DRAFT REPORT OF THE RENEWABLE ENERGY WORKING GROUP
NOT A PUBLIC RECORD: INTRA-AGENCY POLICY DELIBERATION

Summary

This document is the draft report by a renewable energy working group composed of staff from EEA, DOER, and CZM, industry representatives and scientists. A list of the working group members is attached. The charge of the working group is to provide technical information to the ocean management planning team regarding appropriate sites in Massachusetts waters for the development of renewable energy, including tidal, wave and wind energy facilities. Note that this group has not been asked to "select" appropriate sites or to balance the public policy of promoting renewable energy against other interests, such as commercial fisheries or protection of marine habitat. Rather, the charge of this group is to tell ocean planners where the excellent, good, fair and poor sites are for renewable facilities, to enable the planners to balance the relevant interests and policies.

Section 1: Tidal Energy

The working group conducted a preliminary assessment of the potential for tidal energy in the Ocean Management planning area. We reviewed studies conducted to date, consulted with experts on tidal energy, and gathered information about several pending tidal projects. Particularly helpful was a report entitled "Massachusetts Tidal In-Stream Energy Conversion (TISEC): Survey and Characterization of Potential Project Sites," October 2006 [EPRI Report] and follow up conversations with the authors of that report. The EPRI report identified the criteria needed to make a tidal facility successful – peak tidal velocities of at least 3 knots, water depths of between 18-40 meters, depending upon the device, and proximity to transmission interconnections. The EPRI report identified various locations where some or all of these criteria were met, determined whether any of these locations had one or more "fatal flaws" rendering them unsuitable and located the most promising areas for tidal energy based on those criteria. The conclusions in the EPRI report were generally corroborated by TRC in its report entitled "Existing and Potential Ocean-Based Energy Facilities and Associated Infrastructure in Massachusetts" June 26, 2006, by Navigant Consulting, "Massachusetts Renewable Energy Potential", August 6, 2008, and by others familiar with tidal technology.

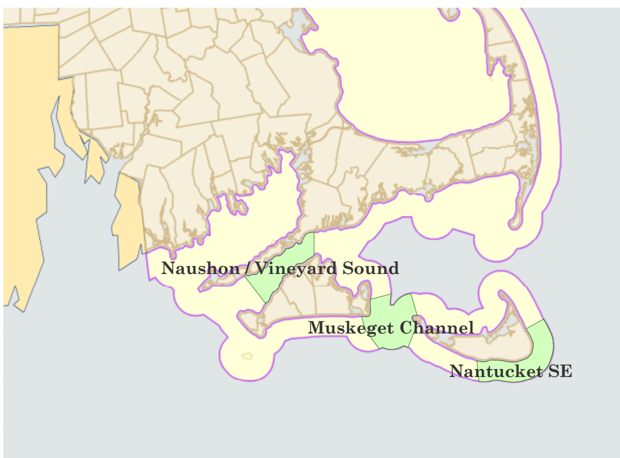
The current consensus is that Massachusetts has marginal resources for tidal energy, using currently available technology. In general, a peak tidal velocity of 4 knots appears to be the bare minimum for an economically viable, utility scale project. According to the EPRI report, there are no known locations in Massachusetts where these velocities are present. In fact, there are only a few known locations where the tidal velocities even approach 3 knots. These areas are Muskeget Channel between Nantucket and Martha's Vineyard, Vineyard Sound between Naushon Island and Norton Point, within the Cape Cod Canal and to the southeast of Nantucket Island. Unfortunately, tidal energy in the Cape Cod Canal appears to be infeasible, because the channel is relatively shallow, and the Army Corps of Engineers has indicated that a tidal device would interfere with navigation.

Notwithstanding the generally unfavorable prognosis for tidal energy, there are currently three potential projects pending. The Town of Edgartown and a private company, Natural Currents Energy Services LLC, are both pursuing separate projects in Muskeget Channel, while the Oceana Energy Company has proposed a project in Vineyard Sound.

Edgartown's preliminary permit is for feasibility and impact studies, design and testing in the Muskeget Channel, but not for construction of any tidal generating facilities. Scientists from U-Mass Dartmouth have received a $250k grant to find locations in Muskeget Channel where currents peak at five knots or more.

The Natural Currents project, according to the Nantucket Independent, would generate three gigawatts of power from a yet undetermined number of unidirectional tidal generators, turbines enclosed in short tubes or double-ended funnels, or open rotors anchored to the bottom. The project is in the preliminary permitting phase of the project and under ideal review and permitting conditions, seeks to have the tidal generators online by 2011.

The Oceana project, according to Cape Cod Online, would include between 50 and 150 in-stream energy conversion devices, each with propeller blades about 35 feet in diameter submerged in water up to 75 feet deep. As ocean currents pass through the propellers, each device would generate between 500 kilowatts and 2 megawatts of electricity, about enough capacity to power 750 homes apiece, according to the FERC application. The proposed Vineyard Sound site would begin at the southwest end of Naushon Island and extend northeast on either side of Lucas Shoal and Middle Ground. The project would tie into a transmission cable linking Falmouth and Martha's Vineyard.



Areas for further exploration of tidal power potential

Based on the foregoing, the working group recommends designating the areas shown at left, Muskaget Channel, the Vineyard Sound area and the area southeast of Nantucket, where tidal potential has also been identified, as tidal demonstration zones, in which tidal facilities would be encouraged. (This recommendation assumes that there are no conflicting uses in such areas, but this assumption will be verified by the reports of other working groups). These demonstration projects are likely to provide useful information about the potential for tidal energy and the locations where tidal is most likely to be successful. Please note that these locations are shown on the map above for general, illustrative purposes, and are not intended to delineate firm boundary markers for tidal demonstration zones.

It should also be noted that there is a potential area for tidal that was not fully explored in the EPRI report. The EPRI authors indicated that they did not have sufficient data to conclusively ascertain the potential for tidal energy in Buzzard's Bay, and there may be locations in Buzzard's Bay with sufficient tidal velocities. The working group recommends launching an effort to investigate that potential.

Wave

The working group reviewed several reports on wave energy, including the TRC Report dated June 26, 2006, and consulted with various industry experts. There is a consensus that wave resources in Massachusetts are quite limited. Even one of the most attractive potential sites, offshore in Truro, has wave heights that are half of the wave energy of sites on the west coast, and the summer waves in Truro would provide half of the energy as the waves in the winter, which is opposite of the area load profile. TRC and others have concluded that wave energy development in Massachusetts waters is unlikely to occur in the next ten years. TRC Report, p. 4-19. The working group does not recommend a major focus on site selection for this technology. Rather, the ocean plan should provide for demonstration projects with appropriate safeguards, and the plan should be revisited if the technology improves to make wave energy feasible in Massachusetts.

Wind

There is a solid consensus that Massachusetts has excellent resources for successful offshore wind, due to high wind speeds and relatively shallow water depths. See, e.g., "Existing and Potential Ocean-Based Energy Facilities and Associated Infrastructure in Massachusetts", June 26, 2006, TRC Environmental Corporation, p. 6-1; "Massachusetts Renewable Energy Potential", August 6, 2008, Navigant, p. 73. There was also consensus within the working group that wind speeds are favorable in all locations within the planning area, although wind speeds tend to be higher further offshore.

Besides wind speed, the working group identified the following additional factors that are relevant considerations for facility siting: water depth, seabed geology, wave heights, proximity to transmission lines, and proximity to areas suitable for marine construction and transportation. However, the working group concluded that none of these factors in and of themselves make any particular site conclusively favorable or unfavorable. For example, while shallow depths are in general preferable, if a deeper location has higher wind speeds, the higher wind speeds may make that site economically more attractive. In addition, the working group recognizes that the technologies for wind energy are rapidly evolving. Thus, there may be locations for offshore wind that are suboptimal today, but may be excellent sites at a later time.

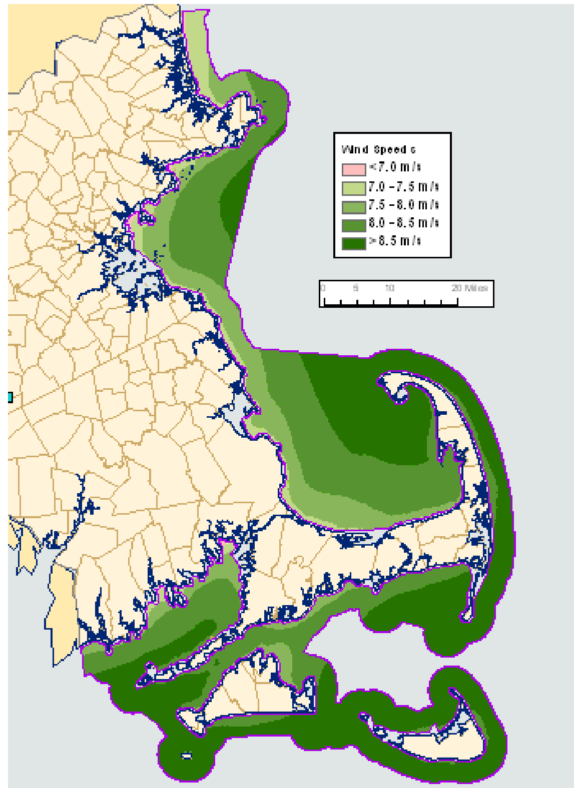
These considerations have led us to conclude that it would be a mistake to designate certain sites at this time as particularly meritorious or unfavorable. Rather, the working group believes that the better approach is as follows. First, map the locations that seem most favorable based on today's technologies and current knowledge about the economics of offshore wind facilities, without excluding any areas that are not within these mapped areas. Second, obtain information from the other working groups to identify areas where offshore wind facilities would pose conflicts with other uses, such as navigation, fisheries, and habitat. Third, exclude areas where such conflicts are likely to be significant, leaving areas that are particularly suitable for offshore wind in both the short term and long-term.

The data and modeling below are a preliminary effort to achieve the first step—that is, a mapping of locations that are most favorable based on current knowledge and technology and those that may become favorable in the future. This preliminary mapping is based on two factors—wind speed and water depth, though other factors are discussed below. We selected those two factors to use for the preliminary modeling because: 1) they are among the most important factors in siting decisions; 2) there is reliable and complete data for each of them; and 3) they can be modeled objectively and numerically.

This section of the report describes the data that we acquired or are in the process of acquiring to assess the short-term suitability of various locations for offshore wind.

<u>Wind Speeds</u>

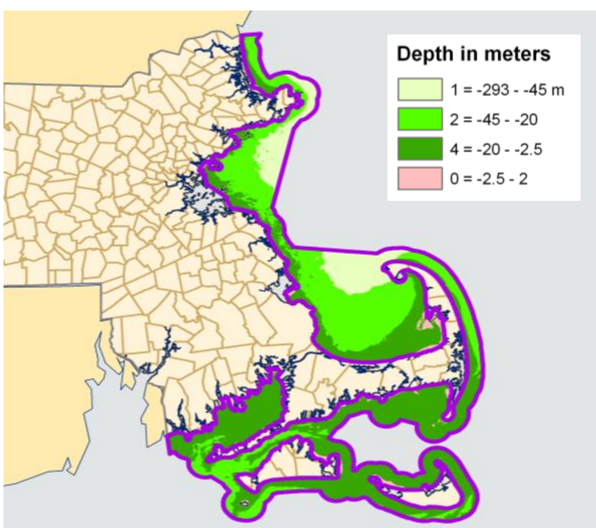
Reliable, adequate wind is, of course, the essential factor in siting wind turbines. The workgroup identified average wind speeds above 7.0 m/s as minimally necessary, with higher average wind speeds being more desirable.



Wind speeds at 70 m elevation

The wind data used in the model were developed by Truewind Solutions, LLC in 2002-2003. The complete data set shows modeled mean sustained wind speeds at heights of 30m, 50m, 70m, and 100m. The MesoMap software system was used for the modeling. The wind speed values were delivered in grids with a 200m x 200m resolution. MassGIS projected the original data from WGS_1984 to Mass. State Plane Mainland NAD83 Meters, resulting in a slight resampling (nearest-neighbor) of the original data. Ratings were assigned to the wind speeds at a height of 70m above ground as follows:

below 7.0 m/s	0 - unsuitable
7.0 – 7.5 m/s	1 – adequate
7.5 – 8.0 m/s	3 – favorable
8,0 – 8.5 m/s	4 – highly favorable
above 8.5 m/s	5 – excellent



30 meter bathymetry

<u>Water Depths</u>

Several sources (TRC report and Cape Wind DEIR) identified 2.5 meters to 20 meters as the range of water depth that was optimal to site wind turbines using currently available technology. At greater depths, current technology requires more expensive multi-legged structures to support the turbine. There is a trade-off, since there is often higher wind speed in deeper waters and hence the long-term revenue stream. In keeping with the overall approach, we have modeled water depths and the model assumes that shallower depths are more favorable to wind siting in the short term.

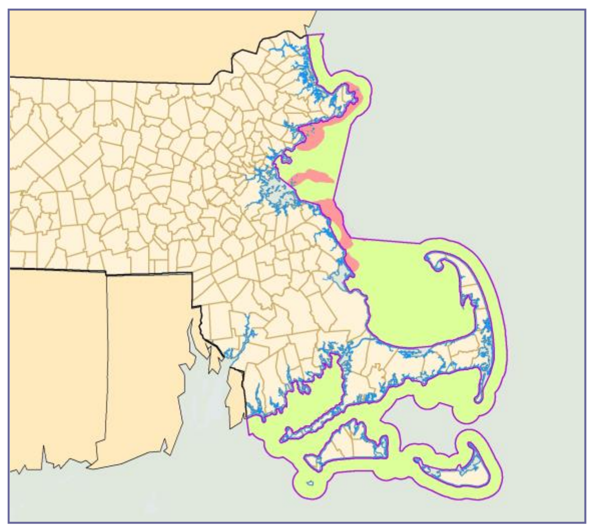
Water depths were compiled in draft form for the entire planning area by Dan Sampson of CZM. The dataset is in the form of a 30 meter mosaic, derived from the most current and accurate sources. Data sources include USGS Open File Reports, NOAA Estuarine Bathymetry, and the NOAA Coastal Relief Model. Since these sources vary in spatial resolution from 2m to 90m, 30m was selected to represent a median spatial resolution for mosaicking. Accuracy is variable depending on source information, but for the least accurate source, NGDC Coastal Relief Model, the vertical accuracy of the soundings is 0.3 m in 0 - 20 m of water, 1.0 m in 20 - 100 m of water, and 1% of the water depth in 100 m of water. A depth of less than 2.5 meters was assigned a rating of 0, meaning that any development of wind turbines would be impractical. Depths between 2.5 meters to 20 meters in depth were assigned a rating of 4 points, from 20 to 45 meters a rating of 2 and deeper than 45 meters a rating of 1.

Beyond wind speed and water depth, there are other factors that affect the suitability of a particular site for a wind farm. Such factors include seabed geology, wave height, proximity to transmission lines, and the availability of a port infrastructure. While these factors were not incorporated into the model, they are discussed below.

Seabed Geology

Seabed geology is relevant for the siting of wind turbines. We made the assumption that –all other things being equal--bedrock at or near the surface was an unfavorable condition.. However, there remains a question about the relative costs of structures anchored directly to bedrock or attached to concrete foundations versus driven monopiles. Examples were offered of proposals using alternative construction techniques, and it was noted that ultimately the foundation and structural difficulties will be only part of the financial equation which includes costs associated with distance from shore or increased revenue from higher wind speeds.

Unfortunately, there is a paucity of reliable data on seabed geology. Areas where bedrock is a predominant feature of the ocean floor were taken from a map published by the USGS, Coastal and Marine Geology Program, at the Woods Hole Science Center in the Open-File Report 2005-1001 titled *CONMAPSG: Continental Margin Mapping (CONMAP) sediments grainsize distribution for the United States East Coast Continental Margin.* The original map was a compilation of grain-size data from the sedimentation laboratory of the Woods Hole Science Center (WHSC) of the Coastal and Marine Geology Program (CMGP) of the U.S. Geological Survey (USGS) and from both published and unpublished studies. The original map scale was 1:2 million, covering the entire East Coast of the United States, so the mapping is very generalized. The working group does not recommend that more data be gathered on seabed geology, because it does not appear feasible to gather data at a sufficiently large scale to be useful for determining suitable sites for a wind farm, and because it is not clear that seabed geology is a critical factor.



Bedrock at 1:2M scale

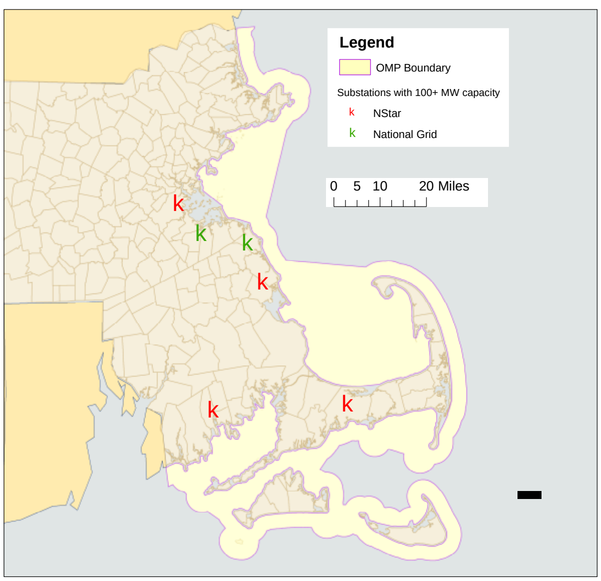
Wave Heights

If the average conditions are such that it is impossible to safely embark and disembark from support vessels to perform routine maintenance on the wind turbine structures for more than a certain number of days per year, then the operating cost is dramatically increased. Additionally, there are cost factors associated with designing to withstand the structural loading imposed by waves during extreme weather events as well as a concern with metal fatigue from repeated, more moderate loads.

A historical archive of modeled wave heights correlated with observations at a few buoys (hindcast) is available for a network of stations developed by the Army Corps of Engineers. This is called the Wave Information System (WIS) network. It provides significant wave height records as well as extreme wave heights. However, this network lies outside the OMP. A real-time model also exists to forecast wave heights within the OMP based on off-shore conditions which is used by the National Weather Service for their marine weather forecast. *What's needed is a historical archive of the near-shore forecasts, or a model which allows for estimation of near-shore conditions based on the WIS data. Such data would allow for looking at historic extreme weather events (dates of such events are available already from NCDC).*

Electrical Transmission Lines and Substations

An important consideration in planning off-shore power generation is connecting it to the electrical grid. Depending on the size of the facility, there are different constraints on how and where this connection can be made. The working group is working with the Department of Public Utilities to identify potential interconnection locations for large (>20MW), medium (5-20 MW) and small (<5 MW) facilities. Detailed mapping will most likely not be available due to homeland security concerns, but approximate locations of interconnection points viewed at a statewide scale can be reported.



Substations with >100 MW Additional Capacity

The several components of the electrical utility infrastructure in Massachusetts need to be considered separately. The transmission grid is comprised of high-voltage lines which carry current at 115kv or higher across the region. These high-voltage lines are connected to primary substations, where the voltage is stepped down to 24kv or less. From there, the electricity is carried through a distribution system to secondary substations and to end users. Power from a major off-shore facility generating power on the scale of Cape Wind, i.e. more than 100 MW, would ideally come ashore within reasonable distance of the transmission grid and even more optimally would connect to it through an existing substation. The Department of Public Utilities, through its contacts at NSTAR and National Grid, developed a list of substation locations within a mile of the coast which would be able to handle significant quantities of additional power. This preliminary analysis provides an estimate of total additional capacity under two scenarios – one as currently configured and also with upgrades to the equipment. The approximate locations of those substations are shown on the map.

However, DPU staff have stressed that substation capacity is only one of the issues that need to be considered – a full "load-flow" analysis and a reliability study are also required for ISO-New England, the electrical grid manager, to approve the connection of new generating capacity to the transmission network. This is because the current flow through transmission lines is a function both of how much power is being generated at facilities throughout the entire system and of where that power is being consumed. Grid managers have to be able to match generating capacity and demand in real-time, and since it can take several days to bring a major generating facility on-line, the intermittent nature of generation from renewable sources may present a significant challenge. There needs to be further analysis and discussion involving the utilities, ISO-NE and renewable energy developers in order to determine what kinds of facilities and how much additional generating capacity can be integrated into the current system.

Smaller sources, on the order of 5-20 MW in size, may be able to inject power into the distribution system downstream of the high-voltage transmission network. Since their contribution is small compared to the major generating facilities, there is not as much concern about reliability. A second phase of reporting from the DPU will address the potential for interconnection of smaller sources to the distribution network.

Port Infrastructure

The working group recognizes the need for a port area that could serve as the base for the construction and deployment of off-shore renewable energy facilities. This dataset, in draft development by CZM, provides an initial inventory of port areas with key industrial attributes, such as deep-water channels, established rail and transportation links, and public utility services conducive to industry. Designated Port Areas are located in Gloucester, Salem, Beverly, Lynn, Mystic River, Chelsea Creek, East Boston, South Boston, Weymouth/Fore River, New Bedford-Fairhaven, and Fall River/Mt. Hope Bay. Additional information about port infrastructure specific to the requirements of renewable energy development will be linked to this mapping.

The following additional information will need to be collected --

- size and orientation of dockside industrial areas available for material storage and fabrication
- square footages and volumes of industrial/commercial buildings for both fabrication and office functions
- material handling capacity such marine cranes and access from storage and fabrication areas to land-side transportation network such as rail and motor freight
- limitations on vessel size related to depth of water dockside and width and depth of channel
- obstructions such as bridges or navigational hazards
- modifications to port facilities that would be necessary to accommodate renewable development projects

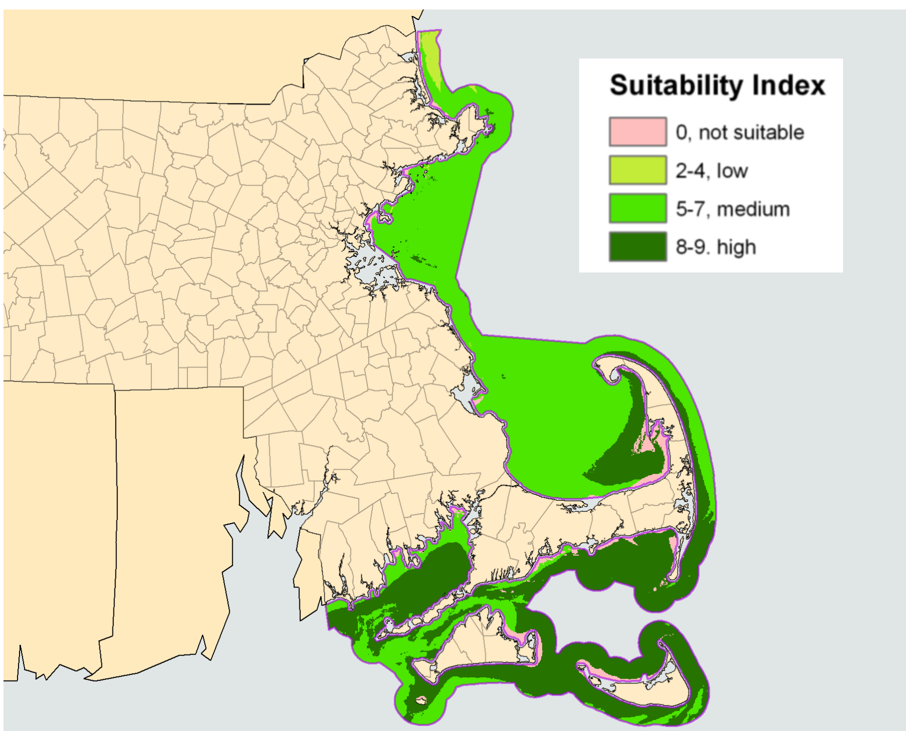
Analysis of Near Term Suitability for Wind Facilities

Using wind speed and water depth alone and ignoring any external factors such as regulatory review or aesthetics, we constructed a simple, preliminary model of short-term and long-term suitability for siting wind turbines.

A grid cell analysis was used, in which the planning area was divided up into 250 meter cells and each cell was assigned a score based on adding up individual ratings according to each of the criteria discussed above. After this addition was performed, areas where mapped criteria indicated that wind power development wasn't feasible were assigned a score of zero. The scoring scheme, as noted in discussion of the individual datasets, is as follows,:

wind	below 7.0 m/s	0
wind	7.0 – 7.5 m/s	1
wind	7.5 – 8.0 m/s	3
wind	8,0 – 8.5 m/s	4
wind	above 8.5 m/s	5
depth	less than 2.5 m	0
depth	2.5 – 20 m	4
depth	20 – 45 m	2
depth	greater than 45 m	1

The result of combining these two criteria is shown on the map below.



Near-term suitability for wind development