North Coast Seafoods

43 Blackmer Street
New Bedford, MA

Feasibility Study of On-Site Wind Energy

Prepared by:

Cape & Islands Self-Reliance Corporation

Clean Energy Design

Horsley Witten Group

Woods Hole Research Center

Clean Power Now

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NOTICE and ACKNOWLEDGEMENTS

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Montigny for meeting with North Coast to discuss the project and provide insight on political support within New Bedford.

ABSTRACT AND KEYWORDS

Through this study, the feasibility of implementing an on-site wind generator is explored for North Coast Seafoods' 43 Blackmer Street site, which consists of 6.62 acres of land with a 55,000 square foot fish processing facility that was constructed in 2005 on a remediated brownfield. According to the zoning code of the City of New Bedford, the site is situated in the "Working Waterfront Overlay District" and "Industrial B" zone.

North Coast Seafoods' New Bedford facility is located in an Economic Target Area, as designated by the State of Massachusetts. The facility consumes 1.4 million kilowatt hours annually. Over the last 7 months, North Coast has been paying an average of 14 cents per kilowatt-hour for electricity, up from 12 cents per kWh when the facility first came on line in March 2005.

The site can easily accommodate a wind turbine, and wind resource data measured on site, indicates that the most economically productive wind is at 100 meters, with an average wind speed of 13.1 miles per hour. Based on the calculations done with the wind data and the on-site electrical usage, there is a range of compelling scenarios utilizing various size machines to meet North Coast Seafoods' behind-the-meter needs for power.

KEY WORDS

City of New Bedford

North Coast Seafoods

Remediated Brownfield

Wind Turbine

NSTAR Electric

Renewable Energy

Simple Payback

Settlement Only Price Taker

Renewable Energy Certificate

TABLE OF CONTENTS

EXECUTIVE SUMMARY

North Coast Seafoods is a third generation, family-run seafood processor and distributor, headquartered in Boston, Massachusetts, which also operates 50,000 square foot processing facility located on a 6.62-acre parcel at 43 Blackmer Street in New Bedford, Massachusetts. The site is located adjacent to the hurricane barrier that separates New Bedford Harbor from Buzzards Bay. The site is low-lying, about 600 feet east of the Acushnet River.

During its first full year of operation, which began in March of 2005, the facility consumed 1,433,752 kilowatt-hours. North Coast Seafoods, as a traditional advocate of sustainable practices and renewable resources, views the implementation of a wind turbine on their site as not only as a means to conserve energy and reduce costs, but also to remain a socially conscious, environmentally responsible, long-term business partner in the New Bedford Area. North Coast Seafoods has plans for expansion of the facility in the future.

North Coast Seafoods decided to explore the feasibility of wind power because their new facility at 43 Blackmer Street in New Bedford seemed to be in a windy location, the cost of electricity has continued to rise and there is a need for constant refrigeration in the fish processing plant.

If this study had been conducted a number of years ago, it would have been determined that 43 Blackmer Street was not an ideal site to locate a wind turbine. This is due to the fact that in the last three to five years, wind turbine manufactures have been increasing the hub heights for their machines. In fact, the GE 1.5 sl machine comes on a 100 meter tower. In years past, the smaller capacity machines were offered on 50 meter towers as the maximum. Now a number of wind turbine manufactures are no longer producing smaller capacity machines and the larger machines are offered with much taller towers.

Wind data has been collected from the 580-foot radio tower adjacent to the North Coast Facility. Meteorological equipment was installed at 65 meters, 80 meters and 100 meters and has been collecting data since October 2005. In addition to providing the direct service of evaluating the feasibility of a wind turbine at 43 Blackmer Street, this effort will significantly improve upon our regional understanding of the wind resource at hub heights now typically employed by modern utility-scale wind turbines. The Truewind resource map indicates an average wind speed of approximately 13.5-14.5 miles per hour at 70 meters, and between 14.5 –15.7 miles per hour at 100 meters.

Measured data collected from the radio tower over an 8 month period from October 2005 through June 2006 indicates that the average wind speeds at 100 meters are 15.9 miles per hour. At 80 meters the average recorded wind speed is 14.9 miles per hour. At 65 meters the average recorded wind speed is 14.1 miles per hour. This data represents the period of the year when winds are more robust, whereas, the wind resource for the remainder the year is somewhat less. To provide a more accurate estimate of the viability of the site's wind resource and to properly reconcile less than a full year of site-collected data, a correlation was made with the BUZM3 meteorological tower to estimate the power produced on an annual basis. The BUZM3 station is located in nearby Buzzard's Bay (see figure 3) and has been collecting continious wind data at 24.8 meters above sea level since 1997.

The correlated annualized data at 100 meters indicates a 14.4 miles per hour average speed, 13.4 miles per hour at 80 meters and 12.9 miles per hour at 65 meters. On-site data collection will continue for North Coast Seafoods so the data can be verified against the BUZM3 data extrapolations that have been done as part of this study.

As part of the feasibility analysis, an exercise was executed to determine whether increasing the tower height on the four turbines evaluated would have a substantial impact on the return on investment. What was determined is that: it makes sense to go up to 100 meters even if the cost per meter of additional tower height from 80m to 100m increased fourfold, because the output of the machine will more than justify the increased cost of the tower.

Based on North Coast Seafoods' desired payback range of 6 years, the recommended installation would be a GE 1.5 sl, which is a 1.5 megawatt turbine with a blade length equivalent to a 2 megawatt turbine. This machine is designed to produce power in lighter wind regime situations, thereby improving the production of power during North Coast Seafoods' peak time of electricity consumption. However, North Coast Seafoods may determine that their needs can be adequately met with the EWT 900 kW turbine. The EWT 900 kW machine has lower installed costs, it matches the annual load of the facility and may be the best machine to maximize potential funding from the Massachusetts Technology Collaborative's Large On-Site Renewables Initiative.

The environmental and permitting issues that were evaluated were avian species and migration; soils; wetlands and coastal resource areas; rare species; and local, county and state zoning and permitting issues as they relate to the installation of a wind turbine at 43 Blackmer Street in New Bedford.

There are no limitations for use of the site as they relate to the soil and geology reports. With relation to the issues of flooding, the adjacent hurricane barrier that is at the mouth of the Acushnet River has been constructed to protect low-lying sites from flooding. There are no wetlands existing at the 43 Blackmer Street lot.

It has also been determined that the site does not contain any priority habitat of rare species or estimated habitat of rare wildlife as defined by the Massachusetts Natural Heritage and Endangered Species Program.

A notice will need to be filed with the Federal Aviation Administration before the project construction begins, since the structure will exceed the threshold of 200 feet above natural grade. However, since the site is adjacent to a 580' radio tower and there are a number of other tall structures in the vicinity, the process should be straight-forward.

Since the City if New Bedford has a height restriction of 100 feet in the Industrial B and Working Waterfront Districts, the proposed project will need approval from the Planning

Board to allow the non-conforming structure to be constructed. The City will also have to authorize a building permit to erect a wind turbine on the site.

Once North Coast Seafoods has determined what size installation best meets their needs, the project team plans to meet with various parties in the City of New Bedford to discuss the project and determine what permits, notices and reviews may need to be completed.

The project team members conducted some preliminary educational outreach on the proposed project by speaking with the Ward Representative, the State Representative and State Senator, as well as the Planning Office in the City of New Bedford. Additional educational outreach efforts will be required as the project moves forward.

INTRODUCTION

Located in the southern end of the New Bedford working waterfront industrial zone, this site provides challenges and opportunities for the construction of a utility-scale wind turbine.

The approach taken in this study was to evaluate the site's wind resource potential with direct measurements taken at the prospective hub heights at which a turbine could be installed. Typical wind resource assessments are conducted with anemometry towers ranging from 30m to 60m in height. This requires some conjecture as to the actual wind resource conditions at the taller heights a wind turbine's nacelle is generally mounted. Regional knowledge of the vertical distribution of the wind resource (wind shear) is quite limited. Therefore, this study was undertaken to provide a solid basis for evaluating which tower height is sufficient to ensure an installation's cost-effectiveness.

The turbines evaluated are the EWT 900 kW turbine; the GE 1.5 MW sl; the Vestas V80 1.85 MW turbine and the Harakosan Z72 2 MW turbine. There are various factors to be considered when evaluating the different models. It should be noted that the nameplate rating of each machine does not necessarily mean that machine will produce the most power. Other factors, such as tower height, blade length and generator configuration affect power production. To put that in perspective, the EWT 900 turbine has the smallest rotor diameter (54 meters), the Harakosan Z72 2 MW has a bit larger rotor diameter (72 meters), the GE 1.5 MW sl has a rotor diameter of 77 meters and the largest of the turbines that were used in our analysis is the Vestas V80 1.8 MW turbine with a rotor diameter of 80 meters. A turbine's rotor diameter is directly proportional to the amount of power that the turbine can capture.

The following factors were used to determine what model may be best suited for the needs of the North Coast Seafoods facility.

- Interpretation of the data from the wind,
- on-site power consumption,
- electricity costs,
- renewable energy credit (REC) sales,
- sale of energy back to the grid as a Settlement Only Price Taker,
- Production Tax Credit values
- Turbine production

Modern wind turbines of the size class applicable to a commercial installation are typically offered on towers of significant height, which exceed the standard 50-meter tower of years past.

EVALUATING THE SITE'S WIND RESOURCE POTENTIAL

The neighboring property to the north is owned by Hall Communications, which operates a multi-purpose 580' radio tower. This cooperative neighbor agreed to host the placement of anemometry equipment for data logging wind resource directly at potential hub heights of proposed turbine(s).

The 580-foot radio transmission tower has been instrumented with standard wind resource anemometry data logging equipment at heights of 210, 260, and 325 feet above the ground (65, 80 and 100m). In addition to providing the direct service of evaluating the feasibility of a wind turbine at the client site, this effort will significantly improve upon our regional understanding of the wind resource at hub heights now typically employed by modern utility-scale wind turbines.

The rationale for correlating the data from the radio tower to the data tower off Cuttyhunk (BUZM3) (see figure 3) is to extrapolate a longer-term trend from a limited data record since we do not yet have data from the radio tower for the summer months. It is critical to make this extrapolation of the wind resource at 43 Blackmer Street based on real wind data since the refrigeration load at the North Coast Seafoods' facility peaks in the summer months when the winds are lighter.

Direct measurements of the wind resource at the height of the prospective installation will also serve to guard against the prospect of disappointing performance of an installation of insufficient height.

Finally, the record gathered at this site will increase the knowledge of the vertical nature of the wind resource (wind shear characteristics) in coastal Southeastern Massachusetts, so that other interests considering wind projects can evaluate prospective projects in the context of actual data, and avoid the pitfalls of installing expensive equipment in characteristically messy, turbulent air where performance is disappointing.

The topography of the site is low-lying land adjacent to the easterly-facing harbor front. The cityscape rises on a gentle ridge to the west and particularly northwest. Southwesterly (towards the prevailing wind) from the site is crowded with multi-story brick buildings nearby then opens onto Clark's Cove less than ½ a mile away.

Being in an industrial zone, the area immediately surrounding the site is populated with large blunt buildings that create a significant impediment to smooth laminar airflow. This disturbed air layer is several times the height of the objects causing the disturbance, and, while only fractionally lower in measured wind speed it causes a drastic reduction in power yield. This has been demonstrated through research of objects causing ground turbulence as shown in the wind shading examples below, which illustrate the percentage of wind speed and subsequent energy loss associated with turbulence caused by a seven story office building.

Figure 1.

Wind Shade

Wind Speed in per cent of Wind Speed Without Obstacle

m height	21	43	64	86	107	129	150	171	193	214	236	257	279	300	321	343	364	386	407	429	450 m
75	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99
73	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	99
70	100	100	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	99	99	99	99
68	100	100	100	100	100	100	100	100	100	99	99	99	99	99	99	99	99	99	99	99	99
65	100	100	100	100	100	100	100	100	99	99	99	99	99	99	99	99	99	99	99	99	99
63	100	100	100	100	100	100	100	99	99	99	99	99	99	99	99	99	99	99	99	99	99
60	100	100	100	100	100	100	99	99	99	99	99	99	99	98	98	98	98	98	98	98	98
58	100	100	100	100	100	99	99	99	99	98	98	98	98	98	98	98	98	98	98	98	98
55	100	100	100	100	100	99	99	98	98	98	98	98	98	98	98	98	98	98	98	98	98
53	100	100	100	100	99	99	98	98	98	97	97	97	97	97	97	97	97	97	98	98	98
50	100	100	100	99	99	98	98	97	97	97	97	97	97	97	97	97	97	97	97	97	97
48	100	100	100	99	98	98	97	96	96	96	96	96	96	96	96	96	96	97	97	97	97
45	100	100	99	99	98	97	96	95	95	95	95	95	95	95	95	96	96	96	96	97	97
43	100	100	99	98	96	95	94	94	93	93	94	94	94	94	95	95	95	96	96	96	96
40	100	100	98	96	95	93	93	92	92	92	92	93	93	94	94	94	95	95	95	96	96
38	100	99	97	95	93	91	90	90	90	90	91	91	92	93	93	94	94	95	95	95	96
35	100	98	95	92	90	88	88	87	87	88	89	90	91	92	92	93	94	94	94	95	95
33	100	97	92	88	86	85	84	84	85	86	87	89	90	91	91	92	93	93	94	94	95
30	99	94	87	83	81	80	81	81	82	84	86	87	88	90	91	92	92	93	94	94	95
28	99	89	81	76	75	75	76	78	79	81	84	86	87	89	90	91	92	93	93	94	94
25	96	81	71	68	68	70	72	74	76	79	82	84	86	88	89	90	91	92	93	94	94
23	90	68	59	58	60	63	67	70	73	77	80	83	85	87	89	90	91	92	93	93	94
20	78	48	43	46	52	57	63	67	71	75	79	82	85	87	88	90	91	92	93	94	94
18	52	21	24	34	43	52	59	65	69	74	79	82	85	87	88	90	91	92	93	94	94
15	4		4	22	36	48	56	63	69	74	79	82	85	87	89	90	91	92	93	94	95
13				13	32	46	56	63	69	75	79	83	86	88	90	91	92	93	94	94	95
10				9	32	47	58	65	71	77	81	85	87	89	91	92	93	94	95	95	96
8				14	38	53	63	70	75	80	84	87	89	91	92	93	94	95	96	96	97
5				31	51	63	72	78	82	85	88	91	92	94	94	95	96	96	97	97	98
3			36	60	72	80	84	88	90	92	94	95	96	97	97	98	98	98	98	99	99

= Obstacle 20 m tall = Turbine Tower 50 m tall

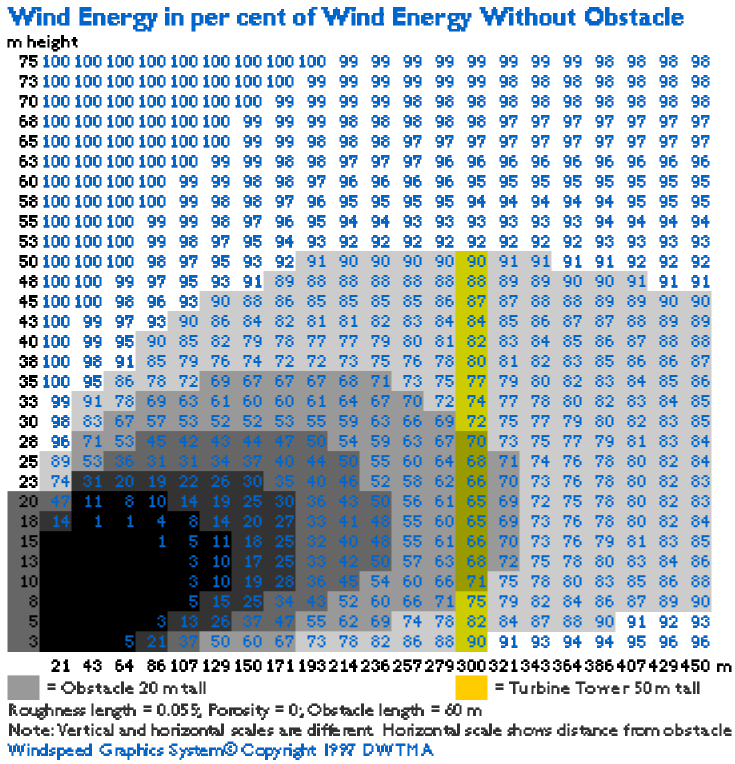
Roughness length = 0.055; Porosity = 0; Obstacle length = 60 m

Note: Vertical and horizontal scales are different. Horizontal scale shows distance from obstacle

This graph gives you an estimate of how wind speeds decrease behind a blunt obstacle, i.e. an obstacle, which is not nicely streamlined. In this case we use a seven-story office building, 20 metres tall and 60 metres wide placed at a distance of 300 m from a wind turbine with a 50 m hub height. You can quite literally see the wind shade as different shades of grey. The blue numbers indicate the wind speed in percent of the wind speed without the obstacle.

Updated 9 June 2003

http://www.windpower.org/en/tour/wres/shade.htm



http://www.windpower.org/en/tour/wres/shade.htm

Wind Resource Assessment Methods:

Anemometer heights and orientation – Three levels of anemometers were planned to obtain valid wind sheer values; the heights – 65, 80, and 100 meters were chosen to give direct values for several possible tower sizes. The anemometers were mounted on specially fabricated 10' offset booms to minimize the radio tower wind shadow influence. The booms were placed across the southwest facing side of the tower triangle with the anemometers toward the northwest and southeast at each level. This orientation minimizes the tower shadow in the predominant prevailing wind directions. Wind vanes were fitted to the west end of each offset boom inboard of the anemometer.

The redundancy of having two anemometers at each of the three measurement heights serves to provide an accurate reading of wind speed in all wind directions. It also provides an ability to check the relative accuracy of the measurements if data sets are examined during a period where wind direction is not causing shadowing from the tower to either instrument.

The data logger used is a Second Wind ‘Nomad 2’ with a total of 20 input channels. Data retrieval is conducted by periodic site visits to swap 32 MB flash cards. These data sets are being supplied to the UMASS RERL for archival, validation and integration into the MTC online database as they are downloaded from the tower site. The data collection from this site will continue until the end of the year, if not longer.

Anemometers at each level were situated on the tower so at least one sensor always experiences an unobstructed view of the wind from any quarter.

Results of a partial year of local wind resource survey:
According to the data monitoring at the radio tower adjacent to North Coast Seafoods’ facility during the last eight months, the wind speeds are averaging 15.9 miles per hour at 100 meters. **The amount of wind shear recorded at the North Coast Seafoods site is substantial:**

	Shear exponent	Resultant wind speed increase with increased tower height	Resultant power generated with increased tower height
80m to 100m	0.32	7.3%	23.5%
65 m to 80m	0.26	5.5%	17.3%

Shear exponent = ln(V2/V1)/ln(H2/H1)

% increase with height: (V2/V1) = $(H2/H1)^{shearexponent}$

% power increase with height = (1 + % increase with height)^3

These robust shear values (increase in wind-speed with increasing height) have a pronounced affect on the power available at different heights above the ground. Figure 2 shows how the energy content of the winds (power density) increases, relative to the measured value at 65m, with increasing height above the ground.

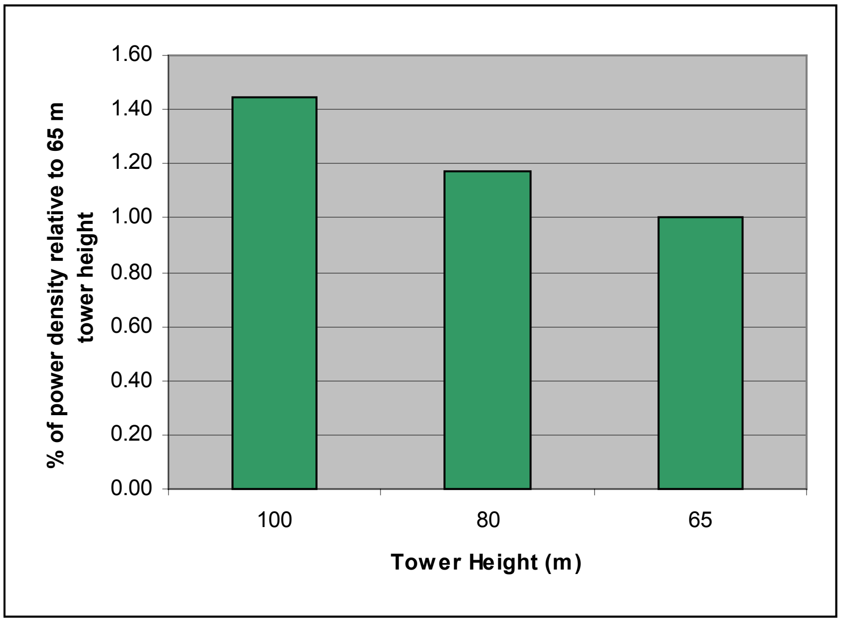


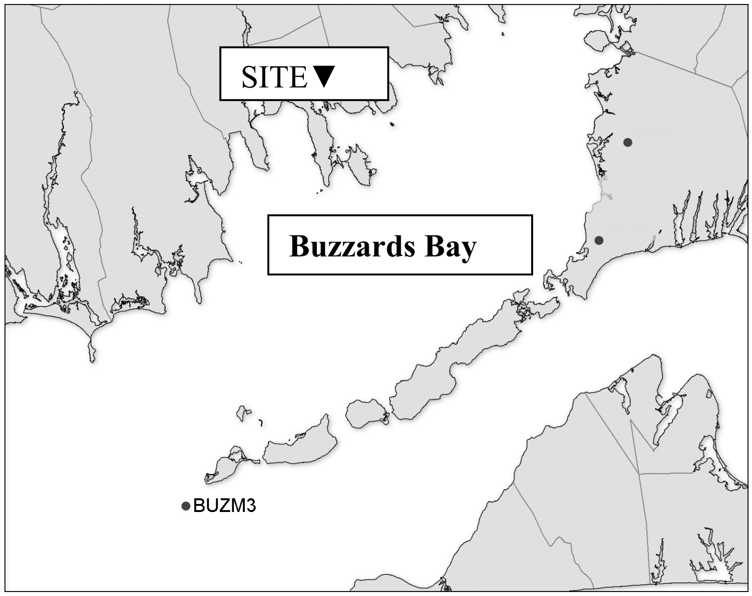
Figure 2. Proportional increases in power density of the 80m and 100m tower heights relative to the 65m recorded height.

Extrapolating the analysis to a full year of data:

Due to the timing of the MTC grant and North Coast Seafoods being eager to move forward with the project should it prove feasible, the on-site analysis of the site's wind resource potential began at the mid-year point. Typically a wind resource assessment is conducted with a full year of site-collected data to accurately evaluate a site's wind resource potential. The region of southern New England experiences a distinct seasonal variation in average wind-speed, with the winter season having distinctly stronger winds and power production capability than the leaner summer season.

A temporally coincidental dataset, recorded at the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) BUZM3 meteorological tower (http://www.ndbc.noaa.gov/station_page.php?station=buzm3) was obtained to extrapolate the site-measured trends to account for the winter-to-summer difference in wind speed.

The BUZM3 meteorological tower is situated south of New Bedford at the mouth of Buzzards Bay (Figure 3).



(Figure 3.)

In addition to the temporally coincident data, seven full years of wind speed data were also obtained to permit an assessment of how the annual variation in cumulative wind intensities would affect power production and peak load shaving potential. The meteorological equipment at BUZM3 tower is mounted 24.8 meters above sea level (masl) and data are reported on 10 minute average intervals. While the correlation between the two sites is not perfect (an R^2 of 0.56) for the purpose of providing an estimate of winter to summer wind conditions it is quite useful**.**

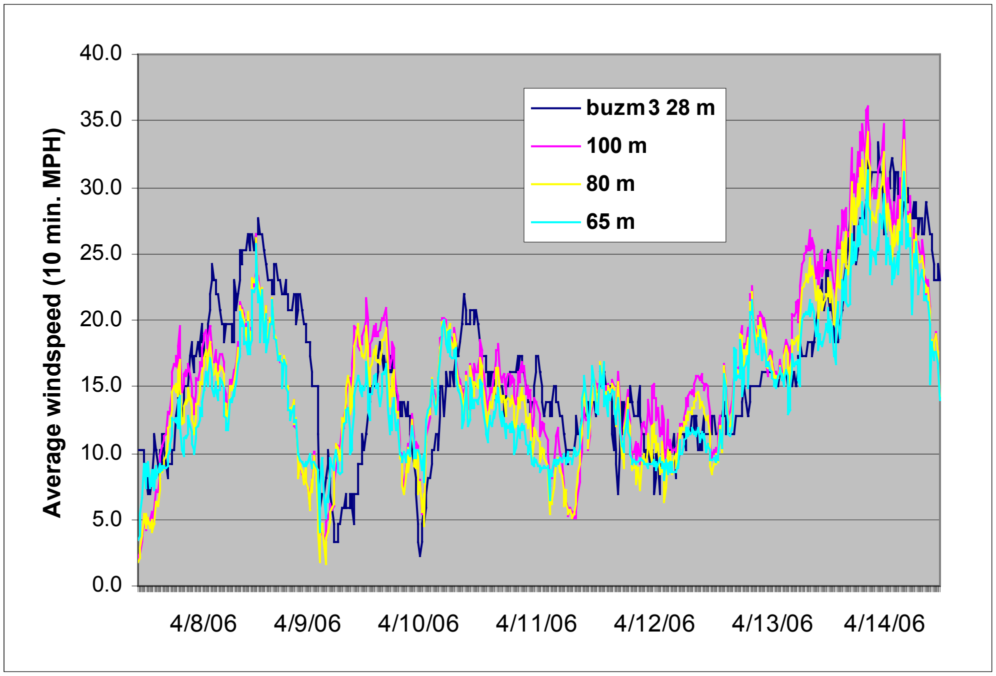
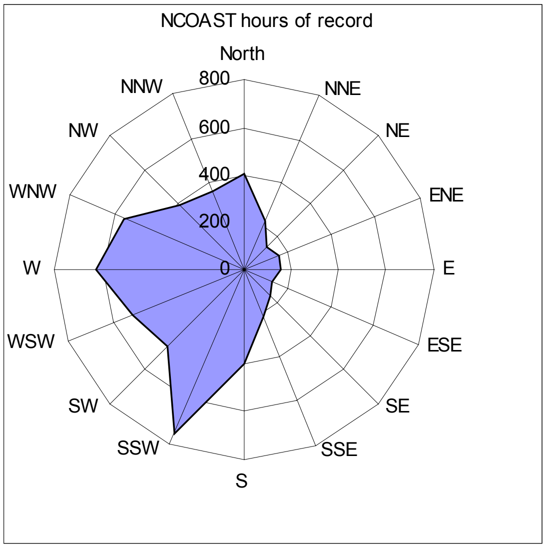


Figure 4. A week of coincidental wind speed data recorded in 10 minute average intervals at the North Coast Seafoods site, New Bedford, MA 41° 37' 21" N 70° 55' 7" W, at heights of 65, 80 and 100m above the ground, and at the NOAA NDBC BUZM3 meteorological tower Buzzards Bay, MA (41°23'48" N 71°02'00" W) at a height of 29masl.



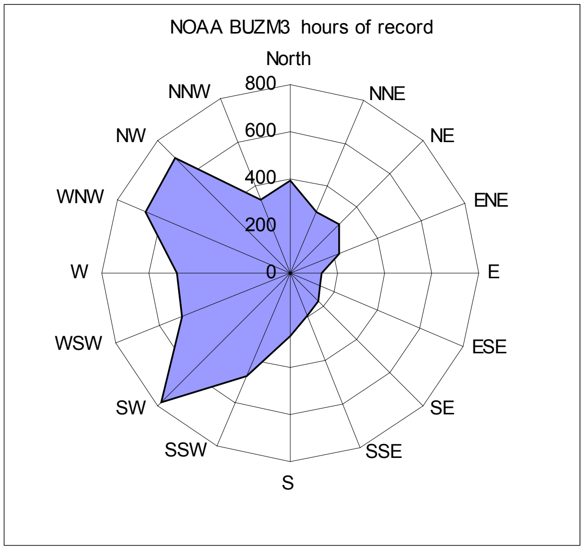


Figure 5. Wind rose diagrams of the North Coast site and the NOAA NBDC BUZM3 tower show the number of hours the wind was blowing from different quarters during the record period.

Data from the North Coast Seafoods and Buzzards Bay (BUZM3) sites were arranged by date and time (timestamp) and missing record intervals were removed for the analysis. To date, approximately 8 months of time elapsed and 223 days of coincidental data have been collected and analyzed.

From year to year, the annual average wind speed varies quite significantly (Figure 6). The seasonal pattern of strong winter winds relative to the summer wind resource also varies from year to year.

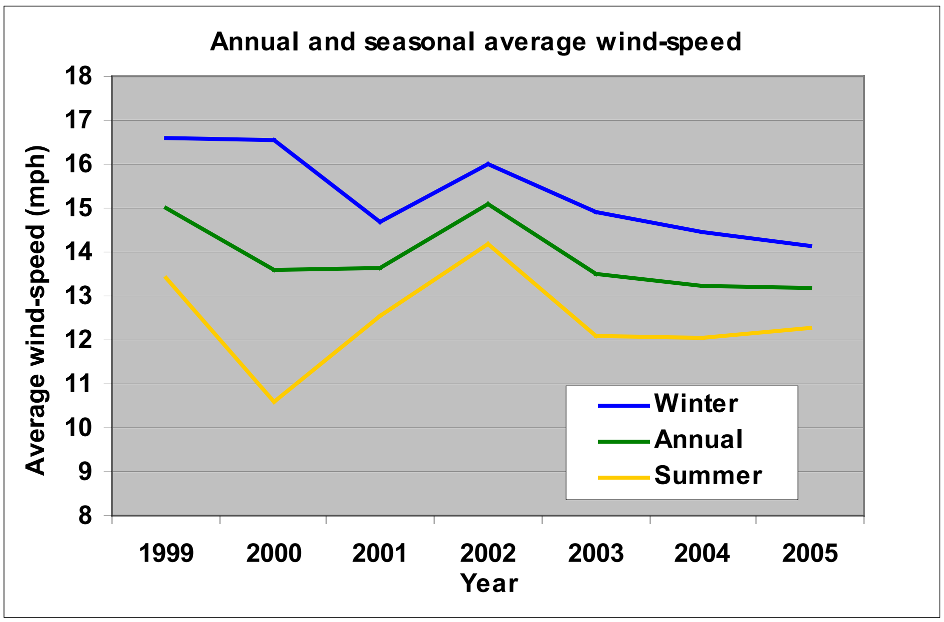


Figure 6. Year-to-year variation in average annual and seasonal wind speeds at the NOAA NBDC BUZM3 meteorological tower.

To obtain an average annual estimate of various turbines output from a partial year of collected data at North Coast's New Bedford site the monthly average wind speed value at each anemometer height (100, 80 & 65m) was divided by the buzm3 monthly average to produce a monthly correlation (Table 1). For the unmeasured summer and fall months June's wind average ratio was applied. This assumed ratio is a conservative estimate of the winds during the lightest wind periods of the year.

	Tower Height		
	100m	80m	65m
Month of record			
April-05	96%	90%	86%
May-05	91%	86%	84%
June-05	85%	79%	78%
July-05	85%	79%	78%
August-05	85%	79%	78%
September-05	85%	79%	78%
October-05	85%	79%	78%
November-05	82%	75%	68%
December-05	77%	71%	66%
January-06	84%	78%	72%
February-06	79%	75%	70%
March-06	87%	81%	76%

Table 1. Proportions of average measured wind speeds at three tower heights relative to the BUZM3 wind speed average for the same time period. The months November through June are based on site measurements (lt. Green). The ratios from July through October are assumed to be the same as June (in beige).

These monthly wind average ratios were applied, on a monthly basis, to each of the 10-minute average wind speed interval data for 3 years of the buzm3 record. The resulting data streams; representing *Good*, *Average* and *Poor* wind resource years (years 2002, 2004 & 2001 respectively) were then multiplied – for each 10 minute average interval – by the power curves of the 4 machines being tested.

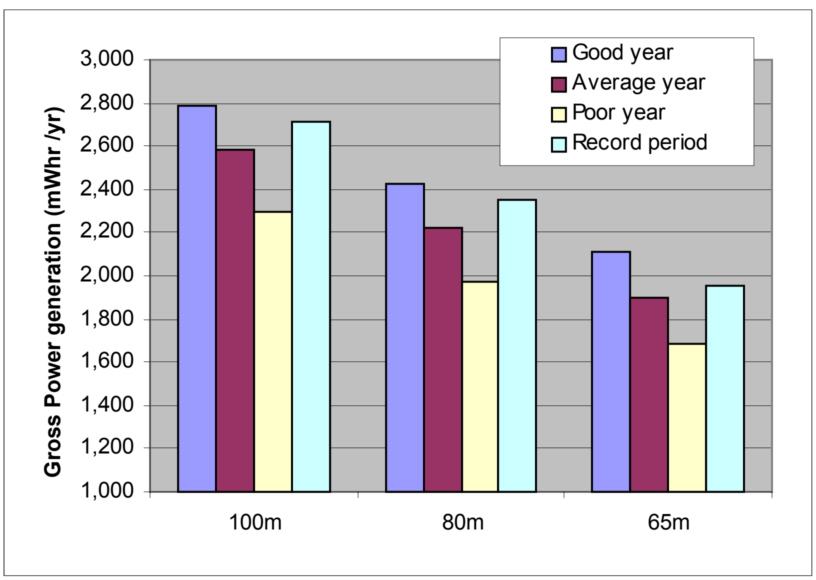


Figure 7. Resulting estimated power production for a GE 1.5sl wind turbine during the period of North Coast anemometry record period (233 days of record). Good, Average and Poor wind resource years power was estimated based on the monthly wind speed average ratio's between the North Coast site and the NOAA BUZM3 tower record. The "Record Period" was estimated directly from the local anemometry record.

The annualized proportions above were used to approximate an annual full year of data the BUZM3 record to the North Coast Seafoods site for calculating power production as described below. It should be noted that the recorded wind resource data for 2006 is somewhat above the six-year average (figure 7). However, the economic analysis in this report is based on an average wind resource year.

Methodology of Data Analysis for Power Production and Consumption

The raw data used for the analysis included Buzzards Bay wind data from 2001, 2002, and 2004, one year of electrical usage data from the site, in 15-minute averages, one year of site electric bills, and the wind data collected at the site, at 100, 80 and 65meters, in 10-minute average increments. From the ISO New England website http://www.iso-ne.com, we obtained hourly Locational Marginal Price (LMP) data from Brayton Point station, the nearest node to the North Coast site. Power curves for the GE 1.5 sl and Vestas V80 were obtained from the Idaho National Laboratory website http://www.inl.gov/wind/software/, and were already formatted in one-tenth of a mile per hour increments. Power curves for the EWT 900-54 and Harakosan Z72 were obtained from the manufacturer. Data points at one-tenth increments were interpolated linearly between the points provided. Harakosan data was not available in tabular format, so the values were read as precisely as possible from the curve.

Based on the comparison of the Buzzards Bay data to the data measured at the site, the wind-speed conversion ratios in Table 1 were used to translate Buzzards Bay data wind-speed 10-minute average increments to correspond with the North Coast site.

In order to calculate the reduction in site demand for the 4 different turbine options, machine performance needed to be evaluated in 15-minute increments and compared to site power usage. The Buzzards Bay wind data in 10-minute averages were converted to 15-minute averages and the time stamps were aligned to the electric data. Using the conversion factors above and the machine power curves, each turbine's output was calculated for each 15-minute period, and subtracted from the site demand for the same period, resulting in a new 15-minute demand. Following the NStar billing cycle, the highest new demand was found for each month. This was compared to the demand for each month with no turbines on site, and a percent reduction in demand charge was calculated. This reduction was averaged for the entire year, and applied to the new bill calculation described later. While it would have been more precise to re-calculate demand charge for each individual month, this was not considered necessary because the demand charges at North Coast Seafoods are relatively low ($3/kw). For a site with high demand charges, in the Boston area for example, a more exhaustive analysis should be performed because it will have a more significant effect on the result.

To calculate annual electric production and revenue generation, hourly averages for the year were used. The 15-minute data for both site demand and wind speed at Buzzards Bay were converted to 1-hour averages, and arranged by calendar year. ISO LMP data for calendar year 2005 at Brayton Point were downloaded from the ISO website, and aligned with the hourly demand and wind data. Power production for each of the 4 machines was calculated using the same method as for the 15-minute data. Using the site power usage data, the net export and import of electricity for each hour of the year was calculated, and then the gross generation revenue was calculated using the ISO prices. This scenario assumes that the facility will be a price-taker in the ISO system. For the electricity purchased when the turbine does not supply the facility's usage, the cost of power was calculated based on the facility's electric rate. This annual calculation was verified by calculating the bill with no turbines and comparing to the actual bill.

RESULTS:

The analysis was performed for the 100 meter, the 80 meter and the 65 meter case. The results of these analyses are presented in the tables provided, and are summarized in the charts on page 26, 27 and 28.

The above data sets were integrated into a spreadsheet of on-site energy consumption and energy production of several proposed turbine types; along with the actual cost of purchased power and real time pricing (over the past year) of excess power sales to provide economic models. Projections of installed costs of the turbines were considered to compare the 'simple payback' and total economic benefit. The installed cost projection of $2,000 per kilowatt was based on averaging the actual cost per installed kilowatt on a number of recent installations of similar class turbines in the northeast and adding $350 to hedge against the rising costs of steel and other factors that are driving the costs of wind installations. The cost calculation for annual operations, maintenance and insurance is based on 2 cents per kilowatt-hour, which will give a more accurate prediction of the maintenance for the machine based on production.

FINANCIAL ANALYSIS

The four potential turbine types were compared on three potential tower heights (as measured by data logging). The offset of electric costs summed with revenue generated by credits and excess power sales was compared to an estimate of the installed cost of the turbines. The results were summarized in the table below, which includes a simple return on investment. The simple return on investment is also shown on a graph below as years of ROI vs. installed tower height. It is clear from this graph that regardless of the choice of turbine, the investment in a 100-meter tower makes the installation economically feasible.

Based on the fact that the facility's peak loads occur in the summer when winds are lighter, North Coast Seafoods requested that an evaluation be made of two 2 MW machines.

The two-turbine scenario would produce a vast majority of their electricity from on site wind power during their peak electrical consumption in the summer months when the wind is lightest. The two machine scenario would then allow revenue to be generated in the shoulder and winter months when they would provide their neighbors with power from the excess capacity or sell it into the grid as a settlement only price taker. However, based on the information gleaned through the interconnection study, the existing primary feed cables and transformer on site would not accommodate this scenario.

The 100 meter hub height is the most economical because of the higher wind speeds. The next best height is 80 meters and the least compelling is 65 meters.

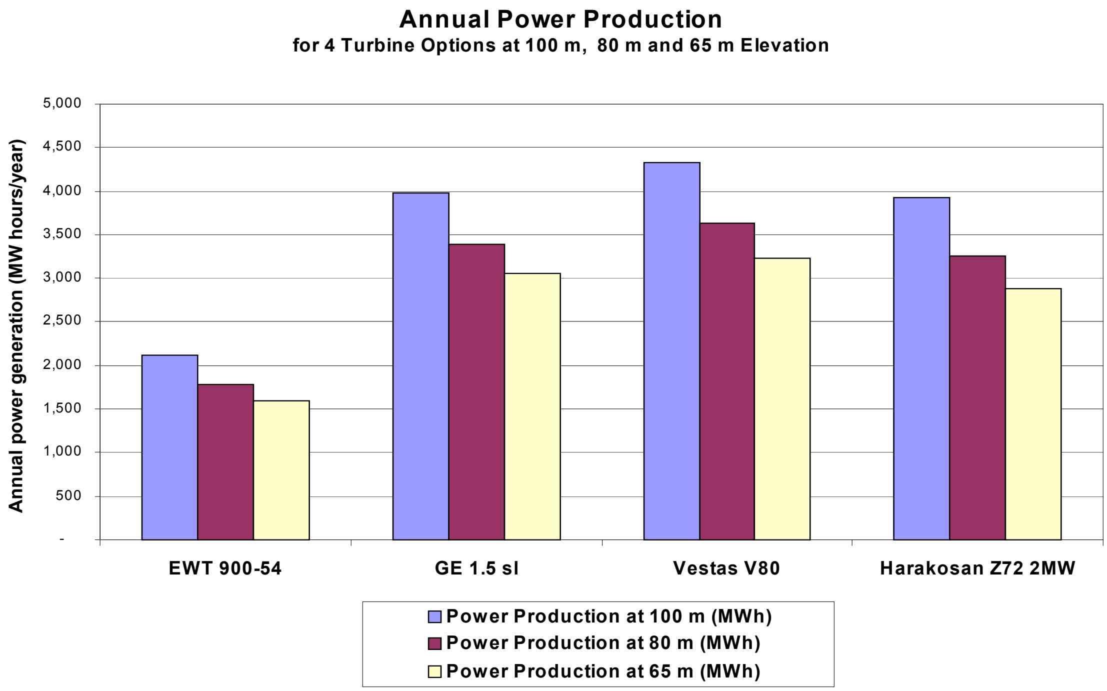


Figure 8.

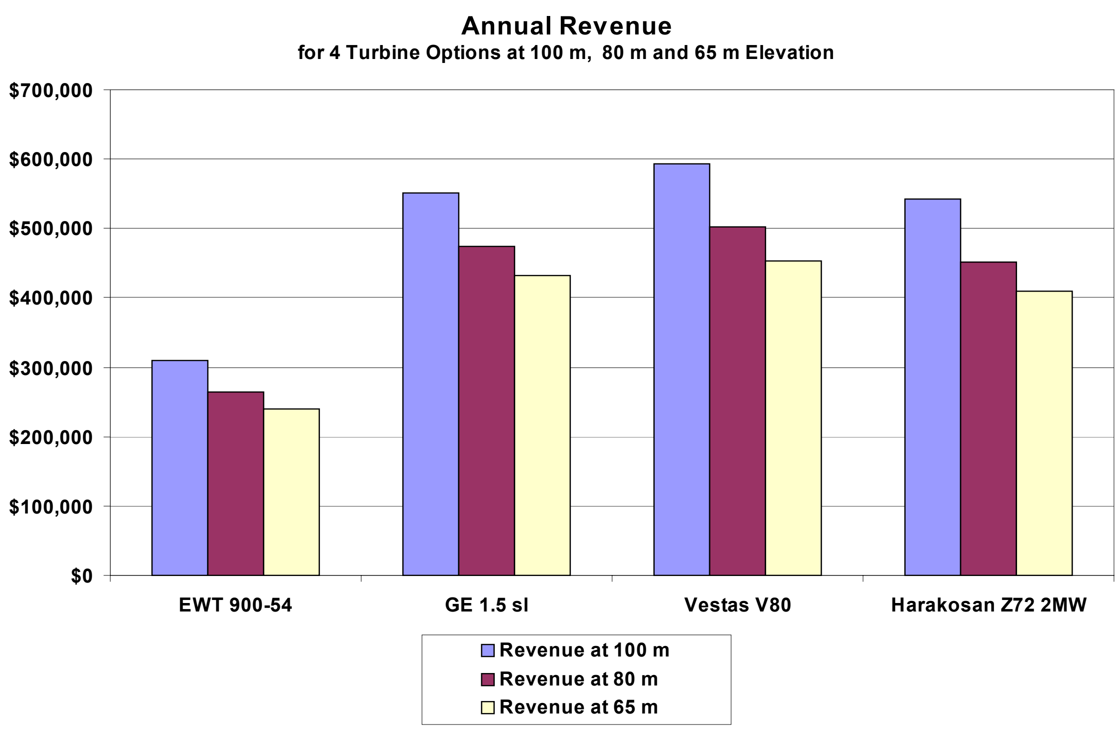


Figure 9.

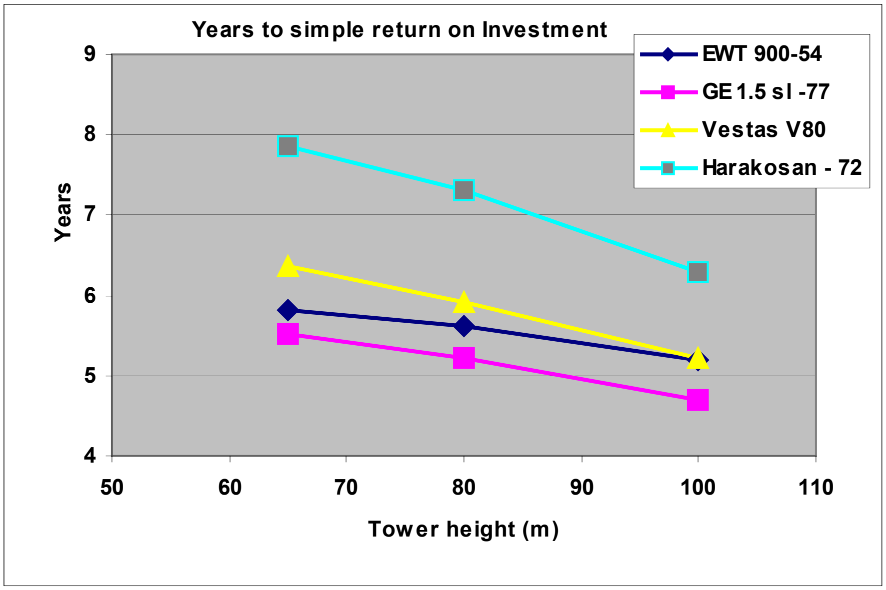


Figure 10.

Further evaluation of tower height vs. return on investment is shown in the graph below comparing an 80 meter hub height to the incremental cost of a 100 meter tower; or credit difference of installing a shorter 65 meter tower. Clearly the incremental cost of tower height has little bearing on the return on investment; but the turbine performance at that height makes the installation more competitive.

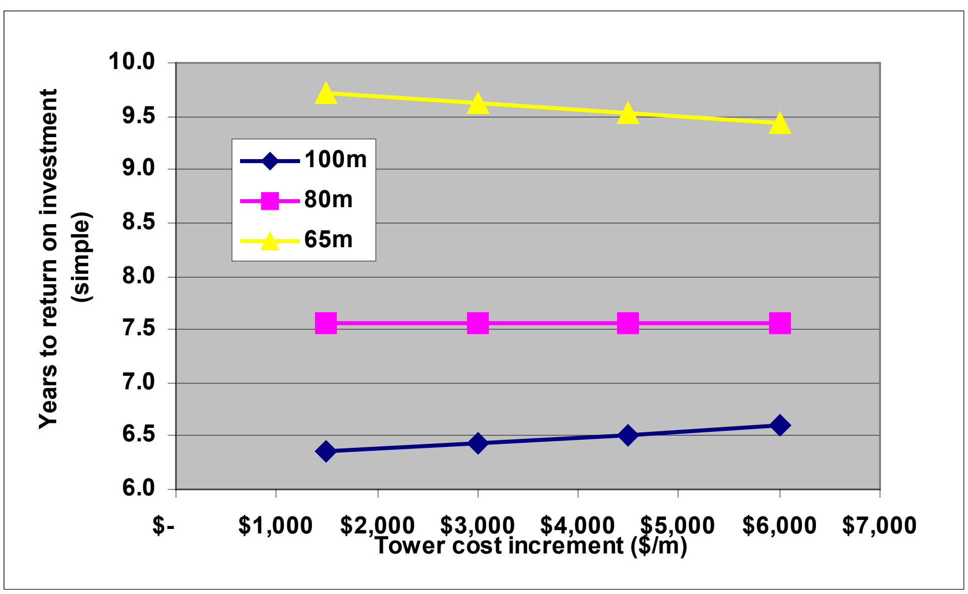


Figure 11.

Results

Based on the annualized data at 100 meters, the EWT 900 with a rotor 54 meters in diameter, has a capacity factor of 27%, produces 2,117 megawatt hours, generates $291,654 annually in savings in electricity costs and production of other revenue with an installed cost of $2,206,654. The GE 1.5 MW sl with a rotor diameter of 77 meters, has a capacity factor of 30%, produces 3,978 megawatt hours, saves $530,209 annually in electricity costs and production of other revenue with an installed cost of $3,602,770. The Vestas V80 with a rotor diameter of 80 meters, a capacity factor of 27%, produces 4,329 megawatt hours and generates $572,980 annually in savings in electricity costs and production of other revenue with an installed cost of $4,237,856. The Harakosan Z72 with a rotor diameter of 72 meters, a capacity factor of 22%, produces 3,925 megawatt hours and saves $522,577 in electricity costs and production of other revenue with an installed cost of $4,592,494.

At a 100 meter installed nacelle height, this analysis indicates that the most economical turbine would be the GE 1.5sl. However, this assumes the installed cost per megawatt of each of the wind turbines is comparable. Current price premiums and potential availability issues will affect this result. Other variables, which will influence the installed cost of turbines more or less equally are: the fluctuation of the international exchange rates, the cost of steel, concrete and transportation.

Based on the annualized data at 80 meters, the EWT 900 has a capacity factor of 23%, produces 1,786 megawatt hours and saves $248,009 annually in electricity costs and production of other revenue with an installed cost of $1,873,636. The GE 1.5 MW sl with has a capacity factor of 26%, produces 3,395 megawatt hours and saves $454,413 32,124,464. The Vestas V80 has a capacity factor of 23%, produces 2,637 megawatt hours and saves $483,324 annually in electricity costs and production of other revenue has an installed cost of $3,688,653. The Harakosan Z72 has a capacity factor of 19%, produces 3,255 megawatt hours and saves $433,430 in electricity costs and production of other revenue with an installed cost of $4,005,501.

Based on the annualized data at 65 meters, the EWT 900 has a capacity factor of 20%, produces 1,595 megawatt hours and saves $224,255 annually in electricity costs and production of other revenue with an installed cost of $1,854,455. The GE 1.5 MW sl with has a capacity factor of 23%, produces 3,054 megawatt hours and saves $413,288. The Vestas V80 has a capacity factor of 21%, produces 3,237 megawatt hours and saves $435,148 annually in electricity costs and production of other revenue with an installed cost of $3,648,720. The Harakosan Z72 has a capacity factor of 16%, produces 2,880 megawatt hours and saves $390,717 in electricity costs and production of other revenue with an installed cost of $3,967,985.

Turbine Summary Tables

The summary tables shown below account for real time data for the numerous variables compared. Average values of any of these variables will approximate but not exactly reflect the real time data summary shown in the table. As an example, the average wind speed for a given day gives a wind turbine energy production figure for that day; and that energy production average may be a good match the average facility load for the same day; but a more critical analysis, such as shown in the summary tables, documents real time wind energy production verses real time facility electric load. This comparison does not allow the averaging out of facility load spikes, nor the wind production spikes or dips; therefore showing the true economic costs or benefits of these events.

100 Meter Turbine Summary Table (Table 2)

100 Meter Options Summary (annualized)				
	100 meters	100 meters	100 meters	100 meters
Turbine Rated Power (kw)	EWT 900kW	GE 1.5sl	Vestas V80	Harakosan
Site Average Windspeed (mph)	14.4	14.4	14.4	14.4
Gross Electricity Production (MWh)	2,117	3,978	4,329	3,925
Electricity to Export (MWh)	1,261	2,984	3,383	2,965
Electricity to Purchase (MWh)	568	430	478	464
Turbine Rated Power (kw)	900	1,500	1,800	2,000
Capacity Factor	27%	30%	27%	22%
Revenue from Sale of Excess ($)	$ 89,297	$ 213,224	$ 242,051	$ 211,913
REC Revenue @ $35	74,079	139,220	151,500	137,373
PTC Value	$ 23,959.30	$ 56,693.04	$ 64,278.56	$ 56,336.51
Annual income from turbine	$ 187,335.80	$ 409,136.60	$ 457,829.75	$ 405,622.14
Cost of Electricity (no on-site gen) ($)	$ 172,534	$ 172,534	$ 172,534	$ 172,534
Demand Charges ($)	12,057	12,057	12,057	12,057
Customer Charges ($)	4,322	4,322	4,322	4,322
Total Current Cost of Electricity	$ 188,913	$ 188,913	$ 188,913	$ 188,913
Cost of Electricity (w/ on-site gen) ($)	$ 69,057	$ 52,292	$ 58,130	$ 56,410
Demand Reduction (%)	7.0%	6.9%	6.2%	6.9%
Demand Charges ($)	11,216	11,227	11,312	11,227
Customer Charges ($)	4,322	4,322	4,322	4,322
Total Future Cost of Electricity	$ 84,596	$ 67,841	$ 73,763	$ 71,959
Electric Bill Savings	$ 104,318	$ 121,072	$ 115,150	$ 116,955
Total Savings & Revenue	**$ 291,654**	**$ 530,209**	**$ 572,980**	**$ 522,577**
Expenses				
Installed Turbine Cost	1,800,000	3,000,000	3,600,000	4,000,000
Incremental Tower Cost	120,000	120,000	120,000	120,000
Total turbine cost	**1,920,000**	**3,120,000**	**3,720,000**	**4,120,000**
Annual Operations & Maintenance (incl. Insurance)	42,331	79,554	86,571	78,499
Warranty Cost	15,000	17,000	17,000	16,000
Total O&M Costs per year for 5 years	**286,654**	**482,770**	**517,856**	**472,494**
Total Installed Cost	**2,206,654**	**3,602,770**	**4,237,856**	**4,592,494**
Simple Return on Investment (years)	**7.57**	**6.80**	**7.40**	**8.79**
% Return on Investment	13.2%	14.7%	13.5%	11.3%

Table notes:
A) Production tax credit value is $19.50 / MWh – a non-fluctuating Federal tax credit for producing renewable energy.

B) Renewable Energy Credit (REC) revenue – the value used was $35/MWh – this is a conservative number based on recent history of longer term REC contracts – the default or penalty value is presently much higher, currently over $50/MWh but this value could diminish in a few years.

C) The average value of excess energy produced is $70.25. This is the average value of excess energy sales over the study period from the New England Independent System Operator (ISO-NE) if the excess power was sold under an independent agreement called 'Settlement only price taker' this is a financial mechanism for excess power producers to be compensated for daily excess production, based on the ISO-NE daily clearing price.

D) The average value of energy purchased for on site use -- $0.12 / kWh or $120 MWh. This average accounts for usage at different rates depending on the time of day. This cost has risen roughly 20% in recent months.

80 Meter Options Summary Table (Table 3)

80 Meter Options Summary (annualized)				
Turbine Rated Power (kw)	EWT 900kW	GE 1.5sl	Vestas V80	Harakosan
Site Average Windspeed (mph)	13.4	13.4	13.4	13.4
Gross Electricity Production (MWh)	1,786	3,395	3,637	3,255
Electricity to Export (MWh)	996	2,459	2,755	2,356
Electricity to Purchase (MWh)	633	488	543	524
Turbine Rated Power (kw)	900	1,500	1,800	2,000
Capacity Factor	23%	26%	23%	19%
Revenue from Sale of Excess ($)	$ 70,197	$ 174,916	$ 196,351	$ 167,732
REC Revenue @ $35	62,522	118,812	127,279	113,925
PTC Value	$18,915	$46,713	$52,349	$44,756
Annual income from turbine	$151,634	$340,441	$375,979	$326,413
Cost of Electricity (no on-site gen) ($)	$ 172,534	$ 172,534	$ 172,534	$ 172,534
Demand Charges ($)	12,057	12,057	12,057	12,057
Customer Charges ($)	4,322	4,322	4,322	4,322
Total Current Cost of Electricity	$ 188,913	$ 188,913	$ 188,913	$ 188,913
Cost of Electricity (w / on-site gen) ($)	$ 76,885	$ 59,289	$ 65,894	$ 66,244
Demand Reduction (%)	6.0%	6.0%	5.8%	6.0%
Demand Charges ($)	11,331	11,331	11,353	11,331
Customer Charges ($)	4,322	4,322	4,322	4,322
Total Future Cost of Electricity	$ 92,538	$ 74,942	$ 81,569	$ 81,897
Electric Bill Savings	$ 96,375	$ 113,971	$ 107,345	$ 107,017
Total Savings & Revenue	**$ 248,009**	**$ 454,413**	**$ 483,324**	**$ 433,430**
Expenses				
Installed Turbine Cost	$ 1,620,000	$ 2,700,000	$ 3,240,000	$ 3,600,000
Incremental Tower Cost	$ -	$ -	$ -	$ -
Total turbine cost	**$ 1,620,000**	**$ 2,700,000**	**$ 3,240,000**	**$ 3,600,000**
Annual Operations & Maintenance (incl. Insurance)	$ 35,727	$ 67,893	$ 72,731	$ 65,100
Warranty Cost	$ 15,000	$ 17,000	$ 17,000	$ 16,000
Total O&M Costs per year for 5 yrs	**$ 253,636**	**$ 424,464**	**$ 448,653**	**$ 405,501**
Total Installed Costs	**$ 1,873,636**	**$ 3,124,464**	**$ 3,688,653**	**$ 4,005,501**
Simple Return on Investment (years)	**7.55**	**6.88**	**7.63**	**9.24**
% Return on Investment	13.2%	14.5%	13.1%	10.8%

At an 80 meter hub height, the analysis indicates that the most economical installation would be the GE 1.5 MW sl turbine.

65 Meter Options Summary Table (Table 4)

65 Meter Options Summary (annualized)				
Turbine Rated Power (kw)	EWT 900kW	GE 1.5sl	Vestas V80	Harakosan
Site Average Windspeed (mph)	12.9	12.9	12.9	12.9
Gross Electricity Production (MWh)	1,595	3,054	3,237	2,880
Electricity to Export (MWh)	837	2,147	2,389	2,011
Electricity to Purchase (MWh)	667	517	575	555
Turbine Rated Power (kw)	900	1,500	1,800	2,000
Capacity Factor	20%	23%	21%	16%
Revenue from Sale of Excess ($)	$ 60,250	$ 155,228	$ 173,104	$ 145,863
REC Revenue @ $35	$ 55,809	$ 106,881	$ 113,302	$ 100,795
PTC Value	$ 15,911	$ 40,797	$ 45,384	$ 38,203
Annual income from turbine	$ 131,970	$ 302,905	$ 331,790	$ 284,861
Cost of Electricity (no on-site gen) ($)	$ 172,534	$ 172,534	$ 172,534	$ 172,534
Demand Charges ($)	$ 12,057	$ 12,057	$ 12,057	$ 12,057
Customer Charges ($)	$ 4,322	$ 4,322	$ 4,322	$ 4,322
Total Current Cost of Electricity	$ 188,913	$ 188,913	$ 188,913	$ 188,913
Cost of Electricity (w/ on-site gen) ($)	$ 80,967	$ 62,862	$ 69,855	$ 67,389
Demand Reduction (%)	5.9%	5.9%	5.6%	5.9%
Demand Charges ($)	$ 11,340	$ 11,347	$ 11,378	$ 11,347
Customer Charges ($)	$ 4,322.00	$ 4,322.00	$ 4,322.00	$ 4,322.00
Total Future Cost of Electricity	$ 96,629	$ 78,531	$ 85,556	$ 83,058
Electric Bill Savings	$ 92,285	$ 110,383	$ 103,358	$ 105,856
Total Savings & Revenue	**$ 224,255**	**$ 413,288**	**$ 435,148**	**$ 390,717**
Expenses				
Installed Turbine Cost	$ 1,620,000.00	$ 2,700,000.00	$ 3,240,000.00	$ 3,600,000.00
Incremental Tower Cost	$ -	$ -	$ -	$ -
Total turbine cost	**$ 1,620,000.00**	**$ 2,700,000.00**	**$ 3,240,000.00**	**$ 3,600,000.00**
Annual Operations & Maintenance (incl. Insurance)	$ 31,891	$ 61,075	$ 64,744	$ 57,597
Warranty Cost	$ 15,000	$ 17,000	$ 17,000	$ 16,000
Total O&M Costs per year for 5 years	**$ 234,455**	**$ 390,373**	**$ 408,720**	**$ 367,985**
Total Installed Cost	**$ 1,854,455**	**$ 3,090,373**	**$ 3,648,720**	**$ 3,967,985**
Simple Return on Investment (years)	**8.27**	**7.48**	**8.39**	**10.16**
% Return on Investment	12.09%	13.37%	11.92%	9.84%

It is clear from the table above that any of the selected machines installed on a 65 meter tower would not meet North Coast Seafoods' desired payback period in the six year range.

Due of North Coast's interest in generating the greatest possible percentage of on-site power and their interest in installing two turbines if possible, further analysis was done to evaluate a single turbine versus a two turbine installation (of the same type) at the optimum tower height of 100 meters. Some assumptions were made as to the exact costs of the additional infrastructure needed to interconnect a second turbine. (table 5.) The results are compared on a bar graph showing simple Return on Investment along with annual revenue generated. (figure 13).

Two Turbine Scenarios shown below in Table 5.

	100 Meter Options Summary for 2 machines (Annualized)				80 Meter Options Summary for 2 Machines (Annualized)			
	EWT 900-54	GE 1.5 sl	Vestas V80	Harakosan	EWT 900-54	GE 1.5 sl	Vestas V80	Harakosan
Site Average Windspeed (mph)	14.4	14.4	14.4	14.4	13.4	13.4	13.4	13.4
Gross Electricity Production (MWh)	4,089	7,707	8,360	7,554	3,497	6,651	7,112	6,358
Electricity to Export (MWh)	3,245	6,723	7,426	6,604	2,714	5,723	6,239	5,465
Electricity to Purchase (MWh)	580	440	490	475	640.430	495.078	550.416	531.519
Turbine Rated Power (kw)	900.0	1,500.0	1,800.0	2,000.0	900.0	1,500.0	1,800.0	2,000.0
Capacity Factor	0.26	0.29	0.27	0.22	0.22	0.25	0.23	0.18
Revenue from Sale of Excess ($)	$ 232,472	$ 484,913	$ 536,345	$ 476,944	$ 194,093	$ 411,977	$ 449,872	$ 394,128
REC Revenue @ $35	143,121	269,741	292,594	264,374	122,400	232,796	248,937	222,522
PTC Value	79,739	150,284	163,017	147,294	68,194	129,701	138,693	123,977
Total Excess Generation Rev	**455,331**	**904,938**	**991,956**	**888,612**	**384,687**	**774,473**	**837,502**	**740,627**
Cost of Electricity (w/ on-site gen) ($)	$ 70,405	$ 53,482	$ 59,507	$ 57,690	$ 77,774	$ 60,164	$ 66,839	$ 67,060
Demand Reduction (%)	7%	7%	6%	7%	6%	6%	6%	6%
Demand Charges ($)	11,216	11,227	11,312	11,227	11,331	11,331	11,353	11,331
Customer Charges ($)	4,322	4,322	4,322	4,322	4,322	4,322	4,322	4,322
Total Future Cost of Electrici	**$ 85,944**	**$ 69,031**	**$ 75,140**	**$ 73,240**	**$ 93,427**	**$ 75,817**	**$ 82,514**	**$ 82,713**
Electric Bill Savings	**$ 102,970**	**$ 119,882**	**$ 113,773**	**$ 115,674**	**$ 95,486**	**$ 113,096**	**$ 106,400**	**$ 106,200**
Total Savings & Revenue	**$ 558,301**	**$ 1,024,820**	**$ 1,105,729**	**$ 1,004,286**	**$ 480,173**	**$ 887,570**	**$ 943,902**	**$ 846,827**
Expenses								
Installed Turbine Cost	$ 3,600,000	$ 6,000,000	$ 7,200,000	$ 8,000,000	$ 3,600,000	$ 6,000,000	$ 7,200,000	$ 8,000,000
Incremental Tower Cost	$ 240,000	$ 240,000	$ 240,000	$ 240,000	$ -	$ -	$ -	$ -
Additional Elect. Infrastructure	$ 250,000	$ 500,000	$ 500,000	$ 500,000	$ 250,000	$ 500,000	$ 500,000	$ 500,000
Total Turbine Cost	**$ 4,090,000**	**$ 6,740,000**	**$ 7,940,000**	**$ 8,740,000**	**$ 3,850,000**	**$ 6,500,000**	**$ 7,700,000**	**$ 8,500,000**
Annual O&M (w/ insurance)	$ 81,783	$ 154,138	$ 167,196	$ 151,071	$ 69,943	$ 133,026	$ 142,249	$ 127,155
Warranty cost	$ 30,000	$ 34,000	$ 34,000	$ 32,000	$ 30,000	$ 34,000	$ 34,000	$ 32,000
Total O&M Costs per year	**$ 111,783**	**$ 188,138**	**$ 201,196**	**$ 183,071**	**$ 99,943**	**$ 167,026**	**$ 176,249**	**$ 159,155**
Total Installed Turbine Cost	**$ 4,201,783**	**$ 6,928,138**	**$ 8,141,196**	**$ 8,923,071**	**$ 3,949,943**	**$ 6,667,026**	**$ 7,876,249**	**$ 8,659,155**
Installed kW	1,800	3,000	3,600	4,000	1,800	3,000	3,600	4,000
Rotor diameter (m)	54	77	80	72	54	77	80	72
Swept area (m2)	4,580	9,313	10,053	8,143	4,580	9,313	10,053	8,143
Annual output/m^2 swept area (MWh)	0.89	0.83	0.83	0.93	0.76	0.71	0.71	0.78
Simple Return on Investment (y	**7.53**	**6.76**	**7.36**	**8.88**	**8.23**	**7.51**	**8.34**	**10.23**

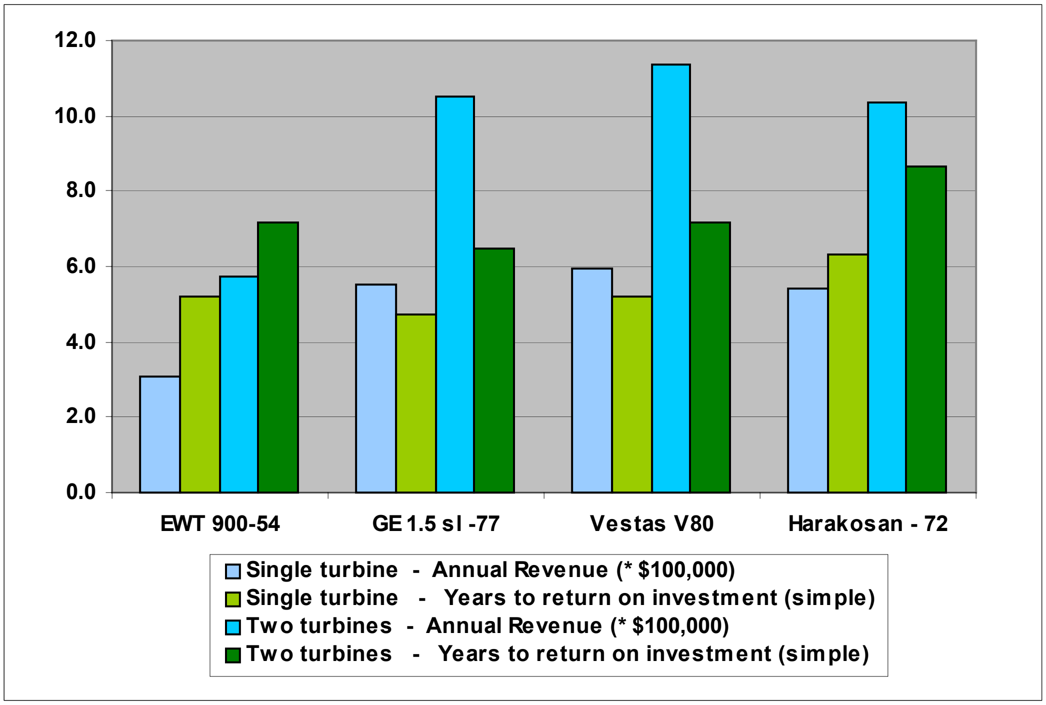


Figure 13.

So while the number of years to simple return on investment increases by approximately two, the net annual income, which will accrue to the facility (at current electrical prices) once the investment is paid off, nearly doubles for each pair of turbine installations evaluated.

TURBINE RECOMMENDATIONS

Analyzing different turbine scenarios:

When North Coast Seafoods applied for an MTC sponsored feasibility analysis, the program CI^3 did not require that 50% of the power be used behind the meter as the new Large On-Site Renewables Initiative does.

North Coast Seafoods requested that an analysis of the wind turbine configuration that would meet all of the facilities' summer-time electrical load on a monthly basis be conducted.

North Coast Seafoods has expressed a strong interest in maximizing the clean, renewable energy produced at their site. This study of resource and feasibility has shown that a properly installed turbine in the size range reviewed is a good investment.

Review of the bar graph above shows only a small incremental increase in simple ROI when a second turbine is added, but the annual revenue value is significantly increased. When combined with investment credits or installation incentives the picture improves further. The ratio of investment and incentives to future annual revenue is beyond the scope of this study.

The logistics of siting two turbines within the property bounds is challenging, as the lot is relatively narrow north to south and with the prevailing winds from the westerly directions the turbines need to be oriented in a north-south line. The absolute minimum spacing of 1.5 rotor diameters across the prevailing wind the larger turbine choices would just push the edges of the lot lines. Cooperative neighboring facilities with an interest and appetite for the power could provide some leeway in siting in the constrained area as well as potentially sharing in the additional costs associated with interconnecting multiple turbines.

North Coast Seafoods indicated that they would consider a payback range of 6 years for a wind installation in New Bedford. Based on that factor, the on-site wind data over the past 8 months and the extrapolated data from BUZM3, the recommended wind turbine installation would be a GE 1.5 sl, which is 1.5 megawatt turbine with a blade length equivalent to a 2 megawatt turbine on a 100 meter tower. This machine is designed to produce power in lighter air situations, thereby improving the production of power in the summertime when on-site electricity consumption peaks due to refrigeration loads. However, North Coast Seafoods may determine that their needs can be adequately met with the EWT 900 kW turbine. The EWT 900 kW machine has lower installed costs, and it matches the annual load of the facility.

Moving forward, requesting quotes for each of these turbines would help assess the variations in installed equipment costs.

INTERCONNECTION ISSUES

Electrical Interconnection

North Coast Seafoods is connected to the NStar Electric Company's (NStar) system through circuit 95 at 13.2 kV. According to NStar, this circuit is capable of handling a maximum wind turbine size of 2,000 kW. Revenue metering for a service of this type is typically provided in the high voltage circuit. The main transformer is a 1000 kVA 13.2 kV delta-connected primary and 480/277-volt wye-connected secondary with a high-resistance ground system. Metering is located on the secondary side of the transformer. This equipment provides a 2500A service protected by a Siemens SBS2500 main breaker.

There are two possible interconnection configurations, depending on the size of the wind turbine, as shown in the diagram provided. For the GE 1.5 MW, Vestas 1.85 MW and Harakosan 2 MW turbines, interconnection would be provided on the high voltage side through a step-up transformer. This high-voltage connection would require a primary metering package as shown, and a disconnect switch for maintenance. For the EWT turbine, which is rated at 900 kW, interconnection can be provided on the low voltage side without a transformer and utilizing the existing secondary side metering. All interconnections should be provided with a circuit breaker, which can be tied in to the utility system for protection.

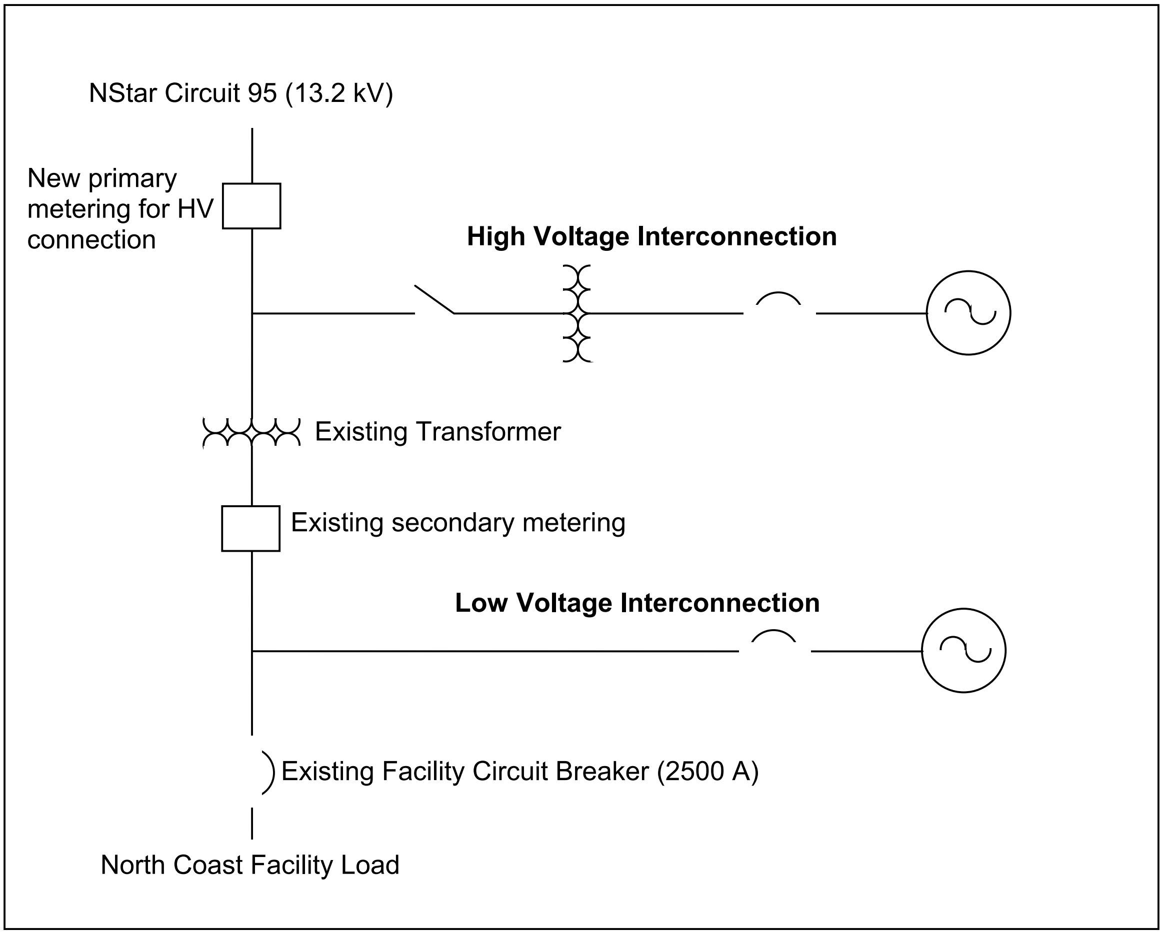


Figure 14.

ENVIRONMENTAL REVIEW

Sound emissions – Background (ambient) noise levels are important to understand the potential perception or impact of a new sound source. Modern wind turbines by design have a low level of noise impact on the surrounding environment.[1] This combined with the setting of a working waterfront industrial district means little to no perceptible impact

[1] Sound from Wind Turbines – 'Noise is a Minor Problem Today'
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Updated 10 May 2003
http://www.windpower.org/en/tour/env/sound.htm

to the neighborhood. The abutting properties are all within the zoned industrial area; and the nearest residential neighborhoods are across a multilane thoroughfare. The general ambient noise level in the industrial zone would be 55- 75 dB(A), the roadway between the industrial zone and the residential area would also have an ambient noise range of 55 - 75 dB(A). The residential neighborhood would have a minimum ambient noise level of 35 dB(A) but this would only occur on a windless (no turbine operation) quiet night; the usual ambient level would range from 40 – 60 dB(A). The overlay map shown below indicates distances and potential sound emissions from a 2-megawatt turbine installation.

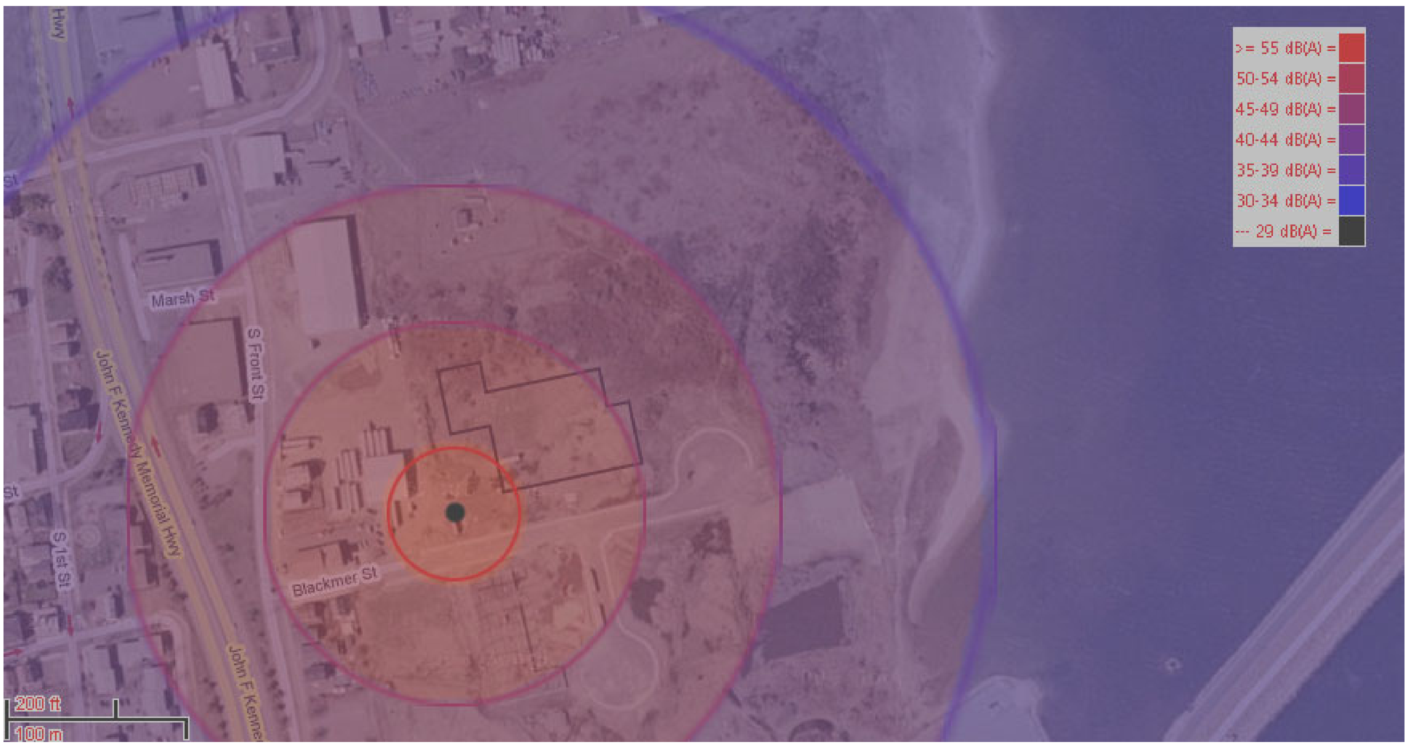

Figure 15

Shadow Analysis

In some locations installation of a wind turbine can cause a shadow casting of the structure and particularly the rotating blades. This is sometimes referred to as 'flicker' although that term is dated in that it implies a rapid blade rotation speed; and this is not the case for modern larger turbines with rotational speeds of 16 to 26 revolutions per minute. However, the moving shadow from a large wind turbine could be considered a nuisance if the shadow area falls across occupied areas of buildings or homes with windows for significant amounts of time during the year.

At the North Coast Seafoods site nearly all the shadow cast area will be on the facilities windowless building or nearby unoccupied space. The exception will be early morning long shadows in the summertime which will cast across J. F. K. Boulevard and into the mixed-use neighborhood to the west and southwest. This shadowing will occur approximately 40 hours per year and only before 9 A. M. The overlay maps (Figures III) show the extent of shadowing – first overall for the year shown in hours; then showing worst case summertime morning shadowing in minutes per day of bright sun. This limited shadowing should not be a significant problem because the duration is so short.

As Horsley Witten’s Environmental and Permitting Review was conducted separately, it is contained in the volume following Figures III.

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