City of Lynn

Wind Turbine Site Screening and Development Options Analysis

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NOTICE AND ACKNOWLEDGEMENTS

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ABSTRACT

This report presents a site screening analysis of the potential for development of a wind energy site or sites at the Regional Waste Water Treatment Facility in Lynn, Massachusetts. The wind consulting team of ESS Group, Inc, Northern Power and LaCapra Associates conducted the study under contract to the MTC. Multiple wind energy plant configurations were investigated for the site project area. Analysis investigated the site wind resource, site physical characteristics, electrical infrastructure, characteristics in the vicinity of the site, environmental concerns and developed 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
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Wind Energy
Wind Turbine

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1.0 INTRODUCTION

The Lynn Renewable Energy Committee is evaluating the regional wastewater treatment plant (WWTP) site as a potential location for a community wind project. The site consists of industrial land on Circle Avenue in Lynn, MA (Figure 1 and 2). The University of Massachusetts Amherst Renewable Energy Research Laboratory (RERL) completed a preliminary wind resource assessment and met tower-siting analysis in February 2004. Wind data has been collected at the site since August 18, 2004.

The Committee is contemplating the installation of a single 1.5 - 2.5 MW-class turbine, but also would like to evaluate information for a smaller turbine (e.g. 660 kW) for comparison. It is currently anticipated that all of the electricity produced by the wind turbine would be utilized at the WWTP; however there is a possibility any excess production could be marketed.

This analysis has been undertaken to address the potential location of a wind turbine or turbines at the regional wastewater treatment facility with the following objectives:(a) identify any fatal flaws that affect the feasibility of installing the contemplated wind turbine and (b) make recommendations regarding wind plant options for the Project site.

Three potential configurations have been examined; 2 – 1.5 MW turbines, 1 – 1.5 MW turbine and 2- 660 kW turbines. Site visits were conducted on October 26 and November 22, 2004. During the visits, the WWTP property and the surrounding area were walked. Information was also reviewed with representatives from the Lynn Water and Sewer Commission, Lynn Economic Development and Industrial Corporation and the Massachusetts Technology Collaborative.

The information presented covers the many factors involved in creating a successful wind power plant at the Lynn 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. Based on this screening assessment it appears that the installation of a wind turbine generator at the Lynn WWTP is a viable option and a Feasibility Study is warranted.

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. On-site monitoring data is limited as the equipment to collect this information was only recently installed. However based on this limited data and other data described below it appears the site has an acceptable wind resource for harvesting wind energy. Additional on-site data will be collected and analyzed if the installation of a wind turbine at the site moves forward. The Lynn WWTP site is on the coast, with uninhibited exposure, except for the relatively distant arm of Nahant across the bay. Therefore we would expect to find a typical coastal wind resource along with coastal weather attributes particular wind directions, sea breezes, and storm patterns. At this preliminary stage we estimate the annual average wind speed for the site at a 60-meter wind turbine hub height is in the range of 6.2 – 7.2 meters per second (m/s). This estimate is based on minimal site collected data, and relies heavily on the True Winds New England map modeling. In addition to the wind speed, wind

direction is of great interest on this site, as it will impact energy output, noise propagation, and wind turbine wear from turbulence. The predominant winds are generally out of the southwest and northwest.

To determine an energy output model for the site we screened known available wind data. This included three of the four sources listed below:

Source	Type	Interval
True Winds New England wind map	Resource prediction based on elevation models, extrapolation	Seasonal, annual averages
RERL: Lynn site anemometry: 39m meteorology mast located by landfill	Industry standard equipment, with multiple levels of speed & direction sensors (10, 30, 39m)	10 minute averages, real time- two month data set (all that was available since installation)
RERL site: Logan Airport	Standard airport monitoring. 10m height, long constant anemometry	Hourly real time data up to 2003
City of Lynn	Harbor master office: Offshore Buoy #44013	Link Not yet received

Data review included:

- A preliminary screening of the data set, including a visual assessment of the quality of the data. and manual inspection for any potential anomalies,
- Formatting the data to allow for necessary filtering,
- Construction of an 8,760-hour year estimate from partial data set, and
- Wind shear estimates and wind resource scaling to appropriate turbine hub heights. Data from the Site met tower (two month data provided) was used for this. The shear estimate was also compared to the True Winds predictions for the relative hub heights.

The resource data and site visit (inspection for flagging, vegetative evidence, local features) provided enough data to estimate a resource for the various hub heights described in Section 7.0, Potential Wind Plant Configurations. Although we have stated an annual average wind speed for the site, adequate data does not exist to predict a seasonal or monthly resource. The relative energy output of a wind turbine is proportionate to the square of the wind resource. Therefore small differences in wind resource will equate to significant changes in energy production. This fact dictates careful analysis and the use of site collected data to determine accurate resource estimates.

The physical characteristic of wind speeds to increase with elevation (to a limit) is referred to as wind shear. Wind Shear is a great benefit, and the major reason why wind turbines are on tall towers. The Lynn site does exhibit good shear as it represents a landform change (e.g. the open sea winds impact the constructed landscape).

Daily wind profiles have not been compiled, nor estimated as the data are not available and this effort is beyond the scope of this report. Daily attributes can be crucial when evaluating the economics of a project and can help answer questions such as whether the wind plant can meet the site loads on a given day, or how much energy may be exported. In this case, based on discussions with plant operators the WWTP facility load profile is large and quite flat and therefore daily wind profiles are somewhat less important to assessing economic viability. It is recommended that this analysis be conducted during the feasibility phase, when more site data is available.

The wind resource for the Lynn site has been characterized using a Capacity Factor estimate for the turbine(s) rather than an absolute wind speed calculation. Capacity Factor determines the relative amount of time the turbine would be producing its rated power (i.e. a 25% Capacity Factor (C.F.) for a site equates to the turbine producing 25% of its rated output averaged over the year)). Industry standards equate the available wind resource to the Capacity Factor of a wind turbine. This allows the economic forecast of the project to be conducted while not over promising the accuracy of the wind resource at this stage. The formal feasibility phase would include a detailed description of at least five months of the site data, correlated to corresponding data from Logan Airport. This along with further review of the wind shear, and possibly a kite study at 80m should provide enough data to confirm the projections.

Site obstructions should be manageable at this site. The impacts to wind resource and therefore energy output from local site obstructions, and/or features will be from turbulence created by the solids dewatering building and the landfill. The three wind turbine sites chosen (Figure 3) are all on ground elevation, and will not take advantage of the height of the landfill.

Although the towers proposed are tall, the landfill will induce turbulence when the wind is coming over the landfill. This turbulence, or upswept air should not induce any major impact from what we currently know, but may require modeling. The dewatering building should present only a low impact although if the small (~660kW) turbines were located North of the dewatering building may see degraded performance.

3.0 SITE PHYSICAL CHARACTERISTICS

The Lynn WWTP consists of many buildings, treatment basins and a landfill with a high beam that is the most prominent structure on the site. An access road wraps around the landfill, providing access to the top, and down into the pit. The landfill is used for incinerator ash and grit waste. The land within the fenced facility is almost entirely used. The facility is extremely dense, with service roads separating the buildings, and relatively few open areas. The ability to absorb wind generation equipment on site is very limited because of size and it must not adversely impact the facilities prime use. Beyond this, the facility has several positive attributes that contribute to its ability to accept large wind turbines. Safety issues are helped as the site is fenced, access is controlled, and a limited number of people work at the facility.

Three potential sites for wind turbines have been designated at the WWTP. The philosophy is to use one or two of the three sites depending on the configuration chosen. The sites chosen balance several factors:

- Not to interfere with existing site purpose,
- Ensure the facility operations will not be interrupted during construction,
- Exposure to the wind resource,
- Minimize the performance degradation induced during certain wind directions,
- Suitable soils for the foundation,
- Access for construction and ongoing maintenance,
- Ability to get the wind turbine, tower, and rotors to the site,
- Room for construction equipment to maneuver, and
- Access to electrical interconnections.

The sites chosen are outside the current landfill area (although in a conversation with Mike Koster, one of Lynn's consulting engineers, he remarked "the old landfill may be outside the current one"). Soil conditions are one of the most important unknowns, as the site is built on filled marsh. Several of the existing structures are built on piles in order to meet the high water table, and poor load carrying characteristics. A wind turbine foundation can be built the same way (with piles), but core samples, and careful design will be required. This has been considered in the capitol cost estimates, by adding in a factor for more difficult foundations.

Roads, and major infrastructure changes should be minimal as the turbine sites are basically accessible except the North East site that will require a temporary road over neighboring land. These sites can be accessed by construction equipment and work with minimal impacts. The South site would require access permission from Garelick Farms for the original installation and possibly in the future if any large components are removed for maintenance, and will require a temporary crane pad. The North site may be able to avoid a crane pad by lifting from Circle Avenue

Turbine, tower and blade transport is an issue, as the secondary roads leading to the site are narrow, twisting, and congested. Although on a preliminary basis, a route by road has been examined and determined to be feasible, given the location of the site to water born access, the land route is secondary. The site is adjacent to a commercial pier owned by EDIC and currently used by a gambling/party vessel. Further evaluation will be necessary to determine if the pier structure can support the proposed use. However, the Lynn Harbor Masters office reports 16' of water in the bay and near the embankment. Tides may be taken advantage of to bring a barge from the Boston Seaport terminal, to the embankment if the dock is not viable. As the wind turbine components will most likely be transported from the manufacturer via sea, this method may be the most direct and would avoid dismantling certain structures if brought in over the road (such as signal lights, telephone and electric wires etc.) and the need for road permits. Therefore there appear to be two alternatives to bring equipment to the site, although water transportation may be the more preferred option.

The crane requirements are also noteworthy, as a tracked crane will be needed for the larger turbines, and the crane will have to be assembled and disassembled on site with the support of a second crane.

Overall, this site should integrate well with wind energy, and may be an ideal example of the distributed generation model within a densely populated area. The preliminary screening indicates sufficient area is available to support the required cranes

The fall zone around the turbine(s) will need to be considered given the proximity of on and offsite structures to possible turbine locations. Because of the tight site conditions, WWTP buildings and other structures will be in the fall zone of the turbines. Similarly, because of the close proximity of facilities on abutting properties and the need to locate turbines fairly close to the property boundaries because of site constraints, off site facilities will also be within the fall zone. This may complicate the permitting and local approvals process. Figure 4 shows the property boundaries and the turbine fall zones based on the blade tip height of the GE 1.5sl and V100 (390 feet and 460 feet) in proximity to the abutting property structures such as the electric transmission line to the south, Garelick Farms property to the west and the commercial buildings to the north and east.

4.0 SITE ELECTRICAL INFRASTRUCTURE

The industrial nature of the site makes the interconnection straightforward and feasible. The site is also a large consumer, currently using more than the largest proposed wind configuration would generate. The site currently has higher voltage (13.8 kV) distribution lines provided to the site. Power within the facility is utilized at various voltages depending on the equipment: higher voltage to the various large loads (pumps, compressors) and medium or low voltage for the basin motors, and within the buildings.

The wind turbines typically generate at medium voltage (480/600) or high voltage (~13.8 kV) for large turbines and would have a transformer located at the base or within the tower, for connection to the collection system (buried conductors in conduit from the turbine) can be tied into the existing site electrical system. Certain upgrades will be required, depending on where the turbines are tied in, most likely enlarging the existing transformer vault, increasing the number of taps, and installing switch gear and metering to utility standards/requirements. At this stage we have assumed the conductors coming into the facility have sufficient capacity for the configurations considered. Further review of the site drawings will be required to determine the conductor capacity at the actual site interconnection points.

Coordination with Massachusetts Electric will be required to review the interconnection standards and possible protection systems required to provide adequate safety. Requirements for interconnecting with the existing distribution grid will need to address equipment such as switchgear and metering. A utility interconnection study will be required because of the need to export power from the site when the production exceeds the load. The interconnection design will have to demonstrate no impacts to the grid, and/or surrounding users. No indications that this would be an issue are known at this time.

The bulk of the wind energy generation can be used on site. The site consumes a large quantity of electricity and annual consumption is estimated at approximately 11,000 MWh's. This equates to an average load of slightly more than 1 MW (as the plant has a relatively flat load profile). The largest proposed wind configuration of 3 MW capacity has a projected annual output of between 6,406, and

7,687 MWh's, more than half of the facilities consumption. There may be times when the wind plant is generating more than the facility can use, and this energy could be exported to the grid. More detailed studies, using yet to be collected wind resource data and facility load profiles can provide accurate projections of how much electricity would be exported. Since the wind plant would be connected to the grid, and electricity will be exported, a formal contractual arrangement will have to be established with the utility, to either buy the exported power, or deliver it to another user.

5.0 CHARACTERISTICS IN THE SITE VICINITY

5.1 General Site Characteristics

The site being considered for the turbine installation is the Regional Waste Water Treatment Plant (WWTP) located at 2 Circle Avenue in Lynn, Massachusetts (Essex County) (Figure 1 and 2). The site generally consists of two parcels totaling approximately 20 acres. The WWTP facility buildings and treatment tanks located in the central and northeast portions of the property and a landfill for the WWTP is located in the southwest portion of the property. The facility also has an incinerator located more or less central to the treatment buildings that has a stack approximately 171.5 feet tall, being the tallest structure presently on the site.

Route 1A, the primary highway route into Lynn, is located approximately 1,000 ft north of the site. Direct access to the site is via Commercial Street, Circle Avenue and Gas Wharf Road, which are heavily utilized by commercial traffic. A site access road is located on the WWTP property and circles the site from Commercial Street to the west of the landfill area.

The topography of the site is generally level, approximately 20 ft National Geodetic Vertical Datum (NGVD) 1929. The western portion of the property (the landfill area) is slightly more elevated than the eastern portion of the property and because it is still active the elevation may increase somewhat beyond the present in accordance with applicable permit requirements.

5.2 Land Use and Community Acceptance

Land uses immediately surrounding the site consist of heavy industrial and commercial uses. Garelick Farms neighbors the WWTP to the west, warehouses, the Department of Public Works (DPW) garage and an auto salvage yard are to the north, and a Brownfield site owned by Keyspan to the east. Further to the east is a power generating facility and substation from which high voltage transmission lines run to the south and along the Lynn Harbor shoreline. A capped landfill is directly south and southwest of the WWTP landfill. Ownership is unclear but would need to be determined to gain permission for access or temporary roads if needed.

The turbine(s) will be approximately 390 or 270 feet high to the tip of the blade, depending on whether General Electric 1.5sl or Vestas V47 turbines are selected. They will be easily visible from Seaport Landing Marina which is located at 154 Lynnway, approximately .75 miles northwest of the

site. Neptune Towers, a 10-story residential high-rise, is located approximately 1,750 ft. north of the site. The turbine(s) will generally be visible to residences on the south (Nahant), north, northeast and northwest sides of the property. The site is generally open and there is therefore little opportunity to provide buffer in the way of trees or other tall structures. The GE turbine will be more visible as it will be higher at the blade tip than the smaller Vestas unit.

The anticipated level of community acceptance is fairly high. Representatives from the City of Lynn indicated they have conducted some public outreach and attended meetings with neighboring property owners as well as the Town of Nahant directly south of the property across Lynn Harbor. Feedback received to date has been positive. Additionally, the Towns of Saugus, Swampscott and Nahant are currently served by the regional facility and will contribute financially to the Regional WWTP to fund the wind turbine project if it goes forward as a long-term investment that will most likely reduce operating costs. To date, there has been no recorded opposition to the project.

It can be anticipated that the main community reaction to the turbines would be due to the 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. If a 1.5 MW turbine is selected, the recommended tower height of 80 meters along with the 77 meter diameter blades will make the turbine considerably higher than the Hull turbine and make it visible for some distance from the site. If the smaller Vestas turbine is selected, it will be about the same height as the Hull turbine or slightly higher. The Vestas turbine may prove to be a more acceptable configuration from a visual perspective as it will be most similar to the one community wind turbine in Hull residents and people in the area are familiar with. However, the location of the site has a number of positive attributes in terms of visibility such as the commercial/industrial nature of the surrounding area and distance to residential receptors

5.3 Airspace and FAA Notification

Logan International Airport is located approximately 6 miles southwest of the WWTP. 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.

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 airport.

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 WWTP or 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 residential areas. Given the site characteristics and heavy industrial use directly abutting the WWTP property, noise is not anticipated to present an issue. The turbine(s) will be sited approximately 1,500 feet from the nearest residence and therefore it is anticipated they will be inaudible or in a worst case, minimally audible and not present a 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. An application to the Conservation Commission may be required if small wetlands are identified near a proposed turbine site as discussed below. The only mapped wetland near the site will not be affected by the project.

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 WWTP site. One wetland has been mapped by MassGIS adjacent to the southern property line, directly southeast of the WWTP treatment tanks and dewatering building. No activities are anticipated at this time that would impact this wetland. There may be smaller isolated wetlands that do not appear on the state mapping. Based on the site visit, any wetlands of this type are not expected to be of high quality or sensitivity and installation of the equipment would be managed to avoid any wetlands identified. An application to the Conservation Commission may be required in this case but is not expected to be a

major issue to the installation. The National Wetlands Inventory has designated the portion of the Lynn coastline (approximately 750 ft south of the site) as estuarine, intertidal, emergent wetland. However no work will be conducted in this area.

An area that may need to be addressed is the possibility that the proposed turbine sites may have subsurface contamination that would be encountered during foundation excavation. Further investigation would be required and soil boring could be taken to address this issue. If hazardous materials are found, it is assumed that, given the limited excavation, the spoils could be addressed under the Massachusetts Contingency Plan requirements. There would be an additional cost associated with the contaminated materials, but the presence of such materials should not preclude the installation.

7.0 POTENTIAL WIND PLANT CONFIGURATION OPTIONS

The WWTP has limited area for the placement of wind turbines as described in Section 3.0. In order to maximize generation, three wind turbine sites have been proposed for consideration in three different wind turbine configurations.

To understand the site choices, a short description on wind turbine airflow requirements is helpful.

Wind turbines ideally need to be located up high, in free air with no obstruction to the wind (including another wind turbine). Wind comes from a variety of directions; therefore the chosen site(s) have to balance the possible detrimental effects of one wind turbine shadowing another when the wind is blowing from a certain direction. Rules of thumb say a wind turbine should not be located within eight - ten rotor diameters downwind to avoid performance degradation and wear, and no closer than three rotor diameters when directly beside each other.

The sites chosen are not able to meet the rule of thumb, but may be still be feasible, as the wind directions that would cause interference (south – south southeast, and north northwest - north) provides only a small portion of the energy.

The three sites cannot all have turbines on them because of this interference. Two options therefore exist:

- Placement of two turbines, one each on the North and South sites,
- Placement of a single turbine on any one of the sites

This is required to ensure the prime power winds (SSW through WNW, and NNE) are equally available to both turbines. If turbines were located at the South and North East sites then the prime SW wind quadrant would first blow through the South site, and then through the second turbine at the North East site therefore degrading the North Site turbine (Note: placing the included wind rose beside the Ortho map, and aligning the North arrows helps depict the constraints).

The potential turbine sites considered ice that could potentially fall off the turbine blade when at rest on a winter day as a prime consideration. Construction access, landfill operations, avoidance of the old landfill, electrical interconnection access, clear runs for the required trenching, soil integrity for foundations and comments from the Director of Operations of the WWTP were also important considerations.

The configurations considered were the following:

- Two Vestas V47 – 660 kW wind turbines
- One GE 1.5sl – 1500 kW wind turbine
- Two GE 1.5sl – 1500 kW wind turbine

These turbines were chosen as representative sizes and from reputable manufacturers (specifications of these turbines are included). The Vestas V47 model is installed at Hull, Massachusetts. The GE 1.5sl is currently one of the leading MW scale machines, and has several features that make it well suited to this site, including a larger 77m rotor offered as an option, for harvesting at marginal wind sites, and power electronics that smooth the output, providing higher power quality to the grid.

The towers considered are the standard offerings: 60m (198') for the V47, and 80m (264') for the GE 1.5sl.

A third alternative, not considered in the configurations that have been explored is a single 3 MW wind turbine. Vestas is currently proposing the V90, and V100 for 2006 installation in the USA providing an option of a single turbine installation with high MWH production. The "90, 100" designation refer to the rotor diameter. These configurations would have rotor lengths considerably larger than the 77-meter rotor supplied with GE 1.5sl. Vestas has recommended the 100m rotor for Lynn, which offers more kWh production, while meeting the expected storm regime conditions at Lynn. Therefore, a V100 rated at 3.0 MW on an 80m tower would be the potential machine for a large single turbine installation.

This wind turbine requires a very large crane for installation. The closest crane with this capacity is currently located in the New York City area. This crane would have to be demobilized and shipped via sea going vessels or barge to the site and reassembled using one or two local cranes.

8.0 PRELIMINARY ESTIMATES OF ENERGY PRODUCTION AND MANAGEMENT CONSIDERATIONS

A preliminary estimate of the economic viability of the project was conducted based on the early estimates of the wind resource and resultant capacity factor for the scenarios, cost data, financing considerations and operation and maintenance estimates.

8.1 Estimated Energy Production

The wind data must be regarded as preliminary. Quick analysis suggests that a GE 1.5sl MW turbine on an 80 meter tower would be expected to produce at about a 25 to 30% capacity factor, i.e. over a year, the turbine would produce between 3,285,000 and 3,942,000 kWh annually. The installation of two GE 1.5sl MW turbines would be expected to produce just under twice those amounts due to some shadowing of the wind resource by one turbine relative to the other. We ran scenarios for both one and two turbine GE installations as well as for a two-turbine Vestas 660-kW installation. The Vestas turbines are the same as the one installed at Hull and would use 60-meter towers. Based on a review of the Vestas specifications, the capacity factor for these turbines would appear to be slightly less than for the GE turbines due to their lower hub height; we ran two Vestas scenarios: 22.5% and 27% capacity factors.

Parameter	Two GE 1.5sl MW	One GE 1.5sl MW	Two Vestas 660 kW
Hub Height (m)	80	80	60
MW	3	1.5	1.32
Capacity Factor (high)	29.3	30	27
Capacity Factor (low)	24.4	25	22.5
Annual Output High (MWh)	7,687	3,942	3,122
Annual Output Low (MWh)	6,406	3,285	2,602

8.2 Cost of Installation[1]

The turbines comprise about 70% of a project's cost. The balance includes other necessary electrical equipment, site and civil work, lighting costs, and permitting. For permitting we have included an allowance of $100,000. Based on recent quotes from turbine manufacturers and experience with other projects, we have estimated the cost of installation as follows:

One GE 1.5sl MW turbine:	$2,300,000
Two GE 1.5sl MW turbines	$4,400,000
Two Vestas 660 kW turbines	$1,600,000

8.3 Ownership and Financing Options

Financing small energy projects is difficult due to their complexity and the fact that most investors focus on larger projects for reasons of scale economy. While there are a number of structures that can be considered, we note that the MTC is evaluating several ownership and financing options for Community Wind projects. These include: municipal ownership and financing, private ownership

[1] Although the V 100 was not included in the screening analysis economic assessment due to it only recently becoming available for installation and being outside the scope of the requested review in the work order, some preliminary cost and production numbers were generated. The predicted performance shows an estimated production of 9,178 MWH/year and an estimated cost (based on .75 Euro/US dollar) of approximately $4,600,000.

and financing (perhaps with a portion of the power sold to the municipality), and public/private partnerships. Options that include private ownership of the turbine may be financially advantageous because they allow the project to use the federal wind production tax credit.

The advantage of using municipal bonds is that current rates for AAA rated municipalities are around 4.5% for 20 years. Financing the project in this manner also would be simpler since it avoids the time and cost of transaction structuring required in a privately financed project.

In the private ownership structure, investors have a higher cost of capital but can take advantage of substantial federal tax benefits available for wind projects. There are two major federal tax benefits to wind project investors: 5-year accelerated depreciation and a Production Tax Credit ("PTC").[2] The PTC is a credit against tax liability currently at the rate of 1.8 cents per kWh. The credit applies to all energy generated in the first 10 years of operation and it, therefore, results in a significant offset to the cost of producing energy from wind projects that qualify.

Additionally, the City would obtain renewable energy certificate ("REC") value[3] because the energy produced will help meet the Massachusetts renewable energy requirements and will have the project energy output to use for its own needs in offsetting electricity costs. They will also have the ability to sell any excess energy and capacity into the energy markets. The scope of this evaluation has not yet allowed for a detailed analysis of the City's load and energy cost information and a full assessment requires the use of a long-term forecast for both energy and REC pricing.

8.4 Operation and Maintenance

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 City will need to assess how to it wishes to proceed. One option will be to dedicate several people to be trained and available on a part-time basis to meet the manufacturer's maintenance requirements. The City could also team with another community that installs its own project. A third option could involve the City's 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. If the City proceeds with further evaluation, we will develop greater detail for the O & M plan in coordination with the City.

[3] Under current law, the PTC does not apply to a project that commences operation after 2005. In our analysis, we have assumed that the PTC is extended (as it has been previously) and that a project at Lynn 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.

[3] RECs for 2004 have been trading between 3 and 5 cents ($30 to $50 per MWh)

9.0 RESULTS AND RECOMMENDATIONS

The results of the Site Screening indicate that the wind resource for the site is adequate and passes first review. The economics of the project based on this level of assessment, although somewhat on the margin, appear reasonable and show potential for improvement given a more detail review and if Renewable Energy Certificates are considered. It is recommended that a more detailed analysis of the City's load and energy cost information be analyzed in the next phase and that long-term forecasts for both energy and REC pricing be considered.

Site infrastructure is conducive to wind plant development and can accommodate up to two turbines. The electrical interconnection for the site is favorable although discussions will need to be undertaken with Massachusetts Electric regarding specific interconnection requirements.

There are no environmental issues that will present a major hurdle to the permitting of 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 77-meter diameter blades, the tip of the blade height would approach 118 meters (400 feet). The GE turbine will be considerably higher than the Hull turbine which is the only comparison locally. It would also make the 1.5 MW turbines visible for some distance from the site. If a Vestas turbine is selected, it will be about the same height as the Hull turbine. Visual simulation would assist in addressing this point.

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 acceptance of the fall zone around the turbines. Two of the proposed locations (the Northeast Site and South Site) have high voltage transmission lines within the fall Zone. Discussions would be advisable with Massachusetts Electric regarding the acceptability of this situation or possibly the need to place a portion of the transmission line underground. Undergrounding would obviously raise the question of whose cost this would be and it could impose additional financial burden on the project. However, there has been public discussion about the possibility of undergrounding this transmission line for other reasons and therefore, it may not be an issue for the wind project. The fall zone issue also exists for the WWTP itself and for the abutting property owners.

Transportation of equipment to the site is an important consideration. Some of the equipment, particularly the turbine blades are quite large. The site appears to have two alternative, viable methods of bringing equipment to the site. The most preferred at this point appears to be by use of water borne transportation to bring the equipment to the EDIC dock which is adjacent to the site. A temporary road would be constructed to bring the equipment to the site from the dock. Transportation over the roadway also appears feasible. Some movement of wires would be required and a rotary and bridge would need

to be negotiated along Route 1A on the assumption equipment would be delivered to the Boston Seaport and then transported north by land.

Based on this screening assessment it appears that the Lynn WWTP is a viable option and a Feasibility Study is warranted. It is recommended that the site proceed to the next level of analysis and that a feasibility study be conducted to more fully explore the elements described in this report and to examine in more detail and further refine 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 1.5sl Wind Turbine Specification
Vestas V47 Wind Turbine Specification
Vestas V90/100 Wind Turbine Specification