Renewable Energy

Riverhead Sewer District – Wind Turbine Feasibility Report

April 2010

Neutral Power

TOWN OF RIVERHEAD

Executive Summary

The Town of Riverhead engaged The Neutral Group in December 2009 to conduct a feasibility study for the development of a large wind turbine generator at the Riverhead Sewer District (RSD) site. A detailed engineering site visit was carried out and relevant data gathered to enable the construction and analysis of wind resource, turbine type and economic models, using proprietary and bespoke software. Investigation of the availability of Federal and State funding for such a project led to an application by the Town of Riverhead for funding under the NYSERDA RFP10 program, however this application was not approved.

Following initial data gathering and a detailed engineering site visit in January 2010, the feasibility study quickly concluded that there are no immediate 'show-stoppers' for the development of a large wind turbine generator on the site. This included evaluation of the following criteria: site constraints and boundaries; site integration; planning & permitting; wind resource; turbine selection and availability; commercial and project economics; civil & structural engineering; electrical & control engineering.

Each of these criteria was then investigated in more detail, through the collection and analysis of relevant site, wind resource, wind turbine and economic data. Computer models of each of these factors were constructed in order to refine and analyze a comprehensive list of wind turbines. Three shortlisted turbines were selected for further sensitivity analysis of their economic performance: the Aeronautica Wind Norwin 54-750; the EWT DW 750/51.5 and the Wind Energy Solutions WES 30. The Norwin 54-750 performed the best, with the following key results:

Physical Characteristics		**Power Production**		**Economics**	
Overall height	270'	Gen Capacity	750KW	Installed cost	$1.60m
Hub height	180'	Annual production	1384 MWHr	Loan repaid in	10-11 years
Rotor diameter	177'	% of site electricity	41%	Annual revenue	$250k
Made in the USA		CO_2 saved over 25 yrs	18,000 tons	IRR	29%

It is recommended that the Town of Riverhead proceeds with the next phase of the RSD wind turbine project by commissioning implementation work, including: determination of a funding plan for the project; an on-site anemometry program of at least 6 months' duration; finalization of permitting requirements via Riverhead officials; drawing up of bid documents, review of draft turbine supply agreements for selected manufacturers; drawing up of outline Grid Connection and Power Purchase Agreements with LIPA; conducting a Geotech study at the selected turbine location and completing the turbine foundation and electrical designs.

Neutral Power is looking forward to continuing work on this exciting project, and submitting proposals as required by the Town of Riverhead.

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Disclaimer

1. Introduction

The Riverhead Sewer District (RSD) is one of the departments of the municipality of the Town of Riverhead. RSD operates a central wastewater processing facility, 12 pumping stations and 25 miles of sewer drains serving the hub area and business district of Riverhead.

The most significant of these sites, and therefore the focus for this project, is the RSD processing plant at River Avenue in the Town of Riverhead. Also on the same site is the Riverhead Scavenger Waste (RSW) Plant, which processes septic waste from five East End towns and Eastern Brookhaven.

The Riverhead Sewer District site processes around 800,000 gallons of waste per day, with a maximum capacity of 1,200,000 gallons per day. The RSD processing equipment currently installed at the site consumes up to 355kW of electrical power, at a monthly cost of around $30,000. The RSW equipment consumes over 100kW.

Riverhead Sewer District has begun to research various options to manage the considerable and rising energy consumption demanded by its waste processing activities; one such option is renewable energy generation. RSD is also currently planning a significant upgrade to these facilities to ensure that they meet the new State Pollutant Discharge Elimination System (SPDES) permit requirements. This upgrade is expected to be online in mid 2012 and will increase the electrical load of the processing plant by a factor of three, with corresponding implications for operating costs to the Riverhead Sewer District.

In December 2009 the Town of Riverhead engaged The Neutral Group to carry out a Wind Energy Assessment project for the RSD site (1). The aim of this project is to assess in detail the potential for renewable electricity generation from an on-site wind turbine, as an energy management measure at Riverhead Sewer District. A key first step towards this aim was to establish that there were no immediate show-stoppers for such a project.

Neutral Power, as the renewable energy division of The Neutral Group, has conducted this study, through a series of site visits, culminating in an engineering visit and site assessment carried out in January 2010. This included a series of meetings and interviews with Riverhead Town officials, engineers from the RSD engineering services provider, H2M, and officials from the Long Island Power Authority, LIPA. At this point, and having carried out initial analysis of the site topography and wind resource, it was concluded that there were no critical planning, physical or economic barriers to the project.

Neutral Power subsequently carried out in depth analysis and simulation of wind resource, mapping and wind turbine performance data, in order to build a series of economic models for the available wind turbine generators which are viable for the site. A number of wind turbine manufacturers and suppliers were contacted to establish their ability and willingness to supply candidate models to the project and indicative pricing was obtained. This has led to a series of recommendations for taking the project to the next stage towards construction and operation of a large wind turbine at RSD.

The study and this report follow a well established process for the evaluation of wind turbine projects of this type, considering and analyzing each of the major areas that drive successful wind turbine development. The next section summarizes the key conclusions and recommendations drawn from each of these sections, in order to provide the reader with an easy reference to each of the detailed chapters which supports the main findings of the study.

2. Key Conclusions and Recommendations

Each of the following chapters reports on a series of detailed analyses, leading to a number of specific conclusions and recommendations, which together define the key variables for the RSD wind turbine project. Together, these lead to a recommended way ahead for the project, which will be subject to further evaluation and decision by the Town of Riverhead. Each is considered in turn here:

Project Constraints and Site Integration

- The boundaries and designation of the site make it suitable for the development of the project.
- The residential zoning designation of adjacent parcels of land remains in spite of their protected status which prevents future residential development. This anomaly was not considered a barrier to on-site wind turbine development by town officials and the residential noise constraint of 50dBA will not be strictly applied to these areas by the Town.
- Protected wetland areas on and near the site will be subject to a strict 100 foot setback.
- A setback distance of tip height plus 33' (10m) will be used from land transportation routes. Noise, shadow flicker and visual influence are not critical constraints for this project, but will need further investigation in the project development phase once turbine selection has been finalized.
- Aviation constraints will be determined by the FAA impact study, which has been submitted to the FAA.
- Two locations within the RSD site were considered in detail for the location of the proposed wind turbine generator. Required setback distances rule out the northerly site for wind turbines with tip heights above 115' (35m) – less than half the size required for a wind turbine capable of generating significant amounts of electricity for the site.
- Integration of the proposed wind turbine into the site is not assessed as problematic; delivery of large turbine components may require some modification of existing roads near to and within the site.

Planning and Permitting

- The Town of Riverhead's Planning Department is supportive and enthusiastic about the project.
- The project will be subject to the Short form of the State Environmental Quality Review process.
- No extensive Ecological studies will be required, but local wetlands are protected by strict setbacks.
- Noise regulations govern sound pressure levels generated at neighboring residential properties. A quirk of local zoning definitions creates some uncertainty regarding noise requirements at the western site boundary, but officials advise that limits will not be strictly imposed in this case.
- Archaeology and cultural heritage issues are unlikely.
- A shadow flicker study indicated that some effects are likely at one to three properties in close proximity to the site, however appropriate and sufficient mitigation options are available.
- A noise propagation study indicated that sound pressure levels at nearby residential properties will meet the Town of Riverhead's noise regulations.
- FCC registered communications systems are unlikely to be significantly affected by a turbine installation, but further assessment is advised to determine the possible impact on point-to-point microwave links.
- Visual impact assessment indicates that a wind turbine will be visible from most of the surrounding area, but the assessment is unable to model the effects of obstructions such as woodland and buildings. Actual visual impact is likely to be much lower than suggested, but further photomontage work is advisable during implementation to assess the true extent of turbine visibility.
- The FAA Aviation Study application was submitted to the FAA on 7 April 2010. The application was reviewed, accepted and forwarded for analysis on the 21st April, with results expected in four to six weeks.

Wind Resource

- A suitable wind resource model was built by using site survey results, wind resource atlases, wind flow modeling and local meteorological reference data. It was concluded that it was sufficiently robust to estimate wind turbine yield and the economic performance of the proposed project.
- It was concluded that the wind resource at the RSD site is likely to be sufficient for a low wind speed turbine model to perform economically.
- It is strongly recommended that on-site anemometry is carried out for at least 6 months to verify these estimates; a suitable equipment specification has been provided.

Turbine Selection

- An initial list of some 139 wind turbines was put together on the basis of suitable generator ratings and then refined by a series of analyses to a shortlist of 5 models.
- Annual yield estimates from these 5 models were determined using the manufacturers' specifications and the NPL wind resource model for the site.
- Each manufacturer provided indicative pricing for their machines, indicating that they would be prepared to sell a suitable wind turbine to the Town of Riverhead.

Commercial and Project Economics

- Outline specifications for Grid Connection and Power Purchase Agreements with LIPA were determined.
- It is concluded that the 2 smaller wind turbine models considered by this study will benefit from subsidies from the LIPA wind rebate program.
- An application made to NYSERDA under RFP10 for funding for project management of the RSD wind turbine project. This application was not successful.
- Summary of wind turbine economic modeling results:

Wind Turbine Model:	**Aeronautica Norwin 54-750KW**	**EWT DW 750/51.5**	**WES 30**
Country of origin	USA	Netherlands	Netherlands
Generating capacity	750 KW	750 KW	250 KW
Hub height	55m (180')	50m (164')	49m (160')
Rotor diameter	54m	51.5m	30m
Installed cost	$1.60m	$1.72m	$0.82m
Annual production at RSD	1384 MWHr	1196 MWHr	318MWHr
% of site elec provided : { pre site upgrade: / post site upgrade:	41% / 23%	37% / 20%	14% / 5%
LIPA wind subsidy received	0	0	$170k
Asset loan repaid at: { 5% energy inflation: / 10% energy inflation:	11 yrs / 10 yrs	13 yrs / 12 yrs	14 yrs / 11 yrs
Revenue per year	$250k	$220k	$70k
Project NPV at 6% discount rate	$2.26m	$1.60m	$1.78m
Project IRR	29%	24%	28%
CO_2 saved over project life (25 yrs)	18,000 tons	15,600 tons	4,158 tons

- Wind turbines in the 750KW range are financially viable for the RSD site and can make a significant contribution to site energy usage, both before and after the planned site upgrade. Small scale turbines in the sub-500KW range suffer from exponentially diminishing returns in terms of electricity generated, although the LIPA wind rebate program does make them financially viable on this site.
- The US built Aeronautical Norwin 54-750KW wind turbine generator performed the best in the RSD wind resource and economic model developed by NPL.
- RSD does not have a high grade wind resource, but current estimates show it is viable for a large wind turbine. Further measurement of wind resource is essential to narrow the margins of error of the financial model, and ensure that predicted levels of electricity generation, and therefore payback on investment, are achieved.
- Further negotiations with LIPA are required to establish what feed-in tariff would be paid for electricity exported from the site and to negotiate the exact terms of the Power Purchase Agreement.
- The development of the RSD wind turbine would benefit from being linked to the planned site upgrade, so that the former does not suffer financially from a delay in the increase in on-site electricity demand.
- Further financial modeling must continue to take a conservative view of the future cost of electricity from LIPA, but continue to plan on the basis that energy costs will continue to rise steadily and significantly over the next 25 years.

Civil & Structural Engineering

- Geotechnical conditions at the site are likely to be suitable for the installation of the wind turbine.
- A soil boring must be carried out at the selected turbine location before a foundation design can be completed
- It is likely that a spread footing foundation will be suitable, whilst use of a more cost effective Patrick & Henderson design may become an option at implementation, depending on confirmed geotechnical conditions.

Electrical & Control Engineering

- The RSD electrical infrastructure is suitable for the addition of a large wind turbine generator, given LIPA grid connection requirements.
- Further work will be required during the project implementation phase to finalize electrical design.

3. Project Constraints

Introduction

The suitable areas for location of a wind turbine on a given site are constrained by many factors, the most obvious being site boundaries, buildings and operations. Roads, railways, overhead electrical conductors and similar structures are usually subject to setback regulations, as are environmental constraints such as waterways or protected habitat areas. These regulations vary between jurisdictions and may be interpreted in different ways by local planning authorities. Most constraints are related to the specification of the wind turbine, for example overall height or noise level, whilst others are imposed as standard setback distances.

Many constraints are defined as part of the design process. For example, some areas may be unsuitable for wind turbine foundations for geotechnical reasons, whilst others may have too high a surface gradient or be inaccessible to installation vehicles. The process of defining and refining constraints is important both to ascertain project feasibility and to inform the turbine selection process.

Mapping, survey drawings, topographic information, aerial photography and other GIS data were used extensively during the course of the feasibility study. Some of these materials and derived information are reproduced in part in this report. These data were obtained from the US Geological Survey (2), the Long Island Power Authority (3), the New York State Geographic Information Systems Clearinghouse (4), the USDA Natural Resources Conservation Service's Web Soil Survey (5), the New York State Office of Parks, Recreation & Historic Preservation (6) and the Riverhead Sewer District's Engineers, H2M P.C. (7), amongst others.

Proposed wind turbine locations

Two potential wind turbine locations were identified during the site visit. The first is at the north of the site, on a mound near a large processing tank. The second location is at the south-west of the site in a less elevated position approximately 75m along a track into the woodland area. These two locations are shown in Figure 3.1.

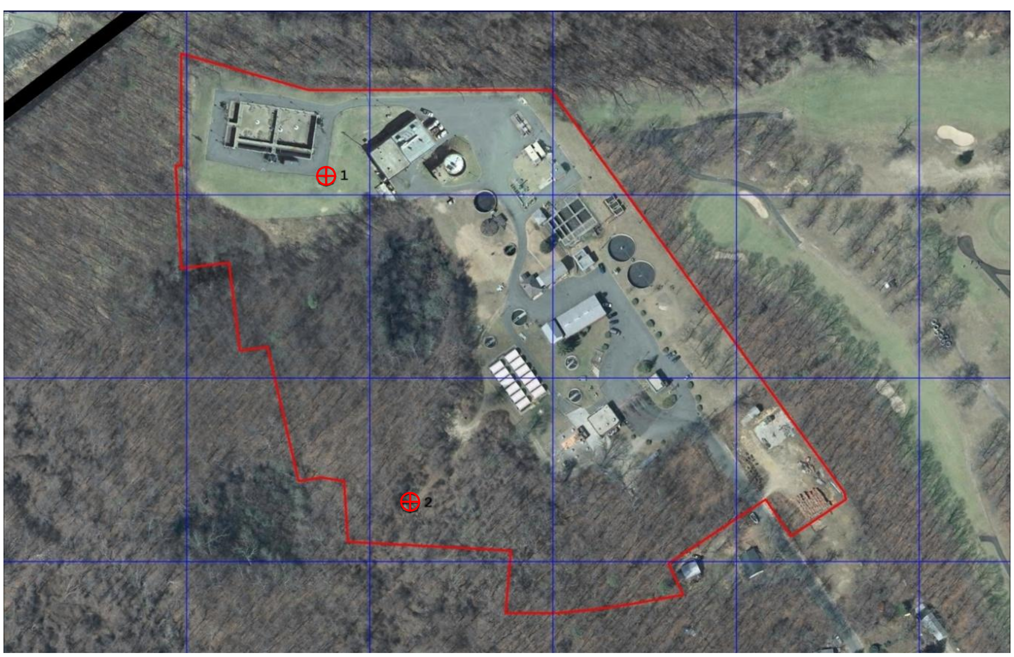


Figure 3.1: Identified turbine locations and site boundary

Site boundary

The site boundary is well defined both physically (by a chain fence) and in town mapping resources. The boundary was digitized based on drawings provided by the Town's Engineer (7) and is shown in Figure 3.1. The land parcels located immediately to the west and south of the RSD site are owned by the Town of Riverhead and protected from development in perpetuity (8). These parcels are currently subject to a residential zoning designation, however their protected status means that residential development will not be allowed. The protected area is shown in Figure 3.2.

The applicable boundary constraint for the RSD site is based on a "topple setback" (a setback based on the maximum tip height of the wind turbine blades). The Riverhead Town Code (9) provides a setback definition of total system height plus 10' for wind energy systems with hub heights of up to 120'. Representatives of the Town of Riverhead Planning Department (8) suggested that a proportionally similar setback would be appropriate for a turbine of up to 300' overall height at this location. It was confirmed that such a setback from the adjacent Town of Riverhead protected land would not be required, subject to the installation of an appropriate fence on the relevant land parcels to restrict public access within the topple radius. Based on this information, the conservative boundary constraint for feasibility purposes will be a setback of tip height plus 10m (33' (10m), applied at all boundaries except that with the Town of Riverhead protected land.

This constraint effectively precludes the use of the first proposed location to the north of the site, as this location is only 150'(45m) from the northern site boundary. The resulting 115' (35m) tip height restriction is insufficient for installation of a wind turbine of significant production capacity, at a sufficient height above the surrounding woodland. Further consideration will therefore focus on the southerly turbine location.

Land transport & aviation

A setback of tip height plus 33' (10m) will also be applied for land transport routes, including off-site roads and railroads, to ensure that safety concerns are minimized. Aviation constraints can only be determined as a result of the FAA aviation impact study, for which the application details will be based on the outcome of the feasibility study. The resulting constraint will be a determined "no effect height", corresponding to the maximum allowable overall system height which is judged to be acceptable given local aviation activities.

Land designation & Zoning

The land occupied by the RSD site is zoned for residential use. In discussions, Town of Riverhead planning officials (8) confirmed that installation of a wind turbine installation on this land would be deemed acceptable use, so long as the project is designed to supply energy to serve the municipal site load and not to operate as a significant exporter of energy. The resulting constraint is therefore that the turbine rating should be matched to the expected electrical load on-site. Due to the variable nature of the site load and the power generated by a wind turbine, the optimum generator rating may in fact exceed the expected average site load, but the balance between power consumed on site and power exported should be reasonable and justifiable.

Regulatory and planning requirements

The Riverhead Town Code (10) imposes a night-time limit of 50dBA on the sound level caused at the boundary of any neighboring property which is zoned for residential use. Discussions with the Town of Riverhead Planning Department (8) suggested that it would not be deemed necessary to enforce this constraint with respect to the Town of Riverhead protected land parcels to the west and south, as these areas will never be developed, regardless of their zoning status. Town officials were therefore content that the resulting noise constraint of 50dBA does not need to be applied to this Town of Riverhead protected land, although it would be preferable if this limit were respected.

There is no existing local ordinance regarding shadow flicker, however the Town of Riverhead Planning Department indicated that excessive shadow flicker effects on receptors in the area should be avoided. Aside from nearby residences, the tee and green areas of the golf course immediately to the east of the RSD site were identified as shadow flicker receptors to be considered. A requirement to minimize the shadow flicker events resulting from the installation of a wind turbine at the RSD site can therefore be considered as a project constraint.

A third factor raised in discussion with the Town of Riverhead authorities was visual impact. Whilst visual impact in the area is difficult to determine accurately due to the extensive woodland coverage, it was agreed that an estimate of the Zone of Visual Influence (ZVI) would be useful and relevant in determining the likely impact of the project. Whilst not strictly a constraint, the ZVI extent should be minimized in the location and selection of a wind turbine for the site.

The subject of ecological impact was discussed with the Town of Riverhead Planning Department (8). No significant single-species impact was thought to be likely, and the Department's opinion was that a detailed ecological impact study or specific species studies would be unnecessary for a project of this type. It was confirmed that projects of similar scope in nearby areas have been completed successfully, with minimal or no requirement for an ecological impact study. Consequently, it is unlikely that ecological constraints represent a significant factor for the project. It is, however, recommended that a general ecology study be commissioned during project implementation.

The only significant environmental constraint raised by the Town of Riverhead Planning Department concerned the wetland areas present on and nearby the RSD site. Both the Town of Riverhead and Suffolk County have imposed restrictions on development in proximity to these protected wetland areas. It was advised that a State setback of 100 feet from the wetland areas would be mandatory for any wind turbine project, with the Town's "Regulated Wetlands" setback of 150 feet preferred. Figure 3.3 shows the wetland areas and the mandatory 100 feet setback, as digitized on the basis of existing site survey drawings and aerial photography. An updated survey of the extent of the wetland areas will be required at the project implementation stage to confirm compliance.

Neighboring residential & business property

There are several residential areas near the site. The first consists of a number of trailers to the north across the railroad. There are also a number of houses to the south and south-east. The only residential properties directly adjacent to the site are to the south-east by the gate on River Ave. The residences within 500m (550 yards) of the southern wind turbine location are shown in Figure 3.4. (One grid square is equal to 1 Km^2). The dense cluster of residences to the north is treated as a unit, with properties at the boundary selected for noise and shadow flicker analysis; if significant impacts are indicated in this area then further investigation will be undertaken.

The primary constraint related to nearby residential property is noise level, with shadow flicker as a secondary consideration. Significant impacts from either factor are unlikely to occur at a distance of more than 500m (550 yards) from the proposed wind turbine, therefore the residential locations identified within this radius will be those initially considered for feasibility purposes.

There are three main business properties near the RSD site. The first is the Suffolk County Golf Course immediately neighboring the site to the east. The second is a small office/commercial complex approximately 360m (400 yards) to the north-west of the likely turbine location, and the third is a small yacht club approximately 330m to the south.

The constraints considered at residential properties are noise level, particularly in comparison to ambient night-time noise levels in the area, and shadow flicker events in the early morning and late evening. The primary relevant constraints for commercial properties are daytime noise levels and shadow flicker events during daytime hours.

Figure 3.2: Extent of shared boundary with Town of Riverhead protected land area

Figure 3.3: Wetland areas, showing 100' setback constraint

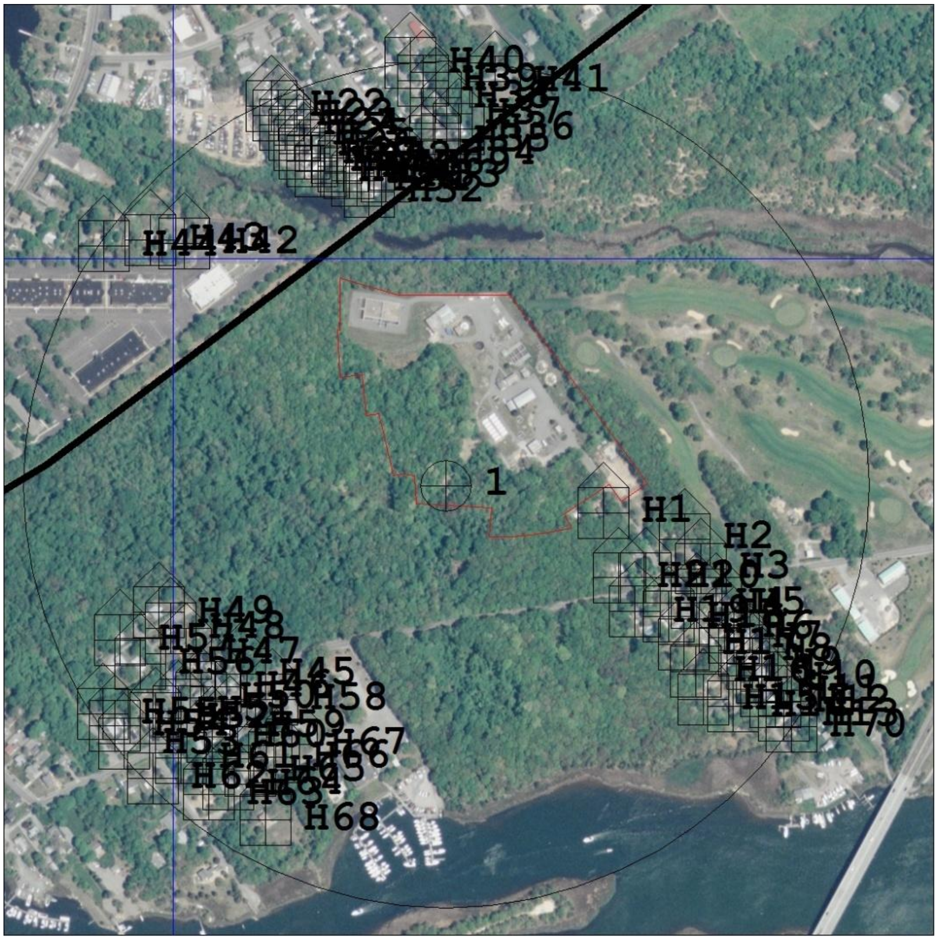


Figure 3.4: Residential locations within 500m (550 yards) of turbine position

Grid connection and construction

A suitable grid interconnection point exists at the RSD site, as discussed in the section on Electrical Engineering. No significant obstruction to grid interconnection has been identified and installation of the necessary conductors and switchgear on site appears to be feasible. A "topple height" setback of tip height plus 10m (33') will also be applied to existing electrical conductors and LIPA hardware serving the site, as indicated by LIPA technical representatives (3).

An initial site survey identified no fundamental impediments to the installation of a wind turbine at the site. The proposed turbine location is on level, undisturbed ground, significantly above the water table and of apparently similar bearing capacity to the developed site area. There is ample space for construction activities and crane pads, although clearing of several trees may be necessary. Access to the location is via a straight unsurfaced track from the main site roadway.

Operational constraints and site integration

The existing buildings and equipment present at the RSD site are visible in Figure 3.2. Large processing tanks make up the majority of installed equipment, with several small buildings and sheds housing the site office and workshop as well as blowers, pumps, control and monitoring panels and other equipment. These installations run across the northern and eastern edges of the site, leaving a large undeveloped and lightly wooded area to the south-west. There appear to be a large number of underground pipes transporting wastewater around the site.

Asphalt surfaced roads, parking and maneuvering areas provide access to all major buildings and equipment, with several large areas available for parking and storage of vehicles and equipment. Overhead electrical cables run from the gate at the south-east of the site along the eastern and northern boundaries.

A major upgrade to the facility is planned over the next 2 years, in order to increase capacity and meet new regulatory requirements. The upgrade, however, will not involve the construction of new buildings or processing tanks; all new equipment will be contained within the existing facilities. The site layout will therefore remain as it exists, whilst significant increases in personnel and traffic on the site are not expected.

Following an initial site survey and discussion of site operations, it is assessed that the presence of a wind turbine generator at the proposed location is unlikely to have a significant impact on site operations. Normal traffic on the site is not significant in the area of the proposed turbine location, being mainly restricted to tanker vehicles which unload at the ramp behind the site office near the main gate. Operation of a wind turbine generates little traffic, mainly restricted to maintenance visits by up to 3 technicians in a small service vehicle for 1 to 2 days every 6 months.

Construction activities would result in minimal direct operational impact to the RSD site, as the proposed turbine location is some 75m from the existing operational areas. Installation equipment and turbine components such as blade and tower sections during construction can likely be held temporarily in the asphalt surfaced area in the north-east of the site. Alternatively, these components can be stored in the open area beside the track in the wooded south-west part of the site. Some clearing of trees will be necessary for storage and crane and vehicle access, but the extent of this requirement will depend on the foundation and turbine type selected.

During the construction period of around 6 weeks, a significant increase in traffic can be expected as equipment, vehicles and turbine components are transported to the site. Turbine components are likely to require up to 5 long loads for blades and tower sections plus another large vehicle carrying the nacelle. The installation crane and other construction equipment are likely to amount to over 30 additional large vehicles accessing the site. Turbine blades and tower components are extremely long loads and maneuvering these into and around the site can be difficult and time consuming. A preliminary examination of the site access and layout indicates that loads of up to 25m in length can be successfully maneuvered from the site entrance to the proposed turbine location; installation of turbines with greater than 50m rotor diameter may be more difficult, requiring temporary widening of the site access and possible removal of obstructions. Similarly, the junction of Riverside Drive and River Ave may prove difficult to negotiate if the selected turbine's blades are greater than 25m in length.

Another consideration is the weight of some of the construction vehicles. The implementation phase of the project will require investigation of the risk of crushing to the existing pipe network transporting wastewater around the site, and specification of any necessary temporary reinforcement or bridging work.

The proposed turbine location in the undeveloped area of the site results in minimal difficulty in micrositing. The primary considerations are likely to be accessibility, noise constraints and setbacks; existing site equipment and operations will have little impact on micrositing at this location.

Installation of electrical equipment can be expected to have a significant impact on site operations, as the main grid connection to the site must be disconnected for a short time to allow work to be completed. However, the impact can be minimized by careful scheduling with respect to site activities. Installation of a new conductor between the site transformer and the wind turbine will affect access as the conductor must cross the site; however the low level of traffic to the northern area of the site indicates that the impact of this work will be minimal and brief.

It is assessed that a detailed integration strategy will not be required for installation of a wind turbine at the RSD site. The separation between the operational area and the proposed turbine location, the low level of site traffic and the minimal construction work required in the main site area indicate that site operations need not be interrupted to allow construction and operation of a wind turbine.

However, construction activities and vehicle access should be carefully scheduled with site management to ensure minimal impact on operational activities. In addition, a full analysis will be required to ensure that all components of the selected wind turbine model can be transported to the desired location within the constraints of the existing road junctions and site layout.

Conclusion

A number of factors constrain the selection and siting of a suitable wind turbine generator for installation at the Riverhead Sewer District site. One consequence is the determination that the northern of the two proposed locations is unsuitable for any machine over 115' (35m) due to a required "topple height" setback from the site boundary. However, the remaining location appears suitable for a range of appropriate wind turbine models.

Site integration is expected to be straightforward, with no interruption of operations at the RSD site required. The most likely source of difficulty is the negotiation of tight junctions and existing site buildings and equipment by the vehicles transporting large wind turbine components. It is likely that loads of up to 25m in length can be successfully delivered; wind turbines with rotor diameters significantly in excess of 50m may require work to widen junctions or roads nearby and within the site.

4. Planning & Permitting

Introduction

The range of permits and permissions required for implementation of a wind energy project vary greatly from one project to another. National and local regulations govern the acceptable extent of human impacts such as sound level, shadow flicker and visual impact. Most large projects are required to submit an extensive pack of studies and reports for review and approval by local residents and a board of planning officials. Electrical, structural and mechanical codes influence technical design details, whilst potential impacts on aviation and telecommunications are often of some concern. Archaeology and cultural heritage impacts can cause delays during implementation; therefore some investigation during the feasibility stage is often advisable.

Ecological impacts are another major topic of interest, with environmental and single species studies sometimes required for large projects. Fortunately smaller projects are rarely subject to the same level of scrutiny; however it is good practice to ensure that all pertinent issues are understood and addressed as soon as possible.

Discussion with Town of Riverhead Planning Department

The Planning Director and Environmental Planner met with the consultant and Sewer District Superintendent on the 28th January 2010 (8). The meeting was very positive and the Planning Department showed support and enthusiasm for the project.

It was made clear that there will be few requirements for formal planning permissions or permits for a small wind project at the RSD site, where the purpose is clearly to supply an on-site load. The Department felt that such a project falls well within the scope of justified supporting activities for the Sewer District processing operations. It was suggested that an expectation of significant export capacity beyond the level of justifiable overspill could lead to questions over the purpose and acceptability of the project. However, this is not a cause for concern as the LIPA tariff, upgraded site load and maximum generator rating make significant export revenue unlikely.

The Department suggested that the project should satisfy the State Environmental Quality Review (SEQR) process through submission of the Short Environmental Assessment Form (EAF) rather than a Full EAF. The project will submit any relevant studies, reports and supporting material as attachments. In the case that submission of a Full EAF were necessary, such documents would be submitted as a response to Section D - “Informational Detail”.

The Department advised that no extensive ecological impact or 12-month single species studies would be required, but cautioned that the project would be subject to strict setback constraints relating to protected wetland areas within and neighboring the RSD site. In detail, there exists a State mandated 100ft setback which would be strictly enforced. In addition, the Town of Riverhead defines a 150ft setback, but the Department advised that this would not be strictly enforced in the case of an otherwise responsible project. It was stressed that an accurate, updated survey would be required during project implementation as the wetland areas have been known to move over time.

There was some discussion regarding an area of land directly to the south-west and west of the RSD site which is owned by the Town and protected from development in perpetuity. This area remains zoned as residential land for administrative reasons, although it is not possible for residential activity to be extended into the area. The Department advised that the “topple height” radius of a wind turbine could be allowed to extend onto this land, provided that a fence is installed to prevent human entry to the area within the radius and that the base and foundations of the wind turbine are located completely on the Sewer District site. The Department also advised that the standard Town of Riverhead Noise Ordinance relating to residentially zoned land would not necessarily be enforced in the case of these protected land parcels since they are not available for residential development. However, despite the generous allowances made for the project, compliance in such matters would be preferred.

Several study topics were suggested by the consultant and taken up by the Planning Department representatives. Specifically of interest were the topics of Noise, Shadow Flicker and Visual Impact. It was agreed that further assessment of these factors would be desirable as part of the feasibility process.

Archaeology and Cultural Heritage

The Planning Department advised that a Cultural Heritage impact study would not be required for a small wind turbine project at the Sewer District site. The Department representatives were unable to suggest any known evidence regarding the potential for archeological impact in the RSD site area.

A map of archeologically sensitive areas in the vicinity was obtained from the New York State Office of Parks, Recreation & Historic Preservation's State Historic Preservation Office (SHPO) (6), an extract of which is shown in Figure 4.1.

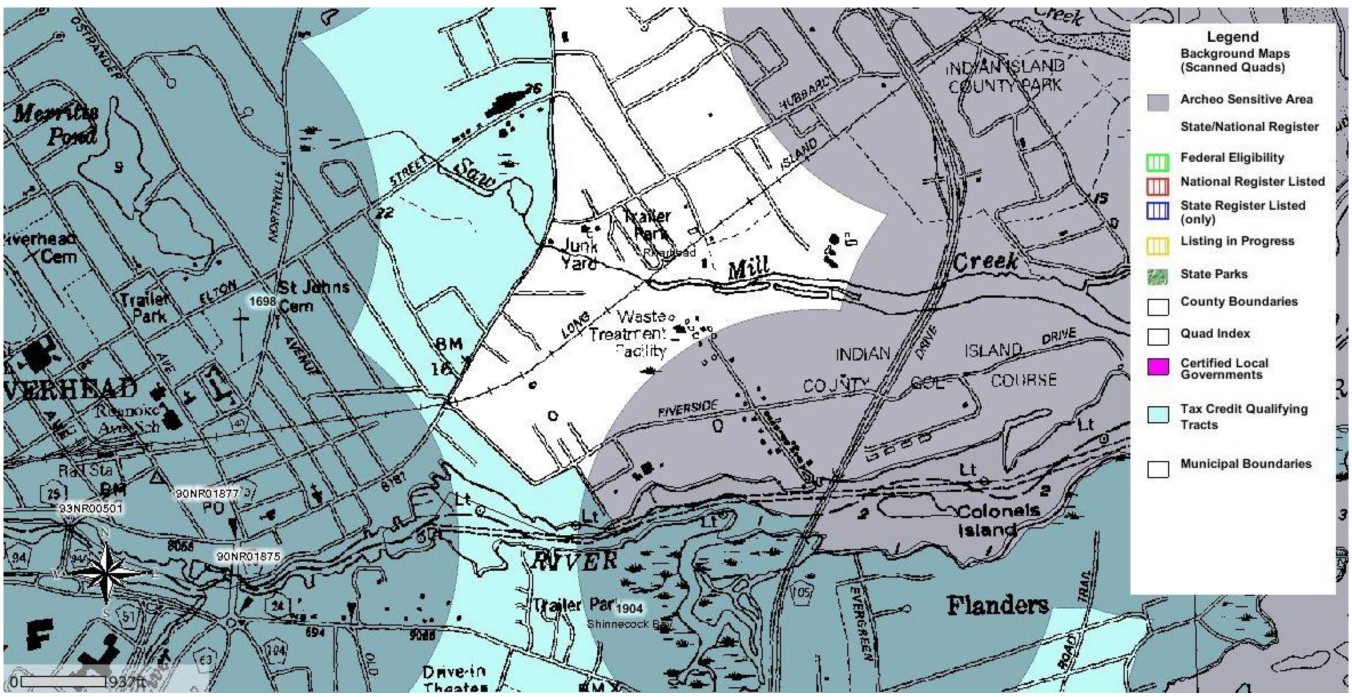


Figure 4.1: Archeologically sensitive areas

The proposed wind turbine location appears to lie at the edge of a marked sensitive area according to the SHPO map. It is therefore possible that some significant archeological feature may be encountered in the course of project implementation. However, the small footprint of a wind turbine base and foundation means that such an encounter remains unlikely. It may be wise to seek the advice of an expert on local archeology during project implementation but this factor does not represent a significant risk at the feasibility stage.

Shadow Flicker

As suggested during discussion with representatives of the Town of Riverhead Planning Department, an investigation was conducted into the potential for occurrence of the “shadow flicker” phenomenon in the Riverhead Sewer District area.

The shadow flicker effect arises when shadows cast by a turbine rotor in motion fall on the position of an observer. The effect occurs inside buildings and is produced when the rotating blade casts a shadow across a narrow aperture such as a window or door, such that the light passing into the aperture can be seen to “flicker” with the passage of each turbine blade (11).

Shadow flicker & health risks

The most common concern regarding shadow flicker relates to possible health risks to individuals suffering from epilepsy and related conditions.

Approximately 0.5% of the population suffer from epilepsy, with approximately 0.025% suffering from photo-sensitive epilepsy. Less than 5% of these (or 0.00125% of the population) are sensitive to the lowest range of frequencies, around 2.5 to 3Hz. The remaining photo-sensitive epileptics are only sensitive to higher frequencies <ref>. There is therefore some risk to around one person in 80,000 from flickering light at a frequency of 2.5Hz. There is no history of epileptic sensitivity to frequencies below 2.5Hz (11).

A typical wind turbine of the larger class suitable for installation at the Riverhead Sewer District site is the Norwin 54-750, manufactured by Aeronautica Windpower, LLC. This machine uses a 3-bladed rotor with a maximum rotational frequency of 26rpm (12). The maximum flicker frequency of a shadow cast by this machine is therefore 78rpm, or 1.3Hz. Since the threshold for posing a risk to health is 2.5Hz, the frequency of any flicker cast from such a wind turbine will be below the risk threshold by a factor of 1.9, and therefore pose no risk to health.

Shadow flicker may not represent a health risk; however it can constitute a significant nuisance under certain circumstances. Shadow flicker events tend to occur in the early morning and late evening, particularly in winter when the sun appears low in the sky. Fortunately, morning events rarely coincide with waking hours and usually pass unnoticed, but evening events can cause nuisance at residential properties.

Turbine & receptor layout

The turbine used for the shadow flicker calculations is the Aeronautica Norwin 54-750. The rotor diameter of this turbine is 54m and the hub height used is 55m (12).

The turbine location used for the calculations is 698324E, 4532763N using the World Geodetic System 1984, Universal Transverse Mercator coordinate system, zone 18 North (UTM WGS 84 Zone 18N). The project layout defines 67 potential receptor locations, all of which will be considered in the shadow flicker calculations. These locations are representative of all residential areas in close proximity to the wind turbine location. In addition, receptors have been defined to consider two tee and green locations on the golf course adjacent to the eastern boundary of the RSD site. These details are shown in Figure 4.2.

Figure 4.2: Potential shadow flicker receptors in the RSD site area

Calculation Method

The shadow flicker calculation takes each building and turbine location in turn, calculating the number of hours per year when the turbine's shadow might fall on the building given the known motion of the sun relative to the turbine location for a representative year.

This calculation is necessarily conservative, resulting in a "worst case" figure for the layout. This is because it calculates all possible times during a year when there exists the **potential** for shadow flicker to be apparent to an observer at the receptor point. In practice, the effect will only be produced if the following conditions are also satisfied at the time of each potential event:

- <u>The effects of shadow flicker are significant at the position of the building</u>. Shadow flicker effects are generally assumed to be insignificant at distances of more than 10 rotor diameters from the turbine (11). Beyond this distance the observer's position cannot fall within the umbra of the blade shadow. Consequently, shadow effects rapidly become insignificant at around 10 diameters distance.

- The weather is relatively cloudless, ie. clear enough for distinct shadows to be cast by the turbine blades. In practice, the annual mean daylight cloud cover recorded for this location is 59.8% (13), therefore overcast conditions represent more than half of daylight hours in the area.
- The wind speed is high enough to cause the turbine rotor to rotate. At speeds below 3m/s the wind turbine blades do not move. Wind resource analysis indicates that these conditions occur approximately 22% of the time in this location.
- The shadow flicker effect is apparent given the size and location of the building's windows. The analysis tests for any possibility of shadow flicker over a relatively large area at the location of each receptor. In reality the effect is likely to be strongly dependent on the size, location and orientation of windows at the property.
- The turbine is running (ie. not stopped or paused) at the time of the potential event. Turbines rarely operate for 100% of any given month, for various operational reasons. Typically a turbine will pause for 15 minutes every day in order to operate the yaw system to untangle internal cabling. This activity may be scheduled to take place during sunrise or sunset hours to prevent potential shadow flicker events. In addition, turbines can be programmed to automatically pause during periods when irritating shadow flicker effects are likely to occur.
- The orientation of the turbine rotor is such that a shadow is cast across the building. The shadow flicker calculations assume a rotor orientation perpendicular to the shadow direction for each building. This orientation is a worst-case scenario which maximizes the affected area. In reality this orientation is unlikely at any given time. The affected area is therefore likely to be reduced and may not include the building.
- There is no obstruction blocking the passage of light from the sun to the building via the turbine rotor. Fixed objects such as trees or other buildings may mask the observer from the shadow flicker effect, but such objects are not considered in the calculations. In a wooded area such as that surrounding the RSD site, tree cover is likely to significantly reduce any shadow flicker effects.

Calculation Parameters

The shadow flicker calculation requires the specification of a number of parameters. These include information identifying the location of the wind farm relative to the sun as well as settings governing the extent of the effects to be considered. The maximum radius around each turbine at which shadows have been calculated is 540m. Beyond this range flicker effects are unlikely to be significant. The calculation is performed for all cases where the solar elevation exceeds 2°, since the sunlight intensity is great enough to cast strong shadows once the sun has risen above this level. These parameters represent a conservative scenario for shadow flicker, and may identify many potential events which are unlikely to occur in practice.

Results

A shadow flicker map of the RSD site area was calculated, and is shown in Figure 4.4. A summary of the shadow flicker calculation results is listed below.

House	Easting	Northing	Days per year	Max hours per day	Mean hours per day	Total hours
5	698509	4532701	108	1.09	0.94	101.3
6	698559	4532624	25	0.36	0.28	7.0
8	698605	4532670	112	0.77	0.60	67.2
9	698624	4532635	88	0.71	0.61	53.4
12	698619	4532593	38	0.46	0.37	14.0
13	698642	4532593	56	0.61	0.50	28.0
14	698652	4532564	22	0.27	0.21	4.7
33	698013	4533018	77	0.53	0.49	37.5
34	697973	4533022	86	0.54	0.42	36.3
35	697918	4533015	57	0.50	0.38	21.7
36	697983	4532582	26	0.32	0.25	6.6
45	697937	4532549	3	0.04	0.03	0.1
65	698490	4532888	129	1.00	0.80	102.7
66	698422	4532946	41	0.60	0.49	20.0

Of the 67 receptors considered, 53 register no potential shadow flicker events even using conservative parameters. The remaining 14 locations register some degree of shadow using this model. 9 of these receptors experience minimal shadow flicker impact; for example, potential events at locations H36 and H45 occur for less than 7 hours per year between the times of 4:46 and 4:55am, and therefore it is highly unlikely that any effect would be noticed.

The locations with a significant potential for shadow flicker effect are those residences located on River Avenue to the south-east of the turbine location and the golf green immediately adjacent to the eastern site boundary. The most extensively affected residence is receptor H5, with 101.3 hours of potential shadow flicker events per year, equal to approximately 1.15% of the period. A shadow flicker event graph for this receptor is shown in Figure 4.3.

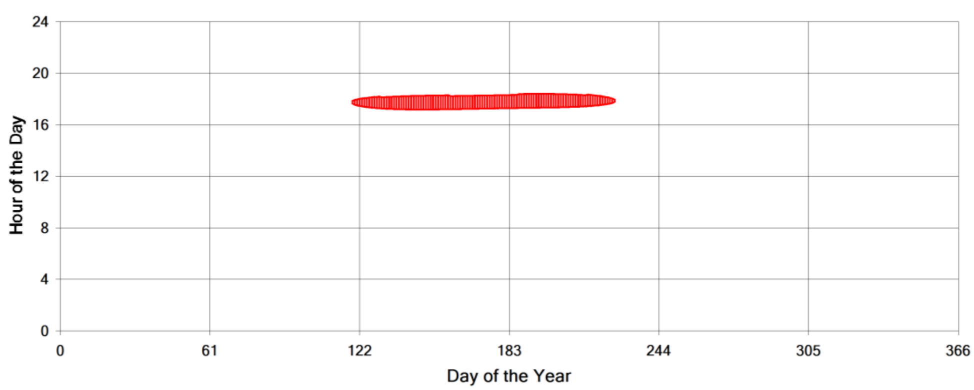


Figure 4.3: Shadow flicker event graph for receptor H5

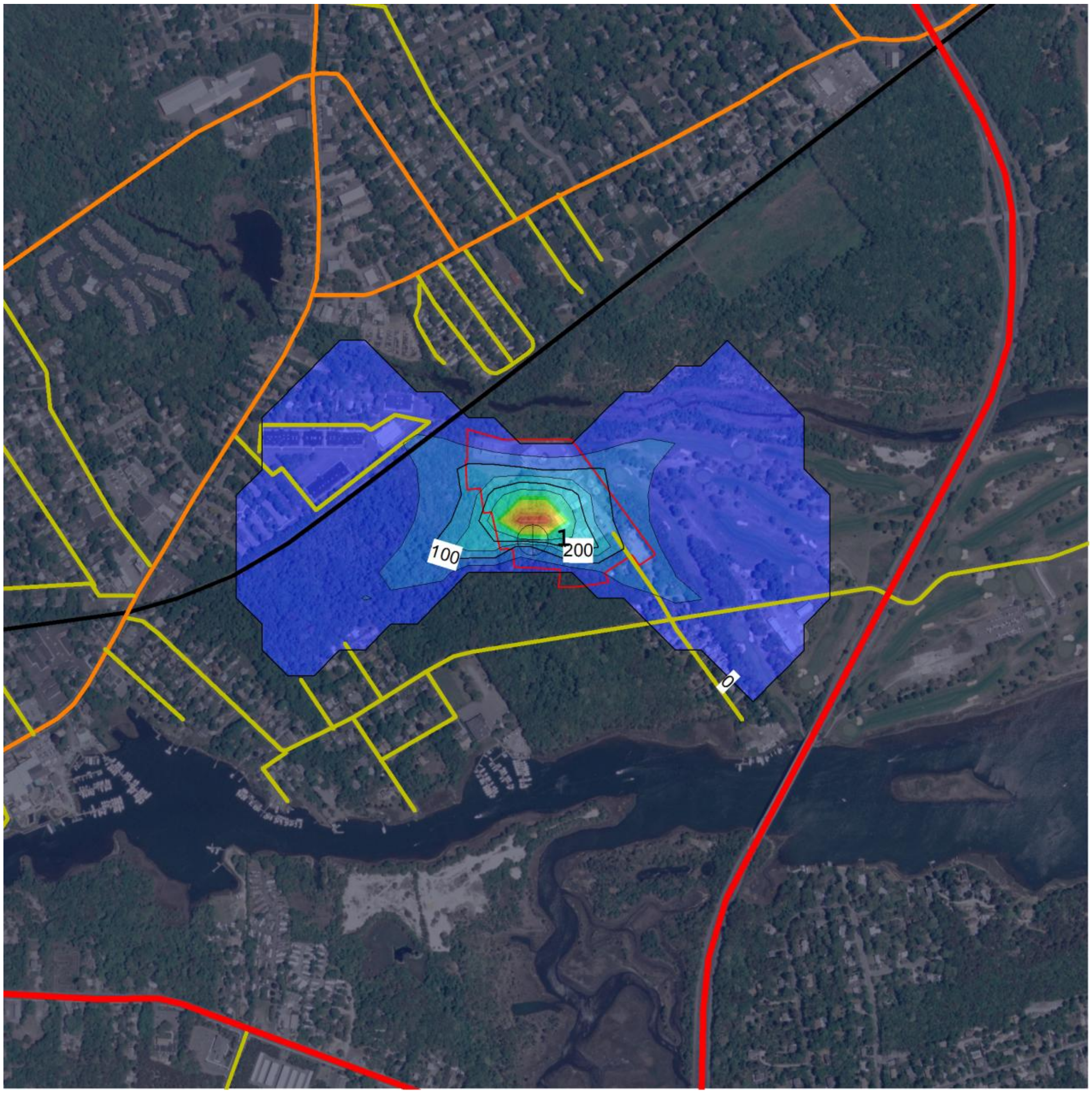


Figure 4.4: Shadow flicker contour map of the RSD site area (hours per year)

As shown in the graph, the potential shadow flicker events at the locations to the south-east of the turbine location occur during the summer months when the surrounding woodland leaf cover is likely to prevent any noticeable shadow flicker at the residences. Additionally, this is the least windy time of year, when the turbine is likely to be least active. However, it is possible that the residences at locations H5, H8, H9 and H13 may experience occasional flicker events despite the attenuating factors. If such effects become apparent it may be necessary to schedule turbine pause events or install a remote pause control at the affected residence. These mitigation techniques will allow flicker events to be avoided when necessary, and are likely to have minimal effect on turbine yield due to the rare occurrence of flicker events and low wind resource during the summer months.

Similar techniques may be used to mitigate flicker effects at the golf course to the east, however screening of sensitive areas using several dense hedges or trees is often a simpler and equally effective approach.

Turbine noise & sound propagation

As noted in the discussion of site constraints, the Town Code imposes limits of 50dBA during the night and 65dBA during the day on the pressure level of sound caused at the property line of any property zoned for residential use or within a noise-sensitive zone (10).

Wind turbines generate noise for two main reasons; aerodynamic noise is caused by the wind passing over the turbine rotor blades and mechanical noise is caused by rotating components, particularly the high speed components in the gearbox and generator (14). Older wind turbine designs using high speed generators typically generate high sound power levels near the nacelle, whilst modern turbines with low speed generators and no gearbox are much quieter.

Aerodynamic noise is usually greater in intensity, particularly at high wind speeds. However, it is also usually masked by other noises attendant to high wind speeds, particularly in wooded areas. Because of this and the fact that aerodynamic noise has a broadband frequency profile, it usually causes little disturbance to nearby residents. Mechanical noise, whilst less intense, is usually more tonal and as a result can cause more annoyance to nearby residents.

A common method used for modeling sound levels in the vicinity of wind turbine generators is known as the "Danish Model" (15). This model is sufficiently accurate over short distances and when only a broadband sound power level figure is available for the wind turbine in question. Where higher accuracy at longer distances is required and detailed octave band sound power level data are available from the turbine manufacturer, the standard ISO 9613-2 1996 'Attenuation of sound during propagation outdoors' provides a suitable method (16). An octave band study is necessary if tonal qualities are to be modeled. Completion of a thorough study based on the ISO standard would be advisable early in the project implementation phase when turbine supply terms are defined and precise adjustments to the turbine specification can be made, as octave band data for the selected turbine model will be available at this point.

The noise calculations were based on the Norwin 54-750 wind turbine, manufactured by Aeronautica Windpower, LLC, identified as typical of the turbine type likely to be selected for the site. A broadband reference sound power level figure of 100dB at the turbine nacelle was provided by the manufacturer. This published level corresponds to a wind speed of 8m/s. It is estimated, based on the available wind resource data for the area, that the hub height wind speed at the Riverhead Sewer District site exceeds 8m/s approximately 21.6% of the time. The wind speed is expected to exceed 10m/s approximately 9.8% of the time. In practice, it is highly unlikely that turbine-generated noise would be noticeable at wind speeds above 10m/s due to ambient wind noise, particularly given the wooded nature of the area surrounding the RSD site.

Based on this information, a wind speed of 10m/s was chosen for analysis and the turbine sound power level adjusted accordingly. A calculation based on the Danish Model was completed, and a sound pressure level contour map produced as shown in Figure 4.5. As indicated on the contour map, the calculated sound pressure level at the nearest residential property is 48dBA. This indicates that the municipal noise limit for the nearest residential property boundaries will not be exceeded. In addition, the acoustically "soft" wooded nature of the turbine location and receptor locations would normally be expected to result in a further attenuation of 3dBA in sound pressure levels; this effect was not included in the modeling process in order to maintain a conservative scenario.

A sound pressure level of up to 55dBA is calculated at the boundary with Town of Riverhead protected land to the West. This is likely to be acceptable as discussed in the site constraints definition, however if necessary it is likely that sound levels at this boundary can also be reduced to 50dBA by making slight adjustments to turbine location and configuration, particularly considering the additional likely attenuation due to the surrounding woodland.

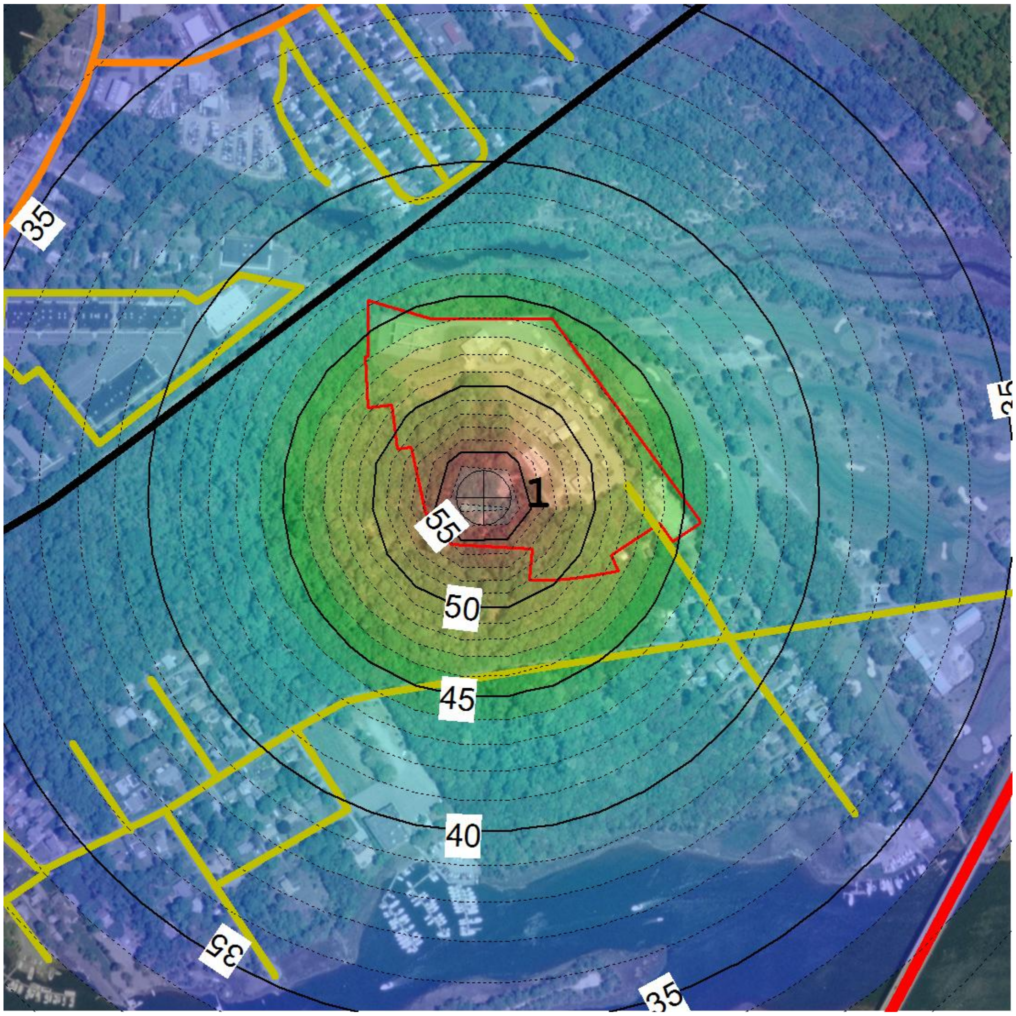


Figure 4.5: Sound pressure level contour map (broadband dBA)

FCC Registered communications

The Federal Communications Commission (FCC) Licensing database (17) was used to investigate the existing transmitter equipment in the vicinity of the RSD site. 11 FCC-registered transmitter towers were identified, ranging from 134 to 304 feet in height. 18 unregistered towers were also identified from the database, ranging from 10 to 140 feet in height. It was unfortunately not possible to determine which, if any, of these devices were part of a point-to-point microwave link of the type which might be disrupted by the installation of a wind turbine rotor. If necessary a more developed consultation may be possible during the project implementation phase, however it did not appear that any of the tall towers identified are located close enough to the proposed wind turbine site to be at major risk of signal interference.

FAA Aviation Study

The Code of Federal Regulations, Title 14 Part 77 requires that the FAA conduct an aeronautical study to determine the impact of any construction or alteration meeting any of several criteria including those listed below (18):

- any construction or alteration exceeding 200 ft above ground level
- any construction or alteration:
    - within 20,000 ft of a public use or military airport which exceeds a 100:1 surface from any point on the runway of each airport with at least one runway more than 3,200 ft
    - within 10,000 ft of a public use or military airport which exceeds a 50:1 surface from any point on the runway of each airport with its longest runway no more than 3,200 ft
    - within 5,000 ft of a public use heliport which exceeds a 25:1 surface

A wind turbine project at the Riverhead Sewer District site is certain to meet at least one of the filing criteria, therefore a proposal will have to be filed with the FAA for analysis. After submission, proposals are inspected by up to eight different Air Traffic Divisions. Their responses are considered along with airport and airspace traffic patterns and the regional Wind Turbine Airspace Specialist determines the impact of the project. The response issued will include either a Determination of No Hazard (DNH) or a Notice of Presumed Hazard (NPH), in which case a "No Effect Height" will be specified along with details of the affected systems or services in the airspace. The normal period from filing to determination is 45 to 60 days (19).

The FAA provides dedicated staff to process proposals and assess the aviation impacts of wind energy projects. The Air Traffic Wind Turbine contacts for New York State are:

Michael Blaich, Specialist	mike.blaich@faa.gov	(404) 305-7081
Angelique Lestrad, Technician	angelique.m.lestrad@faa.gov	(718) 553-2611
Chris Cody, Backup Technician	chris.cody@faa.gov	(404) 305-7083

A preliminary screening exercise was carried out to determine if a wind turbine project located at the Riverhead Sewer District site would be likely to impact on any of the following:

- Air Defense and Homeland Security Radar (Long Range Radar)
- Weather Surveillance Radar
- Military Operations

The screening exercise indicated that the project would be highly likely to have an impact on Long Range Radar due to Line of Sight coverage in the area.

Weather Radar Line of Sight (RLOS) coverage is present at or below 130m above ground level (mAGL) at the proposed turbine location, therefore impact on Weather Surveillance Radar operations was estimated to be likely and notification of the National Telecommunications & Information Administration (NTIA) was advised.

No likely impacts on military airspace or operations were identified. Further confirmation and clarification of any issues may be obtained from the following military Regional Environmental Coordinators if this becomes necessary during the assessment process.

David Brentzel	(USAF)	(404) 562-4211
Anthony M. Parisi, PE	(USN)	(805) 989-9209
LTC Jeff Mowery	(USA)	(404) 305-6915
Mr. Paul Friday	(USMC)	(910) 322-2128 / 449-9791

The Riverhead Sewer District was registered with the FAA as a project Sponsor, with Michael Reichel, Sewer District Superintendent, as the primary point of contact. According to FAA procedures, the Sponsor must be the organization with ultimate responsibility for the construction or alteration activities detailed in the proposal. The FAA proposal was filed on the 7th April 2010 with the project reference **RIVER-000143646-10** and the FAA Aeronautical Study Number (ASN) **2010-WTE-4905-OE**. The application was reviewed, accepted and forwarded for analysis on the 21st April, with results expected in four to six weeks. The submitted location map is shown in Figure 4.6 and summary details of the FAA application are shown in Figure 4.7.

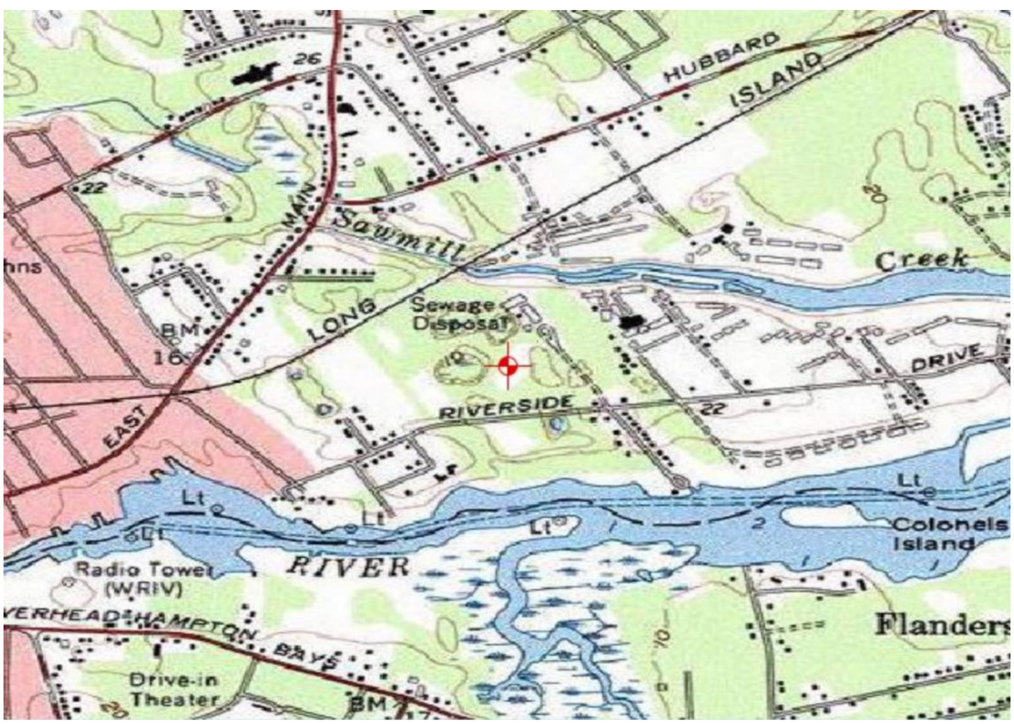


Figure 4.6: FAA proposal project location map

Federal Aviation Administration

« OE/AAA

Notice of Proposed Construction or Alteration - Off Airport

Project Name: RIVER-000143646-10 **Sponsor:** Riverhead Sewer District

Details for Case : Riverhead Sewer District Wind Turbine

Show Project Summary

Case Status

ASN:	2010-WTE-4905-OE
Status:	Accepted
Date Accepted:	04/07/2010
Date Determined:	
Letters:	None
Documents:	None

Construction / Alteration Information

Notice Of:	Construction
Duration:	Permanent
***if Temporary* :**	Months: Days:
Work Schedule - Start:	
Work Schedule - End:	
State Filing:	

Structure Summary

Structure Type:	Wind Turbine
Structure Name:	Riverhead Sewer District Wind Turbine
FCC Number:	
Prior ASN:	

Structure Details

Latitude:	40° 55' 18.28" N
Longitude:	72° 38' 40.70" W
Horizontal Datum:	NAD83
Site Elevation (SE):	24 (nearest foot)
Structure Height (AGL):	302 (nearest foot)
Requested Marking/Lighting:	White Paint/Synchronized Red Lights
***Other* :**	
Recommended Marking/Lighting:	
Current Marking/Lighting:	N/A New Structure
***Other* :**	
Nearest City:	Riverhead
Nearest State:	New York
Description of Location:	Turbine to be installed in a small clearing in light woodland, in undeveloped SW area of site. Site is a water treatment works with several buildings and large processing tanks at Sponsor's address.
Description of Proposal:	The largest considered turbine has a 54m (177ft) rotor diameter and a hub height of 65m (213ft). The overall tip height is 302ft. Several smaller wind turbine options (from approx. 200ft) may be available if necessary to comply with a determined No Effect Height.

Common Frequency Bands

Low Freq	High Freq	Freq Unit	ERP	ERP Unit

Specific Frequencies

Figure 4.7: FAA proposal filing details

Visual impact & Zone of Visual Influence

The visual impact of a wind energy project is usually one of the more significant factors in its impact on the surrounding area. Many wind turbines are considered interesting and even elegant features, but some projects have been accused of causing a detrimental impact on local scenery. Single wind turbine installations usually fall into the former category, whilst large sprawling wind farms can be at risk of becoming a visual nuisance.

A calculation was conducted to determine the Zone of Visual Influence (ZVI) of a wind turbine installed at the proposed location. The chosen model was the Norwin 54-750, a model representative of the largest turbine likely to be selected for the site. The calculation models the theoretical visibility of the wind turbine from ground level, based on the turbine geometry and the supplied topographic data. The calculation was conducted to a radius of 4km from the turbine location, since such a machine is unlikely to be noticeable beyond this distance unless sought out. The results are shown in Figure 4.8.

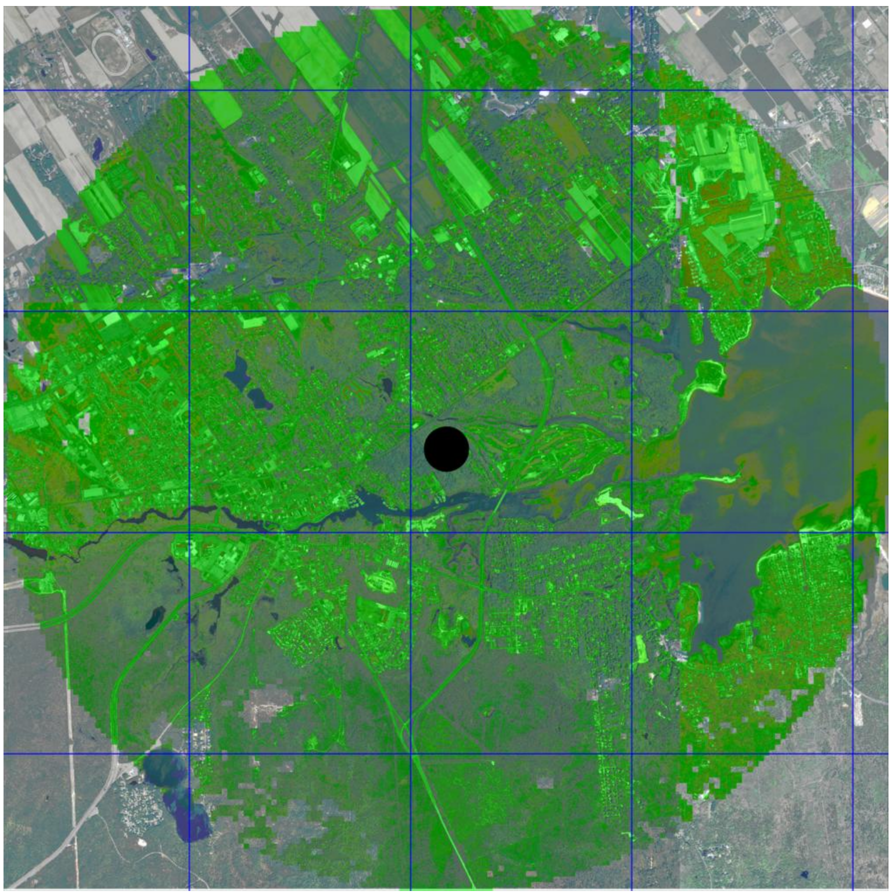


Figure 4.8: Zone of Visual Influence calculation results

As shown, the results indicate that such a wind turbine would be visible from almost every location within the calculated region. This is because the area is extremely flat, with visibility over long distances. However, in reality the ZVI would be much more restricted due to the extensive woodland throughout the area, a factor ignored in the calculation due to the difficulty in modeling such an effect. It is likely that such a turbine would be visible from open or locally elevated areas within this region, but would be hidden from most locations by buildings, woodland and treelines.

When supply of a particular turbine model is secured, the visual impact may be better investigated by generating rendered photomontages based on various viewpoints nearby the RSD site.

Conclusion

A meeting with the Town of Riverhead's Planning Department representatives indicated that project permitting requirements will be minimal, environmental review straightforward and that few planning studies will be required. Several important constraints were discussed along with their application to the project, and form an input to the definition of site design constraints. The scope of study and assessment focuses mainly on human impact, with shadow flicker, noise and visual impact being important factors.

Noise and shadow flicker effects were investigated and found to be within acceptable limits, with effective mitigation strategies available for potential impacts. Visual impact proved difficult to assess accurately due to the combination of extremely flat terrain and extensive distribution of obstructions such as woodland and buildings. It is likely that actual visibility will be quite low, however a more accurate assessment should be made using a photomontage rendering approach during project implementation once the geometry of the selected wind turbine model is known.

Communications impact appears to be low, however there remains scope for further assessment of point-to-point microwave transmission links if the necessary data can be acquired.

Representative project design envelope details were submitted to the FAA for assessment, and forwarded for analysis following review.

5. Wind Resource

Introduction

Assessment of the wind resource at a prospective wind turbine site is a complex process involving several stages of data collection, modeling and statistical analysis. Ideally it is best to undertake a high quality meteorological monitoring campaign at the turbine location and at hub height for a period of at least 12 months. If this can be successfully undertaken it is possible to accurately both the likely performance of any given wind turbine at the site and the corresponding uncertainty levels in the yield estimate; however in many cases this approach is prohibitively expensive or problematic.

Various other resources and methods can be employed to better understand the local wind resource characteristics where on-site anemometry is unavailable. Site surveys, local reference data, existing wind resource mapping and various types of wind flow modeling can provide an estimate of long-term wind characteristics. This is the approach that has been taken with this feasibility study and this section of the report details the results of these activities.

Site Survey

A site survey was conducted in January 2010, with the following points noted which are relevant to a wind resource assessment:

- To the south and west the site is bounded by deciduous woodland, to a height of 33' to 50' (10 to 15m) and to a distance of 200 to 300m.
- Several large areas of open water lie to the south and south-east where the Peconic River runs some 300m south of the site boundary.
- To the east the site boundary is wooded for a distance of 33' to 100' (10 to 30m). Beyond this lies a golf course, consisting mainly of open fairway obstructed by patches of light woodland. The open areas' typical width is 3 to 10 times obstruction height.
- There are several small buildings to the south-east, consisting mainly of residential property of less than 15m height at a distance of approximately 200m amongst the surrounding woodland. Several larger buildings are located at the golf course, approximately 400m from the site.
- The site is bounded by a small creek to the north, beyond which is more woodland to the north-east. The creek is crossed by a railroad 75m to the north of the site boundary, beyond which is a residential area at 120m from the boundary and approximately 350m from the proposed turbine location. The buildings in this area are predominantly less than 10m in height.
- The site is bounded by the railroad to the north-west. Beyond this is a commercial and office development with several large buildings from approximately 125m from the site boundary, separated by car parking space.
- Beginning 200 to 350m from the site's western boundary are more residential and commercial areas, with Riverhead's town center approximately 1km to the west of the site.
- No "flagging" of vegetation was observed at the site, nor were there other visual indicators of a Class I or II wind regime.
- The terrain in the area around the site is relatively flat and uniform. Complex terrain effects such as large scale laminar detachment regions, negative shear or vertical flow are unlikely even at high

wind speeds. There are no topographic features likely to have a significant localized influence on wind speed or selection of an optimum turbine location within the site.

The site's immediate surroundings and the nearby railroad route are shown in the aerial photograph in Figure 5.1.

Figure 5.1: Aerial photograph of the RSD site surroundings and railroad route

Surface roughness characteristics

The site and its surroundings in all directions are populated by obstacles of approximately 10-15m height. The effective plan area density of these obstacles exceeds 20% for some distance in all directions, therefore mutual sheltering will lead to "skimming" flow and a dominant boundary layer regime based on a "virtual ground" surface located approximately 10m above ground level (9).

The surface features observed during the site visit and in the available aerial photography of the site are representative of a characteristic boundary layer roughness length of approximately 1m. This figure corresponds to a determination of a Class 7 or marginal Class 6-7 rating on the reference Revised Davenport roughness classification scale (9). The variation in horizontal wind speed with height above ground level is known as the wind shear profile. There are two generally accepted mathematical models for wind shear; the first is known as the "logarithmic profile" and is derived from the fluid mechanics principle of viscosity applied to the case of turbulent boundary layer flow. The parameter relating to surface roughness is the "roughness length," designated z_0 and measured in meters. The second model, known as the "power law" profile, is purely empirically based and widely used thanks to its simplicity. The roughness parameter in the power law model is the exponent, α. In practice, both models are accurate enough to be confidently used (20).

The site and its surroundings in all directions are populated by obstacles, mainly forest, of approximately 10-15m height. The effective plan area density of these obstacles exceeds 20% for some distance in all directions, therefore mutual sheltering will lead to "skimming" flow and a dominant boundary layer regime based on a "zero-plane displacement height" (or "virtual ground") surface (*d*) located approximately 10m above ground level (21).

The surface features observed during the site visit and in the available aerial photography of the site are representative of a characteristic boundary layer roughness length (z_0) of approximately 1m. This figure corresponds to a determination of a Class 7 or marginal Class 6-7 rating on the well-validated Revised Davenport roughness classification scale (21). The uncertainty related to this determination corresponds to a maximum error of +/- 6% in calculated wind speed.

There are many alternative models for wind flow near and across forested areas, some of which are quite complex. However, the Garratt-Dolman (22) (23) and Jarvis-Hicks (22) (24) models have been found to perform most accurately in modeling forested areas where the frontal area index and leaf area index have not been accurately determined (25). For an area densely populated with obstructions of 10-15m, parameter values of d=10m and z_0=1m agree well with both models.

In winter when the deciduous woodland becomes more porous, the effective displacement height is likely to decrease slightly. Some corresponding variation in roughness length is probable, but these effects are unlikely to significantly change the determined roughness class.

Wind resource maps

The majority of wind resource mapping in the USA is provided by AWS Truewind LLC of Albany, NY, a leading provider of mesoscale and microscale wind flow models and resource assessment services. Their models are well validated and trusted in the industry for site selection purposes.

Most of AWS Truewind's resource-mapping products are derived from a 200m resolution dataset covering most of the continental USA and Canada. These data are based on the output from MesoMap, a proprietary hybrid mesoscale-microscale wind flow model developed and validated in-house over several years. The model compares favorably with other industry standard wind flow modeling tools.

Two different mapping products are available for the Riverhead Sewer District site.

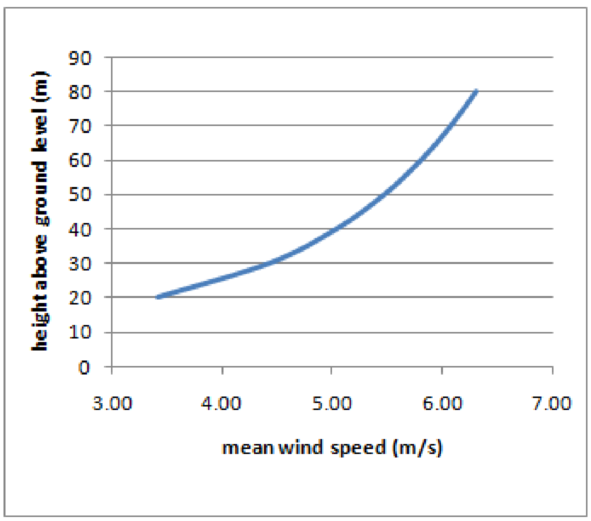
- The AWS Truewind WindNavigator service (26) provides a wind resource map at 2.5km resolution covering most of the USA and Canada. The 2.5km dataset is generated by averaging the values of the 200m dataset for each grid node, and exhibits a standard error of 0.75m/s. The mean annual wind speed values given by this database for the RSD site location are given in the following table:

Height AGL (m)	10	20	30	40	50	60	70	80
Wind speed (m/s)	3.42	4.27	4.86	5.33	5.73	6.07	6.34	6.59

- LIPA provides wind resource map produced by AWS Truewind and funded by NYSERDA which shows the modeled 200m resolution wind speed values for the Long Island area at a height of 100 feet (30.5m) above ground level (27). The resource grid for the RSD location shows a value of approximately 5.25m/s, with a standard error of 0.35m/s.

The wind shear profile given in the WindNavigator data above represents a power law profile with exponent α=0.3155. This corresponds to a roughness length of 1m, the same value determined during the wind resource survey.

Correcting this distribution according to the "virtual ground" level determined during the site survey allows a site-specific estimate of mean annual wind speed at a given height. Applying this model to the figure given by the high-resolution LIPA/AWS Truewind wind resource map gives the wind shear profile shown in Figure 5.2.



Height (m)	Wind speed (m/s)
80	6.31
70	6.08
60	5.81
50	5.48
40	5.05
30	4.44
20	3.42

Figure 5.2: Wind shear profile based on resource mapping data

Reference data

There are few meteorological reference stations near the Riverhead Sewer District site. The closest suitably reliable station is the Westhampton Beach station at Francis S Gabreski Airport, approximately 8km from the proposed wind turbine location.

Hourly weather data covering a ten year period at the Westhampton Beach station were obtained and processed (28). 106,004 records were returned, screened and inspected, of which 77,859 were judged to be valid and complete. Most of the rejected records were duplicated, corrupted or additional to the hourly dataset. The original data fields were converted to standard units and subjected to bounds checking and a basic statistical screening to identify the necessary processing parameters. Finally, the valid data were imported and analyzed using several proprietary and custom software tools.

Airport met stations only record wind speed at one height; therefore it was not possible to investigate the shear profile at this location. The significant features of the dataset are shown in Figure 5.3 and Figure 5.4.

The mean annual wind speed at the reference station over the 10 year period was 2.8 m/s. Whilst this is not cause for concern as regards the wind resource at the RSD site (airport met stations typically use instruments installed at a maximum of 10m above ground level), it is clear that the wind regime experienced by the sensors is not representative of an unimpeded, high-level wind flow.

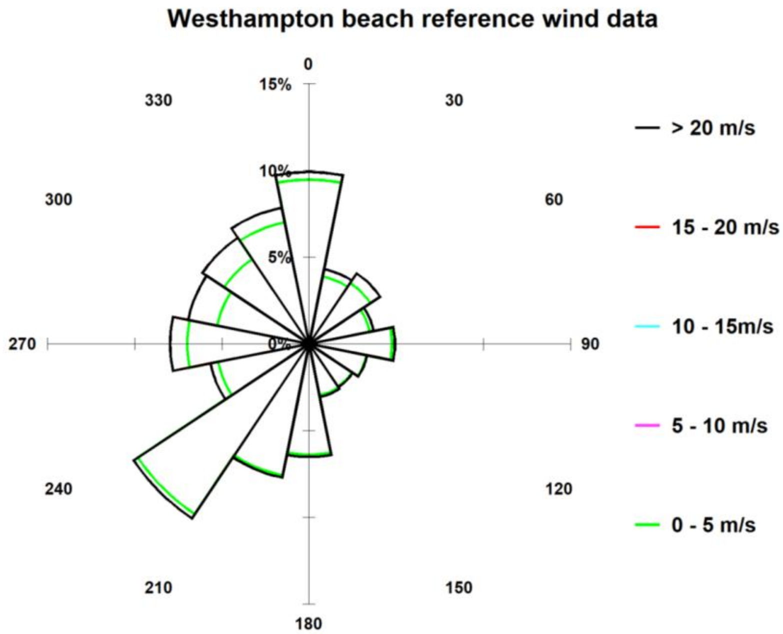


Figure 5.3: Westhampton Beach reference station wind rose

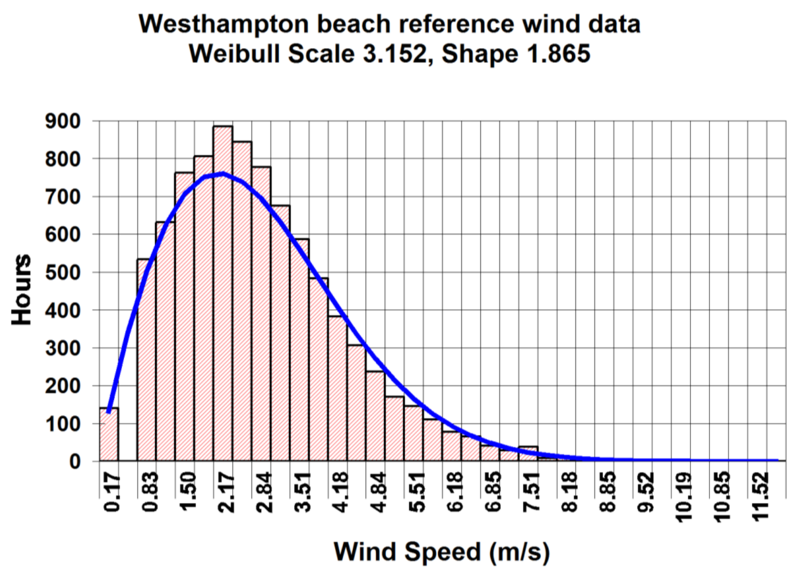


Figure 5.4: Westhampton Beach reference station wind speed distribution

The relative locations of the proposed wind turbine (marked 1) and the reference station (marked A1) are shown in Figure 5.5, along with a section of the LIPA/AWS Truewind wind resource map for Long Island.

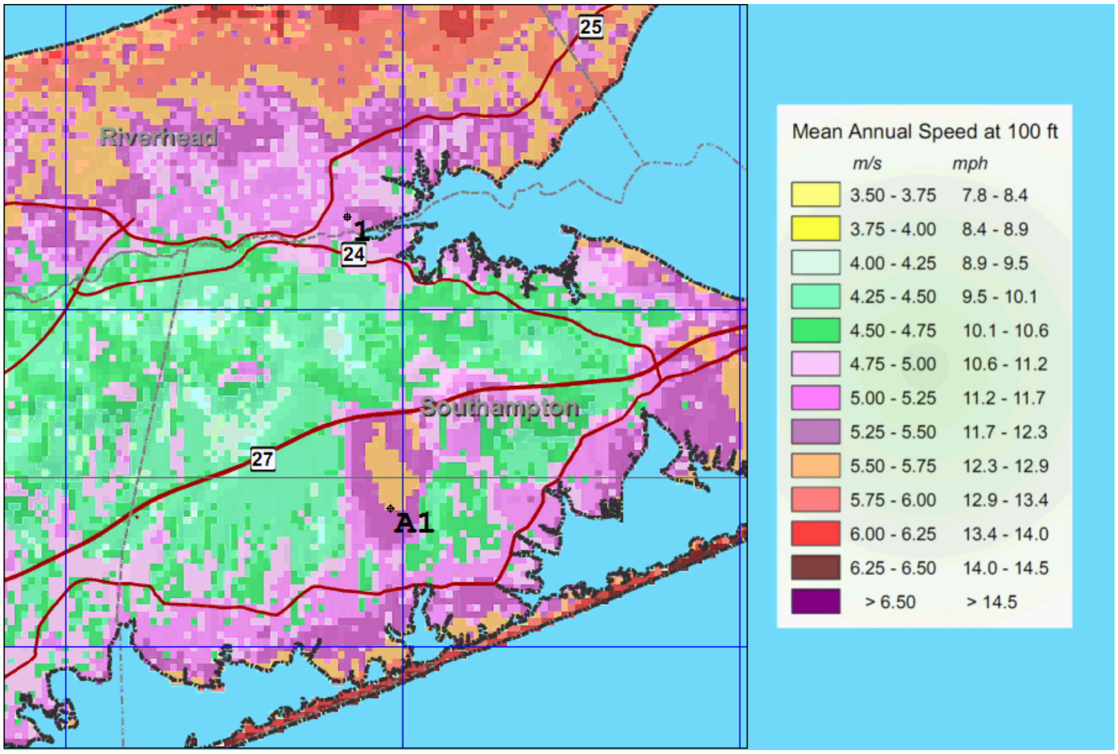


Figure 5.5: Long Island wind atlas, showing locations of reference station (A1) and RSD site (1)

The MS-Micro wind flow model was used to calculate relative wind speeds across the area around the reference station and the RSD site, based on high-resolution topographic data and a basic surface roughness model; the results are shown in Figure 5.6. This calculation indicates that mean wind speeds at the reference station are approximately 15% higher than at the proposed turbine location. The wind atlas suggests values of approximately 5.50m/s at the reference station and 5.25m/s at the RSD site, a 5% difference. The wind atlas model is rather more suitable than MS-Micro for modeling wind regimes over such a large area and is known to have passed validation at many locations in New York State, therefore it is likely to give the more accurate result. However, it is possible that surface roughness effects in the Riverhead area lead to lower mean wind speeds at the RSD site than those predicted by the wind atlas.

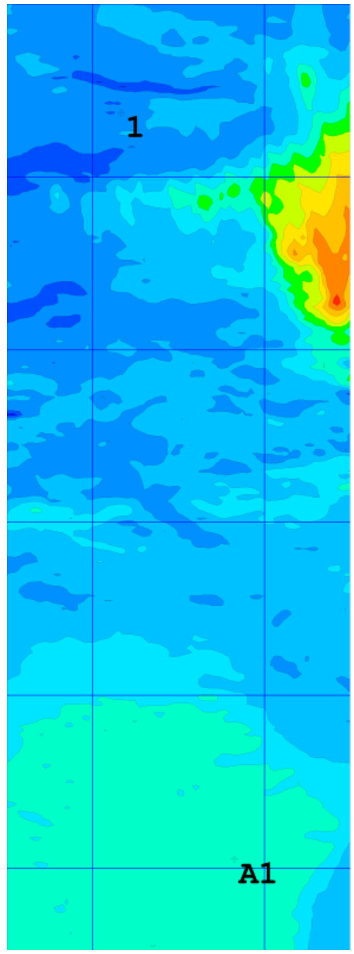


Figure 5.6: Calculated relative wind speed between reference station and turbine site

Defining a wind speed distribution model for the Riverhead Sewer District site

Wind speed distributions are typically modeled using a Weibull distribution (a parametric curve that closely resembles the distributions of many natural phenomena). The wind speed distribution at the reference station can be modeled by a Weibull curve with scale factor 3.152 and shape factor 1.865, as shown in Figure 5.4. As the RSD site is likely to experience the same general weather patterns as the reference station, the shape factor of the wind speed distributions at the two locations are likely to be similar.

Given the available information as detailed above, estimated wind regime models for the RSD site will be based on the mean annual wind speed published in the high-resolution resource map. This will be corrected to hub height using the shear profile conforming to both the site survey results and AWS Truewind's resource model. The shape of the wind speed frequency distribution will be derived from the weather data recorded at the Westhampton Beach weather station.

Also based on the weather record from the reference station between March 2001 and March 2010, the mean recorded temperature was 11°C (52°F), the mean atmospheric pressure was 102kPa, the mean relative humidity was 78% and the mean air density was 0.99kg/m^3.

To illustrate the results given by a model formulated on this basis, an expected wind speed distribution for a height of 50m at the proposed wind turbine location is shown in Figure 5.7. This represents a mean expected (P50) result, in that actual measured values can be expected to exceed the given values with a confidence of 50%.

The combined standard error in wind speed associated with this model was calculated as approximately 7.82%. A wind shear profile for the P90 case (values which the mean wind speed can be expected to exceed with a confidence of 90%) can be calculated as shown in Figure 5.8. A corresponding P90 50m wind speed distribution is shown in Figure 5.9.

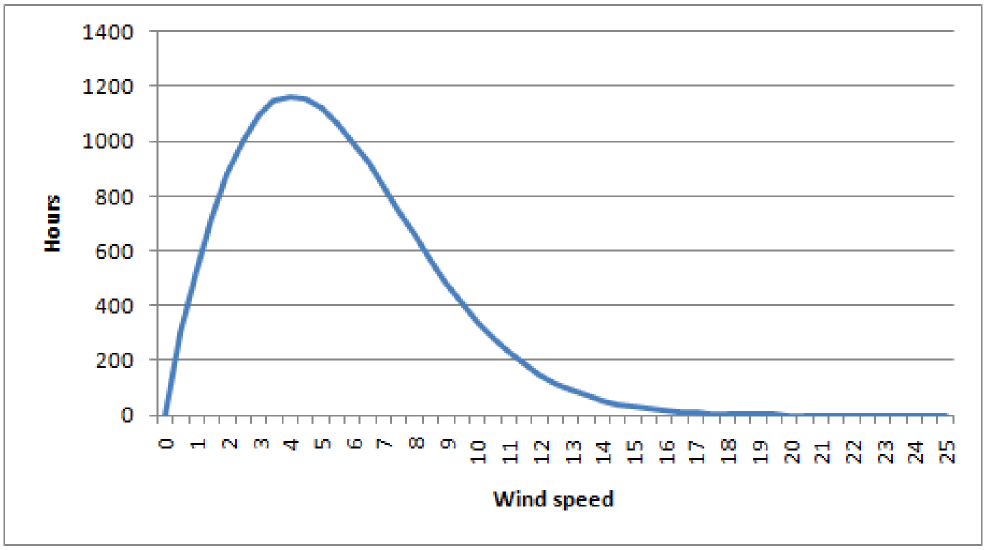
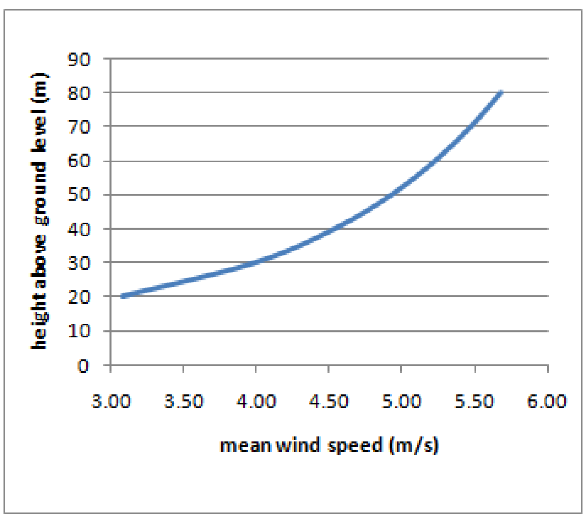


Figure 5.7: Estimated P50 wind regime at 50m above ground level



Height (m)	Wind speed (m/s)
80	5.68
70	5.47
60	5.23
50	4.93
40	4.54
30	4.00
20	3.08

Figure 5.8: Estimated P90 wind shear profile at the RSD site

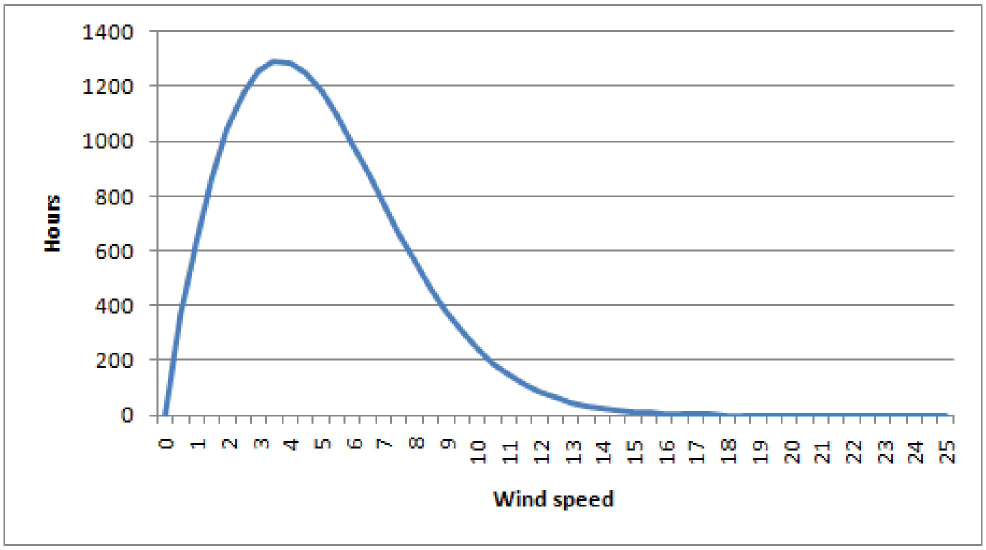


Figure 5.9: Estimated P90 wind regime at 50m above ground level

Conclusion & Recommendations

Using site survey results, wind resource atlases, wind flow modeling and local meteorological reference data, it was possible to estimate a vertical shear profile and annual wind speed distribution for the Riverhead Sewer District site. These distributions provide a wind resource model suitable for use in estimating wind turbine yield and the economic performance of the proposed project.

It was also possible to estimate the uncertainty in the calculated wind model based on the characteristic error distributions of the source data and methods. A corresponding P90 model could then be calculated, allowing a measure of financial risk to be considered in the economic modeling.

On the basis of the wind resource model, the resource at the Riverhead Sewer District site is likely to be sufficient for a low wind speed turbine model to perform economically. However, the uncertainties resulting from a lack of on-site anemometry lead to a significant level of uncertainty. It is therefore recommended that an anemometry campaign should be conducted at the site in order to obtain reliable resource data.

A sample specification for a high quality meteorological monitoring mast of 40m maximum measurement height is given in Appendix B. This tubular steel, guy wire-supported mast is compliant with IEC standards and wind industry best practice for anemometry equipment design and configuration. Ideally a mast of 60m would be deployed, but the limited open ground available at the RSD site precludes this option. A 40m mast will provide a good understanding of shear and turbulence effects amongst the woodland and other obstacles in and around the site and allow wind resource and economic assessments to be made with high levels of confidence.

6. Turbine Selection

Introduction

Many factors are considered when selecting an appropriate wind turbine for a proposed location. Once the machines currently available are identified, they must be assessed on the basis of technical suitability, performance, bankability (the level of financing risk involved) and compliance with site constraints. The main parameters used when selecting a suitable turbine for the Riverhead Sewer District site are summarized below:

- Maximum grid connection capacity – discussions with LIPA (3) indicate that the maximum export capacity of the RSD grid interconnect is 1000kVA. The maximum rating of a wind turbine to be installed at the site should therefore be around 950kVA (ie a sub-MW capacity machine).
- Sewer District site load – the purpose of the proposed wind turbine is to supply the on-site load, rather than to export power. The wind turbine should therefore be specified to match the anticipated site power requirements.
- Power quality requirements – discussions with LIPA (3) indicate that interconnect costs will be minimized where the selected turbine employs full range AC-DC-AC power conversion. An advanced asynchronous machine with grid protection features and power quality management represents a minimum requirement. Other types of generator are likely to be rejected or to result in high interconnect costs.
- Funding availability – the only clear option for project implementation subsidy is the LIPA "Wind Rebate" Program (29). This program offers a significant contribution towards the cost of installing a wind turbine generator at municipal sites, but mandates the use of a machine from a published "Approved wind systems" list (30). There are few machines on the list which could contribute significantly towards the power requirements at the site and of these only two are currently available.
- Site constraints – the various factors constraining turbine location at the site restrict the list of appropriate machines, mainly due to overall height or noise level. These constraints are often a function of the specification of the machine.
- Wind resource – the specific characteristics of the site wind speed distribution, vertical wind shear, turbulence, etc. are likely to suit some wind turbines better than others. Whilst an understanding of the site's wind resource is uncertain in the absence of measured data, general characteristics can be determined from physical observations, modeling and reference data.
- Project risk – a wind turbine is generally not considered "bankable" (representing low investment risk) until machines of the type have been shown to have a good record of performing to warranted standards and low operating and maintenance costs over a long operating period. It is generally accepted that only large organizations with significant financial and legal resources should install new or early production machines. Similarly, legal enforcement of product warranties and other agreements is more straightforward where USA- and European-based manufacturers are concerned.

The current loading parameters for the site's main grid connection were determined from the Riverhead Sewer District's historical electric utility statements (31). These documents suggest that the site currently operates at a relatively steady electrical load of approximately 260kW. However, a major upgrade to the facility is currently planned. Once the upgrade is complete, the site is expected to operate at a steady load of up to 1004.6kW, with an estimated average load of 665kW as calculated by the Town's Engineers (32) (33).

Given LIPA's advised maximum grid export capacity of 1000kVA and the site loading figures above, it was determined that appropriate wind generators for the site should have a maximum rating of 950kVA. With an expected 665kW average site load after the planned upgrade, a generator rating of at least 300kVA should be employed if the project is to result in a significant reduction in site power costs, and therefore prove economically viable.

Model Review and Shortlist

A model review was conducted and an initial list of wind turbine models was produced for consideration, subject to a minimum rating of 300kVA and a maximum rating of 950kVA. Also included were two smaller machines approved by LIPA for the "Wind Rebate" program, as this subsidy is likely to improve the relative economic performance of these options and they therefore represent a useful comparison.

The full list of considered models includes 139 wind turbines currently thought to be available either new or remanufactured, and is shown in Appendix A. Following attempts to contact the manufacturers it was determined that 118 of these machines are either no longer available or currently unavailable for delivery in the USA. Of the remaining 21 machines, two are unlikely to be suitable for the site due to excessive blade length and one is unsuitable due to excessive overall height. Seven machines were rejected for bankability reasons, leaving the eleven models listed below.

Manufacturer	Model	Rated Power (kW)	Rotor Diameter (m)	Specific rating (kW/m^2)
Northern Power Systems	North Wind 100	100	21	0.289
Aeronautica Wind	Norwin 54-750	750	54	0.327
Turbowinds	T600-48	600	48	0.332
Wind Energy Solutions	WES 30	250	30	0.354
EWT	DW 750 / 51.5	750	51.5	0.360
EWT	DW 900 / 54	900	54	0.393
Vestas	V52/850	850	52	0.400
EWT	DW 900 / 51.5	900	51.5	0.432
Aeronautica Wind	Norwin 47-750	750	47	0.432
Turbowinds	T400-34	400	34	0.441
Windflow	Windflow 500	500	36	0.491

Wind turbine shortlist showing low (highlighted) and high wind speed turbines

The six wind turbines with specific ratings of more than 0.37kW/m^2 are suited to sites with high power density and wind speed. The low mean wind speeds available at the Riverhead Sewer District site are likely to be well suited to the five highlighted models with specific ratings below 0.37kW/m^2.

Performance assessment

Technical details were requested from the turbine manufacturers and used to estimate the performance of these wind turbines via simulations carried out on the wind resource model for the RSD site. Performance specifications were not supplied by Turbowinds for the T600-48 turbine. When corrected for mean site air density using the standard methods described in (34) and adjusted for cut-out control hysteresis (35), the turbine power curves are as shown in Figure 6.1.

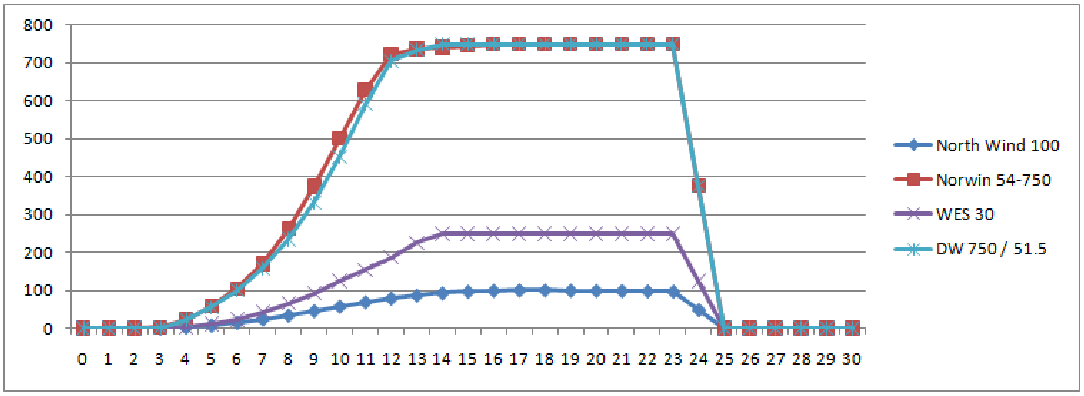


Figure 6.1: Corrected wind turbine power curves

The wind resource model developed for the RSD site was used with the adjusted wind turbine power curves and manufacturer specified tower heights to estimate the production of each machine at the proposed location. The pre- and post-upgrade power consumption levels for the site were used to estimate the likely on-site consumption of energy generated in both scenarios. Additional losses for power consumed on-site can be expected to be small, but an export efficiency of 90% can be assumed for power delivered to the LIPA network. The estimated yield data are as shown in the table.

Manufacturer	**Model**	**Hub Height (m)**	**Total Yield (MWh/year)**	**Total yield consumed on site (MWh/year)**	
				Pre upgrade (260kW)	**Post upgrade (665kW)**
Northern Power Systems	Northwind 100	37	122.1	122.1	122.1
Aeronautica Wind	Norwin 54-750	55	1383.6	930.2	1355.9
Wind Energy Solutions	WES 30	49	318.2	318.2	318.2
EWT	DW 750 / 51.5	50	1196.2	853.6	1175.9

Technical suitability

All four models considered in the yield modeling exercise are likely to be technically suitable for the site according to LIPA requirements and site constraints. However, several details are worth consideration.

The Northwind 100, WES 30 and DW 750/51.5 wind turbines use a "full range" (AC-DC-AC) electronically controlled power converter system, allowing optimal power quality characteristics and grid compatibility. This configuration is optimal from a grid management viewpoint and helps to minimize grid interconnection costs for the project. The Norwin 54-750 turbine uses a dual wound asynchronous induction generator with a thyristor controlled "soft start" facility. This model is likely to be compliant with LIPA grid connection requirements. However, selection of this machine would be likely to result in higher LIPA interconnect costs than a converter connected turbine due to poorer power quality characteristics.

The Northwind 100 turbine has a maximum hub height of only 37m, which may prove to be too low for the proposed turbine location given the wooded nature of the site. This determination can only be made following on-site anemometry. Location of the turbine rotor too close to the treetop level will lead to poor yield and high maintenance costs due to increased turbulence.

The Norwin 54-750 blade components may be up to 27m in length. Components of this size may prove difficult to deliver due to tight vehicle maneuvering requirements both on the RSD site and at the Riverside Drive / River Ave junction. Whilst delivery of these components is likely to be feasible, further investigation of the delivery arrangements, vehicles and routes will be required to confirm any additional costs.

Conclusion

An initial list of wind turbine models was selected on the basis of a suitable range of generator ratings. The list was reduced according to availability, site constraints and bankability to produce a shortlist of machines with appropriate specifications for the site. Five shortlisted models were determined to be suitable for installation at low wind speed sites, the relevant manufacturers and distributers were contacted and pricing and performance data obtained for four machines. Annual yield estimates were calculated using the previously developed site wind resource model and corrected turbine performance data, with the resulting figures providing a good assessment of relative wind turbine performance at the RSD site.

An additional modeling step was conducted to estimate the energy consumed on site for each wind turbine model and both before and after the planned site upgrade.

This analysis therefore identifies several turbine models with properties well matched to the RSD site characteristics, and provides the necessary information for a comparative economic analysis to be carried out. Furthermore, each manufacturer has provided indicative pricing, terms and scope of supply for these models to the RSD wind turbine project.

7. Commercial & Project Economics

Initial PPA & Metering Negotiation

As discussed in Chapter 8 below, initial discussions with LIPA officials about the RSD wind turbine project were positive in terms of establishing the viability of the project. A clear threshold exists in the LIPA region between small scale 'backyard' wind turbines and large machines, up to utility scale. The LIPA rebate program marks this divide, providing subsidies for machines up to a rating of 100 Kva, such as the Norwind 100 machine recently installed at Half Hollow Hills nursery. As a machine of this scale only has the potential to generate about 5% of the site's electricity needs, RSD clearly needs to look to a larger machine to make a significant impact on its grid electricity consumption, and hence its carbon footprint.

LIPA has a well established mechanism for the connection of generating devices to the electric grid, including a formula to finance the engineering costs via a monthly interconnection charge, by multiplying the final cost by 11.4% and dividing it by 12. Meter options are also well defined: the cheaper option is a simple detented meter which simply accounts for electricity used on site and does not measure any export to grid; if export is likely to be significant the generator can pay LIPA to install bi-directional metering, one meter to record the site usage from the LIPA grid and a second to record electricity exported. The rate that LIPA will pay for exported electricity will be determined during the interconnection application process, however the tariff is likely to reflect the basic LIPA "SC-11" buyback or wholesale avoided cost rate, currently approximately $37.50/MWh (1).

Federal, State & Local incentive schemes

Initial research indicates that there is at least one funding scheme potentially applicable to a single turbine wind project at the Riverhead Sewer District site. Most of the New York State schemes do not apply directly in the area as LIPA operates somewhat separately from the other major NY State electrical utilities. The schemes determined to be most relevant to the economic performance of the project are detailed below.

LIPA Wind Energy Rebate

LIPA's Wind Energy Rebate Program includes several formulae which apply separately to commercial and residential projects and non-profit, school and municipality projects.

The program budget for 2009 was $1.2m (2); the Program Manager has indicated (3) that the rebate will continue to be available in 2010. Rates for Municipalities, Schools & Non-Profits are based on expected Annual Energy Production (AEP) figures, typically calculated on the basis of a detailed local wind resource assessment and turbine performance modeling. The total rebate available for municipality projects in 2009 is as follows (4):

- $ 4.50 per kilowatt hour (kWh) for the first 16,000 kWh produced annually, and
- $ 1.50 per kilowatt hour (kWh) thereafter up to a maximum of 101,333 kWh produced annually,
- Subject to a maximum rebate of 60% of total project installed costs, and
- Subject to a maximum rebate of $200,000.

Relevant conditions of the rebate program are as follows (4):

- All wind turbines must be on LIPA's list of approved wind energy systems (5).
- All inverters must be listed on the New York State Public Service Commission Certified Interconnection Equipment list (6).
- The site must be a residential electric customer located in LIPA service territory.
- Only new, grid connected systems are eligible.
- Systems must be installed in accordance with the manufacturer's specifications and with applicable local, state, and national codes and standards, including the state of New York's standard interconnection requirements.
- A system performance meter must be installed.

The procedure for claiming the rebate is (4):

- Projects must apply to LIPA for pre-approval. If granted, pre-approval is valid for 6 months and the corresponding sum from the program budget is reserved for this period. If the project installation is not completed within this six month window, the application can be resubmitted for extension.
- The first 65% of the rebate value will be paid following project installation.
- Actual wind turbine performance data must be supplied to LIPA on a monthly basis for the first year following installation.
- The remaining 35% of the rebate value will be paid one year after installation based on actual annual performance.

The list of approved systems includes a range of wind turbine generators at ratings of up to 250kW. Other options on the list include 100kW, 80kW and 50kW turbine models. Of the three shortlisted wind turbine models, only the Wind Energy Solutions WES 30 is on the approved systems list. The Aeronautica Wind Norwin 54-750 and the EWT DW 750/51.5 are not on the list and therefore are not eligible for this funding program.

LIPA Net Metering Program

LIPA also operate a "net metering" option for customers with embedded wind generation capacity. Net metering is simply a mechanism where, instead of being metered and settled separately according to different import and export tariffs, exported energy is simply subtracted from imported energy to give a "net" meter reading for the site. This is extremely beneficial for project economics as it means that all energy generated has the full value of the import tariff rate.

Details for non-residential customers are as follows:

- The rated capacity of the installed generating equipment must not exceed the highest billing demand in the 12 months prior to installation, subject to an absolute upper limit of 2000kW.
- Where a suitable billing demand history is not available, LIPA will determine the maximum capacity limit based on an analysis of comparable facilities.
- An overall limit of 51,200kW of net metered generation will be imposed across the LIPA service territory; however LIPA may authorize additional capacity at its discretion.
- Generating equipment must be connected in parallel with the customer's load equipment.
- Generating equipment must comply with LIPA's published technical requirements.
- The customer may have to pay for additional transformer equipment if necessary.
- The customer may be required to purchase liability insurance as specified by LIPA and depending on specific conductor loading conditions at the local feeder level.

In the case of the Riverhead Sewer District, it is possible that a net metering arrangement may be available based on the conditions given in the Authority's tariff documentation. Based on these conditions it may be possible to arrange net metering for a generator rated at up to 300kW and installed prior to the site upgrade. If installation is delayed until several months after the site upgrade it may be possible to install a generator rated at up to 800kW on a net metered basis.

Unfortunately, technical and commercial contacts at LIPA indicated that net metering would be problematic for wind generator installations exceeding 100kW rated capacity. Detailed reasons for this suggestion were not given.

The possibility of net metering at the RSD site should be further pursued with LIPA as part of the interconnect application process, but should not be assumed for economic modeling purposes at the feasibility stage.

NYSERDA Renewable Energy Funding Schemes

Several NYSERDA schemes exist, but only 2 have the potential to assist in funding the RSD wind turbine project:

- RFP 10. Deadline for submission was Feb 17th, 2010. See Appendix for a summary page from the application drafted by Neutral Power and submitted by the Town of Riverhead. This application was not approved by NYSERDA. The following details apply:
  - Wind projects can only be funded up to 20KW capacity; this was confirmed unequivocally by NYSERDA officials.
  - There is a facility for funding 'Energy Management'; consultants or new staff for the following activities:
    - Projects to perform Energy Management functions. NYSERDA defines a number of technical criteria for this, none of which are problematic, but the scope of eligible projects is not defined.
    - Inventory of greenhouse gas emissions and development of reduction plans.
    - Implement a regional plan for energy efficiency.
  - Funding limit is $300K for Riverhead – this is based on population size
  - There are the following caveats which could make some projects ineligible, these are the relevant points for the RSD wind turbine project:
    - Staff or consultant time for developing proposals
    - Costs incurred prior to having a signed NYSERDA contract in place – ie. what the consultant is already doing for RSD
    - Failure to meet 'Davis Bacon' wage requirements (minimum rates for public sector projects)
    - Buy American.
- RFP 1613. The deadline was 22 March 2010, with a slightly different set of criteria. A further round is planned at the end of October 2010. It is aimed at project costs for implementation of energy efficiency, clean vehicle fleets and renewable energy generation:
  - There is no energy management strand to it
  - Size limit for wind turbines is 50KW, although the overall maximum for project costs is $1M.

There is also a PON 1260 scheme from NYSERDA, which funds business development activity for US based companies.

Preliminary financial modeling & feasibility

The economic model developed to analyze the feasibility of the Riverhead wind turbine project depends upon several variables, which are defined during the feasibility study process:

- Wind Resource – the most important variable as it is of course responsible for the amount of electricity generated and therefore the income the project achieves over its 25 year lifespan. See section 4 above. The wind speed figures shown below vary for each wind turbine because of the different hub heights of the models selected.
- Wind Turbine Generator performance – determines the amount of electrical energy the wind turbine generator can extract from that wind resource. This depends upon the machine's operational characteristics, which have been determined here from the specifications provided by the relevant manufacturers. See section 5 above.
- Site electricity consumption – significant because it determines the amount of electricity the wind turbine generator is able to supply to the site. Electricity not consumed on the site will be exported to grid at a lower price, so the more consumed on site, the better the economic return. Figures used here for pre-upgrade consumption have been obtained from historical LIPA meter readings and charges. Post-upgrade estimates have been provided by the RSD's Engineers, H2M P.C. and account for the estimated increase in on-site consumption once the planned upgrade has been completed in 2012.
- LIPA Electricity Tariff – the recorded cost of electricity to the RSD site, taken from LIPA bills provided by RSD.
- LIPA Feed-in Price – what LIPA is likely to be prepared to compensate the RSD site for electricity generated on site and sold into the LIPA grid.
- Project cost – the costs of project management, engineering oversight, wind resource measurement etc to achieve project implementation.
- Capital cost – wind turbine purchase and delivery cost, plus construction costs of foundation and site integration.
- Operations & Maintenance (O&M) cost – ongoing operations and maintenance fees, payable to contracted O&M company.
- Interconnect fees – regular payments to LIPA for grid connection.
- Loan rate – interest rate that is likely to be obtained by the Town of Riverhead in raising funds to pay for the wind turbine.
- Discount rate – the rate of return that money invested in this project could achieve if invested elsewhere – used to calculate the Net Present Value of the project.
- General Inflation rate – applied to future project costs such as Operations and Maintenance (O&M).
- Inflation rate for wholesale electricity – analysis of NY State wholesale electricity prices over the last 10 years shows significant volatility and an average rate of increase significantly higher than the general rate of inflation. This is significant for a renewable energy project because it means that the project will save increasing amounts of money in future years. The economic analysis considers 2 different scenarios for future electricity prices to show their effect on the overall project economics. See box below for further analysis.

US Wholesale Electricity Inflation Rates

Examination of data for average retail prices of electricity across the whole of the USA reveals an average inflation rate of 5% for industrial customers. (US Energy Information Administration – Annual Energy Review 2008). The US EIA's analysis of cost of electricity by state, however, shows that New York has among the highest electricity rates in the country, at an average of 16.6 Cents per KWHr, against a US average of 9.74 Cents in 2008. (See http://www.eia.doe.gov/cneaf/electricity/epa/fig7p4.html). NYSERDA's own records of electricity prices for industrial customers (See http://www.nyserda.org/energy_information/nyepq.asp), drawn once again from US EIA figures, show an average increase from 5.2 Cents in 2002 to 10.5 Cents in 2009, an inflation rate of 10.5%. LIPA's rates are even higher than this average, reflecting the premium being paid by all of Long Island for the Shoreham nuclear power plant. This is reflected in the current average tariff being paid by RSD, at 14.5 Cents per KWHr.

Current trends in the World energy market do not suggest that energy price increase is going to slow down in the long term – if anything the rate of increase is likely to get worse, driven by the volatility and long term price rise in the price of crude oil.

For the purposes of this model, 2 rates of energy price inflation were used: 5% and 10%, to show the spread of likely future electricity costs to the town of Riverhead.

General Principles of the Financial Model

The financial model used in this feasibility study simulates the design, build and operations of a variety of wind turbine models over a 27 year period: 2 years for design and build, followed by an expected 25 year lifespan for the machine. It treats the wind turbine as a standalone business, taking into account the planning and construction costs, asset finance and running costs, then calculating the annual revenue generated, based upon the key variables discussed above. The model assumes that the initial costs for design and project management are paid by the Town as an 'equity investment' in the project and that the RSD also provides $30K of working capital for the turbine at commissioning. Length of loan period is then adjusted to enable the business to remain cash positive throughout and the income to the project is counted as the value of the electricity generated at the prevailing LIPA rate, indexed for inflation.

Financial Model Standard Variables

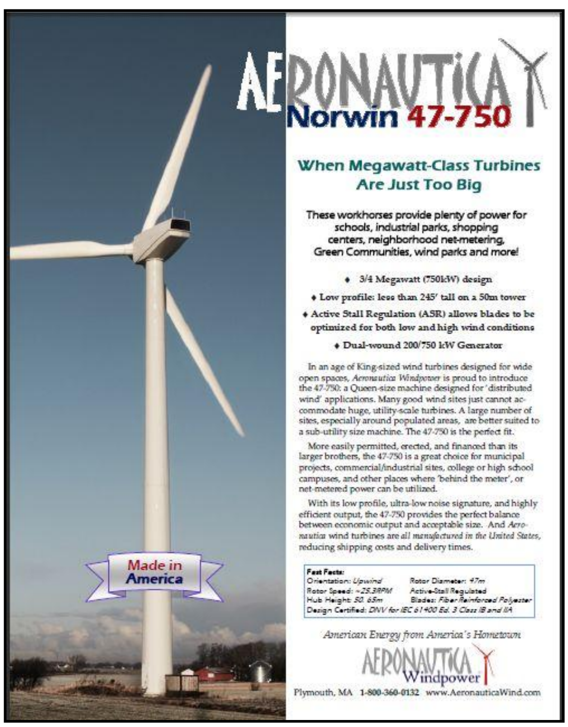
Variables input into the model which are the same for all turbine types:

Model Variable	Value	Notes
Site electricity consumption	260 KW average load = 2280 MWHr a year 665 KW average load = 5830 MWHr a year	Current loading Loading after the site upgrade, due online in mid 2012
LIPA Electricity Tariff	$145 per MWHr	From RSD electricity bills, provided by site. Calculated by taking average delivery & system charges plus supply charges over 2009.
LIPA Feed-in Price	$37.50 per MWhr	Only applies if a bi-directional meter is installed, at cost to the project. Rate is an estimate based upon initial discussions with LIPA and tariff documentation.
LIPA CO_2 Factor	0.523 tonnes of CO_2 per MWHr	Depends upon the carbon 'mix' of electricity generated by LIPA
Project Costs	$105,000	Neutral Power's price for full project implementation, including the cost of this Phase 1 feasibility study ($29,000) – applies to project costs of large scale wind turbine generators in the 500-850 KW range; costs for a 100 KW size machine would be significantly less.
Loan Rate	5%	Figure provided by RSD
Discount Rate	6%	Standard rate
General Inflation Rate	2.5%	
Electricity Inflation Rate	5% best case 10% worst case	Based on US national electricity inflation 1960-2008 Based on NYSERDA electricity inflation 2002-2009

Financial Model 1: Aeronautica Wind Norwin 54-750

Variables which are particular to this model:

Model Variable	Value	Notes
Wind Resource (P50)	5.65 m/s	At turbine hub height 180' (55m)
Annual Power output	1384 KWHr	Allowing for turbine and grid availability and electrical losses
Turbine price: Delivery costs Groundworks / foundations: Electrical works: Installation: Total:	$1,365,000 $26,000 $130,000 $78,000 36,000 $1,599,000	Based upon initial quotation from the Aeronautica Inc. Final price, including delivery would depend upon negotiation of a Turbine Supply Agreement with the company. Other costs estimated using the Wind Turbine Design Cost and Scaling Model (36)
Operations and Maintenance (O&M) Operations: Maintenance:	 $10,000 per year $30,000 per year	 Based upon the Wind Turbine Design Cost and Scaling Model (36)
Grid Interconnect Fees	$12,000 per year	Prices from LIPA, which vary with the turbine type and the sophistication of its power generating equipment
Project start date	Jan 2010	
Wind turbine online	Jul 2011	produces 41% of site electricity
RSD site upgrade complete	Jul 2012	wind turbine produces 23% of site electricity
Wind turbine end of life	Jul 2036	



Aeronautica Norwin 54-750 Scenario 1, best case electricity inflation rate of 5%:

Total Project Cost:	$1,704,000
Working Capital injected at Y2:	$30,000
Loan Value:	$1,599,000
Loan Payback:	11 years
Total Loan Repaid (@ 5% interest)	$2,117,520

Wind Turbine Revenue and carbon savings:			
2011	$83K	362 tons CO2	(based on 6 months' generation)
2012	$203K	724 tons	
2013	$241K	724 tons	
2014	$253K	724 tons	
2015	$265K	724 tons	
2016-2036	$474K	724 tons	Average over period

Project Net Present Value: $2.26 M (based upon 6% discount rate)

Project IRR: 29%

CO_2 saved over project life: 18,100 tons

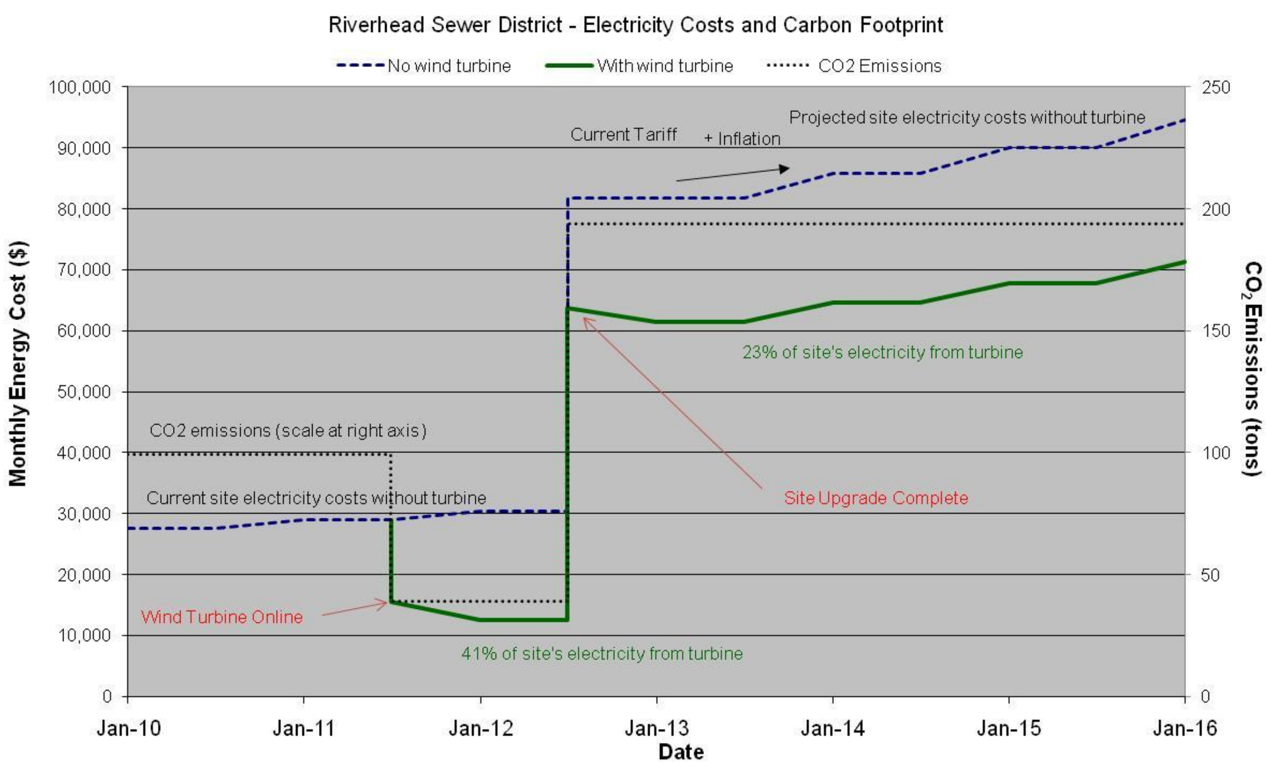


Figure 7.1: RSD Wind Turbine: AWE 54-750, Electricity inflation at 5%

Aeronautica Norwin 54-750 Scenario 2, worst case electricity inflation rate of 10%:

Project start date	Jan 2010	
Wind turbine online	Jul 2011	produces 41% of site electricity
RSD site upgrade complete	Jul 2012	wind turbine produces 23% of site electricity
Wind turbine end of life	Jul 2036	

Total Project Cost:	$1,704,000
Working Capital injected at Y2:	$30,000
Loan Value:	$1,599,000
Loan Payback:	10 years
Total Loan Repaid (@ 5% interest)	$2,070,778

Wind Turbine Annual Revenue and carbon savings:			
2011	$91K	362 tons CO2	Based on 6 months' generation
2012	$236K	724	
2013	$290K	724	
2014	$319K	724	
2015	$351K	724	
2016-2036	$1,177K	724	Average value over 20 years

Project Net Present Value: $7.17 M (based upon 6% discount rate)

Project IRR: 48%

CO_2 saved over project life: 18,100 tons

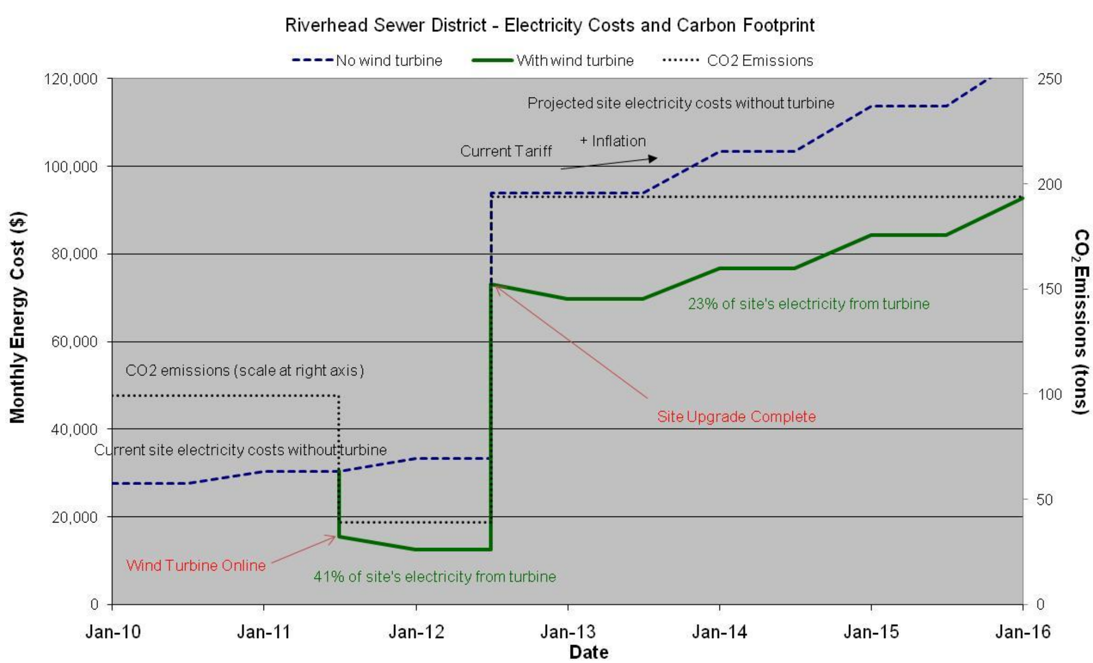


Figure 7.2: RSD Wind Turbine: AWE 52-750, Electricity inflation at 10%

Financial Model 2: EWT DW 750/51.5

Variables which are particular to this model:

Model Variable	Value	Notes
Wind Resource (P50)	5.48 m/s	At turbine hub height 164' (50m). Lower wind speed than the Aeronautica machine because of the lower hub height.
Annual Power output	1196 KWHr	Allowing for turbine and grid availability and electrical losses
Turbine price: Craneage Groundworks / foundations: Electrical works: Total:	$1,500,000 $20,000 $120,000 $78,000 $1,718,000	Based upon initial quotation from the AWE Inc. Final price, including delivery would depend upon negotiation of a Turbine Supply Agreement with the company. Other costs estimated using the Wind Turbine Design Cost and Scaling Model (36).
Operations and Maintenance (O&M) Operations: Maintenance:	 $10,000 per year $30,000 per year	Based upon the Wind Turbine Design Cost and Scaling Model (36)
Grid Interconnect Fees	$10,500 per year	Prices from LIPA, which vary with the turbine type and the sophistication of its power generating equipment
Project start date	Jan 2010	
Wind turbine online	Jul 2011	produces 37% of site electricity
RSD site upgrade complete	Jul 2012	wind turbine produces 20% of site electricity
Wind turbine end of life	Jul 2036	

Manufacturer	EWT
Type	DirectWind 750
Rated power	750 kW
Cut-in wind speed	2.5 m/s
Rated wind speed	13 m/s
Rotor diameter	51 m
Swept area	sqm
Power / rotor speed control	pitch
Tower height(s)	40 to 75 m
Drive	direct drive
Other	speific heights through WWWT

Wind turbine EWT DW 750/51.5 - Scenario 1, best case electricity inflation rate of 5%:

Total Project Cost:	$1,823,000
Working Capital injected at Y2:	$30,000
Loan Value:	$1,718,000
Loan Payback:	13 years
Total Loan Repaid (@ 5% interest)	$2,429,829

Wind Turbine Annual Revenue and carbon savings:			
2011	$75K	313 tons CO2	(based on 6 months' generation)
2012	$180K	626 tons	
2013	$208K	626 tons	
2014	$219K	626 tons	
2015	$230K	626 tons	
2016-2036	$411K	626 tons	Average over period

Project Net Present Value: $1.61 M (based upon 6% discount rate)

Project IRR: 24%

CO_2 saved over project life: 15,638 tons

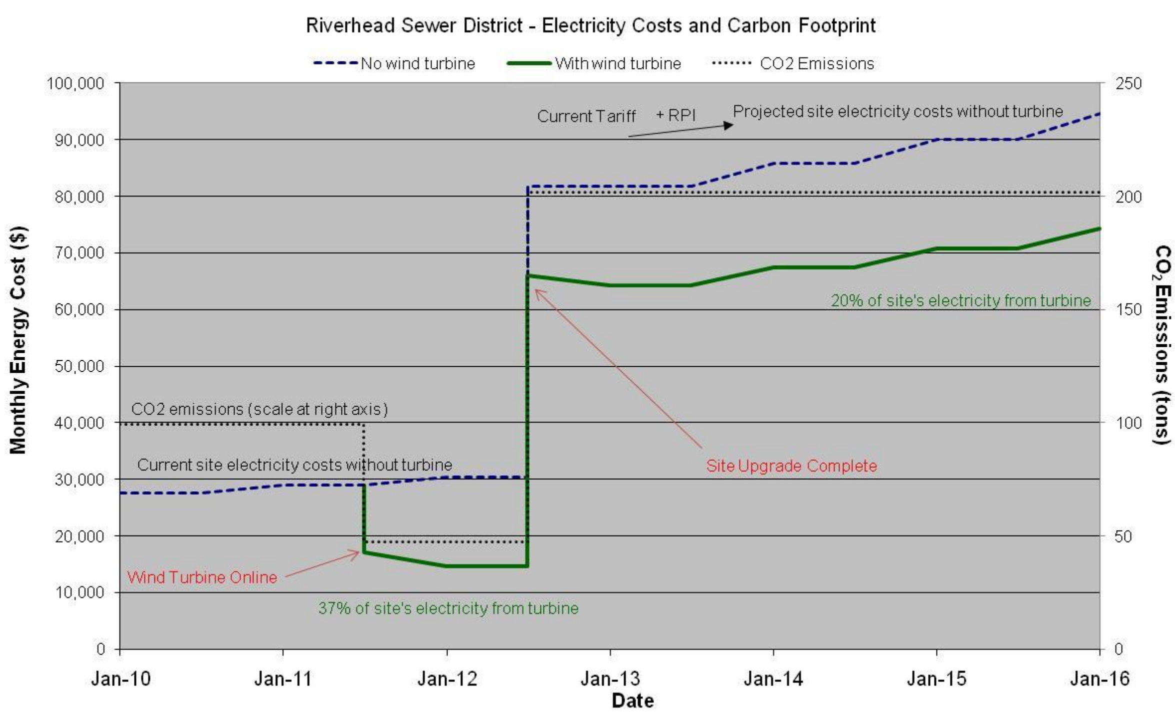


Figure 7.3: RSD Wind Turbine: EWT DW 750/51.5, Electricity inflation at 5%

Wind turbine EWT DW 750/51.5 - Scenario 2, worst case electricity inflation rate of 10%:

Total Project Cost:	$1,823,000
Working Capital injected at Y2:	$30,000
Loan Value:	$1,718,000
Loan Payback:	12 years
Total Loan Repaid (@ 5% interest)	$2,326,009

Wind Turbine Revenue and carbon savings:			
2011	$83K	313 tons CO2	(based on 6 months' generation)
2012	$208K	626 tons	
2013	$251K	626 tons	
2014	$276K	626 tons	
2015	$304K	626 tons	
2016-2036	$1,019K	626 tons	Average over period

Project Net Present Value: $5.87 M (based upon 6% discount rate)

Project IRR: 41%

CO_2 saved over project life: 15,638 tons

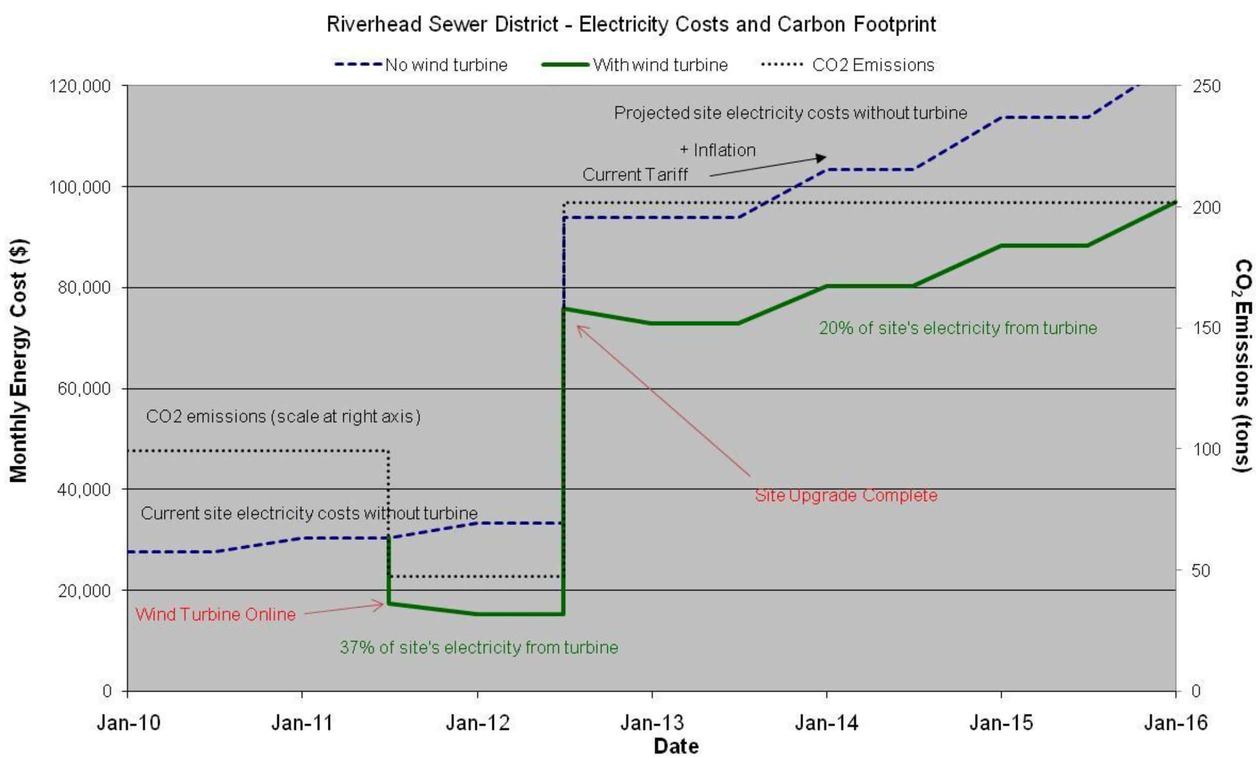


Figure 7.4: RSD Wind Turbine: EWT DW 750/51.5, Electricity inflation at 10%

Financial Model 3: Wind Energy Solutions WES 30

Variables which are particular to this model:

Model Variable	Value	Notes
Wind Resource (P50)	5.44 m/s	At turbine hub height 160' (49m) - again, slightly lower than the other 2 machines.
Annual Power output	318 MWHr	Allowing for turbine and grid availability and electrical losses
Turbine price: Delivery costs Groundworks / foundations: Electrical works: Total:	$682,000 $33,000 $75,000 $30,000 $820,000	Based upon initial quotation from the AWE Inc. Final price, including delivery would depend upon negotiation of a Turbine Supply Agreement with the company. Other costs estimated using the Wind Turbine Design Cost and Scaling Model (36)
Operations and Maintenance (O&M) Operations: Maintenance:	$2,000 per year $2,000 per year	Based upon the Wind Turbine Design Cost and Scaling Model (36)
Grid Interconnect Fees	$200 per year	Prices from LIPA, which vary with the turbine type and the sophistication of its power generating equipment
Project start date	Jan 2010	
Wind turbine online	Jul 2011	produces 14% of site electricity
RSD site upgrade complete	Jul 2012	wind turbine produces 5% of site electricity
Wind turbine end of life	Jul 2036	

Wind turbine WES 30 - Scenario 1, best case electricity inflation rate of 5%:

Total Project Cost: $889,000
Working Capital injected at Y2: $30,000
Income from
LIPA "Wind Rebate" Program (29): $200,000 over 2 years: $130K at commissioning, $70K y+1
Loan Value: $690,000 loan total reduced by the $130K from LIPA
Loan Payback: 14 years
Total Loan Repaid (@ 5% interest) $975,892

Wind Turbine Annual Revenue and carbon savings:			
2011	$25K	83 tons CO_2	(based on 6 months' generation)
2012	$54K	166 tons	
2013	$56K	166 tons	
2014	$60K	166 tons	
2015	$62K	166 tons	
2016-2036	$111K	166 tons	Average over period

Project Net Present Value: $391K (based upon 6% discount rate)

Project IRR: 17% (including the LIPA wind rebate)

CO_2 saved over project life: 4,158 tons

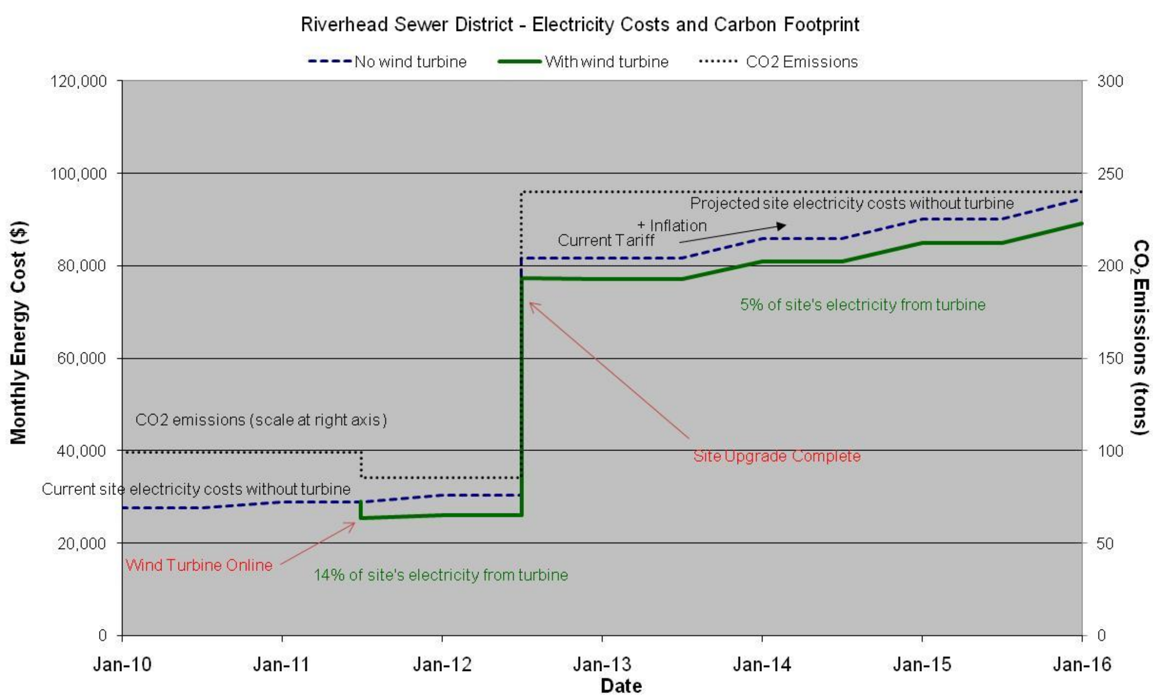


Figure 7.5: RSD Wind Turbine: WES 30 Electricity inflation at 5%

Wind turbine WES 30 - Scenario 2, worst case electricity inflation rate of 10%:

Total Project Cost:	$889,000
Working Capital injected at Y2:	$30,000
Income from	
LIPA "Wind Rebate" Program (29):	$200,000 over 2 years: $130K at commissioning, $70K y+1
Loan Value:	$690,000 loan total reduced by the $130K from LIPA
Loan Payback:	11 years
Total Loan Repaid (@ 5% interest)	$913,752

Wind Turbine Annual Revenue and carbon savings:			
2011	$28K	83 tons CO2	(based on 6 months' generation)
2012	$62K	166 tons	
2013	$68K	166 tons	
2014	$74K	166 tons	
2015	$82K	166 tons	
2016-2036	$274K	166 tons	Average over period

Project Net Present Value: $1.53 M (based upon 6% discount rate)

Project IRR: 28% (including the LIPA wind rebate)

CO_2 saved over project life: 4,158 tons

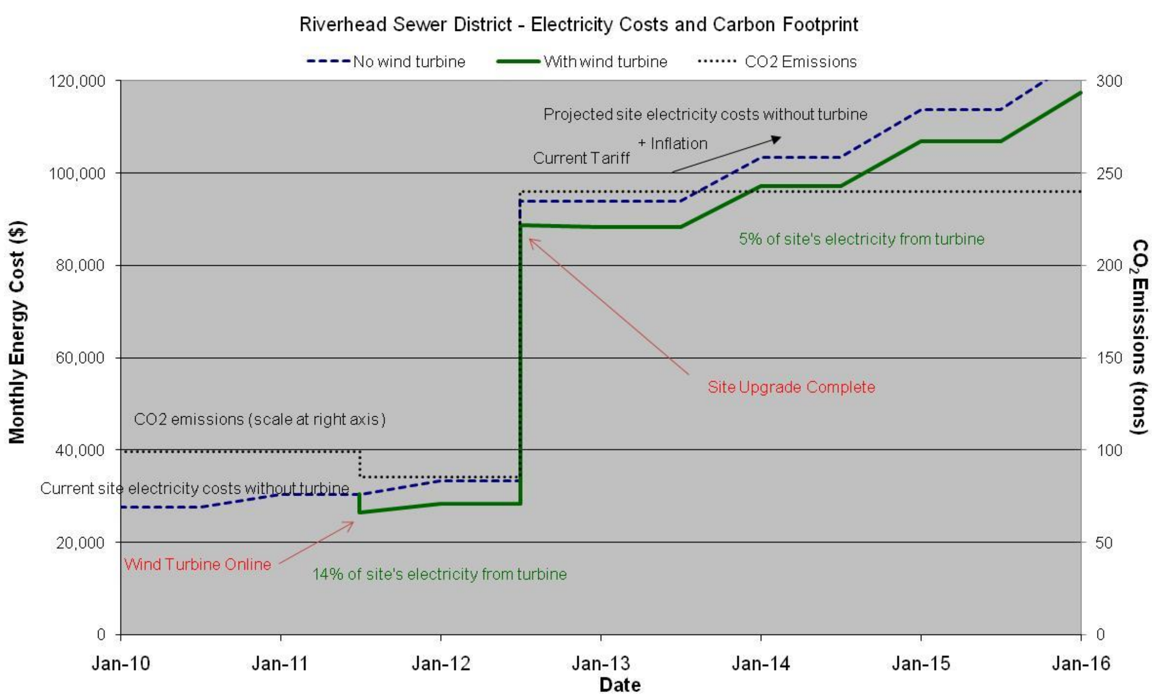


Figure 7.6: RSD Wind Turbine: WES 30 Electricity inflation at 10%

Conclusions

Sensitivity analysis of the economic model has established the following key points:

- The larger wind turbines have attractive NPVs and IRRs, while providing a significant proportion of site electricity requirements, both before and after the site upgrade. The WES 30 benefits very significantly from the LIPA 'Wind Rebate Program' (29), which reduces the loan repayment period from about 24 years to 14, but its contribution to site energy demand is at best below 15%. Any wind turbine smaller than the WES 30, such as the North Wind 100 which is installed at Half Hollow Hills, will have an almost insignificant impact upon the electrical demand of the site.
- The financial viability of any of the wind turbines modeled here is significantly affected by the amount of wind resource. Accurate measurement of the on-site wind regime is important to ensure a reasonable payback time for the project.
- Uncertainty over the rate that LIPA will pay for exported electricity makes the project vulnerable to financial underperformance whenever a significant proportion of its production is not being consumed on-site. Prior to the RSD upgrade the larger turbines will export significant amounts of electricity, because of the varying peaks and troughs of supply and demand between the wind turbine and the site. If the LIPA feed-in tariff is as low as the $37 per MWHr used here, the project will have a lower financial viability, particularly in the period before the RSD upgrade is online. Likewise, if the site upgrade is delayed, this will also reduce the financial viability of the project
- The future price of LIPA wholesale electricity is critical to the project's finances. If LIPA future electricity costs track the long term US national average inflation for electricity, at 5%, the project can payback in the 10 to 11 year timeframe. If LIPA's costs continue to rise at the NYSERDA average of over 10%, payback in 9 years or less is viable.

Recommendations

The following recommendations are made:

- Wind turbines in the 750KW range are financially viable for the RSD site and can make a significant contribution to site energy usage, both before and after the planned site upgrade. Small scale turbines in the sub-500KW range suffer from exponentially diminishing returns in terms of electricity generated, although the LIPA wind rebate program does make them financially viable on this site.
- RSD does not have a high grade wind resource, but current estimates show it is viable for a large wind turbine. Further measurement of wind resource is essential to narrow the margins of error of the financial model, and ensure that predicted levels of electricity generation, and therefore payback on investment, are achieved.
- Further negotiations with LIPA are required to establish what feed-in tariff would be paid for electricity exported from the site and to negotiate the exact terms of the Power Purchase Agreement.
- The development of the RSD wind turbine would benefit from being linked to the planned site upgrade, so that the former does not suffer financially from a delay in the increase in on-site electricity demand.
- Further financial modeling must continue to take a conservative view of the future cost of electricity from LIPA, but continue to plan on the basis that energy costs will continue to rise steadily and significantly over the next 25 years.

8. Civil & Structural Engineering

Introduction

Any wind turbine generator must be supported by a substantial foundation, to bear both the weight of the machine and the large forces associated with the thrust of the turbine in operation. The field of wind turbine foundation design is complex due to the many dynamic load systems involved, and as yet a comprehensive standard approach to design has not been developed. Perhaps as a result of this situation, a number of different approaches are commonly employed even given similar design parameters.

For the purposes of a feasibility study, it is first necessary to ascertain whether the geotechnical conditions necessary to support a wind turbine are likely to be present at the proposed site. If indications are positive, the foundation systems most likely to be suitable should be identified and the likely cost estimated.

Wind turbine foundation types

The foundation forms in common use in the wind energy industry fall into five main categories. These groups are listed below.

- **Spread footing** designs employs a large, flat reinforced concrete slab (usually circular, hexagonal or rectangular), into which the turbine tower is anchored. The slab is usually buried at a shallow depth under an "overburden" layer of soil. This is a gravity foundation, and as such relies on the combination of rigid slab behavior, normal bearing and the combined mass of the slab and overburden to resist overturning (37) (38). Spread footings are the simplest and most widely applicable design and as a consequence they are the most common style of foundation in use, although the implementation details vary widely. Wind turbine manufacturers' reference foundation designs are usually of the spread footing type, e.g. in (39) (40). Suitable for many soil and rock types, they unfortunately require enormous quantities of concrete and steel reinforcement (41) and are therefore expensive. Spread footings for a turbine of up to 900kW rating are likely to measure up to 25 feet in diameter.
- **Rock socket** and **shallow pier** foundations are used where high strength soil types are present near ground level. Constructed as a single column, either solid or occasionally in the form of a heavily reinforced, backfilled shell, static loads are typically supported through end bearing whilst lateral earth pressure and friction provide resistance to overturning and dynamic loads (38). Where available, this approach represents an efficient use of materials but the necessary excavation and blasting can prove expensive. Nevertheless, rock socket foundations are generally less costly than spread footings.
- **Cap and pile** foundations are arranged as a reinforced concrete slab (usually circular or hexagonal), anchored by a ring of deep piles around the cap's perimeter. This design is employed where surface soils are poor but high strength subgrades can be found at greater depths. Loads are borne primarily by the strong subgrades through a combination of end bearing, friction and lateral earth pressure (38). The cap may be relatively deep and heavily reinforced, as it must transfer large loads from the turbine anchor ring to the piles. Whilst the economic performance of cap and pile foundations varies widely with geotechnical conditions, they usually represent a comparatively expensive option. Regardless, in some cases a cap and pile foundation is the only viable solution.

- **Rock anchored** foundations are used where strong soil is found at shallow depths. Similar to cap and pile foundations, but employing a ring of rock anchors to secure the cap to the bearing layer, they are used in similar conditions to rock socket foundations, where they can provide a more efficient and cost effective option. Loads are borne primarily through end bearing at the cap and friction along the anchors (42) (43) (44).
- Several hybrid and proprietary foundation systems are in common use, particularly in the USA where some patented designs have proven highly cost effective. Probably the most widespread example is the **Patrick and Henderson** “Tensionless Pier” foundation (42) (45), a deep pier structure in the form of a heavily reinforced concrete shell slightly wider than the turbine base, with central backfill and topped with a structural slab onto which the turbine tower is anchored (US Patent #5,586,417). The P&H system has been successfully deployed in a wide variety of grades including sands and disturbed soils, and typically proves 25-30% more cost effective than spread footing designs. However, the design requires careful construction; overturning loads are resisted almost completely through lateral earth pressure and the shear strength of the surrounding soil, therefore any sloughing around the excavation must be avoided or carefully remedied if the theoretical bearing capacity of the foundation is to be achieved. Despite this, P&H foundations have a good record for performance, reliability and cost.

Site investigation

A geotechnical survey of the Riverhead Sewer District site was conducted in February 1998 prior to the construction of several new facilities. The study was conducted by Slacke Test Boring, Inc. of Kings Park, Long Island and the resulting report was provided by the Sewer District’s Engineer (46) along with information and drawings regarding the six borehole locations. These locations are as shown in Figure 8.1.

Figure 8.1: Soil Boring locations at the RSD site

The soils encountered were predominantly medium to fine sand with trace small to fine gravel, and characterized as clean, well graded, dense and granular. Soil bearing capacities were reported by the contractor in units of tons per square foot (tsf), where 1 tsf is equal to 2000 pounds per square foot (psf). The level at which a bearing capacity of 2 tsf (4000 psf) was assigned ranged from 11 to 21 feet, whilst the ground water level varied between 12 and 19.7 feet. These results are summarized in the table below.

Boring No.	Depth (ft)	Ground Water (ft)	2.0tsf / 4000psf depth (ft)
1	50	19.7	11
2	50	12	15
3	25	17.7	11
4	35	13.5	20
5	35	14.2	21
6	35	13.2	20

The surface soil appeared to be underconsolidated in some areas, possibly due to previous surface activity. The determination of the report was that the native, structurally rated soils represent a good foundation bearing material. Several provisos were added, particularly that disturbed soils should be avoided and that a more thorough investigation of groundwater variations must be carried out if groundwater conditions are critical to the proposed foundation design.

A Northwind 100kW wind turbine with a 21m rotor and 47.5m overall height is installed at a site in Laurel, approximately 8km from the proposed turbine location. This wind turbine, as shown in Figure 8.2, appears to employ a Patrick & Henderson Tensionless Pier foundation, and is sited in apparently similar sandy conditions to those found at the RSD site.

Figure 8.2: Apparent Patrick & Henderson style foundation in Laurel, NY

A soil report (47) for the Riverhead Sewer District site and surrounding areas was obtained from the USDA Natural Resources Conservation Service's Web Soil Survey tool (5). The report concerns only surface soil characteristics, but can help to identify areas of significant variation in soil conditions. No evidence of such variation is apparent; the proposed turbine location area is characterized as similar to the area investigated at soil boring locations 1 and 2.

It is clear from the soil boring locations marked in Figure 8.1 that the area investigated is located some distance (around 170m) from the likely wind turbine location. The available information indicates that the geotechnical characteristics of these two areas are likely to be similar, and this assumption can be made with sufficient confidence for the purposes of a feasibility study. However, it is essential that a full assessment including a soil boring to at least 40 feet is carried out at the proposed location to confirm the geotechnical conditions before a wind turbine project can be implemented.

The proposed turbine location is in an undeveloped area of the site which has seen little use thus far. The processing site itself is clean and well managed, with no evidence of ground contamination. Whilst it is possible that past industrial activities at the site may have resulted in low level spillages of hydrocarbon fuels and lubricants and specific process-related chemicals such as chlorine, the likelihood of significant ground contamination at the turbine location is very low.

Preliminary foundation selection

Rock socket and rock anchor foundations will almost certainly not be appropriate at this site. It is also unlikely that a cap and pile solution will be necessary as soils of good bearing capacity are present at 10 to 20 foot depths.

Given the various foundation systems available and the existing information regarding geotechnical conditions at the Riverhead Sewer District site, it is likely that the most suitable foundation will be a spread footing design. Indeed, such a design may be mandated or even provided by the eventual wind turbine supplier. It may, however, be possible to use a more efficient design such as the Patrick & Henderson system, allowing a saving of around 25-30% in foundation costs. This possibility should be further investigated during project implementation, following a soil boring exercise at the selected turbine location and in consultation with the Structural Engineer and the wind turbine supplier.

Foundation cost

Foundation costs are generally difficult to estimate accurately until the structural design is completed. However, several extensive studies on the subject have been completed in recent years allowing cost models to be developed and validated. Reasonably confident estimates can be made on the basis of these models (36).

A typical expected cost for the foundation and groundworks for a wind turbine with a rotor diameter of 50m and a hub height of 50m (representative of the larger scale turbines under consideration) is $115,000. A turbine of 40m hub height and 30m rotor diameter (representative of the smaller scale turbines under consideration) has an expected foundation cost of approximately $70,000.

An expected error of +20/-10% should be applied to these figures. Whilst the costing model used was developed and validated predominantly against projects using P&H Tensionless Pier foundations (36), experience suggests that such foundations may prove slightly less expensive than these estimates. Experience also confirms that spread footing designs are likely to cost around 25-30% more than the P&H system (42). Foundation costs are heavily influenced by prevailing steel prices due to the large quantities of reinforcement employed. Whilst recent steel prices have dropped to below 2006 levels, it is by no means certain that the extreme volatility seen in steel markets since late 2007 has abated for the short term. Materials procurement and project costing activities should both be conducted with regard to this source of uncertainty.

Conclusion

Geotechnical conditions at the site are likely to be suitable for installation of a wind turbine generator system. A soil boring must be conducted at the turbine location before a final foundation design can be completed. It is likely that a spread footing foundation will be suitable, whilst use of a more cost effective Patrick & Henderson design may become an option at implementation, depending on confirmed geotechnical conditions.

A spread footing foundation for a wind turbine of the scale under consideration will incorporate heavy reinforcement and measure up to 25 feet in diameter and approximately 4 feet in depth, depending on design details. A P&H foundation would be slightly wider than the turbine base and up to 30 feet in depth.

Expected foundation costs range from $70,000 to $115,000 for the considered range of turbines, subject to an error of +20/-10%.

9. Electrical & Control Engineering

The electrical network at the RSD site is supplied by an overhead conductor running from the gate along the east and north boundaries of the site. A large transformer and 750kW generator are sited at the north east of the site and a second, smaller transformer is located to the north west of the site. Each transformer is connected to metering equipment at the secondary (low voltage) terminals. A buried conductor runs across the site from east to west but is now abandoned. The schematic shown in Figure 9.1 (supplied by LIPA) details the site's electrical supply hardware.

It may be possible to connect a small generator facility (up to 150kVA) to the existing site electrical network without ill effects, however further analysis by an electrical engineer will be required to confirm this. Installation of a larger wind turbine generator anywhere on the site will almost certainly require a separate conductor to be laid between the generator and the main transformer. It may be possible to refurbish and recomission part of the abandoned conductor for this purpose, but further investigation of this option will also require analysis by a qualified electrical engineer. The wind generator is likely to require a dedicated connection to the transformer for several reasons:

- It is unlikely that the existing site equipment is rated to accommodate a large additional generator at either proposed wind turbine location.
- Connecting a large generating machine alongside existing electrical equipment may affect power quality within the site network.
- It is certain that an automated interlock system will be required by LIPA to prevent the existing site generator set and the wind turbine generator from exporting to the grid at the same time, since their combined capacity could potentially exceed the export capacity of the transformer. This arrangement would be much more straightforward if both generators were connected directly to the transformer secondary, as the necessary switchgear could be housed in a single location.

Some new electrical equipment will be required near the transformer, including at least an additional meter and main disconnect switch for the new generator. In accordance with LIPA requirements (48) (49), this additional equipment will be located externally near the Point of Common Coupling (PCC) in a suitable cabinet or shelter box where necessary. LIPA requirements indicate (48) that a generator rated at over 300kVA will require a primary metered connection; therefore installation of a new metering system on the primary side of the site transformer will be required.

As the planned site upgrade will include a significant expansion of the electrical equipment at the site, it is likely that the implementation cost of the project can be reduced slightly by completing the necessary electrical works as part of the upgrade process. However, the significant lead time for the upgrade is likely to make it worthwhile to go ahead with the wind turbine project independently. Given a permissioned electrical system design, implementation can be expected to be a reasonably straightforward process. Either an overhead or buried conductor is likely to be suitable for the connection between wind turbine and transformer, although it is likely that a buried conductor will be required where it crosses a road.

Design and construction of any electrical systems must conform to current nationally and locally adopted electrical codes (50) (51), in practice these are likely to be replicated or exceeded in the utility's interconnect permission requirements (48) (49).

At the feasibility stage of the project the most significant electrical risk is interconnection. Permission to connect to the local transmission or distribution system can only be granted following a thorough "grid study" commissioned by the network operator at the request of the applicant. This study is based on parameters supplied by the project team and can be an expensive exercise requiring analysis of the effect of the new equipment on the local grid network. Costs of $25k to $75k would be expected for a small wind energy project. Primary concerns usually include load flow modeling, harmonics, frequency regulation, low voltage ride through and power factor correction.

Power quality terms

- Load flow study – this exercise determines the real and reactive power flows throughout the electrical network in the steady state under normal operating conditions. This allows the designers to, for example, quantify losses and determine system efficiency, and therefore to optimize the system configuration and specify any necessary correction measures.
- Harmonics – In an ideal case, voltage and current in an AC electrical system vary sinusoidally at a single supply frequency (60Hz in the USA). However, equipment with a non linear response, including many electronic devices, often causes currents and voltages with more complex waveforms. These can be considered as a sum of "harmonic" frequencies at integer multiples of the supply frequency. Harmonics in the power network can reduce the efficiency of machines or even cause damage to equipment designed to operate at a relatively pure supply frequency.
- Frequency regulation – the electrical supply frequency varies as a result of a mismatch between the total electrical supply and load on the network, and is regulated by varying the power delivery at the point of supply in response to variations in load. Wind generators deliver power at a constantly varying rate due to variations in wind speed, and can therefore make it more difficult for the utility to regulate the system frequency. However, many modern wind turbines include regulation systems which considerably improve their effect on supply frequency.
- Low voltage ride through (LVRT) – this refers to the utility's requirements as to the operation of a generating system when there is a voltage drop on the supply network. In most cases it is safe for a wind turbine to simply disconnect if the grid voltage drops below a specified level. However, in some systems this may exacerbate the problem and it is preferable for the generator to "ride through" the fault and continue to provide power to the system.
- Power factor correction – if the voltage and current in an AC system are out of phase, then unnecessary current flows will result as energy is transmitted between the generator and the load without doing useful work. This "reactive" power transmission increases system losses, reduces the useful capacity of conductors and can damage equipment. The ratio of real power to "apparent" power (the vector sum of real and reactive power) is the power factor; maximizing the power factor minimizes the undesirable reactive power. Many utilities operate a "VAR" (VA Reactive) tariff which charges consumers for reactive power draw as well as real power consumption. This encourages customers to ensure that their equipment is electrically efficient, with a high power factor. However, LIPA does not operate such a tariff, preferring to manage reactive power centrally.

A major concern for utilities serving embedded generation systems is an effect known as "islanding". Islanding occurs when a small section of the network is cut off but continues to operate thanks to local embedded power supply. This can become a serious problem if the generator cannot maintain the necessary voltage, frequency and power factor characteristics, possibly causing damage to other grid-connected equipment within the island. Electrical repairs are more complicated and dangerous as disconnected parts of the system may remain live and operate unpredictably, and it may be difficult to synchronize and reconnect the "island" to the grid network when repairs are complete. LIPA requires that any generating equipment be disconnected in such situations to avoid any possibility of islanding (48) (49).

The costs of grid study activities and any required network upgrades are priced into the interconnect charges applied to the project when commissioned. LIPA procedure is to multiply the full interconnect cost by 11.4% and divide by 12 to give a monthly interconnection charge. For example, where the interconnect cost is $50k, the monthly interconnection charge would be $475. This charge is likely to have a long term effect on project economics, although the arrangement is significantly less costly than an up-front interconnect charge for a wind energy project with a 20 year design life.

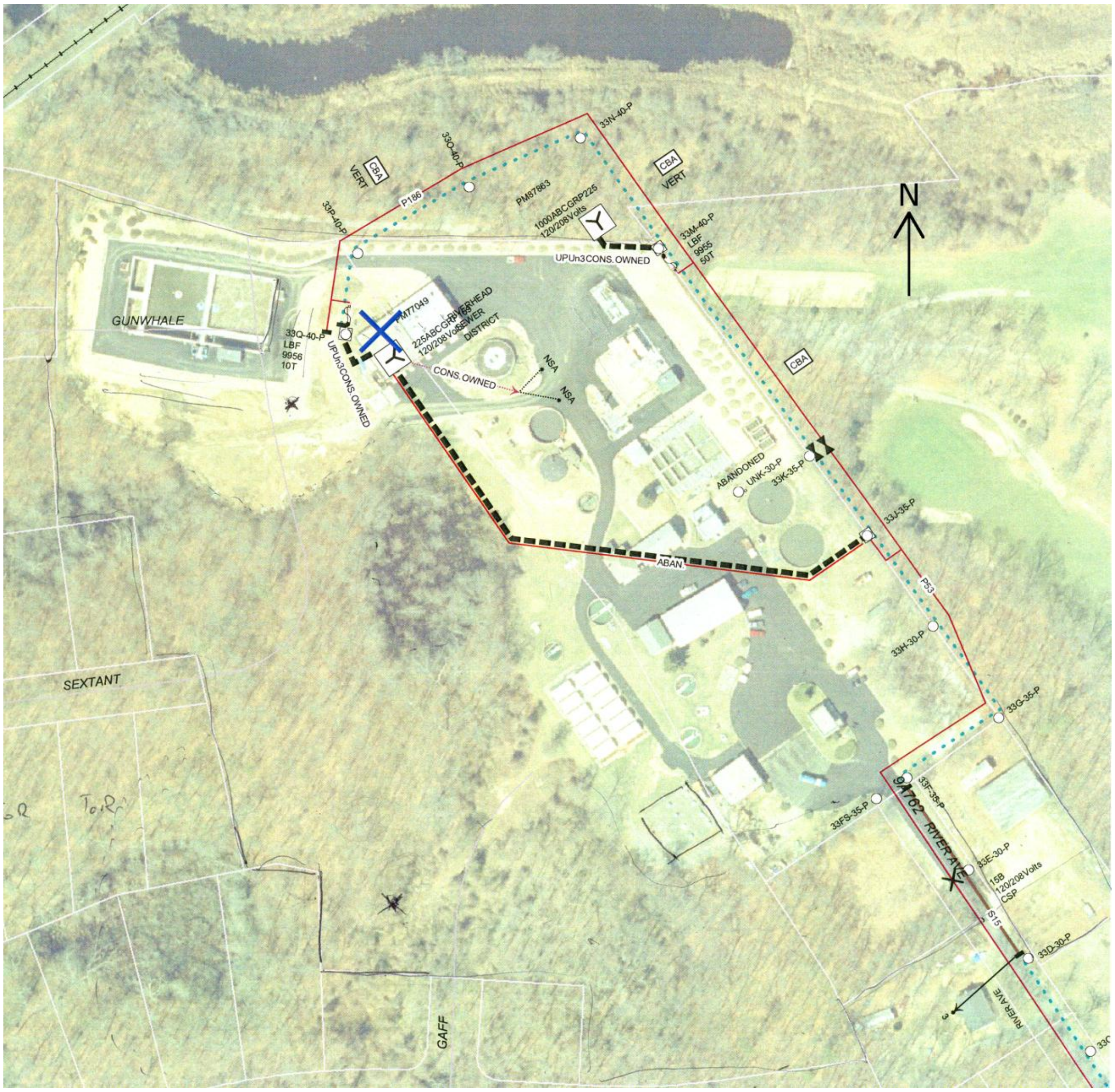


Figure 9.1: RSD electrical supply details, showing approximate location

Consultation with Long Island Power Authority

The proposed project was discussed at length with technical and commercial representatives from the Long Island Power Authority (LIPA) on January 27th, 2010 (3).

The discussion of interconnection issues covered the full potential range of wind turbine system ratings from 100kVA up to 1000kVA. The main technical points discussed are summarized below:

- The Riverhead Sewer District site currently has two separate interconnection points, with LIPA account numbers 957-20-1922-2 and 957-20-1920-1. These two accounts correspond to the separate Riverhead Sewer District and Riverhead Scavenger District operations at the site.
- Historical peak demand figures for the Sewer and Scavenger District connections are approximately 390kW and 150kW.
- Both interconnections are metered on the Low Voltage (LV) transformer terminals; all supply infrastructure up to and including the transformers and metering equipment is owned, operated and maintained by LIPA.

- The Riverhead Sewer District connection is the higher capacity of the two, with a transformer rating of 1000kVA. The Scavenger District transformer is rated at 300kVA.
- LIPA believe that the conductors supplying the site are rated for at minimum of 1500-2000kVA.
- LIPA's technical representatives are confident that the existing Riverhead Sewer District interconnection hardware is sufficient in principle for connection of a generating system rated at up to 1000kVA.
- However, the LIPA representatives cautioned that the particular generator and control technology to be used would be a major factor. Larger machines would be subject to more stringent requirements, but whilst some 1000kVA machines would likely be approved, some smaller machines might be rejected if they failed to meet certain power quality requirements; the relevant documentation was provided by LIPA for reference.
- Direct Transfer Trip (DTT) is typically required for any generating equipment rated above 1000kVA. This prevents harmful islanding issues by tripping the generator in the case of a supply trip on the distribution network, but significantly increases interconnect costs.
- LIPA Supervisory Control and Data Acquisition (SCADA) systems are typically required for any generating equipment rated above 1500kVA. This connects the generator to LIPA's centralized monitoring and control systems. SCADA also significantly increases interconnect costs, particularly as a Verizon leased line is required.
- Any wind turbine (even below 300kVA) using a directly connected synchronous generator would require both DTT and SCADA equipment to meet LIPA requirements.
- LIPA do not operate a reactive power (VAR) tariff, and therefore do not encourage reactive power compensation/power factor correction at customer sites. Instead, compensation is implemented centrally by LIPA. Whilst there may be advantages to this approach in cost and manageability, it may make DTT or other grid trip requirements more likely.
- Asynchronous machines below 300kVA using type tested inverters are unlikely to require DTT or SCADA. At higher ratings these facilities may or may not be required, depending on the power quality characteristics of the machine. Most medium and large scale wind turbines use asynchronous generator technology.
- Wind turbines using a “full range” or “back to back” inverter system (AC-DC-AC) are likely to meet LIPA grid interconnect requirements in most cases with little or no additional equipment. Several modern wind turbine designs incorporate such systems.
- A minimum power factor of 0.95 is required for any connected generator.
- LIPA reminded that the existing backup generator set could not be allowed to generate in parallel with a wind turbine if the combined export power could exceed the rating of the transformer.
- LIPA advised that indicative interconnection costs for a sub-300kVA machine without DTT or SCADA are around $15-20k.
- Advised indicative interconnection costs for a 1000kVA machine requiring additional equipment are in the $100-150k range.
- However, such costs are strongly dependent on the quality of the submission material and the number of design iterations required to gain approval.
- Two metering options are available. If little export is expected, a detented meter can be used; excess generation is not metered and would generate no revenue. If significant export is expected it will be necessary to install bidirectional metering at the customer's cost in order to generate revenue from excess generation.
- In order to begin the grid study and approval process, LIPA require an interconnect application including comprehensive design details for the system, including one-line and three-line diagrams and documentation of the generator system's dynamic and power quality characteristics.

The outcome of the initial discussion with LIPA was very positive. It is likely that interconnection of a wind generator at the RSD site can be achieved at relatively low cost if a suitable machine is selected; LIPA's indicative interconnect costs of $15k to $150k correspond to monthly interconnect charges of $142.50 to $1425. The existing infrastructure is of sufficient capacity to allow installation of a generator rated at up to 1000kVA. However, it has been made clear that interconnection costs will tend towards the high end of the given range if the proposed machine is poorly suited to LIPA's grid requirements or requires significant additional power conditioning or control equipment. It is therefore important to ensure that the turbine selection and electrical design processes are conducted with careful regard to LIPA's requirements.

Preference should be given to generators using electronically managed full range power conversion or well regulated asynchronous machines. Poorly regulated asynchronous and any synchronous machines should be avoided as the consequent negative impact on project economics is likely to be significant.

System design for submission to LIPA should comply with LIPA's interconnection requirements (48) (49), with special regard to the necessary standards compliance of all specified equipment.

Conclusion

Investigation of electrical infrastructure and LIPA grid connection requirements at the Riverhead site has shown that the proposed wind turbine project is feasible and there are no immediate 'show-stoppers' related to electrical supply and interconnection issues. The capacity limits advised by LIPA are sufficient to allow the full range of considered turbine ratings; however LIPA's power quality and operational requirements provide additional criteria for consideration in the turbine selection process.

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Appendix A: Wind turbine models considered

The following wind turbine models were considered during the selection process.

Manufacturer	Model	Rated Power (kW)	Rotor Diameter (m)
Northern Power Systems	North Wind 100	100	21
Wind Energy Solutions	WES 30	250	30
Bonus	B33/300	300	33
Enercon	E32/300	300	32
Bonus	B31/300	300	31
Nordtank	NTK300/31	300	31
Enercon	E30/300	300	30
Windmaster	WM28/300	300	28
Enercon	E33/330	330	33.4
Made	AE-32	330	32
Made	AE-30	330	30
Kenetech	USW33	360	33
Neg Micon	M400	400	36
Vestas	V34/400	400	34.8
Turbowinds	T400-34	400	34
Vestas	WD34	400	34
Neg Micon	M750-400/100	400	31
NEPC	400/100	400	31
Mitsubishi	MWT-450-39	450	39
Bonus	B37/450	450	37
Bonus	B35/450	450	35
Wind World	W490/37	490	37
Jacobs	43/500	500	43
Vestas	V42/500	500	42
Dewind	D4-500	500	41
Jacobs	41/500	500	41
Enercon	E40/500	500	40
Mitsubishi	MHI500	500	40
NedWind	40/500	500	40
Neg Micon	M1500-500	500	40
Zond	Z-40	500	40
Vestas	V39/500	500	39
Nordtank	NTK500/37	500	37
Tacke	TW-500	500	37
Wind World	W3700/500	500	37
Windflow	Windflow 500	500	36
NedWind	35/500	500	35
Windmaster	WM33/500	500	33
Nordtank	NTK550/41	550	41
Norwin	46-ASR-599 kW	599	46
Suzlon	S52/600	600	52
Fuhrlander	FL 600/50	600	50
Dewind	D4	600	48
Enercon	E48/600	600	48

Jacobs	48/600	600	48
Neg Micon	M1800-600/48	600	48
Neg Micon	NM600/48	600	48
Südwind	S48/600	600	48
Turbowinds	T600-48	600	48
Mitsubishi	MWT-600-47	600	47
RRB Energy	Pawan Shakthi PS-600 kW	600	47
Neg Micon	M1800-600/46	600	46
Windtec	646	600	46
Mitsubishi	MWT-600-45	600	45
Wincon	W600/45	600	45
Bonus	B44/600	600	44
Ecotecnia	44	600	44
Enercon	E44/600	600	44
Gamesa	G44/600	600	44
Navantia-Siemens	Bonus Mk-IV	600	44
Neg Micon	M1800-600/44	600	44
Vestas	V44/600	600	44
Goldwind	S43/600	600	43
Jacobs	43/600	600	43
Neg Micon	M1500-600	600	43
Neg Micon	NM43/600	600	43
Nordex	N43/600	600	43
Nordex	S43	600	43
Nordtank	NTK600/43	600	43
Tacke	TW-600	600	43
Gamesa	G42/600	600	42
Vestas	V42/600	600	42
Wind World	W600/42	600	42
Bonus	B41/600	600	41
Enercon	E40/600	600	40
Vestas	V39/600	600	39
Gamesa	G48/660	660	48
Gamesa	G47/660	660	47
Vestas	V47/660	660	47
Made	AE-46/I	660	46
Unison	U57	750	57
Unison	U54	750	54
Aeronautica Wind	Norwin 54-750	750	54
AWE	52-750	750	52
Lagerwey	LW750-52	750	52
Wind World	W5200/750	750	52
EWT	DW 750 / 51.5	750	51.5
Goldwind	S50/750	750	50
Unison	U50	750	50
Windey	WD49-750kW	750	49
Windey	WD50-750kW	750	49
Ecotecnia	48	750	48
Goldwind	S48/750	750	48
Jeumont	J48/750	750	48
Neg Micon	M1500-750/48	750	48
Neg Micon	M1800-750/48	750	48
Neg Micon	NM48/750	750	48

Vestas	NM48	750	48
Wind World	W4800/750	750	48
Windey	WD48-750	750	48
Windstrom Frisia	F48	750	48
NEPC	750/180-47	750	47
Norwin	47-ASR-750 kW	750	47
Aeronautica Wind	Norwin 47-750	750	47
NEPC	750/180-46	750	46
Norwin	46-ASR-750 kW	750	46
Zond	Z-46	750	46
Neg Micon	M1500-750	750	44
Neg Micon	NM44/750	750	44
Vestas	NM44	750	44
Goldwind	S43/750	750	43
Windmaster	WM43/750	750	43
Windmaster	WM40/750	750	40
Made (Gamesa)	AE-59	800	59
Made	AE-56	800	56
Enercon	E53/800	800	52.9
Made	AE-52	800	52
Nordex	N52/800	800	52
Windey	WD52-800kW	800	52
Nordex	N50/800	800	50
Enercon	E48/800	800	48
Gamesa	G58/850	850	58
Fuhrlander	FL 850/56	850	56
Windstrom Frisia	F56	850	56
Gamesa	G52/850	850	52
Vestas	V52/850	850	52
PowerWind	56	900	56
Conergy	Powerwind 56	900	56
AWE	54-900	900	54
ITP	900 kW - 54	900	54
EWT	DW 900 / 54	900	54
AWE	52-900	900	52
Neg Micon	NM52/900	900	52
Vestas	Multipower 52	900	52
Vestas	NM52	900	52
ITP	900 kW - 51.5	900	51.5
EWT	DW 900 / 51.5	900	51.5
Enercon	E44/900	900	44
Suzlon	S64/950	950	64

Appendix B: Meteorological mast specification

Neutral Power Standard Specification for Wind Measurement

40m tubular guyed mast, Version 1, March 2010

Context

The following document specifies the type and general arrangement of anemometry to be used as standard for meteorological masts installed by the Contractor working for Neutral Power.

The exact location of the mast installation will either be defined by Neutral Power or mutually agreed during a preceding site visit with a Neutral Power representative at a date to be agreed after award of any contracts.

Any site specific requirements noted in other related Neutral Power documents shall take precedence over the standard requirements herein.

Where the Contractor is engaged to only install equipment (i.e. not procure) then the installation requirements and practices are relevant only.

Mast & Anchors

The mast shall be tubular and of total overall height noted in Annex I and suitable for installation at the proposed site, and shall comply with the relevant local standards as applicable.

All guy wires and clamps or other metallic parts should be galvanized for inland sites or of stainless steel for coastal sites or other areas where saline or corrosive atmospheric conditions are present (e.g. geothermal or inland saline water bodies). Guywires should be oriented such as to minimize flow effects to the sensors; details of proposed sensor positions are given in Annex I.

The mast should be designed and constructed for a minimum life span of 3 years without any major maintenance requirements.

The mast base and anchors should be protected from any livestock which may be present from time to time.

Anemometry – See Annex I

A “primary anemometer plus redundancy” philosophy is employed by Neutral Power. This entails a mixture of primary anemometers compliant with [1] (Accuracy class 1 or better) combined with “redundant” anemometers of high reliability and experience, but lower cost. Currently our preferred instrument type for ‘redundant’ anemometers is the NRG Maximum #40.

All anemometers shall be mounted so that the cup spindle is vertical and the cup rotation plane is horizontal.

All sensors shall be individually calibrated before field use and calibration certificates shall be supplied. Individual calibration of anemometers in a MEASNET [2] approved wind tunnel, to the MEASNET standard [2] to at least ±1%, is required for primary anemometers. Approved alternative calibration methods for ‘redundant’ anemometers are acceptable (for example NIST calibration or similar for NRG type sensors).

The Contractor should provide an optional consideration for the ongoing annual calibration and post calibration of the sensors.

Anemometer Mounting – See Annex I

Anemometers are to be mounted on booms with cup heights as detailed in Annex I. All booms are to be of circular section, preferably of stainless steel and shall be fully compliant with [1] and [3] for minimum flow distortion (≥ 0.5% deficit or better).

Boom directions should be oriented to comply with [1] and Annex I and should be compact and symmetrical.

For sites where the wind is significantly unidirectional, horizontal booms shall be orientated at 45° to the prevailing wind direction.

Where anemometers use rubber “boots” to protect wiring, these should be non-permanently fixed to the anemometer body using a small bead of sealant.

Wind Vanes – See Annex I

Wind vanes shall be supplied in accordance with the requirements of Annex I. All wind vanes shall comply with the requirements of [2] and should have a maximum dead band of 4°.

All wind vanes are to be mounted on booms similar to those used for the anemometers. Orientation of wind vane booms shall be in the same direction as the anemometer booms and at the heights prescribed in Annex I. The orientation of the wind vanes shall be such that the dead-band is aligned parallel with its mounting boom and pointing towards the mast. After mast erection the orientation of the wind vane boom shall be measured and an appropriate offset programmed into the data logger.

Where wind vanes use rubber “boots” to protect wiring, these should be non-permanently fixed to the wind vane body using a small bead of sealant.

Data Logger

A NRG Symphonie™ GSM enabled data logger shall be used. The logger shall be provided with all applicable SCM cards, antenna and any other peripheral attachments required to meet the functionality specified herein and in Annex I.

The system shall be configured such that batteries will remain suitably charged even through winter months with periods of low sunlight levels.

Data Retrieval

The recorded data shall be available for recovery (downloaded via GSM or CDMA modem) regularly and stored on computer; Neutral Power will provide details of any email addresses to be programmed into the logger.

The Contractor shall advise local requirements for procurement of any SIM card or mobile telephone accounts required.

The system should be capable of a data recovery rate of at least 98% for the top level instruments, and at least 94% for the other sensors.

All data will be transmitted to Neutral Power. The supplier shall coordinate data recovery processes with the nominated representative from Neutral Power to ensure that a robust and reliable system is set up and maintained.

Wiring

All sensor wiring shall be protected from chafing at the tower section joins and guy wire plates, or enclosed in flexible protective conduit, except when traversing the mounting booms. The wiring and flexible conduit (if fitted) shall be spirally wrapped around the mast. All wiring shall be secured in place with regularly spaced industrial grade, UV-resistant cable ties. Any tape used shall be UV-resistant and suitable for a minimum of 3 years' duty in the local environment. All wiring shall enter the logger enclosure through waterproof glands. A suitable sealant compound shall be used to seal points of potential water or dust ingress if necessary.

The arrangement of the sensor wiring at the sensor booms shall comply with [1]. Wiring shall be tidy and secure and cause a minimum of flow disturbance. The sensor wiring shall be enclosed within the support pillars and booms if possible, connecting to the sensors with weatherproof plugs. When external wiring is employed, the "effective boom diameter" (including the wiring and any conduit) shall be used when assessing the boom – anemometer cup separation distance as recommended in [1].

Lightning Protection

A professional lightning protection system shall be installed in accordance with [1]. A separate cable (multi or single strand copper) shall connect the mast top lightning conductor to the earthing rod. All copper connections shall be used to join the lightning protection components.

The final placement of the mast top lightning conductor shall not interfere with the instrumentation. If the installer has any doubt they should contact Neutral Power before installation.

Documentation

Following the site installation an installation report is required before Neutral Power will Take Over the equipment. The documentation provided shall be in accordance with Neutral Power's Standard Requirements for Installation Reporting attached as pro-forma in Annex II.

Maintenance

Neutral Power may require a regular preventative maintenance program to be implemented by the Contractor. The scope of such a program shall include at minimum:

- Six monthly site inspections.
- Visual inspection of tower, including photographs.
- Any and all mechanical adjustments required to correct tower alignment (e.g. guy wire re-tensioning).
- Inspection of anchor points, including wire clamps and report on any corrosion.
- Inspection of logger and wiring terminal block.
- Water proofing of any cable entry points or other areas.
- Replacement of non-rechargeable batteries
- Replacement of memory card (including retention of existing and delivery to Neutral Power as required)
- Repair of any damage.
- Any other maintenance required to ensure smooth and continuous operation of the mast, logger and sensor equipment.

Safety

Installation, maintenance and removal activities shall be conducted according to the procedures and instructions provided by equipment manufacturers. Correct tools and personal protection equipment shall be issued to all staff and all site safety procedures shall be followed. Risk assessment and Safe Systems of Work documentation shall be prepared and approved by site management and Neutral Power before work may commence.

Completion

Taking Over of any met mast (and final payment to Contractor) will occur when the Neutral Power representative confirms full compliance with the Specification in accordance with Neutral Power quality systems. A Neutral Power representative will attend the installation and ensure such compliance.

Warranty

All equipment should be warranted in accordance with manufacturers standard warranties, details of which should be provided to Neutral Power and clarified with any Tender or Quotation provided. A 3 (three) year Warranty on Workmanship should be provided by the Contractor.

Confidentiality

All data provided is the property of Neutral Power and shall remain the property of Neutral Power and may not be used in any way other than as a reference for technical compliance for Neutral Power projects. All data collected by systems installed by the Contractor is the property of Neutral Power and may not be received, stored, held or used by the Contractor or any other party without the explicit written permission of an authorized representative of Neutral Power.

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Annex I – Summary of sensors and their arrangement

Component	**Height** (mAGL)	**Boom Orientation** (° from True North)	**Boom Length** (D= tower diameter)	**Vertical Separation** (D_b= boom diameter)	**Sensor Type** (example)	**Calibration**	**Other information**
Overall Tower height	40	N/A					
Logger/Comms	N/A				Symphonie + iPack		
Anemometer 1 (primary)	39	280	≥8.5D	≥12D_b	Riso P2546A	MEASNET	
Anemometer 2 (secondary/redundant)	39	170	≥8.5D	≥12D_b	NRG #40	NRG	
Anemometer 3 (primary)	30	280	≥8.5D	≥12D_b	Riso P2546A	MEASNET	
Anemometer 4 (primary)	21	280	≥8.5D	≥12D_b	Riso P2546A	MEASNET	
Anemometer 5 (secondary)	21	170	≥8.5D	≥12D_b	NRG #40	NRG	
Anemometer 6 (secondary)	10	280	≥8.5D	≥12D_b	NRG #40	NRG	
Vane 1	37.5	280	≥8.5D	≥12D_b	NRG #200P		Deadband to 100 deg
Vane 2	18.5	170	≥8.5D	≥12D_b	NRG #200P		Deadband to 350 deg
Temperature	~35	N/A			NRG 110S or similar	NRG	
Barometric Pressure	~35	N/A			NRG BP20 or similar	NRG	

Annex II – Pro forma installation report

<table>
<tr><td colspan="7">Neutral Power – Installation Report template</td></tr>
<tr><td>Site Name</td><td colspan="4"></td><td>Site ID</td><td></td></tr>
<tr><td>Site Description</td><td colspan="6"></td></tr>
<tr><td colspan="2">Installation Details</td><td colspan="5">Communication and Logger details</td></tr>
<tr><td>Date Installed</td><td></td><td colspan="2">GSM phone number</td><td></td><td>Logger Type/serial</td><td></td></tr>
<tr><td>Installed by</td><td></td><td colspan="2">Email address</td><td></td><td>Modem serial</td><td></td></tr>
<tr><td>Engineer</td><td></td><td colspan="2">ISP contact</td><td></td><td>SIM PIN/PUK</td><td></td></tr>
<tr><td>Tower Type</td><td></td><td colspan="2">Power Supply</td><td></td><td>Local Time Zone</td><td></td></tr>
<tr><td>Tower Height (mAGL)</td><td></td><td colspan="2">Beacon/aviation details</td><td></td><td>Other2</td><td></td></tr>
<tr><td rowspan="3">Site Coordinates</td><td></td><td>North</td><td rowspan="3">Grid Datum</td><td rowspan="3"></td><td rowspan="3">Magnetic Decl (+N)</td><td rowspan="3"></td></tr>
<tr><td></td><td>East</td></tr>
<tr><td></td><td>Elevation</td></tr>
</table>

Ch	Type (make/model)	Height (mAGL)	Serial #	Boom Azimuth (Deg TN)	Tower – sensor dist (mm)	Slope	Offset	Units	Other (eg. vane deadband)	Tower diameter (mm)
1						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
2						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
3						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
4						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
5						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
6						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
7						(As calibrated) (As programmed)	(As calibrated) (As programmed)			
8	(Copy as required)					(As calibrated) (As programmed)	(As calibrated) (As programmed)			

Other information	
Guy wire orientations	
Foundation, Anchors, soil conditions etc. (if applicable)	
General site conditions – vegetation, obstacles. (if applicable)	
Land owner contact details (if applicable)	
Maintenance contractor details (if applicable)	
Other	

Installation Contractor	
Certified by (Neutral Power)	
Date	

Appendix C: NYSERDA Funding Application under RFP 10

Appendix E

Project Description

Implementation Funding for Small Municipalities
American Recovery and Reinvestment Act (ARRA)

Riverhead Sewer District Renewable Energy Assessment
(Energy Management Personnel Project)

Proposer Description	The Riverhead Sewer District (RSD) is one of the departments of the municipality of the Town of Riverhead. RSD operates a central wastewater processing facility, 12 pumping stations and 25 miles of sewer drains serving the hub area and business district of Riverhead. The most significant of these sites, and therefore the focus for this project, is the RSD processing plant at River Avenue in the Town of Riverhead. Also on the same site is the Riverhead Scavenger Waste (RSW) Plant, which processes septic waste from five East End towns and Eastern Brookhaven.
Project Description	The RSD site processes around 800,000 gallons of waste per day, with a maximum capacity of 1,200,000 gallons per day. The RSD processing equipment currently installed at the site consumes up to 355kW of electrical power, at a monthly cost of around $30,000. The RSW equipment consumes over 100kW. RSD is currently planning a significant upgrade to these facilities to ensure that they meet the increasing demands of the Sewer District's activities. This upgrade is expected to increase the electrical load of the processing plant by a factor of three, with corresponding implications for operating costs to the Riverhead Sewer District. The land containing the RSD processing plant, along with much of the neighboring property, is owned by the Town of Riverhead. Riverhead Sewer District has begun to research various options to manage the considerable and rising energy consumption demanded by its waste processing activities; one such option is renewable energy generation. The aim of the Renewable Energy Assessment project is to assess in detail the potential for on-site renewable energy generation as an energy management measure at Riverhead Sewer District.

Project tasks	The project tasks will be undertaken by an external consultancy specializing in Energy Management and Renewable Energy. The team will investigate and assess each of the major factors relating to an on-site renewable energy project, including: • Project constraints and site integration (Including physical constraints, design envelope and operational impact) • Planning and permitting (Including engineering control, FAA/FCC approval and environmental impact) • Resource assessment • Equipment selection • Commercial arrangements and economic modeling (including power purchase, system performance and economic feasibility) • Civil and Structural Engineering (Including geotechnics and suitable modes of construction for renewable energy plant) • Electrical and Control Engineering (Including interconnect and control systems) Having assessed the relevant factors, the consultancy team will report their findings and recommendations with regard to employing on-site renewable energy generation as part of RSD's energy management strategy. The consultant's report will detail the activities and likely costs involved in implementing a renewable energy project, along with the expected energy savings and economic performance of such a project.
Project Measures	Riverhead Sewer District will engage the services of an external consultancy specializing in Energy Management and Renewable Energy. The consultancy team will produce a series of complementary reports, culminating in specific recommendations with regard to renewable energy production and integration into the site's electrical system. Together, these reports will form a comprehensive assessment of the renewable energy potential at the Riverhead Sewer District site. The subjects addressed in the report will correspond to the factors listed in the Project Description section above, but specifically include: • Project design envelope • Operational impact • Environmental impact • Landscape and visual impact • Noise impact • Telecommunications

- Aviation
- Resource assessment
- Carbon footprint assessment
- Equipment selection
- Equipment supply
- Technical modeling and uncertainty
- Financial modeling and economic feasibility
- Power purchase
- Grid interconnection and permitting
- Operations and maintenance
- Project finance
- Geotechnical conditions
- Foundation design
- Electrical configuration
- Grid compliance
- Supervisory control and communications

Current indications are that a renewable energy project has the potential to significantly reduce the energy costs associated with Riverhead Sewer District's activities. However, a detailed assessment is needed to confidently determine the technical and economic feasibility of such a project.

Project Locations

The project focuses on Riverhead Sewer District's central processing facility at River Avenue (off Riverside Drive), Riverhead, New York 11901. Project activities will include analysis of the site and the immediately surrounding area to determine the various resources and impacts of relevance to the project. In particular, noise, visual impact and environmental assessments may involve surveying and analysis to determine the effect of an on-site renewable energy project at a distance of up to several miles from the site.

The project will therefore consider various factors related to the Riverhead area, and may involve consultation with local residents and other stakeholders.

Project Costs

The total budget for undertaking the assessment project is to be $107,780. This is based on the following consultancy rates applied to an estimate of hours as shown.

Project Manager	$170 /hr	50 hrs
Project Engineer	$120 /hr	592 hrs
Civil/Structural Engineer	$120 /hr	50 hrs
Electrical Engineer	$120 /hr	50 hrs
Project Analyst	$80 /hr	85 hrs
Supervising P.E.	$140 /hr	40 hrs
Environmental Consultant	$120 /hr	32 hrs

These figures include a reasonable contingency and represent an upper limit for the project.

Description of Computer Modelling	Various computer modeling exercises will be employed in the assessment project. Specifically, renewable energy system performance will be modeled using specialist commercial and custom-developed engineering software. Financial and statistical aspects will be modeled using commercial mathematical and spreadsheet software.