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TOWN OF YARMOUTH COMMUNITY WIND PROJECT PREFEASIBILITY STUDY REPORT

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MASSACHUSETTS TECHNOLOGY COLLABORATIVE

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Notice and Acknowledgements

This report was prepared by KEMA, Inc. in the course of performing work sponsored by the Renewable Energy Trust (RET), as administered by the Massachusetts Technology Collaborative (MTC), pursuant to work order number 08-1. The opinions expressed in this report do not necessarily reflect those of MTC or the Commonwealth of Massachusetts, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it.

Other Acknowledgements

KEMA would like to acknowledge the Massachusetts Technology Collaborative, in particular Nils Bolgen for his leadership of this project. In addition, we acknowledge the Town of Yarmouth, specifically Director of Public Works George Allaire and the Town of Yarmouth Energy Committee for their assistance and support during the preparation of this report.

Executive Summary

The Town of Yarmouth, Massachusetts, with the support and leadership of its local Energy Committee, applied to Massachusetts Technology Collaborative seeking a grant to perform a feasibility study for a utility scale wind turbine at the site of the Dennis-Yarmouth Regional High School. That location is presently the only location under consideration and the only one analyzed by this report.

The objectives of this preliminary feasibility study were to:

1) take some early steps toward assessing the feasibility of developing a utility-scale wind turbine project on municipally owned land adjacent to the Dennis-Yarmouth Regional High School, identifying any fatal flaws;

2) provide the Town of Yarmouth (Town) with the preliminary technical, environmental, and financial information required to determine whether to proceed with a full-scale feasibility study;

3) determine whether data collected at nearby wind monitoring stations will be sufficient to forgo additional wind monitoring at the site; and

4) identify general next steps for moving forward with development of the project.

In addition, information from the report may be used as the basis for presentation materials for community education workshops and related activities.

Our findings are as follows:

Site Physical Characteristics. Two locations northwest of the DYRHS were identified as potential locations for a turbine. Both locations would require a variance from existing Yarmouth property line setback bylaws because they would be slightly closer to the Station Avenue Elementary School property line than is allowed. However, because the adjoining property is also occupied and operated by the Dennis-Yarmouth Regional School District, the same entity that owns the DYRHS property, we believe such a variance is likely to be granted. Access for construction vehicles will likely be a factor in determining the final location.

Wind Resource. Specific wind data has not been collected at the potential Project Site. For this study, wind resource data collected from meteorological towers in nearby Hyannis (approx. 5 miles west), and Harwich (approx 7 miles east) indicate that the site should have an adequate though moderate wind resource for a utility scale wind turbine project. Wind speeds are expected to average about 5.8 meters per second at a height of 65 meters. The estimated average annual energy production for a 1.5 MW Fuhrlaender turbine (FL1500) with a 65 meter hub height would be approximately 2.6 million kWh. The site is likely to present relatively high wind shear and turbulence conditions, though they should not pose a problem for appropriately chosen wind turbines.

Site Electrical Infrastructure. Interconnection of a wind turbine at the Yarmouth DYRHS should be technically feasible for projects up to 1.5 MW. The Town should prepare for the interconnection process by maintaining an ongoing dialogue with NSTAR if a project is approved by the Town.

Characteristics of the Site Vicinity. Based on preliminary work, KEMA anticipates that the wind project will have visual impacts on the surrounding community and may have minor noise impacts. However, we also believe that both types of impacts will be mitigated to some extent when considered within the context of the physical features of the immediate project vicinity. KEMA does not anticipate that the project would impact communications towers, obstruct airspace, or impinge on areas of cultural significance.

Environmental and Permitting Issues. We anticipate no undue wildlife or wetland impacts associated with the wind project. Although avian issues will likely be raised during the permitting process and therefore need to be further addressed, we believe that the project will have a net positive effect on wildlife by reducing emissions from fossil fuel generation.

Financial Analysis. The Town should pay careful attention to potential changes in net-metering policies in the near future, as these will have a significant effect on the economic value of the project. Financial modeling results depend heavily on "virtual net-metering" legislation. If enacted, financial modeling predicts that a 1.5 MW project would generate positive overall NPVs (over 20 years) of $2.9 million to $4.3 million for a Town-owned project. Internal rates of return (IRRs) of 7.5% to 9.5% were calculated for a privately-owned project, which are likely below the IRRs necessary to attract a private developer to the Site. Without virtual net-metering, a 1.5 MW project would generate NPVs of $1.5 to $2.6 million for Town-owned projects, while the private ownership IRR would be 6.0% to 7.9%.

Recommendations and Next Steps. Based on our review to date, KEMA recommends that the Town move to install a met tower at the Project Site to gather more site-specific data on wind resources. In addition, Yarmouth should investigate ownership and financing structures between the town and the regional school district. Next steps should include:

- Briefing the Yarmouth Energy Committee and other Town stakeholders about the results of the preliminary Feasibility Study.
- Choosing a turbine size class and determining project ownership structure.

1 Introduction

1.1 Background

The Town of Yarmouth (Town) is seeking to develop a wind project that will help lower the cost of energy for the Town while also taking advantage of the area's wind resources. The Dennis-Yarmouth Regional High School property has been selected as a site for further study. Under contract with the Massachusetts Technology Collaborative (MTC), KEMA and our subcontractor, Ecology and Environment, are working with the Town to evaluate the feasibility of developing a wind turbine project on the DYRHS property.

The feasibility evaluation of the DYRHS site is a two-stage process involving both an initial site screening and a comprehensive project feasibility evaluation. Each of these elements is described in greater detail below:

- **Preliminary Feasibility Study.** This is a comprehensive but cursory evaluation of issues that may affect the ability to install a wind turbine at the project site. It will identify any fatal flaws and may identify topics to be investigated further in the feasibility study. The preliminary study also identifies and evaluates potential wind turbine locations and results in a preliminary recommendation of potential wind development options (i.e., turbine size and location). MTC and the Town will jointly decide whether to continue with the full Feasibility Study.

- **Feasibility Study.** The feasibility study provides additional details about the economic, technical, environmental, regulatory, and community aspects of the potential wind turbine project and outlines next steps for addressing these issues. A pro forma financial analysis of wind project size and ownership options is included in the feasibility study. The feasibility study also includes photosimulations and mapping of potential noise and visual impacts of the project.

1.2 Purpose

The objective of this preliminary feasibility study is to provide the Town of Yarmouth with the information it needs to determine whether it would be technically and economically feasible to locate a wind turbine at the Yarmouth DYRHS. This report addresses the following key topics:

- Suitability of Site Physical Characteristics
- Wind Resource Adequacy
- Suitability of Site Electrical Infrastructure and Required Interconnection Standards
- Compatibility with Vicinity and Community
- Environmental and Permitting Issues
- Financial Analysis of Project Options

2. Site Physical Characteristics

This section examines the suitability of the Dennis-Yarmouth Regional High School property for a wind turbine project. Answers are provided to the following questions:

- What are the general characteristics of the site?
- What location(s) are suitable for a wind turbine?
- Does the site provide adequate spacing from buildings, roads, or related structures for the wind project?
- Will existing road access and site conditions support construction of a wind turbine?
- Are there any operational or safety issues associated with the site?

2.1 Project Property Overview

The Project Area consists of two adjoining properties in the Town of Yarmouth.

The site under consideration is on the Dennis-Yarmouth Regional High School (DYRHS) property at 210 Station Avenue in Yarmouth, Massachusetts. The site is located between Route 6 and Route 28 in the "Mid-Cape" area. Cape Cod is approximately 8 miles wide at this point, and the High School property is situated inland about 2.5 miles from the southern shore. The Dennis-Yarmouth Regional School District owns the high school property. The D-Y Regional School District also owns the adjacent property to the northwest (276 Station Avenue), the site of the Station Avenue Elementary School, as well as the property to the northwest of that (296 Station Avenue), where the Dennis-Yarmouth Regional School District administrative offices are located. The High School property is bordered on all sides by residential properties. Station Avenue, a major north/south road in Yarmouth, borders the property immediately on the southwest.

The DYRHS property contains the high school, a wastewater treatment plant, a maintenance building, and the Werner Schmidt Observatory, operated by the Cape Cod Astronomical Society. Behind and to the northeast of the high school are athletic fields. Directly to the northwest of the high school building there is a playground area with climbing structures, swingsets, etc.

Figure 1 shows a topographic map of the site and surrounding region.

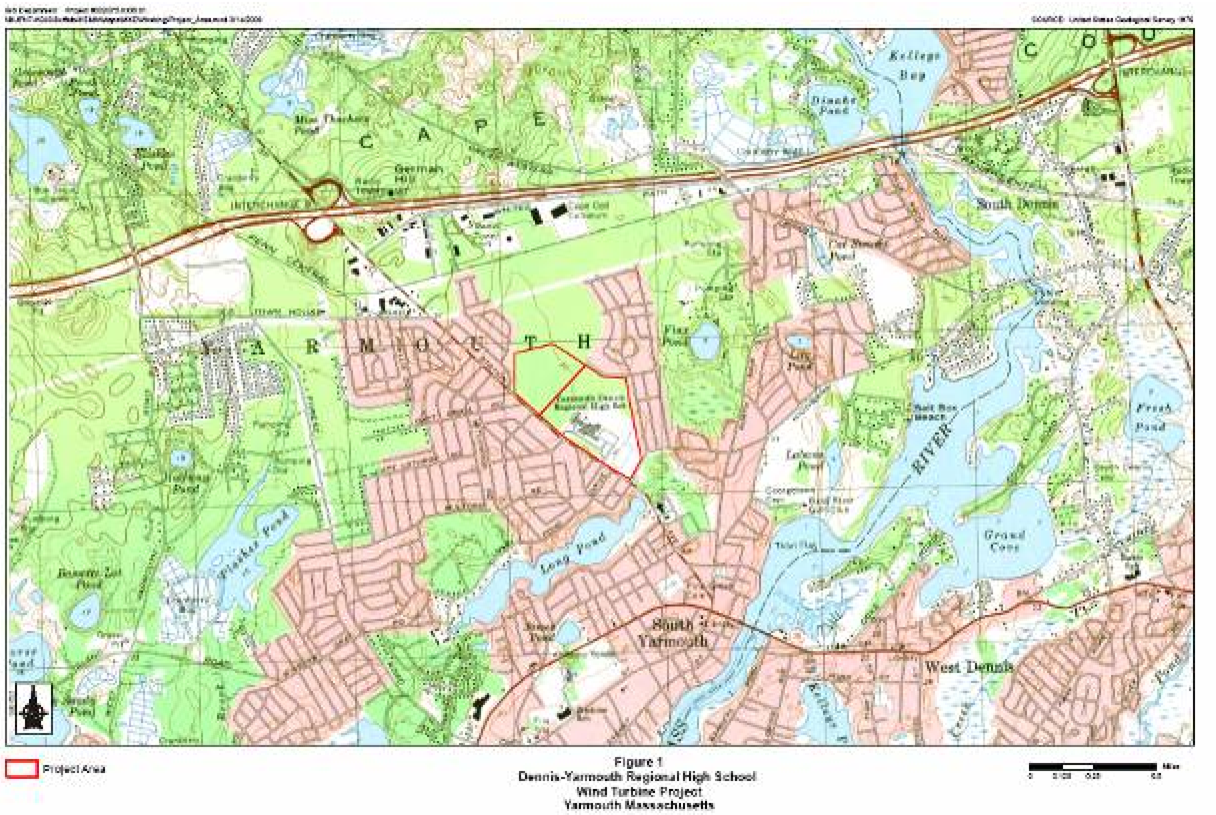

Figure 1: Topographic Map of Dennis-Yarmouth Regional School District Properties and Surrounding Area

The high school property consists of 105.42 acres of mostly level land. A substantial portion of the lot is cleared for the buildings and athletic fields. Pine woodlands border the cleared areas on the northeast, north, and northwest. The recommended area for the potential turbine, which will be discussed below in greater depth, is in the wooded area between the high school and elementary school buildings.

Several geotechnical studies that were conducted as part of construction projects at the high school were provided to KEMA by the Town of Yarmouth. These studies indicate that site soils are glacial outwash deposits of poorly sorted sand and some silt to a depth of at least 20 feet. The wooded areas at the site are comprised of pitch pine with heights generally less than 30 feet. The geotechnical studies estimated that groundwater is at least 15-20 feet below ground level, though this may fluctuate during the year.

A review of available soil survey data identifies two types of non-hydric soils in the Project Area: Carver coarse sand (0-3% slopes) and Carver coarse sand (3-8% slopes) (United States Department of Agriculture, 1993). Surficial geologic maps indicate the Project Area is composed of Harwich Outwash Plain Deposits. Bedrock within the Project Area consists primarily of Pleistocene and Holocene sedimentary rocks (Town of Yarmouth, 2003). According to the United States Geological Society (USGS), four historic earthquakes have occurred in Massachusetts; northern Cape Ann (1727), southern Cape Ann (1744), Cape Ann (1755), and near the coast of northern Massachusetts in 2003 (USGS 2007a). Cape Ann is approximately 65 miles north of Yarmouth, on the northern coast of Massachusetts. The 2003 earthquake had a magnitude of 3.6. Seismic hazard maps indicate a 10%g (peak acceleration) with a 2% exceedance probability within 50 years for the area including the Project site (USGS 2007b). The Massachusetts Executive Office of Public Safety and Security categorizes Massachusetts as located in a moderate earthquake zone that experiences several small tremors every year. Subsurface conditions such as these are considered suitable to support the foundation of a wind turbine.

An aerial photograph of the Project Site is shown on Figure 2.

Figure 2: Aerial Photograph Showing Project Site

2.2 Land Use, Zoning, and Infrastructure

A review of the Massachusetts Geographic Information System (MassGIS) zoning and land use database shows the Project Area is zoned as residential, and is also designated as municipal Openspace used for recreation (MassGIS 2008). Residential neighborhoods surround both schools, with the nearest residences approximately 60 feet away from Project Area boundary. An EOEA Environmental Justice Population abuts the southwest Project Area Boundary, extending from Station Avenue southwest to Nantucket Sound. Town of Yarmouth Comprehensive Plan Maps show the South Yarmouth Historic District located approximately 1,700 feet at its closest distance from the Project Area's southwest corner at the intersection of Station and Regional Avenues. In addition, one Historic Cemetery is located approximately 0.50 mile southeast of the Project Area (Town of Yarmouth, 2001).

The MassGIS Wellhead Protection Database shows that the northern section of the Project area is located within a Zone II Wellhead Protection Area (WHPA) (MassGIS 2007). The boundary of the WHPA passes through the Elementary School parcel, as shown in Figure 2. According to the Town of Yarmouth Water Department, the closest public groundwater supply well, Well # 8, is located approximately 4,000 feet northwest of the Project Area. (Town Water Department 2008).

Records maintained by the Massachusetts Department of Fire Services (DFS) show no underground storage tanks within 0.50 mile of the Project Area (MA DFS 2008), however, the High School Maintenance Department indicated that two underground fuel tanks are located in the Project Area, one to the left of the High School main entrance and one behind the Elementary School at its northeast corner. Both tanks are reportedly monitored for leaks by Veeder-Root Tank Monitoring Systems. No known leaks, spills or related groundwater hazard activity has occurred in the Project Area (Dennis-Yarmouth High School, 2008). The Massachusetts Department of Environmental Protection (DEP) Waste Site and Reportable Release Database listed one spill site within 0.50 mile of the Project Area. The site, located at 105 North Main Street, is approximately 1,960 feet south of the southern Project Area Boundary. The spill occurred in 1995 and is classified as a Potential Release or Threat of Release (REL). The chemical nature of the spill is unknown (MA DEP 2008). We do not expect this release or the presence of underground storage tanks to be of concern to the Project Area or turbine project.

At the DYRHS, there are numerous underground utilities that will need to be considered and avoided if the electrical cables connecting the turbine to the distribution wires are to be placed underground. The location of the underground utilities is further discussed in Section 2.4, Construction Issues.

No additional development is proposed for the site. Yarmouth officials discussed their intention to move the playground located on the northeast side of the high school if that area were to be cleared and utilized for a meteorological tower to gather additional on-site wind resource information.

2.3 Recommended Turbine Location

In 2007 the Town of Yarmouth passed bylaws regulating the filing, siting, installation and operation of "municipal wind energy facilities"[1]. Specific to siting a wind turbine on municipal property, the following size and placement requirements are stipulated in the bylaws:

413.7.4.1 Overall Height Calculation. For purposes of calculating the overall height of a wind turbine, the height shall be calculated as the vertical distance from ground level (AGL) at the base of the tower to the uppermost extension of any blade or the maximum height reached by any part of the wind turbine.

> 413.7.4.2 Setback for Fall Zone Protection. The minimum setback of a wind turbine tower from all property lines and any other wind turbine tower shall be not less than the overall height, as calculated by 413.7.4.1, of the turbine or 300 feet, whichever is greater. The minimum setback of a wind turbine tower from residential structures shall be 1.5 times the tower overall height.
>
> 413.7.4.3 Hub Height. The hub height of the wind turbine, as measured from average natural grade at the base of the tower to the horizontal centerline of the hub around which the blades rotate, shall be not more than two hundred fifty (250) feet, and the blade clearance from the ground immediately below each wind turbine shall be at least thirty (30) feet. A waiver from this provision may be granted only if the Board of Appeals makes a finding that additional height is demonstrated by the applicant to be necessary for adequate operation of the wind energy facility, and the facility will otherwise fulfill the intent and purpose of this bylaw.

Not specifically addressed in the bylaws is the distance of the wind turbine with respect to structures on the DYRHS property. For the purposes of this study it was decided that it would be prudent to maintain a distance from all occupied structures of at least the maximum height of the turbine[2].

In order to meet the hub height requirements set forth in the Yarmouth bylaws, we believe the maximum blade tip height for this location would be about 330-340'. In addition, an FAA study[3] found that a maximum structure height of 374 feet would not affect airspace operational

[1] Town of Yarmouth Bylaws, Section 413: Municipal Wind Energy Facilities
[2] Communication with George Allaire, Director of Public Works, Town of Yarmouth, Massachusetts
[3] FAR PART 77 AIRSPACE OBSTRUCTION REPORT for the Regional High School within Yarmouth, March 9, 2007 by Aviation Systems, Inc for the Massachusetts Technological Collaborative. ASI # 07-N-0448.004.

procedures. Use of the maximum potential allowance of 374 feet would make it impossible to satisfy the setback requirements and still have room for a turbine, and therefore a maximum turbine height of 330 feet was used, obviously a shorter turbine height would allow setbacks which are less restrictive.

Figure 3 depicts the effect of various setback requirements on the placement of a 330 foot turbine within the property lines of DYRHS. According to the setback requirements above, the only area within the property of the DYRHS that doesn't interfere with facilities already in place is a forested region to the northwest of the high school buildings. Within this area there are five setback lines to consider:

1. A 330 foot setback from the property line between the high school and the elementary school
2. A 330 foot setback line from the high school building
3. A 330 foot setback line from the elementary school
4. A 500 foot (1.5 x 330 feet) setback line from the residential structures to the north
5. A 500 foot (1.5 x 330 feet) setback line from the residential structures to the south

Three locations northwest of the DYRHS were considered and are discussed below:

<u>Location 1</u>. This is the only location that met all setback considerations. By applying the setback of 330 feet from the northwest property line (between the high school and the elementary school), and a setback of 330 feet from the high school, one is left with a small triangular patch of land of approximately 350 ft^2 (yellow shaded area in Figure 3). This small area of land is likely unsuitable from the standpoint of access for construction. The close proximity to the septic leaching field also suggests that there may be saturated soil conditions that would be unsuitable for the foundation structure.

It is therefore recommended that the town of Yarmouth seek a Special Permit to allow placement of the turbine closer to the Station Ave Elementary School property line than the 330 feet as required by the bylaw.

Figure 3: Potential areas for placement of a wind turbine at the Dennis Yarmouth Regional High School.

(See accompanying text for scenario/location descriptions.) Note: area and distances are indicative only, and actual property and setback lines should be surveyed with selected turbine specifications before exact placement.

<u>Location 2</u>. If the requirement of 330 feet from the Station Avenue Elementary School property line is waived, then the placement of the turbine can be considered on a much larger piece of land inside the forest (green shaded area in Figure 3). The exact placement of the turbine within this area will be determined by many factors such as soils, access, forest clearing, neighbors, etc. The southern portion of this area is most advantageous from the standpoint of accessibility, however the northern portion of the area is more equidistant from neighboring residents (approx.

900 ft in each direction). There are many buried utility lines in the area which may complicate trenching which is required by the bylaws for interconnection of the electricity wires from the turbine to the street.

Location 3. The forested area north of Location 2 (blue shaded area in Figure 3) would also require a Special Permit. This area however is probably less suitable for turbine placement than Location 2. Access to and construction in this area may be more difficult because of the location of the wastewater treatment plant, the leach field and the playing fields. Creating access direct to this location from Station Avenue would require constructing a 1000 ft road to support delivery of heavy cranes and turbine components. There is also an underground pipeline which runs through the center of the area, for wastewater pumped from the Elementary School (Figure 4), complicating trenching for interconnection as at Location 2. The advantages of this location would be less forest clearing and the ability to use the playing fields for construction staging.

2.4 Construction Issues

Overall, the site is suitable for construction. The site is level and the soils are conducive to foundation construction. The construction of the turbine will require preparation of a foundation, delivery of equipment, installation, and interconnection.

There is a paved public roadway (Station Avenue) that provides direct access to the DYRHS from the State highway (Route 6). The DYRHS is approximately 1.3 miles from Route 6 and about 20 miles from the Cape Cod Canal and Route 3. It appears that the exit 8 off-ramp between Route 6 and Station Ave can facilitate the truck turning radius of approximately 120’ required for delivery of 110 foot long turbine blades (assuming a 1.5 MW turbine). However some clearing of vegetation or temporary removal of signage may be required; a transport company would make the final determination. The turn from Station Ave into the DYRHS driveway may require the removal of some vegetation at the entrance to facilitate the turn.

A separate Community Wind study prepared for the Town of Orleans raised questions about the height of bridges on Route 6 and their compatibility with delivery of the components of a wind turbine. That study proposed barge delivery may be required to avoid those bridges. If the project moves forward, careful consideration by a qualified transportation company will required to ensure the appropriate delivery route.

Some space is required onsite for the turbine component laydown area and crane pad area to facilitate construction. The laydown area is required to store and assemble the components, including the nacelle, hub, and three-blade assembly and tower sections near the foundation. The crane pad is a compact area upon which each crane would rest while lifting the turbine tower sections, nacelle, blades and other equipment needed to assemble the wind turbine. We envision that the potential laydown and crane pad areas would likely be located in the forest adjacent to the northeast side of the school (Figure 3). Access to this area would be through the parking lot. Consideration however would have to be given to the many underground utility lines in this area during equipment movement and assembly (Figure 4). It is anticipated that a portion of the forest will have to be cleared to allow an area not only for the turbine foundation, but also the laydown and crane pad. It is possible that a portion of this area may already have been cleared if a meteorological tower is installed first. In any case, at the determination of the town, these areas could be replanted or landscaped after construction. Depending on the exact placement of the turbine, the playground in the area might also have to be moved.

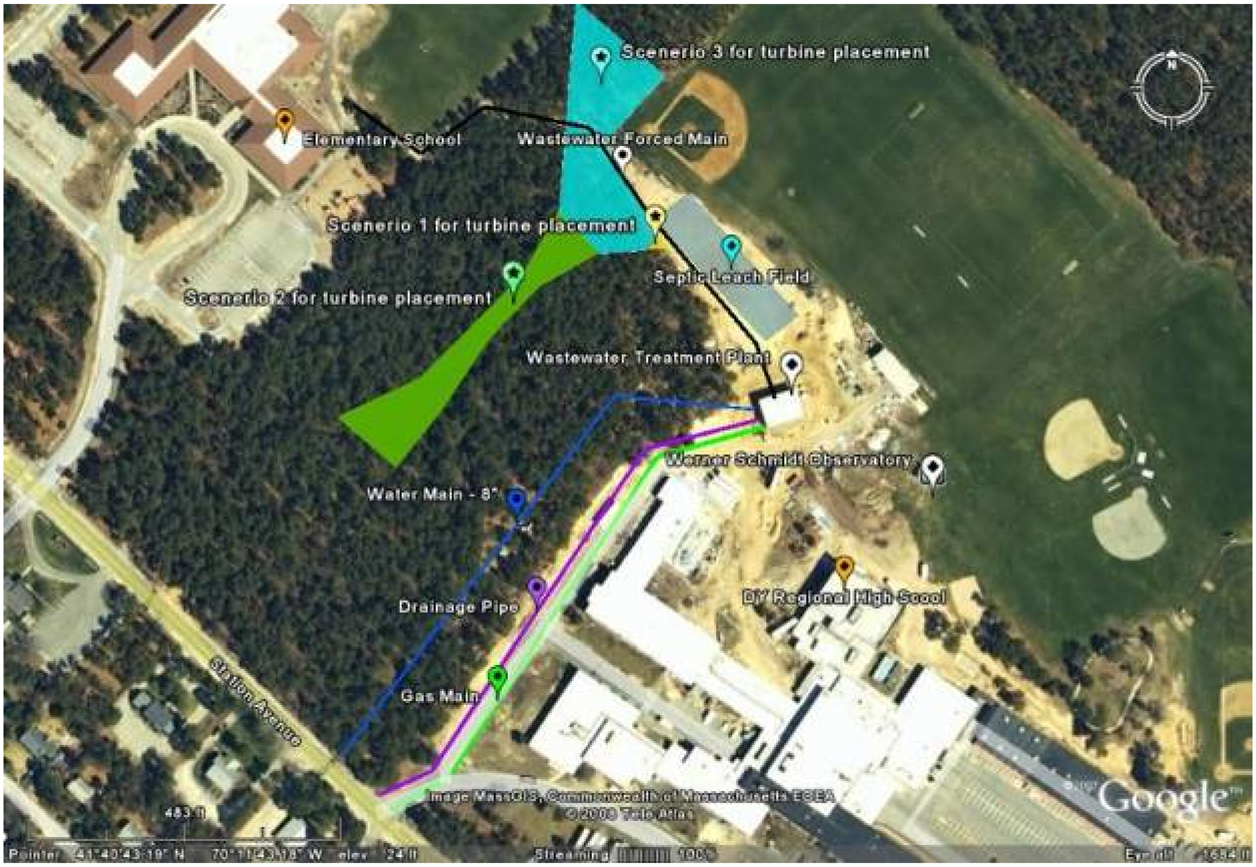

Figure 4: Utility service pipelines near the site under consideration

Note: location and distances are indicative only, and actual pipeline placement should be surveyed before design and construction.

The exact dimensions of a cleared area will depend on many factors, including: 1) the specific turbine selected; 2) the type of cranes to be used; and 3) the construction sequence used by the project contractor. For example, some contractors install the blades to the hub and lift the entire assembly onto the tower base (which requires a larger laydown area); others install the hub to the nacelle and then lift each blade individually. In either case, the site would need to be cleared prior to construction to ensure adequate spacing for ground assembly. Depending on assembly and construction methodology the cleared area could be anywhere between 15,000 to 60,000 ft^2. This would represent a cleared circle approximately 70 ft to 250 ft in diameter.

The construction of a wind turbine poses safety issues similar to the construction of large towers (e.g., construction traffic, use of large construction equipment, etc.). Related issues and concerns should be expressed in the procurement process and will be addressed by a qualified vendor.

2.5 Operational and Safety Issues

Wind turbines in general are very safe machines and impose little physical impact upon their surrounding environments. However, on very rare occasions, wind turbine failures have occurred. In addition, after winter storms ice can build up on wind turbine blades, posing a hazard to people below when it falls off. Wind turbines are large structures with rotating blades and are susceptible to some of the same icing issues as tall buildings, bridges, or support structures. While turbine failures and ice shedding should be considered during the siting process and safety measures should be implemented, the tens of thousands of installed wind turbines worldwide have proven to have very good safety records overall. Setbacks from nearby buildings have been incorporated into the suggested turbine locations to account for these issues.

Icing of turbine blades occurs at temperatures below 0^o C (32^o F) when there is significant humidity in the air or during an ice storm. Ice forms on a wind turbine's blades in relatively thin sheets, just as it does on trees, utility poles, power lines, and communication towers during an ice storm. If a wind turbine operates in icing conditions, two potential scenarios can occur: 1) ice fragments from the rotor may be thrown off from the operating turbine due to aerodynamic and centrifugal forces; or more commonly, 2) ice fragments may fall down from the turbine blades when the machine is shut down or idling without power production. The level and type of risk depends on the weather (especially the wind conditions), the instrumentation of the wind turbine's control system, and the strategy the control system utilizes during icing conditions. Many modern wind turbines incorporate ice sensors that will keep the turbine from functioning when ice has developed on the turbine. Some turbines automatically monitor the correlation of wind speed and power production to the machine's power curve. Significant variation from this power curve suggests that the aerodynamics of the blade's airfoils have been compromised due to icing. In these cases, the turbine is programmed to shut down. Ice sensors, balance monitoring, and preventative shut down are among options that could be incorporated in a wind turbine in Yarmouth.

A common misconception of ice throw is the size of actual ice fragments. Although large ice fragments of up to 2 m can fall from an unmoving turbine (as with all other towers or large structures), ice fragments thrown from a moving turbine are generally in the range of 100 - 1000 grams, with the largest fragments having the approximate size and shape of a paperback book.

Other Massachusetts wind turbines, such as those in Hull, have been built in closer proximity to schools, roads, and pedestrian ways without any reports of dangerous ice throws. Operational and safety issues should also be addressed through the procurement process, selection of a qualified vendor, and implementation of a sound operations and maintenance plan.

To account for the extremely rare occurrence of turbine failure or collapse, sufficient setback from nearby buildings has been specified by the Yarmouth municipal wind turbine bylaw and the assumptions of this report.

Other operational issues such as acoustic and flicker impacts are discussed below, in Section 5.1, Visual and Noise Receptors and Potential Level of Impact.

2.6 Wind Resource Loss and Spacing from Physical Structures

The preferred turbine location is adequately spaced from physical structures that have the potential to result in wind resource loss. To minimize the potential for wake effects, a wind turbine should not be located downwind from any physical structures that could negatively affect wind speeds. The site under consideration will be at least 330 feet away from the current DYRHS building and the elementary school. The suggested locations would be bordered by 40-50 ft trees. For a 1.5 MW turbine, the blades will be a minimum of about 100 ft from the ground, which is still 50 ft above any obstacle in the area. This is sufficient to avoid most turbulence created by surrounding obstructions.

2.7 Summary

The most suitable location for a wind turbine is in the forested area to the northwest of the existing DYRHS building (see Figure 3). There are two potential locations there that we believe would be viable for the placement of a 1.5 MW wind turbine. Both locations will require the Town of Yarmouth to obtain a special permit to alter the setback from property line requirement in the municipal wind turbine bylaws.

Location 2 has more immediate access to a paved area but could require substantial clearing of forest for construction purposes. Location 3 has open playing field area already available for turbine staging but has potential problems with heavy equipment and truck access.

3. Wind Resource

This section provides an initial assessment of the wind resource at the DYRHS site based on data collected at wind monitoring towers in nearby Harwich and Hyannis, supplemented by long-term correlation data collected at Barnstable Municipal Airport, and projected from each monitoring location to the DYRHS using terrain roughness maps to perform a wind flow analysis. It is necessary to analyze this wind monitoring data to confirm that the wind resource is sufficient to support a financially viable project. The following section examines wind monitoring, estimated wind resource, terrain roughness, wind shear, and turbulence.

Wind resource data and modeling from Harwich and Hyannis indicate a moderate wind resource at the recommended location. To obtain more detailed and site specific wind data, the Town may benefit from installing a meteorological (met) tower at the project site, rather than relying on data taken at sites that are several miles away. It is also possible that the Town could engage in shorter-term SODAR-based monitoring to get a better idea of the strength of the wind resource, however the University of Massachusetts Renewable Energy Research Laboratory (RERL) examined the DYRHS site for applicability of SODAR and concluded that because of the intermittent noises emitted by the SODAR machinery and the presence of nearby residences, it would not be able to conduct a SODAR study at the DYRHS, though possibly could do so at the Yarmouth transfer station approximately 1 mile away.

3.1 Overview of Methodology

The typical process that KEMA uses to assess wind resources is to:

- "Normalize" wind resource data measured at the site under consideration. This means comparing the single year of data collected at the site with long-term data (usually 5 to 7 years) collected somewhere within the same region. Based on how windy the conditions were in the region during the period that the site-specific data was gathered compared with the long-term average, the expected average wind speed at the site is adjusted up or down by a certain percentage.

- Predict wind resources at likely turbine hub heights based on measurements taken at lower heights. Typically, RERL places anemometry equipment at three different altitudes on each meteorological (met) tower (e.g., 20, 38, and 50 meters). Using data from multiple heights allows KEMA to determine the change in wind speed as elevation increases (wind shear), and therefore to extrapolate wind resource estimates from anemometer height to hub heights, which typically range from 50 to 80 meters.

In an attempt to avoid spending the time and resources required to install a met tower and gather a full year of wind data, KEMA instead relied on existing data gathered at met towers 5 to 7 miles away in Hyannis, to the west, and Harwich, to the east. Thus, to estimate the resource at the DYRHS site, KEMA used terrain roughness maps to estimate the wind flow to the site from each of the met towers.

The remainder of this chapter presents this methodology in far greater detail, along with calculations and results for each step. In Section 3.8, we present the final wind resource estimates, as well as the resulting energy production for various turbine configurations, the magnitude of uncertainty in our calculations, and possible steps to address this uncertainty.

3.2 Wind Monitoring

KEMA relied on wind data collected by the University of Massachusetts Renewable Energy Research Laboratory (RERL) at nearby met towers in Harwich and Hyannis. RERL had already installed, collected one year of wind data, taken down the two towers, performed preliminary analyses, and reported on the data recorded at these two sites.

3.2.1 Wind Monitoring - Harwich

The location of the Harwich tower base was at 41° 41.4700 N by 70° 03.8317 W, at Harwich High School. This is approximately 6.8 miles east-northeast of the site under consideration at DYRHS. The tower collected wind speed and directional data for a period of one year at heights of 20, 38, and 50 meters. RERL used a guyed, 50-meter NRG Systems tower with five anemometers. A pair of anemometers was located at both 50 meters and 38 meters and a single anemometer was located at 20 meters. At each height, there was also a single wind directional vane. The tower was equipped with a lightning rod and temperature sensor at 2 meters. The data were collected and logged with the use of an NRG model Symphonie Data Logger. Based on our review of the measuring equipment, the mast type and height appear to be in accordance with standard practices, including: adequate spacing between sensors and the supporting mast and boom structures; appropriate orientation of booms relative to prevailing wind direction; and data collection standards.

Data collection began on August 1, 2006 and ended July 31, 2007. The data from the logger were sent to RERL on a regular basis. The logger sampled wind speed and direction once every two seconds. These data points were then combined into 10-minute averages and, along with the standard deviation for those 10-minute periods, assembled into a binary file. The binary files were converted to ASCII text files using the NRG software BaseStation®. The text files were then imported into a database software program where they were subjected to quality assurance (QA) tests by RERL prior to using the data. Based on the data logged, certain points were flagged and omitted during the analysis. Points are flagged if the data recorded was outside the limit of the instrument, icing occurred on the instrument, or if redundant measurements significantly differed.

According to RERL, data recovery at the site was very good, with gross data recovery of 99.82 percent and net data recovery of 99.56 percent. KEMA reviewed the validated data and found it to be consistent with industry data collection standards.

3.2.2 Wind Monitoring - Hyannis

The location of the Hyannis tower base was at 41° 39.885 N by 70° 18.270 W, on a plateau adjacent to a local wastewater treatment plant. The tower was located approximately 5.8 miles west-southwest of the site under consideration at DYRHS. It should be noted that the met tower site was located in the Village of Hyannis, within the Town of Barnstable. While some of the figures in this report provided by RERL refer to it as Barnstable, KEMA otherwise refers to data collected at this tower as the Hyannis met data, distinguishing it from a separate data set taken at the Barnstable Municipal Airport.

The tower collected wind speed and directional data for a period of one year at heights of 10, 30, and 39 meters. RERL mounted give anemometers on a 40-meter, steel, tubular NRG tower. A pair of anemometers was located at both 39 meters and 30 meters, and a single anemometer was located at 20 meters. At each height, there was also a single wind directional vane. The tower was also equipped with a lightning rod, temperature sensor, and grounding cable. The data were collected and logged with an NRG Symphonie Data Logger. Based on our review of the measuring equipment, the mast type and height appear to be in accordance with standard practices, including: adequate spacing between sensors and the supporting mast and boom structures; appropriate orientation of booms relative to prevailing wind direction; and data collection standards. However, a taller tower such as that used in Harwich allows more accurate measurement of wind speeds at heights closer to where the hub of a potential wind project would be located. A taller tower would also allow the lowest boom to be mounted higher on the tower, decreasing interference from nearby trees and buildings.

Data collection began in late March 2005 and ended in late April of 2006. KEMA analyzed wind data from April 2005 through March 2006 for purposes of this report. Based on the data logged, certain points were flagged and omitted during the analysis. Points are flagged if the data recorded was outside the limit of the instrument, icing occurred on the instrument, or if redundant measurements significantly differed.

According to RERL, raw data recovery at the site was excellent, with gross data recovery of 100 percent and net data recovery of 99.98 percent after the quality assurance process. KEMA reviewed the validated data and found it to be consistent with industry data collection standards.

3.3 Wind Data Summary

3.3.1 Wind Data Summary - Harwich

Table 1 provides a summary of the validated data collected by the tower in Harwich. The sensor located at 50 meters indicates an average wind speed of about 5.75 meters per second (m/s) over the data collection period. The data for the 50 m height is plotted in Figure 5.

Measured Monthly Average Wind Speeds (m/s)			
Height	20m	38m	50m
August 2006	2.94	4.24	4.71
September	3.02	4.45	5.00
October	3.83	5.48	6.12
November	3.38	4.78	5.44
December	3.96	5.45	6.16
January 2007	4.28	5.79	6.52
February	4.26	5.67	6.29
March	4,65	6.19	6.89
April	4,18	5.47	6.02
May	3.69	4.88	5.40
June	3.81	5.07	5.60
July	3.20	4.38	4.86
Average	**3.77**	**5.15**	**5.75**

Table 1: Harwich Monthly Average Wind Speed

Above, the monthly average wind speeds at the three different met tower heights are shown for the one-year period during which the data was collected.

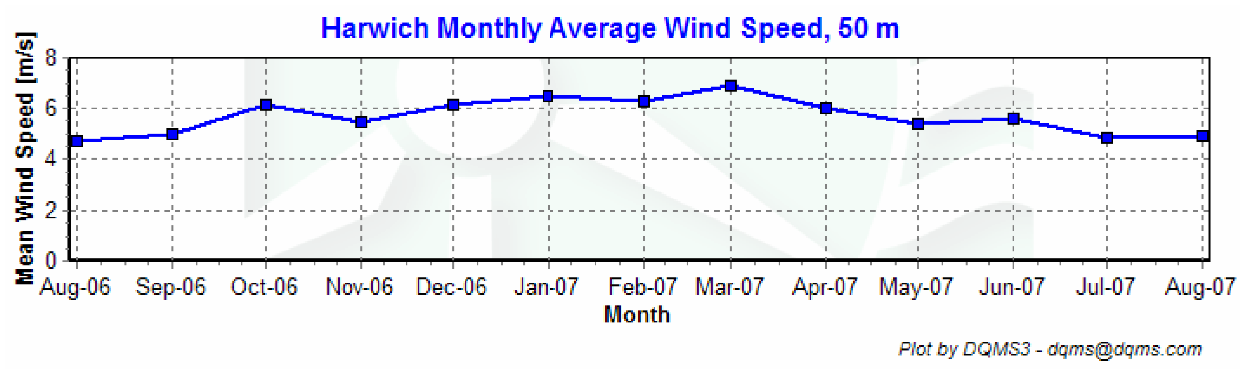

Figure 5: Monthly Average Wind Speed, Harwich

The monthly average wind speeds are plotted for the met tower data. (Courtesy of RERL)

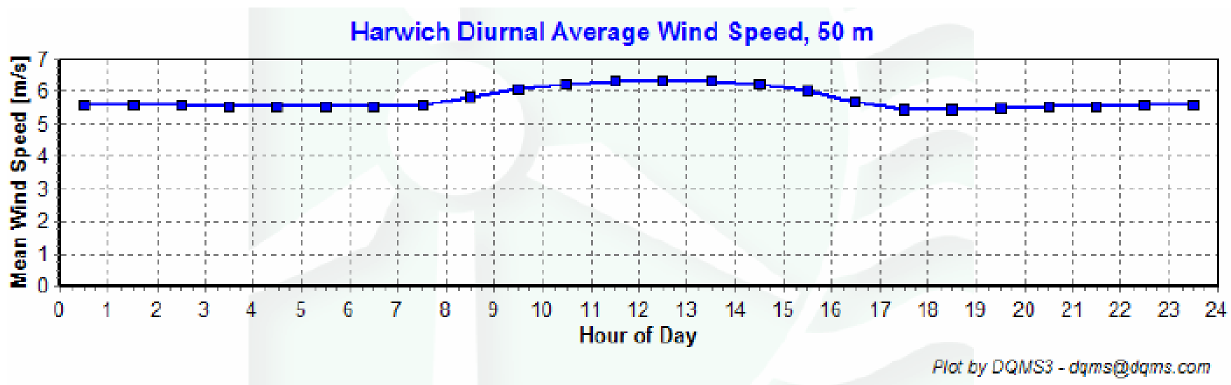

Figure 6: Diurnal Average Wind Speed, Harwich

The average wind speed for each hour of the day is shown at a 50-meter height. (Courtesy of RERL)

The Diurnal Plot of the wind data is shown in Figure 6. The data are taken from the sensors at the 50-meter location. Such a diurnal fluctuation is typical for regions on the Eastern Seaboard. During windier times of the year (fall, winter, and early spring), the diurnal variation will follow a similar pattern but have a larger magnitude than that of late spring and summer.

KEMA's review of wind conditions at other met tower sites on Cape Cod found that similar seasonal fluctuations exist at these sites. Overall, these findings suggest that data collected by the met tower are representative of a "typical" year in terms of seasonality. The overall character of the wind is depicted in the wind rose (Figure 7), which shows the average speed and direction of the wind for the 50-meter met tower sensor.

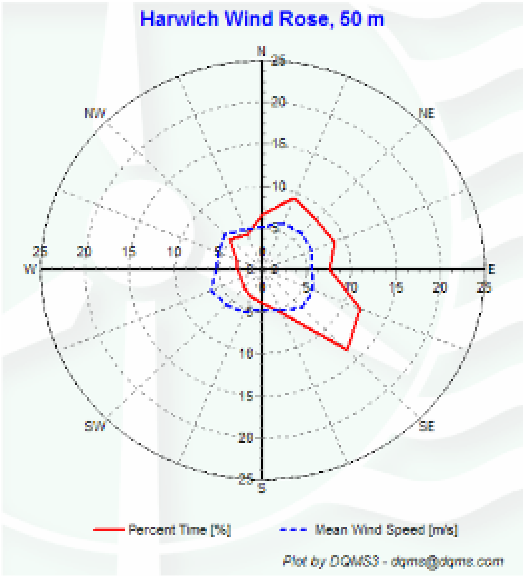

Figure 7: Harwich Wind Rose, 50 m

The wind rose is shown for the Harwich met tower data at 50 m. The plot shows both wind speed and frequency for a given direction.

3.3.2 Wind Data Summary - Hyannis

Table 2 provides a summary of the validated data collected by the tower in Hyannis. The sensor located at 39 meters indicates an average wind speed of about 5.28 meters per second (m/s) over the data collection period. The data for the 39 m height is plotted in Figure 8.

Measured Monthly Average Wind Speeds (m/s)			
Height	39m	30m	10m
April 2005	5.68	5.25	3.87
May	5.72	5.41	4.19
June	5.00	4.70	3.72
July	4.55	4.21	3.13
August	4.46	4.10	2.91
September	4.64	4.26	3.02
October	5.64	5.19	3.66
November	5.33	4.82	3.37
December	5.22	4.75	3.46
January 2006	5.91	5.42	4.00
February	5.94	5.45	4.11
March	5.23	4.82	3.70
Average	**5.28**	**4.87**	**3.60**

Table 2: Hyannis Monthly Average Wind Speed

The monthly average wind speeds at three different heights of the met tower are shown for the one-year period during which the data was collected.

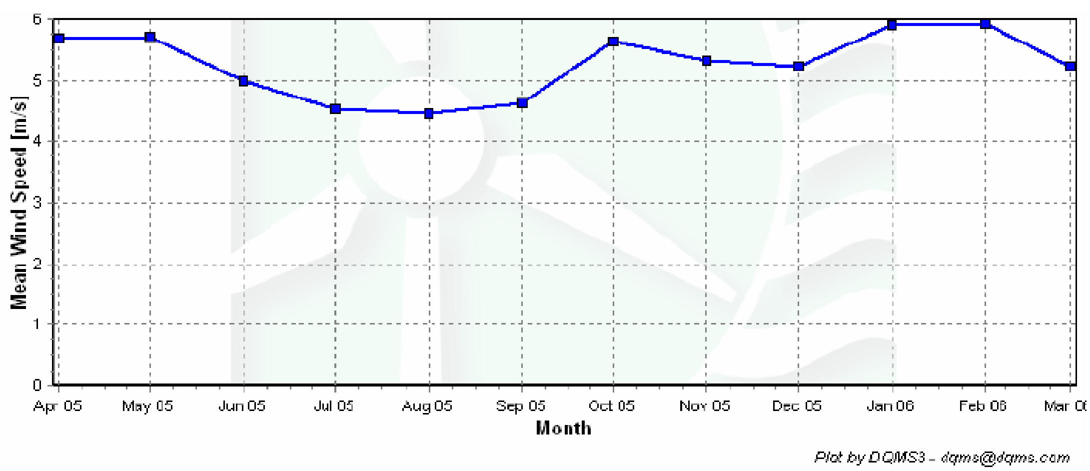

Figure 8: Monthly Average Wind Speed, Hyannis

The monthly average wind speeds are plotted for the met tower data. (Courtesy of RERL)

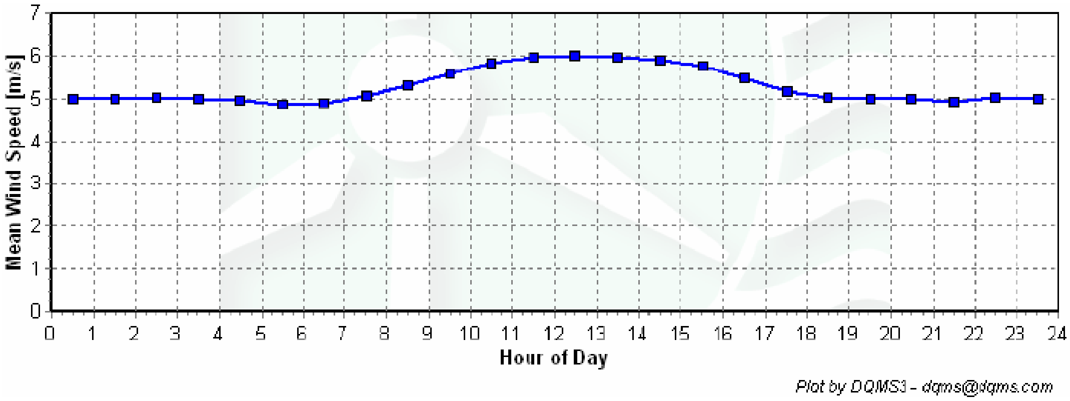

Figure 9: Hyannis Diurnal Average Wind Speed

The average wind speed for each hour of the day is shown at a 39-meter height. (Courtesy of RERL)

The Diurnal Plot of the wind data is shown in Figure 9. The data are taken from the sensors at the 39-meter location. Overall, these findings suggest that data collected by the met tower are representative of a "typical" year in terms of seasonality. The overall character of the wind is depicted in the wind rose (Figure 10), which shows the average speed and direction of the wind for the 39-meter met tower sensor.

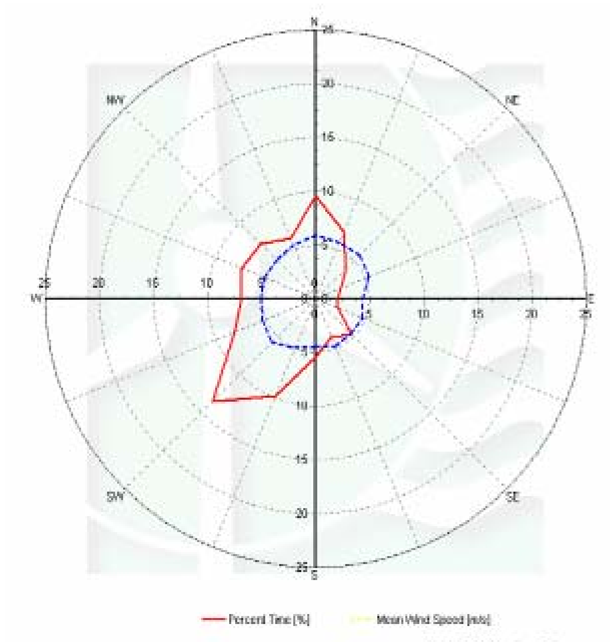

Figure 10: Hyannis Wind Rose, 39 m

The wind rose is shown for the Hyannis met tower data at 39 m. The plot shows both wind speed and frequency for a given direction.

3.4 Wind Shear

Wind shear is the vertical variation of wind speed, and is a function of the roughness of the surrounding terrain. A power law can be used to extrapolate wind speeds at higher elevations based on measured wind speeds below. The power law wind speed profile used by the RERL is:

$$\frac{U(z)}{U(z_r)} = \left(\frac{z}{z_r}\right)^{\alpha} \quad (3)$$

where U(z) is the wind speed at height z, $U(z_r)$ is the wind speed at reference height z_r, and α is the power coefficient that relates to the wind shear.

RERL used power law extrapolations of the measured wind profiles at 20, 38, and 50 meters for Harwich and 10, 30, and 39 meters for Hyannis. According to RERL, wind shear appears to be fairly high at both met tower sites, with a power law exponent (α) of approximately 0.40 for Harwich and 0.31 for Hyannis. The Harwich data is consistent with a roughness length of approximately z_0=3.57 m, which can be described as rough suburban terrain, with mixed trees, cleared areas, and residences. In our view, this roughness length is consistent with the surrounding terrain. The Hyannis data is consistent with a roughness length of approximately z_0=1.33 m, which is a slightly lower roughness than in Harwich, perhaps due to some nearby open areas to the west, north, and east of the met tower. Based on the wind shear measurements in Harwich and Hyannis data, we anticipate similarly high wind shear conditions in Yarmouth.

The consequences of this high roughness are twofold. On the one hand, the wind resource increases rapidly as the turbine tower height increases. However, higher shear levels impose higher levels of mechanical strain on a wind turbine's blades and drive train. This effect will be taken into account when assessing the suitability of different wind turbines for the DYRHS site.

3.5 Turbulence

Turbulence intensity is the ratio of wind speed fluctuations and wind speed, and decreases with height. For Harwich, turbulence intensity ranges from 29 percent at 20 meters to 21 percent at 38 meters, and as low as 19 percent at 50 meters for a wind speed. For Hyannis, turbulence is 20 percent at 39 meters and 21 percent at 30 meters. These are relatively high values, though they are in accordance with the roughness of the terrain, and are consistent between the two data sets. The turbulence intensity is given at 50 meters for Harwich (Figure 11) and for Hyannis (Figure

12). The turbulence intensity is one of the parameters used to select an appropriate wind turbine for the site, as turbulence is the main cause of fatigue loads on wind turbines.

Turbine manufacturers offer wind turbines according to the International Energy Commission (IEC) classification. The IEC classification is based on wind speeds (Class I, II, or III) as well as turbulence intensity (Sub-class A, B, or C). Wind speeds must be taken into account in two ways: the IEC classification designates both an expected average wind speed and an "extreme wind speed". The average wind speed does not specify a design requirement, rather a suggested average operating wind speed. The extreme wind speed, however, designates a design requirement that the wind speed cannot be expected to exceed, with a 50 percent probability, every 50 years. For a given wind turbine model, lower class numbers correspond to designs using smaller rotor diameters, which are intended for higher winds. Higher numbers correspond to larger rotor diameters for low wind areas. For each class of turbine (designated by wind speed characteristics), an associated sub-class categorization is assigned based on the turbulence characteristics. Sub-class A turbines are generally used for sites with a turbulence intensity of greater than 16 percent at hub height, whereas sub-class B turbines are for those with lower turbulence intensity.

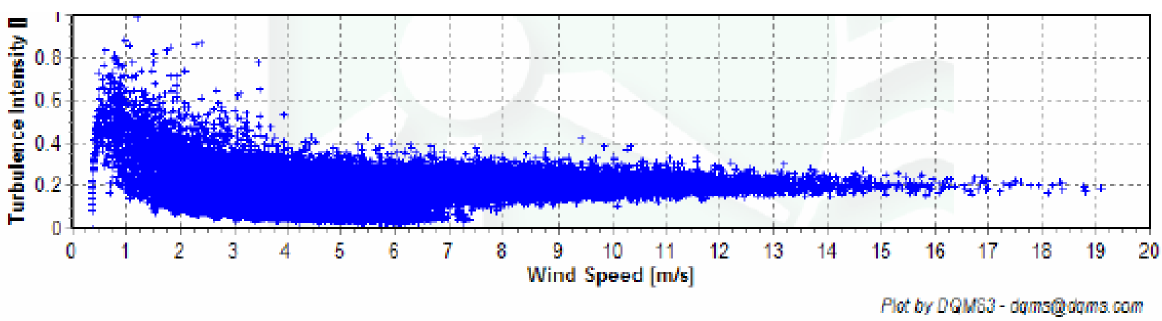

Figure 11: Harwich Turbulence Intensity, 50 m

The turbulence intensity measured at 50 m by the Harwich met tower is shown. The intensity averages 19% at 50 m. (Courtesy of RERL)

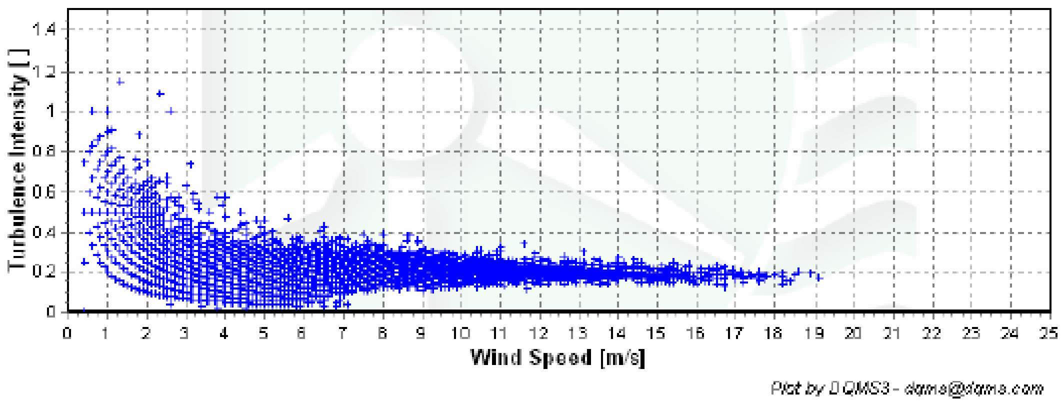

Figure 12: Hyannis Turbulence Intensity, 39 m

The turbulence intensity measured at 39 m by the Hyannis met tower is shown. The intensity averages 20% at 39 m. (Courtesy of RERL)

Regarding wind speed, although a Class III turbine would be generally more appropriate for a site with Yarmouth's average wind speeds, only Class I and II turbines could be considered given the frequency of hurricanes that reach Cape Cod. As Class II turbines are designed for slower wind areas than Class I turbines, Class II designs will almost certainly produce better economic results in Yarmouth. Because of the measured turbulence level of 19 percent at 50 meters for a 10 m/s wind speed, KEMA suggests that only subclass A turbines be considered. Yarmouth should therefore concentrate on Class IIA wind turbines for the DYRHS site. During the procurement process, the issue of turbine class should be readdressed with the manufacturer to take into account the site's turbulence, potential extreme wind speeds, and overall economics of an increased rotor diameter.

We do not expect that the turbulence intensity will cause mechanical problems for the wind turbine, but in combination with the high wind shear, the wind turbine should be chosen appropriately to take these factors into account. During the turbine procurement process, the manufacturer should be made aware of the high turbulence and wind shear conditions.

3.6 Estimating the Wind Resource

3.6.1 Terrain modeling

The vertical wind profile at the met tower and turbine locations as well as the regional distribution of the wind resource depend mainly on the terrain relief and the terrain roughness. The DYRHS has an elevation of approximately 10 meters above sea level and is located in flat or gently rolling terrain. The slope of the terrain surrounding the measuring location is minimal and it is therefore not expected that flow separation will occur.

The terrain roughness is the most important influence on the local wind climate. In areas with high roughness, the wind profile is steeper, causing the wind speeds to be lower near the ground. In wind resource models this is taken into account by the so-called roughness length, which varies from very flat and smooth terrain to built-up areas or areas covered by forests. Most of the land in Yarmouth is populated by dense trees approximately 40 feet in height.

From previous studies it is known that wind flow modeling over forests needs special attention.[4] In order to model the flow over the forest correctly, it is sometimes necessary to take into account the vertical displacement of the wind profile. This is done because the reference plane of the wind profile is not at the surface but at approximately 2/3 the tree height. In this study, however, the measured wind resources indicated that the profile displacement height was minimal and could be modeled well with a power law wind profile.

Because wind speed data was available only from the Harwich and Hyannis met towers, located seven miles west and six miles east of the turbine site, respectively, KEMA conducted two simulations using the MS-Micro/3 wind flow analysis routine provided within WindFarm. The MS-Micro analysis incorporates topographical data and estimated surface roughness data to numerically simulate wind conditions for the entire map region. Although all numerical wind simulations have limitations, MS-Micro is known to perform well for gradual and non-mountainous terrain. MS-Micro is best applied to small wind farms with less than three rows of turbines. Because DYRHS is looking only at a single turbine in gentle topography, MS-Micro is expected to provide reasonable predictions of wind resources throughout the region.

The energy output of the potential turbine at the DYRHS site was estimated using numerical predictions based on both the Harwich and the Hyannis met towers. Because there was some discrepancy between predicted energy output, KEMA modeled energy production as derived from both sites, individually. This methodology, by producing two estimated energy output values at the site under consideration, reflects on the precision associated with simulating local wind conditions from met towers over five miles away. Ideally, a project site's wind conditions would be estimated by using data collected at the site. Because this data was not available for the DYRHS site, some uncertainty exists for predicted wind conditions.

[4] 'Proceedings workshop on the influence of trees on wind farm energy yields', BWEA, 17 March 2004, Glasgow, (http://www.bwea.com/planning/trees.html).

3.6.2 Wind Flow at the Yarmouth Project Site

Using the ReSoft WindFarm software, KEMA extrapolated energy production at the DYRHS site based on data from the Harwich and Hyannis met towers. By using data from met towers located on opposite sides of the High School, with Harwich to the east and Hyannis to west, it is likely that the wind resource at the site will fall somewhere between the two.

Studying maps of the terrain, topography, and building structures between the DYRHS and the two met stations allowed us to generate a roughness map of the area. We did not uncover any areas likely to cause a major variation in wind flow during this exercise, which suggests that the wind flow extrapolation should be relatively accurate, falling within the range of predictions suggested between the two met sites.

3.6.3 Long-Term Data Correlation & Wind Resource at DYRHS

Having explored the one-year wind resource measurements taken by RERL, we will now "normalize" these two wind data sets to account for how windy the data measurement periods were compared to the long-term average. From year to year, the average wind speed in Harwich typically varies by approximately ±4% (one standard deviation) above or below the long-term average, meaning that the 95% confidence interval for the long-term wind speed is ±8%. This estimate can be improved by correlating the wind speed measurements at the site with long-term measurements from a nearby reference meteorological station, enabling an estimate of longer-term wind conditions. For example, if the average wind speeds between April 2005 and March 2006 (the Hyannis wind monitoring period) were significantly lower than the long-term average, we would use the reference data to adjust the average wind speed upward to more accurately reflect the predicted long-term wind speed.

For this correlation, KEMA utilized wind data recordings from a monitoring tower at Barnstable Municipal Airport (BMA), available through the National Oceanic and Atmospheric Administration (NOAA) National Data Center. NOAA provided meteorological data from the BMA site beginning in 1998. BMA is located about 4.4 miles west of the site under consideration, 1.4 miles east of the Hyannis met tower site, and 11.1 miles southwest of the Harwich met tower site.

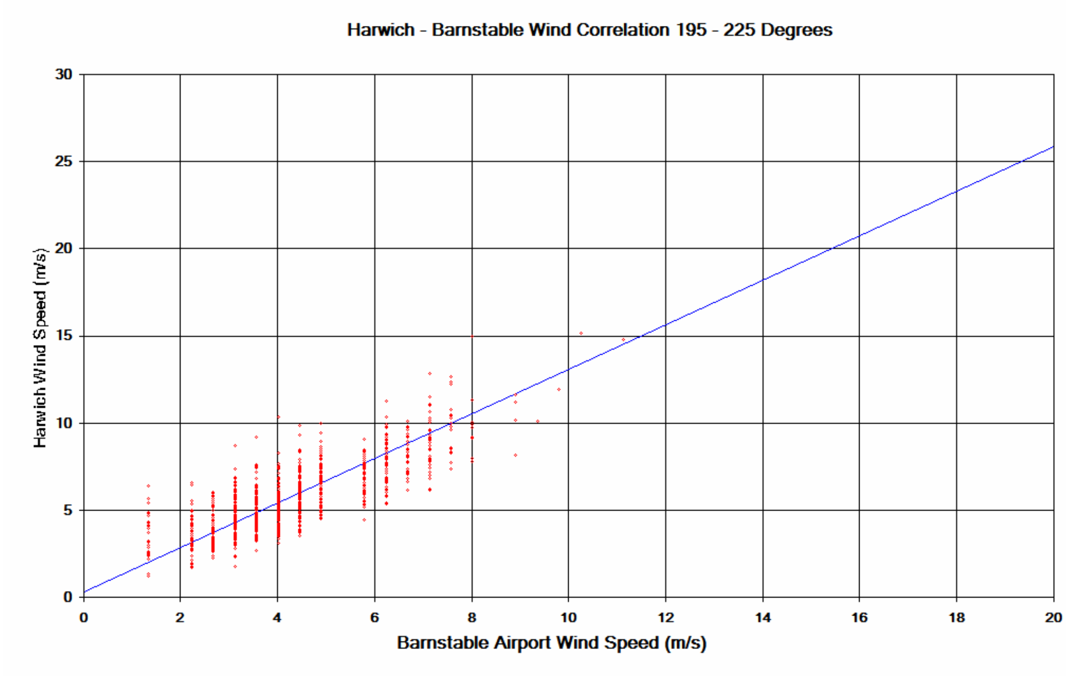

Figure 13: Sample Historic Wind Correlation

A sample correlation between average wind speed at the Harwich met tower and BMA is given for winds from the southwest.

Figure 13 shows the correlation between the average daily wind speeds at BMA and the DYRHS met tower for wind directions between 195º and 225º. The coefficient of regression, R^2, was determined to be 0.798 for wind speeds in this direction. A similar analysis was performed on data for all wind directions and coefficients of regression ranged from 0.715 to 0.929, indicating that the wind speeds at BMA were found to correlate well to those at the Yarmouth met tower.

With the help of WindFarm software, the wind speeds of BMA were linearly correlated to both the Harwich and Hyannis met towers for each direction over the period from to August 1, 2006 to July 31, 2007 for the former, and April 1, 2005 to March 31, 2006 for the latter. The correlation coefficients were used to develop a relation between the wind behavior at the two met tower sites and that at BMA. KEMA used seven years of historic wind data from the airport for each met site—August 2000 to July 2007 for Harwich and April 1999 to March 2006 for Hyannis. The average of the preceding six years was compared to the BMA data for the period concurrent with the two met tower data sets, and correlation parameters were created to relate the measured data to the historical data.

Table 3 presents average wind speeds at 12 meters for the BMA monitoring tower. The wind speed during the 2005-2006 measuring period was somewhat higher than the average during the six years prior to the data measuring period. For the purpose of estimating the annual wind energy production, Harwich's measured wind speeds were decreased by approximately 9.6 percent (as shown in the table), using the ReSoft WindFarm software to reflect the fact that the year in which the wind was measured was a well "above average" year. Hyannis data was measured during an even windier year, causing results to be adjusted downward by 12.9 percent.

Year	Avg. Wind Speed (m/s)	Windex
2000 - 2001	3.47	92.6%
2001 - 2002	3.67	98.0%
2002 - 2003	3.63	97.0%
2003 - 2004	3.63	96.9%
2004 - 2005	3.95	105.3%
2005 - 2006	4.13	110.2%
6-year Avg	*3.75*	*100.0%*
2006 - 2007	**4.10**	**109.6%**

Table 3: BMA Wind Speeds & Normalization Index[5]

The Wind Speed Index is given for years August 2000 through July 2007—the correlation period for Harwich. The WindFarm program calculated a similar index for the Hyannis correlation period.

Using the historical correlation parameters, KEMA predicted wind speeds for a typical year at the Harwich and Hyannis sites. Figure 14 shows the predicted wind speed distribution for the Harwich met tower, at a reference height of 50 meters. Figure 15 shows this data for Hyannis, at a reference height of 39 meters. Table 4 and Table 5 show the numerical wind speed distribution in hours for Harwich and Hyannis, respectively. Figure 16 and Figure 17 show the wind roses for the two sites.

[5] It is important to note that the Harwich met tower wind data spanned a 12-month period from mid-July 2005 through mid-July 2006. The wind speed data that KEMA analyzed from BMA was defined in similar 12-month intervals.

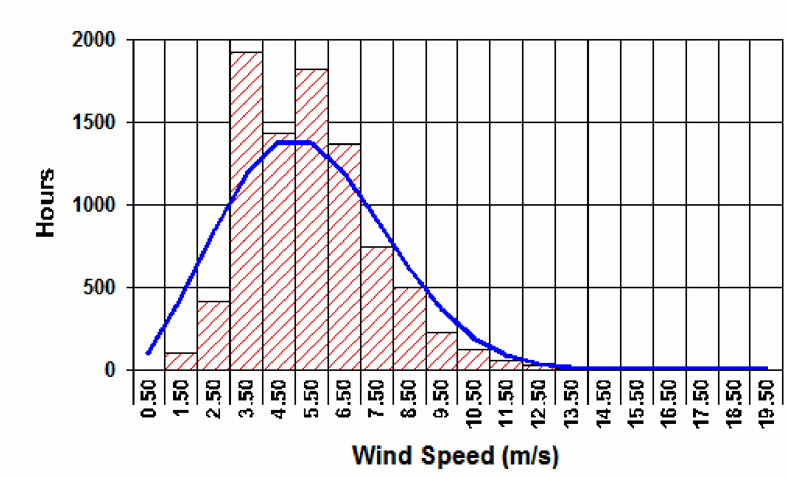

Figure 14: Harwich Average Wind Speed Histogram

The figure above shows the wind speed distribution of the long-term predicted wind resource at 50 m above ground level at the Harwich wind monitoring station, in 1.0 m/s increments. The figure below shows this distribution for Hyannis, in 0.5 m/s increments.

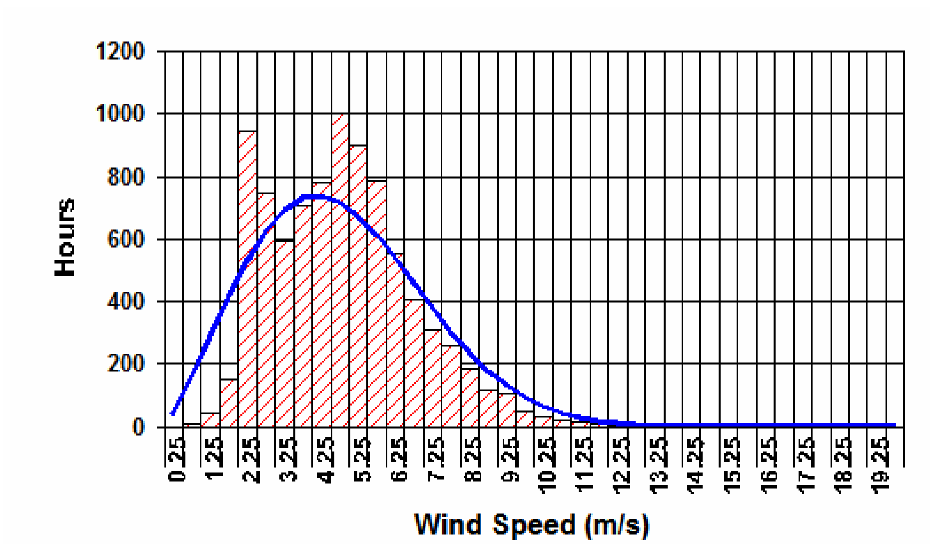

Figure 15: Hyannis Average Wind Speed Histogram

The wind speed distributions for both met towers follow Weibull distributions, as depicted by the blue curves. Hyannis wind speeds appeared slightly lower, but followed a similar Weibull distribution.

Wind Speed (m/s)	0.0-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0
Hours Per Year	0	97	411	1,931	1,438	1,818	1,366	747	501	229
Wind Speed (m/s)	10.0-11.0	11.0-12.0	12.0-13.0	130-14.0	14.0-15.0	15.0-16.0	16.0-17.0	17.0-18.0	18.0-19.0	19.0-20.0
Hours Per Year	118	57	28	10	4	2	1	1	0	0

Table 4: Harwich Predicted Wind Speed Frequency Data

Wind Speed (m/s)	0.0-1.0	1.0-2.0	2.0-3.0	3.0-4.0	4.0-5.0	5.0-6.0	6.0-7.0	7.0-8.0	8.0-9.0	9.0-10.0
Hours Per Year	10	194	1,692	1,301	1,785	1,687	962	570	303	156
Wind Speed (m/s)	10.0-11.0	11.0-12.0	12.0-13.0	13.0-14.0	14.0-15.0	15.0-16.0	16.0-17.0	17.0-18.0	18.0-19.0	19.0-20.0
Hours Per Year	52	27	11	10	2	1	0	0	0	0

Table 5: Hyannis Predicted Wind Speed Frequency Data

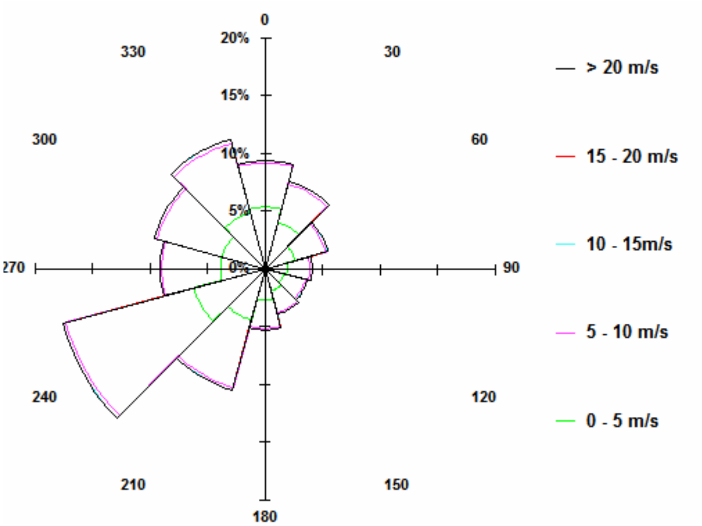

Figure 16: Harwich Wind Rose

The 50 m wind rose, representing the long-term predicted wind resources at the Harwich met tower site, is shown above. The 39 m wind rose for Hyannis is shown below. The wind blows predominantly from the southwest at both sites, though the distribution of the northerly winds varies somewhat between the two sites. These wind roses differ from those presented in section Figure 7 in that they represent normalized data, rather than the single-year data collected by RERL.

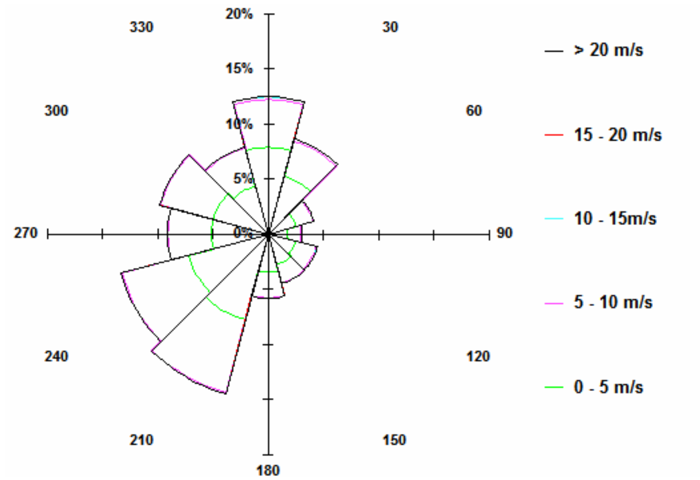

Figure 17: Hyannis Wind Rose

3.7 DYRHS Wind Speeds at Hub Height

As evidenced in the wind profile calculations in Harwich and Hyannis, there is anticipated to be a considerable wind shear at the DYRHS location. Therefore, increasing the hub height will result in a considerable increase in wind speed and corresponding energy production. Due to the height constraints at the DYRHS site, a turbine would almost certainly be limited to a 65-meter tower, if not shorter.

KEMA explored wind speeds at common hub heights for two available Fuhrlaender turbines, the FL1500 and FL600. Because the FL600 produces significantly less output than the FL1500, and therefore significantly lower economic returns, it would most likely be selected only if the Town sought to minimize the height of the turbine. Therefore, KEMA did not explore an FL600 mounted on a 65-meter tower, although the option is available.

Table 6 provides the predicted average wind speed at DYRHS as a function of the hub height. It should be noted that the WindFarm software does not provide a wind speed distribution histogram at each hub height. Because of this, KEMA used output data from the next step of the process, energy yield calculations, to derive the predicted wind speed data shown above.

Predicted Average Wind Speeds at DYRHS		
	Hub Height	
	65m	50m
Based on Harwich data	6.05	5.46
Based on Hyannis data	5.61	5.22
Average	**5.83**	**5.34**

Table 6: DYRHS Predicted Wind Speeds

The table above shows the relative increase in wind speed as a function of hub height.

3.8 Projected energy production

Based on the measurements at the Hyannis and Harwich met towers and the wind resource modeling, KEMA estimated the wind speed and direction distribution for the DYRHS site at selected wind turbine heights. The wind speed distribution gives the number of hours that a particular wind speed blows per year. Using WindFarm, we then combined this wind speed distribution with a power curve for each selected wind turbine to obtain the gross annual wind energy production and corrected for availability and electrical grid efficiency to obtain an estimate for the net annual wind energy production. Energy output predictions were about 10 percent higher using the Harwich data than the Hyannis data.

3.8.1 Selected Wind Turbines

Based on the wind resource and turbine height constraints in Yarmouth, two wind turbines have been considered: the Fuhrlaender 600 (FL 600), which has a power capacity of 600 kW and a rotor diameter of 50 meters, mounted on a 50-meter tower; and the Fuhrlaender 1500 (FL1500), which has a power capacity of 1.5 MW and a rotor diameter of 70 meters, mounted on a 65-meter tower. Both are Class IIA turbines and meet the height restrictions at the Site.

KEMA obtained the power curve from the manufacturer's Northeast distribution arm, Lorax Energy. The power curves used here are for the specified versions of the wind turbines. It should be noted that some manufacturers offer special low-noise turbines, which as a consequence have a lower power output.

3.8.2 Calculation of Net Energy Production

Based on the calculated wind resources, the energy production of a wind turbine at the DYRHS was estimated. The energy production of the two selected wind turbines is reported in Table 7.

'Capacity factor' is a measure of the productivity of a wind turbine, calculated by the amount of power that a wind turbine produces over a set time period, divided by the amount of power that would have been produced if the turbine had been running at full capacity during that same time interval. Most wind turbines operate at a capacity factor of 25% to 40%. Based on whether Hyannis or Harwich was used as the base, the predicted capacity factor ranged from 17.2 to 19.1 percent for the FL600 and 18.7 to 21.1 percent for the FL1500. This range is slightly below what is typically deemed a well-sited wind energy project.

The total percent of time that a wind turbine is capable of producing power is known as the total availability. The following factors influence the total availability:

- **Grid connection efficiency.** The efficiency of the grid connection is estimated to be 97%. This includes the losses in the transformer and the transmission line. This should be confirmed by an electric loss calculation once the grid connection has been defined.

- **Turbine availability.** The technical availability of the turbine is assumed to be 97%. This figure is based on data from modern operational wind farms. Technical availability may be a part of the contract terms between the project owner and the wind turbine supplier. It is worth noting that manufacturers may not guarantee technical availability at the 97% level for small, one or two turbine projects. It is advisable to review this figure when the terms of the warranty are established.

- **Turbine icing and blade fouling.** As serious icing conditions can prevent a wind turbine from operating, it has been assumed that the machine will be shut down for approximately 24 hours per year. Blade fouling is not expected to occur, as this is primarily a problem in very hot climates where severe insect fouling can affect the aerodynamics of the turbine blades.

- **Substation maintenance.** The connection to the grid may have to be temporarily shut down for maintenance. KEMA has assumed that this might occur for a total of 16 hours per year.

- **Utility downtime.** Most wind turbines will fail to efficiently produce energy during lower wind conditions when the grid does not actively supply electricity for the machine's control systems due to a grid power outage. The will occur, on average, approximately 8 hours per year.

- **High wind speed hysteresis.** During very high wind conditions, a wind turbine will shut down to protect its electrical and mechanical components. The machine will only restart when wind conditions fall significantly below the cut-off wind speed. This factor is used to compensate for power loss during this restarting delay. Because Yarmouth rarely experiences winds above the 20 meters per second, neither turbine model would be likely to cut out due to high wind speed hysteresis.

Results of the net production analysis are shown in Table 7 below.

Turbine	Fuhrlaender 600	Fuhrlaender 1500
Nominal power	0.6 MW	1.5 MW
Rotor diameter	50 m	70 m
Hub height	50 m	65 m
Average Wind speed	5.34 m/s	5.83 m/s
Ideal annual energy production	953 MWh	2,617 MWh
Net annual production	890 MWh	2,446 MWh
Capacity factor	18.1%	19.9%
Grid connection efficiency	97%	97%
Turbine availability	97%	97%
Turbine icing and blade fouling	99.7%	99.7%
Substation maintenance	99.8%	99.8%
Utility downtime	99.9%	99.9%
High wind speed hysteresis	100%	100%
Total Availability	93.5%	93.5%

Table 7: Turbine Specifications and Availability

The energy production of the chosen wind turbines is given along with site and turbine specifications. Wind speed, as well as resulting capacity factor and energy output represent averages of the results from the Harwich and Hyannis sites.

3.8.3 Uncertainty Estimates

The use of multiple meteorological data sets already provides a range of wind resource predictions to represent a potential high and low wind scenario. However, for a full-scale feasibility study, KEMA would make an even more conservative estimate of the long-term wind speed at the site (than that from the Hyannis site), based on various uncertainty factors. Typically, it is advised that a “P90” wind distribution scenario is explored, meaning that there is a 90 percent probability that the long-term average wind speed would be at or above the predicted level. Uncertainty factors typically included in this type of analysis are: anemometer accuracy, correlation accuracy, variability of long-term correlation data, wind profile modeling, turbine lifetime uncertainty, and long-term average uncertainty.

Because this is a preliminary feasibility study, these calculations have not yet been made. Furthermore, because we extrapolated the wind resource using met data from towers located far from the site under consideration, there would be a very high degree of uncertainty, potentially leading to an unnecessarily low estimate of the P90 scenario.

3.8.4 Additional Wind Monitoring

Due to the high level of deviation between long-term wind resource and energy yield results from Harwich compared with those of Hyannis, the Town may wish to gain a more accurate reading of the DYRHS site's specific wind resource. To do so, it would have to engage in wind monitoring at the site. This could take the form of a standard met tower, like those erected by RERL at the two nearby sites. Alternatively, the Town could consider short-term use of SODAR, which is also available through RERL. SODAR is a technology that relies on acoustic signals sent up into the atmosphere and reflected back to the SODAR equipment to determine wind speeds at various heights. As discussed above, because of the intermittent sounds emitted by the SODAR machine, it would not be applicable at the DYRHS site but potentially at the Yarmouth transfer station approximately 1 mile away. The SODAR data could similarly be correlated with data from BMA to more accurately determine the relationship between the wind resource at the transfer station site with that at BMA, and would provide a better representation of wind conditions at the DYRHS than is available presently. SODAR equipment typically resides on a portable platform, and therefore can be moved from one location to another far more easily than an anchored met tower. Thus, it is often used at sites where short-term monitoring will suffice. It is also very valuable for predicting wind speeds at different heights, where high turbulence causes great wind speeds to increase rapidly with height.

3.9 Summary

The measured data from the Harwich and Hyannis met towers indicate that the DYRHS has only a moderate wind resource, which might be below the range typically considered for a utility scale wind turbine project. To gain a more accurate reading of the site wind resource, it would be necessary to take wind measurements at the site, either through short-term SODAR monitoring or by collecting a full year of met tower data. The Harwich and Hyannis sites indicated that there were significant levels of wind shear and turbulence. We anticipate that the DYRHS site would present similarly high wind shear and turbulence conditions that should be considered during turbine selection and procurement in regard to operations, maintenance, and influence on component lifespan though these factors should not pose a problem for an appropriately chosen wind turbine.

KEMA developed estimates of the long-term annual average wind speed for the DYRHS site by normalizing met tower data from the Harwich and Hyannis measuring sites to trends at the nearby BMA meteorological monitoring station over the past six years.

Over the long term, the DYRHS site is expected to experience an average wind speed of 5.22 to 5.46 m/s at 50 meters above ground level (AGL) and 5.61 to 6.05 m/s at 65 meters AGL. Energy production calculations were performed, with expected average net energy yields ranging from 900,000 to 1.0 million kWh annually for the 600 kW turbine, or 2.4 million to 2.7 million kWh for the 1.5 MW turbine.

4. Site Electrical Infrastructure

This section discusses key interconnection and other issues associated with developing a wind project at the Yarmouth DYRHS. Overall, our findings suggest that the interconnection should be technically feasible for projects up to 1.5 MW, the largest project that would likely be able to meet the site's height restrictions.

4.1 Interconnection Standards

At the federal level, new distributed generation interconnection requirements impacting large wind power facilities were adopted by the Federal Energy Regulatory Commission (FERC) in Spring 2006. The broad objective of these requirements is to treat distributed generation (DG) units in such a way as to "support the distribution system." Within Massachusetts, interconnection requirements for a potential wind turbine would be subject to NSTAR Interconnection Standard, MDTE No. 162A.

4.1.1 FERC Wind Interconnection Reliability Requirements

FERC proposed new interconnection requirements for wind and alternative energy generators in docket RM05-4-0000 NOPR (Notice of Proposed Rulemaking). This requirement is recommended to apply to conventional generators as well as wind and other renewable energy facilities. A primary objective of this regulation, as it would apply to a wind turbine at the DYRHS, is to ensure that such a facility would have ride through fault clearing capability. This is documented in the so-called Low-Voltage Ride Through (LVRT) requirement. Per this requirement, wind turbines should stay connected to the grid during low voltage events caused by system disturbances. In the event of a disturbance up to a certain magnitude, wind turbines should have the capability to "ride through" grid disturbances, remaining on-line and continuing to support the system.

The LVRT requirement would typically be addressed during the wind turbine procurement process. Most wind turbine manufacturers in the United States have already developed the technical capability to meet this requirement.

4.1.2 Wind Interconnection in Massachusetts

The Department of Telecommunications and Energy (DTE) opened its investigation into distributed generation a few years ago. The investigation focused on the development of interconnection standards, the calculation of standby rates, and the role of DG in distribution company resource planning.

Developed through a collaborative process with industry stakeholders established by the Massachusetts DTE (the Distributed Generation Interconnection Collaborative), the first model DG rules were approved in February 2004. The DTE requires all of Massachusetts' regulated utilities to file tariffs in compliance with these rules. Note that these guidelines apply to the Commonwealth's regulated investor-owned utilities: NSTAR Electric, National Grid, Western Massachusetts Electric Company, and Fitchburg Gas and Electric.

The standard interconnection tariff developed by the Distributed Generation Interconnection Collaborative serves as the basis for each utility's tariff. The tariff generally follows the structure set forth in consensus interconnection documents filed by stakeholders in the federal docket pertaining to FERC's Advance Notice of Proposed Rulemaking (ANOPR) on standard generator interconnection. However, the Massachusetts tariff has simplified some of the complexities found in the FERC consensus documents, and the Collaborative reached compromises on areas of non-consensus in the FERC process.

4.1.3 NStar Interconnection Standard No 162A

NSTAR (the local electricity distribution company for Yarmouth) has a Standard for Interconnection of Distributed Generation (DG), Massachusetts Department of Telecommunications and Energy (MA DTE)[6] No. 162A[7], which describes the interconnection process for connecting distributed generation to NSTAR distribution network. This standard refers often to the "Standards for Interconnecting Distributed Resources with Electric Power Systems" of the Institute of Electrical and Electronics Engineers (IEEE P1547). The IEEE-P1547 forms the basis for the technical considerations at the connection location, including anti-

[6] The MA DTE was responsible for the structure and control of monopoly Telecommunications and Energy in the Commonwealth; developing alternatives to traditional regulation and traditional monopoly arrangements; controlling prices and profits; monitoring service quality; regulating safety in the transportation and gas pipeline areas; and for the siting of energy facilities. The mission of the Department was to ensure that utility consumers are provided with the most reliable service at the lowest possible cost as determined by its orders; to protect the public safety from transportation and gas pipeline related accidents; to oversee the energy facilities siting process; and to ensure that residential ratepayers' rights are protected under regulations. On April 11, 2007, the DTE was divided into two separate agencies: the Department of Telecommunications & Cable (DTC) and the Department of Public Utilities (DPU). The Standard is still referred to as that of the DTE as the DPU has not updated the Standard.

[7] The most recent standard can be found at: http://www.masstech.org/renewableenergy/public_policy/DG/tariff/2007-04-06-NSTAR-DG-Interconnection-Tariff-conformed.pdf

islanding, power quality and ride-through capability of the wind turbine. The current Standards were set forth in March of 2007.

The different interconnection considerations, including transient voltage considerations, voltage and current harmonics, interference, etc., should be specified for the wind generator according to IEEE-519 Standard. Based on this standard, with a projected turbine size of up to 1.5 MW, interconnection of the DYRHS project will be required to include reactive power capabilities to regulate and maintain voltage levels at the Point of Common Connection (PCC) according to NEPOOL and NE ISO requirements.

NSTAR participates in the DG Collaborative process that outlines interconnection procedures, costs, and associated timelines according to four tracks. Based on the size of the potential wind turbine at the DYRHS, Yarmouth would use a Standard Application to apply for interconnection service and to begin the interconnection study process with NSTAR. The interconnection application process requires an electrical one-line drawing for the project and can commence after the final project design has been approved. After submitting the required application and application fee and opting for the Standard Process Initial Review, NSTAR will provide a cost estimate and schedule for the required interconnection studies. This review can take up to 33 days. Once the customer accepts the time and cost estimates for the interconnection, NSTAR will conduct an Impact Study and, if required, perform a Detailed Impact Study. The Impact Study and Detailed Impact Study can require 55 and 30 days, respectively. The entire Standard Application for interconnecting DG can take up to 125 days.

Interconnection costs for equipment, updates, and labor will be borne by the owner of the DG facility. The DG facility will also be responsible for the application fee (approximately $2,500) and the cost of the Impact and Detailed Impact Study, if required.

The different interconnection considerations, including transient voltage considerations, noise, voltage and current harmonics, frequency, interference, and voltage level should be specified for the wind generator according to the MDTE No. 162A. Based on this standard and for a projected turbine size of greater than 1 MW, interconnection of the DYRHS project will be required to include reactive power capabilities to regulate and maintain voltage levels at the Point of Common Connection (PCC) according to NEPOOL requirements. Turbines smaller than 1 MW will not be required to provide reactive capability, unless if designated specifically in the retail rate schedule and the Terms and Conditions for Distribution Services.

Protection requirements for the interconnecting DG system must meet the minimum specifications as set forth in IEEE Standard 1547-2003, UL Standard 1741, and IEEE Standard 929-2000. These standards are designed to minimize the possibility of damage to the electric grid, to prevent harm from occurring to utility personnel, and to prevent damage to other of NSTAR's interconnecting customers. Further discussion of the extensive technical requirements for protection can be found in MDTE No. 162A, section 4.

NSTAR requires that the interconnecting customer maintain the DG facility to the manufacturer's standards. If NSTAR expects that the DG facility is responsible for any interference in the power system or if the facility is producing power outside the requirements of quality agreed to, NSTAR has the authority to investigate and potentially disconnect the DG facility. For emergency maintenance, NSTAR must have access to the disconnect switch on the facility at all times.

The DG facility will be required to use a bi-directional meter if rated capacity is between 60 kW and 1 MW. The meter will have remote access capability and may be an interval meter. If the DG rated capacity is between 1 MW and 5 MW, the system will be required to have a bi-directional, interval meter with remote access. Only DG systems of 60 kW or less are presently allowed by state policy to be eligible for net-metering. Pending legislation on virtual net-metering in the state of Massachusetts would, however, result in significant changes to metering requirements. Virtual net-metering will be discussed further in Section 7.1.2

4.2 Technical Details

4.2.1 Technical Details of DYRHS Wind Turbine Interconnection

Based on preliminary review of the site, the DYRHS distribution feeder terminates at a 500 KVA, 22/13.8 kV to 277/480 V pad mounted transformer owned by NSTAR Electric. The transformer feeds a 480 V, 3-phase, switchgear owned by the High School.

Based on the two electric bills for the DYRHS (account number 1376-729-29) the typical loading varies from 294 kW (lowest demand) to 536 kW (peak demand).

Besides the electrical loads of the high school, there is a small waste treatment plant (WWTP) on the property which treats wastewater from the high school and the elementary school next door. Typical of a WWTP are pumps, compressors and blowers. The school has two emergency stand-by generators supplying 3 phase 277/480 power with auto transfer switches. There are three additional electric utility meters at the high school's address, which service exterior lighting, but their monthly electrical use is small (<$100/mo).

4.2.2 Interconnection Feasibility

Based on the NSTAR Standard for Interconnection of Distributed Generation, M.D.T.E. No. 162A, and details from the DYRHS, we find that a wind turbine with a capacity of up to 1.5 MW could be interconnected with minimal facility and distribution upgrades. Wind projects having a larger capacity have not been investigated in this study. A medium voltage buried cable will need to be constructed from the premise boundary to the wind turbine site (600-900 ft) and a new 1.5 to 2.0 Megavolt-ampere (MVA) step-down transformer (13.8 kV to 600 V) will need to be installed at the turbine site. These issues would be examined further as part of an interconnection study.

4.3 Summary

Interconnection of a wind turbine at the DYRHS should be technically feasible for projects up to 1.5 MW. The interconnection application requires specifications about project generation capacity as well as site electrical drawings. The process can commence after the final project design has been approved. Pending metering legislation should be closely watched to ensure that future metering practices are taken into account for the DYRHS project.

5. Characteristics of the Site Vicinity

This section reviews the characteristics of the vicinity around the DYRHS site under consideration and issues impacting the potential for general community acceptance. Topics covered include potential project impacts related to: visual and noise effects; airspace issues; areas of cultural significance; communications infrastructure; and general community acceptance.

5.1 Visual and Noise Receptors and Potential Level of Impact

The potential visual and noise impacts of the project are best considered in the context of existing dwellings and other activities in relation to the turbine site. Residential properties surround the site under consideration. Location 2 is located about equidistant (900 feet) from properties to the northeast and southwest.

The features of the landscape surrounding the site under consideration also need to be considered when assessing potential visual and noise impacts of the turbine. Though the land is level, woods separate the potential turbine site from residences on all sides and form a potential visual and noise barrier between surrounding dwellings and the potential turbine.

5.1.1 Visual Impact

A 1.5 MW wind turbine atop a 65 meter (212 foot) tower would attain a top height of 100 meters (about 330 feet) at the tip of the rotor blade. Given the relatively flat terrain surrounding the DYRHS, a wind turbine at the potential location would be visible from vantage points in and around Yarmouth. However, such visual impacts are best considered in the context of the immediate vicinity.

We believe that the wooded landscape generally found in Yarmouth will act as a visual barrier from many parts of town. Photosimulations are included in Appendix A, which portray the visual impact of the turbine from different vantage points in town.

A flicker analysis (study of the reach and impact of moving shadows from a wind turbine) was not completed as part of this preliminary feasibility study. The presence of residences on the properties surrounding the site under consideration, and schools in closer proximity, indicate that a flicker analysis will be important to ensure that there is not significant impact.

5.1.2 Sound Impact

Sound levels from the potential turbine should also be considered in the context of the existing features of the landscape and DYRHS vicinity. While sound levels from wind turbines can be quantified, the public's perception of the sound impacts can be quite subjective. This subjectivity stems largely from the wide variations of individual tolerances for sound, and the inability to precisely predict corresponding reactions of annoyance and/or dissatisfaction. However, with continued advances in wind energy technology, sound produced from modern wind turbines has significantly decreased and is often masked by ambient or background noise of the wind itself. For reference, a 1 MW Fuhrlaender wind turbine can be heard at 42 decibels (dBa) at a point 300 feet away and ten feet from the ground. Forty decibels is the equivalent of noise heard from inside an urban environment.[8]

With regard to sound impacts, we believe that the distance from the recommended turbine location to the closest dwellings, combined with features of the natural landscape, will minimize sound impacts associated with the wind turbine. This is an issue that can be further investigated during the preparation of the complete Feasibility Study.

5.2 Airspace Restrictions

National Geospatial Intelligence Agency data was reviewed to evaluate air traffic in the Barnstable County region. Air and nautical maps (Figure 18) indicate two commercial flight paths in the vicinity of the Project Area, as shown in the figure below. Flight path V141 runs northwest and southeast, approximately 5 miles west of the Project Area. Flight path V167 runs northeast and southwest, approximately 6 miles northwest of the Project Area. Both flight paths cross each other approximately 6 miles northwest of the Project Area. The Barnstable Municipal Airport-Boardman Polando Field is located approximately 5 miles southwest of the Project Area. In addition, the Otis Army National Guard Base national airport and the privately owned Long Pond Airport are located approximately 17 miles west and 6 miles northeast of the Project Area, respectively.

MTC commissioned an initial opinion by Aviation Systems, Inc. about the height restrictions for a wind turbine at the DYRHS. That report is included as Appendix B to this report. Aviation Systems, Inc. found that a turbine structure up to 316 feet in height should receive routine approval from the FAA, while a turbine over 374 feet should not be approved.

[8] 30 decibels – whisper, 50 decibels – quiet auto at low speed, 60 decibels – ordinary conversation at 3 feet.

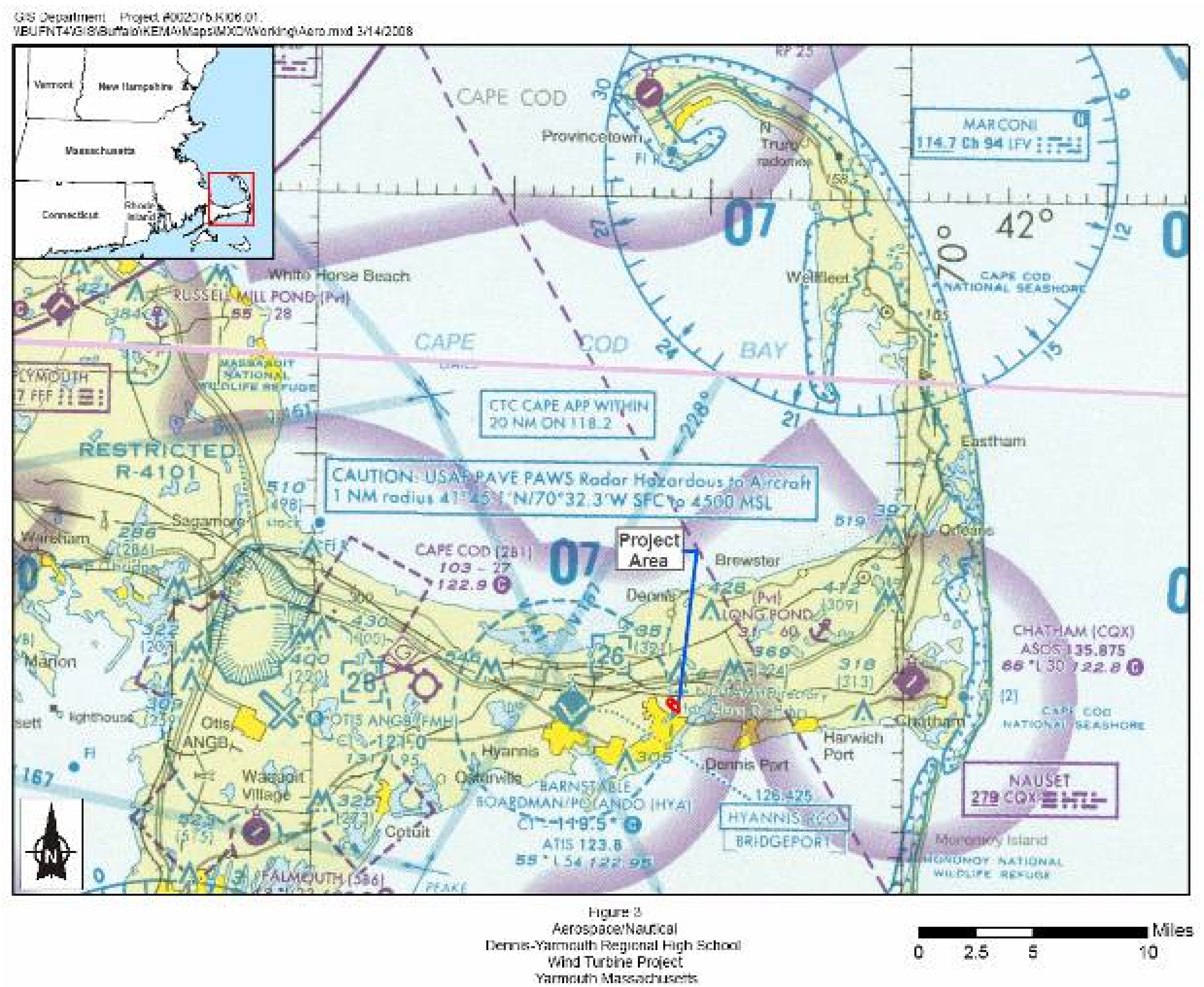

Figure 18: Aerospace/Nautical Map of Project Area

5.3 Pave PAWS Restrictions

The United States Airforce maintains a radar station (Pave PAWS) at the Otis Air National Guard Base in Bourne, about 19 miles to the northeast of the DYRHS. The USAF requires submittal of information regarding any wind turbine installation which may interfere with their radar in order to make a determination. KEMA submitted information about the potential turbine project to the USAF and is awaiting a response.

5.4 Cultural Significance

No known culturally significant resources exist at the project site. Additional investigation of cultural resources, including photosimulations of a turbine from potentially affected sites, can be completed during the complete Feasibility Study.

5.5 Impact on Communications Towers

Wind turbines have the potential to distort incident electromagnetic waves, which may be reflected, scattered, or diffracted by turbine blades and other turbine components. For example, when a wind turbine is placed between a radio, cellular, or microwave transmitter and receiver, it can sometimes reflect portions of the electromagnetic radiation in a way that the reflected wave interferes with the original signal arriving at the receiver. In cases where interference is encountered, the problem can sometimes be resolved by filtering or shielding the turbine generator and alternator. Line of sight microwave transmission is of particular concern to wind turbines. A point to point microwave beam passing through a rotating turbine blade would likely be subject to significant distortion. Wind turbines have also been known to affect television signals on nearby TV sets using traditional antennae for signal reception.

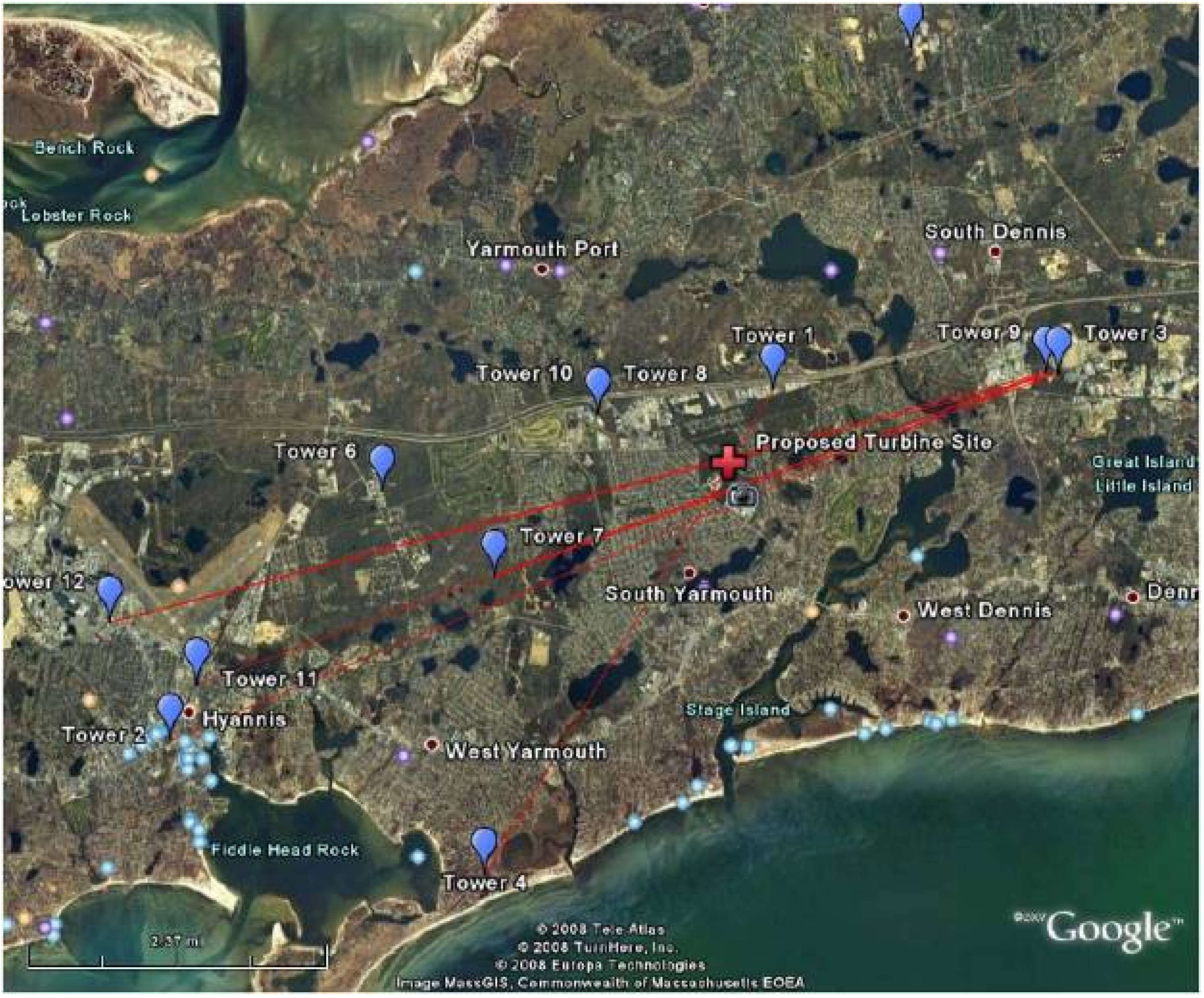

Figure 19: Satellite View of Communications Structures within Three Miles of Project Site

To evaluate the potential impact of a wind turbine at the DYRHS on Yarmouth's nearby communication infrastructure, KEMA identified all such infrastructure within a five-mile radius of the site under consideration. Using data provided by the Federal Communications Commission (FCC), we found 12 such communications structures. The locations of these structures are shown in Figure 19. The lines represent potential communications pathways between structures that might pass near the turbine (i.e., within the Fresnel Zone).

Table 8 provides additional information about each tower, including distance from the potential project site. Of the towers identified, only one was found to be within one mile of the potential project site, while two shorter towers were approximately 1.2 miles to the northwest.

#	Miles from Site	Structure Type	Latitude (NAD 83)	Longitude (NAD 83)	City	Owner
1	.8	Tower	41-41-26.0N	070-11-19.0W	Hyannis	Global Signal Acquisitions LLC
2	4.9	Tower	41-39-06.0N	070-16-56.0W	Hyannis	Verizon New England
3	2.7	Tower	41-41-30.0N	070-08-41.0W	Dennis	Cape Cod Broadcasting Corp (WOCN)
4	3.7	Tower	41-38-08.0N	070-14-04.0W	West Yarmouth	Qantum of Cape Cod, LLC
5	3.7	Tower	41-43-46.0N	070-09-59.0W	Dennis	Qantum of Cape Cod, LLC
6	2.8	Tower	41-40-47.0N	070-14-56.0W	West Yarmouth	Fuller Electric
7	2.0	Tank	41-40-11.0N	070-13-55.0W	Yarmouth	Omnipoint Communications Inc.
8	1.2	Tower	41-41-17.3N	070-12-56.0W	Yarmouth	Commonwealth of Massachusetts Department of State Polic
9	2.8	Tower	41-41-30.5N	070-08-47.8W	Dennis	SBA Properties, Inc.
10	1.2	Tower	41-41-17.4N	070-12-56.1W	South Yarmouth	Town of Yarmouth
11	4.5	Pole	41-39-28.8N	070-16-40.7W	Hyannis	The Woods Hole, Marthas Vineyard & Nantucket Steamship Authority
12	5.0	Building with Tower	41-39-55.4 N	070-17-28.1 W	Hyannis	Corp Brothers Inc

Table 8: Communications Towers

KEMA contacted the owners or engineers for Tower 1, Tower 3, and Tower 9 to gain a better understanding of potential impacts of a wind turbine on these nearby facilities and to identify any potential red flags. Representatives for Tower 3 and Tower 9 reported that the potential turbine site would not cause any complications for communications signals passed through their towers. We have attempted unsuccessfully to contact the owners of Tower 1 and Tower 4, and will continue to do so until we receive an answer.

Unless additional microwave carrying communications towers are erected within the line of sight of the turbine, there should not be any significant impact on point-to-point microwave communications for sites currently under consideration. As a result of their locations relative to the potential project site, and to other nearby communications towers, the remaining towers identified above are not expected to pose a problem for existing communications infrastructure within the vicinity of the project.

5.6 Anticipated Level of Community Acceptance

With leadership provided by the Yarmouth Energy Committee and support from the town government, the Town has taken a proactive approach and laid the groundwork for a potential wind project.

5.6.1 Town of Yarmouth

In order to receive technical funding and assistance to study the feasibility of a wind turbine at the Yarmouth DYRHS, the Town of Yarmouth Energy Committee was asked to perform preliminary site screening and project outreach to select a potential site. In addition, the Town of Yarmouth has dedicated its own resources, including DPW director George Allaire, in support of this project.

5.6.2 Community Concerns

While no direct opposition to the potential wind turbine has been experienced to date, it will be important for the Energy Committee to perform extensive community outreach efforts moving forward. Such outreach efforts could include: an abutters survey, community meetings to inform residences of project updates, and/or informational brochures and letters mailed to local residences. We recommend that this outreach occur at the conclusion of the feasibility stage, at a time when the Town has the information needed to by able to adequately respond to residents' likely questions about the project.

5.7 Summary

Based on preliminary work, KEMA anticipates that the wind project will have perceptible visible and potentially noise impacts on the surrounding community. However, we also believe that both types of impacts will be mitigated by the physical features of the immediate project vicinity. KEMA does not anticipate that the project would impact any nearby communications towers or areas of cultural significance.

6. Environmental and Permitting Issues

6.1 Environmental Impacts

Potential environmental impacts associated with wind turbines include threatened and endangered species and migratory birds as described below. For the potential wind project at the Yarmouth DYRHS, these impacts are considered minor, and KEMA does not expect these to prevent the project from moving forward.

6.1.1 Threatened and Endangered Species

A review of the MassGIS Natural Heritage and Endangered Species Program (NHESP) 2006 Priority Habitat and Estimated Habitat mapping system indicates that the Project Area is not located within MA Estimated Habitats of Rare Wildlife or MA Priority Habitats of Rare Species (MassGIS 2006). Verification requests were sent to the United Stats Fish and Wildlife Service (USFWS) and the MA Natural Heritage and Endangered Species Program (NHESP). Letter responses from these Agencies are pending. Those letters will be included as Appendix C to the final version of this report.

Though the Project Area is not located within MA Estimated Habitats of Rare Wildlife or MA Priority Habitats of Rare Species, there is one federal endangered species, one federal threatened species, three state endangered, ten state threatened, and nineteen state species of concern reported to have occurred in the Town of Yarmouth (MA Department of Fish and Game 2007). Table 9 shows a list of these species and the year of their last known occurrence in Yarmouth.

Table 9: Town of Yarmouth Known Occurrence of Rare Species

Taxonomic Group	Common Name	Scientific Name	Federal Status	MESA (State) Status	Most Recent Observation
Birds					
	Sharp-shinned Hawk	*Accipiter striatus*		SC	2006
	Piping Plover	*Charadrius melodus*	T	T	2002
	Roseate Tern	*Sterna dougallii*	E	E	2004
	Common Tern	*Sterna hirundo*		SC	2004
	Northern Parula	*Parula americana*		T	1983
	Least Tern	*Sterna antillarum*		SC	2004
Butterfly/ Moth					
	Water-Willow Stem Borer	*Papaipema sulphurata*		T	1986
Dragonfly/ Damselfly					
	Comet Darner	*Anax longipes*		SC	1995
	New England Bluet	*Enallagma laterale*		SC	2005
	Pine Barrens Bluet	*Enallagma recurvatum*		T	2000
	Scarlet Bluet	*Enallagma pictum*		T	1999
Fish					
	Bridle Shiner	*Notropis bifrenatus*		SC	1956
Reptile					
	Eastern Box Turtle	*Terrapene carolina*		SC	2002
Vascular Plant					
	Adder's-tongue Fern	*Ophioglossum pusillum*		T	1916
	Swamp Oats	*Sphenopholis pensylvanica*		T	2001
	Bristly Foxtail	*Setaria parviflora*		SC	1989
	Wright's Panic-grass	*Dichanthelium wrightianum*		SC	1988
	Commons's Panic-grass	*Dichanthelium ovale ssp. pseudopubescens*		SC	1989
	Mattamuskeet Panic-grass	*Dichanthelium dichotomum ssp. mattamuskeetense*		E	1989
	Heartleaf Twayblade	*Listera cordata*		E	2003
	Redroot	*Lachnanthes caroliana*		SC	1988
	Long-beaked Bald-sedge	*Rhynchospora scirpoides*		SC	1988
	Inundated Horned-sedge	*Rhynchospora inundata*		T	1988
	Dwarf Bulrush	*Lipocarpha micrantha*		T	1913
	Mitchell's Sedge	*Carex mitchelliana*		T	1907
	Terete Arrowhead	*Sagittaria teres*		SC	2004
	Pondshore Knotweed	*Polygonum puritanorum*		SC	1986

Taxonomic Group	Common Name	Scientific Name	Federal Status	MESA (State) Status	Most Recent Observation
	Subulate Bladderwort	*Utricularia subulata*		SC	1925
	Plymouth Gentian	*Sabatia kennedyana*		SC	2004
	Bushy Rockrose	*Helianthemum dumosum*		SC	1931
	American Sea-blite	*Suaeda calceoliformis*		SC	1928
	New England Blazing Star	*Liatris scariosa var. novae-angliae*		SC	2003
	Saltpond Pennywort	*Hydrocotyle verticillata*		T	2003

Notes:
E - Endangered
T - Threatened
SC - Species of Concern

On March 18, 2008, letters were sent to the United States Fish and Wildlife Service (USFWS) and Massachusetts Natural Heritage and Endangered Species Program (MA NHESP) describing the location of the potential project and requesting verification that no threatened or endangered species are located within the Project area. Letter responses from these Agencies are pending.

6.1.2 Avian Issues

The potential for avian impacts remains a concern for wind energy development. However, smaller projects located away from migratory pathways and important bird areas may have reduced impacts.

There are a number of beneficial impacts on bird populations that would result from an increased use of renewable energy, including wind energy. Air emissions and global climate change have been cited as serious concerns for North American bird populations (see A Birdwatcher's Guide to Global Warming by the National Wildlife Federation and American Bird Conservancy [Price and Glick 2004]). Increased renewable energy use will slow down the negative impacts of global climate change and air emissions on people and wildlife.

In addition to the positive impacts noted above, operation of wind energy facilities also has the potential to result in some adverse impacts by causing injury or death to birds through collisions and resulting in habitat loss, degradation, or displacement. While studies have shown that these negative impacts have occurred at a few sites, the results from numerous studies and reviews of impacts on birds from wind energy facilities in North America and Europe indicate that mortality rates are low, especially compared to other sources of bird mortality (Erickson et al. 2001; NWCC 2004; GAO 2005).

In November 2004, the National Wind Coordinating Committee (NWCC), a consortium of consumer groups, economic development organizations, electric power, environmental organizations, federal government, green power, state government, tribal governments, and the wind industry, issued the second edition of a fact sheet, "Wind Turbine Interactions with Birds and Bats: A Summary of Research Results and Remaining Questions" (NWCC 2004). The following, taken from the fact sheet, is part of an overview on the status of bird issues at wind energy facilities that aptly describes the current understanding:

> Wind energy's ability to generate electricity without many of the environmental impacts associated with other energy sources (air pollution, water pollution, mercury emissions, and greenhouse gas emissions associated with global climate change) can significantly benefit birds, bats, and many other plant and animal species. However, the direct and indirect local and cumulative impacts of wind plants on birds and bats continue to be an issue.

In a September 2005 report to congressional requesters, the United States Government Accountability Office (GAO) reviewed the impacts on wildlife from wind power. The GAO report concluded that outside of the Altamont site in northern California, the research to date has not shown bird kills in alarming numbers (GAO 2005). The GAO review of post-construction mortality studies found that bird fatalities ranged from 0 to 7.28 birds per turbine per year. Similarly, the 2004 NWCC fact sheet shows an average of 2.3 birds per turbine per year (3.1 birds per MW per year) are killed at facilities outside of California. For eastern wind farms, the NWCC fact sheet average was 4.3 birds per turbine per year (3.0 birds per MW per year) based on only two studies. No wind energy facilities in Massachusetts were included in the NWCC compilation. There have been several studies conducted since the time of the NWCC fact sheet with above average bird fatality rates.

In most locations, the presence of a small number of wind turbines is unlikely to cause significant impacts to birds or result in overly contentious permitting. For example, the United States Fish and Wildlife Service (USFWS) draft Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines (USFWS 2003) is recognized to be for wind energy projects with a minimum of five turbines. Therefore, the proposal for one turbine at the Yarmouth site has the benefit of being a very small-scale project compared to traditional wind energy projects.

The site location will utilize disturbed land within the Dennis-Yarmouth High School property owned by the Dennis-Yarmouth Regional School District in the Town of Yarmouth, Barnstable County. The property consists of the high school, athletic fields, and a small, 20-acre woodlot to the northwest of the school grounds. The high school is adjacent to the middle school property, which also has a 40-acre woodlot surrounding the school. Residential housing surrounds the schools.

Birds that may use the site include those that migrate over the site, breeding birds, and wintering birds. Developed land typically provides little and/or poor habitat for birds. The small woodlots may be used by passerines (e.g., songbirds) for foraging and nesting or as stopover sites during migration, because much of the surrounding area is developed, large numbers of birds would not be expected. The athletic fields could also be used by some species for foraging. Therefore, there may be increased avian activity at/near this site. The Yarmouth site is not located within a pronounced raptor migration corridor and no raptor monitoring ("hawk watch") sites are located nearby. Local raptors are expected to be present in low numbers because of the residential nature of the area. There are no large waterbodies or extensive wetlands with open water within the site to attract substantial numbers of waterfowl during migration; however, there are some small inland ponds and rivers (e.g., Long Pond, Flax Pond, Bass River) within one mile of the Yarmouth site that may attract lesser numbers of waterfowl during the migration or the breeding season. Waterfowl may also use the nearby waterbodies during the winter months, until ice forms that would push birds to larger waterbodies. Shorebirds would be expected to use the nearby beaches (see discussion of important bird areas below for the location of these beaches relative to the Yarmouth site) as a stopover location during migration; however, they would not be expected to be at or fly over the site.

Wind energy project sites are typically screened for proximity to areas of significant bird movements (or migratory pathways); sensitive breeding, migratory, or wintering areas; potential presence of threatened or endangered species; or recognized important bird areas (IBAs). The Yarmouth site is not located within an IBA; however, it is very close to an IBA. The West Dennis Beach was identified by Massachusetts Audubon Society (Mass Audubon) as an IBA, one of 79 IBAs across the State of Massachusetts. The IBA is located less than 1.5 miles south of the Yarmouth site. As described by Mass Audubon, an IBA is a site that provides essential habitat to one or more species of breeding, wintering, or migrating birds and generally supports high-priority species, large concentrations of birds, exceptional bird habitat, and/or have substantial research or educational value (Mass Audubon web site visited 3/19/08). The West Dennis Beach IBA includes over 100 acres of salt marsh, coastal beach, and marine/tidal habitat.

This beach located at the mouth of the Bass River has historically been a nesting area for Common Terns (Sterna hirundo, a state species of special concern), Least Terns (Sterna antillarum; a state species of special concern) and Piping Plovers (Charadrius melodus; a federal threatened and state threatened species). Although the West Dennis Beach IBA is close to the Yarmouth site, breeding birds using this IBA are not expected to make local movements over the site.

Five other IBAs are located near to the Yarmouth site: Yarmouth Beaches (3.5 miles southwest), South Cape Beaches – Sandy Neck (4 miles northwest), Kalmus Beach Park (5 miles southwest), Brewster Ponds and Woodlands (5 miles northeast), and Brewster – Eastham Flats (7 miles northeast). The species of ornithological or conservation significance observed at these sites include nesting Common Tern, Least Tern, Piping Plover; Roseate Tern (Sterna dougallii; a federal endangered and state endangered species) known to stage in these areas prior to breeding; and large numbers of shorebirds and waterfowl. Given their distance from the Yarmouth site and because the site does not provide breeding or foraging habitat for these sensitive species, it is anticipated that the one-turbine project will have no impact on these IBAs. Further, the Yarmouth site is not in a flight path between IBAs and waterbodies near the site; thus, daily local movements are not expected over the Yarmouth site. Fortunately, it is not anticipated that the presence of one turbine at the Yarmouth site will affect the habitat or bird utilization at the IBAs.

A review of the Massachusetts Natural Heritage Program list of rare species for the Town of Yarmouth revealed six bird species: Sharp-shinned Hawk (Accipiter striatus; state species of concern), Piping Plover (state-threatened), Roseate Tern (state-endangered), Common Tern (state species of concern), Least Tern (state species of concern), and Northern Parula (state-threatened). While it is possible that Sharp-shinned Hawk or Northern Parula could breed within the woodlots at/near the site, they would be unlikely to breed there given the proximity to the schools. The remaining avian species listed as threatened, endangered, or species of concern provided above are unlikely to regularly occur or breed at the site. Although threatened and endangered species are not likely to breed or use the Yarmouth site as significant habitat, threatened, endangered, and species of concern are present in the West Dennis Beach IBA less than one mile from the site.

Avian issues do not pose a fatal flaw for permitting of one turbine at the Yarmouth site. However, avian issues (e.g. threatened and endangered species, waterbird use of nearby beaches and water bodies, and proximity to an IBA) will likely be raised during the permitting process and therefore will need to be further addressed.

6.1.3 Wetlands

Based on a desktop review of available mapping data, literature, and discussion with the Yarmouth Conservation Commission, one NWI-mapped wetland occurs in the Project Area. In addition, a swamp area, which is not indicated on any available wetland mapping data, is also located in the Project Area. The NWI-mapped wetland is a freshwater emergent feature located in the northwest portion of the Elementary School property, as shown in Figure 2. After reviewing site maps, The Town of Yarmouth Conservation Commission (Commission) noted that this pond-like feature usually has no measurable water depth but supports wetland vegetation. Currently this feature is not mapped as an ILSF, (isolated land subject to flooding) pursuant to the Massachusetts Wetland Act. The Commission also stated that swamp areas are located in the south portion of the site, adjacent to the Dennis-Yarmouth High School tennis courts. The MassGIS wetland database showed no mapped features in this area (MassGIS 2007a). If no project facilities are sited in the vicinity of the above-referenced features, the Commission does not require the submittal of a MA DEP WPA Form 1, Request for Determination of Applicability (Town of Yarmouth Conservation Commission, 2008). A letter requesting written confirmation that the potential project area is not subject to jurisdiction under the Massachusetts Wetlands Protection Act (WPA) (M.G.L.c.131, §40) was sent to the Commission, whose response is pending.

The Project Area is located within the Cape Cod watershed. According to EPA assessment data, the Bass River, located approximately 3,000 feet southeast of the southern Project Area boundary, is listed under Section 303(d) as an impaired water body under Section 305(b) of the CWA (EPA 2002). Two Great Ponds, ponds that are 10 acres or more in size in their natural state, occur in the vicinity of the Project Area. Long Pond and Flax Pond are located approximately 350 and 1600 feet from the southern and eastern Project Area Boundaries, respectively (Town of Yarmouth 2001a).

6.2 Consistency with Local Plans and Permitting

Local, state, and federal permitting requirements were reviewed for potential applicability to a single turbine project at the DYRHS. A detailed summary table of that review is included in Appendix D.

6.2.1 Town Zoning By-Laws

The Yarmouth Zoning By-Laws were reviewed to determine potential consistency with a wind energy project at the Yarmouth DYRHS.

Land within the Project Area is zoned by the Town as residential. According to the Town of Yarmouth Zoning Bylaw, the installation and operation of municipal wind energy facilities are permitted only by a Special Permit issued by the Town Board of Appeals pursuant to Bylaw Section 413, the purpose of which is to "provide regulations to facilitate the development and operation of energy generating wind facilities on municipal property in the Town of Yarmouth, for the economic benefit of the Town. Further, the intent of these regulations is to minimize any adverse impacts of wind turbines on the character of neighborhoods, property values, scenic, historic, and environmental resources of the town; and to protect the health and safety of its inhabitants, while allowing wind energy technologies to be utilized" (Town of Yarmouth 2007). Application to the Board of Appeals for a Special Permit is outlined in detail in Bylaw Section 413.5.

6.2.2 State and Federal Permits Required

6.2.2.1 State Permits

The following tables outline relevant state permitting requirements and the likelihood that each permit would be required at the DYRHS.

Table 10: State Permits and Approvals

Regulatory Agency[1]	Permit Type	Regulated Action	Project Phase	Agency Review or Consultation Required For This Project?
MEOEA	Secretary of Environmental Affairs consent	Review projects of a nature, size or location that are likely, directly or indirectly, to cause damage to the environment	Pre-construction	Yes
MDPU/EFSB	Approval of the Sitting Board	Construction of an energy generating facility	Pre-construction	No
Commonwealth of MA	MGL Chapter 40A: Zoning	New Development	Pre-construction	Yes
EOEA	MEPA Request for Determination of Applicability Environmental Notification Form (or expanded form)	Alteration of more than 25 acres of land	Pre-Construction	Maybe
EOEA	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land	Construction	No
EOEA	Protected Land Regulation Compliance	Activities on protected land	Planning	Yes

Regulatory Agency[1]	Permit Type	Regulated Action	Project Phase	Agency Review or Consultation Required
MEOEA	Article 97 review	Change in use of existing public lands	Planning	Yes
DOER	Application for Statement of Qualification pursuant to Massachusetts Renewable Portfolio Standard	Construction and operation of a new renewable energy facility proposing to sell energy to the grid.	Construction	No
EFSB	Transmission line approval	Transmission interconnection	Construction	No
MDEP	Notice of Intent	Wetland alteration	Construction	Yes
MDEP	Noise Control Policy Compliance	Noise from wind turbine	Operation	Yes
MDEP	NPDES Individual Wastewater/ Storm Water Discharge Permit	Wastewater discharge and storm water runoff during facility operation. NOTE: This program is jointly administered by EPA and MDEP.	Operation	No
DOER	Application for Statement of Qualification pursuant to Massachusetts Renewable Portfolio Standard	Construction and operation of a new renewable energy facility proposing to sell energy to the grid.	Construction	No
EFSB	Transmission line approval	Transmission interconnection	Construction	No
MDEP	Notice of Intent	Wetland alteration	Construction	Yes
MDEP	Noise Control Policy Compliance	Noise from wind turbine	Operation	Yes
MDEP	NPDES Individual Wastewater/Storm Water Discharge Permit	Wastewater discharge and storm water runoff during facility operation. NOTE: This program is jointly administered by EPA and MDEP.	Operation	No
MDEP	Massachusetts Clean Waters Act, Section 401 of Water Quality Certification	Required for federal activities affecting state land.	Construction	Yes

Regulatory Agency[1]	Permit Type	Regulated Action	Project Phase	Agency Review or Consultation Required
Ma Dept of Fish and Game Natural Heritage and Endangered Species Program	Endangered Species Act Consultation / Compliance	Activities that could potentially affect threatened or endangered species	Construction	Yes
Ma Dept of Fish and Game Natural Heritage and Endangered Species Program	Notice of Intent MESA Information Request Form	Wetland alteration. Habitat Impacts	Construction	Yes
MPA	Request for Airspace Review	Structures over 200 feet tall near airports	Construction	No
MDOH	General Access Permit	MESA Info. Reg. - Alteration of state roads	Construction	No
MDOH	Wide load	Transport of oversized loads on state highways	Construction	No
ISO New England	NEPOOL	Interconnection system impact and facility study	Construction	No
MAC	Airspace review	Mass. Aeronautics Commission review of potential aviation impacts involving structures greater than 200 feet in height	Construction	Yes
CZM	Massachusetts General Law Chapter 91 (Public Waterfront Act authorization)	Structures in tidelands, ponds, certain rivers and streams	Construction	No
NHESP	MESA NOI	Notice of Intent to comply with Mass. Endangered Species Act	Pre-construction	Yes
MHC	Archeological / historical review	Identify potential project impacts on sensitive archeological / historical sites	Planning	Yes
DWSP	Water supply protection	Projects affecting water supply protection watersheds	Pre-construction	Yes

MEOEA	Massachusetts Executive Office of Environmental Affairs
DOER	Division of Energy Resources
NHESP	Natural Heritage Endangered Species Program
MHD	Massachusetts Highway Department
ISO/NEPOOL	Independent System Operator/New England Power Pool
MAC	Massachusetts Aeronautics Commission
MHC	Massachusetts Historical Commission
CZM	Office of Coastal Zone Management
DWSP	Division of Water Supply Protection

6.2.2.2 Federal Permits

No federal environmental permitting issues are expected to apply to this project; however, reviews and/or consultations are expected to be required for types of permits. Relevant federal permitting issues are identified in the following table.

Table 11: Federal Permits & Approvals

Regulatory Agency[1]	Permit Type	Regulated Action	Project Phase	Agency Review or Consultation Required For This Project?
USEPA	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites	Pre-Construction	No
USEPA	SPCC Plan	On site storage of oil > 1,320 gallons. Any equipment refueling, etc.	Construction	No
USACOE	Section 10 Nationwide Permit	Construction activities in navigable waters of	Construction	No
USACOE	Section 404 Nationwide Permit (Notification)	Discharge of dredge or fill material into US	Pre-Construction	No
USFWS	Endangered species act compliance	Confirmation of no impacts to threatened	Planning	Yes
USFWS	Migratory Bird Treaty Act Compliance	Migratory bid impacts	Construction	Yes
USNPS	Courtesy Consultation	Location with respect to Cape Cod National Seashore property	Planning	Yes
FERC	Exempt Wholesale Generator (EWG) Status	Selling electric energy at wholesale to a	Construction	No
FERC	Qualifying Facility Certification	Qualification for PURPA benefits for small power production facility	Construction	No
EPA	NEPA	Major federal action affecting the environment	Construction	No
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect navigable airspace (height in excess of 200' or within 20,000' of an airport).	Pre-construction	Yes

USEPA	United States Environmental Protection Agency
USACOE	United States Department of the Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USNPS	United States National Park Service
FAA	Federal Aviation Administration

6.3 Summary

There should be no undue wildlife (non-avian) or wetland impacts associated with the project. However, avian issues will likely be raised during the permitting process and therefore will need to be addressed further. Overall, renewable energy projects, including wind projects, will have a positive effect on wildlife by reducing pollution from fossil fuel generation. While the project should be compatible with local and regional plans, specific wind turbine by-law amendments or zoning appeals may be necessary moving forward. Due to the proximity of the potential turbine location to the elementary school and high school, additional planning and permitting issues associated with turbine setback zones will likely need to be considered.

7. Financial Analysis

The financial viability of any wind turbine project depends on a variety of factors that affect project costs and revenues. On the revenue side, these include on-site electricity use, excess power sold to the grid, and renewable energy certificates (RECs). If a private entity were to develop the project, the Town would also receive payment in lieu of taxes (PILOT) for the use of its land, while the developer would potentially benefit from the Federal Production Tax Credit (PTC). On the cost side, these include turbine capital costs, site preparation and construction costs, utility interconnection fees, debt/financing costs, and a host of other development costs. In addition to these upfront costs, a project owner must pay for turbine operation and maintenance, insurance, and project management/administration.

One of the key drivers of this project is the economic value of having the DYRHS utilize the electricity generated by the wind turbine. Under the previous laws and regulations, the turbine would produce a certain amount of electricity, some of which would be used to offset the electricity used by the DYRHS, and any production in excess of the electricity required by the DYRHS would be sold into the electricity power grid at a wholesale rate.

However, recent energy legislation enacted by the Commonwealth raised the capacity cap for “net metered” facilities from 60 kW to 2 MW. This means that any excess electricity generation would be credited at the default service rate rather than the wholesale rate. The legislation also created a “virtual net metering” provision, which allows owners of net metered facilities to offset electricity use at other facilities within the particular utility’s service territory. In practice, this will enable a potential DYRHS project to offset usage at other town facilities or regional school district buildings. It should be noted that, at the time that this report was originally drafted, the new energy legislation had been proposed but not enacted. Therefore, KEMA modeled scenarios under both the current and previous rules, and presents the results of both sets of analyses below.

7.1 Sources of Revenue and Savings

This section explores the sources of revenues that would be available to the hypothetical DYRHS wind project. The most significant source of revenue would come from the actual turbine output used to offset consumption at the DYRHS facility and elsewhere. The project would also be able to sell RECs. If privately owned, the owner would be able to take advantage of the PTC, while the Town would receive PILOT payments. These revenues are described below.

7.1.1 On-site Power Use and Surplus Power Sales

If the wind turbine is interconnected to the grid on the school side of the electric meter, power generated by the wind turbine will first offset electrical demand of the school. This type of project is commonly referred to as a “behind-the-meter” generation project. Electricity generated by the wind turbine will allow the DYRHS to offset or avoid metered usage charges associated with both electricity generation (e.g., from a power plant) and electricity delivery (e.g., from the cost of wires and associated delivery of electricity to the plant).

The Yarmouth site has a marginal wind resource compared to many other sites. Therefore, it becomes even more important to consider the second factor: the amount of energy from the turbine that can be priced as if it were “behind the meter.” Under previous net metering laws, only the portion of the turbine output that directly coincides with consumption at the DYRHS would be credited at the full price for electricity delivered to the facility.

In contrast, when the wind project generates more electricity than the DYRHS uses at a given point in time, any surplus would be sold back to the grid for the avoided cost of wholesale electricity generation. Previously, as a consequence, a small to medium-sized behind-the-meter project had the potential to be more economical than a large or similar project selling generation to the grid depending upon: 1) electricity costs and rate structure; 2) stand-by and power purchase rates; 3) capacity factor and cost of different turbines located at the same site; and 4) the coincidence of generation and usage. Each of these issues is discussed below.

7.1.2 Net Metering

Without what is known as net metering, the owner of a behind-the-meter wind turbine can only use the portion of the turbine’s generation that coincides with the facility’s energy use to offset the facility’s energy cost, with the remaining portion of the turbine’s output sold back to the grid at the wholesale rate. However, energy legislation known as the Green Communities Act was recently signed into law in Massachusetts. One piece of this legislation allows any energy produced at an on-site facility of up to 2 MW to be treated, for pricing purposes, as if it were offsetting the energy used at the site—not just the portion of the production that coincides with load.[9] Previous Massachusetts law only allowed facilities of up to 60 kW to benefit from net metering.[10]

Beyond simply increasing the cap for net-metered facilities from 60 kW to 2 MW, the new legislation allows municipalities to engage in "virtual net metering" (VNM). This means that a qualified generating facility (e.g., a wind turbine) on municipal property can contribute its net-metered electricity to any other facility within that utility's service territory. Note that the ultimate virtual net metering rules may create a jurisdictional distinction between Yarmouth municipal loads and DY Regional School District Loads.

In Yarmouth, we expect that VNM would effectively mean that the full output from the turbine could be priced as if it were behind any meter in the NSTAR service territory, offsetting the facility's power at the default service rate for the territory. Increasing the cap from 60 kW to 2 MW allows large-scale turbines (e.g., 1.5 MW) to offset the DYRHS' entire onsite load. The entire output from a smaller turbine (e.g., 600 kW) would go toward offsetting the load at the DYRHS. For purposes of this report, we assume that any excess output from a 1.5 MW turbine would be used to offset energy consumption in facilities owned by the Town or the Regional School District.

It should be noted that, with VNM, the Commonwealth has created a new and innovative approach to incentivizing behind-the-meter generating projects that goes above and beyond net metering rules that have been established by other states to date. As a result, the rulemaking process could take a significant amount of time as regulatory authorities (Department of Energy Resources, Department of Public Utilities, etc.) work with stakeholders to establish guidelines and procedures for putting VNM into effect. All assumptions about net metering are subject to changes, interpretations, and clarifications made during the rulemaking process. KEMA has had discussions with members of the committee that helped draft the net metering portion of the energy legislation, and we made our assumptions based on what we believe to be the most likely scenario for how turbine output would be priced under the final rule.

7.1.3 Rate Structure & Avoided Electricity Costs

This section explores the electricity rates paid at the DYRHS, the electricity usage patterns at the school, and the costs that could be avoided through net metering of turbine generation. Turbine

[9] Official Website of the Governor of Massachusetts, "Governor Patrick Signs Energy Bill Promoting Cost Savings, Renewable and Clean Energy Technology," July 2, 2008.
[10] Database of State Incentives for Renewable Energy (DSIRE), "Massachusetts – Net Metering," Updated April 25, 2007. www.dsireusa.org

generation is by far the most important revenue stream for any wind project, with RECs, the PTC, and other revenue streams playing secondary roles.

It should be noted that KEMA completed the financial modeling for this report prior to passage of the Green Communities Act. Although we have updated the report text to reflect the current net metering legislation, the financial modeling results do not reflect the effects of the legislation. The report text notes where the legislation would affect these results; all the effects would improve project economics.

7.1.3.1 Electricity Costs

This analysis assumes that for every kWh of turbine output, the generation, transmission, and transition (energy, measured in kWh) are offset; charges for transition (demand, measured in kVa), distribution, system benefits, and fixed fees are not assumed to be offset. The new legislation established a provision specifically for municipalities that allows them to offset distribution energy charges as well (but not demand-related distribution charges).

The DYRHS currently purchases competitively supplied power (generation) from ConEdison Solutions (ConEd). For purposes of this analysis, we assumed the ConEd rate as the base avoided energy cost. This worked out to a seasonally weighted average of $0.112 per kWh in 2007, based on usage during different months.

In this analysis, we assumed that any excess generation would be used to offset other meters in the Town or Regional School District at the same rate. According to the legislation, the net metering credit for excess generation used to offset load at another meter is credited at a rate equal to the "default service kilowatt-hour charge in the ISO-NE load zone where the customer is located."[11] The applicable ISO-NE generation tariff for a large commercial/ industrial customer (G-3) in the NSTAR service territory is currently $0.146 per kWh. Thus, it is possible that, following the final rulemaking, the rate for excess net-metered generation would actually be higher than that for the energy avoided at the DYRHS meter. If this is the case, it might make sense for the Town to consider interconnecting the turbine to a different facility, such as the elementary school that is also adjacent to the project.

[11] The Commonwealth of Massachusetts, "Bill Summary - Senate, No. 2768 - An Act Relative to Green Communities," pg 70, June 23, 2006. link: http://www.mass.gov/legis/bills/senate/185/st02pdf/st02768.pdf

Transition costs in 2007 were about $0.015 per kWh, transmission costs were less than $0.001 per kWh, and distribution costs were about $0.013 per kWh. This data is summarized in Table 12 below.

Generation (per kWh)			Distribution - Energy (per kWh)			Transition (per kWh)	Transmission (per kWh)
Jul 06 - Jan 07	Feb 07 - Jul 07	Aug 07 - Jan 08	Peak	Low A	Low B		
$ 0.0999	$ 0.1130	$ 0.1099	$ 0.017040	$ 0.014210	$ 0.00894	$ 0.01469	$ 0.00052
Total Cost Offset ($/kWh):							**$0.12268**

Table 12: DYRHS Avoided Electricity Rates

Many utilities charge a standby rate to behind-the-meter generation projects that minimizes the avoided costs.[12] A standby charge is designed to compensate the distribution company for costs associated with maintaining the distribution system and making electricity available when the onsite generating unit is not operating. However, NSTAR's standby rates include an exemption for certain renewable energy projects, including behind-the-meter wind projects, which means that stand-by rates will not affect the project. Accordingly, this project will be able to realize the full economic benefit of avoiding the electricity costs at the DYRHS without having to pay standby charges.

7.1.3.2 DYRHS Electricity Consumption and Expenditures

Based on existing load usage data covering the last two years, the DYRHS uses between 100 and 200 MWh of electricity per month. The peak power demand varies between 250 kW and 520 kW at a power factor that typically ranges from 85 to 94 percent and apparent power[13] that varies between 290 kVA to 540 kVA. Table 13 lists electricity consumption and expenditures at the DYRHS facility from 2007, as well as the maximum portion of the total annual costs that could hypothetically be offset. [14]

[12] Note that the current NSTAR standby rate was part of a settlement that expires in August 2008. While the exemption for renewable energy may be renewed, the status of the rate is uncertain.
[13] Apparent power is the product of the root-mean-square (rms) current and the rms voltage in an AC-circuit. The apparent power is a measure of power in an AC system that accounts for reactive system components.
[14] Based on historical usage provided by Town of Yarmouth.

Table 13: **DYRHS Electricity Usage, Expenditures and Offset Potential**[15]

Average Annual Usage (kWh)	Overall Peak Demand (kW)	Total Annual Costs (Usage & Demand)	Total Annual Avoided Costs ($)	Avoided Cost as % of Total Cost
1,832,000	520 (March)	$ 275,000	$ 225,000	81.7%

7.1.4 Renewable Energy Certificates

Like a number of other states, Massachusetts has created a mechanism for "unbundling" the environmental attributes of energy from the energy itself. Essentially, each unit of energy generated by a renewable energy facility is divided into two separate commodities: the energy itself and "renewable energy certificates" (RECs). For every MWh of energy produced at a wind facility in the Commonwealth, that facility is entitled to sell both the RECs and the energy output. In the case of a net-metered project, the energy is sold back to the utility or load-serving entity, while the RECs can be sold separately. MTC has established a standard financial offer program to buy RECs from community-scale wind projects. The details of this program are described further in Section 7.4.4.

7.2 Optimal Project Size

This study attempts to show the optimal project size that, from an economic perspective, the Town of Yarmouth could feasibly develop at the site. Based on the physical limitations associated at the DYRHS site, a single-turbine project appears to be the only technically feasible option at this time. In general, to maximize the value of a behind–the-meter project, it is important to maximize behind-the-meter usage and minimize sales to the grid. With the creation of virtual net metering provisions, this becomes a moot point, as all turbine output is treated as if it were behind the meter. Therefore, because larger turbines generally have substantially lower installed costs per kWh, bigger is better, so long as the turbine selected does not exceed the 2.0 MW capacity limit for net-metered facilities. (There is also a 10 MW limit on the total size of a multi-turbine project, but this will not affect the Yarmouth project.)

It should also be noted that different turbines have slightly different capacity factors, even at the same hub height, depending on the specific technology and the blade-length-to-generator-capacity ratio. These differences in capacity factor will not be a major factor in project economics for Yarmouth.

[15] Based on 23 months of DYRHS usage data, from July 2004 to May 2006.

KEMA performed an in-depth financial analysis that considered two different turbine sizes and several variables that would significantly affect results. Based on the results of this analysis, KEMA expects that a turbine in the size range of 1.5 MW with a hub height of up to 65 meters would produce far superior results for the DYRHS site. Even under the most favorable wind and legislative conditions considered, the 600 kW FL600 turbine produced poor financial results. It is unlikely that the Town would be able to attract a private developer to a project with such modest economic returns, or that it would derive significant savings from such a project. However, it is possible that other turbines entering the market in the coming years, such as the 600 kW Vestas RRB, will be cheaper and produce more acceptable financial results.

In addition, due consideration should be given to height limitations imposed by local ordinances and FAA airspace restrictions, community concerns (e.g., visual impacts), and overall budget limitations. These factors may force the Town to consider a smaller-scale project.

7.3 Project Ownership

The Town can opt to consider municipal ownership, private ownership, or a hybrid ownership model. In the public model, the turbine is owned by the Town or Regional School District, whereas in the private model, a private developer or financier owns the project. There are risks and benefits to both kinds of ownership. Regardless of which ownership approach is taken, the Town and Regional School District must consider how the two entities will share project costs, revenues, and responsibilities.

7.3.1 Municipal Ownership

Under municipal ownership, the Town would own and operate the turbine itself. The primary benefit of Town ownership is that the benefits of the wind turbine do not have to be shared with a developer, allowing the Town to completely offset some portion of its electricity costs.

The analysis assumes that the project will be financed entirely through debt (i.e., municipal bonding). It is possible, but not guaranteed, that the federal government will make tax-free municipal bonds available to towns as a means of financing projects that sell excess power to the grid. Owning a turbine also exposes the Town to the risks associated with building and operating its own power plant.

If in considering a turbine the Town opts to pursue municipal rather than private ownership, Yarmouth must file a Home Rule petition with the state legislature, allowing the Town to finance and own/operate the turbine. This would also guarantee that the Town can benefit from a VNM policy, if enacted.

7.3.2 Private Ownership

The primary benefit of private ownership is that the Town receives payments in lieu of taxes (PILOT) from the turbine owner for use of the property, and the Town takes on no risk. Under this scenario, the Town also bears no responsibility for the cost and maintenance of the turbine, while locking in a long term energy rate that is expected to be lower than current (and potentially escalating) market rates for electricity. In this scenario, an independent investor would build and own the plant. A fixed-price power purchase agreement (PPA) is established, insulating the Town from the risk of dramatic electricity price increases.

The analysis assumes that Yarmouth receives direct revenues in the form of lease/host payments, and the private investor retains the profits from its investment. PILOT payments capture any lease and property tax payments from the developer to the Town. For purposes of the financial model, PILOT payments are assumed to total $25,000 annually (with the actual amount to be negotiated). Under this scenario, the private developer benefits from federally funded tax advantages, namely the Production Tax Credit and Accelerated Depreciation, while the Town is insulated from the risks associated with building and operating a wind turbine. The Town receives two types of revenues: one from PILOT payments and the other from the savings generated through its ability to purchase power at a fixed price (compared to assumed retail prices).

Besides the potential financial advantages, the private development path offers another major advantage: turbine availability. Due to the high demand for wind turbines, all the major manufacturers have experienced major backlogs, and the industry has not yet seen supply catch up to demand. Furthermore, due to the costs of project operation and maintenance, most turbine manufacturers are unwilling to place small numbers of turbines in regions where they have limited operations. MTC has relationships with multiple private entities that have solved this problem and are currently working to develop, own, and operate community-scale wind projects in Massachusetts and around New England. These developers have made bulk turbine purchases multiple years in advance that can be distributed among numerous small-scale projects as the projects become ready for construction, such as the type of community wind project that Yarmouth is considering, while aggregating their own risk among numerous projects.

7.3.3 Tax Matters and Cost of Financing

Wind projects are highly capital intensive. While a number of financing structures can be considered, our preliminary assessment addresses the two basic approaches: (1) 100% financing using debt; and (2) private financing using 100% equity.

Financing small-scale wind energy projects is difficult due to their complexity and the fact that most investors focus on larger projects for reasons of economy of scale. Our analysis provides Yarmouth with a preliminary understanding of the typical costs for privately developed small-scale projects. We also studied the costs of a municipally owned facility in comparison to a privately financed project. Such a distinction is important because a municipal owner would have a very different financing structure than a private developer. If the Town decides to move forward with a municipally owned facility, it should consider low-cost loans that might be available through state or federal governments.

We assumed a municipal bond interest rate of 4.5 percent over 20 years in this study to reflect the possibility of higher interest rates at the time of project construction for the publicly-financed scenarios. Financing the project in this manner might also avoid the time and cost of transaction-structuring required in a privately financed project. However, due to its tax-exempt status, a municipally financed project would not be able to take advantage of either of the two major federal tax benefits designed to spur investment in wind power development: the Production Tax Credit (PTC)[16], [17] and the 5-year accelerated depreciation mechanism. The PTC is a credit against tax liability currently at the rate of 2.0 cents per kWh—originally 1.5 cents per kWh, and indexed to account for inflation—for the first 10 years that a project is in operation.

7.4 Financial Modeling Approach

Using a financial model provided to KEMA by the Massachusetts Technology Collaborative, we present eight economic scenarios to reflect a range of financing options, net metering scenarios, development approaches, and wind resource regimes for the wind turbine project under consideration at the DYRHS. We determine the Net Present Value (NPV) to the Town for each

[16] The federal Production Tax Credit (PTC) is applicable to tax-paying entities only. Currently, it is at 2.0 cents/kWh escalating with inflation for the first ten years of a wind project. The PTC has been extended several times since its inception in 1992, most recently through the Tax Relief and Health Care Act of 2006 for projects starting operation by the end of 2008.

[17] Under current law, the PTC does not apply to a project that commences operation after 2008. In our analysis, we have assumed that the PTC is extended (as it has been previously) and that a project in Yarmouth will be eligible for the PTC if private investors are involved. We note that one risk of the private finance structure is that the PTC may not be extended.

scenario. For private ownership scenarios, we also determine the Internal Rate of Return (IRR) to the owner/developer.

7.4.1 Scenarios

Scenarios reflect different combinations of the following three variables:

1. Turbine Model: KEMA analyzed two Fuhrlaender turbines—the 1.5 MW FL1500 and the 600 kW FL600. These turbines were selected because they are believed to be available within a reasonable lead time for small-scale projects in the Northeast, whereas many manufacturers either do not supply turbines in the Northeast or prefer to supply large-scale projects that make bulk purchases. The local Fuhrlaender affiliate, Lorax Energy, has provided KEMA with recent pricing data available for both turbines. The additional installation costs are an aggregate of estimates provided to MTC by contractors for various projects in Massachusetts.

2. Project Ownership: KEMA modeled both public and private ownership scenarios. Which ownership model depends on numerous factors, many of which are driven more by the Town's interests and concerns than by project economics. Public ownership offers more upside potential, but also higher levels of risk and responsibility on the part of the Town.

3. Meteorological Data Set: Because no wind monitoring has taken place at the DYRHS site to date, KEMA used data gathered from meteorological (met) towers in nearby Harwich, and Hyannis, as described in Chapter 3. Even when taking into account wind flow from both locations to the DYRHS, energy production results were typically about 10 percent higher when calculated using the Harwich data compared with results calculated from the Hyannis data, with slight variations among turbine models. It is reasonable to assume, though not entirely guaranteed, that the actual Yarmouth wind resource falls somewhere between the two estimates. To make a more accurate wind resource assessment, it would be necessary to erect a met tower much closer to the potential site.

7.4.2 Energy Production Assumptions

One of the most significant assumptions is the turbine's total energy generation, and the resulting capacity factor. These figures were developed through a technical analysis performed by KEMA using ReSoft WindFarm software based on data collected at meteorological (met) towers in Harwich and Hyannis, correlated with long-term wind data from the Barnstable Airport, and extrapolated to the appropriate hub heights. This process is described in depth in Chapter 3.

Table 14 shows the estimated capacity factor, output, and coincident production percentage for each turbine (based on an average of results from the two wind data sets.

Wind Turbine Energy Output Summary		
Turbine Capacity (kW)	**600**	**1,500**
Capacity Factor (%)	18.1%	19.9%
DYRHS Consumption (kWh)	1,832,220	
Turbine Annual Output (kWh)	953,000	2,616,500
Output Used Onsite (kWh)	619,500	1,046,500
Output Sold to Grid (kWh)	333,500	1,570,000
Output Used Onsite (%)	65%	40%
DYRHS Energy Use Offset (%)	34%	57%

Table 14: Wind Turbine Output Summary

For a 1.5 MW turbine, the estimated capacity factor was found to be 18.3 to 21.2 percent, which corresponds to annual energy generation of about 2.6 million kWh, enough to offset the annual consumption of 1.8 million kWh at the DYRHS. About 40 percent of the energy produced would coincide with demand at the facility, although under virtual net metering this will most likely not affect the rate at which the generation is credited. For the 600 kW model, the capacity factor is estimated to be 17.2 to 19.1 percent, with an expected output of 900,000 to 1 million kWh, with coincident energy production of 65 percent. These results are summarized above in Table 14.

7.4.3 Project Costs Assumptions

Using recent industry pricing data and in consideration of site-specific variables, KEMA estimated turbine costs, installation costs, and annual operating costs for each of the turbine models, as summarized in Table 15. These turbine costs are to be considered estimates because turbine pricing can change over short periods of time.

Turbine Assumptions				
Capacity	600 kW		1.5 MW	
Turbine Cost	$ 1,578,000		$ 2,476,000	
Development Costs	$ 548,000		$ 1,001,000	
Total Installed Cost	$ 2,126,000		$ 3,477,000	
Annual O&M Costs	$ 22,000		$ 58,000	
Scenario	Harwich	Hyannis	Harwich	Hyannis
Annual Output (kWh)	1,001,000	905,000	2,775,000	2,458,000

Table 15: Turbine Costs

7.4.4 MTC Standard Financial Offer

The Massachusetts Technology Collaborative (MTC), through its Community Wind Collaborative, has developed a Standard Financial Offer (SFO) as a means of providing financing for community-scale wind projects on municipal land. Currently, the SFO consists of two elements:

- A renewable energy certificate (REC) purchase offer to support financing of the wind project. MTC has a standing offer to buy RECs from any 500 kW to 5 MW wind generating project constructed on land owned by a qualified Massachusetts municipality or municipal entity at a standard price of $40/MWh. The nominal value of the REC contract is based on the nameplate capacity of the project, as follows:
    - $1.2 million/MW for projects up to 3 MW
    - An additional $400,000/MW for additional capacity up to 5 MW (total)
    - REC contracts capped at $4.4 million per project
- Development support of up to $150,000 to enable the municipality to develop the project and seek development partners (developers, contractors, etc.)

MTC will purchase the RECs from the project owner after the RECs have been generated. For additional details about the SFO, please see information available on the MTC's website at www.masstech.org.

To receive the SFO, an entity must agree to find a bulk purchaser of the RECs—typically a load-serving entity (i.e., utility)—for the first three years of the project, with the SFO taking over after the first three years. Once the SFO is exhausted, RECs can be sold into the spot market.

In the current market climate, Massachusetts REC prices are high, and in many cases are sold at prices greater than $40/MWh. While these prices are expected to come down in the coming years, the requirement that the project must sell the RECs to a bulk purchase offtaker for the first three years may actually prove beneficial to project economics.

For a 600 kW project, MTC would offer to purchase up to $720,000 of RECs, whereas for a 1.5 MW project, MTC would purchase up to $1.8 million of RECs. Because the RECs are purchased at a constant rate, the number of years over which the REC purchase takes place varies depending on how fast the project reaches its maximum. It should be noted that the faster the

RECs are generated the greater the positive impact they will have on the project's net present value (NPV), because their present dollar value is greater in earlier years than in later years.

7.5 Financial Model Results

Financial model results for the 600 kW and 1.5 MW turbines are summarized below in Table 16 and Table 17, respectively.

Table 16: Fuhrlaender 600 kW Turbine (FL600) Financial Results

Turbine Size	600 kW			
Electric Rate Escalator	2 % per year			
Ownership	Town	Town	Private	Private
Data Set	Harwich	Hyannis	Harwich	Hyannis
RESULTS:				
NPV	$ -	$ -	$ 643,420	$ 610,909
IRR	NA	NA	0.78%	-0.53%
REVENUES:				
Power Revenue	$ 2,903,854	$ 2,614,989	$ 2,402,424	$ 2,163,439
REC Revenue	$ 783,314	$ 705,393	$ 783,314	$ 705,393
Merchant Revenue	$ -	$ -	$ -	$ -
Total Sales Revenue	$ 3,687,168	$ 3,320,382	$ 3,185,738	$ 2,868,832
EXPENSES:				
Total Operating Expenses	$ 571,951	$ 571,951	$ 1,081,490	$ 1,078,321
EBITDA	$ 3,115,217	$ 2,748,431	$ 2,104,248	$ 1,790,511
Total Interest	$ 1,213,114	$ 1,213,114	$ -	$ -
Total Loan Principal	$ 2,255,630	$ 2,255,630	$ -	$ -
NET CASH FLOW	$ (413,363)	$ (843,181)	$ 2,164,876	$ 1,851,134

Table 17: Fuhrlaender 1.5 MW Turbine (FL1500) Financial Results

Turbine Size	1,500 kW			
Electric Rate Escalator	2% per year			
Ownership	Town	Town	Private	Private
Data Set	Harwich	Hyannis	Harwich	Hyannis
RESULTS:				
NPV	$ 2,697,894	$ 1,831,659	$ 1,223,480	$ 1,099,426
IRR	NA	NA	9.49%	7.45%
REVENUES:				
Power Revenue	$ 8,057,816	$ 6,955,568	$ 6,666,412	$ 5,754,497
REC Revenue	$ 2,118,033	$ 1,876,262	$ 2,118,033	$ 1,876,262
Merchant Revenue	$ -	$ -	$ -	$ -
Total Sales Revenue	$ 10,175,849	$ 8,831,830	$ 8,784,444	$ 7,630,759
EXPENSES:				
Total Operating Expenses	$ 762,470	$ 762,470	$ 1,327,996	$ 1,316,459
EBITDA	$ 9,413,378	$ 8,069,360	$ 7,456,448	$ 6,314,300
Total Interest	$ 1,810,014	$ 1,810,014	$ -	$ -
Total Loan Principal	$ 3,365,490	$ 3,365,490	$ -	$ -
NET CASH FLOW	$ 4,311,507	$ 2,967,488	$ 7,527,655	$ 6,385,489

Under municipal ownership, total net present value (NPV) equals the sum of sales revenue (for contracted power, merchant power, and RECs) minus operating expenses and loan payments. In addition, the Town ownership NPV also includes debt payments, whereas the private ownership NPV factors in payments in lieu of taxes (from the turbine owner to the Town) and certain additional operating expenses (a partnership management fee and right of way easement payments). Detailed summaries and explanations of results are provided in sections 7.5.1 and 7.5.2.

7.5.1 Municipal Ownership

The 600 kW turbine resulted in a negative NPV even with the more optimistic wind data set, with net cash flows of about negative $400,000 to negative $800,000. The 1.5 MW turbine results in a positive 20-year NPV of about $1.8 million to $2.7 million and net cash flow of $3.0 million to $4.3 million, depending on which data set is used.

In general, high capital costs are mitigated by electricity revenues or projected savings to the Town in later project periods. The higher capacity of the 1.5 MW turbine leads to far greater electricity revenues than the 600 kW model. The savings resulting from decreased power costs are included in the calculations of NPV to the Town. Table 18 summarizes the results of the analysis of municipal-ownership options, ranked in order of NPV to the Town.

Table 18: NPV to the Town (Municipal Ownership)

NPV to Town	Turbine Size	Data Set	Cash Flow
$ 2,697,894	1,500 kW	Harwich	$ 4,311,507
$ 1,831,659	1,500 kW	Hyannis	$ 2,967,488
$ -	600 kW	Harwich	$ (413,363)
$ -	600 kW	Hyannis	$ (843,181)

7.5.2 Private Ownership

Using a 10% Internal Rate of Return (IRR) as a benchmark for financial feasibility, the 600 kW turbine does not come close to meeting the benchmark, generating returns of less than 1 percent. The 1.5 MW turbine also appears to miss the benchmark, with an IRR of 7.45 to 9.49 percent, which is unlikely to be significant enough to attract a private developer. It should be noted that the ability of a private investor to take advantage of VNM at a municipally owned facility is unclear at this point; if they cannot, then returns are likely to be lower, in the range of 5.99 to 7.90 percent. This final estimate is based on scenarios that were modeled prior to the passage of VNM legislation, which assumed that only coincident production could be used to offset DYRHS energy costs, with the remainder of electricity sold back to the grid at the lower wholesale rate.

Because the project is assumed to be financed entirely through equity rather than debt (i.e. the turbine is purchased outright), and the federal PTC and accelerated depreciation incentives come into play, the private entity is rewarded with higher cash flows than the Town-owned model. Our analysis assumes that the Town establishes a fixed-price electricity purchase contract with the developer, thereby allowing it to receive a benefit in the form of a protective hedge against rising electricity prices. This hedge is calculated by assuming that electricity prices rise 2% per year faster than the overall inflation rate. Under the current set of assumptions, the developer agrees to sell electricity to the Town at the rate that the Town currently pays for the entire lifetime of the project. The hedge is included along with the PILOT payments in the calculation of the NPV to the Town. Table 19 summarizes the results of the private-ownership scenarios.

Table 19: Economic Analysis Ranked by IRR to the Private Developer

IRR	Turbine Size	Data Set	Net Cash Flow	NPV to Town
9.49%	1,500 kW	Harwich	$ 7,527,655	$ 1,223,480
7.45%	1,500 kW	Hyannis	$ 6,385,489	$ 1,099,426
0.78%	600 kW	Harwich	$ 2,164,876	$ 643,420
-0.53%	600 kW	Hyannis	$ 1,851,134	$ 610,909

7.6 Conclusions

Given the moderate predicted wind resources at the site, combined with the site constraints limiting the turbine capacity and hub height, it appears unlikely that a project at the DYRHS site would achieve significant enough returns to attract a private developer, although this could change if electricity prices continue to rise faster than is assumed in this analysis. A 1.5 MW municipally owned project is projected to achieve a positive NPV, even under the most conservative scenarios that have been modeled thus far. A 600 kW project did not achieve a positive NPV under any municipal scenario. Therefore, KEMA recommends that, if the Town wishes to continue to pursue wind energy development at the site, a municipally owned 1.5 MW turbine be considered.

When deciding whether to proceed with the project, the Town must establish its own investment threshold, taking into consideration its tolerance for risk and the level of effort involved in developing, owning, and operating the project. At a minimum, any project should achieve a positive NPV when using the average of the two wind data sets.

It is important to note that several of the variables examined in constructing the different economic scenarios remain uncertain at the current time. The estimated turbine costs are based on actual manufacturer price quotations, though turbine prices have increased dramatically in the United States in recent years, and may continue to do so. Similarly, electricity costs have risen dramatically in recent years. If they continue to rise at unprecedented rates, this could improve project economics significantly. Finally, while virtual net metering legislation has been passed, the final rulemaking to implement this program has yet to occur, which could have a substantial effect on the economics of the project.

8. Recommendations and Next Steps

8.1 Siting Recommendations

Based on its review of the physical characteristics of the site and surrounding areas, the available wind resources, interconnection issues, potential impacts, and environmental permitting issues, KEMA concludes that a utility-scale 1.5 MW wind turbine with a hub height of up to 65 meters could be sited in one of two locations northwest of the DYRHS.

When selecting a turbine in the 1.5 MW range, the most important factor from a financial perspective will be the specific turbine's performance at sites with moderate wind resources, such as this one. However, the high turbulence and wind shear likely to be experienced at the site will need to be discussed in detail with turbine vendors. The Town must also decide whether the visual and noise impacts of a particular turbine at a given hub height are likely to be acceptable to the community.

Finally, we note that the economics of a given project can be affected by the percentage of power used on site. This financial analysis initially investigated the extent to which energy generated by a wind turbine could be counted as "behind the meter" to offset the Town's electric bills. The potential behind-the-meter use, and thus the value of a wind turbine project, would increase significantly if the legislature adopts virtual net-metering requirements. Passage of any net-metering legislation is likely to improve the economics of a wind energy project.

8.2 Next Steps

Based on our review to date, KEMA recommends that the Town move to install a met tower at the Project Site or conduct SODAR analysis at the transfer station approximately 1 mile away to gather more site-specific data on wind resources. In addition, Yarmouth should investigate ownership and financing structures between the town and the regional school district. We would also recommend briefing other Town stakeholders about the results of the preliminary Feasibility Study.

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