NANTUCKET WIND TURBINES
WHITE PAPER - Mod 4.8
As of September 17, 2010

New information since Mod 4.7

ENERGY COMMITTEE

The Nantucket Energy Committee (NEC) is an advisory committee appointed by the Nantucket Board of Selectmen. The NEC reports to the BOS on energy related issues affecting Nantucket energy users; recommends policy or code amendments; evaluates and explores potential energy production for Nantucket; and serves as a resource for information on renewable and sustainable energy including wind, tidal, solar, wave power, and energy conservation measures.

The following white paper introduces a concept to install 1-3 turbines with a size range of 660 KW to 1.5 MW in the Landfill / Massasoit area, as well as a plan to install solar arrays at the Nantucket Municipal Airport, the Wannacomet Water Company and at the Waste Water Treatment Facility (WWTF).

GENERAL BACKGROUND

Wind has been the fastest growing source of electricity generation in the world. The majority of this growth has been in Europe, where conventional energy costs are higher than those in the U.S. With large untapped wind energy resources throughout the U.S. and declining wind energy costs, the U.S. is now moving forward into the 21st century with an aggressive initiative to accelerate the progress of wind technology.

In 2009 the United States installed 9,900 MW of wind power an increase of 39 percent more capacity. Total US capacity now stands at 35 GW[1]. The United States leads the world in wind capacity additions and in cumulative capacity. The competitive cost of wind had made it the second largest source of new electric power generation in the U.S. for the past three years behind natural gas and ahead of coal[8].

The U.S. lags behind other countries for wind as a percentage of electricity consumption. The U.S. national power capacity is 1032 GW. Wind generation represents just 2% of the U.S. electricity supply, while that percentage is not as high as 20% in Denmark, 12% in Spain, 9% in Portugal, 8% in Ireland, and 7% in Germany.

China is the fastest growing market for wind power [(3)]. Demand for electricity in China is increasing at ~ 10% per year. China has 12.2 GW of installed wind capacity at the end of 2008. It now ranks 4th in the world, only surpassed by the US, Germany, and Spain. Current Chinese policy calls for 100 GW of installed capacity by 2020.

MA Governor Patrick has set a goal of having 2000 MW of installed capacity by 2020. Currently MA has about 7 MW of installed capacity [(7)]. Wind Energy Reform Siting Act Legislation is being proposed by the Governor. The permitting timeline will be reduced from 5+ years to between 1 – 1.5 years

NANTUCKET BACKGROUND

[1] New York Times, Jan 26, 2010

Nantucket's energy costs in winter are some of the highest in the United States. Massachusetts with an average cost of 17.85 ¢/kWh has the third highest electricity rates behind New York (19.42 ¢/kWh) and Connecticut (20.24¢/kWh).

Nantucket has two principal sources of energy. Electric power transmitted from the mainland via two 35 MW and 41 MW under water cables and petroleum products shipped from the mainland. The electric power cost to the consumers includes delivery services (summer rate 7.74 ¢/kWh or winter rate 6.61¢/kWh) and supply services (11.79 ¢/kWh). Nantucket imports approximately 10 million gallons of fuel per year.

Nantucket has some of the highest prevailing winds in the United States. Our wind power is classified as outstanding (17.9 to 19.7 mph) by the US Department of Energy. The long term wind resource in the Nantucket potential project areas is about 8.90 m/s (19.9 mph) at 80 meters above ground level, about 7.64 m/s (17.1 mph) at 50 meters, and 6.50 m/s (14.5 mph) at 30 meters [(2)].

In 2008 at the request of the NEC, The UMass Amherst surveyed 10 Nantucket land based sites for wind turbines [(4)]. Considerations included distance from the airport, distance from housing, and average wind speed / directions. The recommended sites were at the Surfside Waste Water Treatment Facility (WWTF) and at the DPW Solid Waste Treatment facility. Both these sites are heavy power consumers which makes turbines feasible as a way to reduce the Town's operational expenses**.**

In 2009, the Massachusetts Collaborative Trust (MTC) entered into a Work Order with Black & Veatch to perform a wind project feasibility study for the Town of Nantucket [(2)]. The FAA site is an attractive site for Roll-on Roll-off (RORO) methods for transporting wind turbines to the site. A GE 1.5 MW sle turbine at this site yields a capacity factor [(a)] of nearly 47%. A GE 1.5 MW sle turbine located at the FAA site yields a simple payback of 4.5 years with virtual net metering. "Virtual net metering" allows for the Town and community to benefit directly from wind generation anywhere on the Island.

Black & Veatch study noted that a potential location for a wind turbine could be at an abandoned radio tower at the northwestern portion of the site. The 467 ft tower is located adjacent to the DPW office and was once used for cable TV communications. Unexploded ordinance (UXO) is known to exist in and around the northern end of the landfill from previous US Navy operations, and poses as a major safety hazard to the construction and maintenance of a wind turbine. Any development of a project on this site would require the UXO be located and removed by qualified specialists.

DATA ACQUISITION

1. (May 9, 2008) At the request of the NEC, the Massachusetts Technology Collaborative (MTC) provided a grant which enabled Charles McClelland and Mary Knipe of the UMass Renewable Research Laboratory (RERL) to visit ten potential sites on Nantucket Island in order to evaluate their suitability for medium and utility-scale wind turbines.

2. (June 26, 2008) Members of the NEC made a site visit to Hull, MA to discuss their wind turbines. We met with Richard Miller, Operations Manager of Hull Municipal Light Plant.

3. (July 7, 2008) Members of the NEC met with William M. Moore *(Atlantic Renewable Energy Corp)* developer of wind farms and wind turbine consultant. Bill Moore spends summers and votes on Nantucket.

4. (August 7, 2008) The NEC invited the following individuals to their monthly meeting for a discussion on wind energy: Chris Amory an engineer working in Shanghai, China for a company that manufactures wind turbine blades; Dave Fredericks is National Grid's acting Vice President New England South; and William Moore a wind farm consultant.

5. (From October 27 to December 17, 2008) Four Students (Diana Berlo, Jennifer Hunt, Amanda Martori, and Justin Skelly) and Professor Michael Elmes from Worchester Polytechnic Institute (WPI) Department of Management working on certain aspects of the Nantucket Wind Energy Project. The WPI Students had three objectives:

(1) Explore the laws, regulations, and permits required to develop wind power on Nantucket.
(2) Analyze financial and ownership arrangements
(3) Investigate concerns regarding wind power for Nantucket

6. (October 2009) Bartlett's Farm WES 250kW wind turbine came on line on April 22, 2009. The electric power produced is given below:

Month	Energy Produced	Total Capacity	Capacity %
Apr 09	3,208 kWh	60,000 kWh	5.35
May 09	11,512 kWh	186,000 kWh	6.18
June 09	26,872 kWh	180,000 kWh	14.93
July 09	27,744 kWh	186,000 kWh	14.92
Aug 09	17,112 kWh	186,000 kWh	9.20
Sep 09	31,632 kWh	180,000 kWh	17.57
Oct 09	50,408 kWh	186,000 kWh	27.10
Nov 09	54,672 kWh	180,000 kWh	30.37
Dec 09	63,248 kWh	186,000 kWh	34.00
Lifetime	286,408 kWh	1,530,000 kWh	18.72

The turbine sits on a 30 meter tower (98'5"). The top of the blade at its highest point of rotation is 145'6". The windmill starts operating at a wind speed of about 6 mph (2.5 M/S). It will turn out of wind at 56 mph (24 M/S). The survival speed of the windmill is

134 mph (57 M/S). The Bartlett Farm turbine blade failed on Monday Jan 18th. The cause is not presently known

As of August 15, 2010, Hull MA has generated the following[2]:

Hull 1, 660 KW has generated 13,405,490 kWh in 2,922 days.
3,156 days x 24 hrs x 660 KW = 49,991,040 kWh capacity
13,405,490 / 49,991,040 = 26.8% capacity factor

Hull 2, 1.8 MW has generated 16,031,274 kWh in 1,564 days.
1,564 days x 24 hrs x 1,800 KW = 67,564,800 kWh capacity
16,031,274 / 67,564,800 = 23.7% capacity factor

7. (August 6, 2009) Robert Patterson, energy consultant, presented a briefing entitled "*Energy Efficiency/Conservation Programs/Projects Development & Funding*". The briefing included: MA Funding Sources; Next Steps; Leveraging Funding Sources; Points of Contact; and Support Services.

Vestes has sold their 660 KW turbine design to India. There have been problems with the Indian product. The 1.65 MW Vestes would be a better fit for Nantucket. GE Turbine shows great promise. Turbine diameters are shortening enabling high wind protection. Lead time is 6 to 8 months. A 1.65 MW turbine is costing $3.8M. Nantucket needs to obtain a consultant to determine size and make of turbines and then develop a robust cost model.

OPTIMUM BUILD OUT PLAN

Predicted Wind Resource *– the economics of wind power at a given site depends on many factors; one of the most important is wind speed. Understanding wind speed and turbulence is critical to estimating the energy that can be produced at a given site. Winds on the Island may be too high to accommodate full-scale turbines, which typically experience more stress than medium scale turbines at high wind speeds.*

Germany is a world leader in terms of installed wind power, with 20.621 GW installed, yet it has only a fraction of the wind energy potential that North Dakota alone has. Large wind systems require average wind speeds of 6 meters/second (13 mph).

Wind resource potential is divided into: "moderate" means wind speeds of 6.4-7 m/s at a 50-meter height, "good" means 7-7.5 m/s, and "excellent" means 7.5 m/s and higher. Nantucket sites are better than "excellent".

Wind Turbine Component Transportation & Access *– Transporting turbine components and the necessary installation equipment (cranes, flat bed trucks) could add to the cost of wind turbine installation on Nantucket. In addition, there would be some logistical challenges transporting wind turbine components from the harbor to the sites*

[2] Wind Energy in Hull, MA, www.hullwind.org/

because of the trucks' large turning radii needed to move from the dock to the turbine sites. An alternate method of transportation is using heavy lift helicopters.

Distance to transmission/distribution lines for power distribution *– The power generated by any installed wind turbine must be transmitted to adequately sized lines. Proximity to utility distribution or transmission lines is an important cost consideration. All of the proposed sites are within 250 meters of either transmission or distribution lines.*

The power to the Cape requires a booster plant because of line losses. With a variable load such as a Nantucket Wind farm and other facilities, a larger unused stand-by capability may have to be included in future cost analyses.

Noise *– MA State regulations do not allow a rise of 10 dB or greater above background at the property boundary. Modern turbines easily meet these criteria. From a distance of several hundred feet, utility scale turbines can be compared to the sound level of a refrigerator. Any eventual wind turbine should be sited so that it would be minimally audible at the nearest residences. Wind turbines should be sited at least three blade tip height from residences. Distances from mixed use areas may be shorter.*

At the landfill site the background noise is dominated by the sound of the surf. The higher the wind velocity the more the turbine noise, and the higher the background noise from the ocean. Modern turbine towers act like an organ pipe with their own resonance frequency. This resonance frequency can be mitigated by proper muting devices.

Vinalhaven, Maine is home to New England's largest coastal wind-power facility. [3] *The three General Electric 1.5-megawatt turbines are expected to generate 11,605 MWH/yr (Capacity Factor = 29.4%). After paying all expenses and financing costs Vinalhaven is receiving electricity @ $0.055 per kWH. The cost of transmission and distribution is included in a separate delivery charge.*

Most of the Vinalhaven noise complaints have come within the half-mile range. The noise goes away somewhere between one and three miles. The Fox Island Electricity Cooperative (FIEC) offered to buy properties in a subdivision within 1,000 to 1,500 feet of the turbines. A group of residents who live within half a mile to one mile have organized a protest against the noise.

The FIEC conducted an experiment in February 2010 in which the wind turbines were randomly slowed at night for one month to see if it made a difference in noise, which also means a reduction in generated electricity[4]*. Accentech Inc. of Cambridge, MA monitored the sounds and collected data from log-books kept by the residents. The FIEC is considering sound baffling or insulation in the turbines.*

The US DOE National Renewable Energy Laboratory (NREL) is working on the Island's turbine sound issues including possible insulation or sound deadening material in the turbine nacelles. The Maine Technology Institute is working on active sound cancellation technology. General Electric is considering testing a new type of blade technology,

[3] The Martha's Vineyard Times, "*How the Wind Blows in Vinalhaven",* Janet Hefler, May 13, 2010
[4] Cape Cod Times, September 15, 2010, "*CEO: No Easy Fix to Turbine Noise*"

Environmental issues and permitting *– The majority of Nantucket Island is home to diverse wildlife and, as a result, the entire Island has been designated as a Priority Habitat of Rare Species. RERL recommends investigating all applicable environmental designations as soon as a particular site is chosen for a wind project.*

Proximity to airport *– Most sites that are not within about 3 to 5 miles of a public or military airport are not considered a hazard to air traffic. The FAA requires that any structure over 200 feet to be lighted. The WWTF site lies within close proximity to the Nantucket Municipal Airport and so airspace restrictions need to be investigated.*

Potential electric loads offset *– Energy used on-site is more valuable than energy sold on the wholesale market. Several of the proposed sites are within the vicinity of large electric loads which have the potential to contribute substantially to the overall economics of wind power through on-site load offsetting. These include the DPW, Massasoit A & B sites (which lie near the DPW) and the Wastewater Treatment Plant. Current MA regulations require that wind turbine generation be located on the same property as the load being off-set.*

Electricity Storage – Nantucket may be faced with electricity storage to mitigate the peaks and valleys in out put and consumption. Because gravity is not a possibility with the highest point being 100 feet, we are left with a big batteries, large fly wheels, compressed air, and chemical solutions.

TURBINE SPECIFICATIONS

General Electric 1.5 sle: [5]

Rated Capacity:	1,500 kW
Cut-in Wind Speed:	3.5 m/s……..7.83 mph
Rated Wind Speed:	14 m/s…….31.18 mph
Cut-out Wind Speed (10 min avg.):	25 m/s…….55.93 mph
Frequency	50/60 Hz
Voltage	690V
Rotor Diameter:	77 m …… 252.6 ft
Hub Heights:	65/80 m……...213.2 ft / 262.4 ft

For a 1,500kW turbine, on blade can weigh up to 10 tons. GE makes nearly half the wind turbines used in the United Sates. GE assembles the hub and nacelle in Pensacola FL. The blades are manufactured in Newton, Iowa. All the parts are sent to the operational site for final assembly.[6]

Fuhrlander FL 600/ 75

[5] General Electric Company, GE 1.5 MW Wind Turbine, http//www.gepower.com/
[6] New York Times, Feb 21, 2010

Rated Capacity	600 kW
Cut-in Wind Speed	3.5 m/s……. 31.2 mph
Rated Wind Speed	11.0 m/s…….24.6 mph
Cut-out Wind Speed	20.0 m/s…….44.7 mph
Frequency	TBD
Rated Voltage,	690 V
Rotor Diameter	50 m……..164 ft
Standard Hub	75 m…….. 246 ft

VISUAL CHARACTER

The former radio tower at the DPW site was 142 meters (467 feet) high. The high of the rotor at 12 o'clock is between 213.2 + 126.2 = 339.4 ft and 262.4 + 126.2 = 388.6 ft. This is between 72% and 83% of the existing tower height.

TRANSPORTATION PLAN

(Bill Griswold 8/25/09) Any plan to transport wind turbine blades on Nantucket will come up against the physical limits imposed by narrow streets.

Present thinking is that wind turbine blades would probably be transported by barge, from a port in MA or RI. The most logical disembarkation point would be of shore in Madaket. The other parts could be delivered by the freight boat.

FINANCING PLAN

The wind turbines can be publicly or privately financed. The NEC plans to explore a variety of funding sources. Some of these are described below. It might be highly desirable to seek private donations during the initial stages.

> *Richard Miller (Director of Hull Municipal Light Plant): Recommends publicly financed turbines.*
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> *Bill Moore (Atlantic Renewable Energy Corp): Recommends publicly financed turbines, but cautions that the large turbine suppliers prefer to own the turbines and have a lock on the supply of turbines. The turbine market is changing due in part from Boone Pickens experience with large wind farm transmission problems..*
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> *The RET received $150 million over a five-year period (1998-2002); $25 million per year in 2003 and in each following year. The Trust has awarded a cumulative total of more than $250 million since its inception in 1997, plus an additional $55 million in Waste to Energy funds.*
>
> *MTC brings together leaders from industry, academia, and government to advance technology-based solutions that lead to economic growth and a cleaner*

environment in Mass. MTC energizes emerging markets in the high-tech sector by filling gaps in the marketplace, connecting key stakeholders, conducting critical economic analysis, and providing access to intellectual and financial capital. For additional information about MTC, visit www.masstech.org.

"The explosive growth in land-based wind farms owes much to state and federal subsidies for the wind industry: state renewable energy credits (RECs); accelerated depreciation credits; and, perhaps most important, federal tax credits for equity investors who help wind developers finance and construct wind farms[7]. This last subsidy is keyed to actual electricity production, which is why it is called a Production Tax Credit (PTC). Large wind farms simply can't be financed without the PTC, which, in effect, decreases by as much as 40 percent the financing that developers need to build a project. "That's huge," says Bruno Mejean, managing director at Nord/LB New York, a German-based bank and an active wind-energy lender. "You cannot finance these projects without this 40 percent component. That's what makes wind power viable commercially." Investors are happy with the PTC because for a modest return on their money they get huge corporate tax breaks. Wind developers are happy because PTC.'s allow them to build bigger projects."

Cost estimates from feasibility 2008 studies of MA Community Wind projects ranged from $2,800/kW to $3,290/kW.

NET METERING (3)

The Massachusetts Department of Public Utilities (DPU) adopted net metering rules in July 2009. These DPU rules were in accordance with the MA Green Communities Act passed in July 2008.

The MA Green Communities Act allows energy produced at customer-sited generation facilities of up to 2 MW to be sold to the grid as if it were offsetting the energy used at the customers meter.

Previous MA law only allowed facilities up to 60kW to benefit from net metering while for larger facilities only that portion of the production that coincided with load could be credited to the retail site.

Each municipality can net meter up to 10 MW of generation capacity providing that no individual unit exceeds 2 MW.

The net metering credit for generation used to offset load at a customer's meter is credited at a rate equal to the "default service" kilowatt-hour charge.

BUSINESS MODEL

[7] New York Times Magazine Section, September 14, 2008

The Madaket Wind Turbine Project[8] would involve installation of one 1.5-MW turbine at the site of the former radio tower behind the DPW offices south of the Madaket road. The Town would manage the development of the Project and would finance, purchase, own and install the wind turbine at a capital cost currently estimated to be $5.0 million. During operations, the turbine would save on the order of $600,000 per year in electricity and related costs. The total Net Present Value (NPV) of the Project is estimated to range from $2.583 million (capacity value of 36 percent) to $4.613 million (capacity value of 45 percent) over a 20 year period, depending on, among other things, actual wind levels, actual costs, and availability of government incentives. The Madaket wind Turbine is anticipated to begin commercial operation in 2012.

A project with three 660-kW turbines with a capacity factor of 36 has a NPV of $1.538 million. The NPV is very sensitive to capacity factor, which would be expected to be lower for 660-kW turbines than for 1.5-MW turbines. The NPV declines to $466,000 at 32 percent capacity and goes to zero at a capacity factor of 30.8 percent.

LAND BASED SITES

1. SURFSIDE WASTE WATER TREATMENT FACILITY

The daily power requirements at the Surfside Waste Water Treatment Facility (SWWTF) are 6,088 kW/day [9] or 254kW/hr. This would require a wind turbine of 650 KW at 38% capacity in order to supply all the power requirements of the SWWTF.

An alternative would be a solar farm with a capacity of 1.6MW. At an average efficiency of 13%, the output would be 208kW/hr behind the meter, or 82% of the year-round power requirements for the SWWTF. There would be no need to net meter outside the facility. This would yield a cost reduction of $234K per year before the Power Purchase Agreement (PPA) of $91K per year ($.05 per kW/hr) is taken into consideration.

2. NANTUCKET MUNICIPAL AIRPORT

The daily power requirements at the Nantucket Municipal Airport are 4,515 kW/day [10] or 188kW/hr. A solar farm with a capacity of 2.0MW at an average efficiency of 13% would have an output of 260kW/hr, or 72kW/hr more than the year-round power requirements for the Airport. This means that 72kW/hr could either be sold to National Grid on the open market, that future power requirements accommodated, or community Net Metering off-sets permitted.

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[8] CommonWealth Resource Management Corporation memorandum, August 12, 2010, "Madaket Wind Turbine Project Update:, George H. Aronson CRMC

[9] Schedule Z based on FY2010 Metered Consumption- National Grid Meter 8778513016 at WWTP 72 S Shore Rd, Nantucket

[10] Schedule Z based on FY2010 Metered Consumption- sum of four National Grid Meters at Nantucket Municipal Airport

3. WANNACOMET WATER COMPANY PV#1 (Lovers Lane)

The daily power requirements at the Wanacomet Water Company PV Site #1 (Lovers Lane) are 767 kW/day [11] or 32kW/hr. A solar farm with a capacity of 2.0MW at an average efficiency of 13% would have an output of 260kW/hr, or 228kW/hr more than the year-round power requirements for the Site #1. This means that 228kW/hr could either be sold to National Grid on the open market, that future power requirements accommodated, or community Net Metering off-sets permitted.

4. WANNACOMET WATER COMPANY PV#2 (1 Milestone Road)

The daily power requirements at the Wanacomet Water Company PV Site #2 (1 Milestone Road) are 608 kW/day [12] or 25kW/hr. A solar farm with a capacity of 2.0MW at an average efficiency of 13% would have an output of 260kW/hr, or 235kW/hr more than the year-round power requirements for the Site #2. This means that 235kW/hr could either be sold to National Grid on the open market, that future power requirements accommodated, or community Net Metering off-sets permitted.

5. NANTUCKET CONSERVATION LAND

Nantucket conservation land is a very sensitive subject. Much of Nantucket's conservation land has very stringent restrictions, and yet from a philosophical point-of-view wind farms have a significant conservation objective.

The amount of Town owned land available for wind farms is limited. Ideally the conservation land is an untapped resource for windfarms. It will be important to determine what can and can not be accomplished to determine the build out plan.

This would entail communicating with the various conservation groups on the Island and discussing the pros and cons of using their land. On one hand, there would be a strong negative push back, and yet on the other hand the windmill argument is compelling..

As of January, 2009 Nantucket contains approximately 30,000 acres (47 square miles) of which 16,627 or approximately 55 % is in open space as follows.

a. Nantucket Conservation Foundation has 8,858.2 acres;
b. Nantucket Islands Land Bank has 2,530 acres;
c. Trustees of Reservations has 987 acres;
d. Massachusetts Audubon Society has 947 acres;
e. Nantucket Land Council has 339 acres;
f. Boy Scouts of America 98 acres
g. Linda Loring Nature Foundation, Inc. 83 acres

[11] Schedule Z based on FY2010 Metered Consumption- National Grid Meter 235310004 at Wannacomet Water Co, Lovers Lane Pump
[12] Schedule Z based on FY2010 Metered Consumption- National Grid Meter 893090709 at Wannacomet Water Co, 1 Milestone Ave Pump

h. Sconset Trust. Inc 63 acres
i. Madaket Conservation Land Trust 56 acres
j. Other 25 acres
k. Federal, State or Local Government-owned properties have 2,641 acres.

6. FALMOUTH, MA WIND TURBINE

Town of Falmouth Wind Energy Avian Assessment. A 1.5 MW turbine on a tubular tower has a hub height of between 65 and 80 meters (213 to 262 ft); a rotor diameter between 77 to 80 meters (253 to 262 ft) and an overall height with a blade at @ 12 o'clock of 104 to 120 meters (341 to 394 ft). For comparison purposes, the existing tower at the Nantucket Solid Waste Facility is 142.5 meters (468 ft) in height.

7. VINALHAVEN, MAINE WIND FARM

Vinalhaven, Maine is home to New England's largest coastal wind-power facility. The three General Electric 1.5-megawatt turbines are expected to generate 11,605 MWH/yr (Capacity Factor = 29.4%). After paying all expenses and financing costs Vinalhaven is receiving electricity @ $0.055 per kWH. The cost of transmission and distribution is included in a separate delivery charge. [13]

8. BREWSTER, MA WIND FARM

The Brewster, MA Commerce Park wind farm location is relatively remote, with few residential neighbors. [14] The land is located within an industrial park, bordered by the Town Golf Course, sand and gravel operation and a highway. The closest neighbors are 1,800 feet away. The Woodland Senior Living Center is nearly 2,400 feet away from the closest turbine but does not fall within the flickering shadow created by the blades when backlit by the sun.

The Cape and Vineyard Electric Cooperative would pay $10 Million to purchase, install, and maintain the twin 1.65 MW turbines over the 20 year lease period. The Cooperative would lease the land from Brewster for $100,000 per year. The total estimated revenue and savings to the Town over a 15 year period is set at $3.6 million and includes $2.1 million in energy savings and $1.5 million in lease payments. Brewster would receive a little more than 50 percent of the power generated by the turbines. Cooperative member towns would be able to purchase a portion of the remaining electricity, except for 10% allocated to the county's Cape Light Compact. Construction is tentatively scheduled to begin in September 2011.

OFF-SHORE SITES

[13] The Martha's Vineyard Times, "*How the Wind Blows in Vinalhaven",* Janet Hefler, May 13, 2010
[14] Cape Cod Times, September 15, 2010, *"Municipal Wind Power Moving Forward"* Doug Fraser

Wind turbine generator (WTG) foundation design varies by water depth. Monopile foundations would be installed in water depths of 20 meters (65.6 feet or 10 fathoms) or less. Platform structures with three or four piles could be used in water depths greater than 20 meters and less than 45 meters (148 feet) meters. Locations in water depths greater than 45 meters would probably require the use of floating platform technology [mms].

Sites less than 30 miles from shore could use AC cable systems. More distant sites would be connected with direct current (DC) cable systems [mms].

The advantage of off-shore wind farms sites is that the sites are available. The down side is that they are approximately 50% more costly than land based. In addition, there are all sorts of maintenance, environmental, and navigational risks.

Modern wind turbines have a down time of less than 2 percent on land and less than 5 percent at sea.

1. TUCKERNUCK OFF-SHORE SITE

Nantucket has an area south of Tuckernuck Island which is in fairly shallow water. The transmission cable could be brought ashore on Nantucket. However, Dave Fredericks believes that the electric power should be transmitted directly to the mainland via underwater cables. Underwater cables cost about $1.2 million per mile to install.

As electricity production increases more cables can be laid to the mainland and Nantucket could become a significant exporter of electric power. Nantucket will have to rely on the cables as a defacto storage mechanism. Our highest elevation is less than 100 feet so that gravity storage is not an option.

It is necessary to install a 50 m (112 ft) tall meteorological (Met) wind tower on Muskegat Island for the purposes of collect wind and weather data. Wind data may be used for projects within 2 to 5 miles from the Met tower. [15] Wind speed is a function of height, topology, and ground cover. A typical tower weighs as much as 2,200 lbs.

2. BLOCK ISLAND OFF-SHORE SITE

Eight wind turbines are proposed in the ocean three miles southeast of Block Island.[16] They will rise 450 feet above the water from steel frames anchored to the ocean floor. It won the support of most of the year-round and summer residents. This will be the first off-shore wind farm in the United States. The wind farm is being planned by the New Jersey startup Deepwater Wind. It is on track to be installed in 2012 and would go online in 2013.

[15] "*Metrological Towers and Wind Power Analysis*", Alternative Energy Solutions, Inc; John Wolar, December 2008

[16] Providence Sunday Journal, March 7, 2010

The Block Island farm is rated at 11.5 MW. The excess power will be fed to the mainland on a new cable. National Grid agreed to buy the wind energy for 24.4 cents per kWh for 20 years. The price is nearly three times what National grid pays for electricity. The higher price of wind power would be spread among all the 480,000 ratepayers in Rhode Island. Block Island customers would pay the standard rate charged by National Grid plus additional distribution fees.

At present, Block Island is not hooked up to the grid that supplies power to mainland Rhode Island. Block Islanders, instead get their electricity from diesel generators operated by a local power company. They pay prices up to four times higher than what is paid elsewhere in the state. Deepwater has two projects the eight-turbine wind farm in state waters and by 2015 or 2016 a 100-turbine utility-scale development in federal waters 15 miles off the Rhode Island shore. As of January 2010, the electricity rate was 29.79 cents per kWh compared to 14.8 cents per kWh on the mainland

3. CAPE WIND OFF-SHORE SITE

The Minerals Management Service (MMS) is in the final stages of review of a permit application to construct the Cape Wind Project which consists of 130 440-foot-tall wind turbine generators, on Horseshoe Shoals on Nantucket Sound[17].

The electric power cost to Nantucket consumers includes both delivery services (7.432 ¢ kWhr) and supply services (8.828¢ kWhr) or 16.260¢ kWhr [18]. The Power Purchase Agreement (PPA) between Cape Wind and National grid in 2013 will be 20.7 ¢ kWhr (12.5 ¢ kWhr when renewable energy credit of 6.7 ¢ kWhr and 1.5 ¢ kWhr of long-term contract are subtracted [19]. The current National Grid residential rate is 8.1¢ kWhr. This means that the cost of the residential rate will increase by 12.5¢ - 8.1¢ = 4.4 ¢ kWhr. Applied to Nantucket, this a 50% increase in supply costs or 27% increase in total costs.

DEPENDENCY ON PETROLEUM PRODUCTS

How rapidly can electric heating and electric cars come on line so as to reduce the dependency of petroleum products?

> *This is an ultimate goal which will be driven by the competitive market forces. As the cost of electricity is reduced through windfarms, electricity becomes more attractive power source. Nantucket is an ideal location for electric vehicles since the travel distances are short and the speed limits are low.*

Only 17 to 20 percent of energy in gasoline is used to move vehicles (the rest is wasted as heat), whereas 75 to 86 percent of the electricity delivered to an electric vehicle goes into motion.

[17] Advisory Council on Historic Preservation (ACHP) March 5, 2010
[18] National Grid Bill, March 11, 2010
[19] Cape Cod Times, Saturday, May 8, 2010, Patrick Cassidy

NANTUCKET POWER CONSUMPTION

At present Nantucket has two undersea electric cables bringing power from the mainland. The first cable is rated at 35 MW and the second cable at 42 MW. The National Grid maintains a back up capability of 10 MW

Nantucket used 143,688,965 kWh (26.4 MW average) of electricity in CY 2007. Assuming that the supply cost was $0.11 per kWh, the total supply cost would be $15.80 million. Assuming that the transmission cost was $0.066 per kWh, the total transmission cost would be $9.48 million. Nantucket imports approximately 10 million gallons of fuel per year. Assuming that the cost per gallon is $4.50 per gallon, the total fuel cost would be $45 million.

Nantucket monthly electric usage varies from a low of 9,680,462 kWh (13 MW average) in May to 16,653,095 kWh (23.1 MW average) in September. At 40% capacity factor, it would take twenty two (22) 1.5 MW turbines to supply 100% of the Islands electricity in May and thirty nine (39) 1.5 MW turbines in September.

As the cost of electricity becomes competitive, the attractiveness of electric automobiles and electric heating increases. The Cape has been able to keep its electric consumption constant by offsetting increased growth through conservation techniques.

SMART GRID

Intermittency problems can be mitigated by a smart balance of sources, such as a base supply from tidal power, relying on wind at night when it is often plentiful. Using solar by day and turning to a reliable source that can be turned on and off to smooth out the supply or meet peak demand.

Also helpful is interconnecting geographically dispersed sources so that they can back up on another, installing smart electric meters in homes that automatically recharge electric vehicles when demand is low and building facilities that store power for later use.

Reducing consumer demand during peak usage periods requires a smart grid that gives generators and consumers more control over electricity usage on an hour by hour basis.

Smart meters and appliances have the potential to save energy, to shave peak electricity usage, and reduce risks of blackouts. Typical smart meter designs include periodic transmission of current, phase, and frequency data from the user to the electricity distribution company. Utilities will use the data in billing calculations under time-of-day pricing, for load management research, to provide customer feedback, and/or to adjust customer appliances.[20]

PROS AND CONS OF WIND TURBINES

[20] Science, *"The Smart Electricity Grid and Scientific Research",* Jan Beyea, Volume 328, May 21, 2010

Do costs of developing renewable energy outweigh benefits? The pros and cons of wind turbines need to be clearly developed in order to get the voters to accept land based wind turbines? The WPI Study used a sampling technique to rank the wind turbine concerns. The conclusion was that the three most difficult concerns to over come were human factors (aesthetics, public outreach), financial, and avian.

Examples of benefits

a. *The amount of fuel replaced by windfarms will determine the future bulk fuel storage facility requirements*
b. *Wind farms will greatly reduce the tanker truck traffic on the Island.*
c. *Reduction in the cost of electricity*
d. *Reduce the cost of transportation and heating*
e. *Bring new revenue sources into the Nantucket economy*
f. *Nantucket average wind speed (AWS) between 16 and 19 mph*
g. *Bluewater's offer in Delaware of stable-priced electricity — an inflation-adjusted 10 cents per kilowatt hour for the next 25 years*

Certain Problems (numbers indicate relative importance of concern by WPI)

a.	*Human Factors (aesthetics)*	*18*
b.	*Financial*	*17*
c.	*Avian (Migratory Birds)*	*16*
d.	*DPW Land Use*	*15*
e.	*Radar Interference*	*14*
f.	*Maintenance – (20 year life cycle)*	*12*
g.	*Electrical Interference and Lightning*	*12*
h.	*Transportation*	*11*
i.	*Decreased Property Values*	*11*
j.	*Flora*	*9*
k.	*Land Management*	*7*
l.	*Small Scale Turbine Purchases*	*6*
m.	*Turtles / Vibrations*	*6*
n.	*Bats*	*5*
o.	*Salt Spray - Sand blasting*	*4*
p.	*Air Traffic Interference*	*4*
q.	*Winter Issues (Icing / Electrical Failure)*	*2*
r.	*Oil Leakage from Turbine*	*1*
s.	*Marine Life*	*0*
t.	*Flashing from sun reflections*	*0*
u.	*Intermittence and variability of power output*	*0*

ACCOMPLISHED ACTIONS

1. (9/17/08) Obtained approval of the Nantucket Energy Committee Mission Statement from BOS.

2. (9/17/08) Obtained approval from BOS to seek grants which would provide further analysis of the two selected sites (Landfill / Massasoit and Waste

Water Treatment Facility), funding for feasibility studies, environmental permitting, public information forums, technical services and start-up costs.

3. (11/5/08) Kitt Johnson, Edgartown BOS appointee, presented findings on underwater turbines in Muskeget Channel.

4. (11/6/08) Edie Ray, Shorebird Biologist for Nantucket Conservation Foundation, Ken Blackshaw, author of Birding on Nantucket, and Vern Laux, Ornithologist at the Linda Loring Foundation spoke to the NEC on bird migration and other bird concerns on Nantucket

5. (11/21/08) Visited Esther's Island site visit to study vertical turbine, solar arrays, and energy efficient house.

6. (12/17/08) Four WPI students completed a 7 week study on Island sponsored by the NEC entitled "Wind Generation on Nantucket" and presented a briefing on the results to BOS.

7. (1/7/09) BOS approved grant application for Feasibility Analysis for Wind Turbines with MTC.
8. (1/21/09) Attend MA Wind Working Group (MWWG) workshop on Wed, Jan 21 @ MTC in Westborough for presentation by Ed Bodmer, an expert in financial modeling for renewable energy projects. The workshop addressed public, private and hybrid approaches to ownership, management, financing, and risk.

9. Apply to the MTC for a feasibility study by the CWC (Community Wind Collaborative) toward the installation of a ARE442 (or similar) turbine at the Nantucket High School.

10. (9/21/09) Submitted Article 5 to the Special Town Meeting to amend Article 23 of the 2007 ATM by changing the purpose of $35,000 appropriated to include costs associated with the study, permitting, design and construction of municipal renewable energy projects.

11. (6/16/10) Awarded a Professional Services Contract to Commonwealth for $24,500 to Resource Management Corporation to provide professional services in connection with development of wind turbine project at Landfill.

12. (7/22/10) Sustainable Nantucket Presentation to the BOS on Draft Climate Protection Action Plan.

13. (9/8/10) Awarded professional services contract for $9,380 to Atlantic Design Engineers, LLC to prepare a wind turbine routing scope & cost of transportation study.

14. **(9/8/10) Awarded a professional services contract for $24,900 to Normandeau Associates, Inc to conduct an assessment of plant & animal resources that may be affected by the wind project.**

15. **(9/8/10) Granted $390,000 by Massachusetts Clean Energy Center Technology Center for costs incurred in the performance of the Project Plan for costs associated with the design and development of the Wind Project.**

FUTURE ACTIONS

a. Invite William (Bill) Vachon of W A Vachon Associates, Manchester MA to participate in feasibility study leading to the selection of turbine size and manufacturer.

b. Continue environmental permitting process. Investigate electrical interconnections to the grid.

c. Begin public outreach with community based forum for informational purposes

This stage also includes a "Wind 101" instructional public forum offered by MTC to answer questions from the community.

d. Execute MYC's free Standard Financial Offer Service portion of the CWC grant.

Technical services as well as a grant of up to $150K to support project development are provided. A standing offer to purchase Renewable Energy Certificates generated by the project is also available.

e. Investigate the costs and logistics of transporting and installing turbine components on Nantucket.

f. Obtain financing

g. Select a wind turbine developer

h. Select a wind turbine vender

i. Obtain servicing contract

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4. Massachusetts Technology Collaborative (MTC), *Community Wind Collaborative*, Draft Wind Feasibility Study, September 2009, Black & Veatch.

5. Minerals Management Service (MMS), *Cape Wind Energy Project, Final Environmental Impact Statement, Appendix F, Economic Model*, January 2009

6. Renewable Energy Research Laboratory (RERL), *Wind Power in Nantucket: Siting Considerations for a Wind Turbine*, June 16, 2008, Charles E McClelland & Mary Knipe

7. Science Magazine, *Potential for Wind-Generated Electricity in China*, September 11, 2009, pp 1378 – 1380.

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9. UMass Amherst , "*Wind Power in Nantucket: Siting Considerations for a Wind Turbine*" dated June 16, 2008

10. Worchester Polytechnic Institute (WPI), *Wind Generation on Nantucket,* December 2008; Diana Berlo, Jennifer Hunt, Amanda Martori, and Justin Skelly.

11. Wind Working Group (WWG), *Wind Energy Siting Reform Legislation*, September 2009, Kenneth Kimmel, General Counsel, MA Executive Office of Energy and Environmental Affairs.

GLOSSARY OF TERMS

a. **Advisory Council on Historic Preservation (ACHP)** is required to issue advisory to federal agencies

b. **Capacity Factor (CF)** defines the fraction of the rated power of a turbine that is actually realized over the course of a year given expected variations in wind speed.

c. **Community Wind Collaborative (CWC)** was created in 2003 as a multi-million dollar statewide initiative. CWC is dedicated to helping cities and towns tap into clean, renewable wind power. The CWC offers qualified interested communities technical assistance, wind monitoring equipment, data analysis, and competitively secured resources. Community-based initiatives in which the communities actually own local wind turbines are an excellent alternative to traditional developer-initiated approaches.

d. **Cost of Energy (COE)** is the electricity sales price, in dollars per kilowatthour (KWhr) which the owners would need to exceed a specific debt coverage ratio

e. **Discount Rate is the interest amount held out from the amount loaned. The discount rate is a true interest charge.**

f. **Massachusetts Technology Collaborative (MTC)** is an independent economic development agency chartered by the Commonwealth to serve as a catalyst for growing the state's innovation economy. MTC administers the John Adams Innovation Institute and the Renewable Energy Trust.

g. **Minerals Management Service (MMS)** a bureau of the Department of Interior

h. **National Historic Preservation Act (NHPA)**

i. **Net Metering** is a state regulation allowing customers to receive value during periods when their eligible on-site distributed generation (such as a wind turbine or solar array) generates more electricity than they use. That is, the electric meter runs backward whenever a customer's net metered facility is producing more power than is being consumed and their account gets net metering credits for net excess generation at the end of the customer's monthly billing period [(3)].

j. **Net Present Value (NPV) is the sum of the present values (PVs) of the individual cash flows after being adjusted by the discount rate.**

Each cash inflow/outflow is discounted back to its present value (PV). Then they are summed. Therefore NPV is the sum of all terms,

$$\frac{R_t}{(1+i)^t}$$

Where:

***t* - the time of the cash flow**
***i* - the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk.)**
R_t - the net cash flow (the amount of cash, inflow minus outflow) at time *t*.

k. **Outer Continental Shelf (OCS)**

l. **Power Purchase Agreement (PPA)** is the price at which electricity is delivered to the grid is fixed during an initial period typically about 10 years at a level set during an initial bidding period.

m. **Production Tax Credit (PTC)** Under present law, an income tax credit of 2.1 cents/kilowatt-hour is allowed for the production of electricity from utility-scale wind turbines. This incentive, the renewable energy production tax credit (PTC), was created under the Energy Policy Act of 1992. Through the American Recovery and Reinvestment Act (passed in February 2009), Congress acted to provide a three-year extension of the PTC through December 31, 2012. Additionally, wind project developers can choose to receive a 30% investment tax credit (ITC) in place of the PTC for facilities placed in service in 2009 and

2010, and also for facilities placed in service before 2013 if construction begins before the end of 2010. The ITC then qualifies to be converted to a grant from the Department of Treasury. The Treasury Department must pay the grant within 60 days of an application being submitted.

n. **Present Value (PV) is the amount of money today which will become a given amount in the future. For example, at 4% interest $100 will grow to $104 in one year; therefore the present value of $104 one year from now at 4% interest is $100.**

o. **Renewable Energy Trust (RET)** is funded through a monthly charge on electric bills. The Renewable Energy Charge is $0.50 per MWH per month or about $6 a year on average. Nantucket's total charges for 2007 were $71,213.

p. **Unexploded Ordinance (UXO)** is known to exist in and around the northern end of the Nantucket Landfill from previous US Navy operations, and might pose a safety hazard to the construction and maintenance of a wind turbine.

q. **Wind Turbine Generator (WTG)**

CONVERSION FACTORS

a. **Acre:** 1 acre = 43,560 square feet = 4,840 square yards = 1 football filed = 120 yards (including end zones) X 40 yards = 4,800 square yards

b. **Barrel:** 1 barrel of oil = 42 gallons

c. **Hours per year (hr/yr):** 24 hours X 365 days = 8,740 hr/yr (hours per year)

d. **Meter (m):** 1 meter = 3.28 feet

e. **Meters per second (m/sec):** 1 m/sec (meter per second) = 2.237 mph (miles per hour)

f. **Square Mile:** 640 acres = 1 square mile