobs in its initial fabrication stage, just for manufacturing, with additional jobs in subcontractors and vendors. The entire project is predicted to employ over 150 people in direct manufacturing, assembly, maintenance, installation, etc. The second estimate is from FERC (2010d). OPT reports that eight permanent, full-time positions will be created for maintenance and operation; this number could increase by another five positions on a temporary basis to support major overhauls. Approximately 180 full-time positions would be needed over seven months to fabricate the PowerBuoys while an estimated $1,000,000 in wages would go to coastal communities during assembly and deployment. OPT estimates that this would create six family wage jobs and maintain an additional 10 to 12 jobs.

While the eight to 13 O&M positions might not sound like a substantial number of jobs, there were only 1,464 people employed in Reedsport in 2000 (see Tables 60 and 61 above). That is, during major overhaul periods, the wave park could represent an additional 1% employment for Reedsport. Similarly, the temporary jobs during the manufacture, assembly, and deployment could be beneficially absorbed by the Douglas County workforce without creating the stresses of a “boom” phase. OPT has announced the use of local workers (from southern Oregon coastal communities) for this project. If the OPT PowerBuoy technology is deployed in additional wave parks, the likelihood of the 180 full-time (but seven-month) manufacturing jobs turning into permanent jobs increases. Such a development, if sustained, would foster the increase in the related indirect and induced jobs.

9.3 EAST COAST WIND PROJECT

Both Cape Wind and Deepwater Wind mention Quonset Point within North Kingston, Rhode Island, as a staging area for their offshore wind projects. North Kingstown is in Washington County, so the community impacts example for an East Coast wind project focuses on North Kingstown and surrounding communities in that county.

Washington County borders Kent County to the north, New London County (Connecticut) to the west, Suffolk County (New York) to the southwest, Newport County (Rhode Island) to the east, and the Atlantic Ocean to the south. Nine towns make up Washington County: Charlestown, Exeter, Hopkinton, Narragansett, New Shoreham, North Kingstown, Richmond, South Kingstown, and Westerly. In recent history, Washington County has been largely undeveloped, made up of rural farming communities and beach communities. Within the past 20 years, however, the region has experienced rapid growth, with rates up to three times those of the rest of Rhode Island (WCRPC n.d.). Rhode Island has no county government, only 39 municipal governments (RI SOS 2010).

9.3.1 Population Centers

9.3.1.1 Charlestown

Charleston is in the south-central portion of Washington County, in the southwestern part of Rhode Island. Charlestown is a largely rural community, with farming as the main economic activity; there is very little industrial activity in the town. The town of Charlestown officially claims 41.3 square miles, of which 36.3 square miles are land and the rest is inland water. The population for Charlestown is estimated at 8,120 (as of 2007) (RI EDC 2010a), made up of both permanent residents and seasonal residents; it is estimated that the population doubles during the summer months (FEMA 2009).

9.3.1.2 Exeter

The town of Exeter is in the northwest portion of Washington County, and spans 58.2 square miles. The economy of the town is composed mostly of wholesale and retail trade outlets. The population, as of 2007, was estimated to be about 6,195 (RI EDC 2010b).

9.3.1.3 Hopkinton

Hopkinton is located in the western part of Washington County, with a 2007 population of 8,003. The majority of employment is focused in four sectors: manufacturing, construction, healthcare and social assistance, and public administration (RI EDC 2010c).

9.3.1.4 Narragansett

Narragansett is in the southeastern part of Washington County, and is made up of rural residential areas, summer resorts, and fishing communities (FEMA 2009). The estimated population in 2008 was 16,436, and employment is focused in retail trade, accommodation and food services, and public administration (RI EDC 2010d).

9.3.1.5 New Shoreham

New Shoreham encompasses the area of Block Island in Washington County. In the summer months, population and economic activity are greatly augmented by summer visitors, both short- and long-term. The 2007 population was estimated at 1,021; employment is focused in accommodations and food service, public administration, construction, and retail trade, reflective of its attraction to tourists (RI EDC 2010e).

9.3.1.6 North Kingston

North Kingstown is in the southeast portion of Washington County, and spans 58.3 square miles (FEMA 2009). Quonset Point is a small peninsula in Narragansett Bay, located entirely in North Kingstown. As of the 2000 census, the population of North Kingstown was 26,326, and the 2007 population was estimated by the Rhode Island Economic Development Corporation (RI EDC) at 26,708, making it one of the most populous towns in Washington County. North Kingstown is a professional, economically diverse community with a number of different areas of employment (see sections below). The employment is focused in five sectors: manufacturing, retail trade, health care and social assistance, accommodations and food services, and public administration (RI EDC 2010i).

Quonset Point started as a U.S. Naval Complex in 1941 as the United States contemplated its part in World War II. In 1973, the Navy announced closure of the Quonset Point Naval Air Station; it was closed completely as a federally owned naval property in 1994, when the state of Rhode Island took control of the area (PAR Group n.d.). Quonset Development Corporation was created as a quasi-public subsidiary of RI EDC, and started Quonset Business Park, a 3,000-acre development housing various businesses. Because of its infrastructure and water access, it is positioned to become a hub for renewable energy industry initiatives in Rhode Island (QDC n.d.).

Deepwater Wind is interested in 117 acres of waterfront property in the Quonset Business Park as a manufacturing and assembly site for its wind farms, which it is hoping to install off the Rhode Island coast. Deepwater is proposing two projects to be based out of Quonset, for an eventual addition of 800 jobs in the business park. In many ways it could be a profitable partnership for Quonset and the North Kingstown community, as well: after Deepwater starts operations, other companies may be drawn to Quonset Business Park because of the convenient access to water and the appropriate infrastructure (both pre-existing and to be improved) for their projects (Kuffner 2009).

The community of North Kingstown is represented in the governance of Quonset Development Corporation by two members of the town council who also sit on the Corporation's board, thus ensuring that the corporation's development goals are aligned with town service and planning objectives (PAR Group n.d.).

9.3.1.7 Richmond

Richmond is in central Washington County. The town has a 2007 estimated population of 7,659; its main sectors of employment are retail trade, accommodation and food services, and public administration (RI EDC 2010f).

9.3.1.8 South Kingstown

South Kingstown is in the southeastern part of Washington County. It has both a permanent and a seasonal population. There has been recent growth in the resort and tourism industry as well as residential construction (FEMA 2009), and employment is focused in the following sectors: public administration, health care and social assistance, retail trade, and accommodations and food services. As of 2007, the population was estimated at 29,277 (RI EDC 2010g).

9.3.1.9 Westerly

Westerly, in southwestern Washington County, has an estimated 2007 population of 23,408. Employment is concentrated in retail/trade, health care and social assistance, accommodations and food services, and public administration (RI EDC 2010h).

9.3.2 Population

The data on the population of Washington County and North Kingstown are taken from 2006–2008 American Community Survey three-year estimates (U.S. Census Bureau 2009c). The county population is 126,554 persons, with a median age of 40.4 years. Table 64 shows the age/sex distribution. Over a quarter of the population of both Washington County and North Kingstown is between 35 and 54 years old. There is also a significant percentage over 65 years old in both population samples: 13.8% in Washington County and 10.8% in North Kingstown. While Washington County as a whole has a higher proportion of citizens over 65, North Kingstown has a higher proportion of children under 10: 12.6% versus 9.8% in Washington County. Both populations are split fairly evenly between male and female citizens (considering a margin of error of 1.9% for the North Kingstown data in this category).

Table 64
North Kingstown and Washington County, Rhode Island: Age/Sex Distribution, 2006–2008

	Count		Percent	
Parameter	Washington County	North Kingstown	Washington County	North Kingstown
Total population	126,554	28,650	100.0	100.0
Age distribution and sex				
Under 5 years	5,655	1,652	4.5	5.8
5 to 9 years	6,679	1,949	5.3	6.8
10 to 14 years	8,310	2,471	6.6	8.6
15 to 19 years	10,558	1,861	8.3	6.5
20 to 24 years	10,977	1,651	8.7	5.8
25 to 34 years	12,355	3,109	9.8	10.9
35 to 44 years	17,769	4,582	14.0	16.0
45 to 54 years	20,857	4,744	16.5	16.6
55 to 59 years	8,693	1,918	6.9	6.7
60 to 64 years	7,231	1,621	5.7	5.7
65 to 74 years	8,817	1,622	7.0	5.7
75 to 84 years	6,348	958	5.0	3.3
85 years and over	2,305	512	1.8	1.8
Male	61,444	14,507	48.6	50.6
Female	65,110	14,143	51.4	49.4

Source: US BLS (2008).

Table 65 shows the racial and ethnic populations for North Kingstown and Washington County. Both Washington County as a whole and North Kingstown are predominantly white communities, 95.3% and 95.0%, respectively. Washington County is 2.1% Asian, 1.7% Black or African American, 1.4% American Indian or Alaskan Native, and 0.9% some other race. Similarly, North Kingstown is 2.9% Black or African American, 2.9% Asian, and 1.5% American Indian or Alaskan Native.

Table 65
North Kingstown and Washington County, Rhode Island: Race, 2006–2008

Parameter	Count		Percent	
	Washington County	North Kingstown	Washington County	North Kingstown
Total population	126,554	28,650	100.0	100.0
White	120,609	27,212	95.3	95.0
Black or African American	2,197	832	1.7	2.9
American Indian and Alaska Native	1,780	430	1.4	1.5
Asian	2,715	832	2.1	2.9
Native Hawaiian and Other Pacific Islander	N	N	N	N
Some other race	1,101	N	0.9	N

Source: US BLS (2008).

9.3.3 Employment

As Table 66 shows, the employment patterns by industry are similar in Washington County and North Kingstown. The highest percentage of the employed population works in management, professional, and related occupations: 39.9% in Washington County and 45.9% in North Kingstown. Sales and office occupations make up 24.1% of employment in Washington County and 20.9% in North Kingstown. Service occupations are the third most common type of employment at 17.9% in Washington County and 13.5% in North Kingstown; following service are construction, extraction, maintenance, and repair occupations (9.2% in Washington County, 9.8% in North Kingstown), then production, transportation, and material moving occupations (8.3% Washington County, 9.5% North Kingstown). The smallest percentage of the working population is employed in farming, fishing, and forestry occupations (0.6% Washington County, 0.3% North Kingstown).

Table 67 resummarizes the employment data by occupation rather than industry. The most populated industries are educational services (25.9% in Washington County) and health care and social assistance (22.1% in North Kingstown). The least-populated industry is agriculture, forestry, fishing and hunting, and mining, at 1.0% in Washington County and 0.7% in North Kingstown. About 10% of the working population is in each of the following occupations: retail trade; construction; manufacturing; professional, scientific, management, administrative and waste management services; the arts, entertainment, and recreation; and accommodation and food services, and the finance and insurance, real estate, renting, and leasing industries. The remaining industries (wholesale trade, transportation, warehousing, utilities, information, other services, and public administration) each contain roughly less than 5% of the working population.

Table 66
North Kingstown and Washington County, Rhode Island: Occupation, 2006–2008

Parameter	Count		Percent	
	Washington County	North Kingstown	Washington County	North Kingstown
Civilian-employed population 16 years and over	67,857	14,632	100.0	100.0
Management, professional, and related occupations	27,105	6,723	39.9	45.9
Service occupations	12,137	1,971	17.9	13.5
Sales and office occupations	16,358	3,061	24.1	20.9
Farming, fishing, and forestry occupations	390	50	0.6	0.3
Construction, extraction, maintenance, and repair occupations	6,223	1,433	9.2	9.8
Production, transportation, and material moving occupations	5,644	1,394	8.3	9.5

Source: US BLS (2008).

Table 67
North Kingstown and Washington County, Rhode Island: Occupation, 2006–2008

Parameter	Count		Percent	
	Washington County	North Kingstown	Washington County	North Kingstown
Civilian-employed population 16 years and over	67,857	14,632	100.0	100.0
Agriculture, forestry, fishing and hunting, and mining	682	104	1.0	0.7
Construction	5,356	1,119	7.9	7.6
Manufacturing	6,647	2,127	9.8	14.5
Wholesale trade	1,420	368	2.1	2.5
Retail trade	8,006	1,674	11.8	11.4
Transportation, warehousing, and utilities	2,118	531	3.1	3.6
Information	991	384	1.5	2.6
Finance, insurance, real estate, rental and leasing	4,936	1,263	7.3	8.6
Professional, scientific, management, administrative, and waste management services	6,647	1,463	9.8	10.0
Educational services, health care, and social assistance	17,570	3,232	25.9	22.1
Arts, entertainment, recreation, accommodation, and food services	7,847	1,305	11.6	8.9
Other services, except public administration	2,269	399	3.3	2.7
Public administration	3,368	663	5.0	4.5

Source: US BLS (2008).

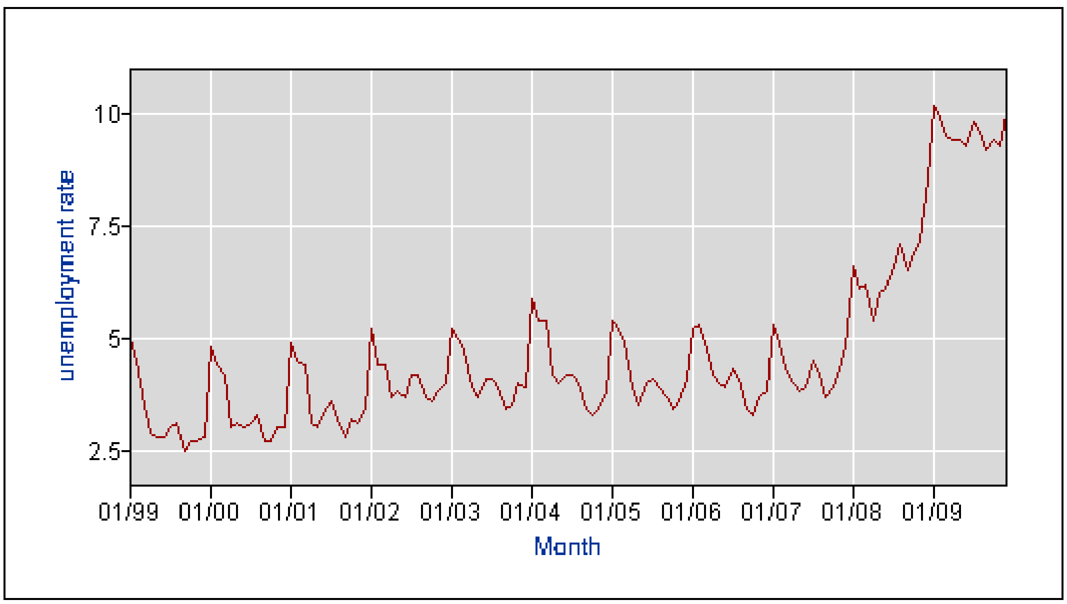
9.3.4 Income, Poverty, and Unemployment Rates

During the 2006–2008 survey period, Washington County had a median household income of $71,275 and a median family income of $87,832. As Table 68 shows, about 3.2% of the families had income below the poverty level (U.S. Census Bureau 2009c). Figures 38 and 39 show the monthly unemployment rate from 1999 to 2008. Note the seasonality in the unemployment rate, which is reflected in much higher rates during January, February, and March, when construction and recreational opportunities shut down for the winter. The general economic downturn in 2008 is apparent; the unemployment rate in Washington County and North Kingstown is nearly double the long-term averages. With an unemployment rate hovering around 10% and roughly 68,000 workers in Washington County, approximately 6,800 people are searching for employment. Similarly, there might be an estimated 1,400 persons seeking employment within the town of North Kingston. Deepwater Wind's proposal to build a manufacturing area at Quonset Point with an estimated 800 direct jobs would add substantially to employment in the county (RI Office of the Governor 2009a).

Table 68
Median Income and Poverty Level Statistics: Washington County and North Kingstown, Rhode Island, 2006–2008

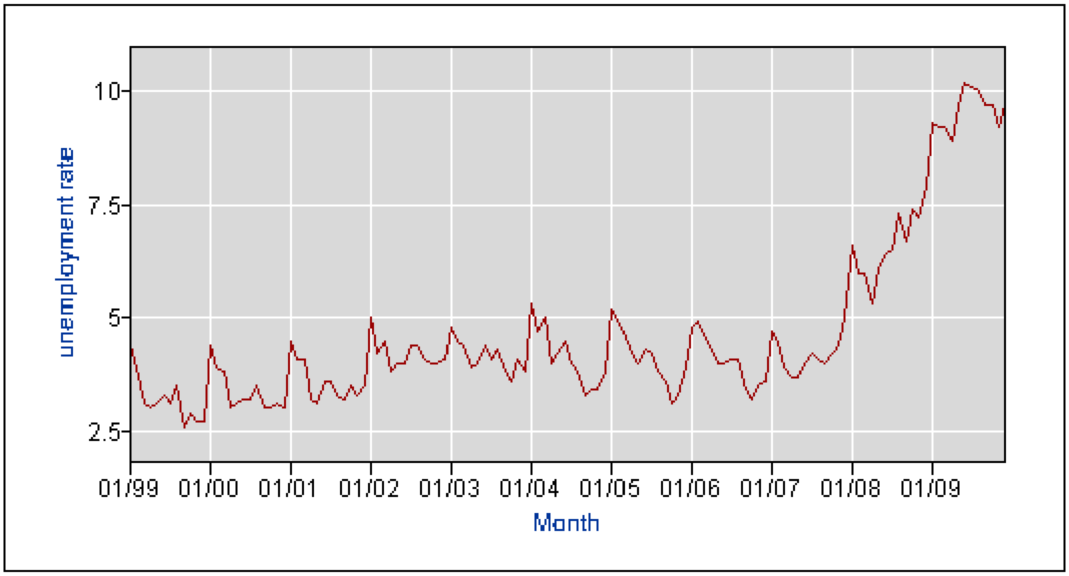
	Count/Percentage	
Parameter	Washington County	North Kingstown
Median household income (dollars)	$71,725	$79,908
Median family income (dollars)	$87,832	$92,354
Percentage of families whose income in the past 12 months is below the poverty level	3.2%	4.5%

Source: US BLS (2008).



Source: US BLS (2008).

Figure 44. Unemployment rate for 1999–2009, Washington County, Rhode Island.



Source: US BLS (2010).

Figure 45. Unemployment rate for 1999–2009, North Kingstown, Rhode Island.

9.3.5 Education

Table 69 summarizes the level of education attained by the population in Washington County at 25 years or older. Approximately 92.3% finished high school and 41.2% completed a bachelor's or higher degree. Nearly one in five workers holds a graduate or professional degree, indicating the availability of an educated workforce for a potential new business in the area.

Table 69
Education Levels in Washington County and North Kingstown

Parameter	Count		Percent	
	Washington County	North Kingstown	Washington County	North Kingstown
Population 25 years and over	84,375	19,066		
Less than 9th grade	1,722	410	2.0	2.2
9th to 12th grade, no diploma	4,735	991	5.6	5.2
High school graduate (includes equivalency)	21,190	4,416	25.1	23.2
Some college, no degree	15,559	3,761	18.4	19.7
Associate's degree	6,437	1,252	7.6	6.6
Bachelor's degree	20,796	4,813	24.6	25.2
Graduate or professional degree	13,936	3,423	16.5	18.0
Percent high school graduate or higher			92.35	92.65
Percent bachelor's degree or higher			41.2	43.20

9.3.6 Health and Welfare

North Kingstown is making progress on reducing the number of children with elevated levels of lead in their blood. By 2008, the percentage had dropped to 1.6% from 3.3% in 2004. In 2008, about 39% of the children participated in the Headstart program, while the rate of child abuse and neglect was 7.4 per 1,000 children. The downturn in the economy is reflected in the percentage of children receiving food stamps/Supplemental Nutrition Assistance Program (SNAP) benefits. In 2006, 47% of the children received such assistance. By 2008, the proportion had climbed to 65% (Annie E. Casey Foundation 2008).

9.3.7 Potential Impacts

Section 2.4.18.1, Table 25 summarizes the characteristics of the Cape Wind (Massachusetts), Deepwater Wind (Rhode Island), and Bluewater Wind (Delaware) wind farms. The capacity ranges from about 400 to 450 MW. The estimates range from 381 to 500 jobs during the construction and installation phase and from 50 to 80 jobs during the O&M phase. Should Deepwater Wind's proposal to build a manufacturing area at Quonset Point to supply multiple wind farms come to fruition, an estimated 800 direct jobs would be available to the surrounding communities (RI Office of the Governor 2009a).

As mentioned in Section 9.3.4, the unemployment rate in Washington County and North Kingstown is nearly double the long-term averages. With an unemployment rate hovering around 10% and roughly 68,000 workers in Washington County, approximately 6,800 people are searching for employment. Similarly, there might be an estimated 1,400 persons seeking employment within the town of North Kingston. Thus, there is an ample labor supply for the estimated number of jobs. No "boom" effect with its concomitant stresses on the community is anticipated. On the other hand, the additional employment could lower the percentage of children receiving food stamps/SNAP benefits (Section 9.3.6), unemployment rate, and other measures of socioeconomic stress.

9.4 EXTRAPOLATION TO OTHER AREAS

Section 2.4.18 identifies approximately 11 wind farms and 12 wave farms. While it is not likely that all of these projects will reach commercial operation, the nearly two dozen projects represent the first steps in the development of an offshore renewable energy industry.

Permanent (multi-year) jobs are associated with the operating phase of each project. The number of O&M jobs per project is small enough to be absorbed by local communities without difficulty.

A larger number of jobs is associated with the assembly and installation of the energy units making up each farm. These are time-limited, however, with estimates ranging from seven months (Reedsport, Oregon OPT wave farm) to two years (Cape Wind, Massachusetts). While these jobs provide a short-term boost to the local economies, they depend on multiple, consecutive projects to grow into more permanent positions. Deepwater Wind mentioned using the Quonset Point, Rhode Island, site to stage multiple projects.

Key parameters to the magnitude of community, regional, and national impacts include:

- The proportion of the labor force that is drawn from the local labor pools.
- The proportion of the goods (e.g., underwater transmission cables and the vessels to install the cables) imported from outside the U.S
- The manufacturing locations for the energy generating units. (For example, OPT specifies that the PowerBuoys will be manufactured within Oregon. Cape Wind will use Siemens turbines, but it is not known at this time where they will be manufactured.)
- The manufacturing locations for material supporting the manufacture of the energy generating units (supply chains).

Chapter 8 discusses the need for a "critical mass" of projects before companies are willing to commit to investing in new manufacturing facilities located in the U.S. However, should this "critical mass" be reached, then a greater proportion of the expenditures over the entire life cycle of a renewable energy project would remain within the nation. This increase in the direct impacts associated with a project, in turn, increases the indirect and induced impacts associated with that project.

The difference in the magnitude of the project-level impacts examined in the case studies and the potential number of jobs estimated by USDOE NREL (2010d) is due to two factors: 1) the difference between direct and total impacts and 2) a growth of new domestic industries to support the entire supply chain for offshore energy projects. That is, the case study reports only the "direct impacts"—the number of jobs directly associated with the construction, installation, and operating phases of an offshore renewable energy project. USDOE NREL (2010d) also considers the "indirect impacts"—the number of jobs involved in backfilling the supply chain (e.g., steel mill jobs created or preserved to replace the steel used in a wave project) and "induced impacts"—the number of jobs created when households spend earnings from the direct jobs. The estimated number of indirect and induced jobs is directly related to the proportion of the supply chain located in the U.S. For example, if turbines are assembled in the U.S., those jobs stay in the U.S. If the individual components that make up a turbine are manufactured in the U.S., then those jobs also stay in the U.S. However, if turbines are manufactured and assembled overseas and imported to the U.S., then those expenditures "leak" from the domestic economy and show minimal job creation or preservation.

10 OBSERVATIONS

This report is prepared during a time of time of great flux—the potential birth of a new domestic energy industry—that started with the Energy Policy Act of 2005 when Congress designated MMS as the agency with oversight of alternative energy uses of federal offshore region. Since then, the regulatory framework is being created and put into operation on the national and state levels (Chapters 2 and 5). Individual components of that framework come in a variety of forms including, but not limited to:

- Memoranda of understanding that clarify jurisdictions among federal agencies
- Interagency task force to coordinate national policy for oceans and coasts
- Exploratory and commercial leases in OCS regions
- BOEM participation in state renewable energy task forces
- Regional collaboratives (e.g., West Coast Governors' Agreement on Ocean Health, Oregon Wave Energy Trust, Northeast Regional Ocean Council, Mid-Atlantic Regional Council on the Ocean, and the U.S. Offshore Wind Collaborative).
- Memoranda of understanding between and among states for coordination and cooperation in the permitting and development of offshore energy projects.
- State ocean plans that identify areas suitable for offshore renewable energy projects, including areas abutting federal offshore areas.

That is, the regulatory framework for the development of offshore renewable energy is evolving through coordinated and cooperative efforts among federal, state, and tribal governments as well as outreach and communication with local governments and other stakeholders.

ERG examined marine infrastructure that currently exists to support offshore renewable energy development (Chapter 7). ERG identified 57 deep-water ports (35 on the East Coast and 22 on the West Coast) as well as an additional 99 ports that could accommodate exploration, construction, installation, and operating activities. ERG identified 64 shipyards along the East Coast and 57 shipyards along the West Coast. ERG examined the availability of marine transportation and identified 98 ocean-going vessels and 551 offshore supply vessels that meet Jones Act requirements, plus an additional 5,707 tugs and 27,577 dry barges that ply the coastal waters. ERG noted that Europe used oil and gas industry vessels modified to install offshore wind turbines for two decades prior to developing specialized Turbine Installation Vessels (Hogue 2009; Baird Maritime 2010). Kaiser and Snyder (2011) examine the financial considerations in the decision to modify an existing vessel or to build a new vessel for turbine installation.

ERG examined the energy infrastructure (primarily substations and transmission lines) and noted that getting the power to shore and integrated into the land-based grid might be the weakest link in the chain of events to develop offshore renewable energy. The difficulties include the geographic availability of a substation capable of handling the high voltage transmission, transmission costs as a significant portion of overall project costs, and the intermittent nature of wind power. For example, Figure 46 is a map of New Jersey and major substations. Figure 47 is a map of the offshore wind areas of interest. The reader can see that the areas of interest for wind energy are off the southern part of New Jersey while the northern part has more (and higher voltage capacity) substations. In recognition of this dilemma, several East Coast governors sent letters to FERC asking about installing a transmission "backbone" that would link all offshore energy projects (Nathans 2009; DE Office of the Governor 2010).

ERG observed that the total number of jobs created or preserved with the development of offshore renewable energy sources depends of the portion of the supply chain located within the U.S. While there are manufacturing facilities for onshore wind turbines, at the time of the study, there are no manufacturing facilities for the larger offshore wind turbines. Similarly, medium- and high-voltage submarine cables, at this time, are typically manufactured outside the U.S. and installed by foreign companies. A research need, then, is the identification of a "tipping point" where demand for certain products and services is sufficient for companies to invest in developing a domestic supply chain for this industry.

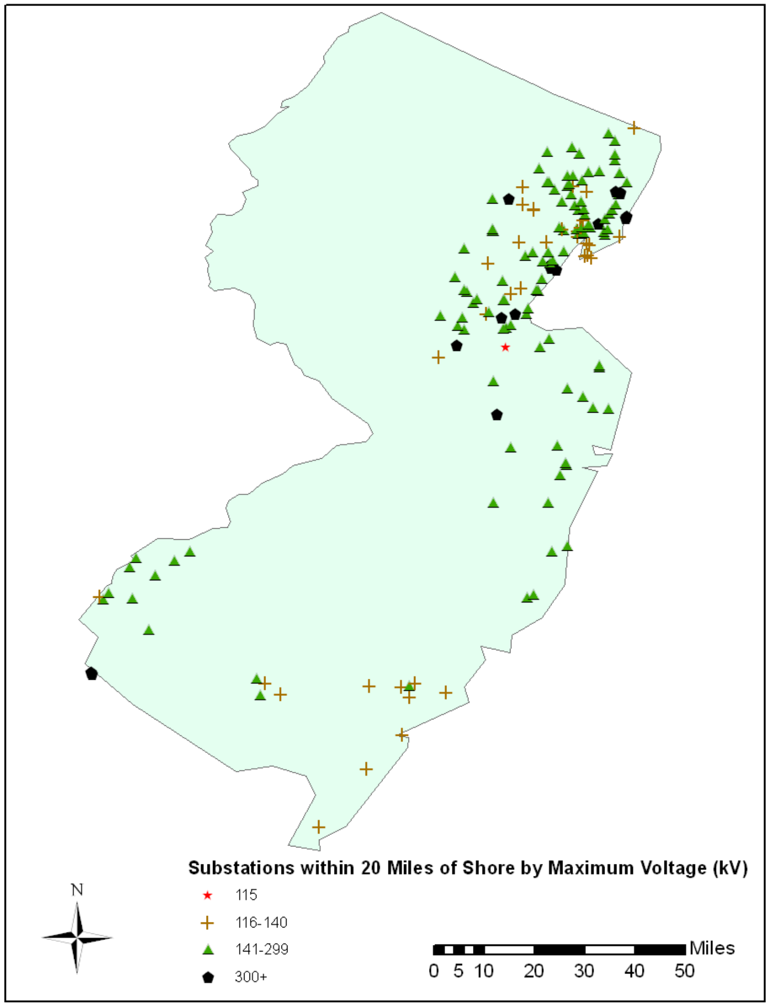


Figure 46. New Jersey substations within 20 miles of shore.

Figure 47. OCS blocks proposed for wind resources data collection off of Delaware and New Jersey.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the sound use of our land and water resources, protecting our fish, wildlife and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island communities.

The Bureau of Ocean Energy Management

The Bureau of Ocean Energy Management (BOEM) works to manage the exploration and development of the nation's offshore resources in a way that appropriately balances economic development, energy independence, and environmental protection through oil and gas leases, renewable energy development and environmental reviews and studies.