ANALYSIS GROUP
ECONOMIC, FINANCIAL and STRATEGY CONSULTANTS

Strategic Options for Investment in Transmission in Support of Offshore Wind Development in Massachusetts

Summary Report with Expanded Technical Information

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This White Paper was commissioned by the Massachusetts Renewable Energy Trust ("MRET").

This paper represents the views of the authors, and not necessarily the views of the MRET or the employer of the authors.

TABLE OF CONTENTS

1. BACKGROUND: THIS REPORT

The Massachusetts Renewable Energy Trust ("MRET"), in cooperation with the Massachusetts Clean Energy Center ("MCEC") engaged an Analysis Group team led by Dr. Susan Tierney to establish a technical and policy framework and actionable policy recommendations for the integration of offshore wind power into the existing power transmission/distribution system in Massachusetts. The study was designed to take into consideration a number of dimensions that might affect the design of a workable framework for offshore transmission, including the potential for wind resources in nearby offshore locations, key power system technical factors, the prevailing energy and environmental policy framework, the structure of the electric industry in the region, local economic and industrial development objectives, and federal and state regulatory authorities.

Analysis Group coordinated its review and analysis with a team of state energy and environmental policy officials, including those at the MCEC, the Executive Office of Energy and Environmental Affairs, the Department of Public Utilities, the Division of Energy Resources, and the Office of Coastal Zone Management. Further, Analysis Group conducted its study by building off of the work of a variety of organizations currently examining issues related to the delivery of offshore wind power, including ISO-New England ("ISO-NE"), the Massachusetts Offshore Wind Collaborative, the Massachusetts Technology Collaborative ("MTC"), and other relevant state agencies.

The Commonwealth's energy agencies have requested this report as a complement to many other state-led efforts already underway in support of wind resource development in the state or off of its shores. Among other things, these efforts include: the Governor's establishment of a goal of having 2,000 megawatts ("MW") of wind energy in Massachusetts (and its bordering federal waters) by 2020; the Massachusetts Ocean Management Plan under development by the Secretary of Energy and Environmental Affairs; the Port and Support Infrastructure Analysis for Offshore Energy Development being conducted through the MCEC; hosting a wind-blade test facility in Massachusetts; developing a proposal to reform the process the state uses to site onshore wind facilities; and a host of other policies that target green and renewable power more generally, such as the Green Communities Act (including its provision that utilities enter into long-term contracts for renewable power), the Renewable Portfolio Standard, the Green Jobs Act, and the Global Warming Solutions Act.

This Technical Report provides recommendations to the state for a menu of high-level options that could be pursued to facilitate transmission to link offshore wind resources with the onshore electric grid. Those recommendations are described at the end of this Technical Report, following sections that detail the policy context for the development of offshore wind, the technical potential for wind development in and around the Massachusetts coastline, important technical considerations that set the stage for integrating wind into the region's electric grid, and other background issues relevant for evaluating the strategic options for accessing offshore wind. This Technical Report follows the release of a higher-level Summary Report (issued on December 2, 2009), and provides more detailed background, context, and discussion.

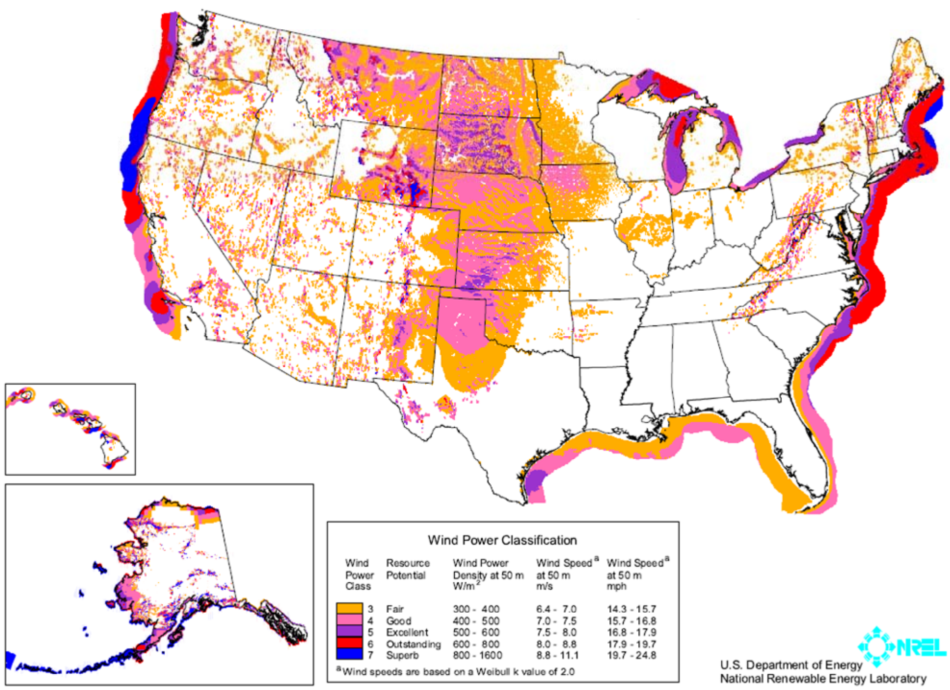
2. CONTEXT: MASSACHUSETTS' ABUNDANT OFFSHORE WIND RESOURCE

Wind is one of the few significant indigenous energy resources located in, and in close proximity to, Massachusetts. It is also renewable, emits no greenhouse gases ("GHG") to generate electricity, and is capable of producing power at a fuel price that is both extremely low and beyond the control of foreign suppliers. These features distinguish this energy resource from the other sources of supply used to generate electricity in or around the state. Massachusetts imports nearly all of the fuel used to generate power, and to heat and cool people's homes, offices, schools, shops and factories in the state. As of 2007, 94 percent of the energy consumed in Massachusetts was derived from GHG-producing fossil fuels, including coal, natural gas, and petroleum products used for heating, transportation and electricity generation.[1]

Even compared to other parts of the U.S. that have strong wind resources, those located in Massachusetts (primarily offshore) are very rich. As shown in Figure 1 below, Massachusetts' offshore wind resources are outstanding from a technical potential point of view and relative to those located in other parts of the U.S.[2]

Figure 1

U.S. Wind Resources by Class of Wind – Including Off-Shore Areas



Source: U.S. Wind Resource Map, National Renewable Energy Laboratory, May 2009, available at: http://www.windpoweringamerica.gov/pdfs/wind_maps/us_windmap.pdf.

Massachusetts has by far the best and most accessible offshore wind resource potential in New England, with excellent potential along nearly all of the state's shoreline. This valuable resource results in part from the water depth in Massachusetts' offshore areas (see Figure 2) and its wind speeds (see Figure 3). (These figures are from the draft and final versions of Massachusetts Ocean Management Plan. The draft plan was released in June 2009, with the final plan released in December 2009.)

Figure 2
Water Depth – Offshore Massachusetts

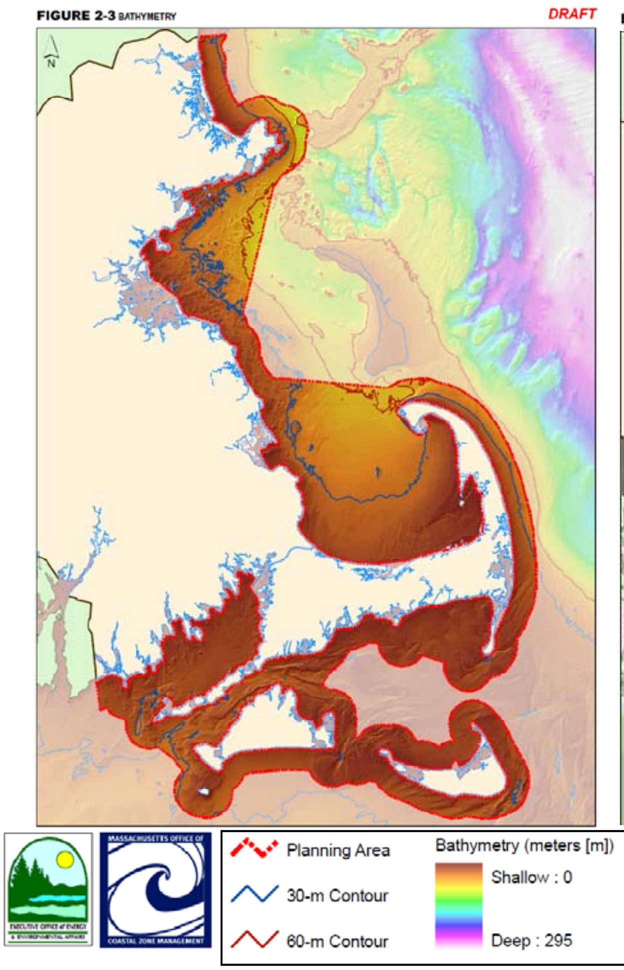
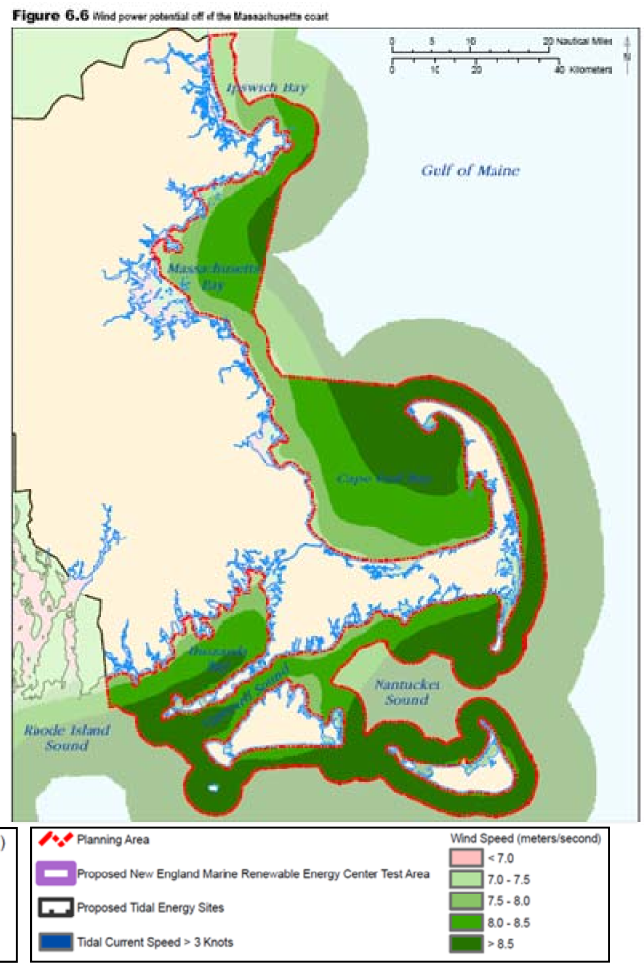


Figure 3
Wind Speed – Offshore Massachusetts

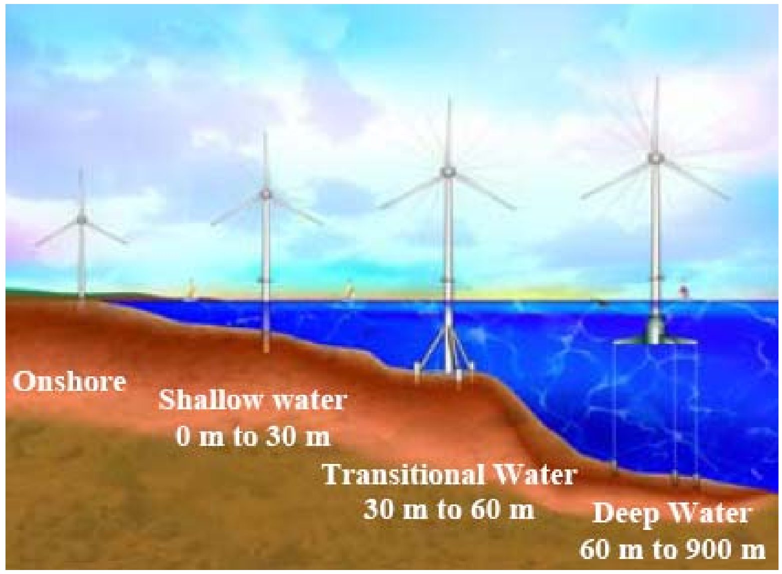


Source: Draft Massachusetts Ocean Management Plan, June 2009 and Massachusetts Ocean Management Plan, December 2009.

Water Depth and Wind Turbine Mounting Technologies

Water depth and wind speed matter for wind development because they affect the technological feasibility and economic viability of offshore wind projects. For example, currently available mounting technology (primarily monopole) for wind turbines is only suited for projects in water up to about 30 meters in depth. Projects at depths beyond 30 meters require stiffer, more substantial technologies that are just starting to be deployed today but are likely to become more prevalent within the next 5 to 10 years. For depths of greater than 60 meters, floating structures and advanced technologies may be required, and are not likely to be widely used for at least 10 years. (See Figure 4.)

Figure 4
Technology Progression for Offshore Wind Turbines

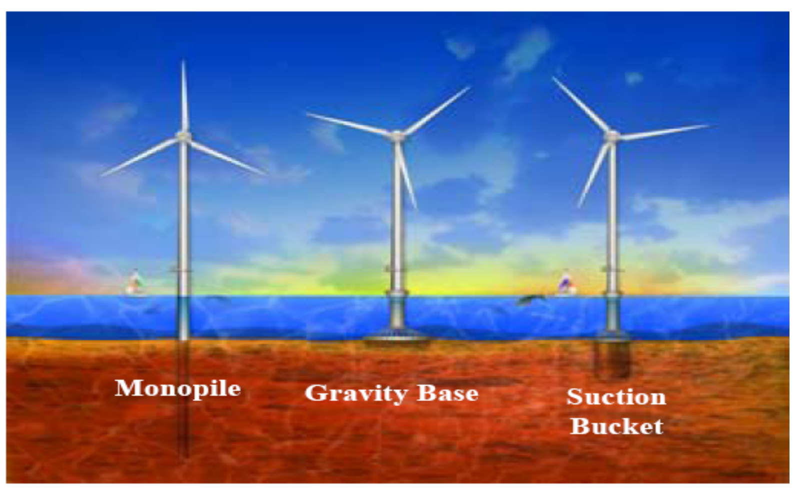


Source: Energy from Offshore Wind; W. Musial, S. Butterfield, B. Ram,, NREL & Energetics; Presented at Offshore Technology Conference, Houston, Texas, May 2006.

Shallow Water

Often used in shallow water (up to 30 meters), monopiles are simple and proven, and their footprint and effect on the seafloor is minimal. (See Figure 5.) Monopiles are used throughout most of the existing offshore wind farms worldwide, such as the 160-MW Horns Rev wind farm about 10 miles off the west coast of Denmark.[3] As depth increases though, monopiles not only need to be longer, but also thicker, which implies more materials and cost.

Figure 5
Shallow Water Mounting Technologies



Source: W. Musial, S. Butterfield, B. Ram, B., "Energy from Offshore Wind," NREL & Energetics, Presented at Offshore Technology Conference, Houston, Texas, May 2006.

Gravity base foundations (essentially large slabs of concrete) are an alternative to monopiles, and they have been used in the 160-MW Nysted wind farm off the southeastern coast of Denmark. Gravity base foundations have more flexibility than monopiles, but they require much more preparation of the seafloor. Suction bucket foundations are different from monopoles (which are driven deep into the sea floor) and gravity base foundations (which sit on top of the sea floor). Suction buckets are steel tubes that resemble an upside-down bucket, and drive themselves into the sea floor through the hydrostatic pressure produced by creating a vacuum inside the bucket. Suction works not only to drive these foundations into the sea floor, but also to keep them anchored there. Suction buckets have not yet been used commercially in the context of wind power in deep or shallow water, but have the potential to be an effective hybrid (e.g., between monopoles and gravity bases).[4]

Transitional Depth

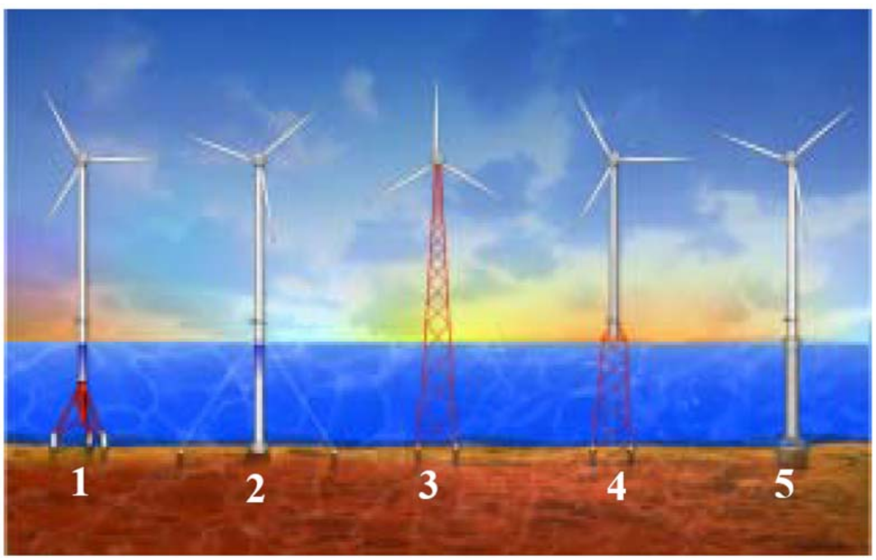
In depths between 30 and 60 meters, wind turbine mounting systems require stiffer, wider bases (for added rigidity and stability) with more than one anchor point. These types of mounting systems are already standard in the oil & gas industries, but have not often been used in offshore wind projects. Figure 6 shows an array of potential transitional depth mounting technologies.[5]

Wind turbines at transitional depths are not yet well-tested in the United States, but a handful of small projects are currently in operation in Europe. In particular, the Beatrice project in the Beatrice Oilfield off of Moray Firth, UK, is installed at a depth of between 40-45 meters. This project has only two 5-MW REpower turbines for a total of 10 MW of capacity.[6] The Beatrice project uses a mounting technology, developed by OWEC Tower AS, similar to the fourth tower design shown in Figure 6 (e.g., a submerged jacket structure with transition to a tube tower).[7] In addition the Alpha Ventus project north of Borkum, Germany is at a depth of approximately 30 meters. This project has twelve 5-MW Multibrid and REpower turbines for a total of 60 MW of capacity.[8] The Alpha Ventus project uses a mounting technology similar to the first tower design shown in Figure 6 (e.g., a tripod tower).[9]

Deep Water

Beyond 60 meters in depth, as yet unproven floating mounting structures become necessary for wind development. The range of possible configurations for floating structures includes some very similar to those in use already for securing oilrigs to the sea floor. Figure 7

<u>Figure 6</u>
Transitional Depth Mounting Technologies



1 - Tripod Tower
2 - Guyed monopole
3 - Full-height jacket (truss)
4 - Submerged jacket with transition to tube tower
5 - Enhanced suction bucket or gravity base

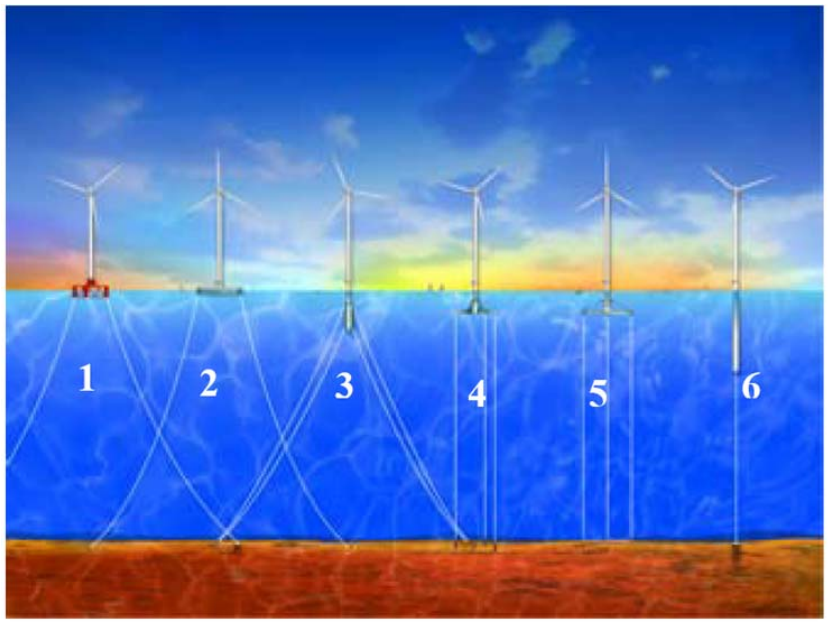
Source: W. Musial, S. Butterfield, B. Ram, B., "Energy from Offshore Wind," NREL & Energetics, Presented at Offshore Technology Conference, Houston, Texas, May 2006.

depicts an array of potential transitional depth mounting technologies.[10]

While there are no operational floating wind turbines in the United States, the first test project with a floating turbine, named Hywind, was brought online by StatoilHydro on September 8, 2009, near Karmoy, Norway. The Hywind project has just one 3 MW Siemens turbine that is located at a depth of about 100 meters. The Hywind project uses a mounting technology somewhat similar to the third tower design shown in Figure 7, but with only one tier of guy-wires (three wires total).[11]

<u>Figure 7</u>

Deep Water Mounting Technologies



1 - Semi-submersible Dutch tri-floater
2 - Barge
3 - Spar-buoy with two tiers of guy-wires
4 - Three-arm mono-hull tension leg platform (TLP)
5 - Concrete TLP with gravity anchor
6 - Deep water spar

Source: Energy from Offshore Wind; W. Musial, S. Butterfield, B. Ram; NREL & Energetics; Presented at Offshore Technology Conference, Houston, Texas, May 2006.

Offshore Wind Resource Potential

As discussed further below, the estimates of wind resource potential in the waters off the shore of Massachusetts, and New England in general, have varied in recent years, in part as a result of differing assumptions and differing measurements taken at different points in time.

New England Wind Resources

In addition, assumptions about siting constraints greatly affect wind resource potential estimates. In 2008, in a study prepared for ISO-NE as part of its recent planning studies known as the "New England Governors' Economic Blueprint," Levitan & Associates estimated that, assuming no siting constraints, New England possesses approximately 73,000 MW (or 73 gigawatts ("GW") of potential offshore wind resources in water of 30 meters or less in depth.[12] The Levitan & Associates wind study was included in the "New England 2030 Power System Study," prepared by ISO-NE as support for the New England Governors' 2009 economic study request. Overall, this study intended to analyze the impact of integrating large-scale wind resources into the New England grid.

According to this assessment, these resources are accessible with current technology. While the majority of New England's wind resources are estimated to be located off the coast of Massachusetts, Rhode Island and Maine also have good wind resources, with approximately 19 GW and 4.3 GW respectively.[13] In the case of Maine, most of its wind resources are located in water deeper than 30 meters making it tougher to access them using current technology, and making the above estimate an understatement as mounting technologies improve over time. A University of Maine study estimates that there is potentially

149 GW of wind potential in the area within 50 miles from the Maine coast,[14] but this potential will not be realized without new mounting technologies.

Massachusetts Wind Resources:

As mentioned above, Massachusetts offshore waters are home to the best wind resources in New England. Assuming no siting constraints and extrapolating from the Levitan & Associates analysis performed for the ISO-NE in 2008, Massachusetts may have at least 49 GW of potential wind resources in water 30 meters or less, which could be accessed today with current technology.[15] Off-shore wind is expected to have much higher output during on-peak periods and higher capacity factors more generally, as compared to on-shore wind in New England.[16]

When potential near-shore siting constraints are taken into account, the estimates of resource potential are much smaller, though they still vary considerably.[17] One of the scenarios from the Levitan & Associates study conservatively excludes areas within three miles of the shoreline, based on an assumption that siting constraints will be too severe in this area for wind development. Taking this constraint into account, Massachusetts' offshore wind resource potential, accessible with current technology, may be about 3 GW for depths up to 30 meters.[18] Levitan & Associates also generated a scenario that does not exclude inshore areas but still considers general siting constraints, and puts the Commonwealth's offshore wind potential at about 16 GW for water with depth of 30 meters or less.[19] Similarly, the Massachusetts Ocean Management Plan, described later in this report, cites an estimate that accounts for near-shore siting constraints, and yields approximately 6.3 GW for waters 20 meters or less in depth.[20]

As wind turbine mounting technology improves, deeper waters will become accessible to wind development on more practical terms. When still considering potential siting constraints but no longer constraining depth, there is more than 35 GW of wind resource capacity located within 20 miles of the state's shoreline.[21] This estimate is based on the ISO-NE study discussed above, as well as a study published by the National Renewable Energy Laboratory ("NREL") in 2004 focusing on the future possibilities for offshore wind in the United States. Looking even further toward the future, NREL estimates suggest that there may be in excess of 200 GW of potential wind resources in water with depth of greater than 30 meters off the coast of Massachusetts.[22]

All of these estimates wind resource potential compare to New England's existing electrical capacity of 34 GW as of the summer of 2009.[23]

Economic and Environmental Benefits of Offshore Wind Development

Massachusetts' offshore wind resources offer the citizens of the Commonwealth a source of low-carbon, renewable energy, with the added benefit of providing jobs to the local economy. Numerous studies in recent years have focused attention on the employment impacts associated with clean energy development (such as investment in offshore wind resources).

For example, a 2007 NREL study examined the feasibility and implications of having wind account for 20 percent of U.S. electricity demand by 2030. The scenarios suggest that investment in offshore wind would create a large number of jobs in the U.S. and avoid a significant amount of GHG emissions and other criteria pollutants. (These impacts are summarized in Table 1, below.)

Table 1

Potential Benefits of Large Amounts of Wind Energy in the U.S.

Type of Benefit	Basis	At 54 GW	At 78 GW
Energy Supplied	40% capacity factor	187 TWh	273 TWh
Percent of Current U.S. Electric Supply	2548 TWh consumed (2004)	5.30%	7.70%
Potential Jobs created during Construction Phase	39,000 jobs/year/GW	2,110,680 jobs/year	3,040,830 job/year
Potential jobs created Permanent O&M	1,100 jobs/GW	59,532 jobs	85,767 jobs
Capital Invested	$1800/kW – $1500/kW	$97.4 billion	$124.8 billion
SO_2 Avoided (Metric tons/year)	9.26 tons/yr/MW	501,151	722,002
NO_X Avoided (Metric tons/year)	3.29 tons/yr/MW	178,054	256,521
CO_2 Avoided (Metric tons/year)	3,281 tons/yr/MW	177,567,720	255,819,570

Source: W. Musial, "Offshore Wind Electricity: A Viable Energy Option for Coastal United States," NWTC/NREL, *Marine Technology Society Journal*, Fall 2007.

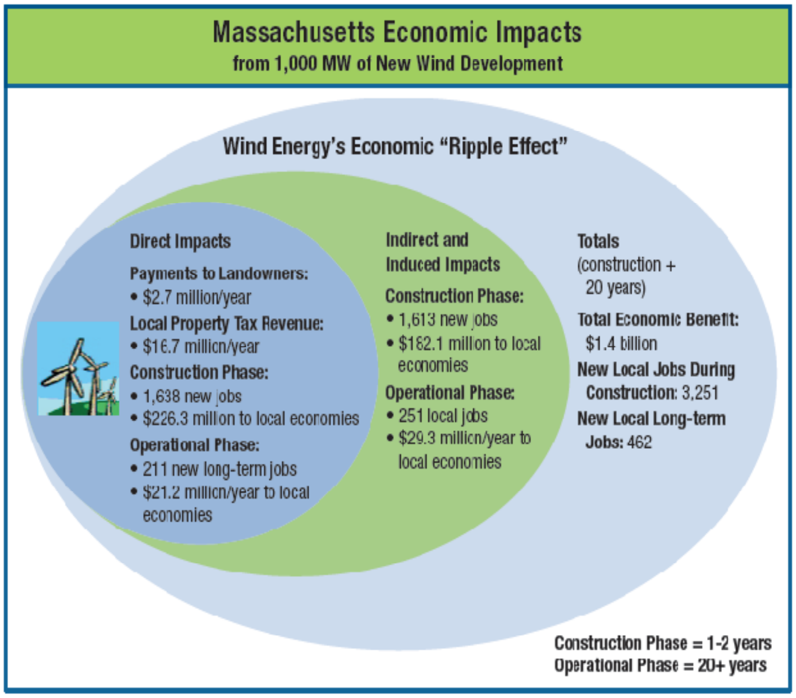
A scenario under which 78 GW of wind power were installed in the U.S. predicted that: approximately 3 million short-term jobs would be created nationally during the construction phase; over 85,000 operating and maintenance jobs would be created; and over 250 million metric tons of CO_2, 720,000 metric tons of SO_2, and over 250,000 metric tons of NO_X would be avoided annually.[24]

With some of the best offshore wind resources in the country, Massachusetts stands to obtain significant economic and environmental benefits from wind development. In March 2009, the U.S. Department of Energy ("DOE") estimated that the cumulative economic impact from just 1,000 MW of wind power in the state would amount to $1.4 billion in economic benefit, annual CO_2 reductions of 2.6 million tons, annual water savings of 1.3 billion gallons, 3,251 new local jobs added during construction, and 462 new local long-term jobs added.[25] These are summarized in Figure 8 (which is from the DOE report).

According to a recent study prepared by researchers at the University of Massachusetts at Amherst of economic benefits from clean energy investments, wind power development provides significant direct job creation. Investment in wind projects provides 157 percent higher direct and indirect job creation than in the oil and natural gas production sectors.[26] Wind power projects provide 88 percent domestic content as a share of total industry output (i.e., the portion of economic activity related to the investment that takes place in the U.S.), which is 5 percentage points higher than investments in the oil and natural gas industries.[27]

Wind development has moved into a new phase in recent years. There has been a significant increase in the demand for and supply of wind projects in various parts of the country. In 2008, the U.S. market added over 8,500 MW of new wind capacity, increasing the nation's cumulative total by 50 percent to over 25,300 MW and pushing the U.S. above Germany as the country with the largest amount of wind power capacity installed.[28] The new wind capacity added in the U.S. in 2008 represented 42 percent of all generating capacity entering commercial operations in 2008, and up from 35 percent of all capacity additions in 2007.[29] During the first four months of 2009 alone, over 3,200 MW of new wind capacity was installed, bringing the total installed capacity to over 28,000 MW. By contrast, during the prior decade, nearly all of the generating capacity added in the U.S. was at power plants that use natural gas as the primary fuel.

Figure 8



Source: DOE Wind Benefits Report, March 31, 2009.

There are many reasons (apart from the raw abundance of the wind resource itself) why wind project development has increased dramatically in recent years. Among the more important ones are:

- Manufacturing and technological improvements that have generally lowered the cost of wind turbines. This is a significant trend from the vantage point of the past decade, even taking into account the fact that there were relatively small cost increases in the past few years in light of increases in the prices of various commodities used in the manufacturing of equipment for wind turbines and installations.

> Wind project installed costs declined dramatically from the beginnings of the industry in California in the 1980s to the early 2000s, falling by roughly $2,700/kW over this period.[fn] More recently, however, costs have increased. Among the sample of projects built in 2007…[the average reported installed cost] is up $140/kW (9%) from the average cost of installed projects in 2006 ($1,570/kW), and up roughly $370/kW (27%) from the average cost of projects installed from 2001 through 2003.[30]

- Relatively high energy prices that increase the economic attractiveness of generating projects (like wind turbines) that otherwise have high capital costs and low fuel costs. Fossil fuel prices rose significantly during the past decade. The price of oil – used to provide peaking electrical power in many parts of the country and thus affecting the price of power on the margin – is now nearly six times the level it was a decade ago.[31] Similarly, natural gas prices rose sharply from 1999 to 2008. The average price of natural gas for power generation was $2.67 per mcf of gas in 1999, compared to $9.11 per mcf in 2008 (3.5 times the 1999 level). At their height in June 2008, natural gas prices averaged $12.17 per mcf during the month of June 2008.[32] Even the price of coal – the fuel used to produce approximately half of the power in the U.S. – rose by 80 percent from 1999 through August 2009 (from $ 24.72 to $44.67 per ton of coal).[33] While prices of natural gas and oil have dropped in 2009 relative to 2008, the rising fossil-fuel prices over most of the period since 1999 has increased electricity prices – and thus helped to stimulate the economic investment in renewable fuels that compete with other sources of electricity.

- Investment incentives (such as the federal production tax credit, the investment tax credit, and other similar state-specific incentives) have spurred wind development). These provided investment support for wind and other renewable power development in recent years. Under present law, an income tax credit is allowed for the production of electricity from qualified wind energy facilities and other sources of renewable energy. The current value of the credit is 2.1 cents/KWh of electricity produced. The credit was created under the Energy Policy Act of 1992 (at the value of 1.5 cents/KWh, which has since been adjusted annually for inflation) and applies to electricity produced by a qualified wind facility placed in service after December 31, 1992, and on or before December 31, 2012. The production tax credit ("PTC") is only applicable to utility-scale wind turbines, not smaller turbines used to power individual homes or businesses. The PTC was scheduled to expire on December 31, 2008, but the American Recovery and Reinvestment Act ("ARRA"), passed in February 2009, extended the credit for three additional years. Since its establishment in 1992, the PTC has undergone a series of one- or two-year extensions, and has been allowed to lapse in three different years: 1999, 2001 and 2003. The federal government's uninterrupted commitment to the PTC from 2005 through the present has given the industry a steady base to build upon, enabling four straight years of growth. The most impressive expansion of the wind industry was seen in 2008, when a record 8,500 MW of new wind power capacity was added.[34]

- Technological improvements in wind turbines. Output from wind turbines has been progressively improving through higher capacity factors.

> In the best wind resource areas, capacity factors in excess of 40% are increasingly common. Of the 112 projects in the sample installed prior to 2004, for example, only 4 (3.6%) had capacity factors in excess of 40% in 2007 (in capacity terms, 56 MW, or 1%, exceeded 40%). Of the 58 projects installed from 2004 through 2006, on the other hand, 15 (25.9%) achieved capacity factors in excess of 40% in 2007 (in capacity terms, 836 MW, or 16.7%, exceeded 40%). These increases in capacity factors over time suggest that improved turbine designs, higher hub heights, and/or improved siting are outweighing the otherwise-presumed trend towards lower-value wind resource sites as the best locations are developed.[35]

- The adoption of renewable energy-related requirements (e.g., the Renewable Portfolio Standard ("RPS")) in many states that has created more demand for renewable power.

In recent years, the demand for renewable electricity has accelerated as a consequence of state and federal policies and the growth of voluntary green power purchase markets, along with the generally improving economics of renewable energy development. The National Renewable Energy Laboratory (NREL)[fn] estimates that U.S. green power sales totaled 8.5 million MWh in 2005 and approximately 12 million MWh in 2006. The 2006 figure represents a three-fold increase from just three years earlier.[fn] The U.S. Environmental Protection Agency's (EPA) Green Power Partnership has helped spur the phenomenal growth in commercial customer purchases, from less than 400,000 MWh in annual purchase commitments in 2001 to nearly 7 million MWh in 2006, an 18-fold increase in just five years.[fn] At the same time, 25 states plus the District of Columbia have enacted renewable portfolio standards (RPS) requirements ranging from 2% to 30% of total electricity supply, to be achieved over the next five to 15 years. However, U.S. non-hydro renewable electricity generation provided only about 2.3% of the total U.S. electricity supply in 2005. And global demand for renewable energy equipment is already leading to supply shortages for wind turbines and photovoltaic modules.[36]

- The design of certain wholesale power markets (e.g., in New England, New York, Texas, and parts of the Midwest) that provide both transmission access with a single region-wide transmission rate, and a "single-clearing price" energy pricing structure supports wind development.

  > Well-structured regional wholesale electricity markets operated independently allow far greater amounts of renewable energy and demand response resources to be integrated into the nation's electric grid. In fact, approximately 73 percent of installed wind capacity is now located in regions with such markets, while only 44 percent of wind energy potential is found in these areas. Large, regional energy markets provide for cost-effective balancing of generation and load with significant penetrations of variable, non-dispatchable power sources, and they facilitate delivery of resources remote from load centers. A summary of utility industry research by the Utility Wind Integration Group (www.uwig.org) states that 'well-functioning hour-ahead and day-ahead markets provide the best means of addressing the variability in wind plant output.' Further, 'consolidation of balancing areas or the use of dynamic scheduling can improve system reliability and reduce the cost of integrating additional wind generation into electric system operation.[37]

- The expectation that the nation's requirements for electricity production with a lower carbon footprint cannot be accomplished without significantly greater reliance on wind energy.

  > Without utility-scale wind, solar and geothermal facilities and adequate transmission access, we won't be able to meet future energy demand, much less reduce carbon emissions to levels needed to avoid the damaging effects of climate change.[38]

Typically, though, wind is located where people (i.e., electricity consumers) generally are not. This means that wind power development and deployment are inextricably tied to electric transmission. Thus, to realize the significant near-term potential for wind power development, new transmission will be needed. (This is true for wind in the center of the nation, on mountain ridges and in offshore areas.)

3. BACKGROUND: INITIATIVES OF THE COMMONWEALTH OF MASSACHUSETTS IN EXPLOITING ITS OFFSHORE WIND RESOURCES

Over the past several years, Massachusetts policy makers have come to appreciate the valuable energy and economic-development resource that stands in the waters just off of the state's coastline. Governor Deval Patrick identified wind power as "a centerpiece of the clean-energy economy we are creating for Massachusetts"[39] and the legislature has complemented this effort by adopting a series of new laws that have created a fertile environment for wind power development in the state.

In 2008 alone, the Massachusetts legislature enacted four laws that will positively impact the development of offshore wind. Enacted in May of 2008, the *Oceans Act* requires the development of a first-in-the-nation comprehensive management plan for Massachusetts's state waters (extending three miles out from the shoreline), and includes among its goals the requirement that the plan "foster sustainable uses that capitalize on economic opportunity without significant detriment to the ecology or natural beauty of the ocean." The Oceans Act creates a 17-member ocean advisory commission to advise the Secretary of Energy and Environmental Affairs in developing the management plan, amends the Ocean Sanctuaries Act to allow for the siting of "appropriate scale" wind, wave, and tidal power in state waters (except for the Cape Cod Ocean Sanctuary), and is part of a plan to balance new and traditional uses of the ocean with preservation of natural resources.[40]

Signed in July 2008, *The Green Communities Act* is a comprehensive energy reform bill that accelerates the rate of increase in the proportion of renewable energy to total generation required of all electricity suppliers under the state's RPS. The result is an increase from 4 percent of sales to 15 percent by 2020, and a revised goal that 20 percent of all electricity come from renewable and alternative sources also by 2020. The Act also requires utilities to enter into long-term (10 to 15 years) power purchase contracts with the developers of renewable energy projects, with the intention of improving the economics of and financing for renewable projects. In addition, the Act modifies other authorities: for example, the state Division of Energy Resources is expanded and elevated into the Department of Energy Resources, and now includes a Green Communities Division to provide technical and financial assistance to municipalities for energy efficiency and renewable energy efforts. The program will receive $10 million annually in funding from a variety of sources to further these efforts. Lastly, recognizing that siting is frequently an obstacle to renewable energy development, the Act creates an energy facilities siting commission to review, in part, "whether current laws and regulations do not adequately facilitate the siting of renewable and alternative energy facilities" to propose changes.

Signed in August 2008, the *Green Jobs Act* furthers the growth of the clean energy industry in the state by providing support for research and development, entrepreneurship, and workforce development. The Act directed millions of state dollars toward growing the local alternative-energy sector, by providing funding for seed grants to companies, universities, and nonprofits; workforce development grants to state higher education facilities, vocational schools, and nonprofits; and by providing low-income job training. In addition, the Act created the MCEC, which aims to support the clean energy sector through direct investments in new and existing clean energy companies, providing assistance enabling companies to access capital and other resources for growth, and promoting training programs to build an energy workforce.[41]

Last but not least, also signed in August 2008, the *Global Warming Solutions Act* requires the reduction of GHG emissions by 80 percent of 1990 levels by 2050, with a reduction of up to 25 percent by 2020. The Act establishes statewide and regional registries of greenhouse gas emissions, and calls upon the Massachusetts Department of Environmental Protection to determine the baseline emissions level of 1990 and calculate the expected 2020 emissions levels if no new controls were imposed after January 1, 2009 (the "business as usual" level). The Secretary of Energy and Environmental Affairs will set a 2020 emissions limit between 10 percent and 25 percent below 1990 levels, and by January 1, 2011 adopt a plan for meeting that limit. The Secretary will also set 2030 and 2040 limits, leading up to the required 80 percent reduction by 2050. This gradual reduction of emissions levels will spur innovation and entrepreneurship in clean energy technologies, including offshore wind, in the state.[42]

The Patrick Administration has made strong efforts to support development of the state's rich wind resource. On January 13, 2009, Governor Patrick announced a goal of developing 2,000 MW of wind power capacity – enough to power 800,000 Massachusetts homes – by 2020. Governor Patrick also directed the Secretary of Energy and Environmental Affairs to use the 2,000 MW wind goal, as well as the mandates and incentives provided by the various clean energy statutes enacted in 2008, to guide the state's efforts to dramatically increase the development and deployment of clean, renewable wind power in the coming years. Installing 2,000 MW of wind capacity would meet an estimated 10 percent of the state's current electric load, and by displacing electricity generated by fossil fuels, use of wind turbines on this scale would reduce greenhouse gas emissions by 3.1 million tons, or roughly 12 percent of emissions from power plants today.[43]

In testimony before a congressional committee in March 2009, the Massachusetts Secretary of Energy and Environmental Affairs, Ian Bowles, highlighted that "The East Coast is a different matter. Here, offshore wind is superior to remote onshore wind in terms of resource size, distribution, capacity factor, reliability, minimization of environmental impact, and – this is the key – proximity to population centers. This enormous energy resource is located just a short distance from the major load centers of the East Coast, but unlike on-land wind, tapping it will require development and policy assistance to get it over the commercialization hurdle. We will fail as a nation if we do not take this moment in our history – a time of aggressive federal funding and policymaking for sustainable energy development – to capture this resource once and for all for the benefit of current and future generations."[44]

On May 12, 2009 U.S. Secretary of Energy Steven Chu announced the selection of Massachusetts as one of two *Wind Technology Testing Centers* in the country to receive $25 million in funding from the American Recovery and Reinvestment Act.[45] The Center (located in Charlestown and originally designated under a 2007 initiative) will test commercial-sized wind turbine blades to increase reliability, reduce cost, facilitate other technical advancements and speed deployment of the next generation of wind turbine blades into the marketplace. The Center will be the first commercial large blade test facility in the nation to allow testing of blades longer than 50 meters (which currently can be performed in Europe but not in the United States) and in fact will be equipped to assess turbine blades up to 90 meters long - nearly the length of a football field. The Center, the groundbreaking for which was celebrated on December 1, 2009, will be operated in partnership with NREL. [46]

A senior Massachusetts state official, Greg Watson (Senior Advisor to Secretary Bowles on Clean Energy Technology and Vice President for Sustainable Development and Renewable Energy at the MTC), has been an active player for years in launching the U.S. Offshore Wind Collaborative ("USOWC") with other entities, including the MTC, the U.S. DOE, and GE Wind Energy. The goal of USOWC is to address the technical, environmental, economic, and regulatory issues necessary to catalyze the sustainable development of offshore wind energy in the waters of the U.S. In recent months, Greg Watson has said, "It would work both ways, right? You could export electricity from the Midwest to the East, but you could also transport electricity from the coasts westward…We're just beginning to see that we have both the potential and the need to organize the East Coast states, because all of a sudden, we have a resource that's strategically important…We've been importing all of our energy. Now, all of a sudden, we have a strategic resource, and it's plentiful."[47] He has also noted "People are concerned about the future of the oceans; in terms of the ecosystem…We think we have an argument to say that one of the biggest challenges facing the ocean environment is climate change. And that the ocean can provide an environment where some of the solutions to this can actually be sited if it's done right."[48]

Testifying before the U.S. House of Representatives in June 2009, Paul Hibbard, Chairman of the Massachusetts Department of Public Utilities, stated that:

> The very best wind resource in our country – from the perspectives of resource size, distribution, capacity factor, reliability, proximity to population centers, and minimization of environmental impact – is located a short distance off the major load centers of the East Coast. For sure, offshore wind turbine installation may currently cost more than onshore wind development, but better wind resource economics, decreasing unit costs with increased development opportunities, and the absence of the need for cross-country transmission could make offshore wind competitive with remote wind farms. The higher cost of construction may well be more than offset by the markedly lower cost of transmission... Given the sheer magnitude of this resource potential so close to our nation's major load centers, and the opportunity to have it developed incrementally, disbursed geographically, and through many different interconnections along the coast (improving power system reliability), we would miss an enormous opportunity to not focus aggressively on its development, and we would be making a grave mistake to preclude its development by overwhelming local markets with a high volume of power from distant generation sources.[49]

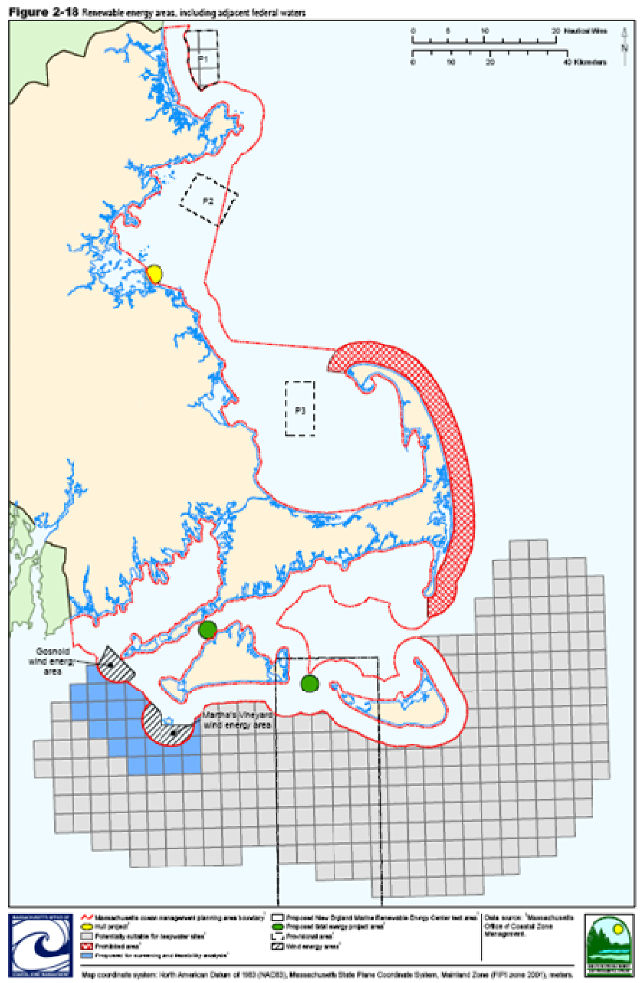
The MCEC has recently solicited a *Port and Support Infrastructure Analysis for Offshore Energy Development*, which will analyze shore and port facilities with a view toward identifying appropriate port facilities, estimating upgrades to make the locations suitable to support offshore energy development, and quantifying economic impacts on the port area and surrounds. Report findings are expected by early 2010.

On December 2, 2009, Governor Patrick announced that National Grid and Cape Wind have agreed to enter into negotiations for a long-term contract under which the utility would purchase the electricity generated by Cape Wind. A power purchase agreement is reported to be a critical requirement for financing Cape Wind, and getting it into construction and operation in time to qualify for federal incentives under the ARRA that could reduce the cost of the project by 30 percent. [50]

At the end of December 2009, Secretary Bowles published the *Massachusetts Ocean Management Plan,* as directed by the Oceans Act. In this Plan, Secretary Bowles identified several areas of the state's waters for the development of commercial scale wind projects, and proposed a framework under which "community scale" wind turbines could be sited in state ocean waters. The Plan's designated areas for renewable energy are shown on Figure 9. (In Figure 9, these areas are labeled "MREC Proposed Areas" (which are areas designated for renewable energy development, and open to wind, wave, or tidal), "Proposed for Designation and Feasibility Analysis," "Proposed for Screening and Feasibility Analysis," "Provisional Area," and "Subject to Screening for Potential Deepwater Sites.")

<u>Figure 9</u>

Renewable Energy Areas, Including Adjacent Federal Waters



Source: Massachusetts Ocean Management Plan, December 2009.

As a frontrunner in such pursuits, Massachusetts is still one of several states on the Northeast Coast actively pursuing offshore wind development. Several other states stretching from Maine to Delaware are exploring the feasibility of such projects off of their shores. For example:

- In September 2009, Maine officials announced that the state had identified seven offshore areas that could be suitable places for testing wind power technology. Under a state law adopted in June, state officials must, before December 15, 2010, select at least one and potentially as many as five sites for test projects. One site will be designated as a wind energy research center operated by the University of Maine. Private companies would be sought to develop projects on any other sites.[51]

- In 2008, Rhode Island issued a request for proposals from offshore wind developers that could contribute to providing at least 15 percent of the state's electricity needs. Deepwater Wind was subsequently selected as the winner and entered into a joint venture with the state, through which Deepwater Wind will build an initial 20 MW test phase in state waters by 2012, with a subsequent commercial phase adding 100 turbines in federal waters off of the Rhode Island coast. The exact location of this wind farm has not yet been determined. It is expected that the results of the Special Area Management Plan ("SAMP") permitting process (due in 2010) will dictate where the project will be located.[52]

- In September 2009, the Maryland Energy Administration announced that it was soliciting interest from wind developers to develop offshore wind facilities more than 12 miles off the state's coastline. Responses to the request for interest were due January 31, 2010 – to be announced thereafter.[53]

- In June 2008, Delaware officials announced that they modified the state's renewable energy credit ("REC") system so that RECs from offshore wind energy would count at a relative value of 350 percent (compared to a typical 1-to-1 basis for RECs) toward the state's RPS for utility Delmarva Power & Light. (In-state customer-sited photovoltaic generation and fuel cells using renewable fuels installed before 2014 also qualify for a greater than 1-to-1 REC multiplier in Delaware). This act followed a separate announcement the day earlier that Bluewater Wind had signed a 25-year contract with Delmarva Power to sell the utility up to 200 MW of power from an offshore wind farm that will be built 11.5 miles off the coast of Delaware beginning as early as 2012. The contract was contingent upon the Delaware legislature changing the RPS to allow for RECs coming from the offshore wind farm to be credited to Delmarva's account at a rate of 350 percent per REC.[54]

4. THE CHICKEN-AND-EGG PROBLEM ASSOCIATED WITH TRANSMISSION INVESTMENT FOR WIND DEVELOPMENT

Massachusetts' offshore wind resources are located in places relatively distant from the high-voltage transmission grid that would be needed to move any wind-generated electricity to consumers. This means that development of this rich wind power resource is inextricably tied to electric transmission which does not yet exist in the vicinity of the windy areas offshore. Thus, to realize the significant near-term potential for wind power development, new transmission will be needed.

It is well understood, however, that in the current framework for transmission investment, wind development and transmission expansion suffers from a classic chicken-and-egg problem. Most transmission facilities tend to be added by transmission companies where needed to assure that customers continue to receive reliable electricity service. Sometimes transmission is planned and built to enable new power plant facilities to deliver their power to customers, and typically transmission utilities are willing to invest in such facilities because they can be assured of recouping their investment from the consumers who benefit from the transmission enhancements.

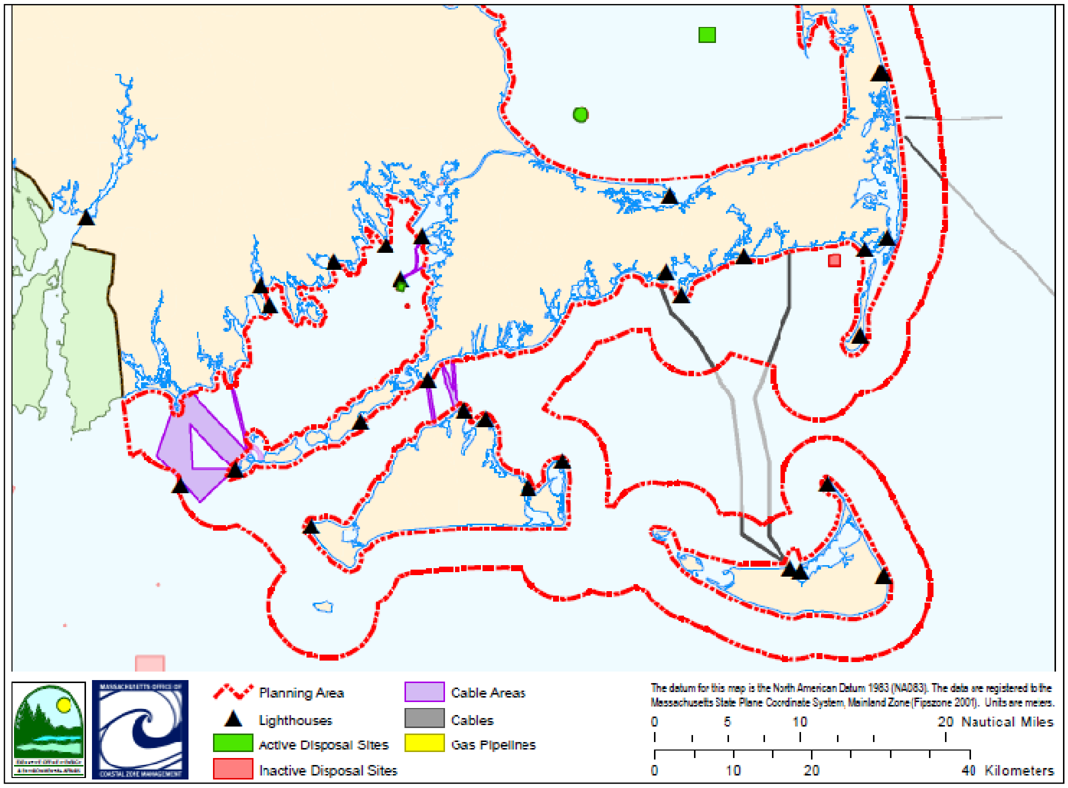
By contrast, transmission companies typically have little interest in building transmission infrastructure in areas where there are no power plants or little power demand because of concerns about who will pay for their transmission investment. Similarly, there tends to be little interest in building renewable generating capacity in remote areas with little power demand and no transmission infrastructure to move power to load centers, since without transmission there is no way to deliver their power to customers. This problem is particularly pronounced in renewable-rich areas which are remote and distant from customer loads.

Each piece of potentially costly infrastructure – the wind project developments themselves, and the transmission projects to service them – wants the other to be developed first. Without more creative mechanisms to plan for and provide investment recovery than currently exist, the situation may well remain a stalemate: wind projects cannot really proceed without transmission access; and transmission investment does not tend to proceed without assurances that wind projects will develop, and that the transmission investment costs can be repaid by the beneficiaries of the facilities.

As shown in Figure 10, which depicts the infrastructure that currently exists in Massachusetts' ocean waters, there is little transmission already built in the offshore state (or federal) ocean. This is generally true, but it is particularly the case in the areas that the Massachusetts Ocean Management Plan has designated as appropriate for commercial-scale wind facilities. Except for the cables that connect the Island of Nantucket with the electric grid on Cape Cod, there is a dearth of transmission leading to the areas that offer significant wind resources.

Without some way to break the chicken-and-egg problem, development of these windy offshore areas for power generation may end up in a stall. The current transmission framework in New England (described in Section 5) does not on its own solve the problem. Some other regions with significant wind power potential have attempted to crack the chicken-and-egg problem in ways that provide helpful insights for Massachusetts (described in Section 6).

<u>Figure 10</u>
Utility Infrastructure Located in Massachusetts' Ocean Waters



Note: Cables represent identified, specific routes. Cable areas do not refer to specific routes and are as reported by the National Oceanic and Atmospheric Administration.

Source: Draft Massachusetts Ocean Management Plan, June 2009, Figure 2-10.

5. THE BASIC TRANSMISSION FRAMEWORK IN NEW ENGLAND

For more than a decade, the high-voltage, interstate transmission system in the six New England states has been managed by a single, independent system operator: ISO-New England. The individual transmission lines, substations and other facilities of the high-voltage grid are actually owned and maintained by the region's transmission utilities, including National Grid (with facilities in parts of Massachusetts, New Hampshire and Rhode Island), Northeast Utilities (with facilities in parts of Massachusetts, Connecticut, and New Hampshire), NSTAR (with facilities in Massachusetts), and other transmission utility companies. (Figure 11 shows the locations of the high-voltage transmission system in New England, including transmission projects now approved.)

However, a variety of functions that relate to the adequacy of, use of, and investment recovery for the high-voltage transmission system come under the responsibility of ISO-NE. Among others, these functions include transmission system planning, studies for interconnecting transmission and generating facilities (including wind power projects) to the regional high-voltage transmission system, and the administration of the regional transmission tariff. ISO-NE's tariff governs the terms, conditions and charges under which anyone may have access to and use the transmission facilities owned by the transmission companies, and collects funds to repay the owners for their investment in transmission facilities. As an operator of an interstate transmission system, ISO-NE is regulated by the Federal Energy Regulatory Commission ("FERC").

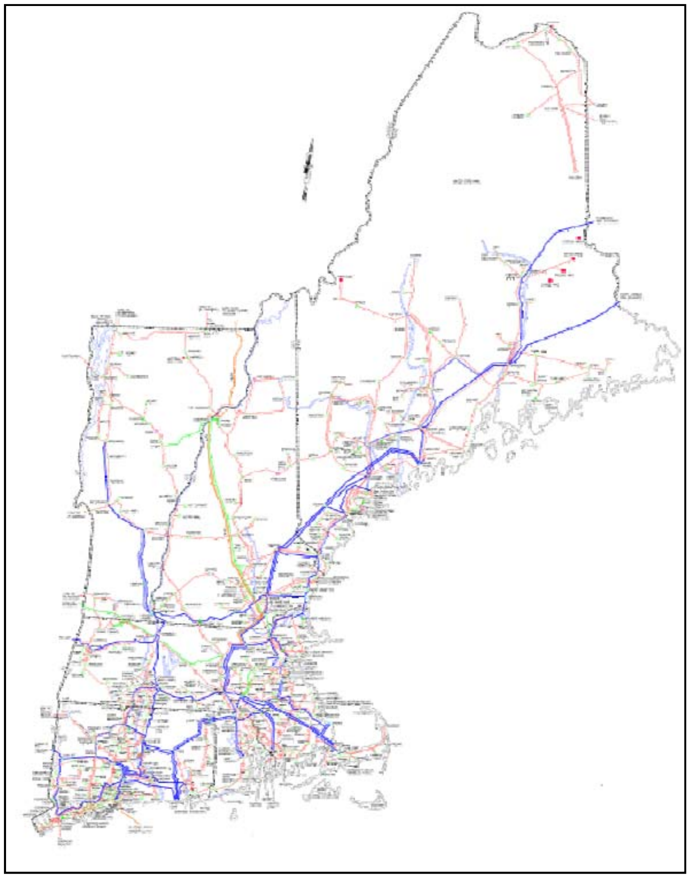
Historically and until recently, most of the region's high-voltage transmission facilities were built as part of large power generating projects and efforts to interconnect various parts of New England into a single interconnected system. Many utilities jointly planned generation and transmission projects together. However, with the gradual adoption of non-discriminatory "open access" transmission policies by the FERC since the early 1990s, and as a result of the restructuring of the electric industry in five of the six New England states during the late 1990s, most of the planning and investment in transmission infrastructure has been in parallel with, rather than in collaboration with, planning for generation facilities.

In the past few years, the ISO-NE and transmission companies have undertaken major investment in transmission infrastructure across the New England region. For the most part, regional reliability needs – as compared to economic development or investments to lower overall electricity costs – have driven most of this new infrastructure development. As of mid-2009, the cumulative investment in new transmission since 2002 was estimated to be $3.962 billion region-wide.[55]

Under the current tariff rules for adding transmission in New England, there are several types of facilities – each of which has a different set of investment recovery policies. "Regional Benefit Upgrades" are transmission upgrades for the high-voltage system (i.e., 115 kV and above) that have been incorporated into the ISO-NE Regional System Plan. This plan identifies facilities that are: (a) "Reliability Transmission Upgrades" (those necessary to ensure the continued reliability of the New England transmission system, after making certain assumptions about the size, timing and location of growth in customer demand and changes in the sources of supply); and (b) "Market Efficiency Transmission Upgrades" (those designed primarily to lower the cost to produce power in the region (i.e., where the carrying costs of the transmission project are lower than the reduction in the region's total production cost)). The ISO-NE tariff recovers the costs of such Reliability and Market Efficiency Transmission Upgrades from all electricity customers that use transmission service in the region, and allocates the costs to customers according to the size of their electricity use (relative to total regional customer load).

Some other transmission facilities in New England are considered to be "Local Benefit Upgrades" whose costs are assigned to the electricity provider (who in turn passes these costs along to its customers) in a particular subregion of New England. Finally, there are some specific projects funded directly by the sponsor or "the participant;" these include interconnection facilities (e.g., those that link a power plant to the high-voltage transmission facility), "merchant power lines" or other voluntary "elective" transmission upgrades – all of which have costs that are paid for directly by the participants of the project (i.e., the direct beneficiaries of these projects).

Figure 11
High-Voltage Transmission System in New England



Source: New England 2030 Power System Study: Preliminary Maps and Cost Estimates for Potential Transmission; ISO-NE Planning Advisory Committee; August 14, 2009.

Under these policies and tariff rules, it is generally understood that transmission facilities that are needed to connect a wind farm – whether located in an offshore area, or on a terrestrial site – to the New England high-voltage Pool Transmission Facility System ("PTF System"), would have to be paid for as a participant funded cost (e.g., interconnection facility). Therefore, New England's regional transmission cost-recovery rules anticipate that the developer/investor in the offshore wind project would directly absorb the costs of the transmission facilities needed to connect to the onshore high-voltage system – a situation that resembles the chicken-and-egg stalemate described above.

Over the past year, and at the request of the region's Governors, the ISO-NE has carried out studies that explore the implications for the region's on-shore PTF transmission system of importing large quantities of renewable energy, of building it within the region, or of bringing it to loads from offshore locations in the region. This study is described in Section 7 of this report.

6. TRANSMISSION MODELS USED TO SUPPORT WIND DEVELOPMENT IN OTHER REGIONS WHERE LARGE WIND RESOURCES EXIST

Transmission Models for Wind Power: Key Concepts and Distinctions

There are several different approaches that have been used in parts of the U.S. and Europe to provide transmission facilities in advance of wind power development, thereby breaking the chicken-and-egg problem. Typically in these approaches, the provider of transmission facilities (and investment) is separate from the wind power developer (and investor). Often, but not always, the transmission provider is a utility company; usually, the wind project is developed by another entity (or more than one developer, where a transmission system supports multiple wind farms). The electricity produced by the wind farm is typically then sold to a third party.

Both transmission and wind power facilities are capital-intensive projects: they have relatively high up-front costs and relatively low ongoing operating costs. They tend to exhibit economies of scale, such that it may be more expensive in the long run to build multiple small transmission facilities to support a large number of wind projects, as compared to initially building a larger, higher-capacity, higher-voltage transmission system that can accommodate large transfers of wind-generated electricity. That approach, however, can break the financial back of the first wind project, if it is expected to carry the cost of a transmission project that is scaled for many subsequent wind projects over time. This creates the inevitable stalemate under traditional transmission cost-recovery policy.

Thus, the chicken-and-egg problem intersects with a complex set of other questions important for any transmission-development framework for wind:

- Is the provision of a transmission system to provide access to a windy area a "public good" – just as development of roads is considered a classic function of government, to support commerce, economic development, and quality of life? Or is it a private good, in the same way that traditional transmission-system investment is deemed to be provided for the use and benefit of electricity customers who buy electricity service?
- Who benefits from providing access for wind power development? All electricity consumers in the state, given the state's RPS requirement? The eventual buyers of power from the projects? All taxpayers in the state, given the new tax revenues that will accrue from jobs, economic development, and potential royalties paid to the state as a result of the development? The developer, investors, lenders, and/or owners of the wind farm, who stand to benefit financially from the project? Electricity customers in a larger region who are able to obtain renewable energy within the Northeast? All of these groups, in different ways? Only some constituencies?
- Who should pay for transmission facilities that need to be built to connect offshore wind farms to the mainland's electric grid? The wind developer? The buyer of power? The broader set of customers in the larger regional market? Some combination of all of these parties?
- How should payments be structured to assure the transmission developer that it will recover its investment costs if it builds a line and puts it into service in advance of the completion of the wind farm – and perhaps well in advance of a sufficient number of wind turbines to fully utilize the line's capacity?

- If there is a region with significant potential to build multiple wind projects over time, then what framework (if any) is in place to encourage efficient development of transmission facilities that can support more than a single wind farm?
- Who should decide who pays for the offshore transmission investment to connect the wind farms to the grid? The parties that voluntarily contract to develop and build the facilities, in the event that they are part of a merchant transmission line? The state utility regulator (e.g., the Massachusetts Department of Public Utilities), in the event that the offshore transmission facilities are considered jurisdictional investment, not part of the regional transmission tariff? The federal utility regulator (i.e., FERC), in the event that the facility is deemed part of the region's high-voltage system? The state legislature, in the event that the state's taxpayers were viewed as the project's beneficiaries?

The approaches that others have taken in answering these questions are summarized below.

Who pays? Based on the experience in various regions of the country, the answers tend to fit into two basic approaches: In one, often called the "participant funded" or "direct assignment" model, the costs of transmission are assigned to and recovered from only those parties that directly benefit from the incremental transmission investment. Under the direct assignment model, transmission investment costs tend to be allocated to beneficiaries in proportion to the amount of benefits they receive. In other words, those who benefit the most from the transmission investment will bear the most cost. Under some regions' policies, beneficiaries (i.e., those being assigned – either directly or indirectly – the costs of transmission investment) may be the developers of wind projects, who in turn pass along these costs to buyers of their renewable power on a "delivered electricity price" basis (often referred to as a "merchant" approach to investment recovery). Alternatively, the beneficiaries may be the customers of a utility that has a requirement to buy renewable power and who support that utility's incremental investment required to deliver that power to them. These "benefitting" customers pick up the transmission costs directly, rather than having the costs embedded into the price of the renewable power.

By contrast, the other approach to the question of "who pays" involves a more uniform assignment of transmission costs across a wider region. This approach is often called a "socialized" investment-recovery model. Everyone (e.g., all buyers of electricity in a wide region) picks up the cost of the transmission investment. Typically under a socialized cost-allocation model, the cost of transmission investment is distributed on a uniform basis (typically $/kW) among *all* market participants, such that those who use the most electric resources will bear the most cost.

To date, there are some instances (see below for Texas and Southern California Edison ("SCE")) in which "beneficiaries" of transmission facilities for wind are considered to be the broad group of electricity customers in a regional power market or a utility's service territory or region, in light of a public policy requiring reliance on renewable energy as a part of the electricity supply mix sold in the state. Where this is true, the costs tend to be broadly socialized, since all of the customers are considered beneficiaries of the transmission built to support wind power development.

How are payments structured? There tend to be two different systems under which the users of transmission (e.g., either the wind developer, or the electricity buyer) repay the transmission provider for making the investment in transmission facilities. One is a tariff payment system, and the other is a contract-based payment system.

Tariffed rates are assigned to users of an electric system, with all customers who buy power under similar terms and conditions of service paying a similar rate. Rates may vary, depending upon the size of the customer's demand on the system, or the quality of the service (e.g., whether it is firm service or can be interrupted under certain circumstances). The tariffed rates are structured so that they recover the cost of providing the service: that is, so that the investment costs and operating costs are repaid to the transmission provider. The tariff must be approved by a utility regulator, and establishes the terms under which a customer seeking to obtain transmission service would be able to obtain it. Depending upon how the tariff is structured, rates may be socialized across all customers in that electric system, or the costs of certain transmission facilities may be assigned only to a subset of customers (e.g., those deemed to benefit from those facilities).

By contrast, under contract-based investment recovery, the buyer of a service (e.g., use of transmission) enters into an agreement with the seller of the service (e.g., provision of transmission), and that agreement establishes the terms, conditions and price of service. The contract establishes the rights, obligations, and assignment of risks between the parties. For example, a utility that buys power from a wind farm in order to meet its RPS requirements may enter into a contract with a transmission provider to build transmission facilities to connect the wind farm to the utility's service territory. The contract sets forth the rights over the capacity on the line, the support payments, and other aspects of service. Contract-based investment recovery is typically associated with a merchant cost-allocation model.

There are some rare instances where wind power-related transmission costs are socialized in light of the facilities' "strategic benefits," as much as for their reliability benefits or economic savings for power production. A prime example is a set of high-voltage facilities proposed to be built in windy areas of Kansas, Oklahoma, and the northern part of Texas (in the Southwest Power Pool ("SPP") region). These transmission lines are seen as needed largely to enable in-region wind power to be developed and resold to out-of-region customers. The strategic benefits include some not typically taken into account in transmission planning studies, including economic development objectives for renewable resources, fuel diversity, air emissions reduction, and reduction in vulnerability to extreme events on the grid. That said, this approach looks to electricity customers – more than taxpayers – to support these strategic benefits.

How are economic development benefits supported? To date, most policy support aimed at stimulating investment in renewable energy for economic development purposes has focused on the renewable energy end of the renewable/transmission spectrum. These public policies endeavor to facilitate the creation of markets for renewable power (e.g., through the RPS and the related markets for renewable energy credits); developing advanced technologies for renewable energy (e.g., through research and development); and through long-term contracting (e.g., for power from a particular project). These investment-stimulus policies do not tend to focus on supporting the transmission projects needed to upgrade the grid to move renewable power over long distances to consumers.

Some states, like North Dakota, provide a number of incentives (e.g., corporate renewable energy tax credits; reductions and/or exemptions from property taxes) directed toward wind generation projects, rather than toward the transmission facilities they require. Some states, like California and New York, have supported research and development on transmission gaps for renewable energy; on ways to characterize the benefits of transmission for renewables so that the benefits include more than traditional reliability or low-cost power supply objectives; on issues related to integrating non-dispatchable renewable energy into the grid; and so forth. However, there are few examples where transmission investment has been specifically supported by economic development mechanisms – with certain notable exceptions in the past (e.g., the establishment of the Tennessee Valley Authority) and in the present (e.g., the economic-stimulus funding for transmission projects that is part of the American Recovery and Reinvestment Act). Instead, transmission investment strategies have tended to focus on the benefits internal to the electric system rather than external economic development benefits like job creation, tax benefits, royalty creation, or other such factors associated with investment in "public good" infrastructure projects. Recent actions of FERC to support development of transmission projects designed to deliver wind energy have fit squarely within the traditional framework of transmission cost recovery by users of the transmission system (e.g., FERC's 2009 decision to establish preliminary regulatory treatment of the proposed multi-state Green Power Express project).

Overview of Transmission Cost-Recovery Models

In practice, there are only a few archetypal ways in which transmission projects tend to be designed with respect to business models, user arrangements and investment-recovery approaches. For simplicity, these can be thought of as "classic" approaches – the "classic" socialized utility transmission approach; the "classic" merchant, contract-based approach; and the "classic" economic development transmission model. The key elements of each are summarized in Table 2.

Even across these core approaches, there is variation. For example, within the "socialized" model, there can be approaches that aim to support broad transmission expansion in support of wind generation with a broad, socialized cost-recovery approach in which all electricity users in a region are considered beneficiaries and all pay for the transmission investment (as in the Texas "CREZ" model). In another approach where all the region's electricity customers pay a common, socialized rate for transmission upgrades (as in the SPP's "Balanced Portfolio" model), the overall system plan was specifically configured in a way to ensure that all electricity customers would receive net benefits (i.e., some combination of reliability and power supply efficiencies) from the combination of power line upgrades. These SPP upgrades included not only projects designed to deliver wind, but also other high voltage grid enhancements as well. Even though in both of these cases (Texas CREZ and SPP's portfolio) the projects are being developed by transmission provider utilities, a clear "economic development" mandate underpins the rationale for finding a way to have a broad set of customers support renewable power development for the benefit of the region's economy as well as for the electrical benefits that could result.

Table 2

Core-Transmission Cost-Recovery Models

"Classic" Socialized Transmission Model (with utility-style tariff)	**"Classic" Merchant Transmission Model** (with contract)	**"Classic" Economic Development Transmission Model** (with tariff or contract approach)

Core attributes:
• Transmission facility investment is driven by a utility's (or state's, or region's) overall goal to provide transmission access to a set of preferred generation resources (e.g., expressed through an RPS requirement that favors purchases of renewable energy).
• The beneficiaries are broadly defined by some entity (e.g., transmission planners), with approvals by a regulator. A collaborative planning approach may be used to identify the appropriate configuration of the proposed transmission enhancements.
• In approving the tariff to recover the costs of the transmission investment, the regulator identifies those classes of customers that benefit from the investment, the costs that will be assigned to them, and the design of the tariff to recover those cost. The tariff recovers the investment costs, and may apply to the seller (e.g., wind facility) or user (e.g., electricity customer).
▪ Benefits and costs tend to focus on electrical-system attributes (e.g., lower electricity bills; access to needed supply regions; reliability benefits). Typically, the analysis includes only monetary benefits and costs associated with production and use of electricity. In some areas, benefits may include economic development goals.
▪ The facilities tend to be fully integrated into the network (AC lines, including both network facilities and/or "radial" lines providing "point-to-point" service).
▪ Note: The August 2009 Seventh Circuit Court decision requires evidentiary basis for demonstrating a nexus between those who benefit and those who pay.
Examples relating to transmission for wind resources include:
▪ Texas' "Competitive Renewable Energy Zones" ("CREZ")
▪ Southwest Power Pool's ("SPP") "Balanced Portfolio"
▪ Southern California Edison's ("SCE") Tehachapi lines
	Core attributes
	• Transmission facility investment is driven by interests of a specific entity (the "beneficiary") willing to enter into a contract with a transmission provider to get a line built.
	• For example, a buyer may seek access to lower-cost supplies, and the cost of the line is worth it, given such potential energy cost savings. A seller may seek access to a higher-cost market.
	• A transmission provider makes the investment, with investment recovery covered in the contract terms. The costs of the line are not included in a traditional regulated tariff.
	• Access to the line is typically "controllable" (e.g., using direct-current ("DC") transmission technology), with the paying party having rights to the line's capacity, while others do not.
	• Regulators (e.g., FERC; state siting regulators) have approved certain merchant lines (under the contract model) when the parties to the contract bear the primary risks and rewards, without other risks and rewards being passed to third parties.
	• Note: It is sometimes difficult to obtain multi-state approvals for these lines, if a regulator views the line as crossing an area that does not otherwise benefit from it.
	Examples (not necessarily related to transmission for wind resources) include:
	▪ Cross Sound Cable, connecting Connecticut and Long Island (DC cable)
	▪ Neptune Cable, connecting Long Island and New Jersey (DC cable)
	▪ Northeast Utilities/NSTAR proposal to build a DC transmission line between Hydro-Quebec and New England
		Core attributes
		▪ Transmission facility investment is driven by public authority with a mission that may go beyond activities related to electricity supply and delivery.
		▪ For example, the mission may include regional economic development, flood control, rural electrification. The public authority is authorized to carry out investments to serve multiple missions with its customers paying rates that recover the investment. Often the power is subsidized, so the delivery facilities' costs are bundled with the low-cost power.
		▪ As a public entity, it typically has certain attributes that other entities lack:
		    ▪ It may be able to access low-cost capital (e.g., where bond covenants require it to set rates to recover its investment costs)
		    ▪ It may set its own rates; not subject to state or federal rate regulation.
		    ▪ It may have eminent domain and other site-access rights.
		▪ Note: If the authority is not a monopoly, then it may face challenges in investment recovery, which may require that its risk is underwritten by taxpayers.
		Examples (not necessarily related to transmission for wind resources) include:
		▪ Tennessee Valley Authority
		▪ Bonneville Power Administration
		▪ Western Area Power Administration
		▪ New York Power Authority

In the SCE Tehachapi project, the utility's customers are underwriting the transmission investment to connect the windy Tehachapi region with the distant customer load centers, and are doing so in advance of wind projects actually being developed. Over time, as new wind projects enter service, they will be assigned more of the costs of transmission, and SCE's broader set of ratepayers will be assigned a smaller share of transmission costs. The rationale for this approach is based, in part, on the state's broad goal to support low-carbon renewable energy resource development.

There are examples of merchant projects where the seller of renewable power is paying for or plans to underwrite the cost of transmission investment (as in the case of the proposed line to be paid for by Hydro-Quebec, and built by Northeast Utilities/NSTAR); and there are examples where the buyer underwrites the line in order to get access to lower-cost supplies (as in the case of the Cross-Sound Cable, with Long Island Power Authority paying for the line under contract to the builder, TransEnergie).

Socialized Transmission Cost-Recovery Models

Texas Competitive Renewable Energy Zones:

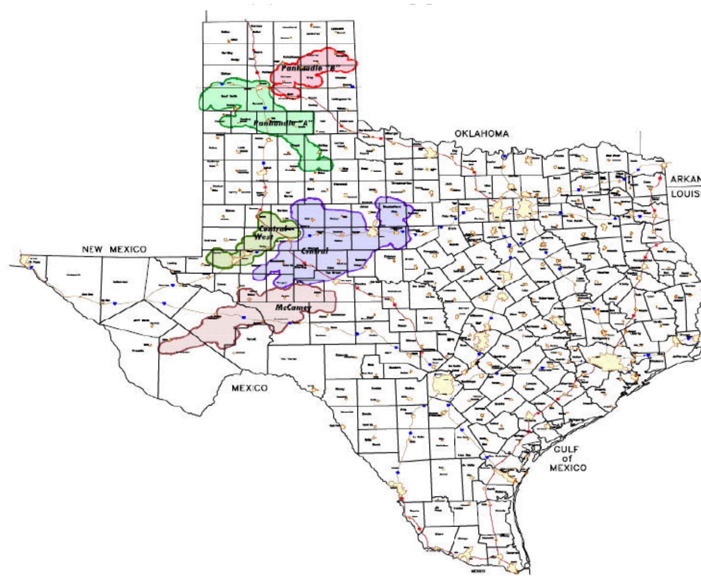
The panhandle and western portions of Texas are rich in potential wind power, but have historically lacked the high-voltage transmission infrastructure needed to move electricity to the state's densely populated areas (e.g., Dallas, Fort Worth, Houston, etc.). In 2005, the Texas legislature passed Senate Bill 20, in part to develop transmission infrastructure in advance of wind power development, thereby breaking the chicken-and-egg stalemate. Senate Bill 20 directed the Public Utilities Commission of Texas ("PUCT") to identify and select the most productive wind zones in the state and devise a transmission plan to move electricity generated from these zones – known as Competitive Renewable Energy Zones ("CREZ") – to customers.[56]

The PUCT asked the state's electric grid operator, the Electric Reliability Council of Texas ("ERCOT") to collect wind data and nominate the geographic boundaries of a number of CREZs based on transmission cost calculations for each CREZ. In December 2006, ERCOT published a comprehensive report which identified the geographic areas that the PUCT might consider in designating CREZs.[57] In July 2007, after evaluating the potential for wind-generation in about 25 areas in the state, the PUCT designated eight areas as CREZs, which were combined into five zones (see Figure 12). The PUCT then tasked ERCOT with developing cost estimates for constructing high-voltage transmission from these zones. ERCOT "evaluated 12 options to build transmission for additions of 1,000 MW to 4,600 MW of wind energy. ERCOT found that the transmission addition would cost between $15 million and $1.5 billion, depending on the distance required. The transmission cost [would] average[s] $180/kW of wind energy, or about 10% of the $1,800/kW capital cost [fn]."[58]

In April 2008, ERCOT published a study identifying transmission plans for four scenarios, whose projected transmission-related costs ranged from $2.95 billion to $6.38 billion (equivalent to $350 per kW to $570 per kW), and whose projects could accommodate wind generation (installed capacity) amounts ranging from 12,053 MW to 24,859 MW.[59] Three months later the PUCT approved the development of Scenario 2 (see Figure 13), with an estimated cost of $4.93 billion and the ability to move approximately 18,500 MW of wind power from the CREZs to load centers.[60] In January 2009, the PUCT awarded the development of CREZ transmission plan segments to 11 entities – five established transmission providers, three new entrants, and three Texas cooperatives. The PUCT intends to stagger the transmission filings over time, with the intent of having the first of these transmission projects online by 2011 or 2012.[61]

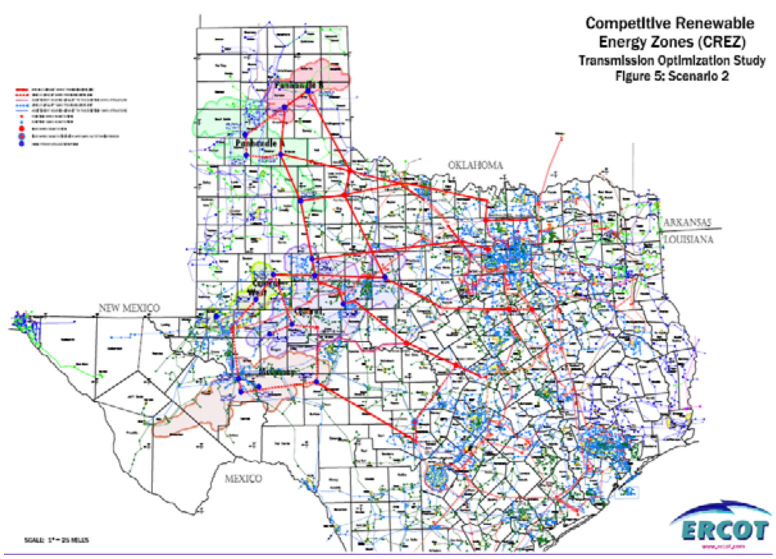
Other than the costs of the direct generator interconnection facilities, the cost of transmission will be broadly socialized and spread across all load serving entities in ERCOT, allocated in proportion to the load each serves. The estimated aggregate cost of $4.3 billion is projected to amount to approximately $4.00 per month per residential customer once construction is complete and costs are reflected in rates.[62] Senate Bill 20 and PUCT regulations have dispensed with demonstration of need requirements for transmission built to serve CREZs (i.e., transmission proposed for CREZ automatically meets 'used and useful' and prudence criteria) and guarantees cost recovery.[63]

Figure 12



Source: ERCOT, (available at http://www.ercot.com/news/presentations/2007/CREZ-11-02-07_public.pdf).

Figure 13
Texas Competitive Renewable Energy Zones with Transmission



Source: ERCOT, "Competitive Renewable Energy Zones (CREZ) Transmission Optimization Study," 2008, Figure 5: Scenario 2.

California's Location Constrained Resource Interconnection Tariff:

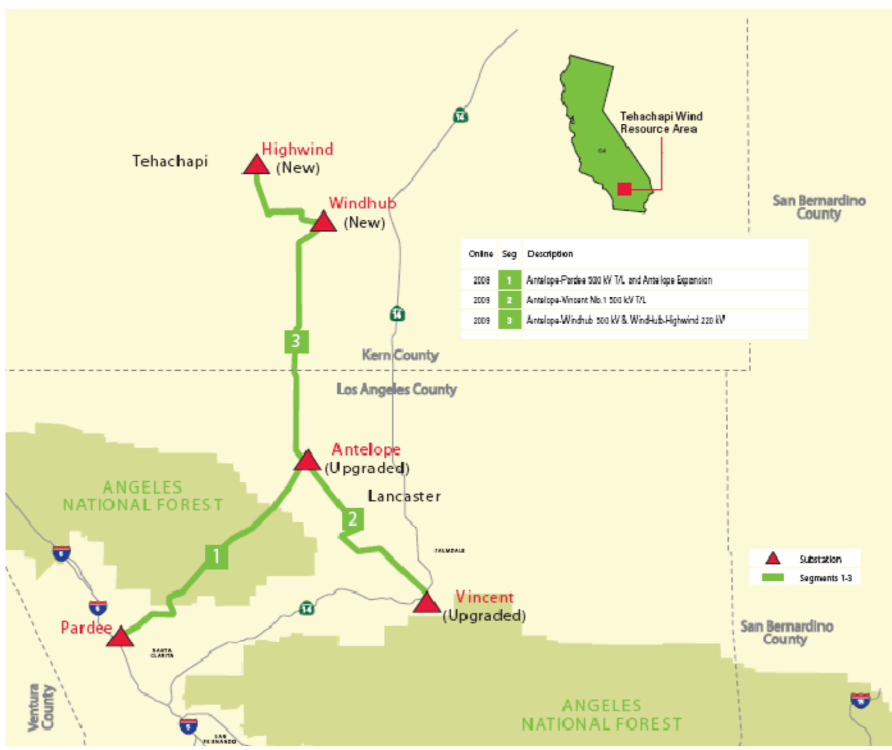
California's grid operator ("CAISO") has utilized a socialized transmission cost-recovery approach to support up-front investment of transmission in advance of new generation for areas that are "location-constrained" but rich in potential resources. Location-constrained resources include wind resources and other "fuels" that cannot be transported, and which must produce power at the geographic site of the resource. CAISO's Location Constrained Resource Interconnection ("LCRI") tariff was approved by FERC in December 2007 and will be a part of the region-wide transmission access charge levied upon all ratepayers. Under the approved mechanism, the cost of transmission investment to connect location-constrained resources to the existing high-voltage electric grid will initially be broadly socialized and recovered through this tariff. Over time, each generator that interconnects is responsible for paying its pro-rata share of the going-forward costs of using the line. As additional projects are developed and completed, they too pick up their pro rata shares of transmission costs until the renewable resource area is fully developed.[64]

Under the LCRI mechanism the cost and risk of the location-constrained area not being fully utilized by generators is socialized across all CAISO ratepayers. CAISO is effectively allowing ratepayers to fund transmission lines that do not meet reliability or economic tests in order to achieve a different policy goal: encouraging the development of locationally constrained resources such as wind and solar power.[65]

To qualify, transmission facilities must be included in CAISO's transmission planning process and turned over to CAISO's operational control once in service. In addition, there must be a demonstrated interest for at least 60 percent of the transmission capacity, of which at least 25 percent must be from firm interconnection agreements. The remaining 35 percentage points of "demonstrated interest" can be shown in one of several ways: through power purchase agreements for at least five years; being in the CAISO interconnection queue and paying a cash deposit to CAISO equal to the projected sum of all interconnection costs; and/or paying a cash deposit equal to five percent of a generator's pro-rata share of the capital costs associated with the proposed transmission line.[66]

California's first LCRI project – the SCE Tehachapi Renewable Transmission Project – was approved by the California Public Utilities Commission in March 2007. The project consists of 220 kV and 500 kV transmission lines, as well new substations to connect the Tehachapi Wind Resource Area in southern Kern County to load centers in Los Angeles County. Construction is currently underway on the first segments of the project, which will have a total capacity of 1,000 MW, and are expected to come online in phases by 2010. (See Figure 14.) SCE is currently in the permitting process for additional segments of the project, representing an additional 3,000 MW of transmission capacity.[67]

<u>Figure 14</u>
SCE's Tehachapi Renewable Transmission Project



Source: Southern California Edison website, (available at http://www.sce.com/NR/rdonlyres/C2503560-4411-4844-98AD-E38FAF2D24D2/0/0811_TRTP13Map.pdf).

Southwest Power Pool's Balanced Portfolio Approach:

The SPP, covering the largely rural areas of Oklahoma, Kansas, Nebraska and rural southwest areas, is the oldest North American Reliability Organization still in operation. The area is rich in potential wind resources but is constrained by the region's current transmission grid which is composed primarily of relatively low voltage lines.

As part of SPP's long-term transmission planning process, a conceptual study was undertaken in 2007 that outlined a "Balanced Portfolio" approach for the development of extra-high-voltage transmission. Subsequently, SPP developed tariff language that was approved (with modification) by FERC in October 2008. Under the Balanced Portfolio approach, SPP evaluates the benefits of a group of economic transmission projects collectively rather than evaluating individual transmission projects on a project-by-project basis. Also, the entire cost of the set of approved transmission projects is allocated to all zones in SPP using a "postage-stamp" rate (i.e., all customers would benefit from EHV upgrades, so all should pay). The aim of approach is to find a portfolio of system-wide economic transmission projects that are both cost-effective (i.e., the net present value of benefits exceeds the net present value of costs) and balanced (i.e., each zone in the SPP must have total benefits that are greater than total costs).[68] This portfolio approach is intended to alleviate potential disputes that may arise from the construction of a single transmission project whose costs are assigned to all zones, but that benefit one zone but not others; if all individual zones do not receive net benefits, the group of proposed upgrades is revised until each zone receives positive net benefits.[69]

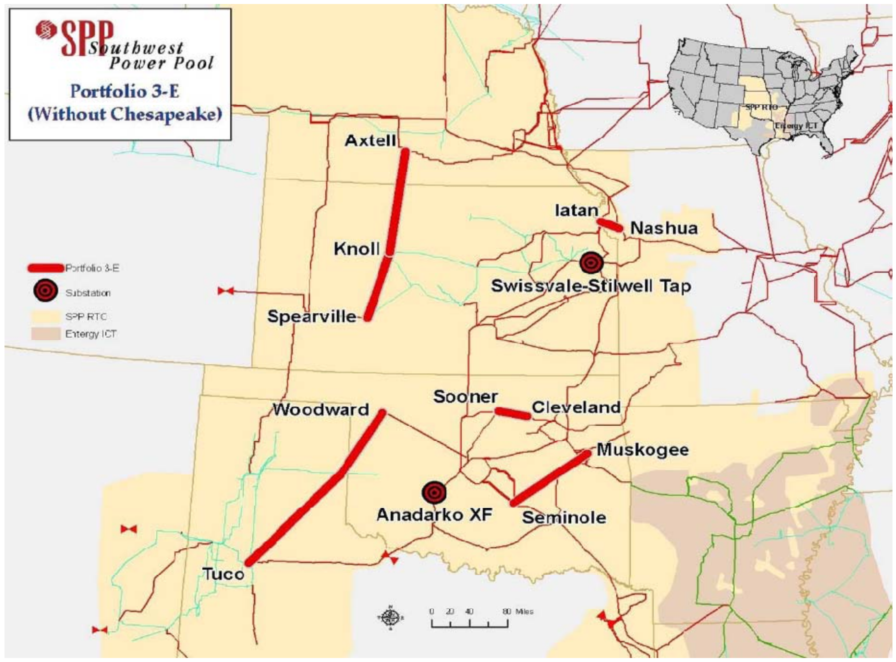
This approach was adopted with the blessing of SPP's "Regional State Committee" ("RSC") – the organization composed of retail regulatory commissioners from public utility commissions in the SPP states of Arkansas, Kansas, Louisiana, Missouri, New Mexico, Oklahoma, and Texas. Under SPP rules approved by the FERC, the RSC (rather than the SPP Board) has direct decision-making authority on specific topics; these rules give state regulators greater decision-making roles on regional transmission matters than exists in other areas, under the terms of the rules proposed by SPP and accepted by FERC. SPP's RSC has:

> primary responsibility for determining regional proposals and the transition process in the following areas: (1) whether and to what extent participant funding would be used for transmission enhancements; (2) whether license plate[70] or postage stamp rates will be used for the regional access charge; (3) financial transmission right (FTR) allocation where a locational price methodology is used; and (4) the transition mechanism to be used to assure that existing firm customers receive FTRs equivalent to the customers' existing firm rights. We stated that, if the RSC reaches a decision on the methodology that should be used, SPP would file this methodology …[Also], the RSC should determine the approach for resource adequacy across the entire region, and that, with respect to transmission planning, the RSC should determine whether transmission upgrades for remote resources will be included in the regional transmission planning process, as well as the role of [transmission owners] in proposing transmission upgrades in the regional planning process.[71]

In April 2009, the SPP RSC and SPP Board of Directors approved the first group of high-voltage transmission projects under the Balanced Portfolio approach. The $700 million cost of the collective group of projects will be funded through FERC-approved postage stamp rates under which all ratepayers in the SPP region bear the cost and risk associated with the projects. The 2009 balanced portfolio includes five new 345 kV transmission lines, a 345 kV transformer, and a new connection between two existing 345 kV lines, shown in Figure 15. SPP analyzed over 50 different transmission projects in order to identify this group of seven projects that met the requirements of the Balanced Portfolio approach (i.e., each SPP zone receives positive net benefits).[72]

Figure 15

Approved Group of Transmission Projects Under SPP's Balanced Portfolio Approach



Source: "Portfolio of New EHV Transmission Projects Approved: Benefits Will Be Balanced Across SPP Region," SPP Press Release, April 29, 2009.

Merchant Transmission Cost-Recovery Models

The merchant transmission model is a contract-based cost-recovery model in which a specific market participant (the "beneficiary") enters into a contract with a transmission developer in order to fund new investment. Unlike the socialized model, no cost recovery is made through a regulated tariff levied upon some or all ratepayers. The transmission developer instead recovers its investment directly from the beneficiary though the contract terms. In return, the beneficiary is given priority rights to use the new transmission capacity. The beneficiary may be willing to enter into such a contract – and bear the primary risks and rewards – for a variety of reasons including the ability to sell power into a higher-cost market or the ability to acquire lower-cost power.

Two of the earliest examples of merchant transmission models are the Cross-Sound Cable ("CSC") Project and the Neptune transmission project. The CSC project is a 330-MW high-voltage direct-current ("HVDC") transmission line constructed in 2002 by TransEnergie and paid for under the terms of a contract with the Long Island Power Authority ("LIPA"). This submarine cable connects Shoreham, New York and New Haven, Connecticut and was built to provide LIPA with access to lower-cost sources of electricity in New England.[73] The Neptune transmission project is very similar: it was constructed by Neptune Regional Transmission System under a 2004 contract also with LIPA. The $600 million, 65-

mile long transmission line is an undersea HVDC system that connects Sayreville, New Jersey, to North Hempstead, New York, and has a capacity of 660 MW. LIPA funded the project in order to have access to lower-cost power in New Jersey (and other parts of the PJM region). Together, the Neptune and Cross Sound cable systems provide LIPA with direct access to two independent power pools in the PJM and New England markets and improved electric system reliability on Long Island.[74]

More recently, Northeast Utilities Services Company ("NU") and NSTAR filed an application with FERC in December 2008 for approval of a 20-year bilateral transmission service agreement with HQ Energy Services ("HQ"). Under the terms of the contract, NU and NSTAR would sell HQ 1,200 MW of firm transmission capacity, at a cost-based rate, over a new HVDC transmission line that would interconnect New England and HQ's system in Canada. NU's and NSTAR's investment cost would not be recovered through the New England wide tariff; instead, HQ would compensate NU and NSTAR for building, operating, and maintaining the U.S. portion of the line through this contract-based rate. As part of the transaction, HQ would sell and deliver 1,200 MW of hydro generation to purchasers in New England under separate long term power purchase agreements. FERC approved the project, ruling that it was a participant-funded project in which the risks and priorities assigned to HQ.[75]

Economic Development Transmission Cost-Recovery Models

Under a classic economic development transmission model, transmission investment is driven by a public authority whose mission may go beyond activities related solely to electric supply and delivery. For example, the mission may include regional economic development, flood control, rural electrification. The public authority is authorized to carry out investments to serve multiple missions with its customers paying rates that recover the investment. Often investment in the generating capacity has been subsidized at some point, and the delivery facilities' costs are bundled with the power supply. As a public entity, it typically has certain attributes that other entities lack, including: the ability to access low-cost capital (e.g., where bond covenants require it to set rates to recover its investment costs); the ability to set its own electric rates, which are not subject to state or federal rate regulation; and the power of eminent domain and other site-access rights.

Examples of public authorities that have operated under this model include several federal agencies: the Tennessee Valley Authority ("TVA"), the Bonneville Power Administration, the Western Area Power Administration ("WAPA"), and the Southwestern and Southeastern Power Administrations. The roles, responsibilities, authorities and geographic service areas of these various federal agencies differ considering under the terms of their enabling legislation.

The TVA, for example, was established as a federal government corporation during the New Deal in 1933, for the purpose of rural electrification, industrial and other development, and flood control in the multi-state area of the Tennessee Valley. "Today, TVA operates the nation's largest public power system and supplies power in most of Tennessee, northern Alabama, northeastern Mississippi, and southwestern Kentucky and in portions of northern Georgia, western North Carolina, and southwestern Virginia to a population of nearly nine million people. In 2008, the revenues from TVA's power program were $10.4 billion and accounted for virtually all of TVA's revenues….Initially, all TVA operations were funded by federal appropriations. Direct appropriations for the TVA power program ended in 1959, and appropriations for TVA's stewardship, economic development, and multipurpose activities ended in 1999. Since 1999, TVA has funded all of its operations almost entirely from the sale of electricity and power system financings."[76] TVA has quite exclusive authority to undertake generation and transmission investment and provide bundled wholesale power supply to scores of municipal and cooperative utilities that serve nearly 9 million people in TVA's service territory.[77]

In many ways, TVA operates much like many large vertically-integrated electric utilities in the U.S. However, unlike other utilities, TVA operates under federal laws that give it special service territory protections and guarantees and financing capabilities that arise in large part from the TVA's status as a federal power corporation entity. By law, TVA's Board of Directors has unilateral authority to set its own rates, and must do so to assure that its rates cover its cost of providing electric service. TVA's statute and its revenues from the sales of electricity provide strong financial support for TVA's bonds, which are highly rated and enjoy certain tax exemptions. As a result of all of these circumstances, TVA has a low cost of capital compared to many other electric companies in neighboring states with whom it might potentially compete. Within its service territory, TVA supplies virtually all of its power to the TVA Distributors within a service territory established and maintained by federal law. The TVA Distributors in turn are required to purchase from TVA, and to resell to retail customers on terms and at rates essentially the same as the rates charged the TVA Distributors by TVA.

By contrast to TVA, WAPA operates in a very different fashion. Although like TVA, WAPA markets and transmits power supply to various customers within a geographic area, WAPA does not have exclusive service territory protections or obligations. Its core business is to market power from federally-owned hydroelectric power plants within a 15-state service territory. In FY 2007, WAPA sold power to about 670 wholesale customers (municipal and rural cooperative utilities) who, in turn, provide retail electric service to millions of consumers in these central and western States: Arizona, California, Colorado, Iowa, Kansas, Minnesota, Montana, Nebraska, Nevada, New Mexico, North Dakota, South Dakota, Texas, Utah and Wyoming.[78] WAPA's rates must recover all costs to provide service, including recovery of the Federal investment in the power facilities (with interest) and certain costs assigned to power for repayment, such as aid to irrigation.

WAPA's transmission services also differ from those of TVA, and are more interspersed with facilities owned by others. WAPA delivers power over an integrated 17,000 circuit-mile, high-voltage transmission system that intersects with facilities owned by many other public and investor-owned transmission systems. WAPA offers transmission services to others (including entities that are not power marketing customers) under a FERC-approved Open Access Transmission Tariff. In recent years, WAPA has planned, constructed and co-invested in transmission facilities in cooperative partnerships with investor-owned utilities and transmission companies. For example, in partnership with Trans-Elect and Pacific Gas & Electric, WAPA was a participant in the California "Path 15" project that opened up a chronic transmission bottleneck within California. WAPA also has received significant funding under the American Recovery and Reinvestment Act to support new transmission investment.

Several states have also established power authorities. Examples include two power authorities in New York State: the New York Power Authority ("NYPA"), originally established to transmit and sell power from various federal hydropower projects; and the Long Island Power Authority ("LIPA"), established as part of a state-driven initiative during the late 1990s to close the Shoreham Nuclear Power Plant on Long Island, transfer the other assets of the Long Island Lighting Company, and own the generation, transmission and distribution facilities located on much of Long Island.

A recent example of a state authority being established to carry out various power delivery functions is the Wyoming Infrastructure Authority ("WIA"). WIA is a "is a quasi-governmental instrumentality of State of Wyoming. Created in 2004 by the State Legislature, the WIA's mission is to diversify and expand the state's economy through improvements in Wyoming's electric transmission infrastructure to facilitate the consumption of Wyoming energy in the form of wind, natural gas, coal and nuclear, where applicable. The Authority can participate in planning, financing, constructing, developing, acquiring, maintaining and operating electric transmission facilities and their supporting infrastructure. Legislation provided the WIA with bonding authority of $1 Billion and other powers to promote transmission development in the State and throughout the region. It also provided the State Treasurer, with the approval of the State Loan and Investment Board, the authority to invest in WIA bonds."[79] As of this writing, the WIA has not yet financed new infrastructure but is involved in planning and development activities for many transmission projects in the state and in cooperation with neighboring states.

Transmission Models Used in Europe for Offshore Wind

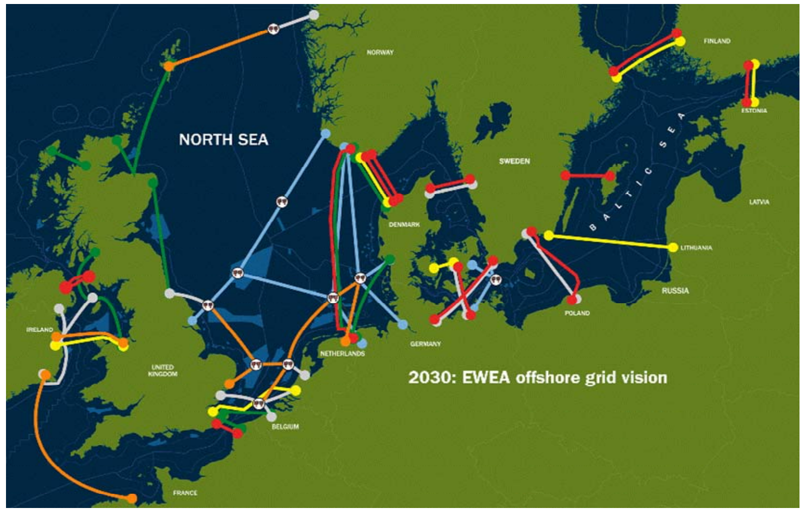
Even with significant increases in wind development in the U.S. in recent years, the vast majority of currently operational offshore wind capacity is located in Western Europe. The existence of relatively shallow waters (30 meters or less) for large distances from shore in areas such as the North Sea has allowed European countries to develop offshore wind farms using existing technology. Policies and regulations vary from country to country, but in general European countries support offshore wind, and are actively considering and moving toward inter-country policies, interconnections, and transmission projects to continue to build their support for offshore wind.

Regional Planning – Offshore Grid*:* Individual countries like Germany, France, Spain and the UK are each preparing comprehensive planning approaches for wind zones and interconnection.[80] In addition, the European Transmission System Operators association has proposed dedicated regional multinational offshore wind energy grid plans to coordinate the development and implementation of the necessary infrastructure on a regional and European level, thus minimizing the total costs of offshore projects (e.g. coordinated planning in the North Sea and the Baltic Sea).[81]

The EU is currently performing the first large-scale European study to explore the benefits of a highly interconnected harmonized European grid designed to allow for the interconnection of significant wind power. The TradeWind Project will provide recommendations and guidelines for action at the EU and national levels to move toward a single European grid and power market enabling more citizens to benefit from wind power. So far, this effort has identified 42 onshore interconnectors and a corresponding time schedule for upgrading that would benefit the power system and help integrate wind power. Investments for these projects would largely be made by individual Member States.[82]

The European Wind Energy Association ("EWEA") is also looking at what would be needed (and possible) to develop a large-scale offshore grid by 2030. (See Figure 16.) Roughly 2 GW of offshore wind is currently online in Europe; EWEA predicts about 40 GW by 2020, producing 148 TWh (about 4 percent of total demand in Europe). By 2030 EWEA predicts 150 GW, producing about 563 TWh (about 13-17 percent of total European demand).[83]

Figure 16
EWEA Offshore Grid Vision: 2030



= Currently existing
= Currently planned
= Under study
= Under study (EWEA recommendation)
= EWEA recommended grids by 2020
= EWEA recommended grids by 2030

Source: Oceans of Opportunity: Harnessing Europe's Largest Domestic Energy Resource, European Wind Energy Association, September 2009.

As a major step in the right direction, on December 7, 2009, Denmark, France, Germany, Ireland, Luxembourg, the Netherlands, Sweden and the United Kingdom all signed the North Seas Countries Offshore Grid Initiative declaration, which promises cooperation in the examination and planning for an offshore wind energy "Supergrid" in the North and North West Seas.[84] Some specific objectives have been laid out in the organizational plans:

To identify national ambitions for offshore renewable energy sources, shortcomings in present and future cross border grid infrastructure developments and national policies on relevant issues which have impacts on the sustainable development of an offshore North Seas grid (incl. maritime physical planning for offshore wind, site selection, grid configurations),

To facilitate a coordinated electricity infrastructure development, both offshore and the necessary onshore connections, in view of the large amounts of wind power planned,

To achieve a compatible political and regulatory basis for long term offshore infrastructure developments within the North Seas region,

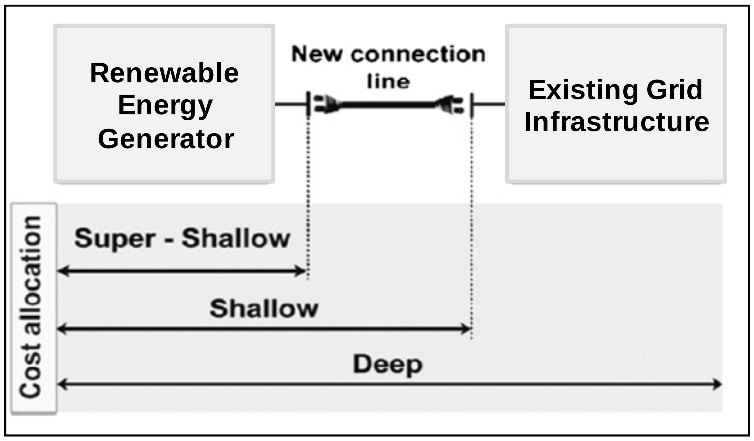
To foster a joint commitment of all relevant stakeholders to tackle all technical, market, regulatory and policy barriers, and,

To organize a workshop with relevant stakeholders, at the beginning of 2010 to prepare a strategic working plan aiming at coordinating the offshore wind and infrastructure developments in the North Seas and listing the potential actions, studies and issues to be tackled by the North Seas Countries' Offshore Grid Initiative.[85]

Transmission Cost Allocation: Models for transmission cost allocation for offshore renewable projects vary across different European countries. The three basic frameworks for allocating costs have been characterized as "super-shallow," "shallow," and "deep," referring to the level of monetary contribution required of the wind-farm developer for transmission costs to interconnect with the on-shore grid. (See Figure 17.)[86]

- ***Super-Shallow*** – The renewable project developer pays only for the cost of interconnecting the plant to the grid, and not for grid upgrades/reinforcements. Any necessary grid upgrades/ reinforcements are paid for by the grid operator, and typically passed onto consumers (i.e., socialized) through tariffs. Examples include Germany (for offshore wind), Belgium, Ireland, Italy and Denmark.
- ***Shallow*** **–** Hybrid approach whereby the renewable developer pays a portion of any necessary grid upgrades/reinforcements, with the remainder socialized. Examples include Finland, Austria and the Czech Republic.
- ***Deep*** **–** The renewable developer pays for all costs associated with connecting its project to the high-voltage network, including all network upgrades/reinforcements. This approach is viewed as potentially causing a first-mover disadvantage, since future developers could benefit from new infrastructure at no cost. Examples include Great Britain, Netherlands, Slovenia, Hungary, and Germany (for onshore renewables).

Figure 17
Transmission Cost Allocation Methods



Source: Swider et al., "Conditions and Costs for Renewables Electricity Grid Connection: Examples in Europe," *Renewable Energy*, 33 (2008) 1832-1942.

Country-Specific Transmission Model Details:

Germany:

Figure 18
German TSO Territories

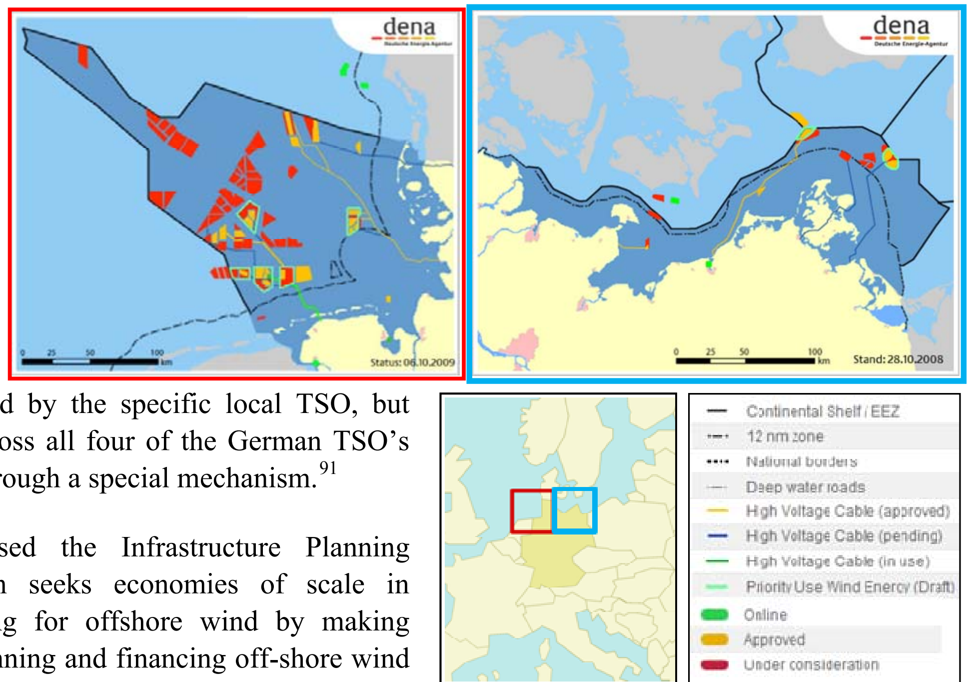
Source: Facts about the German Electric Grid, Vattenfall, June 2009.

Germany has different transmission cost allocation models for different types or renewable energy, with offshore wind currently getting preferential treatment. Transmission costs for connection of offshore wind farms to the onshore grid are considered super-shallow, while costs for connecting other energy sources (including other renewable energy sources) are generally deep.[87] Furthermore, Germany's Renewable Energy Sources Act of 2004 dictates that renewable energy has priority in grid connection and also power dispatch.[88] Conventional power sources must always reduce generation in case of congestion in order to accommodate generation from renewable energy sources as long as existing transmission capacity is not exceeded. All energy generated by renewable generators must be purchased the Transmission System Operators ("TSO").[89]

In general, the transmission-related costs of delivering an increasing amount of renewable energy in Germany are recovered as part of the use-of-system charge for each TSO.[90] However, the costs associated with connecting offshore wind to the onshore grid are initially absorbed by the specific local TSO, but eventually distributed across all four of the German TSO's (depicted in Figure 18) through a special mechanism.[91]

Figure 19

German Offshore Wind Development



Source: Deutsche Energie-Agentur (DENA) (German Energy Agency), (available at: http://www.offshore-wind.de).

In 2006 Germany passed the Infrastructure Planning Acceleration Act, which seeks economies of scale in construction and planning for offshore wind by making TSOs responsible for planning and financing off-shore wind farm grid connection (as noted above), but also for bundling possible future wind farm connections during planning to avoid a one-wind farm-one-cable type system.[92] As yet another step toward promotion of offshore wind resources, TSOs are also expected to preemptively invest in any infrastructure necessary (e.g., new transmission, reinforcements, upgrades, etc.) for connecting offshore wind farms to the established onshore grid.[93] (Figure 19 depicts the current state of German offshore wind development).

Norway:

Figure 20

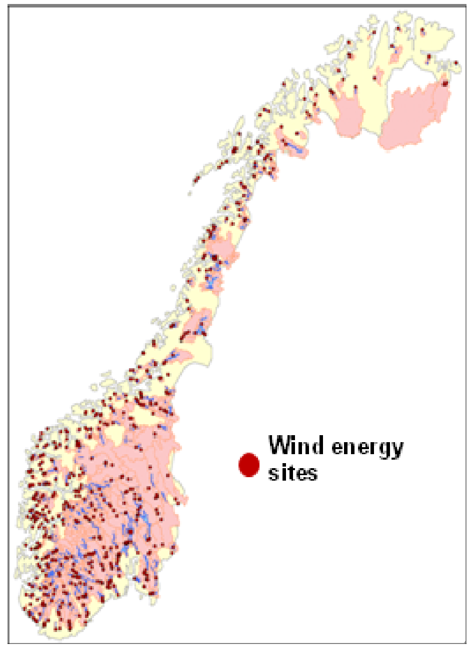
Norway – Geographic Layout

Source: www.treehugger.com/norway-offshore-wind-z02.jpg.

In Norway (see Figures 20 and 21), Statnett (the state-owned transmission grid owner/operator) is responsible for most grid expansion and maintenance. Funding for ongoing use of the transmission system is paid for through the point-of-connection tariff, which varies by location. Funding for grid expansion, reinforcement and upgrade, is paid for through the general transmission tariff and/or a "construction contribution."[94]

The general tariff includes a connection charge and a demand charge. The construction contribution is a one-time payment charged to those benefitting from the grid investment, and can be levied to cover the costs of connecting new customers, or for the reinforcement of the network for existing customers.[95] Statnett has the discretion to allocate the construction contribution between customers connected to the grid at the time the installation is completed, and future customers connecting up to 10 years after completion of the installation. Moreover, Statnett may choose to incrementally allocate the investment contribution when new customers connect, or instead it may request that contributions are made in advance subsequently adjusting proportionally as more connections are made.[96] (This system is somewhat similar to that which Southern California Edison used for their Tehachapi project.)

Figure 21
Norwegian Wind Energy Sites



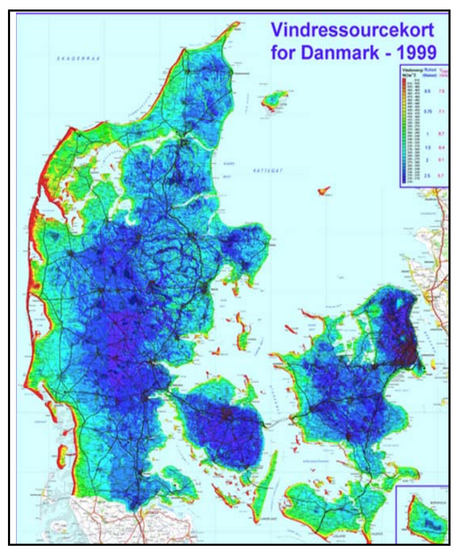
Source: www.kraftnytt.no/default.asp?page=21869&article=28402.

Overall Norway prefers to increase utilization of existing lines rather than building new lines, and has only built one large power line in the last 10 years.[97]

Denmark

In Denmark (see Figure 22), Energinet.dk (the state-owned transmission grid owner/operator) is responsible for investments in electric and gas networks. Its stated position is that transmission infrastructure must support, and therefore be expanded to accommodate, the increasing use of renewable energy coming online. In addition, off-shore wind is a priority and a major consideration related to grid expansion in Denmark.[98]

Figure 22
Denmark – Wind Resources
Wind Energy Sites



Source: www.travlang.com/factbook/maps/da-map.gif.

The cost of interconnection to the transmission grid in Denmark is typically super-shallow. The TSO (and/or distribution company) funds any costs beyond simply interconnecting the offshore wind facility to the grid, and these other transmission costs are spread over all transmission system users. These transmission costs are recovered through a point-of-connection tariff, which has three components: a grid charge, a system charge, and a Public Service Obligation ("PSO") component. The grid and system charges are associated with the major transmission grid, reserve capacity and other related costs. The PSO is levied on all users in a uniform fashion, using postage stamp rates (i.e., same charge regardless of location) that are directly related to the costs of renewable energy. The PSO is intended to allow renewable producers to be guaranteed a fixed price for supply. In addition, most renewable energy sources are not required to pay transmission access charges, and those that do are eligible for an exemption for up to 10 years.[99]

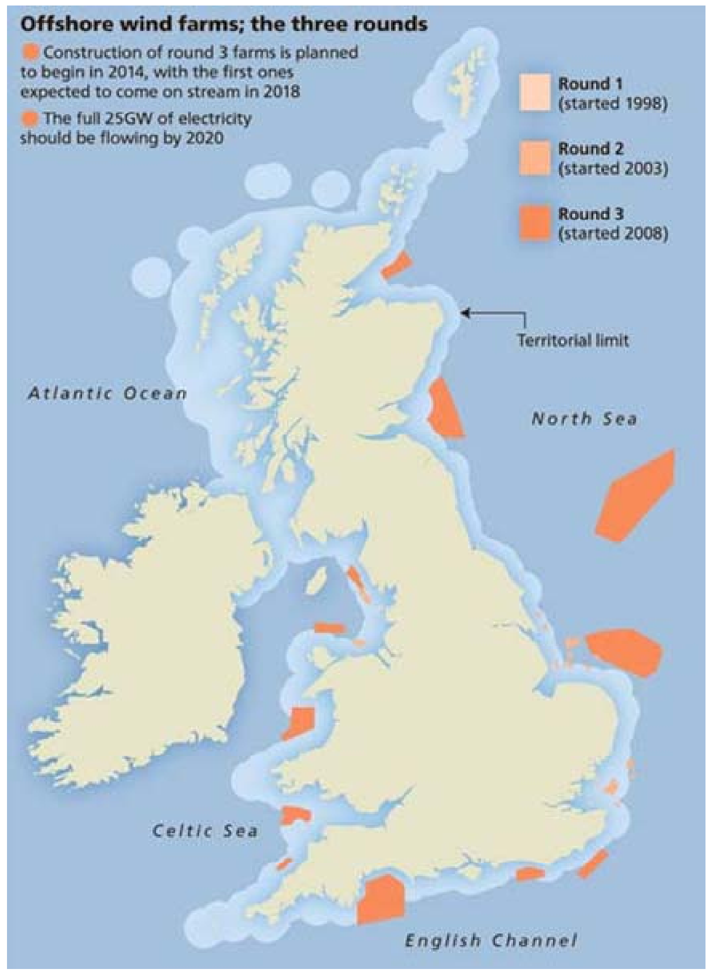
Somewhat similar to the Texas CREZ model, Denmark utilizes strategic zones or geographic areas for offshore wind development. Municipalities have been required to allocate such zones since 1994, and siting and permitting in these areas are essentially fast tracked.[100]

United Kingdom

The UK has a somewhat novel approach to facilitating the creation Source: Wind Resources Atlas for Denmark of offshore transmission: Private entities will build, own and operate offshore transmission facilities (see Figure 23). Offshore Transmission Owners ("OFTO") will be chosen on the basis of a competitive bidding process. In its capacity as National Electricity Transmission System Operator ("NETSO"), National Grid Electricity Transmission PLC ("National Grid") will have primary authority over the offshore grid, but is prohibited from owning, or seeking to own, offshore transmission assets. That said, other National Grid affiliates are permitted to bid for and own offshore transmission assets. OFTOs receive a 20-year revenue stream from NETSO for each project, with 10 percent being subject to performance requirements. Ultimately, NETSO will recover its costs through basic transmission charges.[101]

In the UK, transmission operators typically recover costs through a combination of charges: connection charges (typically shallow, but can vary) levied on the generator; and use-of-system charges (locational) levied on generators, suppliers and customers. Regulators are generally willing to allow regulated firms to earn higher returns than their cost of capital when returns are achieved from cost savings beyond a benchmark, knowing that the next 'ratchet' will convey these benefits to consumers.[102]

Figure 23
UK – Proposed Wind Development



Source: www.timesonline.co.uk/multimedia/archive/00347/map_347887a.jpg.

7. STUDIES OF THE COSTS ASSOCIATED WITH DEVELOPING TRANSMISSION IN SUPPORT OF WIND RESOURCES

In recent years, a number of studies have analyzed the cost to build out a transmission system in support of developing domestic wind resources. Many of these have been conducted in the context of state-level transmission planning for "renewable energy zones" (as in Texas and Colorado); others have been more national in scope. Most recently, the New England Governors requested a study to be performed by the region's grid operator, ISO-NE, to explore the cost implications for the onshore regional transmission grid of adding different levels of wind generating capacity. The various scenarios examined included wind development on land within New England, in the offshore waters of New England's coastal states and in adjacent federal waters, and from outside the region (e.g., Canada, New York, and/or the Midwest).

Studies of Transmission Costs for Offshore Wind

Without even considering transmission costs, building offshore wind facilities will in general be much more costly than building wind facilities on land. Exact differences vary by location but studies indicate that the cost of building offshore wind generation, excluding transmission, will typically be roughly double the cost of building terrestrial wind generation. However, this cost difference is largely counteracted by the generally higher wind speeds and capacity factor offshore: "The wind offshore tends to flow at higher speeds, thus allowing turbines to produce more electricity… The potential energy produced from the wind is directly proportional to the cube of the wind speed, meaning a few miles an hour increase in wind speed would produce a significantly larger amount of electricity. For instance, a turbine at a site with an average wind speed of 16 mph would produce 50% more electricity than at a site with the exact same turbine with average wind speeds of 14 mph. The power of the wind is significantly less on land."[103]

The costs associated with transmission for offshore wind differ from those for onshore wind, and are typically substantial. A number of existing studies have provided information specifically about the cost of submarine cables for power projects. Some of these studies relate to hypothetical offshore wind projects (e.g., an NREL conceptual study of offshore wind farms). Some relate to specific proposed offshore wind projects (e.g., Cape Wind). Still others relate to submarine transmission investment that has actually occurred in connection with non-wind power projects. These cost estimates are summarized in Table 3, below. In order to make an apples-to-apples comparison across the studies, the estimates of transmission costs have been converted to a cost per mile, and updated to reflect the cost in 2009 U.S. dollars, using the Handy-Whitman Index for "total transmission plant."

There are two technology options available for the transmission system associated with offshore wind power: high-voltage alternating current ("HVAC") and high-voltage direct current ("HVDC"). According to a March 2007 publication issued by NREL, HVAC is generally thought to be the most economical option for distances shorter than 50 km. Between 50 and 80 km offshore, HVAC and HVDC are expected to be similar in cost. For lines longer than 80 km, HVDC systems will likely be least cost, mainly because the effective capacity of a given HVAC cable drops off with distance due to the capacitive and inductive characteristics of the cable and their associated line losses.[104] HVDC transmission avoids these line losses entirely, so it is the preferred technology for longer distances. Moreover, to maintain an apples-to-apples comparison of transmission costs, the cost of an HVDC system must include the cost of converter stations necessary to convert from AC to DC at the wind farm, and then back from DC to AC at the point of connection to the onshore grid. HVAC transmission system does not require conversion because their AC power is already compatible with the onshore grid.

With these technology cost and performance differentials for wind projects in mind, the comparison of terrestrial versus offshore wind must also take into account the relative cost of transmission. Distance and technology choices matter, of course. Given the abstract nature of proposals to date,[105] it is hard to draw concrete conclusions about all-in costs (including transmission) to purchase renewable energy delivered by terrestrial wind resources that are located quite a long way away from customer load centers in Massachusetts (e.g., in Quebec, or in the wind-rich areas of the Upper Midwest states), as compared to purchasing power from more local offshore wind projects close to Massachusetts customers. However, given that potential Upper Midwest wind resources are located significantly further away from New England electricity consumers than are potential Massachusetts offshore resources, common sense suggests that there are comparative economic advantages for development of local wind resources, especially when in-state and in-region economic development benefits are taken into consideration.

Table 3

Summary of Submarine Transmission Cost Estimates

Source	Characteristics of the Project Studied	Year of the Study/Estimate	Transmission Cost Estimate as of Study Date	Updated 2009 Transmission Cost Estimates*
Cape Wind Project transmission plan	Four 115 kV transmission lines, range of scenarios from 11-27.5 miles, 468 MW installed capacity	2003 (date of direct testimony)	$3.7 million/mile	$5.4 million/mile
Cape Wind Project transmission studies (ESS Study, produced for Cape Wind Associates, LLC)	HVAC option: 115 kV AC submarine cable, 420 MW installed capacity, 35 miles	2003	$3.7 million/mile	$5.4 million/mile
	HVDC option, +/- 150 kV DC submarine cable, 420 MW installed capacity, 35 miles, includes two converter stations	2003	$4.7 million/mile	$6.8 million/mile
NREL – conceptual study of offshore wind farms	150 kV transmission line, ≤30 miles, for a hypothetical 500-MW wind farm	2007	$1.3 million/mile	$1.4 million/mile
1st Int'l Workshop on Feasibility of HVDC Transmission Networks for Offshore Windfarms (Sweden)	HVDC Transmission facilities and converter stations for 400 MW of wind, 60 miles, (~1/3 of the total cost of the wind farm)	2000	$5.5 million/mile	$8.9 million/mile
Renewable Energy Research Lab ("RERL"), UMASS, Amherst study of transmission options for U.S. offshore wind cost of sub-marine transmission cable for both wind and non-wind projects.	Non-wind project, 3 miles, 4 single-core cables for a 138 kV AC line with 130-MW capacity	2002 RERL study of 1999 project in Juneau, Alaska	$3.8 million/mile	$6.1 million/mile
	Cross-Sound HVDC Cable non-wind project, 24 miles, 330-MW capacity, includes two converter stations	2002 RERL study of 2002 project from Long Island, NY to CT	$5.1 million/mile	$7.5 million/mile

Notes:

* Transmission costs were converted where necessary into dollars per mile, and were then converted to July 2009 U.S. dollars using the change in the Handy Whitman Index for "total transmission plant."

Sources:

- Direct Testimony dated February 2003 from "Final Decision in the Matter of the Petition of Cape Wind for Approval to Construct Two 115 kV Electric Transmission Lines," Massachusetts Energy Facilities Siting Board, May 11, 2005, footnotes 33 and 35.
- J. Green, A. Bowen, L.J. Fingersh, and Y. Wan, "Electrical Collection and Transmission Systems for Offshore Wind Power," National Renewable Energy Laboratory, March 2007.
- Jennie Weatherill, et al., Review, First International Workshop on Feasibility of HVDC Transmission Networks for Offshore Wind Farms, 2000. Available at: http://www.owen.eru.rl.ac.uk/documents/stockholm_hvdc_summary.pdf.
- Transmission Options for Offshore Wind Farms in the United States; Renewable Energy Research Lab, University of Massachusetts, American Wind Energy Association, 2002.
- Appendix 3-C: Transmission Issues for Offshore Wind Farms, Cape Wind, 2003. (This document is an edited revision of a paper entitled "Limitations of Long Transmission Cables for Offshore Wind Farms," ESS, Inc. 2003.)

Offshore Wind Transmission Study Details

The transmission studies summarized in Table 2 are described in more detail below. As reflected in Table 2, all estimates of transmission costs detailed below have been converted to a cost per mile, and updated to reflect the cost in 2009 U.S. dollars, using the Handy-Whitman Index for "total transmission plant."

Cape Wind Project transmission plan

In 2003, the Cape Wind Project submitted a transmission plan to the Massachusetts Energy Facilities Siting Board ("Siting Board") as part of the offshore wind siting/permitting process. Cape Wind Associates, LLC submitted several potential transmission options of varying cost for their project, both AC and DC options, with the AC cables being 115 kV and the DC cables being 150 kV. Ultimately, the Siting Board selected the Barnstable Interconnect transmission option, citing the fact that: "…the Barnstable Interconnect would be preferable to both the Harwich Alternative and the New Bedford Alternative with respect to providing reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost." The cost for the Barnstable Interconnect was estimated at approximately $5.4 million/mile.

Cape Wind Project transmission studies (ESS Study, produced for Cape Wind Associates, LLC)

In 2003, ESS, Inc. performed a transmission study for Cape Wind Associates, LLC as part of the transmission planning process for the Cape Wind Project. This study broke down the costs of both AC and DC system options utilizing the Barnstable Interconnect route. The AC option includes four three-core 115-kV cables over a distance of 35 miles, at an installed cost of $5.4 million/mile, or $12,825 dollars/MW/mile. The DC option includes four single-core 630 mm^2 150-kV cables over a distance of 35 miles, as well as the two necessary converter stations, at an installed cost of approximately $6.8 million/mile, or $16,180 dollars/MW/mile.

1st Int'l Workshop on Feasibility of HVDC Transmission Networks for Offshore Windfarms (Sweden):

This offshore wind transmission cost estimate comes from a review of documents presented at the "First International Workshop on Feasibility of HVDC Transmission Networks for Offshore Wind Farms," held in Stockholm, Sweden in March of 2000. The Workshop included sessions on a number of topics, including: "HVDC Transmission Systems – New Converter and Cable Technologies," "Advances in Offshore Wind Energy Technology," "Systems aspects and Grid Interconnection," and "Business Models for the Operation of Offshore HVDC Transmission Networks." During this Workshop, participants discussed the difficulty of estimating prices for equipment and installation costs (including cable laying), and related transmission costs. These costs were for a hypothetical 400-MW offshore wind farm, with 60 miles of transmission. The cost amounted to approximately $6.2 million/mile for the converter stations and $2.7 million/mile for the cables, or cumulatively $22,227 dollars/MW/mile. (Note that while the cost of cable varies with distance and capacity, the cost of the converter station varies by capacity).

NREL – conceptual study of offshore wind farms

In 2007, NREL published a study on "Electrical Collection and Transmission Systems for Offshore Wind Power," which was presented at the Offshore Technology Conference in Houston, Texas, in April 2007. This study focused on development of a simple model for cost and performance of electrical systems for offshore wind power. The model's approach to estimating costs is flexible and designed in a way that allows for various parameters (e.g., number of turbines, turbine size, turbine array configuration, and distance from shore) to vary in different assessments. Among other examples, the study includes two representative but hypothetical estimates of the cost of submarine transmission cables. In particular, these hypothetical cables are AC with a conductor size of 630 mm^2, contain a single layer of steel armor and are XLPE insulated. The average of the two cost estimates provided was approximately $1.4 million/mile.

Renewable Energy Research Lab ("RERL"), UMASS, Amherst study of transmission options for U.S. offshore wind cost of sub-marine transmission cable for both wind and non-wind projects

In 2002, the Renewable Energy Research Lab at the University of Massachusetts, Amherst, presented a study for the American Wind Energy Association ("AWEA") entitled "Transmission Options for Offshore Wind Farms in the United States." This study addresses some of the prominent forward-looking issues related to transmission for offshore wind, including choosing between different voltages, choosing between AC and DC systems, the lack of domestically manufactured medium and high-voltage insulated submarine cables, and the lack of equipment for and experience with large-scale submarine cable laying. The study also presented summarized cost information and other project aspects for multiple submarine transmission cables projects, with some examples from wind projects and some from non-wind projects.

One of the non-wind transmission examples is that of a project in Juneau, Alaska in 1999. The project consisted of four single-core AC cables with a capacity of 130 MW and voltage of 138 kV. The cost for this cable was approximately $6.1 million/mile, or $46,944 dollars/MW/mile.

Another non-wind transmission project example is that of a project from 2002 across Long Island Sound, linking Long Island, New York to Connecticut. This 24 mile long DC cable project had a capacity of 330 MW (+16 MW loss), and voltage of +/-150 kV. The cost for this project was approximately $7.5 million/mile, or $23,763 dollars/MW/mile, and includes the cost of the converter stations.

This study also contains information about lower capacity projects that may be less relevant in the context of large-scale offshore wind, but worth mentioning given the scarcity of reliable transmission cost information. One non-wind project from 1996 in Nantucket, MA, consisted of one 3-core 46 kV AC cable, 26 miles long, with a 35 MW capacity, and had cost of $1.9 million/mile or $54,896 dollars/MW/mile. One Danish wind-related transmission project from 2001 called Middelgrunden consisted of two parallel 30kV AC cables, 2 miles long, with a 40 MW capacity, and had a cost of $3.6 million/mile or $90,594 dollars/MW/mile.

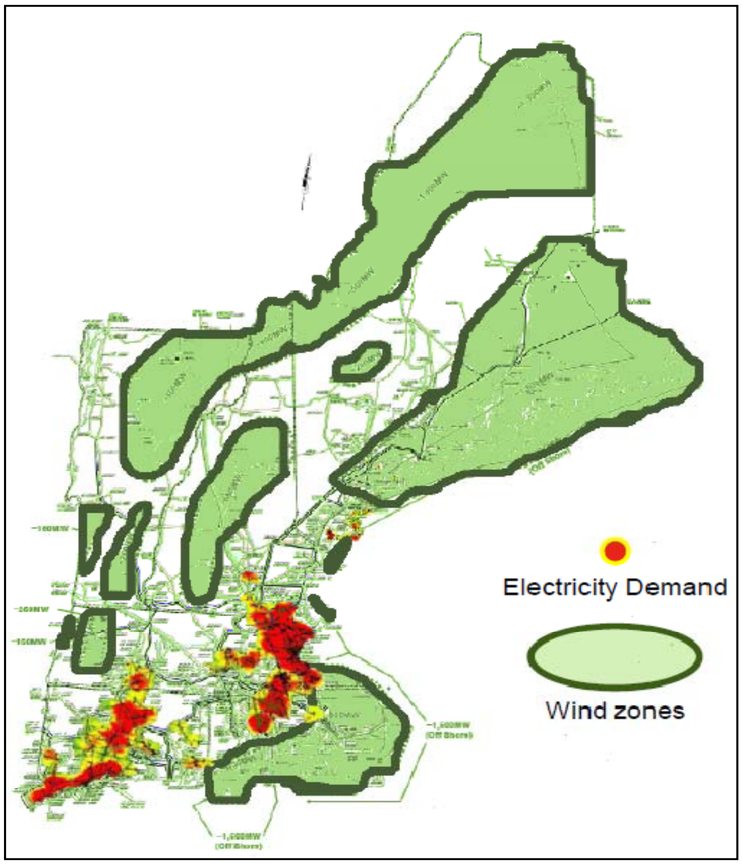
ISO-New England's "Governors' Economic Blueprint" Study

Certain in-region transmission implications of local offshore versus long-distance renewable projects have recently been examined in ISO-NE's study for the New England Governors. This economic study was designed to identify "significant sources of renewable energy available to New England, the most effective means to integrate them into our power grid, and the estimated costs."[106] During the 2nd and 3rd quarters of 2009, ISO-NE conducted a "scenario analysis" to examine different amounts and locations for development of renewable power, and focused primarily on the implications for the onshore delivery system of wind resource development in and outside of New England.

The study is indicative of the type of analytic work being done in this region to sharpen understanding of the implications for the region's onshore high-voltage transmission infrastructure of integrating large amounts of offshore wind, and it shows that adding large amounts of wind is technically feasible. However, the study only examined the costs of transmission in New England's high-voltage transmission system, and did not include transmission facilities needed either to bring external wind resources to New England's borders (e.g., across the Midwest and New York), or to interconnect offshore wind projects to the onshore system within New England, or even to interconnect terrestrial wind farms in, say, Maine, with the high-voltage system in New England. Therefore, while this study is an important step, it provides only partial information about the transmission-related costs associated with wind development, and further work is necessary.

ISO-NE conceptually identified wind projects and transmission requirements as of the year 2030 for multiple scenarios, each representing a different combination of wind resource availability onshore and offshore. Most scenarios were examined for wind projects located inside of New England (e.g., with up to 12,000 MW of wind in New England, including 7,500 MW onshore and 4,500 MW offshore with the amounts evenly distributed between Maine, Massachusetts and Rhode Island) but a few scenarios with wind located from outside of New England (e.g., from Quebec, and New Brunswick) were also examined. The New England wind zones relative to load centers are shown in Figure 24.

<u>Figure 24</u>
New England Wind Zones



Source: New England 2030 Power System Study: Preliminary Maps and Cost Estimates for Potential Transmission; ISO-NE Planning Advisory Committee; August 14, 2009.

The results of the study are shown in Table 4, which presents the high-level features of the key scenarios, along with the on-shore transmission enhancements that would be needed to accommodate the wind resources in each scenario. The Table also presents the estimated range of in-region, onshore transmission costs associated with each scenario.

This table provides neither sufficient detail nor cost elements for drawing conclusions about the economics of delivered wind power into New England. On the transmission side, it includes only those costs related to onshore upgrades of the New England transmission system, and includes no costs associated of connecting a wind resource to the onshore New England grid. For some scenarios these costs would be quite high.

Furthermore, given the different combinations of transmission technology (i.e., AC versus DC lines) and voltage levels (e.g., 345 kV, 500 kV, 765 kV), along with the amount of wind-generating capacity capable of being carried by the system (ranging from 2,000 MW to 10,000 MW), one cannot draw clear cost comparisons across the scenarios. Finally – and again, by design – none of these scenarios includes the costs of constructing and/or operating the wind farms themselves.

Table 4
Preliminary Transmission Cost Estimates –
ISO-NE Scenario Analysis of New England Transmission Expansion for Wind
Costs Associated with Onshore Transmission Enhancements within New England*

	Description of Scenario	Approx. Circuit Miles of New On-Shore Transmission	Preliminary order-of-magnitude cost estimate range by voltage class (2009 dollars)	Mid-range cost estimate
1	2,000 MW On and Offshore Wind	1,785	345 kV/HVDC: $4.7B to $7.9B	$6.4B
2	2,000 MW Offshore Wind	1,015	345 kV/HVDC: $3.6B to $6.0B	$4.8B
3	4 000 MW On and Offshore Wind	3 615	345 kV: $8.0B to $13.2B 500 kV: $10.8B to $17.9B	$10.7B $14.3B
4	4,000 MW Offshore Wind	1,430	345 kV/HVDC: $4.7B to $7.6B	$6.1B
5	5,500 MW (1,400 MW inland, near coast, 4,000 MW offshore)	1,430	345 kV/HVDC: $4.7B to $7.6B	$6.1B
6	8,000 MW On and Offshore Wind	4,320	500 kV: $13.4B to $22.4B 765 kV: $17.3B to $28.9B	$17.9B $23.0B
7	12,000 MW On and Offshore Wind	4,320	500 kV: $14.5B to $24.2B 765 kV: $18.9B to $31.5B	$19.3B $25.2B
8	1,500 MW New Brunswick Interconnection	400	+/-450 kV HVDC: $1.5B to $2.5B	$2.0B
9	1,500 MW Québec Interconnection	280	+/-450 kV HVDC: $11B to $19B +/ 450 kV HVDC: $1.1B to $1.9B	$16B $1.6B
10	10,000 MW New York Interconnection	1,020	500 kV: $4.7B to $7.7B 765 kV: $6.8B to $11.2B	$6.3B $8.9B
11	New England & Eastern Canada Wind (5,500 MW NE, 3,000 MW New Brunswick & Quebec)	2,110	$4.7B to $7.6B for NE, plus $2.6 to $4.4 for CA. Total ~$7B to $12B	N/A
12	New England & Eastern Canada Wind (12,000 MW NE, 3,000 MW New Brunswick & Quebec)	5,000	$14.5B to $31.5B for NE, plus $2.6 to $4.4 for CA. Total ~$17B to $36B	N/A

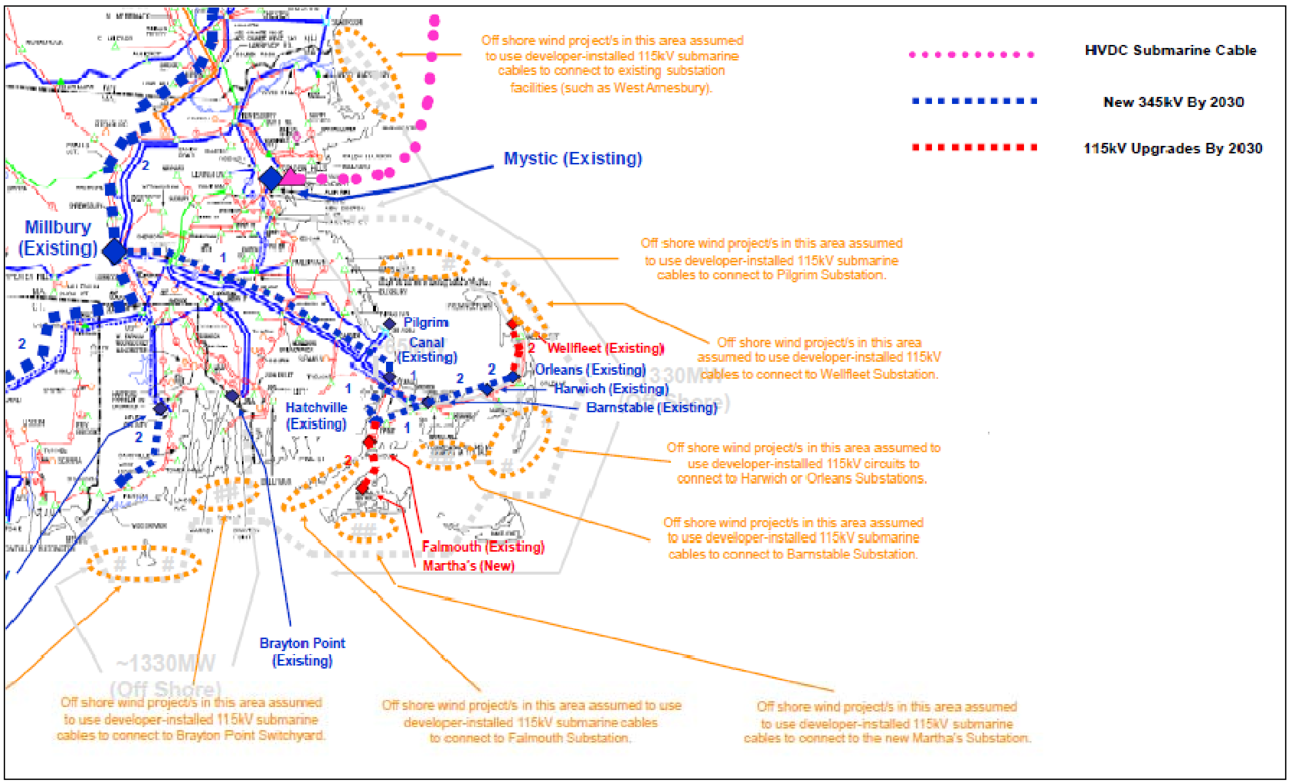
Source: ISO-NE, Draft New England 2030 Power System Study – 2009 Economic Study: Scenario Analysis of Renewable Resource Development, September 8, 2009.

* Unless otherwise specified, cost estimates only include on-shore transmission facilities within New England. Specifically, the costs estimates do not include: (a) any costs to interconnect wind projects to New England's high-voltage system, whether the facilities are located on land in New England or in New England's offshore waters; (b) costs to add transmission facilities in Québec and New Brunswick to bring renewable power from those regions to the border of New England; or (c) the cost of building transmission from the Midwest to the NY-NE border. The dollar estimates shown above only includes the cost of integrating energy from the NY-NE border to load centers in New England.

The report suggests preliminary thinking of the ISO-NE with regard to possible technical configurations for transmission to connect windy areas offshore of Southeastern Massachusetts to the grid. As shown in Figure 25, offshore wind farms south of Martha's Vineyard could be interconnected via 115 kV lines through various new or existing substations (e.g., Falmouth, Barnstable, Martha's Vineyard); projects south of the Elizabeth Islands could connect through the Falmouth substation (with nearby offshore wind farms to the West of that location possibly connecting through the Brayton Point substation in Somerset). The analysis suggests that interconnecting 4,500 MW of offshore wind is possible in terms of capability of the onshore grid, but would still require some expansion of the onshore system to deliver power to customers in the region.

<u>Figure 25</u>

Potential Transmission System Expansion to Interconnect Wind Projects Deemed Feasible
4,000 MW Off-Shore Wind Scenario



Source: New England 2030 Power System Study: Preliminary Maps and Cost Estimates for Potential Transmission; ISO-NE Planning Advisory Committee; August 14, 2009.

Overall, the Governors' Economic Blueprint study reached a number of conclusions, including: (a) the transmission scenarios that were developed are generally robust, workable solutions with cost estimates based on actual project experience; (b) more detailed transmission studies, however, will be required if the region pursues specific projects, since all of these scenarios are conceptual; and (c) new voltage classes will be needed for higher wind penetration scenarios (345 kV is the backbone of the existing system).

8. STRATEGIC TRANSMISSION OPTIONS AVAILABLE TO THE COMMONWEALTH IN SUPPORT OF OFFSHORE WIND DEVELOPMENT IN THE OCEANS NEAR MASSACHUSETTS

Given the rich resources located off the coast of Massachusetts, the Commonwealth faces a number of decisions about whether, and potentially how and when, to take proactive steps to help provide transmission access to windy offshore areas. Facilitating access to transmission would assist potential developers of offshore wind farms by cracking the chicken-and-egg problem, and providing a way to connect projects to the onshore grid and thereby deliver renewable energy to customers in Massachusetts and neighboring regions.

The final section of this report summarizes a core set of strategic policy options and approaches that Massachusetts state officials may wish to consider as part of their overall strategy to support offshore wind for economic development, environmental, and other electricity policy goals. These options have been informed by the types of technical, policy, structural, and environmental issues described previously. Some of these options may require new enabling legislation; others may require executive-branch authority alone. All of the options would depend upon innovative methods for investment recovery, as well as require more detailed analysis.

Core Attributes of and Assessment Criteria for Strategic Transmission Models

The strategic transmission options discussed here involve two key dimensions: the basic character of the physical layout of the offshore transmission system, and the basic ownership/investment structure for the offshore transmission system. It is assumed here that the transmission system connecting one or more offshore wind farms to the onshore grid is owned by an entity other than the developer of the wind farm. (This is not an essential feature of offshore transmission for offshore wind, but instances where common ownership or at least common planning for both facilities makes the chicken-and-egg problem far less difficult. It is for this reason that the focus here is on other situations.)

Each of the dimensions ("core attributes") discussed here introduces different implications and choices for policy-makers – such as who pays for and benefits from supporting the development of transmission facilities for offshore wind, and in turn suggests different degrees of difficulty in adopting a particular approach.

Core Attributes: From a strategic point of view, two initial questions are: (1) what is the vision for offshore wind development in Massachusetts, and (2) how might different physical configurations and ownership structures of an offshore power delivery system enable this vision?

1. ***Physical Layout of the Offshore Transmission System:*** The first dimension relates to the character of the physical configuration of the transmission facilities for offshore wind:

   - ***"Radial System"*** – One option for the submarine transmission system design is a radial system, which in essence is like an extension cord (a "radial" line), providing transmission service between two points (the wind farm and the connection to the grid). Figures 26a through 26d depict various conceptual designs for radial-line systems supporting transmission from one or more wind farm projects.[107] With regard to electrical carrying capacity, it is necessary to consider whether the main trunk line would have: (1) just enough capacity for the single wind farm it was designed to service, or (2) enough capacity to support more than one wind farm (potentially starting with one and adding more over time) without requiring upgrades to the transmission capacity of the submarine cable itself. These options have different implications for solving the chicken-and-egg problem, at least in terms of having a mechanism to support the investment costs of the capacity not needed by the initial wind farm, since those costs may make that first project uneconomic if it were required to carry transmission investment costs intended to service one or more future wind project(s).

- ***"Network Model"*** – Another option for the submarine transmission system is a design more like a backbone (know as a "network" system), capable of connecting to multiple wind farms. Figures 27a and 27b illustrates two possible configurations, where the offshore transmission system is connected to the onshore grid in more than one location, making it a loop.[108] In this type of scenario, it would be necessary to determine whether the loop would connect to shore only within the boundaries of Massachusetts, or whether it would expand over time (or from the beginning) to connect wind farms with electricity customers in multiple regions (e.g., customers in Maine, Rhode Island, Long Island, New Jersey). Connecting into more than one state would increase the need for Massachusetts to work proactively and constructively with counterparts in the neighboring state(s) to develop parallel policy mechanisms to support the development of the interstate offshore transmission system. The state would also have to consider whether the initial segments of the loop would be designed for a future large-scale build-out of wind facilities over time, and also how much carrying capacity the main trunk line would have. Similar to the radial system, the main trunk line could have: (1) just enough capacity for the single wind farm it was designed to service, or (2) enough capacity to support more than one wind farm (potentially starting with one and adding more over time). As with the radial system approach, the greater the capacity of the initial line beyond the needs of the first wind farm built, the more support for transmission costs will need to be provided beyond what the first wind farm can bear, and the more troublesome the chicken-and-egg problem.

Conceptual Designs for Submarine Transmission Facilities for Offshore Wind:

Figure 26a
Radial Configuration for Single Wind Farm

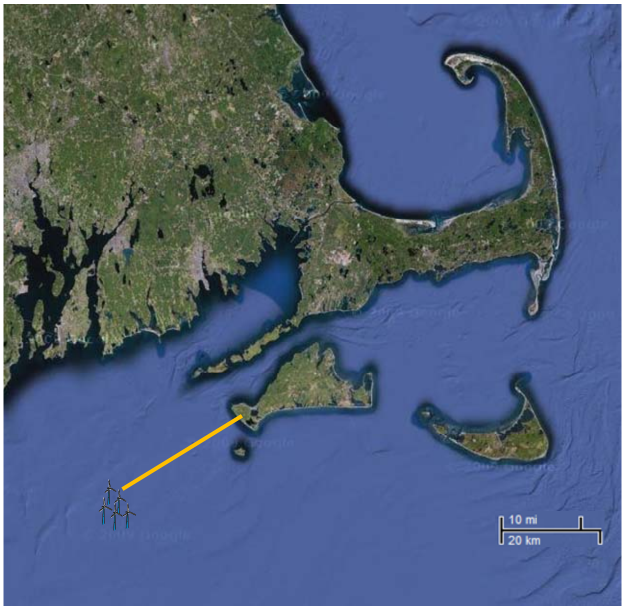


Figure 26b
Radial Configuration for Multiple Wind Farms

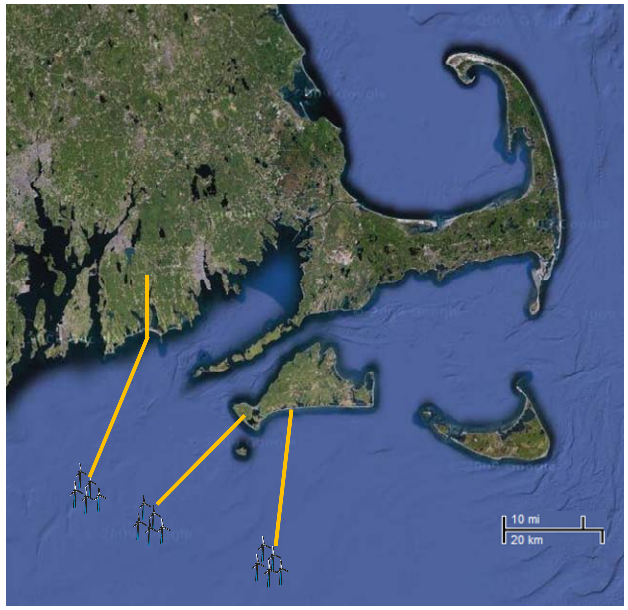


Figure 26c
Radial Configuration for Groups of Wind Farms

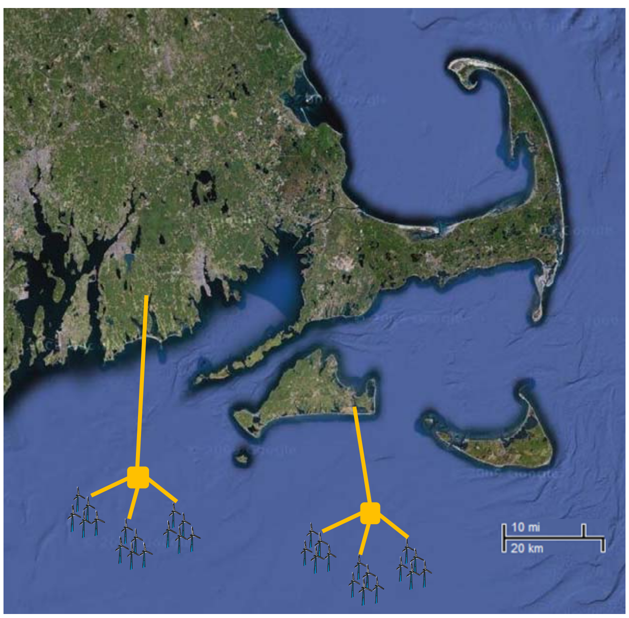
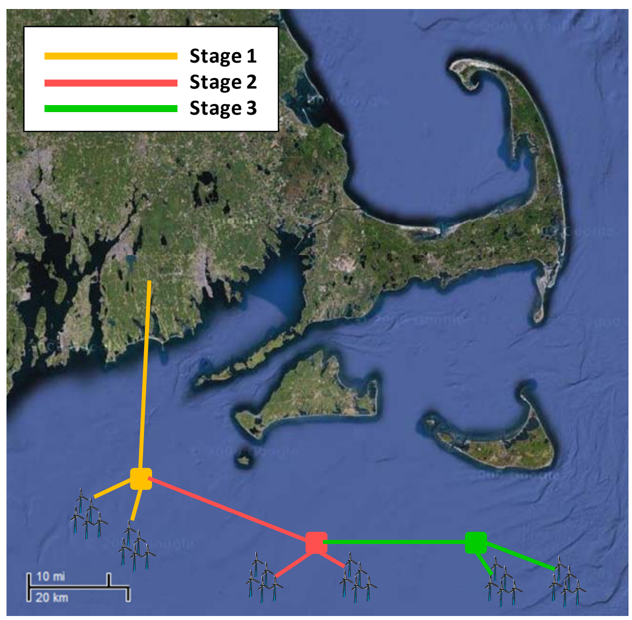


Figure 26d
Staged Radial Configuration for Multiple Wind Farms



Both of these physical configuration options require further analysis with regard to certain of the technical details and a relatively precise estimate of costs.

2. ***Ownership/Investment Approach of the Offshore Transmission System***: In addition to the physical configuration, a second core dimension relates to the structure of ownership and investment of the offshore transmission system. This affects the institutional framework and business model underlying the delivery system. Three primary options are detailed below (but given that they can represent different combinations of ownership and investment considerations some of these options are variants of similar ideas).

   - ***Investor-Owned Utility Approach*** – One option is for the offshore transmission system to be developed by a traditional transmission company, under a traditional cost-based investment structure, with the transmission rate established by regulators.
     - Presumably, this case could apply where the utility were expected to provide transmission service as part of its obligations in a service territory that extends into state waters (or even adjacent federal waters), assuming that such authority and obligations were established under new law in the state.
     - The utility might recover the costs of its investment from different parties over time, starting with retail and wholesale customers of the utility and eventually from the wind farms that develop along the system (similar to the SCE Tehachapi model).
     - Alternatively, Massachusetts could establish new authority for a utility to perform this function, with investment support recovered from all electricity customers in the Commonwealth in light of the broad economic, energy, and environmental benefits afforded by opening up the offshore area to development (in the same way that the public has traditionally provided most of the funding for road development in a state).

Figure 27a
Network Configuration for Multiple Wind Farms

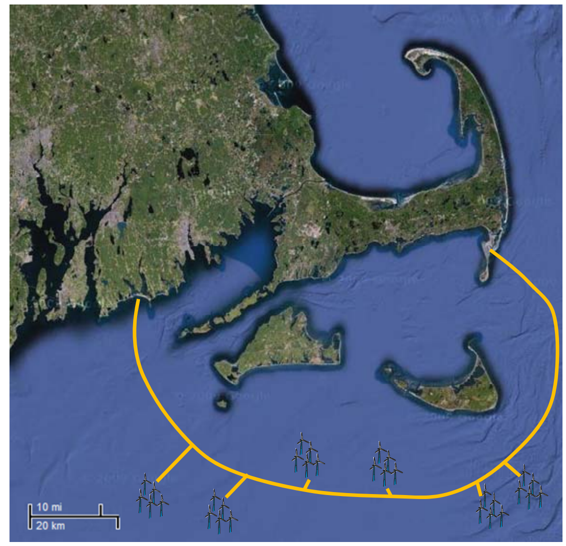
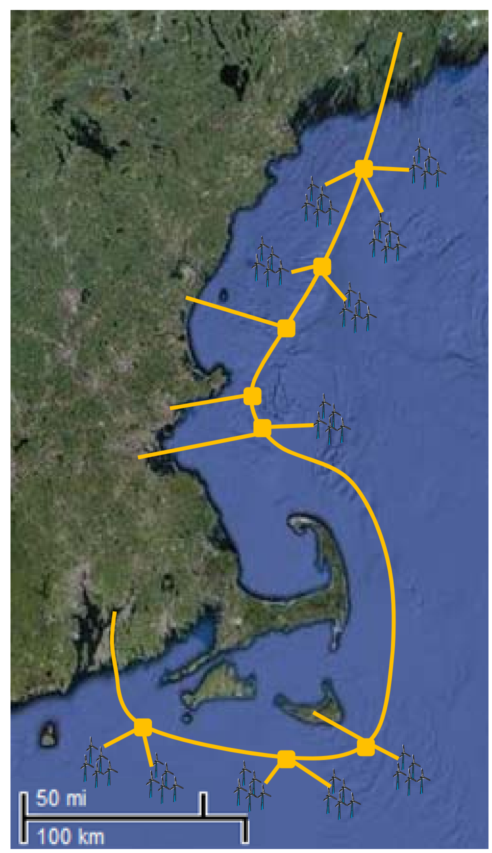


Figure 27b
Network Configuration for Multiple Wind Farms



- ***Merchant Approach*** – A second option is for the offshore transmission system to be developed and owned by a non-utility transmission entity (or a utility transmission company, but in a merchant context), with all of the costs paid for directly by the beneficiaries of the project.
    - In this model, the wind project would contract with a transmission developer to develop/build/operate a radial line to interconnect the w***in***d farm to the high-voltage, onshore grid. The wind project's power supply agreements would be structured to recover the costs of such a line, either directly as a pass-through to buyers of the power, or as part of the delivered cost of power. The transmission costs would be directly assigned in this model – otherwise known as participant-funded or beneficiary-funded.
    - Alternatively, if more broadly, the citizens/taxpayers of the state were considered to be the beneficiaries of opening up access to offshore windy areas of the state, a merchant model could provide for the taxpayers and/or ratepayers of the state (under new legislative authority) to cover the costs of the merchant "access road" to the offshore wind zones. In return, the state's taxpayers/ratepayers could receive the benefit of such things as: (1) revenues (e.g., royalty payments) from the development of the wind project; (2) sellable rights to the new capacity established with the new transmission facilities; and (3) indirect taxes paid by the owners of infrastructure development. (Alternatively, there could be tax exemptions provided for these facilities, in which case their investment and operating cost would be reduced).
    - Any contract with the transmission provider (which establishes the terms and conditions of service and compensation) would require a counterparty and the state would need to decide whether that would be a state agency or one or more of the utilities in the state.
- ***Public Authority Approach*** – A third option is for the offshore transmission system to be developed and owned by a state agency which would have responsibility to plan, build, fund, and otherwise provide transmission access to the offshore wind resources of the state.
    - The public offshore transmission authority could own and operate the facility, or contract with another party (e.g., a transmission utility or merchant transmission company) to own and operate the system.
    - The state would need to determine how the public authority would recover its investment (e.g., through fees collected from users of the state's electric system, and/or developers of offshore wind; from tax proceeds). The specific direction chosen here depends largely on whether the public authority is seen as providing a public good or service (e.g., an open access highway, available to anyone and critical for enabling commerce but supported through taxes) or a private good or service (e.g., designed to be provided to particular users at use-based fees for service).
    - A policy outcome that establishes offshore transmission development as a public good could imply the need for a long-term legislative commitment to fund the projects through annual appropriations, in which case potential funding constraints should be carefully considered.

- Alternatively, the offshore transmission authority could be funded through a dedicated funding stream – such as a new "offshore transmission fee" assessed on all sales of electricity in the state. This could follow various approaches: a fee analogous to the mandatory per-kWh charge collected from all consumers in the state in order to support energy efficiency programs, as authorized in the Green Communities Act; or the provisions set forth in the annual state budget under which state agency costs to carry out its emergency-response functions related to nuclear plants located in or near Massachusetts are charged through to certain electricity customers, pursuant to determinations of the Massachusetts Department of Public Utilities.

Assessment Criteria: These options provide different pathways to accomplishing the goal of building out transmission for offshore wind. Given these various ownership/investment models and possible physical configurations, state policy makers will be aided by screening them in terms of several criteria aimed at identifying options that fit well with the state's broad goals for developing and accessing its wind resource, as well as with the overall structure of the state's electric industry and its economic development agencies.

- Will this model support investment in offshore transmission for wind projects in Massachusetts? Are the financial/economic incentives sufficient?
- Does the overall transmission model fit with the timing and magnitude of development of offshore wind resources, and with the character of the technologies (e.g., for wind turbines located at different depths and in areas with different wind speeds; for submarine cables and systems)?
- Is the model of transmission investment recovery likely to align with institutions, authorities, and electric-industry structures in Massachusetts? Does the model require regional cooperation/coordination for planning, siting and/or cost support?
- Who bears the risk (of investment recovery) for a project whose capacity could be underutilized for at least some period of time? In other words, who pays for the transmission project? Do those who bear the risk get sufficient benefits to warrant support?
- How heavy are the set of political lifts and other implementation challenges that would be required to achieve each model? Would new legislative authority be required? Would efforts be required in more than one state?

Strategic Option Set for Consideration by Massachusetts Policy Makers to Support Transmission for Offshore Wind

All of the options listed in this final and more limited strategic option set assume that the Commonwealth of Massachusetts plays, at minimum, the role of facilitator of transmission facilities for offshore wind. In other words, these options assume that without some form of pro-active assistance (including, at a minimum, coordination, convening, planning, etc.), the chicken-and-egg problems associated with developing offshore wind and transmission will inhibit the state's pursuit of its goals for development of its rich, local offshore wind resources. In some of the options, the state would play a light-handed role, providing only facilitation activities (but which would nonetheless require funding support). In others, the state would play a more aggressive role by becoming a direct participant in the electric industry, including serving as project manager, funder, and/or owner of the transmission facility or facilities. These activities could be carried out through a newly established Massachusetts Offshore Transmission Authority or through an existing Commonwealth of Massachusetts executive branch agency, including – as appropriate – the Executive Office of Energy and Environmental Affairs, the Division of Energy Resources, and/or the MCEC.

Options in which the Commonwealth of Massachusetts acts as a provider of information, analysis and other services in support of offshore transmission for wind power development:

- *Establish (e.g., as part of the MCEC) and support an office to facilitate information exchange, planning studies, siting advice, and other analyses on transmission issues for wind project developers interested in siting wind farms in the offshore waters of Massachusetts and adjacent federal waters*. This activity could include related activities, such as:
  - Convening industry groups to share information on transmission technology and technical feasibility of phased construction of lines to support multiple wind projects over time.
  - Developing model contract provisions for the transmission-related elements of long-term wind-energy contracts.
  - Helping fund, carry out, or otherwise support the preparation of technical transmission interconnection and system-planning studies for specific offshore projects that meet certain development milestones. Unlike the Governors' Economic Blueprint Study, these studies would not be conceptual in nature, and would instead assess the specific interconnection needs of a particular offshore wind project and its impacts on the onshore grid.
- *Identify Massachusetts offshore renewable energy zones for the purpose of developing transmission planning studies*. This could include such activities as:
  - Undertaking a process to identify one or more specific Massachusetts offshore wind energy zones (e.g., "MOSWEZ"). Such zones could be in state ocean waters identified for utility-scale wind in the Commonwealth's Ocean Management Plan, and/or in federal waters offshore of Massachusetts. These zones would be areas into which the Commonwealth would consider developing or sponsoring the development of transmission infrastructure to connect wind projects with the onshore high-voltage transmission system.
  - In conjunction with the process of identifying potential offshore wind zones, conducting a solicitation of interest (e.g., an open season process) to determine the level and timing of demand for transmission capacity among prospective offshore wind project developers in particular areas of the Commonwealth's and adjacent offshore waters.
  - Carrying out a detailed study to examine the economic trade-offs of supporting multiple radial facilities to support offshore wind, versus the economics of supporting the development of a backbone transmission highway to give access to offshore wind facilities in a very-large MOSWEZ. This study would examine the engineering costs and economic benefits/costs of alternative configurations. The purpose of the study would be to better understand the cost

and investment-recovery implications of a phased versus non-phased approach to the various physical configurations.

Options in which the Commonwealth of Massachusetts acts as a pro-active agent in ensuring development of needed offshore transmission for wind power development:

- *Lead regional efforts to develop offshore transmission in New England*, including:
  - Coordinating efforts with neighboring states in New England to explore whether and if so how to jointly develop an interstate, offshore transmission backbone system, enabling development of large regional offshore wind zones. This could be carried out through establishing a memorandum of understanding among multiple states, with any/all of the functions and purposes identified above. There are examples in other regions (e.g., the Rockies) in which neighboring states are exploring mechanisms that would support collaboration to support transmission investment to connect wind-rich resource areas with distant load centers. Additionally, there may be models in other areas of public policy (e.g., voluntary agreements by states to enter into an interstate compact) that might be applicable to efforts in this area. Discussions may cover such topics as institution building, governance issues, cost-allocation principles, planning approaches, and mechanisms to solicit private transmission proposals to serve interstate policy goals.
- *Expand service territories of electric utilities into offshore state oceans*.
  - Extending the service franchise area of electric utility companies in coastal communities of Massachusetts, so that the franchise includes not only the terrestrial area of a municipality but also the offshore area that extends three miles out into the ocean. Extending the service territory of the utility would indicate the service territory whose retail and wholesale customers might be responsible for supporting the costs of the "local benefit" upgrades to the transmission system. Presumably, to the extent that the customers in that territory (or sub-zone of the state) support the investment in transmission to provide access to offshore wind zones, those customers would get the value of transmission capacity and/or transmission congestion contracts.
- *Contract for the development/construction of offshore transmission in Massachusetts*. This could be accomplished through:
  - Using existing authority of the MCEC (or other state entity, as appropriate) and solicit competitive proposals from utilities and/or merchant transmission companies to construct offshore radial transmission facilities. In this option:
    - The state would proceed with a process to solicit interest in wind project development in a particular offshore wind zone.
    - The state would contract with the winning transmission provider, who would undertake detailed transmission studies, interconnection processes, siting/permitting, and construction.
    - The transmission costs could be recovered in a number of alternative ways: (a) through an assessment on Massachusetts electricity customers, pursuant to cost-

allocation determinations by the Department of Public Utilities that would assure full investment recovery of the state's costs to support offshore transmission; (b) through an assessment on Massachusetts taxpayers, subject to new legislative authority; and/or (c) as wind projects come on line, also through model contract terms/provisions in long-term contracts signed by the offshore wind project developers and the buyers of their renewable power.

- *Establish a Massachusetts Offshore Transmission Authority ("MOSTA").* This would involve:
  - Enacting new statutory authority to utilize or create a state agency (e.g., MCEC) or authority (new Massachusetts Offshore Transmission Authority ("MOSTA")) to arrange for the construction of a transmission line, to own the facility (or contract with another entity to own it), and to recover costs from all or some subset of Massachusetts electric consumers and/or taxpayers.
  - Developing and financing transmission facilities in advance of and/or timed with the development of wind projects in the state and/or federal ocean waters offshore of Massachusetts.
  - Setting rates to recover its costs to develop/finance/construct/maintain offshore transmission projects from a set of electricity customers. There could be a strong rationale for having the entire body of retail electricity customers in Massachusetts help pay fees to support the MOSTA's investments to assure the availability of renewable energy production and economic development from offshore wind development. These electricity customers are roughly the same set of people in Massachusetts who, as taxpayers and residents, will receive the indirect benefit from the tax contributions provided by the wind power project and any associated economic activity in the state). The authority should be established in a structure or form that enables it to be self-financing through a combination of user fees, payments from wind projects, royalty-based fees, and/or a variety of other revenue streams (including annual appropriations from the state legislature, loan guarantees, bond guarantees, and/or other means of public funding).

Table 5 provides a preliminary screen to assist state energy officials in assessing these options. With the exception of the more proactive roles for Massachusetts state government – in the form of a Massachusetts Offshore Wind Transmission Authority (which might be viewed as alternative strategies to accomplish similar objectives) – the options can be viewed as additive, rather than mutually exclusive.

These options indicate that there are many paths forward for Massachusetts to help realize its vision of a state that is creatively and effectively tapping its abundant wind resources for the benefit of the economy, the environment, and the well-being of its citizens.

Table 5

Assessment of Optional Actions for the Commonwealth of Massachusetts to Consider Undertaking in Support of Offshore Transmission for Offshore Wind Development

Role of state government:		Potential Implications for: Investment in offshore transmission to support wind development	Sequencing of MA offshore wind project development	Alignment with existing state and regional institutions	Balance of risk and reward, benefits and costs	Direct cost to carry out	Ease of Implementation
Status quo	Business as usual	Very ineffective	Very ineffective	✓ but does not address chicken & egg stalemate	Very low	Very low	Very easy
Information providers	Share information	Indirectly supportive	Moderately supportive	✓	High value to out-of-pocket cost	Low	Easy
	Pay for transmission studies	Directionally supportive	Significantly supportive for individual projects	Viewed as subsidy for individual projects	Uncertain – will require picking winners, so could be misses	Moderate	May be hard to establish the list of projects to be supported
	Identify MA offshore wind zones (for transmission)	Very supportive	Moderately supportive	✓	Potentially high value relative to out-of-pocket cost	Moderate	Has been accomplished in other regions
Pro-active agent to accomplish offshore transmission	Convene regional discussions, develop MOU	Directionally supportive	Moderately supportive	✓	Low out-of-pocket cost; moderate time investment	Low	Would require focused attention of senior state officials
	Expand utility service area into ocean	Supportive	Supportive	✓	Depends upon structure adopted	Low	No apparent precedent; will still require investment recovery solutions
	CEC (or other entity) contract for transmission projects	Highly supportive	Highly supportive	May be viewed as "non-market" solution – but addresses chicken & egg stalemate	Depends upon structure adopted	Low out-of-pocket cost at the outset; may require high cost for eventual investments	No apparent precedent, but may be viewed as relatively positive approach
	Establish MA Offshore transmission Authority	Highly supportive	Highly supportive	May be viewed as "non-market" solution – but addresses chicken & egg stalemate	Depends upon structure adopted	Moderate out-of-pocket cost at the outset; may require high cost for eventual investments	Precedents exist in other states and regions (under state and federal law)

ENDNOTES

[1] Energy Information Administration ("EIA"), "Table S3. Energy Consumption Estimates by Source, 2007," (accessible at: http://www.eia.doe.gov/emeu/states/sep_sum/html/sum_btu_tot.html), and "State Ranking 1. Total Energy Production, 2007," (available at: http://tonto.eia.doe.gov/state/state_energy_rankings.cfm).

[2] Estimates of wind resource potential can generally be classified into two categories. "Technical potential" represents the amount of offshore wind potential that could be captured given existing technologies, but does not include any consideration about whether it is economic to do so. "Technical" estimates may or may not take into account siting constraints, such as wildlife habitats, shipping lanes, and other competing uses. "Economic potential" is a subset of technical potential, and represents the amount of offshore wind resource that could realistically be captured after considering cost. Estimates presented throughout this Technical Report are of technical potential.

[3] W. Musial and B. Ram, "Energy from Offshore Wind," National Renewable Energy Laboratory, Offshore Technology Conference, Houston, Texas May 1–4, 2006.

[4] Ibid.

[5] Ibid.

[6] Offshore Statistics, European Wind Energy Association, January 2009, (available at: http://www.ewea.org/fileadmin/ewea_documents/documents/statistics/Offshore_Wind_Farms_2008.pdf).

[7] Beatrice Wind Farm Development Project website, (available at: http://www.beatricewind.co.uk/home/). "It should be noted that Deepwater Wind has licensed the OWEC Tower AS jacketed technology, in use at the Beatrice project, for use in New Jersey and Rhode Island. The hope is that this technology would allow Deepwater Wind to install turbines 10-15 miles from the NJ and RI shores."

[8] Offshore Statistics, European Wind Energy Association, January 2009, (available at: http://www.ewea.org/fileadmin/ewea_documents/documents/statistics/Offshore_Wind_Farms_2008.pdf).

[9] Alpha Ventus Project website, (available at: http://www.alpha-ventus.de/index.php?id=80).

[10] W. Musial and B. Ram, "Energy from Offshore Wind," National Renewable Energy Laboratory, Offshore Technology Conference, Houston, Texas May 1–4, 2006.

[11] StanoilHydro website, (available at: http://www.statoilhydro.com/en/NewsAndMedia/News/2009/Pages/InnovativePowerPlantOpened.aspx).

[12] Levitan & Associates, "Phase II Wind Study," prepared for ISO-NE, March 2008.

[13] Based on information in ISO-NE, "New England 2030 Power System Study Draft: Demand and Resource Assumptions," May 15, 2009; and Levitan & Associates, "Phase II Wind Study," prepared for ISO-NE, March 2008. These calculations of approximately 19 GW and 4.3 GW of potential offshore wind resources for Rhode Island and Maine in water 30 meters or less have been prepared by Analysis Group, based on estimates from the two aforementioned documents. The "Phase II Wind Study" estimates approximately 73 GW of potential offshore wind resources in New England in waters 30 meters or less, but it does not break out that estimate by state. The "New England 2030 Power System Study Draft: Demand and Resource Assumptions" subsequently breaks down the wind resource potential by state using Levitan & Associates maps, which visually illustrate wind resource distribution throughout coastal New England, and assigns resource amounts to each state by roughly allocating resources by geographic area. The "New England 2030 Power System Study Draft: Demand and Resource Assumptions" analysis was performed on a Levitan & Associates estimate that excluded a siting buffer zone from shore to 3-miles out, but in this case the resource proportions by state described above were applied to the larger 73 GW estimate that does not exclude a 3-mile buffer zone.

[14] University of Maine website, (available at: http://www.umaine.edu/mediaresources/rd-fast-facts/offshore-wind-energy/?tpl=textonly.com).

[15] ISO-NE, "New England 2030 Power System Study Draft: Demand and Resource Assumptions," May 15, 2009; and Levitan & Associates, "Phase II Wind Study," prepared for ISO-NE, March 2008. This calculation of approximately 49 GW of

potential offshore wind resources off the coast of Massachusetts in water 30 meters or less is similar to those described above for Rhode Island and Maine.

16 J. Norden (Manager, Renewable Resource Integration, ISO-NE), "Wind Power Integration in New England," presentation to the AWEA Offshore Workshop, Boston, Massachusetts, December 2&3, 2009.

17 One of the primary issues related to building wind farms near shore is that of siting constraints. These constraints range from conflicts with other uses (e.g., commercial fishing, recreational fishing, shipping lanes), to environmental factors (e.g., habitat and migratory areas for protected, endangered or even non-threatened species of fish, mammals, birds, etc; and sensitive and/or protected ecosystems), and others. Since these siting constraints are most often highly specific to particular areas, it is very time-consuming and difficult to analyze issues brought up by all relevant stakeholders and devise a precise method by which to scale down unconstrained wind resource potential estimates (that are originally based simply on wind data and do not consider siting constraints). Instead, it is usually easiest to use a simple "exclusion factor" when trying to account for these constraints, and when comparing resource potential across different regions, or even within specific regions that may have different siting constraint issues. The Navigant Consulting study ("Massachusetts Renewable Energy Potential: Final Report," Prepared for the Massachusetts Department of Energy Resources (DOER) and Massachusetts Technology Collaborative (MTC), Navigant Consulting, August 6, 2008) cited in the "Draft Massachusetts Ocean Management Plan" uses a 66.6 percent exclusion factor (e.g., 66.6 percent of resources are excluded) for waters between 0 – 20 miles from shore, similar to those introduced in "Future for Offshore Wind Energy in the United States" by Musial and Butterfield, 2004, cited below.

18 ISO-NE, "New England 2030 Power System Study Draft: Demand and Resource Assumptions," May 15, 2009; and Levitan & Associates, "Phase II Wind Study," prepared for ISO-NE, March 2008. This estimate incorporates the same ratios as those used above for breaking out Massachusetts wind resource potential from an overall New England estimate. Given the fact that all sites within 3 miles of shore are excluded in this example, a slightly lower exclusion factor of 50 percent was used for the small remaining windy areas, yielding approximately 3 GW of offshore wind resource potential.

19 ISO-NE, "New England 2030 Power System Study Draft: Demand and Resource Assumptions," Attachment 2 (citing study prepared by Levitan & Associates, "Phase II Wind Study"), May 15, 2009. This estimate takes the 49 GW estimate cited above, which includes no siting constraints, and applies a 66.6 percent exclusion factor. This calculation yields a resource potential, with a mix of siting constraints taken into consideration, of approximately 16 GW.

20 "Massachusetts Renewable Energy Potential: Final Report," Prepared for the Massachusetts Department of Energy Resources (DOER) and Massachusetts Technology Collaborative (MTC), Navigant Consulting, August 6, 2008; cited in the "Massachusetts Ocean Management Plan," Massachusetts Executive Office of Energy and Environmental Affairs, December 2009.

21 ISO-NE, "New England 2030 Power System Study Draft: Demand and Resource Assumptions," Attachment 2 (citing study prepared by Levitan & Associates, "Phase II Wind Study"), May 15, 2009; and W. Musial, and S. Butterfield, "Future for Offshore Wind Energy in the United States," National Renewable Energy Laboratory, presented to Energy Ocean 2004, Palm Beach, Florida, June 2004. For this estimate, the NREL study cited here provides an estimate of wind resource potential between miles 5-20 offshore, and the Levitan & Associates study provides an estimate of wind resource potential between shore and three miles out. The remaining mile unaccounted for (the 4th mile) is assumed to be similar in resource potential to the third mile out. All estimates relied upon here were originally for New England, but were scaled down to just Massachusetts using the method described above. An exclusion factor of 60 percent was used in this case rather than 66 percent to account for the fact that much of the deepwater resources will likely have fewer exclusion criteria than was assumed in Musial & Butterfield (2004), due in part to the fact that Massachusetts is actively seeking to facilitate offshore wind development.

22 W. Musial, "Offshore Wind Electricity: A Viable Energy Option for Coastal United States," National Renewable Energy Laboratory, *Marine Technology Society Journal*, Fall 2007; and W. Musial, and S. Butterfield, "Future for Offshore Wind Energy in the United States," National Renewable Energy Laboratory, presented to Energy Ocean 2004, Palm Beach, Florida, June 2004. This forward-looking estimate relies upon wind resource potential estimates that were originally for New England, but were scaled down to just Massachusetts using the method described above. Exclusion criteria were similar to those above, but with exclusion factors nearing zero in the far-offshore deepwater areas. This estimate also accounts for continuing technological improvement and increase in average capacity factors.

23 ISO-NE, "CELT Report [Capacity, Energy, Load and Transmission]," 2009.

[24] W. Musial, "Offshore Wind Electricity: A Viable Energy Option for Coastal United States," National Renewable Energy Laboratory, *Marine Technology Society Journal*, Fall 2007.

[25] U.S. Department of Energy ("DOE"), "Economic Benefits, Carbon Dioxide (CO2) Emissions Reductions, and Water Conservation Benefits from 1,000 Megawatts (MW) of New Wind Power in Massachusetts," March 31, 2009 (available at: http://www.windpoweringamerica.gov/pdfs/economic_development/2009/ma_wind_benefits_factsheet.pdf).

[26] R. Pollin, J. Heintz, and H. Garrett-Peltier, "The Economic Benefits of Investing in Clean Energy: How the economic stimulus program and new legislation can boost U.S. economic growth and employment," Department of Economics and Political Economy Research Institute (PERI), University of Massachusetts, Amherst, June 2009, page 28.

[27] Ibid, page 36.

[28] "Annual Wind Industry Report: Year Ending 2008," American Wind Energy Association, April 2009.

[29] EIA, "Table ES3. New and Planned U.S. Electric Generating Units by Operating Company, Plant and Month, 2008-2009," *Electric Power Monthly*, August 25, 2008; EIA, "Table ES3. New and Planned U.S. Electric Generating Units by Operating Company, Plant and Month, 2007-2008," *Electric Power Monthly*, March 2008; and DOE, "Economic Benefits, Carbon Dioxide (CO2) Emissions Reductions, and Water Conservation Benefits from 1,000 Megawatts (MW) of New Wind Power in Massachusetts," March 31, 2009, (available at: http://www.windpoweringamerica.gov/pdfs/economic_development/2009/ma_wind_benefits_factsheet.pdf).

[30] U.S. DOE Annual Wind Report, May 2008, page 21.

[31] The price of liquid petroleum fuels used for power generation (i.e., distillate fuel oil, residual fuel oil, jet fuel, kerosene, and waste oil) averaged $95.94 in 2008, compared to $16.03 per barrel in 1999 – a six-fold price increase. EIA., Table 4.1. Receipts, Average Cost, and Quality of Fossil Fuels: Total (All Sectors), 1995 through August 2009, Report No.: DOE/EIA-0226 (2009/11), (available at http://www.eia.doe.gov/cneaf/electricity/epm/table4_1.html). In the U.S. in 2008, 1 percent of electricity was produced by combustion of liquid petroleum fuels, including residual fuel oil, distillate fuel and others. http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html

[32] EIA., Table 4.1. Receipts, Average Cost, and Quality of Fossil Fuels: Total (All Sectors), 1995 through August 2009, Report No.: DOE/EIA-0226 (2009/11), (available at: http://www.eia.doe.gov/cneaf/electricity/epm/table4_1.html).

[33] EIA, Table 4.1. Receipts, Average Cost, and Quality of Fossil Fuels: Total (All Sectors), 1995 through August 2009, Report No.: DOE/EIA-0226 (2009/11), (available at: http://www.eia.doe.gov/cneaf/electricity/epm/table4_1.html).

[34] "Annual Wind Industry Report: Year Ending 2008," American Wind Energy Association, April 2009.

[35] U.S. DOE Annual Wind Report, May 2008, pages 23-24.

[36] B. Swezey, et al., "A Preliminary Examination of the Supply and Demand Balance for Renewable Electricity," NREL, October, 2007.

[37] Letter from AWEA to FERC Chairman Kelliher, February 26, 2007.

[38] Western Resources Associates, "Smart Lines: Transmission for the New Renewable Energy Economy," 2008.

[39] Governor Deval Patrick's Official Website, 2009 Press Releases (available at: http://www.mass.gov/?pageID=gov3pressrelease&L=1&L0=Home&sid=Agov3&b=pressrelease&f=090113_Goals_Wind_Power&csid=Agov3).

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[45] Governor Deval Patrick's Official Website, 2008 Press Releases, (available at: http://www.mass.gov/?pageID=gov3terminal&L=3&L0=Home&L1=Media+Center&L2=Speeches&sid=Agov3&b=terminalcontent&f=text_2008-05-28_oceans&csid=Agov3) and "Secretary Chu, Governor Patrick Announce $25 Million for Massachusetts Wind Technology Testing Center," U.S. Department of Energy Website, May 12, 2009, (available at: http://www.energy.gov/news2009/7392.htm).

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[55] Steven Rourke, "EBC Energy Seminar New England Transmission Update," ISO-NE System Planning, presentation to the EBC Energy Seminar, April 2, 2009.

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