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Boston Harbor Islands Renewables Planning Guide

Urban Harbors Institute, University of Massachusetts Boston

Island Alliance

BOSTON HARBOR ISLANDS RENEWABLES

PLANNING GUIDE

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Boston Harbor Islands National Park Area

by

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Acknowledgements

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Introduction

This document presents a summary of findings and recommendations from a predevelopment study of the feasibility of establishing renewable energy power generation on several of the grid-tied Boston Harbor Islands. The scope of the study was to investigate the factors and issues associated with installing a mix of renewables—wind, solar, wave and tidal/current power generating facilities—with a combined output of between one and ten megawatts at sites on or around five of the Boston Harbor Islands. Four of these islands are presently grid-tied: Long Island, Moon Island, Spectacle Island, and Thompson Island. A fifth island, Peddocks Island, in the same region of the harbor as the other four, is included in the study because it is the site of the most significant visitor facility improvements planned for the park in the near future. As part of those plans, a utility connection to the mainland will provide the infrastructure to support those uses, including a grid connection.

This Planning Guide presents information relevant to the development of grid-tied renewable energy facilities on the islands. It is the final product of a two-year predevelopment feasibility study which entailed information gathering, planning, analysis, and extensive and continuous discussions with officials and staff of local, state and federal government, industry representatives, harbor and island interest groups, and citizens of metropolitan Boston.

The feasibility study that informed and culminated in this *Boston Harbor Islands Renewables Planning Guide* consisted of the following tasks:

Island Survey

> A characterization of the natural and built environments of the five islands and surrounding waters, including: existing and planned buildings, uses, and activities; historic and cultural resources (to the extent documented in existing sources); island ownership and management structure; and an overview of the categories of potential environmental and community issues associated with developing renewable energy facilities; and a description of the electric distribution network on and to the islands.

Resource Analysis

> A description and quantification of the solar, wind, and tidal/wave resources on and around the five islands.

Development Options

> An investigation and description of the renewable energy technologies available and suitable for the islands, potential sites and project scales; and the potential ownership structures.

Preliminary Environmental and Community Impacts Analysis

> An identification and description of potential environmental (natural, cultural and historic resources) and community concerns.

Financial Feasibility

A review of the costs and revenues associated with developing and operating renewable energy facilities.

Outreach and Education

A public outreach and education plan was prepared at the outset and conducted throughout the duration of the predevelopment study.

The project team was comprised of the Urban Harbors Institute, University of Massachusetts Boston; the Island Alliance, the nonprofit partner of the Boston Harbor Islands National Park Area; the Renewable Energy Research Laboratory at the University of Massachusetts Amherst; and Timeless Technologies. Individuals from numerous municipal, state, and federal agencies, nongovernmental organizations, and private industry contributed valuable information, guidance and assistance throughout the planning process.

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I. Basis and Background for Renewable Energy on the Boston Harbor Islands

The idea to investigate the feasibility of renewable energy on the Boston Harbor Islands took form during meetings of the Subcommittee for Renewable Energy and Sustainable Design (SRESD). SRESD is a subcommittee of the Boston Harbor Islands Partnership's Planning Committee (see Institutional Setting of the BHINPA in section I.A). Members of SRESD are from the Boston Harbor Islands Partnership organizations, the entities that make up the Advisory Council, and other interested governmental agencies and nongovernmental organizations.

SRESD's charge is to promote and help coordinate the development of renewable energy sources and an ethic of sustainability for the islands. This mission is founded in the park's policies formulated during the planning process for the development of the General Management Plan for the Boston Harbor Islands National Park Area. Any renewable energy and sustainable development on the islands will be done in harmony with the overall goal of the park which is to preserve, protect, promote and to program the Boston Harbor Islands as a national resource.

The national significance of the Boston Harbor Islands is captured in four interconnected park themes, one of which is "renewal and reconnection." Boston Harbor and its islands provided a rich and sustaining environment for human life until pollution and technological changes in transportation of people and goods severed people's everyday connection to the harbor. The successful efforts over the past decade to improve the harbor's water quality have revitalized the harbor's living resources and brought the human community back to the harbor.

The BHINPA supports this reconnection by providing access for public enjoyment and by telling the islands' stories from formation, to early Native American use, through more recent military, commercial, institutional, and recreational development. The story of the harbor and the islands is one of evolving uses and the well-documented and continuing journey from environmental degradation to restoration. This shapes a sub-theme of the park which is for the Boston Harbor Islands to serve as "a beacon for sustainable development and renewable resources" through the use of renewable resources and "green" technology to meet present needs without compromising the ability of future generations to meet their needs.

Individually, the organizations that make up the Boston Harbor Islands Partnership have been pioneers in the stewardship of our nation's natural and cultural heritage. Collectively, they are in the forefront of national park stewardship.

Project Goals

The renewable energy project to be explored through this feasibility study has four main goals:

- Advance sustainable development policies of the Boston Harbor Islands national park area;
- generate revenue to support the park;
- educate the public on renewable energy; and
- contribute to the supply of green power and a greater reliance on renewable energy.

Advance sustainable development policies of the park

Among the goal and policies of the park's GMP is the following:

> The Partnership conducts its activities in a manner consistent with the principles of sustainability with reference to energy use. It demonstrates a preference for, and promotes, renewable energy as well as ensuring that energy is used wisely and economically. It encourages energy upgrades to include renewable technologies (GMP, p. 90).

Most of the principals involved in this predevelopment feasibility study had worked together for several years in an effort to make Spectacle Island a showcase for renewable energy and sustainable design. Those efforts succeeded in securing $500,000 in federal funds for a "zero emissions" project on Spectacle Island: the installation of 8 kW of photovoltaic panels on the visitors center roof, an interpretive display for public education, and purchase of several electric vehicles, bicycles, and a vessel for island use. The SRESD is also working on upgrading or establishing small photovoltaic systems several of the islands, and investigating the use alternative fuels for island operations, and developing a waste management plan for the islands.

In addition to being compatible with and advancing policies of the park's General Management Plan, the generation of renewable energy is consistent with recommendations of the Commonwealth of Massachusetts' State Sustainability Program. Renewable energy reduces greenhouse gas emissions, produces fewer air pollutants such as sulfur dioxide and nitrous oxide, the leading causes of acid rain and ground-level smog. The Agency Sustainability Planning and Implementation Guide (2004) suggests that state agencies "should identify opportunities on state properties and at state facilities to install equipment for distributed generation of electricity using renewable energy …" Further, the establishment of renewable energy facilities is consistent with the Massachusetts Climate Protection Plan (2004 which represents the Commonwealth's commitment to implementing the regional climate change plan adopted by the New England Governors and Eastern Canadian Premiers (NEG/ECP) in August 2001.

Generate revenue to support the park

> Successful implementation of this [Boston Harbor Islands General Management] plan is contingent upon increasing the financial contributions from all private sources,… The park funding model requires a more entrepreneurial approach to programming than that employed in traditional parks. The Island Alliance is charged by the Partnership with generating private revenue to support the park. (GMP p. 86).

A renewable energy project would fulfill at least two of the goals and purposes, (including revenue generation) for park infrastructure articulated in the GMP (p.87):

> Park infrastructure is the only development envisioned for the Boston Harbor Islands national park area. It should be consistent with at least one of the purposes below and leave park resources unimpaired. Infrastructure (park facilities) is built for the following purposes:

- to protect and preserve park resources
- to support park programs and education
- to provide visitor safety or amenities
- to accommodate an increasing number of visitors
- to generate revenue for park programs and operations
- to support park management and maintenance

Educate the public on renewable energy

Education is one of the principle goals of the BHINPA:

> Park visitors and the general public understand and appreciate the resources and values of the island system, through the park themes: Islands on the Edge, Home in the Harbor, Portal to New England, and Renewal and Reconnection (GMP, p. 54)

The park presents a wonderful opportunity to educate people on the history, cultural traditions, natural resources, and environmental conditions of the region. Renewable energy facilities would be a prominent feature of the park with interpretive displays and educational material and programming helping people understand the relationship between energy and environmental quality.

Contribute to the supply of green power

The large population of metropolitan Boston uses significant amounts of electricity. Demand for electricity from renewable resources is growing as people become more appreciative of the environmental benefits of clean energy and as the Renewable Energy Portfolio Standard increases the amount of electricity that is generated from renewable energy sources and the restructuring of the Massachusetts electric industry allows consumers the opportunity to seek suppliers of green power.

Finally, in contemplating the appropriateness of renewable energy facilities on the Boston Harbor Islands, consider the following:

> The Boston Harbor Islands National Park Area was created in 1996 as a new model national park for the 21st century. Its contemporary features, uncharacteristic of most national park areas, such as the waste-water treatment plants at Deer and Nut Islands, the Willauer School and Outward Bound Education Center on Thompson Island, the public health and human services facilities on Long Island, and the police firing range and fire-fighter training facility on Moon Island are accommodated and, in fact, honored as socially necessary and not inconsistent with the vision of Boston Harbor Islands as a near urban park area and a dramatic new conceptualization of a National Park unit. Indeed, the General Management Plan of BHINPA invokes imperatives and challenges of the new millennium in its strong advocacy for renewable energy and of principles of environmental sustainability, responsibility and educational leadership.

II. The Boston Harbor Islands National Park Area: Existing and Planned Conditions

The five islands that are the subject of this Planning Guide are part of the Boston Harbor Islands National Park Area (BHINPA) established by Congress in 1996. The park consists of 34 islands lying within Boston Harbor. These islands are owned and managed by nine separate city, state, and federal agencies or nonprofit organizations; the legislation designating these islands as a unit of the National Park System did not change ownership of the islands.

Figure 1: The Boston Harbor Islands National Park Area and surrounding communities. Map is from the General Management Plan for The Boston Harbor islands: A National Park Area, General Management (2002).

A. Institutional Setting of the BHINPA

The Boston Harbor Islands National Park Area is managed by the 13-member Boston Harbor Islands **Partnership** which is responsible for overall policy coordinating the federal, state, local and private nonprofit owners/managers of the park's 34 islands. Rather than the National Park Service (NPS) owning and managing the park, the legislation made the NPS a nonland-owning participant of the Partnership. The membership of the Partnership is established by law to have representation from:

National Park Service	Boston Redevelopment Authority
US Coast Guard	Thompson Island Outward Bound Education Center
Massachusetts Department of Conservation and Recreation (2 seats)	The Trustees of Reservations
Massachusetts Water Resources Authority	Island Alliance
Massachusetts Port Authority	Boston Harbor Islands Advisory Council (two seats)
City of Boston, Mayor's Office of Environmental Services	

Decisions made by the Partnership are the product of discussion and cooperation among the members. Much of the work of the Partnership is carried out by one of six standing committees: Planning, Finance and Legislation, Education and Programs, Park Operations, Events and Marketing, and Nominating and Bylaws. There are also several active subcommittees, the one most relevant to the topic of this Planning Guide is the Planning Committee's Subcommittee for Renewable Energy and Sustainable Design. Committee membership is open to Partners, Advisory Council members, and other cooperators' representatives.

The park's legislation created the **Island Alliance** as a nonprofit organization charged with generating private funding for the park. It works to attract investment and support for the park from the private sector, coordinating outside activities to provide necessary strategic and financial resources.

The **Advisory Council**, a permanent federal advisory committee created by the park legislation, consists of 28 representatives of municipalities, educational and cultural institutions, environmental organizations, business and commercial entities, Boston Harbor advocacy organizations, Native American interests, and community groups. The Council's purpose is to advise and make recommendations to the Partnership on the development and implementation of the general management plan for the islands, including ongoing park operations. It is the primary mechanism of the Partnership to consult with the general public on park planning and management. The Council does this through public meetings, workshops, and forums. A list of Advisory Council members (2004) is in the appendices.

The Boston Harbor Islands national park area is operated day to day by the owners and managers of islands who work through the Partnership to introduce consistency and coordination parkwide and to create parkwide programs. The National Park Service's role is to help coordinate the Partnership and Advisory Council, to provide information and orientation to the public, to develop and operate programs, and to help assure that the park will be managed to NPS standards, as the law requires.

B. Park Planning

The Partnership has adopted the tiered planning process used for all units of the national park system. A General Management Plan (GMP) for the Boston Harbor Islands National Park Area was prepared and adopted by the Partnership in 2002. The GMP establishes the philosophical underpinnings of long-term park management; it focuses on why the park was established and what resource conditions and visitor experiences should be achieved and maintained over time. It articulates the park’s mission, goals, and management prescriptions for resource protection, types and general intensities of development, and visitor carrying capacities.

The park Strategic Plan focuses on the park's capability to set and meet long-term goals through a resource assessment of its fiscal and human resources. The first strategic plan was developed concurrently with the GMP in 2002. The plan includes a description of the condition of the natural and cultural resources in the park and the condition (capability) of the park's infrastructure in meeting long-term goals. It identifies anticipated funding sources for proposed actions.

In addition to these park-wide plans which set overall policy and direction for management of the park, island owners or the Island Alliance have had plans prepared specific to individual islands or initiatives. Two relevant examples are the City of Boston’s “Long Island Limited Public Access Plan” and the plan for an Eco-Family Camp on Peddocks Island. Spectacle Island, a certified closed landfill also has a plan in the form of Preliminary Design Guidelines which describe in general terms the proposed uses of the island.

C. Park Financing: Revenue Generation

Funds to carry out the park’s mission are from government appropriations, philanthropy, use fees, income from commercial operations, and revenue-generating activities. When Congress created the Boston Harbor Islands national park area, it also created a new funding method. The park operates under the requirement that federal funding for the park be matched by nonfederal funding. Federal funds that may be appropriated over time must equate to a ratio of one federal dollar to at least three dollars from other sources. Each of the nonfederal Partnership agencies, except the Advisory Council, contributes to the nonfederal portion of park financing.

Successful implementation of the park’s General Management Plan depends on increasing financial contributions from private sources. The park’s legislation created the Island Alliance as a nonprofit organization charged with generating private revenue for the park. New funding is sought through fund raising, fee retention, and revenue generation to support the mission and operation of the park, as allowed by law. This park funding model suggests a more entrepreneurial approach to programming than that employed in traditional parks. The interest in developing renewable energy in the BHINPA is, in part, an initiative to generate revenue (and/or cost savings) for the park and its owners/managers.

D. The Affected Environment

The Five Islands subject of this Boston Harbor Island Renewables Planning Guide

Five of the Boston Harbor Islands were the subject of the predevelopment feasibility study and are included in this Planning Guide: Long Island, Moon Island, Spectacle Island, Thompson Island and Peddocks Island. All except Peddocks Island are currently grid-tied; an independent project of the Island Alliance to connect Peddocks Island to the grid is discussed later.

Figure 2: The study area, five islands of the Boston Harbor Islands National Park Area.

Long Island and Moon Island are owned by the City of Boston, Spectacle Island is jointly owned by the City of Boston and Commonwealth of Massachusetts (Department of Conservation and Recreation), and Thompson Island is owned by the Thompson Island Outward Bound Education Center, a private nonprofit organization. Long, Spectacle and Thompson are within the municipal boundary of the City of Boston, Moon Island is within the municipal boundary of the City of Quincy, and Peddocks Island within the boundary of the Town of Hull.

Table 1: The five islands subject of the Boston Harbor Islands predevelopment of renewables feasibility study.

	Owner	Size	Political Jurisdiction
Long Island	City of Boston	214 acres	Boston
Moon Island	City of Boston	44 acres	Quincy
Peddocks Island	Mass. DCR	188 acres	Hull
Spectacle Island	City of Boston and Mass. DCR	97 acres	Boston
Thompson Island	Thompson Island Outward Bound Education Center	157 acres	Boston

Existing Conditions and Use of Each Island

Long Island: Long Island is the largest of the Boston Harbor Islands at 214 acres and a length of 1.75 miles. The Boston Public Health Commission operates health care and social service programs in a campus setting of 19 buildings on 35 acres at the center of the island. Long Island Head, a hill at the northern end of the island, is the site of Long Island Head Lighthouse and the remains of Fort Strong, both considered important historic and cultural features of the park. Consequently, the park's General Management Plan designates Long Island Head for historic preservation. An abandoned 1950 Nike missile base is located near the southwest end of the island.

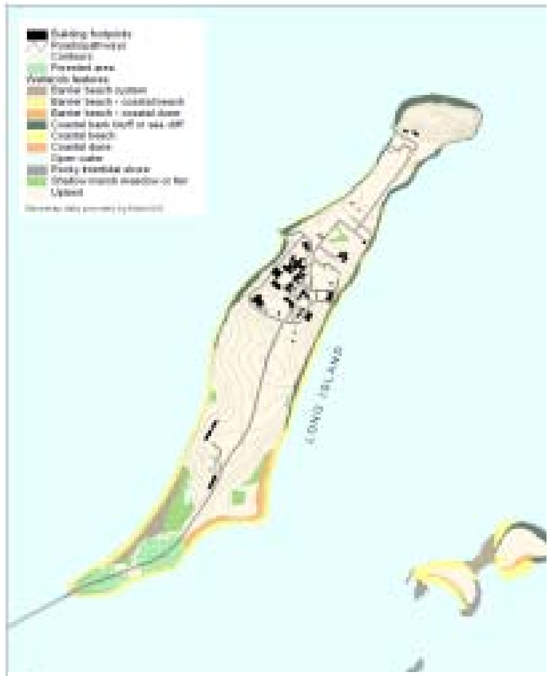

Figure 3: Long Island existing conditions

Long Island is used currently for several outdoor activities, including the city's Harbor Discoveries camp, a partnership with the New England Aquarium, the Boston Public Health Commission's Kids with Asthma-Can Camp, and a fishing derby hosted by the city's Park and Recreation Department. In 2002, the City of Boston issued a plan for opening Long Island Head and the Parade Ground (just north of the campus) to limited public visitation. A new handicap-accessible pier is being designed to support water transportation to Long Island.

Moon Island is a 44-acre island dominated by four abandoned granite settling tanks built in the 1880s as part of the City of Boston's sewage treatment facilities until the 1960s. The Boston Fire Department has a training facility on the north end of the island and the Boston Police Department maintains a firing range on the south end. The island is not open to the public.

Figure 4: Moon Island existing conditions

Peddocks Island: Peddocks is the third largest (188 acres) of the Boston Harbor Islands. It is composed of five drumlins connected by sand or gravel bars called tombolos. It is one of the few harbor islands to yield archeological evidence of prehistoric habitation. Peddocks, unlike nearly every other island in Boston Harbor, remains inhabited; a number of families still summer on Peddocks.

Peddocks Island is rich in historical significance. In 1900, the federal government built Fort Andrews on Peddocks Island. Unfortunately its buildings are deteriorating at a rapid pace and many of them appear beyond repair. The historical fort narrows down appropriate sites for distributed generation on the island, but several areas appear suitable for potential wind turbines, and several of the buildings considered restorable show promise for photovoltaic installations.

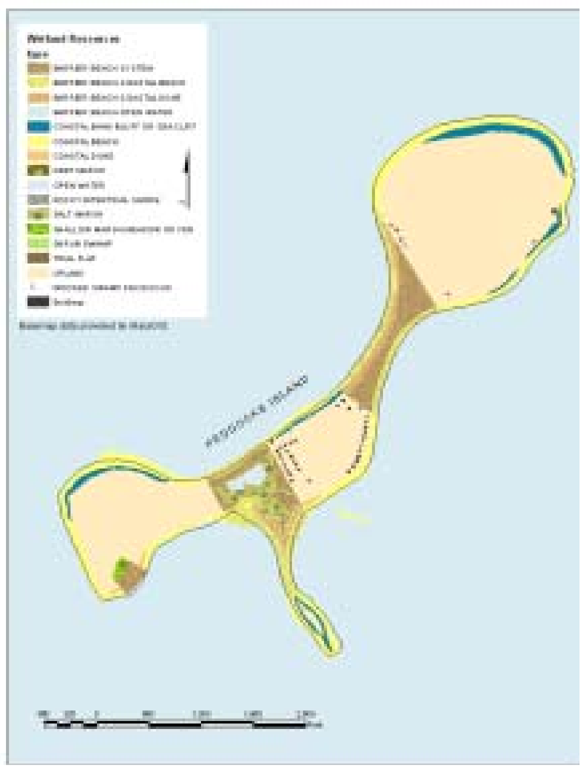

Figure 5: Peddocks Island existing conditions

Figure 6: Spectacle Island existing conditions

Spectacle Island: During the past decade, Spectacle Island received over 3.6 million cubic yards of material excavated from the Central Artery/Tunnel project to cap a former city dump and to create a landform suitable for park use. Thousands of trees and shrubs, grasses and flowers have been planted on the island. The dominant feature of Spectacle Island is its two hills that rise 155 feet and 125 feet above mean sea level. A Visitors Center has been constructed on the western shoreline adjacent to a large pier with a recreational boat marina. The island has two recreational beaches on the west and south ends and is laced with five miles of multiple use trails. Upon its scheduled opening in the summer of 2005, Spectacle will become one of the hub islands of the park, meaning that ferries from the mainland will bring visitors to the island as the starting point for exploring the other islands. It is envisioned that Spectacle Island will host an ever-changing program of public events and activities including, specifically, those featuring renewable energy and sustainable design.

Figure 7: Thompson Island existing conditions

Thompson Island is a 157-acre island owned by the Thompson Island Outward Bound Education Center. It is a rich natural area with 50 acres of saltmarsh, open fields, forest, and ponds. A campus of a dozen or so buildings occupies the north-central portion of the island, and houses the Willauer School, an independent middle school, and the Outward Bound program for inner-city youth. The campus includes a residence hall, an auditorium, a gym, dining and conference areas, environmental education area. Ropes courses are located at both ends of the island. In July 2002 the National Park Service and the Massachusetts Department of Environmental Management jointly purchased a conservation easement on approximately 89 acres (18.8 acres in the northeast and 70 acres in the southwest of the island. The University of Massachusetts Amherst's Renewable Energy Research

Lab installed has operated wind monitoring equipment on the island since 1998. The monitoring tower was originally located in a central section of the island, but in 2001 was moved to its current site near the western shoreline. Anemometers and wind direction vanes are installed at 25 and 40 m above the tower base which is at 4 meters above sea level (Elkinton, 2005).

Plans for the Future Use and Development of the Islands

Existing site plans and plans for new and upgraded facilities were reviewed and discussions held with the island owners and mangers to document existing and planned uses for the islands. The General Management Plan (2002) for the Boston Harbor Islands National Park Area was consulted for the management recommendations for future development and preservation of each of the islands under study. The objective is to seek compatibility in the siting of renewable energy facilities with existing and planned uses. There are also a number of plans specific to particular islands, e.g., the City of Boston's Long Island Limited Public Access Plan (2002) and the plans for the Peddocks Island Eco-Retreat and Family Camp, which require that a final determination of compatibility for some sites be made in a later phase of this project.

The General Management Plan for the Boston Harbor Islands specifies five types of management areas for the park. The management areas for the five islands under study are shown in figure 8. All five of the management areas exist on the islands being studied: Managed Landscapes; Special use; Visitor Services and Park Facilities; Natural Features, and Historic Preservation.

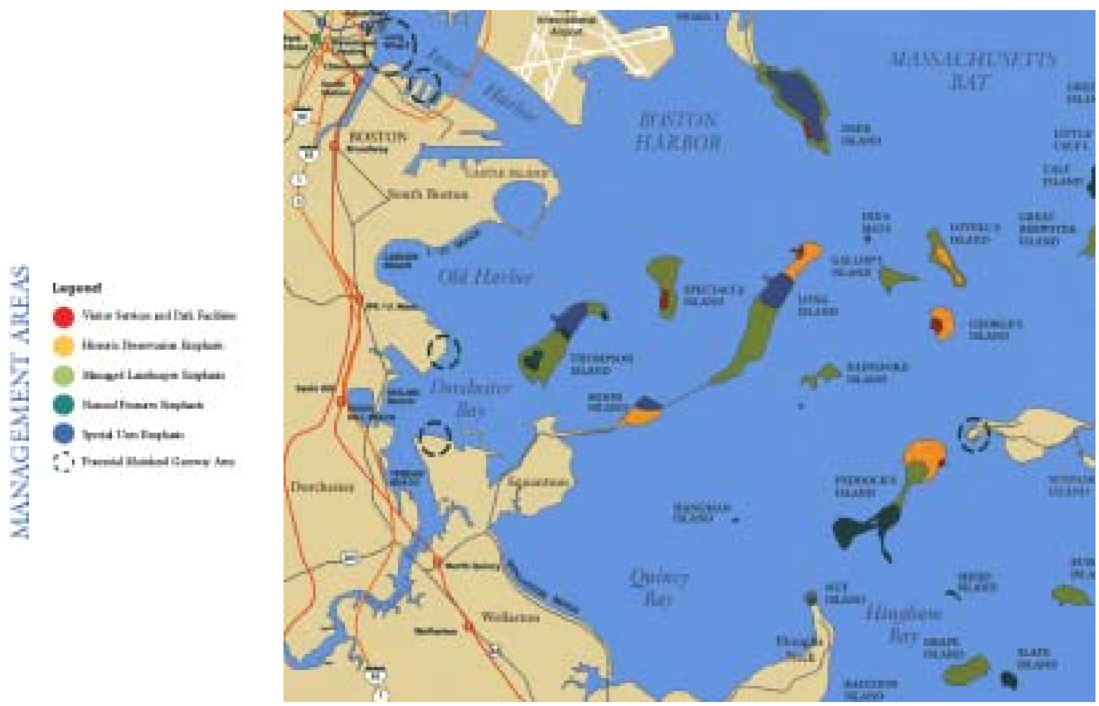

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Figure 8: Management Areas, from the General Management Plan for the Boston Harbor Islands National Park Area.

The park planners utilize management area designations as the basis for establishing standards for:

- desired resource conditions;
- visitor experiences to be achieved;
- kinds and levels of visitor use;
- management activities;
- development appropriate for maintaining the desired conditions; and
- whether a specific action would be consistent

Each of the management areas emphasize different objectives for the above standards and the siting of potential renewable energy facilities seeks to conform to these objectives.

Criteria for evaluating Proposed Revenue Generating Activities on the Islands

The General Management Plan (p. 86) lists a number of criteria to be used in evaluating proposed revenue generating activities on the islands. The following are those criteria relevant to the development of renewable energy on the Boston Harbor Islands. The study and recommendations in this Planning Guide were shaped by these standards:

Resource protection and preservation: will not impair park resources or associated values

Management areas: will not impinge on areas of natural features or managed landscape emphasis

Construction standards: both new construction and adaptive reuse of existing structures adhere to Partnership development guidelines.

Carrying capacity: consistent with the carrying capacity of the proposed location

Program relevance: activities with a direct thematic relationship to the islands are preferred

Linkage or synergy: activities with potential for direct linkage or synergy with other projects and programs affecting the islands are preferred

Constituency building: revenue generating programs enhance the park's identity and expand its constituency

Further, the GMP (p. 87) envisions park infrastructure to be the only development on the BHINPA, and such infrastructure development should be consistent with at least one of six stated purposes and leave park resources unimpaired. A renewable energy project is consistent with at least two of these purposes: (1) to generated revenue for park programs and operations, and (2) to support park programs and education.

E. Regional energy distribution system

Four of the islands, Long, Moon, Spectacle and Thompson, are presently grid-connected. Peddocks Island currently does not have a grid connection to the distribution system, though a study commissioned recently by the Island Alliance is determining the feasibility and costs of establishing a connection. This is described further later in this section.

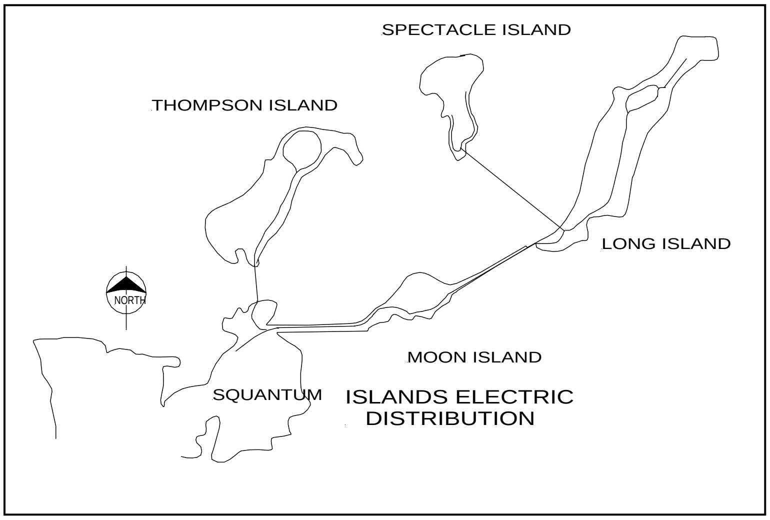


Figure 9. Electric distribution system for Long, Moon, Spectacle and Thompson islands.

In total, the four grid connected islands have approximately six linear miles of grid connected distribution with a peak power demand swing from approximately 420 to 650 kWp (kilowatts-peak). Some service is above ground, some is below ground, some is through conduit across bridges and some is through conduit under the harbor. Distribution and network complexity, kilovolt (kV) and Kilovolt-amp (kVA) capacity levels vary across the targeted infrastructure. Age and therefore expected life of cables, switchgear and substations are also variable.

To ascertain the constraints on the distribution system as it now exists, a detailed breakout of each node variation of the distribution network was compiled. This provides existing Kilovolt-amp (kVA) capacity, feeder kV levels and age or upgrade schedule estimates for the system. This information is critical to determining maximum Distributed Generation (DG) that the current system will support, or what changes and/or upgrades to the grid may be necessary.

The following is a summary of the electric distribution system for each island. Additional information, especially on the low voltage normal distribution system and electrical deficiencies and recommendations for upgrades, is detailed in the Island Survey Report (UHI, 2002).

Long Island The main incoming electrical service from Quincy is an overhead feed at 13.8 kV, three phase. It originates from National Grid's Massachusetts Electric Company (MECO) distribution system. This 13.8 kV line is transformed (through three, utility-owned 333 kVA transformers, 1,000 kVA total capacity) to 4160 volt, three phase (plus neutral) at the security gatehouse at Moon Island. From this point on it becomes an NSTAR distribution system. The lines run along the causeway in an underground trench and then go up a riser pole at the beginning of Moon Island

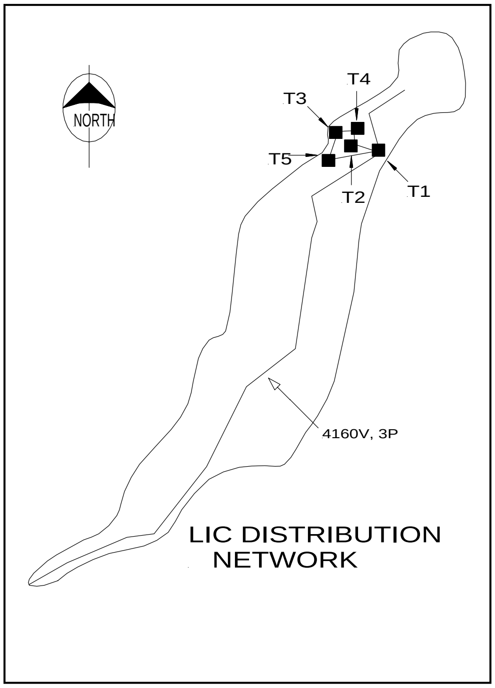


Figure 10. Long Island Campus distribution network.

where power consumption for this island is met. Then the lines run overhead until they meet the bridge to Long Island, then drop down and run across the bridge in a special trough (conduit) mounted on the bridge support structure. From there the lines are generally located on poles and, at approximately the halfway point between the bridge and the Long Island Campus (LIC), they interface with voltage regulators. These provide autotransformer action, as needed (i.e., equivalent to automatic transformer tap changing), to stabilize the voltage on Long Island. From these regulators, the lines continue to LIC and stop at the water tower where the primary metering from NSTAR is located. From that point they go over head to the Powerhouse substation number one and via network feeders go under ground through tunnels to substations number two, three, four and five (see figure 10). From the Powerhouse the lines also continue overhead across the island down to the sewerage treatment plant and the MWRA shaft. The low voltage distribution system (208/120 volt) consists of five electrical substation step down transformers.

<u>Moon Island</u> is served by a 600 volt, 3ū overhead line. This feeder is tapped and stepped down from the 4160 volt, 3ū feeders traveling from the security gatehouse to Long Island. It starts at the end of the Long Island Causeway and travels northwest along the seawall on telephone poles to the Fire Academy building. It terminates in the south corner of the building's garage where it is transformed to a low voltage system. The power distribution essentially ends at this location (figure 11).

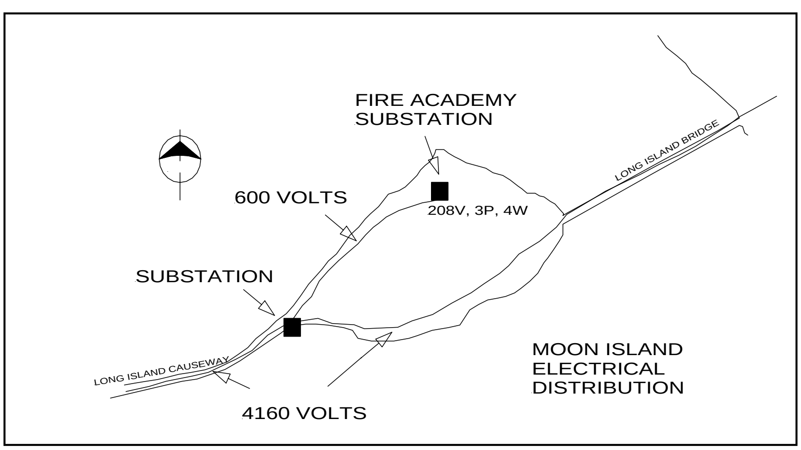


Figure 11. Moon Island electrical distribution network.

The low voltage distribution system (208/120 volt) consists of a 30 kVA electrical substation step down transformer in the garage of the Fire Academy.

Power demand for Moon Island varies between 5 and 25 kW depending on time of year and number of activities at the facilities.

Peddocks Island currently does not have a grid connected distribution system. Connection to the mainland was disrupted many years ago. As mentioned above, a plan has been prepared to provide a new feed to the island along with other utilities. The new connection will serve as a distribution network for power to the island as well as for renewable power wheeled from the island into the grid.

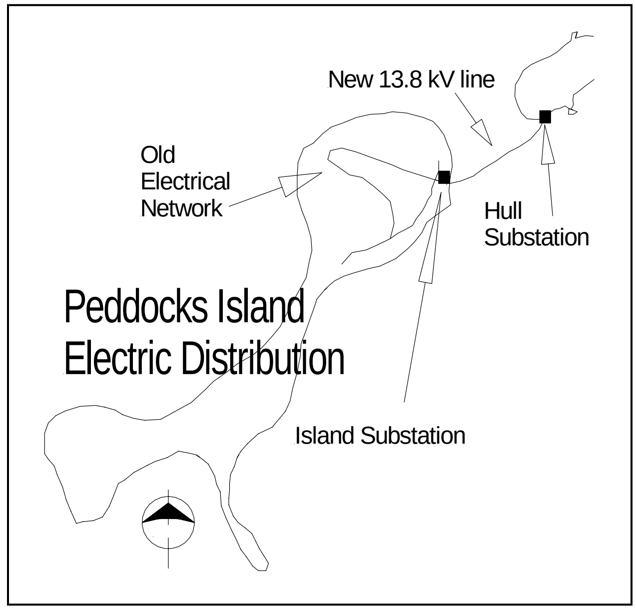


Figure 12: Former and potential new electric distribution networks for Peddocks Island.

Spectacle Island. Spectacle Island is served by an undersea cable rated at 15 kV, 3ū . This one year old cable is tapped from the 4160/2400 volt, 3ū , 4 wire, 4#1/0 line near the southwest end of Long Island, then travels across the channel, and terminates at the South Beach switchgear on Spectacle Island. From there power is distributed to several locations on the island (figure 13). The low voltage distribution system (480/277 volt secondary) consists of two 75 kVA electrical substation step down transformers fused at 20 and 30 amps, 4160 volt primary. If the recommended improvements to the Long Island feeder from Moon Island are made, there should be no operational issues with regard to DG into the power grid from renewable energy sources on Spectacle Island.

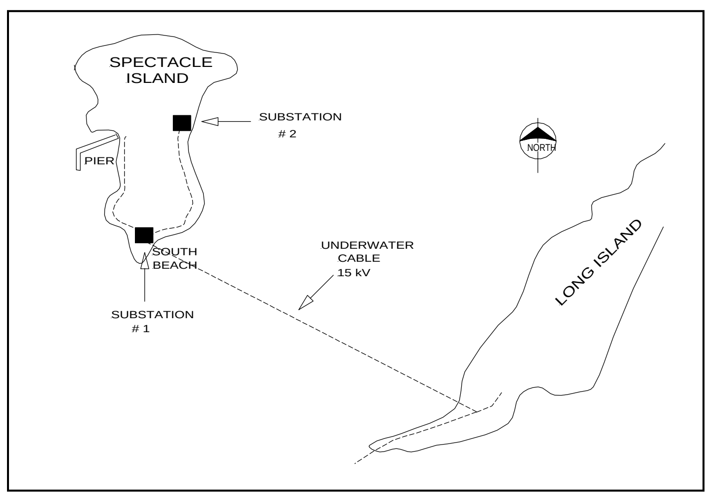


Figure 13. Spectacle Island cable and distribution network.

Thompson Island is served by a 15 kV, 3ū undersea cable. This three year old cable is tapped from a line in Squantum and travels under a shallow channel to a manhole connection on the southern most tip of the island. It continues underground along the central dirt road northwest to the campus and terminates in the basement of the Hughes Building. From there power is distributed to other buildings on the island (figure 14). The low voltage distribution system (208/120 volt) consists of a 100 kVA electrical substation step down transformer. This transformer is located in the basement of Hughes Hall.

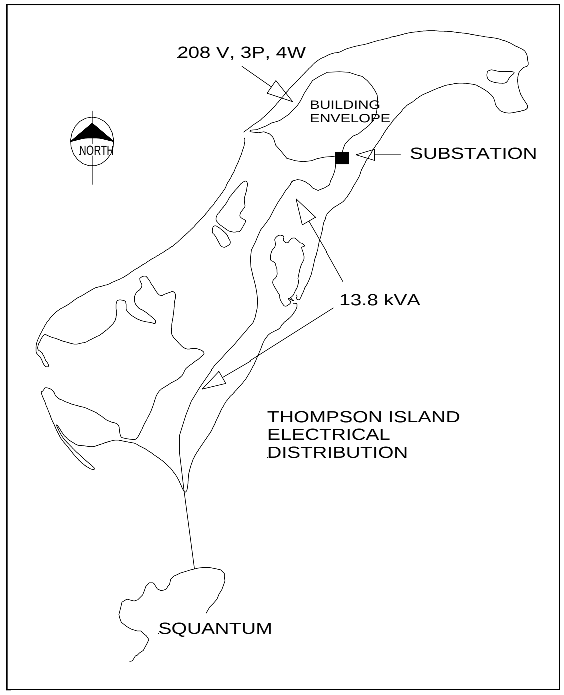


Figure 14: Thompson Island electrical distribution network

Interconnection

The Federal Energy Regulatory Commission (FERC) is in the process of developing renewable energy interconnection standards and agreements for the nation that can be universally applied. Until FERC develops, approves and implements a standard set of rules pertaining to interconnecting qualified renewable energy facilities into the nation's grid, it will be necessary to utilize standards developed by local utilities. In the case of the five islands targeted in this study standard interconnection documents for NSTAR Services Company and National Grid will have to be followed.

Long, Moon and Spectacle Islands: The 4160 volt feeder cable connecting these islands to the mainland grid may represent a weak grid issue. This feeder cable is part of the NSTAR distribution system which connects (at the gatehouse at Moon Island) to the main service line from Quincy owned by National Grid. Based on communications with NSTAR, it is believed that currently the maximum capacity of lines from National Grid to Moon, Long and Spectacle is 1 MW. With this condition, the installation of wind power on Long Island would require monitoring of the cable and, possibly, controls on the turbine. Additionally, the line is in poor condition, especially as it crosses the bridge between Moon and Long Islands. There are reports of several recent incidents of sparking and melting of wires. This issue is discussed further in section VII, Obstacles to development and strategies for overcoming them.

Adding wind energy generators to the electric grid require a utility impact study of the distribution network—in this case both NSTAR and National Grid distribution network—with particular attention to the condition and capacity of the feeder cable connecting Long Island.

III. Resource Analysis

As part of the feasibility study an assessment was made of the total power and yearly energy that can be produced from solar, wind, and ocean resources at sites on the subject islands.

A. Amount of Resource

Wind

The single most important statistic in describing a site's wind power resource is the annual average wind speed at the proposed turbine's hub-height. For megawatt-scale wind power, the hub-height is often assumed to be 65m (213 ft) if a turbine height is not yet chosen. Since wind speed usually increases at higher elevations above ground level, the height at which wind is measured is always specified when referring to wind speeds.

Wind speed is typically measured for at least a year at a target site before developing wind resource. Existing data and regional models can be very useful in discussing preliminary feasibility and applicability of wind technologies. Modeled data and data that have already been gathered in the Boston Harbor are discussed below.

Existing Data

The Renewable Energy Research Laboratory (RERL) at University of Massachusetts Amherst has been monitoring wind speeds on Thompson Island since May of 1998. Annual average wind speeds have been 5.9 m/s (13 mph) at 40m (131 ft).

Figure 15: Map of Thompson Island showing present location (near west shore) and former location (near center of island) of the meteorological tower installed by RERL.

In October of 2001, the meteorological tower was moved a short distance from the center of Thompson Island to the western edge of the island, as seen in the map in figure 15. The wind speeds in the following years appear to be higher on average at the new site (when correlated with long-term wind data at Logan airport). The main gains seem to be in the winds from the north and from the west over the nearby water. The most recent wind data report from RERL for the period from December 2004 to February 2005 reported a mean wind speed of 6.55 m/s (14.74 mph) at 40 meters and prevailing wind direction was from the northwest. This pattern is noteworthy for two reasons. First, it points out that wind speeds are strongly influenced by topography. And second, it calls attention to the need to monitor at a specific location, and over longer periods for a more thorough understanding of wind patterns.

For comparison, Hull Municipal Light Board made the decision to install a 660 kW wind turbine based on an estimated annual average speed of 5.8 m/s (13 mph) at 24.4m (80 ft), measured on the Hull site, which was scaled up to 6.33 m/s at 50 m. Those estimations were based on the data available at that time, which were limited and only partially documented, primarily monthly summary speeds from a Vachon study in 1985-1987 (Ellis *et al.*, 1999).

Other Data

Long-term wind data from Logan Airport are available, although airport wind data are in general less useful for wind power resource analysis. Annual average wind speeds there have been 5 m/s (11 mph) at about 10 m (33 ft). Hull Municipal Light has records of wind speeds measured from the top of their wind turbine, but these data lack precision and accuracy because the instruments are influenced by the wake of the upwind turbine. (Those records could conceivably be combined with power production records, power curves, and pressure and temperature data to better estimate wind speed.)

The National Oceanographic and Atmospheric Agency (NOAA) maintains a monitoring buoy, designated as buoy 44013 in the outer harbor about 18 miles from Boston. Their website (http://www.ndbc.noaa.gov/hist.shtml) offers hourly averages of wind speed and direction. Between 1984-1993, wind speeds at that site averaged 6 m/s (13.5 mph) at 5 m (16 ft) above sea level.

Model results

Truewind, LLC applied a detailed atmospheric model of wind patterns in southern New England (Truewind, 2002). Figures 16 and 17 show the results of the model in the Boston Harbor Islands, at two levels, 65m and 30m. The maps show that the winds can be expected to be stronger as one moves away from the inner harbor; for instance, Long Island has a greater wind resource than Thompson Island. Note that the colors differ in the two legends.

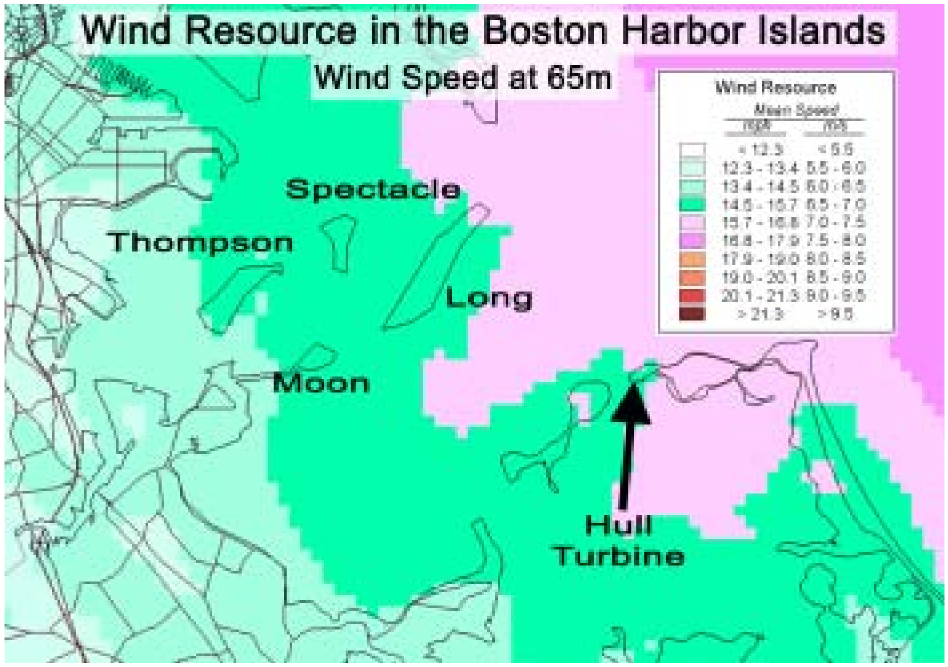
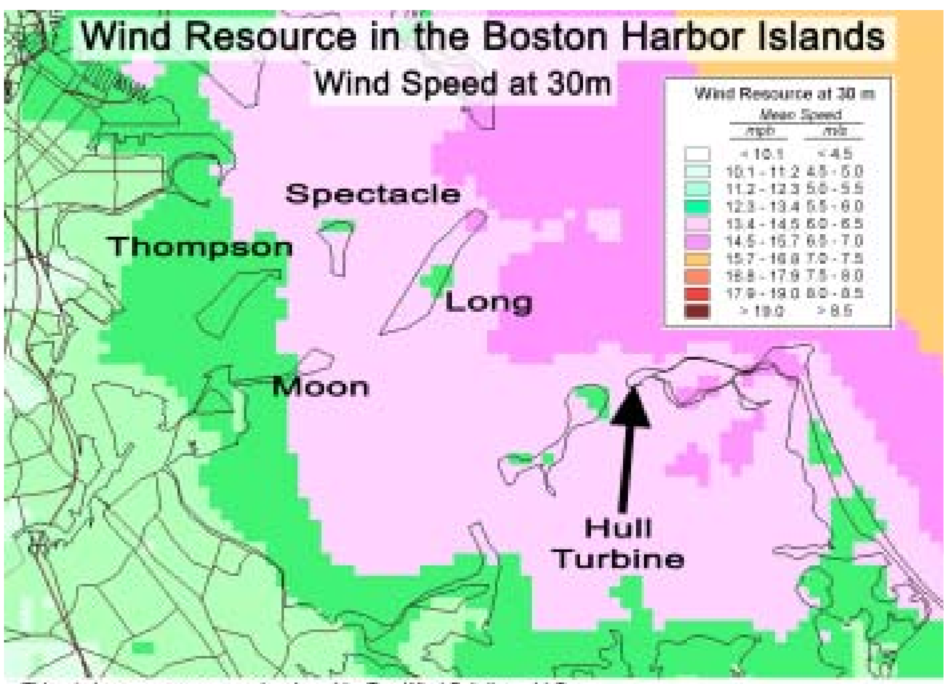


Figure 16: The results at 65m of the detailed atmospheric model of wind patterns in southern New England by Truewind, LLC (2002).



This wind resource map was developed by TrueWind Solutions, LLC,
under contract to AWS Scientific, Inc. as part of a project jointly funded by the Connecticut Clean Energy Fund,
the Massachusetts Technology Collaborative, and Northeast Utilities System.
For more information on the map, its validation and assumptions, and its areas of uncertainty,
refer to the full report, Project Report - Wind Resource Maps of Southern New England

Figure 17: The results at 30m of the detailed atmospheric model of wind patterns in southern New England by Truewind, LLC (2002).

Wind direction data are also available for the Boston Harbor. Figures 18 and 19 show wind energy roses from Hull and from Thompson Island. A wind energy rose is a plot of energy as a function of the wind direction, based on speed and direction data. The figures show that the winter wind speeds and available wind energy is strongly biased toward the west and northwest directions. For this reason, the sites chosen for study were primarily on the west and northwest sides of the islands. In the summer when winds are slower, southwest winds predominate.

The average turbulence intensity on Thompson Island has been around 14%, though the newer site nearer the water has so far shown lower turbulence. At the earlier site, the winds from the north were particularly turbulent, presumably a rolling wake from the island's head.

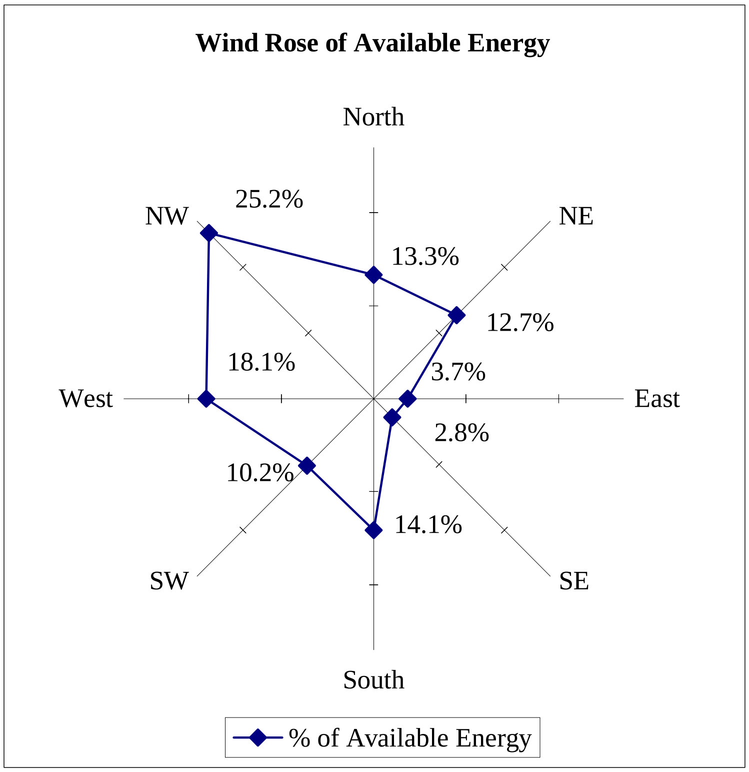


Figure 18: Wind energy versus wind direction at Hull, MA, (Vachon, 1987)

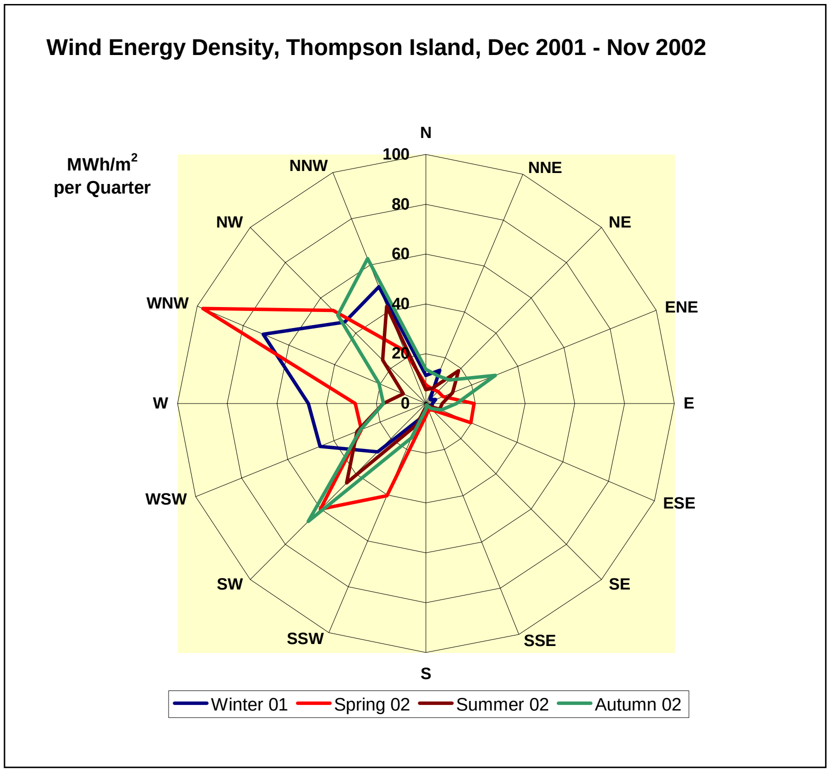


Figure 19: Seasonal Wind Energy Density versus wind direction at Thompson Island.

Solar

Existing Data

Monitoring stations that calculate the radiation from the sun have been set up at 239 locations across the U.S. and its territories by the U.S. Department of Energy National Renewable Energy Laboratory (http://rredc.nrel.gov/solar). This data has been collected for over 30 years and normalized for various tilt angles relative to earth latitude location. These values are generally expressed in kilowatt-hours per square meter per day (kWh/m^2/day). Because of a few convenient factors, these values can also be read directly as "sun-hours a day" and used as multipliers when calculating energy potential from known photovoltaic power levels.

Other factors that will also affect the total energy output of a photovoltaic installation are related to the solar window (shading), solar cell technology and inverter efficiency.

Insolation data for Boston which is at 42.37^o N latitude was used to perform the solar resource analysis at each of the five Islands subject of this report. Table 2 lists these values for flat plate panels facing south at several fixed tilt positions. There are several tilt positions shown because array installation tilts will vary from island to island depending on site conditions and design constraints.

Table 2: Insolation data used for the solar resource analysis

Tilt (^{o})		Jan	Feb	Mar	Ap	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0	Average	1.9	2.7	3.7	4.7	5.6	6.1	6.1	5.4	4.3	3.0	1.9	1.5	3.9
	Min/Max	1.5/2.2	2.2/3.3	3.2/4.4	4.0/5.4	4.8/6.4	5.3/7.0	5.2/6.6	4.8/6.0	3.9/4.7	2.7/3.5	1.5/2.2	1.2/1.8	3.7/4.1
Lat-15	Average	3.0	3.8	4.6	5.2	5.7	6.0	6.0	5.7	5.0	4.1	2.8	2.5	4.5
	Min/Max	2.2/3.7	2.8/5.0	3.7/5.6	4.3/6.0	4.8/6.6	5.2/6.9	5.2/6.65	0/6.5	4.5/5.7	3.5/4.8	2.1/3.5	1.7/3.1	4.2/4.8
Lat	Average	3.4	4.2	4.7	5.0	5.3	5.5	5.6	5.5	5.1	4.3	3.1	2.9	4.6
	Min/Max	2.5/4.3	3.0/5.5	3.8/5.5	4.1/5.9	4.6/6.2	4.7/6.4	4.8/6.1	4.8/6.2	4.5/5.8	3.7/5.1	2.3/4.0	1.9/3.6	4.2/4.9

Solar Radiation for Flat-Plate Collectors Facing South at Fixed Tilt (Sun-hrs/day)

The algorithm to calculate the annual solar energy production for each site will take into account all the site-specific factors for a photovoltaic installation. This equation will take the following form:

$$kWh/yr = ft^2 \text{ x } pf \text{ x } kW/ft^2 \text{ x } sw \text{ x } si \text{ x } ie \text{ x } 365 \text{ days/yr}$$, where

- ft^2 is the surface area identified for photovoltaic installation
- *pf* is the packing factor, or % of surface area that can be utilized
- kW/ft^2 is the solar cell power efficiency at the solar constant
- *sw* is the solar window, or % of unobscured solar path across array
- *si* is the average sun-hrs per day from chart above
- *ie* is inverter efficiency
- *365* is a multiplier to obtain yearly energy output
- *kWh/yr* is the AC kilowatt hours (energy) output of array over one year.

The first three factors in the equation, i.e., $ft^2 \text{ x } pf \text{ x } kW/ft^2$ will give the peak power output of the array (kW_p).

There are a number of different ways to calculate the power and energy expected for particular solar sites. The results of the approach used in this study were compared with the results of using a specific PV panel and solar insolation model at the University of Massachusetts. The model used measured solar data from Thompson Island. Results were similar to the approach presented here, but depend significantly on the PV panel that is chosen and on component efficiencies.

B. Renewable Energy Resource Analysis: Power and Energy Estimations

There are two major components to consider in analyzing how much renewable energy can be captured and deployed at a given site. The first is the known renewable resources, based on data collected and averaged over time, applied to current energy conversion technologies. The result of that calculation provides a total amount of power (MW) and energy (GWh) possible for chosen sites. The second set of factors are limitations associated with infrastructural and societal considerations such as government regulations and community perceptions. The following section presents information on the first component, subsequent sections evaluate the second set of factors.

Wind

Based on the Truewind model, the following wind speeds are assumed for preliminary power estimation:

Table 3: Annual wind speeds

Site	Hub height	Estimated Annual Average Wind Speed at hub height, based on TrueWind's map (m/s)
Long Island	65m	7
Spectacle Island	65m	7
	30m	6
Thompson Island	65m	6.5
Moon Island	65m	6.5

Rather than assume more precision than is given in the maps, speed estimates have been rounded to the nearer bound. The data from the meteorological tower on Thompson Island match the predictions well.

The report on the TrueWind study (TrueWind, 2002) includes the following comment about the estimation of the winds in the Boston Harbor:

> The wind maps were independently reviewed by NREL. Focusing mainly on the wind power, NREL gave a generally positive review of the map, but suggested that it significantly underestimated the wind resource in Boston Harbor based on measurements at Logan Airport, the Boston Harbor buoy, Boston/Hull, and other stations. TrueWind consequently raised the mean wind speed in this area by up to 5% and the mean wind power by up to 15% (the power increasing as the cube of the wind speed). The reason for the low map speed is unknown, but we speculate that the model is underestimating the easterly summer sea breeze.

The potential annual energy production of the harbor island wind sites can be estimated based on a number of assumptions. Annual average wind speed is important but not sufficient for estimating wind power production. The distribution of wind speeds, turbulence, shear, and the air density are each influential, as is the turbine itself. For these sites, we have assumed a Weibull shape factor of k=2 (see definitions in Appendix). We have assumed that the air density and turbulence are within the range assumed by most available manufacturers' power curves. In fact, the air density will vary with temperature and weather patterns, but can be expected to average around the typical sea level density of 1.225 kg/m3, which the curves are based on. The availability factor was assumed to be 97% for all turbines.

In order to estimate the annual energy production on each site, manufacturers' power curves for the following turbines were used:

- Vestas V47, at a rated power of 660 kW and a hub height of 65 m
- Nordex N62, at a rated power of 1300 kW and a hub height of 65 m
- Fuhrländer FL30, at a rated power of 33 kW and a hub height of 30 m (for a scenario on Spectacle Island with smaller turbines)

These three turbines were chosen only to be representative of machines in their respective size ranges. Other turbines may be available. Typical power outputs in various wind regimes are given in Table 4, based on the assumptions listed above.

Table 4. Annual Energy Production per turbine (MWh/year), as a function of annual average wind speed

Annual average speed at hub height, m/s (mph):	**5.50** (12.30)	**6.00** (13.42)	**6.50** (14.54)	**7.00** (15.66)	**7.50** (16.78)	**8.00** (17.90)
N62	1900	2300	2800	3300	3800	4200
V47	1100	1400	1600	1900	2100	2400
FL30	71	85	98	110	120	130

Estimated Capacity Factors

Capacity factor is the ratio of the actual energy produced in a given period, to the hypothetical maximum possible, running full time at rated power.

Capacity factor for a given turbine model, and thus annual energy production, can be estimated as a function of a site's annual average wind speed. These figures are shown in Table 5 for two of the turbines that are available in the US. A variety of assumptions must be made to estimate capacity factors, so these are approximations and should be used only for comparison. The collection of on-site wind resource data is critical to refining capacity factor estimates.

Table 5: Capacity factors for select turbines and annual energy production as a function of annual average wind speed.

Annual average wind speed at hub height	GE 1.5 SL, 1.5 MW		Vestas V80, 1.8 MW	
	Est. Capacity Factor	Est. MWh/yr	Est. Capacity Factor	Est. MWh/yr
6.0 m/s	24%	3,150	21%	3,310
6.5 m/s	28%	3,720	25%	3,970
7.0 m/s	32%	4,270	29%	4,620
7.5 m/s	36%	4,790	33%	5,250

Assumptions:

- Based on manufacturer's data
- Assume Rayleigh distribution, constant sea level air density, etc.
- Assume 10% losses to account for unavailability, transformer losses, turbulence, turbine variability, etc.
- GE 1.5 SL: Assume 22 m/s cut-out, per manufacturer supplied curves (whereas specs describe a 20 m/s cutout)
- Binning for estimates is conservative, i.e. based on the lower end of ranges.
- Note that when considering TrueWind speed estimates, they are given at a hub height of 70 m. Higher and lower towers are possible. E.g., higher hub heights could result in a higher capacity factor.

Photovoltaics

The solar electricity energy production is calculated with the algorithm in the preceding section using attributes particular to each site and installation (surface area, array tilt, and packing factor) and the solar window parameters. The analysis of energy production is presented in the following section with the identification of alternative sites.

IV. Identification of Alternative Technologies and Sites

A. Wind Power

Technologies

It is not the purpose of this Planning Guide to identify or recommend particular turbine manufacturers or models. However, the nature of this project—its high profile and need to minimize risk—suggests that the selection of turbines for this project should be based on demonstrated reliability, i.e., commercial technology with a large installed base (as opposed to prototype machines).

Turbine size options considered in this study are:

“Commercial” scale: 600 kW to 1.5 MW, and

“Medium” scale: 50 kW to 500 kW

Commercial scale

The wind industry currently concentrates on the megawatt scale range of turbines, so there are more models available with established track records. The economics of this scale is better than smaller machines as the investment cost per kW of installed power is less.

The larger machines are taller, ranging from 270 to 360 feet from the ground to the top tip of the blade.

Two examples of turbines in this category are

Model	Power (kW)	Hub height	Rotor diameter	Swept Area	Speed of revolution
Vestas V47	660	40 to 55 m	47 m	1,735 m^2	28.5 rpm
GE Wind 1.5SL	1500	65 m	77 m	4,657 m^2	10.1 – 20.4 rpm

The Vestas V47 is familiar to Boston Harbor; a V47 has been operational in Hull since 2001 and is already visible from many points on these islands

“Medium” scale: 50 kW to 500 kW

Model	Power	Hub height	Rotor diameter	Swept Area	Speed of revolution
Fuhrlander F250	250	42 to 50 m	29.5	706 m^2	29 rpm
Fuhrlander FL-100	100	30 m	21 m	346 m^2	32 rpm

Preliminary identification of sites for further study

Based on analyses of fundamental siting criteria such as existing and planned future land uses (as presented in adopted plans and by island owners); the utility distribution network (age, capacity, location); known natural, cultural, and historic resources; information on energy resources; and preliminary feedback from harbor and island stakeholders, a range of sites was selected for both wind and photovoltaic installations as a prerequisite for determining a realistic peak power output and technology mix that is possible and plausible on these five Islands. *There is no intention to develop this number of sites for either wind or photovoltaics; this stage simply identifies a finite number of sites to subject to further analysis.*

The criteria for the preliminary site identification for wind turbines are:

Compatibility with management areas of the Boston Harbor Island General Management Plan:

> Study sites are all within the areas designated as "Managed Landscape" and "Special Use." The former are areas that are predominantly open and managed to preserve their cultural and natural features. These areas reflect the imprint of human use. The latter areas contain a range of uses developed previously; natural resources have been eliminated or highly modified. Areas designated special use areas have already been developed by public agencies and will continue to be used for non-park programs.

Natural, cultural and historic resources

> Study sites were selected to avoid areas of known resources of natural, cultural or historic importance. Further investigation will be conducted as specific sites are identified and appropriate measures to avoid, minimize and mitigate effects on these resources will be taken.

Compatibility with other plans for the islands:

> Study sites respect and avoid interfering with special purpose plans for the islands such as the Long Island Limited Public Access Plan and the plan for the eco-family retreat proposed for Peddocks Island.

Preferences of island owners and managers

> Study sites reflect preferences of island owners and managers to avoid interference with existing or planned activities.

Adequate energy resources

> Selected sites take advantage of wind and solar energy resources.

Electrical connections

> Sites are in proximity to the islands' existing electrical distribution network.

Table 6 and Figures 20 and 21(a-e) present the alternative wind turbine sites selected for initial study and subjected to further analysis.

Table 6. Preliminary sites for wind turbines selected for further study.

Site Key	Island	Site	Site Key	Island	Site
L2	Long Island	Sewer plant	S3	Spectacle Island	South Drumlin
L3	Long Island	Sewer plant	S4	Spectacle Island	South Drumlin
L4	Long Island	Around Nike site	S5	Spectacle Island,	South Drumlin
L7	Long Island	Around Nike site	T5	Thompson Island	South central
M1	Moon Island	North	P1	Peddocks Island	Highest Point
M2	Moon Island	Peak	P2	Peddocks Island	Tombolo
S1A	Spectacle Island	North Drumlin	P3	Peddocks Island	Northern Peak
S1	Spectacle Island	North Drumlin	P4	Peddocks Island	NW Peak
S2	Spectacle Island	North Drumlin			

Figure 20: Study sites for wind turbines on the five islands.

Figure 21a: Wind turbine study sites on Long Island

Figure 21b: Wind turbine study sites on Moon Island.

Figure 21c: Wind turbine study sites on Peddocks Island.

Figure 21d: Wind turbine study sites on Spectacle Island.

Figure 21e: Wind turbine study sites on Thompson Island (note: only T5 considered for study).

Table 7: Potential Annual Energy per Turbine for preliminary study sites.

Site	Site #*	Hub Height used for this example	Estimated Annual Avg Wind Speed at hub height, based on TrueWind's map	Energy per Turbine: Approximate possible MWh/yr, Based on wind speed		
				N62	V47	FL30
Long Island	L2, L3, L4, L7	65m	7	3300	1900	--
Spectacle	S1A	65m	7	3300	1900	--
	S1 – S5	30m	6	--	--	76
Thompson	T5	65m	6.5	2800	1600	--
Moon	M1-M2	65m	6.5	2800	1600	--
Peddocks	P1 – P2					

B. Photovoltaics

Preliminary identification of sites for photovoltaic installations includes building roofs and ground level locations. The existing buildings on the islands provide exceptional locations for photovoltaic arrays: large flat roofs, low parapet heights, minimum obstructions, and good solar windows. Ground locations on Spectacle Island take advantage of south facing slopes. On Moon Island, the vast area of the abandoned wastewater settling tanks provide an interesting opportunity worth consideration.

Table 8: Preliminary sites for photovoltaics for further study.

Island	Location	Island	Location
Long Island	Fire Station	Spectacle Island	South Drumlin
Long Island	Garage	Thompson Island	Weather Station
Long Island	Morris	Thompson Island	Hughes Hall
Long Island	Tobin	Thompson Island	Lewis Gardner
Long Island	McGilvery	Thompson Island	Bartlett
Long Island	Ward ABCD	Thompson Island	New Building
Long Island	Nichols	Moon Island	Fire Academy
Spectacle Island	North Drumlin	Moon Island	Seepage Pits

The following table presents the results of the calculations for each of the identified sites on Long Island utilizing the algorithm in section II.A. for solar electric energy production. Values for the surface areas and solar window parameters in the equation were taken from data collected for the Island Survey.

At the time of this writing, commercially available solar cell power conversion efficiency varies from approximately 0.008 to 0.015 kW/ft^2. A value of 0.010 will be used for a realistic value of medium priced technology.

Table 9: Solar Resource Analysis

Island	Location	Peak Power (kW_p)	Annual Energy (kWh)
Long Island	Fire Station	8.78	10,138.07
Long Island	Garage	16.80	18,377.60
Long Island	Morris	68.75	79,384.08
Long Island	Tobin	60.79	70,192.85
Long Island	McGilvery	72.90	70,885.04
Long Island	Ward ABCD	20.52	19,952.83
Long Island	Nichols	46.71	42,580.25
Spectacle Island	North Drumlin	1044.47	1,327,834.00
Spectacle Island	South Drumlin	578.75	735,759.40
Thompson Island	Weather Station	609.84	818,358.00
Thompson Island	Hughes Hall	12.40	12,810.84
Thompson Island	Lewis Gardner	11.28	15,142.25
Thompson Island	Bartlett	12.25	16,438.55
Thompson Island	New Building	17.47	9,756.12
Moon Island	Fire Academy	17.42	20,114.48
Moon Island	Seepage Pits	650.00	872,249.60

C. Development and ownership options

A number of entities could participate in the development and/or ownership of renewable energy facilities on the subject islands of the BHINPA.

Public ownership: municipal, state, or federal government

- i) City of Boston: owner of Long, Moon, and part of Spectacle Island
- ii) Commonwealth of Massachusetts Department of Conservation and Recreation: owner of Peddocks Island and part of Spectacle Island
- iii) Hull Municipal Light Plant (HMLP): owner and operator of a wind turbine one-quarter of a mile across Hull Gut from Peddocks Island (which is within Hull's municipal jurisdiction)
- iv) Massachusetts HEFA, and its PowerOptions energy buying consortium.
- v) National Park Service
- vi) Massachusetts Technology Collaborative

Nonprofit ownership (existing groups)

i) Island Alliance
ii) Massachusetts Municipal Wholesale Electric Company (MMWEC)
iii) Mass Energy Consumers Alliance (MassEnergy)

Nonprofit ownership, group formed for this purpose

i) Special-purpose entity created under a non-profit listed above
ii) Cooperative or other community group

Private developer(s)

Joint venture of some combination of the above

D. Financing

There are several possible sources for financing renewable energy development and these are related somewhat to the ownership option selected:

Direct investment by the project developer and partners.

Debt: funds borrowed through commercial lender based on future revenue from energy generation and sales.

Grants: organizations such as the Massachusetts Technology Collaborative provide grants to support development of renewable energy projects as it did by providing funds to support this predevelopment feasibility study.

E. Operation and maintenance (O&M)

The on-going work of operating only a few turbines does not require full-time staff. The operation and maintenance would be most efficient if the O&M entity is also maintaining other, nearby wind turbines. The expectation is that there will be more turbines installed in southern New England in the next few years, so ideally, the maintenance of the Harbor Island turbines could be subcontracted to a crew that works on other turbines in the region. A crew with experience in wind power equipment is recommended, rather than a more general maintenance service.

V. Environmental, Community and Regulatory Assessment

Any potential development of renewable energy facilities on the Boston Harbor Islands must be compatible with the national park's environmental, historical and cultural resources, consistent with laws and regulations protecting these resources, public safety, and health, and be harmonious with community values. Section A below summarizes the major categories of potential environmental and community impacts associated with establishing renewable energy on the Boston Harbor Islands. For each category, a description of the issue, the existing conditions, the principal regulatory authorities, and status and findings are presented. These assessments were used as the screening criteria for final site selections.

Section B summarizes a number of other regulatory and administrative authorities that may be relevant to an eventual renewable energy project on the Boston Harbor Islands.

A. Overview of potential environmental and community impacts

Wind Power

<u>Birds</u>

Issues

Wind turbines may affect birds in three principal ways:

- Loss or degradation of habitat
- Exclusion from important habitat (by disturbance/avoidance/barrier-effects)
- Collision mortality

Existing Conditions

Information on bird species, numbers, type of use, and spatial and temporal patterns of use for Boston Harbor was compiled from existing published and unpublished research as part of this predevelopment feasibility study (Hatch 2004). Potential impacts were identified along with information on the relevant federal and state regulatory programs.

The two principal sources for recent quantitative information are (1) a three-year study of birds on the islands during the breeding season, 2001-2003 (Paton et al. 2003), and, (2) an ongoing volunteer project, "Take a Second Look" (TASL), that has gathered bird numbers from throughout Boston Harbor several times each year since 1980, with particular interest in the large numbers of wintering and migrant waterbirds.

The Paton study (conducted only during the breeding season) covered many islands but excluded (for logistic and security reasons) two of those being considered for turbines: Moon and Long. These exclusions do not substantially affect the general thrust of this report because the two islands do not contain exceptional habitats and are unlikely to be of distinctive importance in respect to bird/turbine interactions. The study did not include some adjacent mainland areas where gulls and terns nest so that, for these species, the numbers of breeders using the Harbor are underestimated.

Earlier regional censuses of colonial waterbirds were conducted in 1977, 1984 and 1994 by USFWS and MDFW. Unfortunately, the work in 2001-2003 is not directly comparable to the earlier surveys. Although most of the TASL counts are mainland-based, they do extend to Long Island and thus provide systematic coverage (by telescope) of most of the harbor waters and they do document important concentrations of birds, especially migrant and wintering waterbirds. Summaries are available on the web (http://www.gis.net/~szendeh/tasl.htm); datasheets with finer-scale raw data are held by TASL.

Birds of Conservation Concern 2002 (BCC 2002) is a report prepared by USFWS that presents, for each region, lists of species of concern that include (but do not separate) breeding, wintering and staging species. For this area (New England/Mid-Atlantic Coast: BCR 30) the list comprises 32 species (excluding those listed under the ESA) of which four nest and two winter in Boston Harbor. Many of the others may occur during migration as resting transients ("staging") or flying overhead, but records are inadequate for any assessment. One species, the Peregrine Falcon, has been recently de-listed from the ESA; it nests in the city of Boston, in Quincy, and elsewhere in eastern Massachusetts and may hunt in the area. The four species nesting in Boston Harbor include one shorebird: American Oystercatcher (thriving in Massachusetts while southern numbers flounder), two seabirds (Common and Least Tern), and one landbird (Baltimore Oriole). The two wintering species are a shorebird that nests in the High Arctic, the Purple Sandpiper, and a seabird that nests from Maine to Labrador, the Razorbill.

Another initiative for bird conservation is the designation of special habitat in the form of Important Bird Areas (IBA). This ongoing international effort stems from BirdLife International (concept developed in 1985), is currently administered in the U.S. by the National Audubon Society, and is spearheaded in Massachusetts by the Massachusetts Audubon Society (MAS) (program launched in 2000). IBAs are sites that provide essential habitat for breeding, wintering or migrating birds; they generally support high-priority species, large concentrations of birds, exceptional habitat, and/or have substantial research or educational value.

Most IBAs are actual or potential protected areas, such as designated nature reserves or areas with a management plan. The IBA designation itself provides no statutory protection but draws attention to valuable areas. An additional program for identifying IBAs, focusing on those of global rank, is run by the American Bird Conservancy (ABC), using criteria that are allegedly similar to those of MAS. Boston Harbor does not appear on ABC's list.

During the first round of evaluations, 2000-2002, ninety sites in Massachusetts were nominated for IBA status. Of these, 79 were accepted and additional nominations are expected. Boston Harbor was nominated (on or after December 18, 2002) on the grounds of meeting five of the criteria identified by MAS. The site name of the IBA is “Boston Harbor Islands National Recreation Area.” Because of this designation as an IBA, proposals for developments in the area are likely to receive closer scrutiny than might otherwise occur.

It is important to understand that the Boston Harbor IBA is not homogeneous; the whole area is not uniformly important to the birds identified in the nomination.

The Boston Harbor Islands provide only small patches of terrestrial habitats and are of limited value for nesting landbirds. The islands may be used as transient rest-stops by many migrants arriving from offshore and such birds could island-hop, probably by day, to reach a suitable refueling site. For diverse waterbirds, the islands provide potential nesting sites safe from terrestrial predators and close to suitable food. The widespread presence of rats, which readily colonize islands (and of other mammals such as raccoon and domestic rabbit, some introduced by humans), has probably limited such nesting. The outer islands are particularly important for nesting seabirds; while wading birds (herons, egrets) as well as gulls are more widely distributed.

The waters and shorelines surrounding the islands provide essential resources for the nesting waterbirds, as well as for abundant transient and wintering seabirds (especially seaducks), and transient shorebirds (sandpipers, plovers etc.) feeding on intertidal mudflats. The adjacent open spaces of Logan Airport are important for wintering and migrant raptors and for some nesting shorebirds and terns.

Regulatory Authorities

The Endangered Species Act (16 U.S.C. 1531–1544; ESA) provides strict protection for listed species and the ecosystems of which they form a part. Harming a single individual can lead to serious penalties. In Boston Harbor, three species of listed birds are of potential concern: Bald Eagle, Piping Plover and Roseate Tern. All have been recorded in the area, none frequently, and none have nested recently, nor do they face high risks in the area. Bald Eagles could be found in Boston Harbor at any time of year, typically along shorelines or perched on rocks or in trees. Piping Plovers are summer visitors (and transient migrants) that favor sandy or mixed beaches. Roseate Terns are also summer visitors, they nest with Common Terns on predator-free islands and feed at sea, often over sandbars or schools of predatory fish. Any of these three species could start nesting in the area in the future but no critical habitat has been designated and, at present, the risks posed by potential wind turbines appear negligible.

The Migratory Bird Treaty Act (16 U.S.C. 703–712; MBTA), the cornerstone of bird conservation, makes it unlawful to kill (etc), by any means, any migratory bird. This category includes almost all species found in Boston Harbor. The Act is a strict liability statute, wherein no proof of intent is part of a violation, and there is no provision for allowing unauthorized take. Bald and Golden Eagles receive additional protection under the Bald and Golden Eagle Protection Act (16 U.S.C. 668 – 668d; BGEPA). In practice, prosecutions arising from violations of the MBTA at wind power sites have been infrequent and the USFWS has used prosecutorial discretion where good faith efforts have been made to avoid the take of migratory birds. Generally, interest is likely to be focused on large concentrations of birds at risk and on species identified as being of conservation concern.

Massachusetts Endangered Species Act: According to the BHINPA General Management Plan, the U.S. Fish and Wildlife Service reports several federally listed endangered and threatened species of fish, turtles, birds, and mammals near or in coastal waters of Massachusetts, but not known to be found among the Boston Harbor Islands. There are no island species on the federal list. The Massachusetts Natural Heritage Program lists six rare species known to exist within the park, including two species listed as threatened and four of special concern. Birds are the barn owl, common tern, least tern, and Northern harrier; plants are the sea beach dock and American sea blite.

The Massachusetts list of Endangered, Threatened and Special Concern species includes those species that are or may become at risk of extirpation as breeders in Massachusetts. It includes 28 bird species of which 10 are also Federally-listed (either under the ESA or in BCC 2002 for BCR30). Eight species on the Massachusetts list occur in the Boston Harbor national park area: of these, six are noted above under the Federal lists, these are the three ESA species, Peregrine Falcon, and two terns. The remaining two on the list comprise one recent (probable) breeder in Boston Harbor, the Barn Owl, and one wintering species, the Long-eared Owl.

Findings

While it is understood that broad generalizations are not necessarily sufficient for assessing potential avian issues, the five islands in Boston Harbor being studied here are inner islands, remote from those outer islands most important for nesting waterbirds. Wintering ducks occur in the vicinity of all five. For all of them, more information is needed on use by transient landbird migrants.

Observations specific to each of the five islands:

Moon Island: More information is needed for breeding birds. Road connection to mainland means that terrestrial predators have access.

Long Island: More information needed for breeding birds. Road connection to mainland means that terrestrial predators have access. Brant (an Arctic-nesting goose) may use grassy areas in spring and could be at risk of collisions and disturbance effects, however this habitat is not limiting. Listed species wintering: Long-eared Owl (and other owls) reported to use the pine plantation at southern end. Likely effect of turbine: unknown, although owls may be collision-prone.

Spectacle Island: Formerly was nesting site for gulls and wading birds. Current use by landbirds is low because most of the island is covered by newly-installed grass. Bird use will increase (numbers of species and individuals) as vegetation develops and management will influence composition. Listed species nesting: American Oystercatcher. Effect of turbines unknown, but guess negligible.

Peddocks Island most heavily used by landbirds, woodland and shrubland habitats possibly of particular importance to irregular occurrences of transients. Former site of wading bird colony. Listed species nesting: American Oystercatcher, Baltimore Oriole. Effect of turbines on these unknown but guess very small.

Thompson Island: Wetlands on the site need attention to establish bird use. Listed species nesting: American Oystercatcher. Effect of turbines unknown, but guess negligible.

Habitat loss is likely to have small adverse effects on breeding birds and unknown adverse effects on transient migrants. Disturbance will adversely affect waterbirds to an unknown extent (principally in winter) but such habitats are not limiting. Collision mortalities will occur, probably very few, but their frequency cannot be predicted precisely. Studies at the Hull turbine may be appropriate.

None of these effects is expected to be biologically important (at level of the population), but this conclusion would be strengthened by additional data on how migrants use the islands, flight altitudes, and effects of disturbance. Local mitigation for local effects may be appropriate.

<u>Navigable airspace</u>

Issue

Tall structures in proximity to airports could have an affect on the safe and efficient utilization of navigable airspace by aircraft or on the operation of the airport.

Existing Conditions

The five islands share their Boston Harbor location with Logan International Airport. The islands are located SSE of the airport, from two to five and one-half miles distant. Turbines considered for the study sites might range in height (to tip of blade) from 130 to 325 feet above ground level. The wind turbine installed in 2001 at Pemberton Point in Hull is 240 feet in height above ground level.

Regulatory Authorities

The Federal Aviation Administration (FAA) of the US Department of Transportation, is responsible for review of any proposed construction that would intrude into navigable airspace. Federal regulations at 14 CFR Part 77 (pursuant to 49 U.S.C. Section 44718) require the filing of a notice for the proposed construction or alteration of certain objects that may affect the navigable airspace. Notice is required to be filed with the FAA as early as possible in the planning stage of a project, but not less than 30 days before construction will begin.

Notice is required to be filed for the construction or alteration of objects:

1. that are greater than 200 feet in height above ground level (AGL) at their location; or
2. near a public-use or military airport. Specifically:
    a) within 20,000 feet of an airport with at least one runway more than 3,200 feet in length and the object would exceed a slope of 100:1 horizontally (100 feet horizontally for each 1 foot vertically) from the nearest point of the nearest runway, or
    b) within 10,000 feet of an airport that does not have a runway more than 3,200 feet in length and the object would exceed a 50:1 horizontal slope from the nearest point of the nearest runway; or
3. upon request by the FAA if it believes the proposal may exceed an obstruction standard . . . or may cause transmitted signals to be reflected upon ground-based or airborne air navigation communication equipment, or affect instrument procedures, . . . or may affect air traffic control radar.

Notification to the FAA is made on FAA Form 7460-1, Notice of Proposed Construction or Alteration, accompanied by graphics and maps depicting the proposed project.

According to FAA Advisory Circular AC 70/7460-2K, *Proposed Construction or Alteration of Objects that May Affect the Navigable Airspace*, the FAA will conduct an initial screening and notify the filer that:

1. the proposal is not identified as an obstruction and would not be a hazard to air navigation, or
2. the proposal would be an obstruction unless reduced to a specified height and is presumed to be a hazard to air navigation pending further study.

In the latter case, the proponent may elect to reduce the height or request further study within 60 days, if the FAA hasn't already initiated further study. Once the study is initiated, public notice is distributed for comment to agencies, organizations, and individuals with known aeronautical interests. During this stage, the FAA may negotiate with the proponent resolution of any adverse effects on aeronautical operations.

After the study is completed, the FAA issues a:

1. Determination of Hazard to Air Navigation, or
2. Determination of No Hazard to Air Navigation.

The FAA determination is a conclusion based on the study of a structure's projected impact on the safe and efficient use of the navigable airspace by aircraft. It is not to be construed as an approval or disapproval of the project.

Findings and Status

To learn how the regulatory standards would be applied to the set of seventeen alternative study sites, it was necessary to submit specific turbine height data to the Air Traffic Division of FAA's New England Region. The turbine chosen for this assessment was the GE 1.5SL on a 60 meter tower at all sites except for S1 – S5, which is was a Fuhrländer F100 on a 30 meter tower. The FAA conducted a preliminary screening and reported that the turbine heights as proposed for many of study sites exceeded the obstruction standards. Table 10 summarizes the study proposals and findings.

Table 10. Summary of Turbine Sites and FAA Standards

Turbine Code	Island	77.23 (a)(2)	77.23(a) (2)	77.23(a)(3)	77.25(a)(2)	77.25(b)	77.25(d)(2)	77.25(d)(2)	77.25(d)	Site Elevation (ft)	Structure Height (ft)	**Overall Height (ft)**
		horiz.	slope	variable	horiz.	conical (20:1)	inner slope (50:1)	outer slope (40:1)	buffer to previous (7:1)			
L3	Long	114		120	- na -	26	- na -	52	- na -	10	323	**333**
L2	Long	114		120	- na -	21	- na -	48	- na -	10	323	**333**
L4	Long	109		120	- na -	OK	- na -	- na -	- na -	13	323	**336**
L7	Long	94		130	- na -	- na -	- na -	- na -	- na -	23	323	**346**
M1	Moon	61		- na -	- na -	- na -	- na -	- na -	- na -	3	323	**326**
M2	Moon	69		- na -	- na -	- na -	- na -	- na -	- na -	72	323	**395**
S1	Spectacle	OK	- na -	- na -	56	- na -	- na -	- na -	- na -	92	133	**225**
S1A	Spectacle	123	- na -	160	220	OK	- na -	- na -	- na -	66	323	**389**
S2	Spectacle	OK	- na -	- na -	33	OK	- na -	- na -	- na -	69	133	**202**
S3	Spectacle	OK	- na -	- na -	- na -	OK	- na -	- na -	- na -	43	133	**176**
S4	Spectacle	OK	- na -	- na -	- na -	OK	- na -	- na -	- na -	66	133	**199**
S5	Spectacle	OK	- na -	- na -	- na -	OK	- na -	- na -	- na -	43	133	**176**
T5	Thompson	118		60	- na -	OK	- na -	- na -	- na -	30	323	**353**
P1	Peddocks	- na -	OK	220	- na -	- na -	- na -	OK	- na -	111	323	**434**
P2	Peddocks	- na -	OK	120	- na -	- na -	- na -	- na -	OK	3	323	**326**
P4	Peddocks	- na -	OK	180	- na -	- na -	- na -	OK	- na -	68	323	**391**
P3	Peddocks	- na -	OK	200	- na -	- na -	- na -	OK	- na -	88	323	**411**

Key:

- na - Site does not fall within the area covered by regulation

OK Site falls within the area covered by regulation and proposed structure does not exceed obstruction standard

120 Site falls within the area covered by regulation and exceeds obstruction standards by XX feet

The first column is keyed to the maps in figures 21(a) through (e). Columns three to eight present the findings pertaining to each study site (for the suggested turbine heights) under the individual sections of Title 14 of the Code of Federal Regulations, each of which establishes a different standard for determining obstruction of navigable airspace. The last columns provide relevant data on each study site and structure proposed for evaluation.

This information has been used as one of the criteria to narrow down potential sites and determine sizes of turbines.

Terrestrial and Wetlands Resources

Issue

Construction of land-based renewable energy facilities that might impact wetlands, natural resources or habitat of rare or endangered species.

Existing Conditions

Several plants of conservation concern and animal species are known to occur on the Boston Harbor Islands and consulting the Massachusetts Natural Heritage and Endangered Species Program (MNHESP) will be an essential step once sites are finalized.

Regulatory Authorities

Endangered Species Act: The federal Endangered Species Act conserves the ecosystems on which endangered and threatened species depend. The U.S. Fish and Wildlife Service is responsible for administering the law for terrestrial and freshwater species (the National Marine Fisheries Service is responsible for marine species under the act).

The U.S. Fish and Wildlife Service has developed voluntary guidance intended to assist wind energy development to avoid or minimize impacts to wildlife and their habitats. This includes (1) proper evaluation of potential Wind Resource Areas (WRAs), (2) proper location and design of turbines and associated structures within WRAs selected for development, and (3) pre- and post-construction research and monitoring to identify and/or assess impacts to wildlife.

Massachusetts Endangered Species Act: According to the BHINPA General Management Plan, the U.S. Fish and Wildlife Service reports several federally listed endangered and threatened species of fish, turtles, birds, and mammals near or in coastal waters of Massachusetts, but not known to be found among the Boston Harbor Islands. There are no island species on the federal list. The Massachusetts Natural Heritage Program lists six rare species known to exist within the park, including two species listed as threatened and four of special concern. They are the birds barn owl, common tern, least tern, and Northern harrier, and the plants sea beach dock and American sea blite.

Findings

Wetlands have been avoided in the siting of renewable energy facilities. Habitat conditions and the presence of protected species will be investigated at the time final site selection.

Historical, Cultural, and Archeological Resources [1]

Exiting conditions

Buildings and Structures: Many of the Boston Harbor Islands contain buildings and structures related to such uses as coastal defense, agriculture, commercial fishing, year-round and summer habitation, resort life, industry, public health, immigration, and social welfare. On the 34 islands, more than 100 buildings and structures, including sea walls, forts, lighthouses, gun emplacements, concrete bunkers, wood-framed cottages, and brick military and institutional buildings, reflect the long history and changing character of the Boston Harbor Islands.

With several notable exceptions, the buildings and structures of the Boston Harbor Islands have not been evaluated with National Register criteria for their historical significance. The Boston Harbor Islands Partnership's research agenda for the coming years includes evaluation of these resources.

Structures currently on the Register are the three national historic landmarks: Fort Warren on Georges Island; Boston Light on Little Brewster. and Long Wharf on the Boston waterfront.

There are three sites on the National Register of Historic Places: Long Island Head Light on Long Island, Graves Light on The Graves, and Nix's Mate Daybeacon.

Fort Andrews, erected on Peddocks Island in the first decade of this century, is a rare example of a relatively intact coastal fort of the Endicott Period (1888-1905), although its 26 remaining buildings and structures have suffered over 50 years of abandonment and are generally in poor condition.

Approximately 30 cottages on Peddocks Island, dating from the early 20th century, are the last remaining residential structures on the harbor islands (aside from year-round institutional residences on Thompson and Little Brewster). They are occupied by their owners during the summer and allude to the former prevalence of summer communities and recreational activities in the harbor, as well as fishing communities. (In recent years, the Massachusetts Department of Conservation and Recreation (DCR) has been acquiring, evaluating, and removing the cottages as owners vacate them.)

[1] This section is taken from the General Management Plan for the Boston Harbor Islands: A National Park Area.

Cultural Landscapes: The Boston Harbor Islands contain numerous cultural landscapes. As with structures, a number of cultural landscapes of the Boston Harbor Islands are potentially eligible for the National Register of Historic Places.

Most cultural landscapes of the harbor islands are characterized as "historic vernacular," meaning that they were imprinted by the settlement, customs, and everyday use of people who altered the physical, biological, and cultural character of their surroundings. Fields and forests once inhabited by American Indians were later used as Euro-American farms and pastures, that, when abandoned, were transformed through natural succession into stands of trees, shrubs, vines, and herbaceous vegetation.

Many islands may also have "ethnographic landscapes," those containing natural and cultural resources that associated people define as "heritage resources" such as contemporary settlements, subsistence communities, and burial grounds. Such places can be found on Peddocks Island and Long Island among others. The islands were once seasonal homes for Indians.

A surprising number of harbor islands and associated peninsulas contain "historic designed landscapes," those consciously laid out by a landscape gardener, architect, or horticulturist according to design principles or by others in a recognized style or tradition. These include the vestiges of military landscape design on several islands. Many island landscapes are also recognized as "historic sites," those places associated with a historic activity, event, or person. Such sites include the lighthouses on Little Brewster, The Graves and Long Island.

Archeological Sites: The Boston Harbor Islands have a rich human history, some of which is revealed by physical evidence including pre-contact and historic archeological resources. The islands began to separate from the mainland during the Late Archaic period (3000 BC to 1000 BC), but have produced artifacts from the Early Archaic period, indicating that native peoples were living on the shores of river estuaries. The Middle and Late Woodland periods (300 BC to 1000 AD) are most heavily represented in the archeological record, but erosion may have taken out earlier sites.

The islands contain evidence of American Indian use of such archeological significance that, to date, 21 islands have been designated within an archeological district listed on the National Register of Historic Places (December 21, 1985). . Archeologists assume that all islands not surveyed potentially have prehistoric or pre-contact sites.

Archeological sites of the historic period have not been systematically surveyed, although many are known to exist on the islands. Fifteen types of sites are known: agricultural, cemetery, fishing colony, fortification, hospital, hotel or resort, industrial, poorhouse, prison, prisoner-of-war camp, quarantine, sewage treatment, lighthouses, dumps, and miscellaneous other site types.

Ethnographic Sites: Many contemporary American Indians have cultural ties to the Boston Harbor Islands, and other groups may also feel connections to the islands based on long-standing use. Although little research has been conducted to identify any of these traditionally associated groups, they might include Irish immigrant families or groups of former island inhabitants including fishermen, lighthouse keepers, and "communities of caring," people who tended to the sick. Ethnographic sites on the Boston Harbor Islands have not been professionally documented.

Administrative and Regulatory Authorities

General Management Plan for the Boston Harbor Islands: As described in section two, the park's General Management Plan designates specific management areas for all property in the park. For each of the six different management areas the plan describes a broad direction for resource management, visitor use, and development of park facilities or infrastructure. Areas of the park that contain historic buildings, structures, or landscapes are in the Historic Preservation management area where the historic resources are to be preserved, restored, reconstructed or adaptively reused for visitor education and appreciation. These areas encompass, among others, the forts and fortifications on Long and Peddocks Islands, the lighthouse on Long Island, and the granite wastewater treatment structures on Moon Island.

Section 106 of the National Historic Preservation Act (NHPA)(16 USC Part 470): The NHPA requires Federal agencies to review all actions which may affect a property listed on the National Register of Historic Places, or which may affect a property eligible for listing. Specifically, section 106 of the Act (16 U.S.C. 470(f)) requires that a Federal agency involved in a proposed project or activity is responsible for initiating and completing the review process. The agency must confer with the State Historic Preservation Officer (SHPO) and the NHPA. Section 106 of the National Historic Preservation Act also requires consultation with Federally-recognized tribes that may have cultural ties to the area.

The National Register is an inventory of the United States' historic resources and is maintained by the National Park Service. The inventory includes buildings, structures, objects, sites, districts, and archeological resources that may be significant at the national, state or local level. The requirements of section 106 also encompasses significant properties which have not yet been listed or formally determined to be eligible for listing.

Under the NHPA proposed actions are evaluated as to their potential effects. Potential effects may occur when a proposal might alter the characteristics or use of the historic property that qualified it for inclusion in the National Register. If an adverse effect is identified, appropriate measures to avoid, minimize, or mitigate the effect are implemented.

Massachusetts Historical Commission. The Massachusetts Historical Commission is the primary repository of information and has lead responsibility for overseeing protection of resources of historic, cultural and archeological significance in the Commonwealth. It has authority through M.G.L. Chapter 9, Sections 26-27c and regulations at 950 CMR 71.00 to review proposed activities that have the potential to affect these resources. Once a feasible project is identified based on this planning guide, the MHC should be consulted and a project notification form completed and submitted to the MHC.

Findings

The siting analysis conducted for this study included avoiding the GMP's Historic Preservation management areas. This eliminates the possibility of having a direct physical impact on these resources. At the time a project at a particular location is pursued, the effects of having wind turbines visible from historic sites both in and outside the park must be further evaluated. Archeological surveys may need to be done at the final sites.

Aesthetics and community acceptance

Issue

Visual or aesthetic effects of new structures in the landscape is a primary consideration in siting wind turbines. Visual impacts are of less significance for photovoltaic arrays, particularly when installed on existing structures, except when the structure is of historical significance. Visual impact and community acceptance is a function of both physical context and viewers' perceptions about the particular structure as well as about renewable energy in general. The significance of visual impacts seems most pronounced in areas valued for their natural beauty, free of existing man-made structures.

Selecting sites with minimum visual intrusion is the key consideration, but sizing, design, screening and color choices are ways to further mitigate the impact.

Existing conditions

Figure 21 shows the distances of the five islands from a number of locations on the mainland shoreline. Most of the selected shoreline points are parks and other locations where the public has access to the waterfront.

The only sure way to assess the acceptability of the potential visual impact of a possible installation is through community outreach, providing the potentially effected public with accurate information and providing early and timely opportunities for public input. Photo simulations of existing views with wind turbines superimposed are a way to graphically illustrate the visual impact of the structure on the landscape.

Existing renewable energy facilities around the harbor provide some insight into public reaction to these technologies. The favorable reception for the Town of Hull's 660kW wind machine, the photovoltaic installations on Peddocks Island, and the roof-mounted photovoltaic installed on the Visitor Center on Spectacle Island are instructive and are being carefully followed and evaluated. Published studies from the US and Europe are also being reviewed with respect to effects of such installations on community character and aesthetics. In many of these instances, wind turbines become popular attractions for both residents and visitors.

The "impacted public," for a national park, should be considered to be larger than the surrounding community. There is a national interest in siting facilities such as these in a national park area (statement made at US Department of Energy's Technical Tutorial on Wind Energy Systems, Boston, Sept. 30, 2003).

A technique such as landscape character assessment is used to identify broad locations which may be appropriate and those where unacceptable harm would be done to the visual qualities of the landscape. Industrialized areas, for example, may be better able to accommodate visual impacts.

Figure 21: Representative distances from the mainland shoreline to the five study islands.

Native American interests

Issue

American Indians value the Boston Harbor Islands as a place to celebrate and commemorate their cultural heritage. Prior to European contact American Indians lived on the islands during the warmer months. The Native Americans fished in the waters surrounding the islands, hunted, foraged, and cleared parts of the islands for growing crops. They also used the islands for social and ceremonial activities. The islands are also associated with a tragic time for the American Indians. During the King Philip's War, a number of Native Americans for forcefully relocated to the islands, most notably Deer Island for incarceration, but possibly also Peddocks Island and Long Island, among others. A sizable percentage died from starvation and exposure.

Existing Conditions

As yet, research has not revealed exactly where Native Americans were held on the islands, or the locations of any island burial ground from the period. This is due, in part, because of extensive disturbance of the islands to construct military and institutional facilities over the past centuries and partly because comprehensive studies have not been undertaken on of all the islands.

B. Administrative and Other Regulatory Authorities

The park operates under many laws that require consultation and review by outside parties, notably the National Environmental Policy Act of 1969 (NEPA), the Massachusetts Environmental Policy Act (MEPA), and Section 106 of the National Historic Preservation Act of 1966. In compliance with environmental laws, the environmental costs and benefits of proposed actions must be fully and openly evaluated before activities take place that may impact the human environment. Prior endorsement of the Boston Harbor Island Partnership as well as affected partnership entities will also be necessary for a project to move forward.

Many of the relevant laws and regulations are describe in the preceding section. This section summarizes additional the administrative and regulatory authorities that may be applicable to the development of wind and solar power on the Boston Harbor Islands.

It is explicit in the 1996 law establishing the national park that the jurisdiction of the Commonwealth of Massachusetts, or any of its political subdivisions, remains unchanged. Therefore, all administrative or legal obligations of the island owners is in effect.

National Park Service

Unlike other units of the national park system, the National Park Service (NPS) does not own the property within the park, but is a nonland-owning participant in the 13-member Partnership that coordinates and introduces consistency in the management of the park by the federal, state, municipal and private sector owners of the islands. The legislation creating the park requires that it be managed to NPS standards.

At a national level, the National Park Service is responsible for ensuring that the resources of the National Park System are passed on “unimpaired” for the enjoyment of future generations. Park management decisions are predicated on the test that actions will not impair resources or the values associated with them. The Boston Harbor Islands.

In recent years, there have been a number of proposals for offshore wind farms along the east coast of the U.S. Several of these are in proximity to a national park. In these cases the NPS, while generally supportive of nonpolluting energy sources, must focus on the impact of the proposal on the park’s resources.

It’s worth noting that development of wind energy is strongly endorsed by the Secretary of the Interior, as expressed in the Secretary's Renewable Energy on Public Land Initiative.

Massachusetts Environmental Policy Act (MEPA)

The Massachusetts Environmental Policy Act requires state agencies to study the environmental consequences of their direct actions as well as those activities that require a state permit, state financial assistance, or land transfer from state agencies. MEPA review is not a permitting process, but a mechanism for assessment, consideration of alternatives, and development of feasible and practicable measures to avoid, minimize or mitigation damage to the environment.

MEPA applies to projects at or above certain thresholds such as: alteration of 25 or more acres of land; alteration of significant habitat including wetlands resources.

A renewable energy project on the islands will involve state actions (permitting and possibly funding). It is anticipated that a project will require at least a filing of an Environmental Notification Form.

Permit for Post-closure of a landfill (Spectacle Island)

Spectacle Island is a former landfill that has been closed in accordance with the state’s Solid Waste Management Facility Regulations. Any plan for a post-closure use that was not approved during the closure process must be reviewed and receive a permit from the Massachusetts Department of Environmental

Protection. Several factors must be taken into consideration: (1) proposed construction cannot interfere with the integrity of the final cover of the landfill, (2) structures must be above ground and no construction can pierce the low permeability barrier, (3) additional cover material may need to be added to ensure that landfill cover is maintained, (4) the use must not interferer with the facility monitoring systems in place, and (5) in the case of Spectacle, all development must be consistent the dedication of the island as a park facility, (described in Preliminary Design Guidelines) and approved by the Spectacle Island Park Advisory Committee. The guidelines state that opportunities for development of buildable sites should be pursued. While private developments must be park related and provide public uses, an “environmentally efficient” infrastructure for utilities and waste disposal is a state goal of the design plan.

Municipal Zoning

Long Island is owned by the City of Boston and within its municipal jurisdiction. It is zone B-1 Retail Businesses & Office (Zoning Districts, City of Boston, Map 2A, Boston Harbor). Allowable uses are general business categories. The maximum height of buildings in the B-1 district is 40 feet, but section 16-2 notes that this height limitation does not apply to windmills, among other uses.

Moon Island is owned by the City of Boston but lies within the municipal jurisdiction of the City of Quincy and is, therefore, subject to that municipality’s land use regulations including the Quincy Zoning Ordinance and wetlands regulations.

Moon Island is in the “Open Space” zoning district (section 17.12.040 of the Quincy Zoning Ordinance). The purpose of the Open Space district is to identify those areas dedicated or used for public or semipublic uses such as parks and recreation areas, cemeteries and open space reservations. Within an Open Space district, no buildings or premises shall be used, and no building or structure shall be permitted for other than one of the following specified purposes:

1. Conservation of soil, water, plants and wildlife;
2. Recreation, including play and sporting areas, education and nature study, golf, skating, boating, swimming and fishing where otherwise legally permitted;
3. Forestry, including tree nurseries;
4. Storage of materials and/or equipment for cemetery, parks or playground purposes.

Within an Open Space district, no structure or building shall be erected, altered or used by a public agency, except as permitted above.

Lands acquired and utilized for public or semipublic open space purposes by a private organization may be included in the Open Space district.

The portion of Moon Island identified as potential turbine sites is not designated as permanently protected open space on the build-out maps prepared for the City by the Executive Office of Environmental Affairs. The property was acquired by the City of Boston many years ago for siting of wastewater holding tanks and the city has, more recently, established a fire training academy and police firing range on the property. One of the two potential sites for a turbine is the site of a smaller, no longer functioning wind turbine, installed in 1978. Further research is needed on the status of the property and whether uses are constrained by deed restrictions or covenants.

Peddocks Island is owned by the Commonwealth of Massachusetts and within the municipal jurisdiction of the Town of Hull. The Zoning Map for the town of Hull places all of Peddocks Island in the “Conservation” district.

Long Island is owned by the City of Boston and is within its municipal jurisdiction. The island is zoned B-1 Business and Office.

The Commonwealth and its agencies and departments are immune from municipal zoning regulations as long as the entity is performing an essential government function.

Article 97

Article 97 of the Amendments to the Constitution of the Commonwealth of Massachusetts states in part that any land or easements taken or acquired for natural resource purposes shall not be used for any purpose inconsistent with recreational, conservation, or parkland related uses unless the Massachusetts legislature approves the change by a two-thirds vote of each branch of the state legislature.

State policy (EOEA-MEPA) states that, as a general rule, EOEA and its agencies shall not sell, transfer, lease, relinquish, release, alienate, or change the control or use of any right or interest of the Commonwealth in and to Article 97 land. The goal of this policy is to ensure no net loss of Article 97 lands under the ownership and control of the Commonwealth and its political subdivisions.

EOEA policy defines an Article 97 land disposition as: a) any transfer or conveyance of ownership or other interests; b) any change in physical or legal control; and c) any change in use, in and to Article 97 land or interests in Article 97 land owned or held by the Commonwealth or its political subdivisions, whether by deed, easement, lease or any other instrument effectuating such transfer, conveyance or change. A revocable permit or license is not considered a disposition as long as no interest in real property is transferred to the permittee or licensee, and no change in control or use that is in conflict with the controlling agency's mission, as determined by the controlling agency, occurs thereby.

Whether the siting of renewable energy facilities on state or municipal land would be a conversion of Article 97 lands depends on the means by which the land was originally acquired, the purpose of the acquisition, and the manner in which the right to construct a facility is granted.

Map of Scenic Landscapes

In 1981, the Massachusetts Department of Environmental Management (predecessor of DCR) created a map of scenic landscapes as identified by the Massachusetts Landscape Inventory Project. Most of the Boston Harbor Islands are included. The designations are general in nature and are intended for general planning purposes only.

Coastal Zone Management Federal Consistency

Federal Consistency is the requirement, found in Section 307 of the Coastal Zone Management Act (16 USC §1456 and pursuant regulations at 15 CFR part 930), that *federal actions* that have reasonably foreseeable effects on any land or water use or natural resource of the coastal zone must be consistent with the enforceable policies of a coastal state's federally-approved Coastal Management Program.

If establishing renewable energy facilities on these islands entails a federal action, i.e., federal license or permit, federal funding, or a direct activity of a federal agency, and is anticipated to have an effect on coastal resources, a consistency determination by the Massachusetts Coastal Zone Management Office is required.

To gauge when projects may significantly affect the coastal zone, CZM relies to some extent on established environmental review thresholds. Often, projects that are below the thresholds of the Massachusetts Environmental Policy Act (MEPA) (301 CMR 11.03: MEPA Review Thresholds) are determined to have minimal effects on the resources of the coast and are not reviewed by CZM. However, there are exceptions.

Possible actions that could trigger a federal consistency review include the National Park Service being directly involved in establishing renewable energy facilities, or the advisory reviews conducted by the FAA or Massachusetts Historic Commission (under the NHPA). The proposed sites for wind turbines have avoided sensitive coastal resources so the potential effects on natural resources should be minimal. One policy of the Massachusetts Coastal Zone Management Program Plan that may come into play in a federal consistency determination is Protected Areas Policy No. 3 which seeks to ensure that proposed developments in or near designated or registered historic districts or sites respect the preservation intent of the designation and that potential adverse effects are minimized.

VI. Preferred Alternative

The preferred alternative is a configuration of renewable energy facilities on the Boston Harbor Islands which achieves the goals set out for the project and is responsive to the physical and environmental conditions of the islands, costs and revenues, and the institutional and socio-political considerations associated with Boston Harbor and the park.

The recommended sites were selected based on a consideration of the factors presented in section IV, particularly potential community impacts, i.e., visualizations, potential impacts on environmental, historical, and cultural resources, air navigation, and the utility distribution network (capacity, age, location). The ownership, financial and operational aspects of the preferred alternative are based on an assessment of alternatives.

The preferred alternative is presented with options. For wind turbines, the options relate to siting and size of the turbine. For photovoltaics, the option is simply one of magnitude, related to cost. Reasons for and implications of the options are described below.

The preferred alternative for wind power is:

- two 660 kW turbines on Long Island at sites in the vicinity of the former Nike installation, labeled L4 and L7 on Figures 20 and 21a;

  as an alternative, one 1.5 MW wind turbine at either one of the above sites.

- one 1.5 MW turbine located on Moon Island at M2;

  as an alternative, one 660 kW turbine at M2.

- A 660 kW turbine on Peddocks Island at the south end of the tombolo at P2, and

- a 100 kW turbine on Spectacle Island on the northwest slope of the south drumlin at S4.

The alternatives suggested for Long and Moon Islands respond to the acquisition, O&M, and aesthetic advantages of using the same model turbine. The use of 660 kW turbines on Long Island is more readily consistent with FAA obstruction standards.

These particular sites and the turbine sizes respond to the key opportunities and constraints. The number of turbines will produce a sufficient amount of renewable energy and revenue to fulfill project objectives and be economically feasible, while remaining compatible with the park mission and policies and the various siting constraints. It is also possible, if circumstances permit or dictate, to do any one or any combination of the above sites and turbines.

Table 11. Preferred alternative (shaded) for wind energy and optional configurations.

	Wind power							
	Site	Site #*	Turbine size	Hub Height	Alternative Turbine option	Hub height	Estimated Annual Average Wind Speed (m/s) at hub height, based on TrueWind's map	Annual Energy, based on Truewind (MWh/yr)[5]
1	Long Island	L7	660 kW[1]	50m	1.5 MW	65m	6.5	1,626
2	Long Island	L4	660 kW	50m			6.5	1,626
2a	Moon Island	M2	1.5 MW[2]	65m	660 kW	50m	6.5	3,696
3	Peddocks Island	P2	660 kW	50m			6.5	1,626
4	Spectacle Island	S4	100 kW[3]	30m	250 kW[4]	40m	5.5	246
	Total Capacity		3.5 MW					8,574

* see Table 6 and Figure 21a - e
1 Vestas V47
2 GE 1.5SL
3 Fuhrländer FL-100
4 Fuhrländer F250
5 based on assumptions detailed in Tables 12 and 13

Long Island

The southern end of Long Island has area suitable for two wind turbines. The City of Boston, the island's owner, is interested in considering renewable energy to reduce utility costs at its facilities, for the revenue from the sale of surplus electricity and RECs, and as part of its commitment to sustainability. It is known that the height of a 1.5 MW turbine on a 65 meter tower would penetrate certain of the FAA's surfaces, so 660 kW turbines have been proposed. Assessment of the potential to reduce the tower height for a 1.5 MW turbine or a further investigation of the obstruction standards is needed to determine the feasibility of the larger turbine.

The capacity and condition of the NSTAR feeder lines from National Grid to Moon, Long and Spectacle is one of the principal considerations in the feasibility and limitation on amount of renewable energy generating facilities on these islands.

Moon Island

Moon Island can support a turbine in one of two potential sites. The first is on the northwest slope of the hill, and the second is at the location of the small wind turbine at the north corner of the island. The Moon Island location might be considered an alternative to one of the Long Island sites or an additional location. The advantages of this site over Long Island is the avoidance of transmission along the electric cable spanning the Long Island bridge and much less an issue with air navigation surfaces. It is closer to the residential neighborhoods of Quincy, so its aesthetics need further, more refined exploration.

Peddocks Island

Peddock's Island is not currently grid-tied. If significant renewable energy generation is to be developed on Peddock's, an electric cable connecting Peddock's Island to the mainland will need to be installed. Two routes are conceivable: connecting to Hull and feeding the electricity to the Hull Municipal Light Plant, or connecting to the Mass Electric (National Grid) distribution network from Quincy.

A study commissioned by the Island Alliance was recently completed on the alternatives for providing wastewater treatment, potable water, and electricity in support of future development envisioned for Peddocks Island. One of the options studied is to connect the island to Hull bringing water, wastewater and power lines through a utility tunnel beneath Hull Gut. The estimated cost of this utility connection is $3.9 million which could be paid for in whole or in part with funds from a restricted grant received by the Island Alliance from Duke Energy. The capacity of the planned electric line would support the wind turbines proposed for Peddocks.

Spectacle Island

One medium size turbine is proposed for Spectacle Island largely because of height limitations resulting from the island's proximity to Logan Airport. Spectacle is serviced by a new 15 kV undersea cable connecting to Long Island, so has no interconnection issues beyond those that exist for Long Island. Spectacle Island is a Massachusetts Department of Environmental Protection certified closed landfill site. If the turbine is sited on the landfill portion of the island, it will be necessary to submit a post-closure permit application to DEP. Post closure use must not interfere with the facility monitoring systems installed on the island and must be consistent with the dedication of the island as a park facility.

Project Ownership Structure and Financing

The goals that drive the interest in developing renewable energy in the Boston Harbor Islands national park area are fundamental to determining the appropriate ownership structure. The most attractive ownership structure is the one that offers the best combination of maximizing the amount of revenue to benefit the park and support activities within the park, and limits the risk for the island owners, the Partnership, and the Island Alliance.

The ownership structure that would appear to best respond to these criteria is for the Island Alliance to be project developer, responsible for financing, developing and operating the renewable energy assets. To do this the Island Alliance forms a taxable subsidiary, specifically, a limited liability corporation (LLC). The LLC's board of directors would include representatives of the City of Boston and the Massachusetts Department of Conservation and Recreation (the islands' owners), and wind power professionals. Through this LLC, the Island Alliance would enter into a joint venture with other (taxable) partners also structured as an LLC, to help capitalize the project. The nonprofit would include a small professional staff to perform some of the development roles while other tasks are subcontracted.

This arrangement avoids jeopardizing the Island Alliance's tax-exempt status and shields it from most of the liability. It positions the Island Alliance to capture a reasonable portion of the revenues, allows others to invest in the project, and takes advantage of the tax benefits available for developing wind power.

The Island Alliance does not have a large amount of its own funds to invest in a renewable energy project. However, the Island Alliance's status in the park's legislation as developer for the park could be converted to equity in the project; i.e., the Island Alliance's legislatively-defined role in revenue generating initiatives should be considered an asset it brings to the project. Additionally, the Island Alliance would be the logical recipient of any grant funds that might be available for the development of renewable energy. Finally, the Island Alliance has the ability to borrow funds, which could be justified to increase its stake in and share of revenues from the project.

The alternative of the City of Boston, for example, owning the renewable energy generating facilities was considered, but determined to be laden with more uncertainties and potential risks. Massachusetts General Laws clearly authorizes municipalities to construct or purchase plants for the manufacture or distribution of electricity. This would likely require authorization by a two-thirds vote of the Boston City Council in each of two consecutive years and ratified by a majority of voters in an annual or special city election. Among the risks of city ownership is that the city would be required to purchase any existing power generation and distribution facilities within the municipality if the owners of those facilities elected to sell. While it is unlikely to that generators within the city limits would elect to sell, the possibility that some distributors may elect to sell cannot be ruled out. This statutory requirement presumably was established to protect small generation and distribution facilities from unfair competition by a municipal monopoly.

Assuming the Island Alliance decides to develop utility connections to the mainland, and those connections are to Hull, the Hull Municipal Light Plant (HMLP) is a logical partner in the renewable energy project on Peddocks. HMLP has experience with the development and operation of wind power and has access to capital. The generation of additional renewable energy makes sense for Hull as the electricity it purchases from its suppliers is quite expensive.

Project Economics

This section estimates the costs and revenues for the preferred alternative for wind power as described above.

Projected revenue is the value of the energy generated from selling the energy to the regional grid (or, possibly, to the Hull Municipal Light Plant in the case of a turbine on Peddocks Island), the displacement cost of purchasing energy for the facilities on Long Island and Moon Island, and the sale of renewable energy certificates. Taxable entities also benefit from a federal tax credit.

The Massachusetts Electric Utility Restructuring Act (1997) established the renewable energy portfolio standard which requires that one percent of energy provided by retail electricity suppliers be generated from new renewable energy sources by the end of 2003. This requirement increases by one-half percent each year until 2009 at which time it reaches four percent. The requirement increases by one percent per year, thereafter. Each Renewable Energy Certificate represents one MWh of electricity produced by a renewable energy source and purchased by a retail electric supplier at market value or as a fixed price under a long-term agreement. Price per kWh has historically ranged from 2.5 to 5.1 cents, subject to market conditions. There is no guarantee that future Certificate prices won't fall well below 2.5 cent/kWh.

The production tax credit (PTC) for wind energy was recently reauthorized through the end of 2005. The PTC provides a tax credit of 1.5 cents per kilowatt-hour (in 1992 dollars, adjusted for inflation; current value is 1.8 cents/kWh) for power produced by wind turbines. The credit is a business credit that applies to electricity generated from wind plants for sale wholesale. It is available for the first 10 years of a wind plant's operation. The company with ownership of the wind generators is able to subtract the value of the PTC from its federal tax bill.

For public entities (which are unable to take advantage of the PTC) the federal government offers a renewable energy production incentive (REPI) payment. This payment is equivalent to the PTC but is subject to annual appropriation. As such, it is difficult to rely on REPI payments. However, it is not unreasonable to anticipate that some portion of revenue from these payments will be available to a project.

Table 12: An example of costs and revenues, 1.5 MW turbine, Moon Island.

Turbine type	**GE 1.5sl**
Turbine height	65 meters
Rated Power	1,500 kW
Assumed Annual Mean Wind Speed	6.5 m/s
Capacity Factor	29%
Availability	97%
Hours per year	8,760
Annual Energy Production KWh/year	3,696,282
Revenues	
Energy Price $/kWh	0.04
Mass RECs $/kWh	0.035
Federal tax credit	0.018
Revenue rate $/kWh	0.093
Estimated Annual Revenue	$343,754
Costs (excluding finance costs)	
Installed cost ($2M/MW)	$3,000,00,00
Annual admin, maintenance and insurance (.012/kWh)	$44, 355
Net annual revenue after expenses	$299,399

Table 13: Example of costs and revenues, 660 kW turbine (Long, Peddocks Island)

Turbine type	**Vestas V47**
Turbine height	50 meters
Rated Power	660 kW
Assumed Annual Mean Wind Speed	6.5 m/s
Capacity Factor	29%
Availability	97%
Hours per year	8,760
Annual Energy Production kWh/year	1,626,364
Net metered kWh/year (est.)	175,200
Electricity sold kWh/year	1,451,164
Revenues	
Energy Price $/kWh *	0.047
Mass RECs $/kWh	0.035
Federal tax credit	0.018
Revenue rate $/kWh	0.10
Estimated Annual Revenue	$162,636
Costs	
Installed cost ($2M/MW)	$1,332,000
Annual admin, maintenance and insurance (.012/kWh)	$19,516
Net annual revenue after expenses	$143,120

* $/kWh is the weighted average of the retail price for net metered use and wholesale price for electricity sold.

Applying these assumptions and estimates to the preferred alternative: two 660 kW turbines on Long Island, one 1.5 MW turbine on Moon Island and one 660 kW turbine on Peddocks Island, net annual revenue is approximately $728,759. This is the amount of money available for equity partners, financing costs, and profit.

Table 14 Preferred alternatives for solar energy.

Location	Peak Power (kW_p)	Annual Energy (kWh)
Long Island		
1. Fire Station	8.78	10,138.07
2. Garage	16.80	18,377.60
3. Morris	68.75	79,384.08
4. Tobin	60.79	70,192.85
5. McGilvery	72.90	70,885.04
6. Ward ABCD	20.52	19,952.83
7. Nichols	46.71	42,580.25
Long Island total PV	*295.25*	*311,510.70*
Peddocks Island		
2. New Guardhouse (VC)	11.20	14,385.67
Peddocks total PV	*11.20*	*14,385.67*
Moon Island		
Fire Academy	17.42	20,114.48
Moon Island total PV	*17.42*	*20,114.48*
TOTAL	**323.87**	**346,010.85**

Recommendations for project development

Wind data resource assessment

As this Planning Guide was being finalized, RERL placed a SODAR unit (wind monitoring device) on Long Island in the vicinity of the proposed turbine locations. RERL has been gathering data on Thompson Island for a number of years and this is acceptable for evaluating the feasibility of turbines on Thompson. Average wind speeds on the other four more eastern islands can be predicted to be greater than Thompson's speeds. Correlation with other data (including Logan airport data, and wind speeds estimated from Hull's power production records) could be used to estimate how the winds vary over space, but special models of wind in complex terrain are less reliable than actual data. Having data from a location on Long Island will be very useful.

Interconnection

Once final site selection and power production levels are decided, the utility impact study process is initiated by submitting a "Notice of Intent to Interconnect a Qualifying Facility or On-site Generating Facility to NSTAR's Distribution System." The cost of the study is in the vicinity of $20,000.00.

Recommendations for avoiding and mitigating potential impacts on birds

Direct

- Minimize the clearance of trees and shrubs for the turbine(s) and for the installation process: minimize the footprint.
- Incorporate appropriate design features: use monopoles not lattice towers, avoid using guywires, bury all power lines, minimize lighting, follow current best practice with respect to birds.
- In future, be prepared to retrofit turbines with appropriate bird/bat-friendly features if such become available.

Indirect

- The listed species most likely to benefit from specific actions in the Harbor is the Common Tern. In this area it is largely dependent for nesting on artificial sites, probably because of rats and other predators (Hatch 2001). Installation of a new nesting platform as well as monitoring and maintenance of the platform in Hull would be valuable. Any new platform should be remote from turbines. Posting and protection of existing tern colonies is also important.
- Removal of rats from the Brewsters might allow several seabirds to nest.
- Elimination of all introduced predators, including domestic cats.

VII. Obstacles to development and strategies for overcoming them

Interconnectivity

Turbine development on Long Island and, possibly, Moon Island is dependent on upgrade of the 4160 volt feeder cable connecting the islands to the mainland grid. This feeder cable is part of the NSTAR distribution system which connects (at the gatehouse at Moon Island) to the main service line from Quincy owned by National Grid. Based on communications with NSTAR, it is believed that currently the maximum capacity of lines from National Grid to Moon, Long and Spectacle is one MW. Further, this line, especially as it crosses the bridge between Moon and Long Islands is in poor condition; there are reports of several recent incidents of sparking and melting of wires.

When this feasibility study began, a request by the City of Boston for $30 million to rehabilitate the bridge to Long Island was included in the Metropolitan Planning Organization's Transportation Improvement Program (TIP). The TIP lists all transit and roadway projects anticipated to be implemented with federal and non-federal-aid during the subsequent three-year period. This project has since been indefinitely postponed by the MPO. A permanent upgrade of the utility lines would have been part of this project.

The electric lines serving Long Island need to be replaced. Incidents of the lines sparking and melting will only increase with time and the need to continually repair the lines seems inconsistent with safety and reliability requirements of a major public health services facility such as operates on Long Island. This is a very compelling reason for NSTAR to upgrade the line.

Adding wind energy generators to the electric grid requires a utility impact study of the distribution network and, in this case, particular attention to the condition and capacity of the feeder cable connecting Long Island. These studies are done by NSTAR at the expense of the proponent. NSTAR shared some general information about the facilities serving this area, but a study of both NSTAR's and National Grid's distribution network is necessary before a project for these islands can move forward.

Parkwide Scenic Resources Study

Visual or aesthetic effects of new structures in the landscape is a primary consideration in siting wind turbines generally, and was one the primary issues the predevelopment study for the Boston Harbor Islands attempted to address. As is typically done, the study team prepared visualization of turbines positioned at various locations on the islands and presented them at meetings of stakeholders and the public (examples in Appendix B). We received no unfavorable reaction to these images during this process.

There is an interest among members of the Partnership (Island Alliance and the National Park Service, in particular) to explore the issue of scenic viewscapes within the park in a more comprehensive manner. While visual resources are among the park's attributes and values, there is no identification of where or qualification of what those resources are. The Planning Committee of the Partnership has taken on the task of conducting a Viewshed Study, or scenic evaluation, for the park to provide answers to those questions. As of the date of this Planning Guide, the Island Alliance has issued an RFP for a viewshed study which “is proposed as a tool for identifying and classifying important visual attributes of the area encompassing the Boston Harbor Islands National Park Area. This study is proposed in an effort to be deliberate, transparent and prospective regarding any significant, view-altering proposed infrastructure changes including the possibility of the placement of wind machine(s) in the park area.”

Consequently, the acceptability of the visual impacts of any proposed turbine on the park’s viewscapes might best be determined in the context of that study. It is anticipated by this study’s project team that the locations being considered for wind turbines in the Planning Guide will not be found among the park’s priority viewscapes. The subject islands are in the inner reaches of the harbor, adjacent to urbanized landscapes, and are themselves among the more heavily developed islands.

The viewshed study will provide information on the qualities and relative importance of various viewscapes within the park, but is not designed to determine the acceptability of a particular structure such as a wind turbine, even when placed in a location of “low” scenic attributes. Visualizations of any specific proposal (similar to those done during this feasibility study), need to be prepared and presented to the public and organized interest groups to determine general acceptability. Visual impacts to any National Register sites or eligible sites in proximity to any of the final sites will need to be addressed.

Revenue Sharing

When park-related revenues are being generated on the islands, each island owner uses the revenue first to maintain its own island-related operations. “Excess” revenues are pooled in a parkwide fund for the Partnership to be administered by the Island Alliance acting as the fiscal agent. Legislation at the state level is necessary to enable the creation and retention of fees by state and local agencies as well as for the opportunity for long-term leases to attract private investment.

Designation of the park did not change the authorities of any of the island owners. They are free to use their land within the park in ways that are consistent with their own missions, having agreed only to do so consistent with the park’s policies. An island owner could install renewable energy facilities on its own without interference from the Park’s Partnership, particularly if it is consistent with a predevelopment feasibility study endorsed by the Partnership.

Navigable Airspace

Review by FAA of the preliminary wind turbine sites provided information that assisted in reducing the number of sites for further consideration. Once sites and turbine sizes are finalized, notification to the FAA on FAA Form 7460-1, Notice of Proposed Construction or Alteration, will need to be made. That notification will be circulated for and advisory review to interested parties including the Air Transport Association of America, which represents most of the major air carriers at Logan, the Massachusetts Port Authority, and the public.

VIII. Outreach and Education

An extensive public outreach and education effort was conducted throughout the course of this predevelopment study. It was guided by an Outreach and Education plan prepared at the outset of the project, but every opportunity to reach or engage the public was taken as it presented itself.

The project team worked closely with a large group of project partners and collaborators. This group served well as the project's informal steering committee.

George Price, Superintendent, Boston Harbor Islands National Park Area
Peter Lewenberg, Special Assistant to the Secretary, Executive Office of Environmental Affairs
Doug Welch, Island Alliance
Howard Bernstein, Mass. Division of Energy Resources
Sue Brown, Boston Parks & Recreation
Brian Taylor, LIC,
Brad Swing, Mayor's Office of Environmental Services, City of Boston
Sarah Zaphiris, Mayor's Office, City of Boston
Sarah Meginness, Healthy Cities Initiative, Boston Public Health Commission
Larry Chretien, Mass Energy
Ellen Berkland, Archaeologist, City of Boston Environment Department

The Boston Harbor Islands Advisory Council, representing 28 different entities and interests, was a valuable sounding board at regular intervals during the feasibility study (see Appendix E for list of members).

An Outreach and Education Plan prepared at the beginning of the study outlined the measures to be taken to ensure the public and stakeholders would be adequately informed of the study as it progressed and have ample opportunity to participate in decision making. This plan is in Appendix A.

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Appendices

Outreach and Education Plan

The ultimate success of this project will depend, in part, on public acceptance and endorsement of the proposed development scenarios. General public acceptance can be enhanced through a timely and inclusive outreach and education process. The material presented to the public must be developed with integrity, be accurate, and complete.

For this project, the "public" is defined both as the organized stakeholders such as public officials and harbor and islands advocacy groups, as well as the general public. The project's outreach and education plan is designed to reach out to both types of constituencies in ways most effective for each. The outreach and education efforts consist of 1) material developed and distributed to reach the public through a variety of outlets and 2) opportunities throughout the project for both the organized and general public to be presented information and provide input and reaction.

The following are components of the public outreach and education program for this project. Unless otherwise noted, timing of the activity will be determined by the team and steering committee as the project progresses.

1. Create a project steering committee of vested and informed individuals to advise on and assist with public outreach efforts and other matters. Meetings with the project Steering Committee will occur throughout the project (May 2002).
2. Maintain regular communication with the island owners. This may involve several departments or officials of each government or entity. For example, the team will meet regularly with several City of Boston departments: Boston Public Health Commission, Department of Neighborhood Development, and the Environment Department. The latter provided important input during development of the project scope and it is in the interest of the project to provide adequate and timely information in response.
3. Regularly attend meetings of groups with an interest in the project. Such groups include the (Boston) Mayor's Energy Management Board and the Subcommittee for Renewable Energy and Sustainable Development (of the Boston Harbor Islands Partnership).
4. News releases, prepared stories, or interviews
    a) Newspapers: Issue an initial press release to introduce the project to the public following preliminary meetings with all *key* stakeholders, including representatives of the City of Boston, City of Quincy, Mass. Department of Environmental Management, Boston Harbor Islands Partnership, Boston Harbor Islands Advisory Council, and Friends of the Boston Harbor Islands.

       Issue regular news releases at significant milestones in the course of the project. As an alternative to a press release, arrange for stories to be written or broadcast by

       Newspapers to receive press releases and/or story invitation include:

        Boston Globe

Boston Herald

Patriot Ledger

Community and Neighborhood newspapers around the harbor

Mass Media (University of Massachusetts newspaper) and others

b) Radio and television: Issue releases or story invitations to local radio and television stations. For example:

Community access cable in surrounding communities

College radio stations such as WUMB (University of Massachusetts Boston) and Emerson College radio which aired an interviews on the project in March.

Regional stations

c) Newsletters of organizations: one of the best ways to inform people with a particular interest in the harbor and islands is through the newsletters of organizations active around the harbor. Among these are:

Save the Harbor/Save the Bay

The Boston Harbor Association

Friends of the Boston Harbor Islands

Mass Audubon

National Park Service

d) Web pages: Create a project page as part of the Urban Harbors Institute's web site. Create links to web sites of the National Park Service's Boston Harbor Islands page, the City of Boston, the Renewable Energy Research Laboratory at UMass Boston, and others.

5. Maintain regular communication with the Boston Harbor Islands Partnership and Advisory Council to keep these organizations apprised of project status and progress.

   Present regular reports at:

   Partnership meetings

   Advisory Council meetings

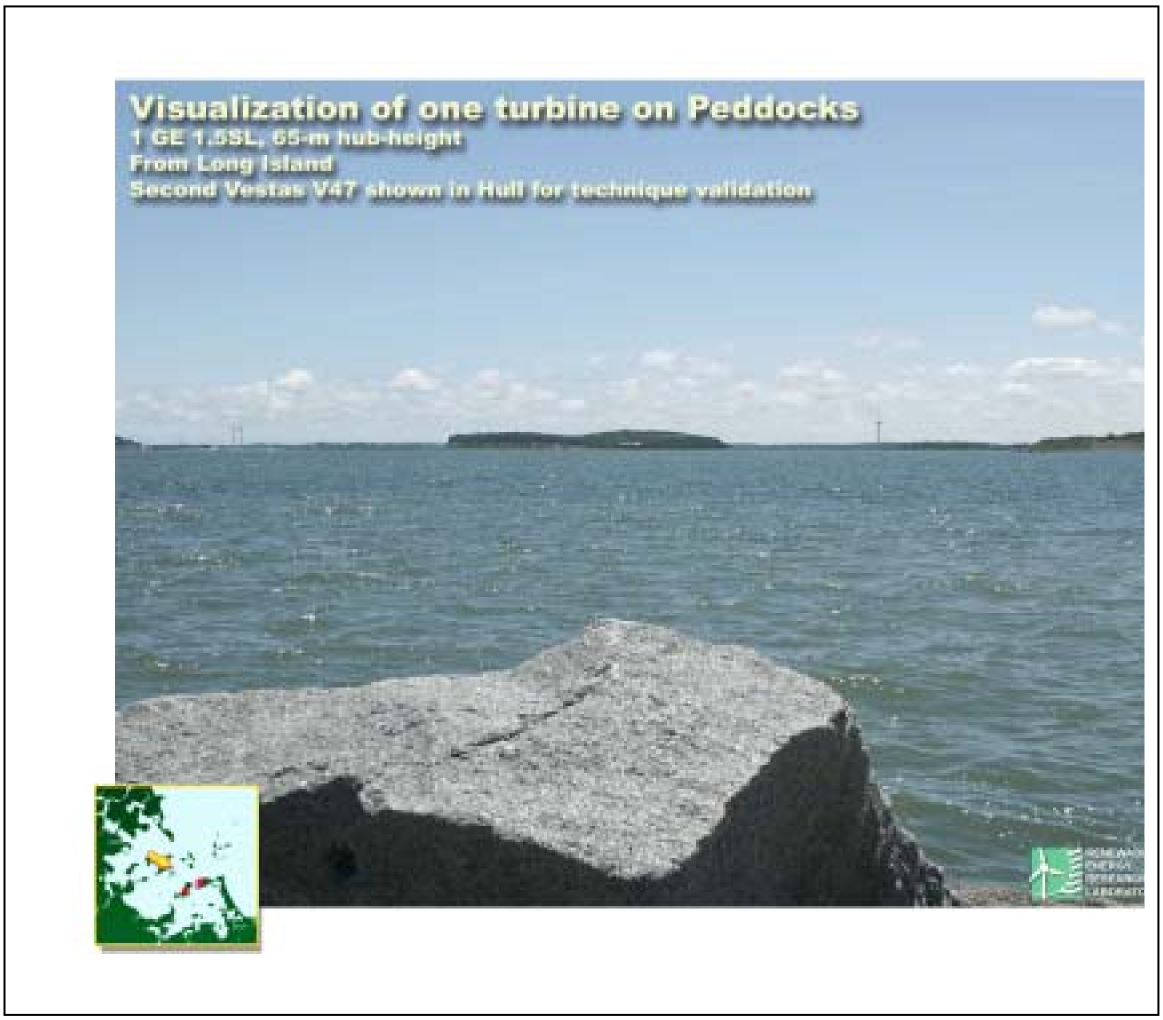
6. Prepare and distribute fact sheets: Appropriate subjects could include the 1) the theme of sustainability for the Boston Harbor Islands National Park area, 2) renewable energy resources of the harbor and islands, 3) the technologies, 4) the process and benefits.

7. Field trips: Invite others who have an interest in the project on the team's trips to the islands. This would provide and opportunity for people to get a first-hand look at the resources. This might include project-sponsored visits to the wind turbine at Pemberton Point in Hull.

8. Make presentations at appropriate conferences and workshops during the course of the project.

9. Speak to harbor advocacy, community, or neighborhood groups upon request.
10. Plan, organize, and sponsor three public education and outreach meetings. Locations of these open public meetings would likely be Boston and Quincy. The purpose of these sessions is to inform the public and solicit public reaction and input. The first of these meetings would be scheduled after the island survey and resource analysis are complete and at least initial work has been done on the development scenarios, environmental impact analysis and financial feasibility. This scheduling is designed to allow the team to be able to present solid information and answer questions, yet be early enough in project formulation to take advantage of public input.
11. Meet with NSTAR Distributed Power Generation (DG) personnel to investigate interconnection issues that may have an impact on development scenarios. This includes potential upgrades to network feeders and power distribution systems within their service territory.
12. Meet with and brief federal and state elected officials on the goals and benefits of the project.
13. Develop information about renewable energy on the Boston Harbor Islands to become part of the interpretive talks by park rangers to visitors. Integrate this information into interpretive materials on display at gateways and the islands and on the ferries.

Sample visualizations



Summary of findings for Tidal and Wave Energy in the area surrounding the five islands subject of the Predevelopment of Renewables in the Boston Harbor Islands National Park Area

Tidal and Wave Energy

Waves and tides contain large amounts of energy that can be converted to electrical energy. Commercial wave powered electrical generation technologies are relatively new, however, and only a small number have been tested in artificial wave tanks and at sea, let alone deployed for actual power production.

Waves are created as wind blows over the ocean surface. The amount of energy generated by waves depends upon wind speed, length of time the wind blows, and the distance over which the wind blows (fetch). Energy is stored in waves until it is released when the waves reach they the coastline. Tides, which originate from the motions of the earth, moon and sun, contain significant amounts of energy, though electrical generation is only practical in areas with exceptionally high tides.

Devices for capturing wave energy are designed for offshore, nearshore or shoreline applications. While wave energy is less in nearshore environments, installations are less complex and costly. There are three general types of shoreline devices:

- oscillating water column (OWC): a submerged (sometimes partially) structure, with an opening to the sea below the water line. As waves enter the opening they cause the water column within the structure to rise and fall, compressing the air above and forcefully releasing it to the atmosphere through a turbine which drives an electric generator. This type of structure can be incorporated into a breakwater or seawall.
- tapered channel: this installation has a gradually narrowing channel with wall heights extending above mean sea level. The waves enter the wide end of the channel and become amplified as they move through the narrowing channel until the waves crest and spill over the walls to a reservoir. The reservoir serves as the water supply for a conventional low head turbine.
- pivoting flap: this device consists of a rectangular box, open to the sea at one end with a pendulum flap hinged over the opening. The action of the waves causes the flap to swing back and forth powering a hydraulic pump and generator.

Tidal power is produced, most commonly, by creating a basin which fills during the flood stage of the tide. On the ebb tide, the water flows out through a powerhouse and turbine to produce electricity. The basin is usually created by constructing a barrier across a river estuary or an embayment. It is also conceivable that an existing basin could be utilized for this purpose if it were of adequate size.

Boston Harbor Waves

Boston Harbor is protected from ocean waves by the land embracing it (the peninsulas of Hull and Winthrop), the islands within it, and the distant arm of Cape Cod. Waves are determined in part by the fetch, or the length of water across which the wind is blowing. Protective land greatly reduces the fetch, and therefore reduces wave height in the Harbor. Waves are also a function of the harbor cross-section (depth and width) and the sustained wind velocity. Of the four islands under study, Thompson, Spectacle, Moon, and Long Island, the east side of Long island will have the highest energy waves.

The nearest wave data is collected from station 44013, which is 16 miles northeast of Boston at 42.35n, 70.69W, has an average significant wave height of 0.7 meters, an average wave period of 5.7 seconds, and an average dominant wave period of 8.0 seconds. Significant wave height is defined as the average height of the highest one-third of the waves during a sampling period (20 minutes). The wave period is the period of the highest one-third of the wave observed during the sampling period. The dominant wave period is the period with the maximum wave energy. Average wave height and period also vary seasonally in the Boston Harbor, with stronger waves in the winter months.

Given the distance of the wave data buoy from the islands covered by this report, and the presence of “blocking” islands, we conclude that the wave resource does not warrant further investigation at this time. We do note, however, that MTC is conducting a detailed near-shore wave resource assessment in early 2003.

Table 1: Wave height and period at Boston Harbor Site 44013, 6/86-12/93.

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec
Ave. Single Wave Height (m)	0.8	0.9	0.9	0.9	0.6	0.5	0.4	0.4	0.5	0.8	0.8	0.9
Ave. Wave Period (s)	5.4	5.5	5.9	6.1	6.0	5.9	5.6	5.9	5.7	5.9	5.1	5.3
Ave. Dom. Wave Period (s)	7.7	7.6	8.4	8.6	8.2	8.0	7.7	8.4	8.2	8.5	7.4	7.7

Boston Harbor Tides

Boston Harbor has an average daily tide range of 9.5 ft. This average varies slightly within the Harbor, with a mean tide range of 9.48 ft. at Nut Island, 9.09 ft. at Boston Light, and 9.55 ft. at the Boston Harbor data station. The averages also vary from month to month. The predicted tide range is between 8 and 14 feet, but storm tides can rise to 18 or 19 feet.

Table 2: Average tidal range in Boston Harbor for 2001 (in meters above MLLW).

Site	Station #	MHHW	MHW	MLW	MLLW	GT	MN
Boston Harbor	8443970	3.185	3.055	0.158	0.045	.0140	2.897
Nut Island	8444525	2.847	3.028	0.140	0.030	3.124	2.888
Boston Light	8444162	3.023	2.885	0.146	0.037	2.986	2.739

MHHW - Mean Higher-High Water
MHW – Mean High Water
MLW – Mean Low Water
MLLW – Mean Lower-Low Water
GT - Difference between MHHW and MLLW (Diurnal Range)
MN – Difference between MHW and MLW (Mean Range)

Tidal energy is practical only in areas with large tides and where the shoreline environment is conducive to the creation of tidal basins. In general, the tidal range in Boston Harbor is considered insufficient to support an economically viable commercial installation. However, subsequent tasks will include further assessment of the potential to utilize tidal power in the study area.

Table 3: Average monthly tidal range in 2001 at Boston Harbor Site 8443970 (meters above MLLW).

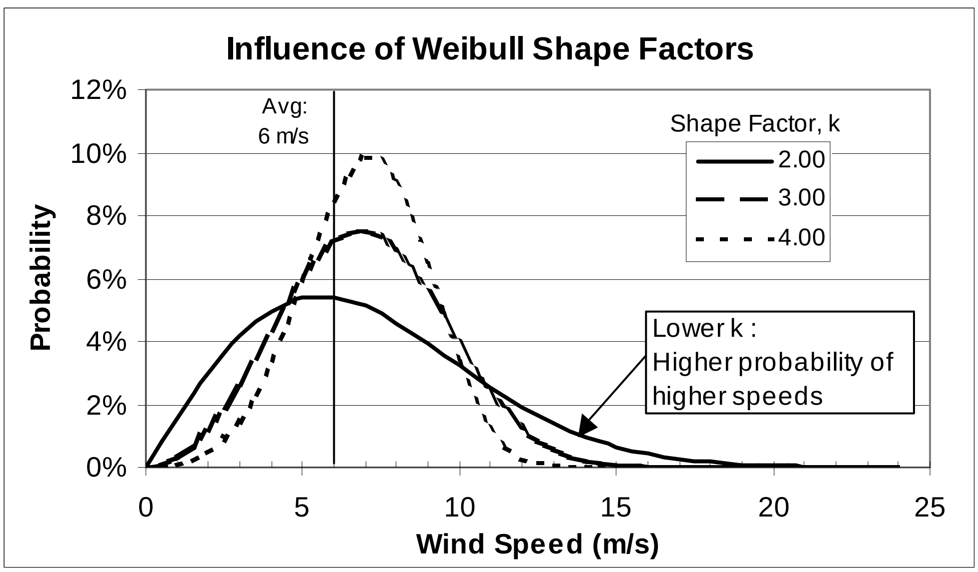
Month	MHHW	MHW	MLW	MLLW	GT	MN
January	3.171	3.040	0.139	0.022	3.149	2.901
February	3.091	2.956	0.027	-0.067	3.158	2.929
March	3.227	3.117	0.170	0.079	3.148	2.947
April	3.172	3.061	0.109	0.002	3.170	2.952
May	3.188	3.085	0.148	0.027	3.161	2.937
June	3.203	3.070	0.151	0.033	3.170	2.919
July	3.236	3.082	0.163	0.042	3.194	2.919
August	3.213	3.066	0.174	0.072	3.141	2.892
September	3.210	3.084	0.223	0.129	3.081	2.861
October	3.155	3.046	0.217	0.114	3.041	2.829
November	3.141	3.005	0.176	0.050	3.091	2.829
December	3.214	3.047	0.198	0.040	3.174	2.849

Definitions related to wind energy

For a further discussion of the significance of these terms, see Manwell et al. (2002.)

Weibull shape factor: The probability distribution of wind speeds can be represented by a Weibull distribution, which describes the shape of the function with a "shape factor", k, and a scale factor, c, which is a function of the average wind speed. Most wind regimes have a shape factor between 1.5 and 4. The figure below shows the distribution defined by three different shape factors.

A lower k describes a lower concentration around the average speed, and a higher probability of higher wind speeds, for which power output is much higher. Roughly speaking, a lower k is an indicator of higher power output. Thompson Island data have correlated well with a shape factor of slightly under 2.0, so using a k value of 2 is probably appropriate or slightly conservative.



Influence of the Weibull Shape Factor on Wind Speed Distribution.

Availability: The availability for a wind power installation is an indicator of the mechanical and electrical reliability of the system. It is the percent of time that the wind turbine is either producing power, or would be producing power if the winds were sufficient. Modern, megawatt-scale wind machines with mature designs have availabilities in the range of 97% or higher (Vachon et al, 1999).

Capacity Factor: Since wind is not a constant power source, the turbine nearly always produces less than its "rated" power. The capacity factor is an indictor of how It is calculated as the energy (kWh) produced over a period, divided by the rating times the number of hours in the period. For instance, Hull's 660-kW turbine made 1,597,000 kWh in its first year (8760 hours) so the capacity factor is 1,597,000/(660 * 8760) = 27.6%. (Note that this method of calculating capacity factor implicitly includes availability, since the hours that the turbine was down for maintenance was not subtracted from the 8760 hours of operation.) The capacity factor is primarily a function of a site's wind speeds, though the turbine design also contributes.

Turbulence intensity: Turbulence intensity over a given time interval is calculated as the ratio of the standard deviation of the wind speed, to the average wind speed over that interval. Turbulence intensities typically range between 10% and 40%. Higher turbulence intensity reduces the power output of a turbine, and also increases the wear on the turbine. Turbine manufacturers' power curves are typically for a given range of turbulence intensity; if the power is to be estimated in a region of higher turbulence, the curves must be derated. Turbulence can also affect the accuracy of the measurement equipment; highly turbulent winds accelerate cup anemometers, leading to higher readings.

Boston Harbor Islands Advisory Council

2003
by Interest Groups

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Wampanoag Tribe of Gay Head (Aquinnah)
Member and Voting Partner

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Mohican Nation
Member

Linda Poolaw
Delaware Tribe of Western Oklahoma (Anadarko)
Member

John Sam Sapiel
Penobscot Nation
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Narragansett Tribe
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Vivien Li
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Chris McCabe
Town of Hull
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