Town of Paxton
Asnebumskit Hill

Wind Turbine Site Screening and Development Options Analysis

March 2005

PREPARED BY

ESS Group, Inc.

Northern Power Systems

LaCapra Associates, Inc.

Funded by the Community Wind Collaborative of the Renewable Energy Trust

MASSACHUSETTS TECHNOLOGY COLLABORATIVE

NOTICE AND ACKNOWLEDGEMENTS

This report was prepared by ESS Group, Inc, Northern Power and La Capra Associates, 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 05-04. 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.

ABSTRACT

This report presents a site screening analysis of the potential for development of a wind energy site or sites on Asnebumskit Hill in the Town of Paxton, Massachusetts. The wind consulting team of ESS Group, Inc, Northern Power and La Capra Associates, Inc. conducted the study under contract to the MTC. Multiple wind energy plant configurations were investigated for the site project area. Analysis covered the site wind resource, site physical characteristics, electrical infrastructure, characteristics in the vicinity of the site, environmental concerns and preliminary estimates of energy costs. The goal of the study was to screen the site to determine if there were any factors that would present a sufficient constraint so as to make development of wind energy infeasible and to provide initial information that would be further developed in the Feasibility and Development study.

The following is a list of Keywords.

Configuration
Electric Interconnection
Electric Load
ESS Group
FAA
Icing
La Capra Associates
Land Use
Low Income Initiative
MTC
Noise
Northern Power
Paxton
Receptor
Renewable Energy Certificates
Telecommunication
Turbulence
Visual
Wind Energy
Wind Turbine

TABLE OF CONTENTS

SECTION **PAGE**

FIGURES

APPENDICES

1.0 INTRODUCTION

The ESS Group, Northern Power and La Capra Associates team has been retained by the MTC to conduct a wind turbine site screening and development option analysis for a site located in the Town of Paxton, Massachusetts on Asnebumskit Hill (Figure 1 and 2). The University of Massachusetts Amherst Renewable Energy Research Laboratory (RERL) first installed wind monitoring equipment at the Yankee Network Tower, Asnebumskit Hill, in late June 2003 (Figure 2). Wind data has been collected at the site since June 24, 2003.

The MTC under its Low Income initiative (LII) plans to procure, install, own and operate several wind turbines to be located at candidate sites across the Commonwealth. Electric energy from these turbines will be sold into the wholesale market or used on site if there is a resident load. Revenues from the sale of the electric energy and renewable energy certificates (REC) will be used for the operation and maintenance of the wind turbines and associated structures and to fund the LII program. Asnebumskit Hill in Paxton is being considered as a potential site for a wind turbine under the LII program. The Town of Paxton owns two parcels of property on the northwest side of Asnebumskit Hill that total approximately 32 acres. Other parcels on Asnebumskit Hill may also provide good sites or possibly better sites than the town owned parcels. Therefore, adjoining parcels were also considered when evaluating the configuration of the wind turbine to maximize the available wind resource. The parcels include ones owned by American Tower Corporation, Paul Flynn, Radio Tower Communications and possibly others.

MTC in coordination with the Town of Paxton is contemplating the installation of a single 1.5 - 2.5 MW-class turbine. It is currently anticipated that power from the wind turbine would be sold at wholesale to the Town of Paxton for distribution to customers of the Paxton Municipal Light Company. During peak generation periods or depending on Paxton's load, excess power would be available for sale to ISO-New England or other load serving entities.

This analysis has been undertaken to address the potential location of a wind turbine (or turbines) at Asnebumskit Hill with the following objectives:(a) identify the best location for a wind turbine on property owned by Paxton, (b) identify the best location for a single turbine on Asnebumskit Hill irrespective of property ownership, (c) develop a configuration that will allow for the maximum number of turbines on Asnebumskit Hill, (d) identify any fatal flaws that affect the feasibility of installing the contemplated wind turbine, and (e) make recommendations regarding wind plant options for the Project site.

Three potential configurations have been examined; one 1.5 MW turbine on Paxton property, one 1.5 MW turbine at the best site and four 1.5 MW turbines. A site visit was conducted on December 14, 2004. During the visit, Asnubumskit Hill was walked and the surrounding area investigated. Information was also reviewed with representatives from the Paxton Municipal Light Company and the Massachusetts Technology Collaborative.

The information presented covers the many factors involved in creating a successful wind power plant at the Paxton site. This early phase of Site Screening is intended to uncover barriers and obstacles to the development of a project. To effectively do this, we have designated several options for wind plant configuration, and evaluated these in relation to the site factors, the surrounding community, and economic value.

2.0 SITE WIND RESOURCE

The quality of the site wind resource is the most important factor in a wind project, as wind is the fuel that drives the wind plant. Asnebumskit Hill has an excellent wind resource due to its height, north-south orientation and several topographic features. The site benefits from two topographic features that accelerate the wind:

1. Asnebumskit Hill rises up from a long fetch of lower elevation, undulating terrain to the west-southwest, which forces the air mass to concentrate as it rises up and over Asnebumskit Hill, accelerating as it does so.
2. The predominant southeast and northwest winds also come through local topographic features such as Cooper Hill to the southwest and the Paxton village rise to the north of Cook Reservoir. These features provide boundaries for the air moving along Cook Reservoir, funneling the air mass from the sides onto the western slope of Asnebumskit Hill and increasing wind speed.

An anemometer installed by RERL on the Yankee Network Tower in late June 2003 is currently measuring the wind resource on Asnebumskit Hill. It is mounted at a height of 78 meters above ground (elevation 420m). Over a year of on-site data exists. This is a significant benefit to estimating the potential output for the various configurations. The wind characteristics as measured at the site present good potential. The daily profile (Diurnal) has morning and evening peaks, providing a potentially good match with the electric loads of a residential community. Predictable winter winds exist and will to a certain extent match the winter load conditions.

2.1 Wind Data Evaluation

The annual average wind speed for the period collected by the RERL site is 8.0 m/s at 78m height above ground, on the high point of land. The measured data shows a higher average than that predicted by the TrueWinds New England wind maps. The TrueWinds predictions are based on elevation, which does not factor in the site-specific influences such as the topographic features listed above. The resource has a significant seasonal component, highlighted by a 9.8 m/s average for the December 2003 through March 2004 period. The 78m-anemometer height is close to the hub height of a MW scale wind turbine, and therefore no scaling for wind shear was done for the production estimates. An additional lower level anemometer would help qualify the wind shear and expected resource at the other potential sites. A resource of this magnitude has commercial potential for very competitive generation.

2.2 Wind Resource Characteristics

The site has complex terrain, which does impact the wind resource. In addition to the positive benefits described above, certain site features like turbulence, up slope winds, radio tower interference, trees, and icing produce negative effects on the wind resource quality as described below. These must be carefully considered when siting the wind turbines, and predicting MWH output.

1. Turbulence is created as the wind impacts the western upslope, and flows over the hill, around the obstructions. The turbulence intensity (TI) is a measured value that is being recorded by the RERL equipment. The TI as recorded at the monitoring station is .12 -.15. This is within reasonable limits for wind turbine operation. The values did not coincide with either a particular average wind direction or with the peak winter winds. Further anemometry and possibly site modeling are recommended as actual sites are chosen to ensure proper placement of the wind turbines.
2. Upslope winds are winds that have a more vertical component imparted to them as they travel up the slope of a hill. When they hit a wind turbine at the angle imparted by the slope rather than straight on, significant reductions in production, increased wear, and possibly noise occur. Therefore upslope winds are avoided when siting a wind turbine. The designated Paxton municipal site, while away from residences and being the highest point on Paxton municipal land, is on a steep upslope.
3. Several telecommunication towers are present in the site area. These will cause turbulence, and, therefore, a reasonable distance must be maintained between the turbines and radio towers.
4. The site area is generally heavily wooded although trees are of relatively short height because of the persistent winds. The trees affect wind flow, more so at the SW wind turbine site, where the trees are taller, and more conifers are present. The recommended 80m towers will reduce turbulence from the trees.
5. Icing can require a turbine to shut down, or run at limited performance, because ice on the blades will spoil the blades' aerodynamic "lift." Ice can also damage equipment. The Paxton site is known to have "clear ice." This is the most tenacious ice; it can cause the most damage, as it adheres well and is very heavy. Icing events and their duration should be further investigated for their reduction of energy output and for design and warranty considerations. The predicted output in this report has been reduced minimally to account for ice. Regional historic data can be used and correlated with site events to help further evaluate these events. Further reduction may be warranted as a result of additional investigation.

3.0 SITE PHYSICAL CHARACTERISTICS

The Asnebumskit Hill site is located in the Town of Paxton in a heavily wooded area of central Massachusetts. Asnebumskit Road provides access to the area. The site area owned by the Town of Paxton is almost entirely undeveloped. Other abutting properties within the site area that may be considered have some development with telecommunication towers and support buildings. It is expected that soils at the site will be suitable for a wind turbine foundation although it is highly likely ledge will be encountered. Core samples and careful design will be required. As described in the Site Wind Resource section, Asnebumskit Hill has several excellent attributes necessary for a successful wind turbine project. The complex terrain, while requiring careful examination, offers several energetic sites.

Access requirements can be divided into two categories; on-site requirements and delivery of equipment to the site from manufacturers. On-site access is limited, as the area is wooded, has steep grades, several obstacles (buildings and natural features), and minimal open area for construction needs. In addition to having room for foundations, clearing is required for wind turbine erection, crane pads, lay down of tower sections and rotor assembly, and to allow trucks to turn around. These areas will have to be cleared of trees and a level crane pad (~30' x 30') built adjacent to each foundation. Allowances for boom swing, rotor assembly, and lift are required to provide adequate clearance. Depending on final site

configuration, it may be possible to limit the tower lay down areas, through creative use of trucks and multiple cranes. Roads will be required to each turbine site. The roads will need to be at least 24' wide, within grade guidelines, and have adequate weight bearing capability. These roads may be narrowed, and plantings made post-installation, although they will continue to be used for service access. A turn-around area may be avoided at the SW end of the turbine access road if the road is reasonably straight, and construction occurs in good weather – therefore allowing trucks to back in or out.

Delivery of equipment will most likely be from several locations including seaports and fabrication facilities via truck. Preliminary route exploration determined access is available from Interstate routes 495 and 195. Several phone lines, traffic light and electric line lifts will be required along with several narrow street closures and traffic accommodations to allow truck access. Route 122 which would most likely be used to access Asnebumskit Road is also a somewhat narrow winding road. Additional data for transport of material to the site will be developed in the Feasibility Study.

Asnebumskit Road may require modification to several inside curbs to allow vehicle passage on tight curves. It may be possible to minimize these cuts through the use of steerable trailers. Several tree limbs and other potential obstacles will need to be removed. Access should be complete without changing the character of the road, as the lower section, and fork in the road are relatively straight. Once on site, allowance will be needed for truck turnaround, crane mobilization and, demobilization, and staging areas. These areas will be created as part of the turbine road construction.

4.0 SITE ELECTRICAL INFRASTRUCTURE

The site area has access to an existing three-phase, high voltage distribution line that runs along Asnebumskit Road and connects to the distribution line that runs along Pleasant Street at the intersection with Asnebumskit Hill Road. The distribution line operates at a voltage of 13.8 kV and is owned and maintained by Paxton Municipal Light Company. Discussions with the power company indicated that the Asnebumskit Hill Road distribution line is a 336 kcmil aluminum transmission cable in a Hendricks configuration with a reference ampacity of 530. Therefore the line should be rated for approximately 10 MW[1], providing ample capacity for the potential wind configurations proposed which would have a maximum production of 6 MW. The line currently has maximum load of 231 kW, with the highest residential demand at the lower end of Asnebumskit Hill Road. There are no substations along this distribution line or in the vicinity of the proposed wind turbine site. Pole and pad transformers are located along the line to reduce voltage for use by the residential and commercial customers.

The local line is suitable for the various wind project scenarios that have been evaluated, as is the larger distribution line along Pleasant Street. No major modifications are anticipated to handle the proposed output of the wind turbines. Coordination with Paxton Municipal Light Plant and possibly Massachusetts Electric will be required to review the interconnection standards and possible protection systems required to provide adequate safety. An interconnection study would be required to verify this for all the cases evaluated, especially the four turbine scenario. The site area is also located adjacent to several

[1] 530 amps x 13800 volts x 1.73 x 0.8 pf is ~ 10 MW

commercial telecommunication facilities that could be potential uses of power generated by the proposed wind turbine.

A substation would be required and most likely built near the top of the hill to provide interconnection point for the wind turbines[2] and could possibly serve the telecommunication facilities located in the project area. A potential location for the substation would be near the end of the line toward the southern end of Asnebumskit Hill Road. This location would provide direct access to the wind turbine collection system. The substation would incorporate metering, and any power quality filtering equipment required. Proper design of the substation and interconnection would insure there is no adverse effect on customers currently served by the line

5.0 CHARACTERISTICS IN THE SITE VICINITY

5.1 General Site Characteristics

The site being considered for the turbine installation is at Asnebumskit Hill Paxton, Massachusetts (Worcester County) (Figure 1 and 2). The site generally consists of wooded land totaling approximately 32 acres of town owned property. Adjoining parcels that may be considered for leasing include American Tower Corporation (19 acres), Paul Flynn (3 acres) and Radio Tower Communication Corp. (9.5 acres) and several others. Even though the site is heavily wooded there is considerable infrastructure in the project vicinity. Telecommunication towers are located along the ridge, a water tower is located on the town owned property and three residential areas are located in the project vicinity, one generally west along Asnebumskit Road, one generally southwest along Meadowbrook Road, and one south along Indian Hill Road. The tallest structure in the area is 366 ft above ground level. Table 5.1-1 identifies active FCC antenna structures registered in the Town.

TABLE 5.1-1
FCC Registered Antenna Structures

Owner/Name	Latitude/Longitude	Height Above Ground (ft)	Status
Radio Tower Communication Corp	42-18-11.0N 071-53-50.0W	252.0	Constructed
Industrial Communications & Electronics, Inc.	42-18-05.0N 071-53-49-0W	124.7	Constructed
Capstar Radio Operating Company	42-18-34.0N 071-54-11.0W	366.1	Constructed
Capstar Radio Operating Company	42-18-34-0N 071-54-08.0W	192.0	Constructed
Pinnacle Towers LLC	42-18-13.9N 071-53-48.9W	266.1	Constructed

[2] The wind turbines typically generate at medium voltage (480/600) or high voltage (~13.8 kV)

Owner/Name	Latitude/Longitude	Height Above Ground (ft)	Status
Pinnacle Towers LLC	42-18-15.7N 071-53-50.0W	250	Constructed
Pinnacle Towers LLC	42-18-18.8N 071-53-49.3W	100.9	Constructed
National Grid USA Service Company, Inc.	42-18-12.3N 071-53-48.3W	36.6	Constructed

Pleasant Street (Route 122) is the primary highway route into this area of Paxton and is located approximately 0.5 miles west of the site. Direct access to the site is via Asnebumskit Road, a local roadway that is used by residential traffic and some light service vehicles.

The site sits atop a rather substantial cliff at approximately 400 to 420 meters National Geodetic Vertical Datum (NGVD) 1929, and topography of the surrounding area generally consists of 15-25% slopes with a major decrease in elevation to the west of the site.

5.2 Land Use and Community Acceptance

Land uses immediately surrounding the site consist of heavily wooded areas, residential development and utility uses. Six telecommunication towers are located on the ridge in the general vicinity of the site area and, depending on the particular turbine site, are either to the north, east or south. Additional information on other antennas that may be on these towers such as cell communication or microwave should be gathered during the next phase of the site evaluation. A single water tower is located on town property to the west of the ridge at an approximate elevation of 390 meters, and residential areas are located approximately 1,700 feet to the west along Asnebumskit Road, approximately 4,000 feet southwest along Meadowbrook Drive, and over one mile south along Indian Hill Road. The closest sensitive receptor to a proposed turbine location is a single residential dwelling off Asnebumskit Road at a distance of approximately 700 feet. Further to the north is an additional radio tower licensed to Capstar Radio (WSRS). Adjacent uses to the south, southeast and east consist of undeveloped forested land. An area of permanently protected open space is located east of the Asnebumskit residential area, with Tanglewood and Knollwood Roads bordering the protected area to the west and Asnebumskit Road bordering the protected area to the east (MA biomapper).

The turbine(s) will be mounted on towers approximately 80 meters (260 feet) tall with a blade diameter of approximately 70.5 meters (230 feet) depending on whether General Electric 1.5 or Vestas V80 turbines are selected. This will make the height of the turbine when the blade is in the vertical position approximately 115 meters (380 feet). The elevation of the site location sits approximately 60 meters (200 feet) above the elevation of the nearby residential area. The turbines will be highly visible from the residences along Route 122, the Asnebumskit Road residential area, the Meadowbrook Drive residential area, and the Indian Hill Road residential area. The site is heavily wooded which provides some opportunity for buffer.

The anticipated level of community acceptance is reasonably high. The Town of Paxton seems to be in favor of wind energy. A special subcommittee of the Planning Board is drafting new By-laws to address the locating of commercial wind turbines within the town. Based on discussions with the municipal light company officials, the nearest resident to the potential wind turbine location, Mr. Jackson, is a wind energy advocate and supports the project.

It can be anticipated that the main community reaction to the turbines would be due to visibility. Visibility can be a highly subjective matter. Some find the appearance of the turbines to be positive, and others find it to be negative. Experience with the Hull wind turbine has shown that the visual aspect has not proved to be detrimental at that location. Either the 1.5 MW GE turbine or the 1.8 MW Vestas turbine will be considerably taller than the Hull turbine so the turbine(s) will be visible for some distance from the site. However, the site is located in a highly wooded area where the majority of the surrounding area is undeveloped and the presence of numerous telecommunication towers has provided an opportunity for residents to become accustomed to tall structures on the ridge of the hill.

5.2.1 Zoning

The area on Asnebumskit Hill under consideration is zoned General Residence B in accordance with Paxton's By-law. The current By-law states commercial wind energy conversion systems are subject to additional determinations by the Board of Appeals (Section 3.3.11 (6)). The present By-laws are not specific as to the required submittal and standards for a commercial wind turbine. Based on what is currently required for wind generating systems that are installed as accessory to a residential or horticultural use, the following may be anticipated. Site plan review and approval would be required by the Town for these systems. Test data or other evidence must be submitted to the Town of Paxton to substantiate that the system will not cause electromagnetic interference at abutting residences and maximum allowable noise levels are 75 dB(A) at the nearest property line. Wind systems are exempt from the maximum height allowable for structures in Paxton as detailed in Section 4.4.3 of the Zoning By-laws.

The Town has established a special committee under the Planning Board to review and revise the By-laws for commercial Wind Energy Conversion Systems (WECS). It is anticipated that the new By-law revision would govern an installation at the proposed sites. An early draft of the proposed By-law would replace section 3.3.11(6) with a new section 3.12. This new section more specifically details the information required to be submitted with a special permit application to the Planning Board. Some of the requirements include setback provisions (height to the tip of the vertical blade), an exemption from height requirements, noise limits, compliance with FAA, no disrupting electromagnetic interference, and interconnection requirements. A special overlay district has also been proposed to designate the area in the town where commercial wind turbines could be allowed. A technical report is required documenting the wind quality and project feasibility at the site and an approval may be issued if the Planning Board finds:

1. The proposal is not detrimental or injurious to the public health and or safety or to the character of the surrounding neighborhood.
2. The proposal is essential or desirable to the public convenience.
3. Installation of the WECS will not create a substantially adverse visual impact when viewed from a common public viewing area.

The proposed locations for the wind turbines identified in the screening analysis and discussed in Section 7.0 are presently within the proposed overly district. Figure 2 shows the estimated property boundaries for the various parcels where the turbine locations have been identified. The conceptual layout shows turbines less than the setback distance from property lines. This turbine layout considered the best locations from a wind resource perspective while nominating locations that were either on Town property or on other abutting parcels with reasonable access. Zoning setback requirements relate to maintaining a safe distance from habitable structures. The proposed locations do not have habitable structures within the turbine fall zones, and therefore easements or other property arrangements may be possible (and are contemplated in the draft By-law) to satisfy the setback requirement. A more detailed review of the turbine locations and accurate delineation of the property bounds will need to be undertaken for final turbine siting to take into consideration the setback and other zoning requirements.

5.3 Airspace and FAA Notification

Several airports are located in the vicinity of the proposed site. These include

- Logan International Airport approximately 45 miles east
- Worcester Municipal Airport approximately 3 miles southeast
- Fitchburg Municipal Airport approximately 20 miles northeast
- Ware Airport (private) approximately 15 miles west
- Gardner Municipal Airport approximately 40 miles northwest

The Federal Aviation Administration (FAA) requires notification and possible subsequent obstruction marking and lighting on structures that may impact the National Airspace System in accordance with guidance in the FAA's Advisory Circular AC70/7460-1K Obstruction Marking and Lighting.

Notification involves submitting a Notice of Proposed Construction or Alteration form (FAA Form 7460-1) to the FAA Regional Air Traffic Division office. Based on review of the FAA requirements and given the height of the proposed turbine(s), submittal of the Notification form will be required.

Marking and/or lighting requirements of structures varies depending on height, terrain, weather patterns, geographic location, and in the case of wind turbines, the number of turbines and the layout of the design. The FAA will recommend the use of only those markings and/or lighting systems that meet an acceptable level of safety to air navigation.

Wind turbine support structures with a height greater than 200 feet AGL may require marking, although this has not been a common practice. Flashing aviation red obstruction lights may be required to operate during night hours. Lighting via flashing white obstruction lights is normally recommended by the FAA for structures with a height of 200 feet AGL or higher. When medium intensity flashing white obstruction lights are installed on structures with a height less than 500 feet AGL, other marking methods such as painted bands may be omitted. High intensity flashing white obstruction lights are not typically recommended on structures with a height less than 500 feet AGL.

The site already has tall radio tower structures, at least one of which, at 366 feet AGL is generally as tall as the turbine. Marking lights will be required but it is not anticipated that the turbines will be classified as a hazard to air traffic by the FAA given the distance from the various airports.

5.4 Noise

Massachusetts state law does not allow a rise of 10dB or greater above background noise levels at a property boundary (Massachusetts Air Pollution Control Regulations 310 CMR 7.10). This sound level is unlikely to be reached at the property bounds. Turbines of the type being considered for this site are relatively low in noise generation from both the mechanical components and the rotor rotation. Additionally, the predominant winds at the site will tend to somewhat minimize any noise propagation toward the closest sensitive receptors which are residential areas. Town zoning By-laws also impose a noise limit as described previously. Noise propagation should not be an issue for the prevailing summer winds from the southwest to west, as they will blow toward the uninhabited properties. Noise may present a concern to be further studied during northwest and northeast winds, as they would fall or tumble down the eastern slopes to the residences southeast of the site. These northwest and northeast winds are also more prevalent during the winter months, which coincide with limited foliage "barrier" of the deciduous trees. The positive aspect is, residences tend to be more closed in the colder months, and inhabitants spend less time outside. The turbine(s) will be sited approximately 700 feet from the nearest residence and therefore, based on the distance and prevailing winds, it is anticipated they will be inaudible or in a worst case minimally audible and not present noise interference issue.

6.0 ENVIRONMENTAL CONCERNS

It is anticipated at this time that the permitting of the proposed wind turbines will not be overly contentious based on the site and surrounding community. Zoning issues (mainly related to height and fall down radius), possible road use permits for transporting large components and visibility are likely to be the major matters to be addressed.

Environmental impacts for the installation are deemed to be minimal and acceptable and will not have any unreasonable impact on the permitting of the project. Based on a review of Massachusetts GIS clearinghouse, no rare, threatened, or endangered species have been identified in proximity to the Asnebumskit Hill site. Additional no wetlands have been identified in the vicinity of the proposed turbine sites.

7.0 POTENTIAL WIND PLANT CONFIGURATION OPTIONS

Wind plant configurations are based on a desire by the MTC to examine a location on property owned by the Town of Paxton and to also examine abutting property that may offer a superior site and whose landowners have expressed a willingness to discuss the siting of wind power on their lands. A single turbine on town owned property was desired for the LII Program as well as consideration of the maximum number of turbines that could be configured to best utilize the wind resource. To meet these goals, the project team developed three wind plant scenarios:

1. One turbine on Paxton Town land,
2. One turbine on the most energetic site, and
3. Maximize the number of turbines to capture the best winds, while minimizing impact to each other, and/or the existing radio towers and nearby residences.

7.1 Turbine Sites

Five sites have been identified along the ridge to address the three siting scenarios. Although five potential sites for turbines have been identified, the proposed site layout consists of a maximum of four turbines as shown on Figure 2. If the site at Pax-5 is used then Pax-1 would not be available due to turbulence and shading due to the sites' close proximity. Minimum rotor spacing of approximately three rotor diameters was used to separate the four sites. The prevailing southwest and northwest winds and related power and storm winds will flow evenly over the turbines, while certain less prevalent winds may require one or two of the turbines to curtail operations, to prevent turbulence from causing wear on the turbines.

Siting the turbines away from the radio towers is a challenge. Consideration was given to interference with the radio towers, turbulence around the towers, and operation of radio and turbine equipment. Turbine sites Pax-1 and 5 are the closest to a radio tower. The five possible sites are:

Pax-1

This site as proposed offers good construction access and setback from upslope winds. Ideally, it would be closer to the summit. Siting the turbine to the northeast of the existing tower should be considered during full feasibility study, as this may offer increased output.

Pax-2 and 3

These locations are sited perpendicular to the prevailing winds along an existing "jeep" road, beyond where predicted turbulence impacts from the western upslope may occur. They offer direct access by upgrading the road for construction/operations use. Pax-3 output may be decreased due to its lower elevation, but both sites are away from buildings and residences.

Pax-4

This location may offer the best opportunity to maximize a site. It is at high elevation on relatively level land, away from any upslope turbulence and from the radio towers. The site will require a road to be built, and is the closest of all the potential sites to a residence.

Pax-5

This location is on town owned land. It may be advantageous to move the turbine farther north to allow more distance to the radio tower, while still remaining on Paxton town land. This move would need to be balanced to maintain distance from the residences, allow for construction needs and for service access.

All the sites will need to consider pedestrian traffic. The land is currently used for walking, potentially hunting, as the open woods, western views, and small paths are conducive to recreation. Motorized vehicle traffic is not prevalent, but consideration for this in the future will be needed. Pedestrians and turbines can coexist as long as normal precautions are taken. The site need not be fenced off but warnings and/or insurance protocol will be needed- especially in light of potential icing conditions in the fall and spring. The current radio towers are approachable by pedestrians and they also have potential for falling ice.

7.2 Turbine Configurations

Three configurations have been identified utilizing the above sites that meet the goals

- **A single turbine on town land (Pax 5)**

  This configuration is located to maximize resource, and elevation, meet minimum setbacks from the residential area, and provide for accessibility/construction, all while staying on town land. This site will require a road being built in from the south, (parallel to the slope) to enable crane and truck access. The collection system will have a direct line to the aforementioned substation. Both the access and collection line will have to go over private land. The lower energy production, potential for wear due to turbulence/upslope winds, and requirement to access the turbine from private land make this site and this scenario problematic.

- **A single turbine on private land (Pax 1)**

  This configuration is located at the best site to maximize resource, ease of construction, and provide lowest cost. This site meets all requirements in terms of a good wind turbine site. Minimal road and infrastructure changes would be required. The site maintains adequate separation from residential areas. Pax 1 is slightly below and upwind (for prevailing winds) of the southernmost radio tower, providing clear air for the turbine, and separation for radio tower operations.

- **Maximum number of turbines configuration (Pax 1, 2, 3, 4)**

  This scenario sited the maximum turbines, on the site, while maintaining the required spatial distances, clearances from obstructions, and setbacks from residential areas. This configuration would surround the radio towers (Pax1, and Pax4) and stretch the impact down to the SW for Pax3. This scenario does meet turbine requirements (turbulence, access, and spacing) and would be reasonably accessed via the construction of roads over good terrain, and /or existing jeep roads. This configuration would place the turbines on two or potentially three different properties.

Beyond the obvious site constraints of wind resource and access, consideration was given to; turbulence, upslope winds, topographic wind enhancements, and influential wind directions. These factors required the sites to be away from the edge of the upslope, sited parallel to the ridge, and not overlap when the "power winds" were blowing from the NW, and potentially the NE.

Spatial considerations were given for radio tower interference and turbine wake effects. Noise impacts were considered for the Asnebumskit residential neighborhood.

Visually the four-turbine layout provides an array of turbines spaced along the ridge, in a natural fashion, flowing with the ridge elevation changes. The radio towers will fill the gap between Pax 1, and Pax 4, again trying to balance the effect.

Radio tower influence will have to be studied further with more detailed information about the specific types of signals, frequencies, and use of each tower. Typically, cell phone and FM radio transmission should not present problems. No direct radomes (microwave) equipment was noted to be in a line of sight with Pax 1, Pax 4.

This evaluation considered either a GE 1.5ls, 1.5 MW turbine or a Vestas V80, 1.65 MW turbine. These turbines were chosen as representative sizes from reputable manufacturers (specifications of these turbines are included). The GE 1.5sl is currently one of the leading MW scale machines; it has several features that make it well suited to this site, including a 70.5 m rotor and power electronics that smooth the output, providing higher power quality to the grid. The Vestas V80 is similar to the GE unit with a slightly larger rotor diameter and larger MW production rating of 1.65 MW. Both machines were considered with the smaller rotor option, as the icing and winds of the Paxton site will not typically allow use of the larger available rotors.

8.0 PRELIMINARY ESTIMATES OF ENERGY COST AND MANAGEMENT CONSIDERATIONS

Preliminary estimates have been made that provide a range of cost information to guide MTC and the Town of Paxton in their decision to install one or multiple wind turbines in Paxton. Because small differences in the assumptions used can result in substantial changes in the unit cost[3], we intend that this

[3] In this document, we generally discuss cost in terms of $/MWh. A price of $60/MWh is the same as 6 cents per KWh.

Section serve as a framework for discussion; at this early stage; the information provided should not be treated as definitive.

Wind project energy costs are the product of four factors: (1) the wind resource; (2) the cost of equipment installation; (3) tax matters and the cost of financing; and (4) the cost of operations and maintenance. Typically the first three factors are most important because wind projects are capital intensive. For small projects, the O&M cost can also be significant because of the absence of economies of scale.

Since the MTC is considering funding a single turbine, item (3) must be dealt with in a different manner than typical projects. With regard to that turbine, MTC seeks to estimate revenues that could reasonably be obtained from sales of energy to Paxton Municipal Light Plant (PMLP) and Renewable Energy Credits (RECs) to the general market with the proceeds being allocated to MTC's Low Income Initiatives.

8.1 Assessment Approach

There is limited relevant experience with projects of this size in the Northeast. We started with the information available regarding the potential sites in Paxton and made adjustments based on our experience and a review of published studies concerning community-scale projects.[4] For each of the key factors listed above, we developed a range of scenarios that we input into a spreadsheet model that produces a 20-year cash flow forecast reflecting financing and operating costs and tax matters as appropriate to the scenario. We compared the total production costs under various site/configuration and wind speed scenarios: (1) MTC-Owned Single Turbine on Municipal Land; (2) MTC-Owned Single Turbine on Private Land; and (3) MTC-Owned Single Turbine plus Paxton-Owned Three Turbines on Private Land. The results are a 20-year series of energy costs which we have adjusted to a levelized value (i.e. a fixed price for the full forecast period that is financially equivalent to the 20 years of projected actual costs) for comparison purposes. We used a 20-year forecast based on the reasonable expectation that wind turbines have a 20 to 25 year useful life. In all scenarios, because the entities involved are all non-private, tax-exempt groups, tax-related assumptions were excluded. We chose to assess MTC's financial position using a value for its cost of capital similar to a municipal bond financing scenario, and also assuming MTC would be satisfied to just recoup its initial investment (a zero cost is assigned to MTC capital).

[4] We found the study entitled "A Comparative Analysis of Community Wind Power Development Options in Oregon" to be most helpful. It can be found at: http://www.energytrust.org/RR/wind/OR_Community_Wind_Report.pdf.

8.2 Assumptions

The key assumptions modeled are as follows:

8.2.1 Wind Resource

The wind data must be regarded as preliminary. Initial analysis suggests that a GE 1.5 MW turbine on an 80 meter tower would be expected to produce at about a 27% to 30% capacity factor on the municipal site (3,548,000 to 3,942,000 kWh annually). The same turbine is expected to produce at a higher capacity factor (33%-37%) on the private land site due to its better wind regime. The turbine could produce between 4,336,000 and 4,862,000 kWh annually. The installation of four GE 1.5 MW turbines on the private land would be expected to produce just under four times those amounts due to some shadowing of the wind resource among the turbines. We ran the financial model to include both high and low capacity factor expectations for the three scenarios discussed.

Parameter	One GE 1.5 MW (Municipal)	One GE 1.5 MW (Private)	Four GE 1.5 MW (Private)
Hub Height (m)	80	80	80
MW	1.5	1.5	6
Capacity Factor (high)	30	37	35
Capacity Factor (low)	27	33	31
Annual Output High (MWh)	3,942	4,862	18,396
Annual Output Low (MWh)	3,548	4,336	16,294

8.2.2 Cost of Installation

At the time we conducted this portion of the study, we only examined GE 1.5 MW turbine costs. Costs may be somewhat different for Vestas V80 MW turbines and we will examine those costs at the next stage of review. Turbines comprise about 50% of a project's cost. The balance includes other necessary electrical equipment, site and civil work, installation, turbine lighting costs, substation and permitting/legal costs. We included a 10% contingency due to the expected difficulty with development of the sites. Based on recent quotes from turbine manufacturers and experience with other projects, we have estimated the total cost of installation with contingency below. These total costs are somewhat higher than previous studies, mainly due to site specific issues and recent increases in the installed costs and other site-specific issues. Also, there may be some slightly higher costs associated with turbines built on private land if a new road is needed.

One GE 1.5 MW turbine:	$2,700,000
Four GE 1.5 MW turbines	$8,950,000

We note that the four turbine scenario would require various decisions regarding allocation and sharing of costs between two owners. Until the scenarios are better defined, we have assumed

that costs and revenues are allocated proportionally among the owners based on the MW owned by each party.

8.2.3 Cost of Capital and Financing

Since most of these scenarios assume MTC will fully fund a single turbine, we needed to provide a measure of cost to compare the various sites. While there are a number of structures that could be considered, our preliminary assessment assumes 100% financing using municipal bonds or an equivalent cost of capital for the MTC-owned turbine. We also considered a 0% cost of capital option for determining a minimum floor for MTC to recover its initial outlay. While private ownership of the turbines can also be an option, no additional analysis was conducted at this stage.

Current rates for AAA rated municipalities are around 4.5% for 20 years. We chose to use 5% in this study to reflect the possibility of higher interest rates at the time of project construction. We also made the preliminary assumption that any turbine owned by Paxton could also be financed using municipal bonds. This may present tax and legal issues if the Town is the owner. On the other hand, it may be acceptable if PMLP owns the turbines and uses the output to serve the utility's load. Further review of this issue is warranted once the scenarios are better defined. To the extent permissible, financing the project using tax-exempt municipal bonds also would be simpler since it avoids the time and cost of transaction structuring required in a privately financed project. In all these cases, the owners, being tax-exempt, would not be able to take advantage of any related tax benefits. If further review suggests that a "taxable structure" should be considered, we can promptly provide the analysis.

8.2.4 Operation and Maintenance

The O&M category includes items such as insurance, land lease costs (if applicable), equipment maintenance, repair and replacement, and administration.[5] In the MTC-Owned Turbine on Municipal Land scenario, the project does not pay property taxes or land leases. However, in the other scenarios, private land leases are assumed to be $4,000 per turbine annually. Our installed cost numbers for all modeled projects include a warranty for two years, so the maintenance costs are somewhat lower in those years. For years three to five, an additional warranty could be purchased, so we included the warranty extension into the model's O&M. After year five, we forecast O&M costs to increase over time based on studies of expected equipment repair and replacement costs over the project life.

It is premature to identify a specific plan for performing the maintenance and repair work for a project. As part of the warranty commitment, the turbine manufacturer will specify its requirements and the project owner will need to assess how it wishes to proceed. One option

[3] We have modeled these as incremental costs, but a Town owned project may be able to reduce or eliminate some components. For example, it may be possible to add the wind turbine installation to the City's existing insurance policies without a material change in the premiums.

will be to dedicate several people to be trained and available on a part-time basis to meet the manufacturer's maintenance requirements. The owner could also team with another community that installs its own project to share in the cost of having a maintenance staff. A third option could involve the owner retaining the manufacturer under contract individually or as part of a group of communities. Our forecast of maintenance and repair costs for this analysis is based on generic maintenance cost information increased slightly to reflect the likelihood that small installations will involve higher than average costs. A more detailed assessment would be necessary if the project is to proceed.

8.3 Results

The cost analysis included three siting scenarios at high and low capacity factors: (1) MTC-Owned Single Turbine on Municipal Land; (2) MTC-Owned Single Turbine on Private Land; and (3) MTC-Owned Single Turbine plus Paxton-Owned Three Turbines on Private Land. In addition to assuming a 5% return on capital, we also modeled the minimum cost for MTC with a 0% return on capital.

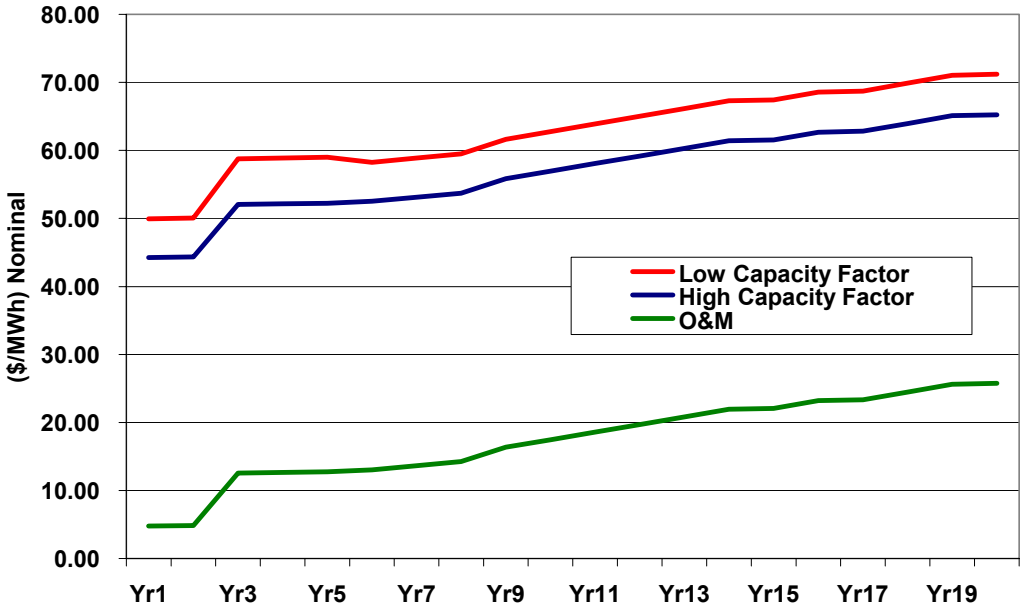
20-Year Levelized Cost in $ per MWh

Wind Turbine	Cost ($/MWh)	
	High/Low (5% Return)	High/Low (0% Return)
Single GE 1.5 MW on Municipal Land	$73/$80	$54/$59
Single GE 1.5 MW on Private Land	$62/$69	$47/$51
Four GE 1.5 MW on Private Land (MTC/Paxton)	$55/$61	$42/$46 (MTC Turbine)

The prices shown in the table above are levelized costs for 20 years for a range of high and low capacity factors. In comparing site configurations, it appears that installing a turbine on the private land site is more economical, despite having to make lease payments, due to its much higher capacity factor potential. Economies of scale improve costs further when multiple turbines are placed on this site.

The graph below is indicative of the potential annual, per unit, total cost trajectory for the three Paxton-owned GE 1.5 turbines on private land. While financing payments are level, operating costs increase with inflation, and maintenance costs increase as the turbines age.

Estimated Cost Trajectory of Paxton-Owned Project on Private Land



8.4 Discussion of Revenue from Energy and REC Sales

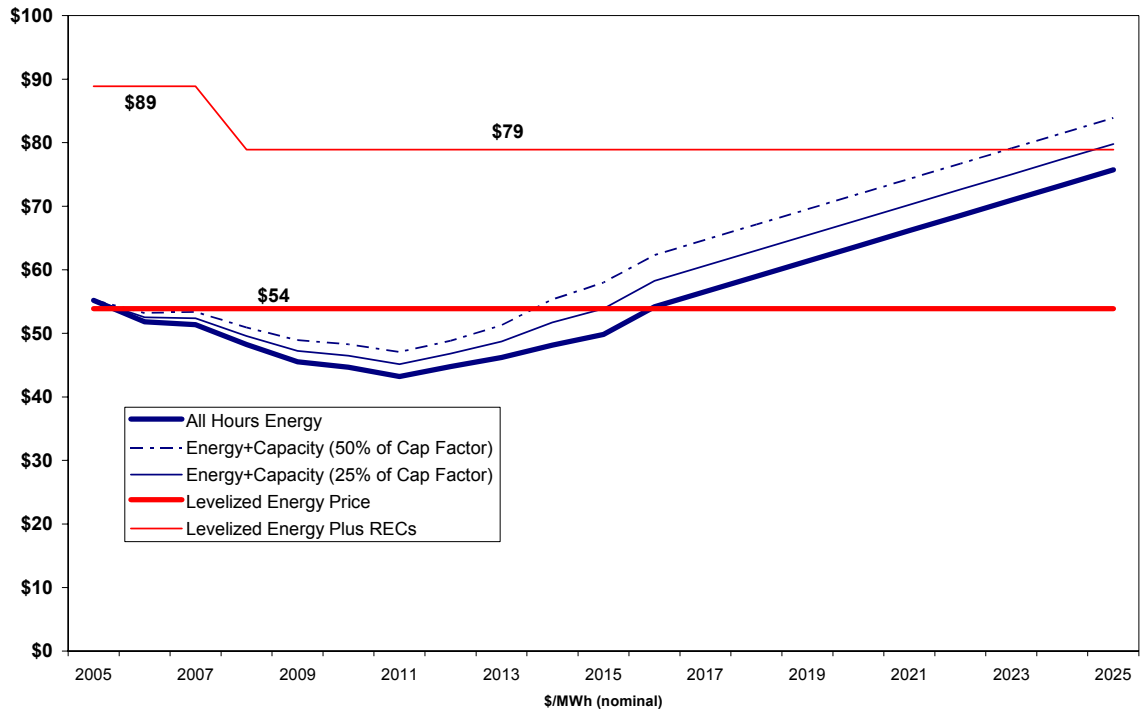
In the cases where MTC will own the turbine, we understand that it is considering (1) selling the output of the energy to the Paxton Municipal Light Department and (2) marketing the RECs separately. There are many pricing methods that MTC may pursue, among them a cost-based approach or a market-based approach. The cost-based approach looks to the financials of the project, while the market-based approach is based on forecasts of the energy and REC markets.

In the cost-based approach, MTC has discretion on how it wishes to address financing assumptions. MTC may want to consider some level of return on capital or opportunity cost associated with funding the project for the purposes of determining reasonable contract prices. To design an appropriate analysis of this structure, we first compare the costs of the projects relative to one another, whether it is assuming a 5% or 0% return as shown in the results section. This cost-based approach provides a reasonable basis for determining the minimum revenue required from energy and REC sales. It shows a large range of $47/MWh to $80/MWh in the various scenarios, depending on capacity factor and expected rate of return.

Recently, MMWEC[6], on behalf of a group of municipal utilities including PMLP, purchased all the output from a 15 MW wind project in the Berkshires. The contract for energy and capacity for the entire output of the project was reported to be a fixed price of 3.65 cents/kWh for 22 years. This is well below MMWEC's current and projected prices for energy. The renewable energy credits will be sold to third parties with MTC purchasing the RECs for years 6 through 15 at approximately $20.00 per credit. This REC price could be used in conjunction with levelized "cost" described previously to calculate an energy price to PMLP. The market-based approach can also look to similar transactions for pricing guidance.

For a market-based approach, it may be safe to assume that a portion of MMWEC's portfolio consists of buying short-term, spot market energy, which means their future marginal cost would be equivalent to some sort of market forecast. For the purposes of this analysis, we used an ISO-NE market price projection to reflect MMWEC's and PLMP's marginal cost (see chart below). The levelized cost comes out to be about $54/MWh (5.4 cents/kWh) for the 20 year duration.

Forecast of Regional Energy, Capacity, and REC Market Prices



With the market-based approach, MTC must also consider whether to place value on the capacity portion of a wind turbine in ISO-NE's capacity market. Currently, there is an oversupply of generation in the market, so capacity payments are extremely low. In our market model, however, we anticipate significantly higher capacity payments in future years in order to stimulate new generation to come on-line. According to existing ISO-NE rules, the portion of a wind generator's

[6] Paxton Municipal Light Company is a member of the Massachusetts Municipal Wholesale Electricity Company (MMWEC), which acts as a power purchaser for multiple municipal power companies.

capacity that can receive capacity payments has been set at the higher of (1) the sustained maximum net output average over a four consecutive hour period (for summer and winter capability periods) or (2) the unit's nameplate rating adjusted for unit output at peak. Since very few wind projects have been built in ISO-NE to date and there are discussions to change these rules due to wind's intermittent nature, we have discounted the capacity value in this review. We provide two representative capacity values in the graph above that reflect 50% and 25% of a wind facility's average capacity factor, which adds, on average, $5 and $2.50 per MWh, respectively.

For REC sales, the current market price for Massachusetts RPS-eligible RECs is about $45/MWh for 2005 and $40/MWh for 2006. These high prices are the result of a short-term supply shortfall and do not necessarily reflect what long-term contract prices will be. In the near-term and long-term projections, we estimate REC prices to be in the range of $25-$35/MWh for 2006-2007 and $10-$25/MWh thereafter[7]. If MTC chooses to offer a long-term, fixed energy price contract to PMLP at $54/MWh, the graph above shows the potential combined (energy + RECs) revenue for MTC and LII, which starts at $89/MWh initially and declines to $79/MWh, assuming the higher end of REC prices. At these levels, all the projects appear economically viable relative to their costs, except in the case of a single turbine with low capacity factor on municipal land. However, if REC prices turn out to be $10-$15/MWh lower than the higher-end estimate, building on private land would be the economical option, given the site's better wind regime. Since energy revenue alone is not sufficient to support these projects, careful analysis of future REC value is important in the next phase of the study.

Given the increasing cost trajectory of any wind facility, MTC may want to consider marketing energy at some escalation rate that would more closely match its cost profile and projected energy prices, rather than offering a fixed price contract. However, offering a fixed price contract does produce a simpler transaction process.

8.5 Conclusions on Economic Considerations

MTC and Paxton have several options in regards to site selection and contract prices. In choosing a site, the private land will generate more energy with its higher capacity factor, thus reducing per unit costs. Furthermore, by ordering multiple turbines in coordination with the Town of Paxton or Paxton Municipal Light Department, there is an opportunity to reduce capital costs per turbine. These assumptions will need further verification as the project proceeds.

As for determining reasonable contract pricing, a range of approaches can be used to produce potentially acceptable results. In order to proceed to the next phase, MTC and Paxton would need to select which siting scenarios and partnership relationships are of most interest. We then can focus in on the details of these scenarios, including: project size, MTC's cost of capital, site valuation, REC pricing, and contract pricing.

[7] These REC prices are estimates only and may not reflect actual prices in the future. It would be appropriate in further analyses to test alternative REC sales price assumptions.

9.0 RESULTS AND RECOMMENDATIONS

It appears from the Site Screening that the wind resource is very good and capable of supporting a commercial installation. The least feasible location for a turbine installation is on the Town of Paxton property with the site, Pax – 5, being only marginally acceptable. The windiest site is Pax-1 which is not on Paxton property. Site Pax – 4 may offer the best option of any site as it is high and level and furthest away from upslope winds and turbulence from the telecommunication towers. In a full build out scenario, the site can support up to four turbines if property abutting the Town's land can be utilized.

The economics of the project based on this level of assessment appear favorable. However, the most promising sites from a wind resource and revenue perspective are not on Paxton property. Decisions are required regarding site selection, ownership, financing, operation and maintenance, electricity and Renewable Energy Certificate sales before a more definitive economic evaluation can be presented.

The electric infrastructure is conducive to wind plant development and can accommodate up to four turbines without major modifications to existing facilities. Electrical interconnection discussions and studies will be required with the Paxton Municipal Light Company and possibly Massachusetts Electric regarding specific interconnection requirements.

There are no environmental issues that will present a major hurdle to permitting the proposed turbines, and all environmental matters appear to be manageable. It can be anticipated that the main community reaction, if any, to the turbines would be due to the visibility. A 1.5 MW turbine would have a tower height of 80 meters and, along with the 70.5 meter diameter blades, the tip of the blade height would approach 115 meters (380 feet). Present high structures on the site may serve to soften the visual appearance of the turbines and residents may be more willing to accept the new structures having become somewhat accustomed to the telecommunication towers. Visual simulations will assist in addressing this issue.

Noise is not anticipated to be a major concern, and the heights of the structures are not expected to pose a hazard to airspace. A notice will need to be filed with the FAA which will result in the specification of lighting requirements for the turbines.

One potential area of concern is the requirements of the town zoning, in particular the setback requirements. When the new commercial wind energy conversion systems By-law is finalized, turbine siting will need to be reviewed in light of its requirements. This could have the effect of limiting the turbine locations and possibly preclude siting in the most advantageous wind resource location. A more detailed review of the turbine locations and accurate delineation of the property bounds will need to be undertaken for final turbine siting to take into consideration the setback and other zoning requirements.

Transportation of equipment to the site is an important consideration. Some of the equipment, particularly the turbine blades, is quite large. A preliminary review of the possible transportation routes to the site indicates transportation is feasible. Some movement of facilities such as traffic lights and

electric/telephone wires would be required. This should be reviewed in more detail in the next phase of study.

The site's wind resource will require further definition for final turbine placement. This would include a more formal effort including a second anemometer(s) on the southwest edge of the site (possibly on the FAA monopole tower) which will contribute valuable information, along with kite measurements (for turbulence indication) and possibly computer modeling.

Based on this screening assessment it appears that Asnebumskit Hill site is a serious candidate site for wind turbine installations and a Feasibility Study is warranted to examine in more detail the various site attributes and other essential considerations such as the wind resource, economics, zoning, site access, construction and the various configurations described.

Figures

Appendix A

Wind Rose
Data Table of Wind Speed

Appendix B

GE 1.5 Wind Turbine Specification
Vestas V80 Wind Turbine Specification