APPLIED TECHNOLOGY AND MANAGEMENT

FINAL REPORT

TOWN OF PORTSMOUTH, RI WIND RESOURCE AND ECONOMIC ASSESSMENT

PREPARED BY:

APPLIED TECHNOLOGY AND MANAGEMENT, INC.
LORIA EMERGING ENERGY CONSULTING, LLC
SUSTAINABLE ENERGY ADVANTAGE, LLC

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EXECUTIVE SUMMARY

Applied Technology and Management (ATM) has completed a limited feasibility study of locating a wind turbine generator (WTG) at the Portsmouth Middle School or the High School for the Town of Portsmouth (the Town). The study evaluated two different sized WTG's at locations identified by the Town. The study included

1. A detailed wind resource analysis was performed using long term weather data.
2. A detailed energy use analysis was performed comparing the average hourly WTG energy production with the average hourly energy consumption at each school.
3. An electrical interconnection assessment was performed to determine how the WTG would be electrically connected and operate in parallel with the local electric utility so that reliability of the electric supply to each school would not be compromised.
4. A financial analysis was performed including the use of the Town's Clean Renewable Energy Bond (CREB) award and other available financial incentives and the value of the energy produced from the WTG to the Town.

The results of the study indicate

1. Within the scope of the study, no fatal flaws were identified that would prevent the development of a WTG project at either school.
2. The wind resource is greater at the Middle School than at the High School. The results of the analysis indicate that the average annual wind speed is 7.08 meters per second (m/s) and 6.74 m/s at the Middle School and High School, respectively. The WTG net capacity factor is expected to range from 29 to 31 % (depending on the size of the WTG) at the Middle School and 26 to 28 % at the High School.
3. The energy use is approximately the same at both schools. Approximately 25 to 55 % of WTG electrical output would be used by the Schools, depending on the size of the turbine. The remaining WTG electric output would be sold to a retail electric supplier, such as Constellation New Energy.
4. The cost of developing a WTG project is roughly the same at both schools, approximately $2.1 M for a 600 kW WTG and approximately $3.2 M for a 1500 kW WTG.
5. A WTG located at the Middle School is more economically attractive because the wind resource is stronger at the Middle School and the electric loads and capital costs are essentially the same for both schools.

6. A large WTG will provide more economic benefit than a smaller turbine. However, funding in addition to the $2.6 M CREBS award will be required to pay for the cost of developing a 1500 kW WTG project.
7. At the projected electricity and REC values, the development of a 1500 kW WTG at the Middle School appears to be the most economically attractive option for the Town. The degree of economic return will depend on actual electricity and REC prices, project costs and wind speeds. These projects should be able to absorb some fluctuation in actual revenues and are projected, overall, to meet the Town's economic criteria.
8. The option of installing a 600 kW WTG at the schools deserves careful scrutiny. While the analysis offers a positive NPV, the 600 kW project will likely experience multiple years of negative cash flows requiring that the project rely on other sources of revenue to support itself and repay project debt.

The Town should also stay abreast of the wind turbine market. The demand for WTGs currently exceeds supply. Turbine pricing has increased significantly over the past few years due to increases in commodity prices and because of increases in demand. Currently, most manufacturers state that they cannot provide a turbine before 2009. Prices and availability may change and prices my come down if Federal incentives are extend. Also, a unit between 600 and 1500 kW may be best match for the Town.

To confirm the feasibility of developing a WTG project at either school, an environmental and permitting review must be performed. In addition, utility electrical interconnection analyses will be required to confirm the cost to interconnect with the electric utility.

The following sections describe the approach to the study and the results in detail.

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INTRODUCTION

Applied Technology and Management (ATM) had prepared a formal feasibility study of a potential wind energy project for the Town of Portsmouth (the Town). The study evaluated the application of a single wind turbine generator (WTG) at either the Portsmouth High School or at the Portsmouth Middle School. The electricity produced by the WTG would be used to first displace purchases of electricity by either school from the local electric utility and the retail energy supplier. Electricity produced by the WTG that is not used by the school would be sold to a retail energy supplier.

The scope of the study addressed the following issues for both schools:

1. selection of two different WTGs for each school for the basis of the study
2. wind energy resource assessment
3. energy analysis of the coincidence of school energy consumption and WTG electrical production
4. electrical engineering requirements to interconnect the WTGs with the schools and the electric utility
5. capital and operating and maintenance cost estimates
6. economic analysis of the lifecycle cost, savings, and revenues generated by the WTG projects.

The limited feasibility study did not include environmental or permitting review or any level of geotechnical investigation at the WTG sites selected by the Town. The feasibility study evaluated the technical and economic issues at two different locations for two different WTGs and was not intended to be an optimization study of the potential project. The following sections describe the approach and results of each of the above tasks.

The study was conducted in cooperation with LORIA Emerging Energy Consulting, LLC and Sustainable Energy Advantage, LLC.

WIND RESOURCE ASSESSMENT

A wind resource assessment was performed on the two potential Portsmouth wind sites, the Portsmouth High School and the Portsmouth Middle School. The assessment was performed using AWS Truewind average annual wind speed predictions, short term wind history data from the Portsmouth Abbey School and the Raytheon facility (both located in Portsmouth close to the two potential sites) and long term data from the Newport state airport located close to the Portsmouth border in Middletown, RI. Figure 1 illustrates the location of the aforementioned sites and a description of each of the data sources follows.

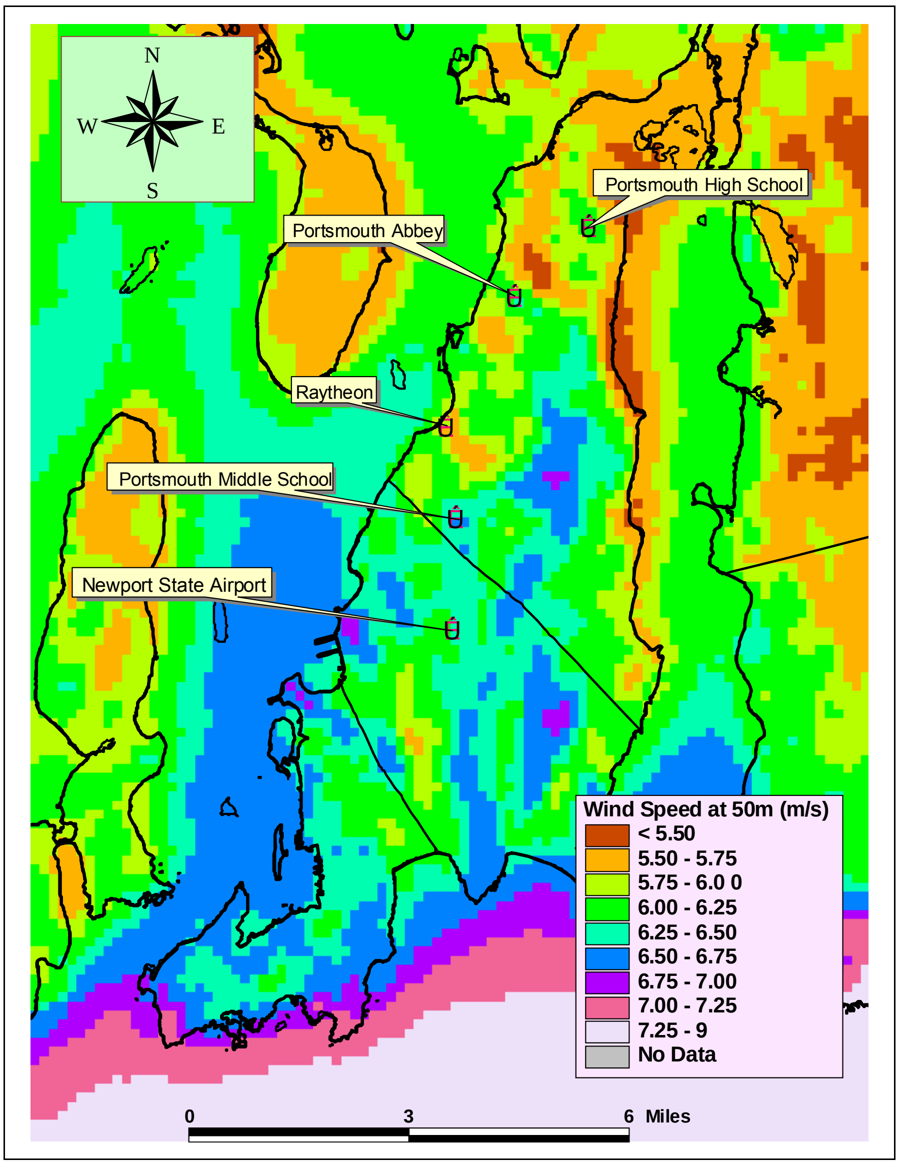

Figure 1. Map Illustrating Potential Sites and Data Source Locations

DATA

AWS TRUEWIND

Average annual wind speeds at 50m and 100m elevation were purchased from AWS Truewind. This data is the output of their mesoscale meteorological model and wind flow simulation model which are used in this case to produce the average annual wind speeds for the region. The model grid cell resolution is 200m x 200m with an extent covering all of the New England states as well as state and federal waters. The AWS model predicted wind speeds were developed for both 50m and 100m elevations with an accuracy of ± 0.49 m/s.

PORTSMOUTH ABBEY DATA

Data from the meteorological (met) tower which was located at the Portsmouth Abbey School, prior to installation of the wind turbine, was available from 1/1/05 through 6/30/05. This data was supplied on disc by the Town of Portsmouth (Personal communication with Gary Gump). The data provided was hourly wind speed at 50m elevation which was understood to have been the output of a previous consultant's extrapolation from 45m.

RAYTHEON DATA

Data from the met tower, which was located at the Raytheon facility, was available from 7/27/2005 through 1/18/2007, with some small data gaps and a sizable data gap from 8/23/06 through 11/7/06. A portion of this data was supplied on disc by the Town of Portsmouth (Personal communication with Gary Gump) and the remainder obtained from Raytheon (Personal communication with Bill Saslow). The Raytheon data was obtained at 20, 30, and 40m elevations. The data provided was a combination of 10 minute, 30 minute and hourly wind speeds.

NEWPORT STATE AIRPORT DATA

Historical wind speed data taken at a 5m elevation was obtained from the NOAAs weather station located at the Newport State Airport. This data spans the period from 1978 through 2006, at varying sampling frequencies and has multiple gaps of varying sizes. Table 1 shows the inventory of this data. A typical month (30days) would have 720 hours of data. As can be seen in Table 1, only the years after 2000 have what appears to be a full year of hourly data. To avoid any skew in the data due to the data gaps, only data from 2000 through 2006 was used for the analysis.

Table 1. Data Inventory Summary

Newport State Airport Data Inventory Summary *The values represent the number of readings taken for the month(across) of the year(down). A typical month with hourly readings would have 720 (30*24) readings.												
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1978	70	7	158	196	194	196	176	195	170	192	185	206
1979	220	184	198	194	195	180	185	176	203	195	183	203
1980	201	191	199	191	153	154	120	139	155	161	170	187
1981	191	170	195	175	186	164	117	147	94	104	68	86
1982	65	44	96	110	122	96	64	59	70	96	142	153
1983	140	152	186	176	164	128	128	150	140	147	138	126
1984	161	154	146	54	43	91	85	56	77	70	39	31
1985	19	1	0	2	2	6	4	0	10	0	0	0
1986	0	0	0	10	21	18	18	17	11	9	7	18
1987	6	12	7	6	3	25	6	9	14	17	42	57
1988	54	48	36	53	57	41	53	43	57	80	51	58
1989	64	49	47	61	58	100	95	92	102	131	122	158
1990	143	145	128	98	126	125	106	97	100	120	123	133
1991	124	127	145	122	83	73	45	47	41	110	104	94
1992	82	82	108	93	81	45	3	5	9	10	0	1
1993	11	0	0	0	0	0	0	0	0	11	12	20
1994	11	13	10	20	23	19	42	12	24	25	14	16
1995	13	21	16	18	15	17	32	23	26	0	0	0
1996	0	1	0	0	0	0	0	0	0	0	0	0
1999	405	81	200	710	737	717	736	741	709	709	715	725
2000	733	676	734	712	742	683	741	730	718	739	708	741
2001	741	667	739	681	706	708	739	738	712	730	710	740
2002	742	669	739	872	960	833	731	738	706	716	709	730
2003	707	651	708	714	714	710	877	1122	914	931	901	947
2004	896	788	1029	955	1061	925	1057	1179	977	997	872	986
2005	1109	837	1021	913	1123	966	1033	1073	886	1117	934	970
2006	1026	798	839	765	1050	1039	893	920	497	931	1005	867
2007	944	814	961	948	841	0	0	0	0	0	0	0

STATION CORRELATION

In order to asses the winds at both the Portsmouth Middle School and High School the wind data should be long term and representative for each schools specific location. This long term record for each school can be projected from the data of surrounding sites.

The airport data can be used to predict long term data at the Raytheon and Portsmouth Abbey locations both of which have shorter term records. This can only be done if the relationship between the airport site and these two sites are statistically significant. In order to understand if the relationships are statistically significant the relationship of wind speed between two sets of locations were compared:

- Data Set 1: Newport State Airport and the Portsmouth Abbey School
- Data Set 2: Newport State Airport and the Raytheon Facility

ELEVATION PROJECTION OF WIND DATA TO 80M

Before being able to compare the data it is necessary to project all the data to the same elevation. The elevation at which the wind data was taken between sites did vary; however both data sets were extrapolated to their 80m elevation wind speeds using the standard power law wind shear formula and the surface roughness coefficient which was derived from AWS Truewind data. The wind shear formula is:

$$v_2 = v_1 * \left(\frac{h_2}{h_1}\right)^{\alpha}$$

where v is the velocity; h is the corresponding height and α is the roughness coefficient. The surface roughness at each of the relevant sites was backed out of the wind shear equation using the AWS Truewind average annual wind speeds at 50m and 100m. Table 2 shows the variables and resulting surface roughness for each of the sites.

Table 2. Surface Roughness Calculation Summary

Location	Wind Speed at 50m (m/s)	Wind Speed at 100m (m/s)	Surface Roughness
Newport State Airport	6.493	7.310	0.171
Portsmouth Middle School	6.593	7.354	0.158
Raytheon	5.809	6.789	0.225
Portsmouth Abbey	6.287	7.148	0.185
Portsmouth High School	6.200	7.047	0.185

In addition, the Raytheon site had measured data at three different heights (20m, 30m and 40m). The surface roughness was calculated at each available time step using the three possible ratios (40m-20m, 40m-30m, and 30m-20m). The values of each ratio were averaged and a resultant surface roughness of .359 was calculated. This value is higher than that predicted by AWS Truewind, however using the AWS Truewind data results in a more conservative assessment, since it predicts lower wind speeds at higher elevations than using the site calculated value. Since this approach was conservative and similar data was not available at each site, the AWS Truewind derived values were used for all sites in this analysis.

STATION WIND SPEED COMPARISON

Comparitive plots of wind speeds between Portsmouth Abbey and Raytheon vs. Newport State Airport are shown in Figures 2 and 3, respectively. A linear regression of the two data sets and the 1:1 fit are also plotted. Testing of various forms for both of the data comparisons showed that the best fit relationship is linear. The coefficients for the linear regression equation along with the coefficient of determination (R^2) are also presented.

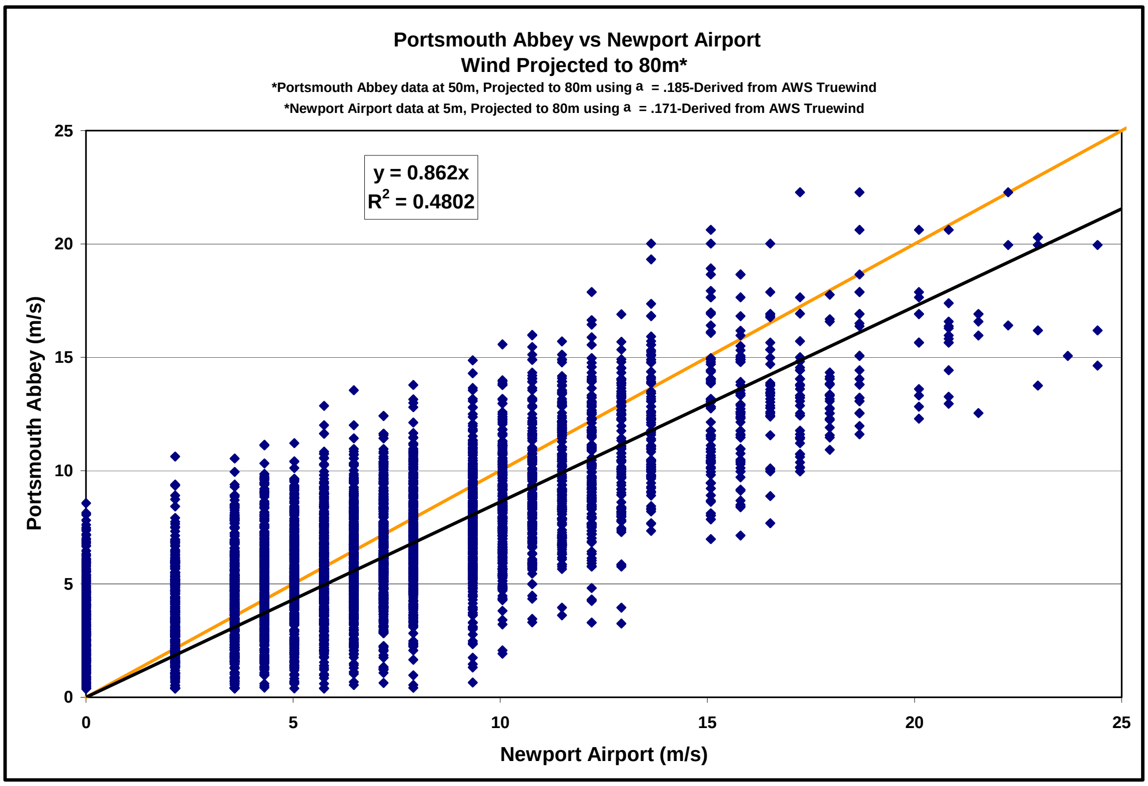

Figure 2. Comparative Wind Speed Plot of Portsmouth Abbey versus Newport State Airport

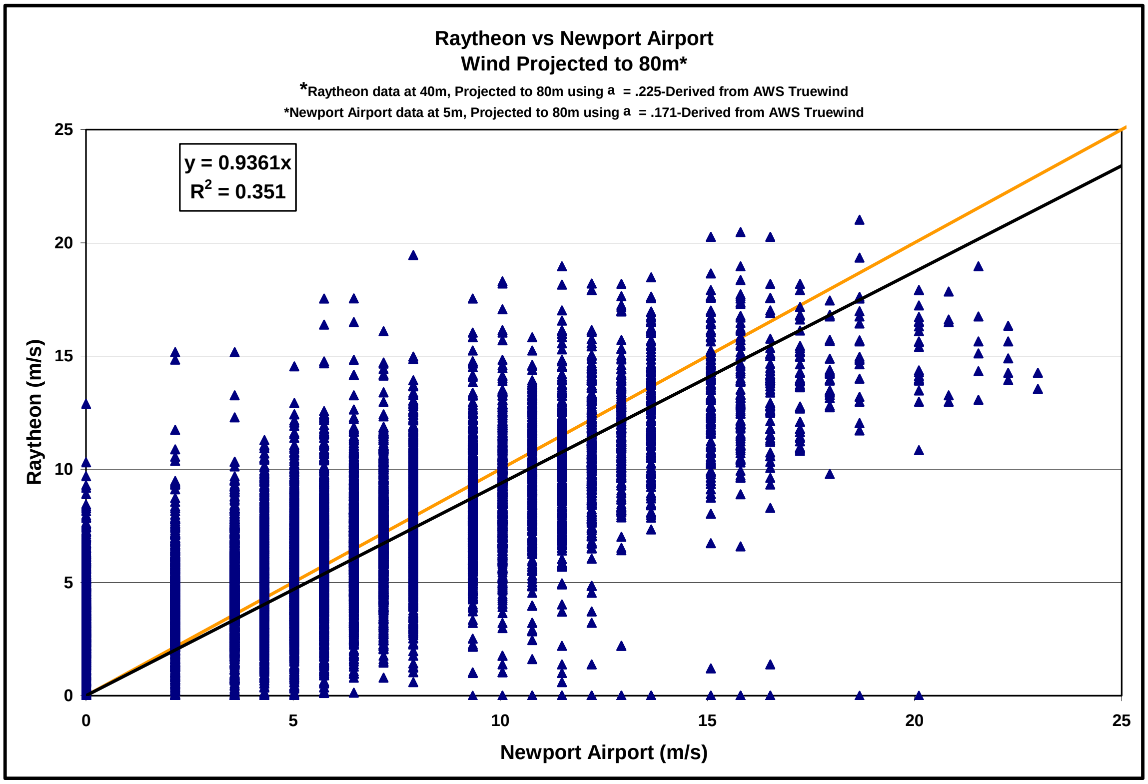

Figure 3. Comparative Wind Speed Plot of Raytheon versus Newport State Airport

The regression was forced through zero for two reasons; first, by inspection of the data, it is clear that the Newport sensor records wind values in discrete bins and that there are no bins less than 2 m/s, implying that a significant fraction of values below 2 m/s are recorded as 0 m/s; second, it is likely that when the wind is zero wind at the airport, the same would be true at Raytheon and the Portsmouth Abbey School. For both analyses however, the coefficient of determination (R^2) value is low, indicating that the relationship between the two sites and Newport is not statistically significant.

From a qualitative review of the data it is apparent that a form of linear relationship exists between the each of the two sites and Newport. Since the y–intercept is zero (meaning that zero wind at the airport corresponds to zero wind at the site) a linear relationship is essentially a ratio between the two. If the regression analysis had proven more statistically significant, it would have been appropriate to use the relationship correlating each site to the airport to develop a synthetic, long term data record at the site. The developed long term record could then have been scaled by the difference in average annual wind speed (predicted from AWS model) at the met data site to that of the potential turbine site (e.g., ratio of average annual wind speed at Portsmouth Abbey to that at the Portsmouth High School). However, since the regression analysis did not prove to be statistically significant an alternative approach was chosen.

STATION CORRELATION CONCLUSIONS

A linear relationship simplified to a ratio was observed between the two sites, the alternative approach was to relate the record at the Newport State Airport to the two potential sites by their respective ratios of average annual wind speed. Table 3 shows the average annual wind speed and ratios for the sites.

Table 3. Summary of Average Annual Wind Speeds and Ratios Compared to Newport State Airport

Location	Average Annual Wind Speed at 80m Elevation (m/s)	Ratio of Average Annual Wind Speed to Newport State Airport
Newport State Airport	7.015	1.00
Portsmouth Middle School	7.076	1.01
Raytheon	6.447	0.92
Portsmouth Abbey	6.850	0.98
Portsmouth High School	6.738	0.96

WIND TURBINE SELECTION

WTGs are designed for different average wind speeds. Some units are designed for high wind speed regimes and some for low wind speed regimes. The performance curve (power generation vs. wind speed) is different for each WTG. Therefore, the WTG must be selected before the energy resource assessment can be completed and the WTG energy production estimated with any degree of accuracy.

ATM worked with the Town to select two WTGs for each school for purposes of this study. The Town decided to evaluate WTGs between minimum and maximum size range of 600 kW to 1,500 kW and subsequently a vendor survey of the WTGs in this size range was conducted. Eight manufactures of WTGs in this size range were identified, but not all manufacturers offer each of their units in the US. These manufacturers include:

1. Siemens
2. Nordex
3. Gamesa
4. Mitsubishi

5. Vestas
6. Fuhrlander
7. Suzlon
8. General Electric (GE) (The only US manufacturer in this size range.)

The WTG sizes available from these manufactures are 600 kW, 850 kW, 1250 kW, and 1500 kW. Several manufacturers provide WTGs rated at 600 kW and 1500 kW. Only Gamesa and Vestas manufacture 850 kW WTGs, but do not offer them in the US. Only Fuhrlander manufacturers a 1250 kW WTG, but this unit does not appear appropriate for low wind speed regimes, such as Portsmouth, because of the relatively small rotor diameter which will not produce as much energy as larger diameter rotors. (The 600 kW and 1500 kW WTGs have area/rating ratios of 3.3 and 3.2 m2/kW, respectively. The 1000 kW WTG has an area/rating ratio of only 2.4 m2/kW so it will not produce as much energy at the predominate low wind speeds.)

Therefore, at this time only 600 kW and 1500 kW WTGs are available in the US appropriate for Portsmouth's wind regime. Performance and price quotations from Fuhrlander for its 600 kW (model FL600) and 1500 kW (model FL1500) WTG and from GE for its1500 kW (model 1.5 sle) WTG were evaluated. Both 1500 kW WTGs were selected with a 77 m rotor diameter for low wind speed applications such as found in Portsmouth.

WIND RESOURCE AND ENERGY PRODUCTION AT THE POTENTIAL TURBINE SITES

The wind time series from the Newport State Airport based on the record from 2000 through 2006 was used to generate a similar time series at each of the two potential wind turbine sites. For the study ATM is investigating two different heights at the Middle School and at the High school sites. The two heights (50m and 80m) are representative of the hub height of the two different candidate WTGs

Using the appropriate ratio of wind speeds and site specific roughness coefficients to develop the representative vertical profile of the wind, a time series of wind speed was generated for the two heights at each of the two sites. An example of the calculated annual average wind speed at Portsmouth High School at 80m is presented in Figure 4. Similarly, the monthly average wind speed at 80m for the Portsmouth High School site is presented in Figure 5. Similar data was generated for the 50m height at the High School and for both heights at the Middle School.

Figure 6 shows the monthly averages of each of these sites and Figures 7 through 10 show the weekly averages for each of these sites. As they are based on the same data set, the trend is the same at each of the sites as can be seen in the figures. The wind speed is also clearly strongest in the winter and reduced in the summer months as might be expected.

The wind time series was then processed and statistically analyzed to develop representative P50 and P90 years for each height at each site. The P50 and P90 year statistics were based on the Newport annual average wind speeds over the wind record used and represent the 50th and 10th percentile of the actual values (i.e. the annual average for which 50 percent of the values are greater and the annual average for which 90 percent of the values are greater, respectively).

Using the P50 and P90 hourly wind years data, hourly production estimates were also generated. The production estimates for a particular WTG are provided by vendors in the form of a power production curve as a function of the wind speed. The performance curve is used in conjunction with wind resource data at the proposed hub height to estimate potential power production from the WTG at the site. The assumed power curves for the two WTGs used in this study are presented in Figure 11.

In addition to monthly and weekly estimates, the hourly wind and corresponding potential power was investigated for an average and a poor wind year. Plots of the P50 and P90 estimated power generation for each of the candidate WTGs are shown in Figures 12 though 19 along with the estimated hourly average load at each of the sites for comparison. These energy generation estimates include an allowance for system losses of 11 percent, which was deducted from the gross WTG generation. The hourly average loads were developed for each school from the electric load data available for two years (8/1/04 to 7/31/06).

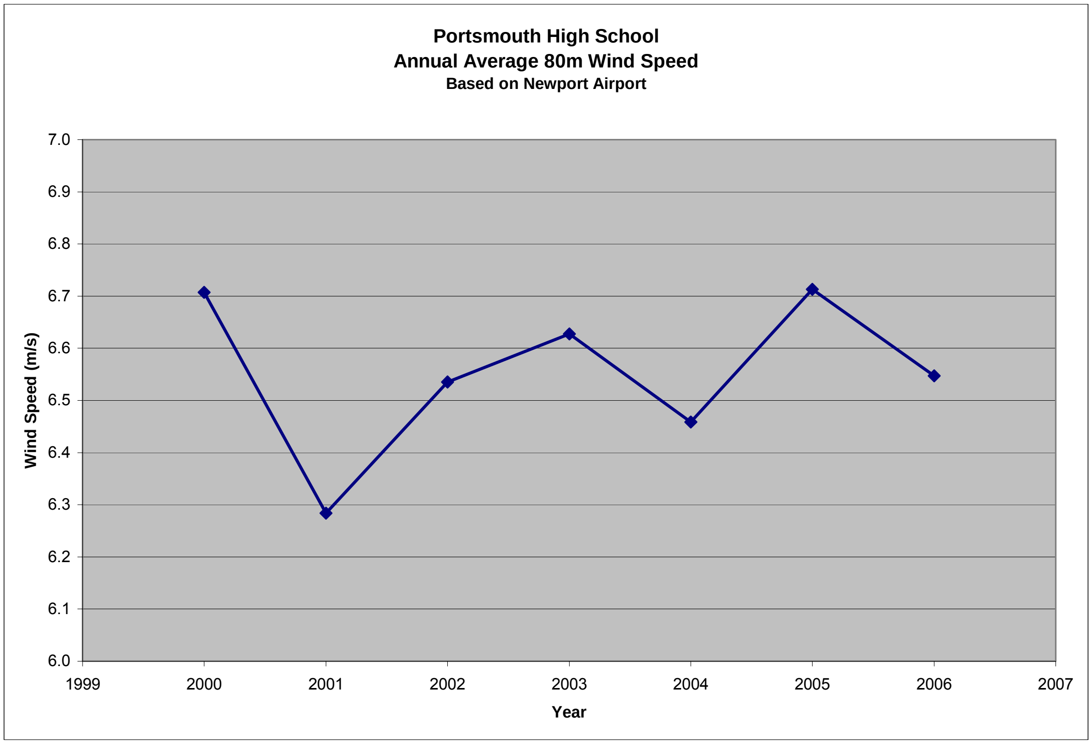

Figure 4. Calculated Annual Average Wind Speed at Portsmouth High School at 80m Elevation

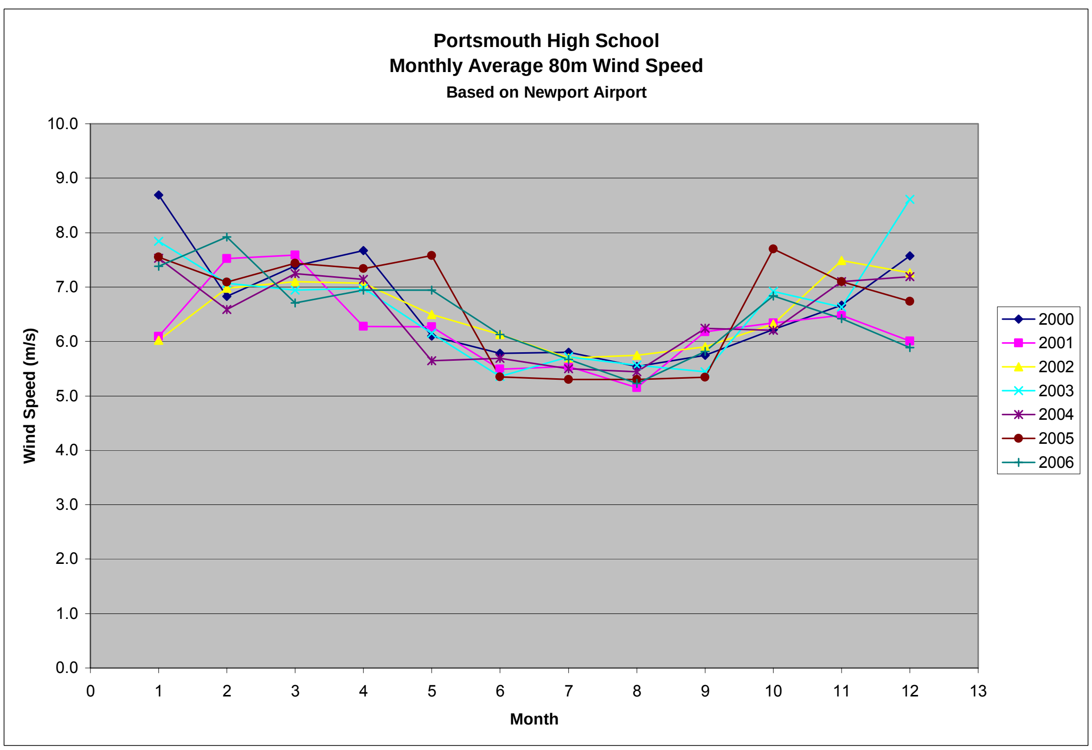

Figure 5. Calculated Monthly Average Wind Speed at Portsmouth High School at 80m Elevation

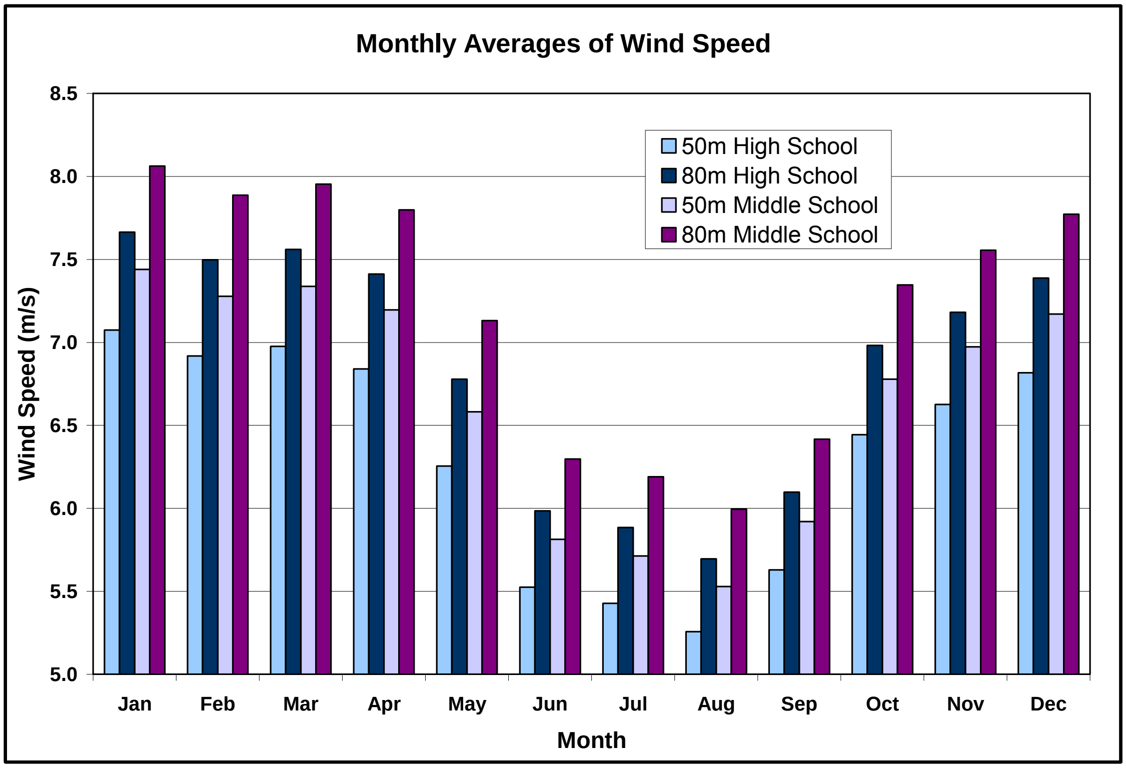

Figure 6. Monthly Averages of Wind Speed at the Potential Sites

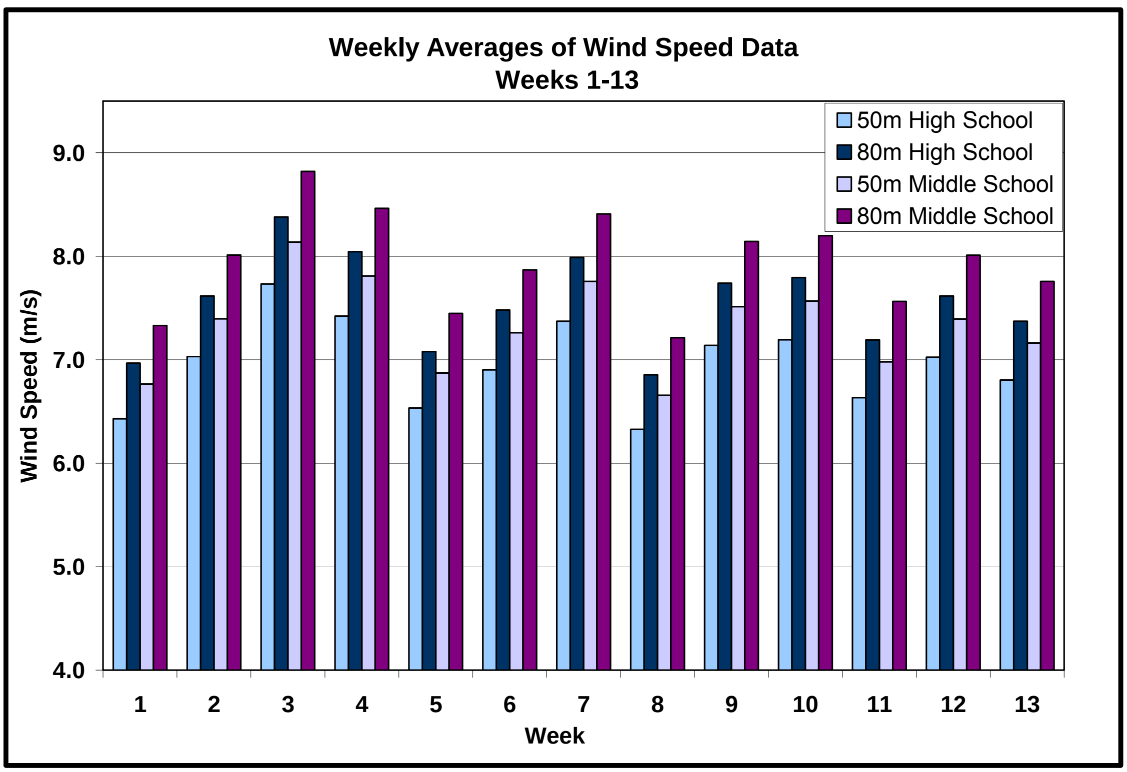

Figure 7. Weekly Averages of Wind Speed at the Potential Sites for Weeks 1 - 13

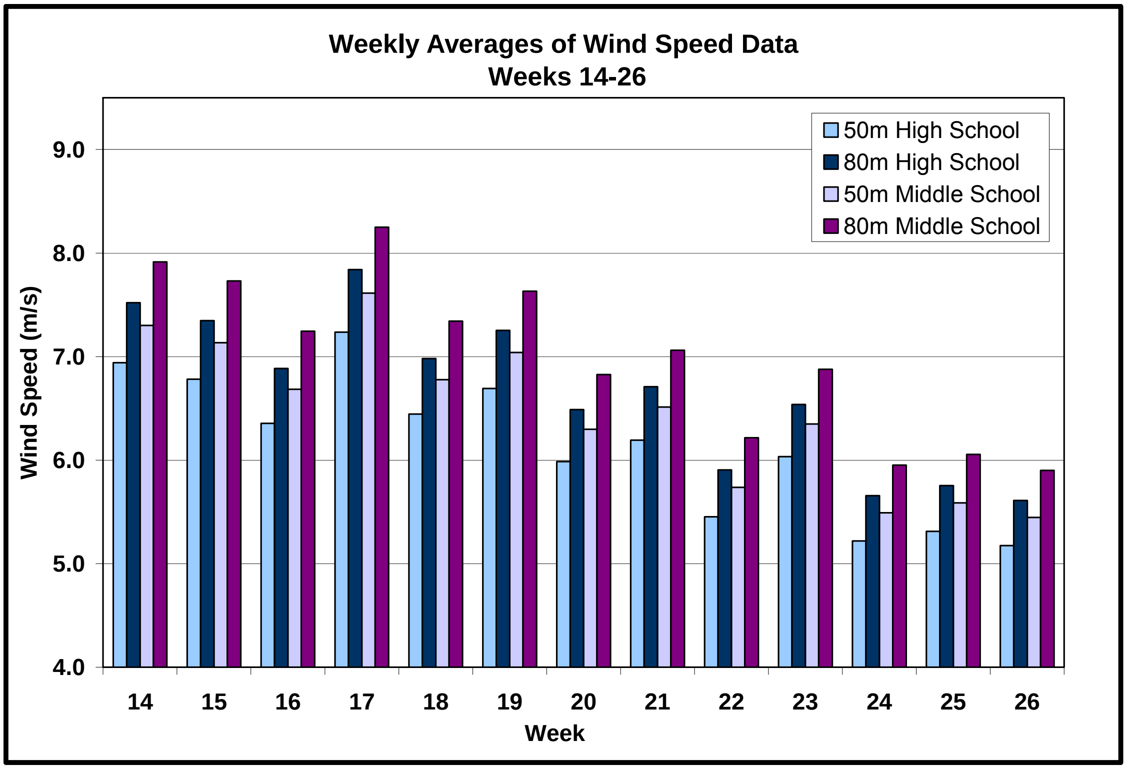

Figure 8. Weekly Averages of Wind Speed at the Potential Sites for Weeks 14 – 26

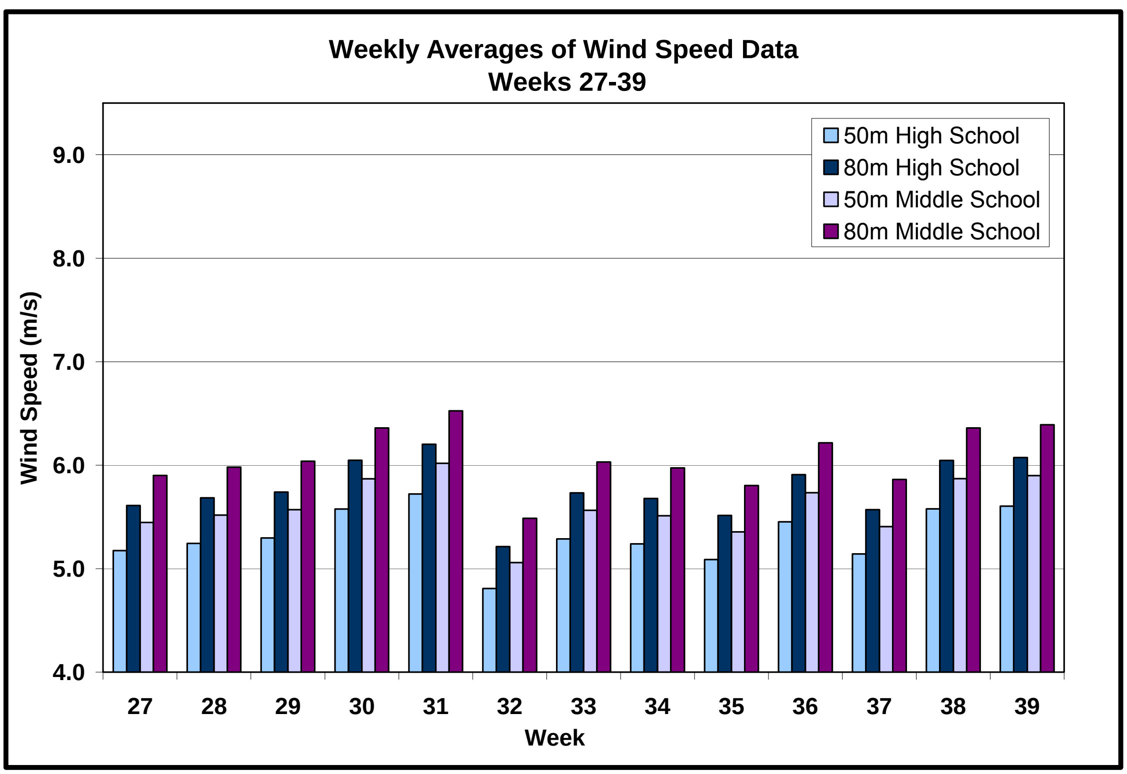

Figure 9. Weekly Averages of Wind Speed at the Potential Sites for Weeks 27 – 39

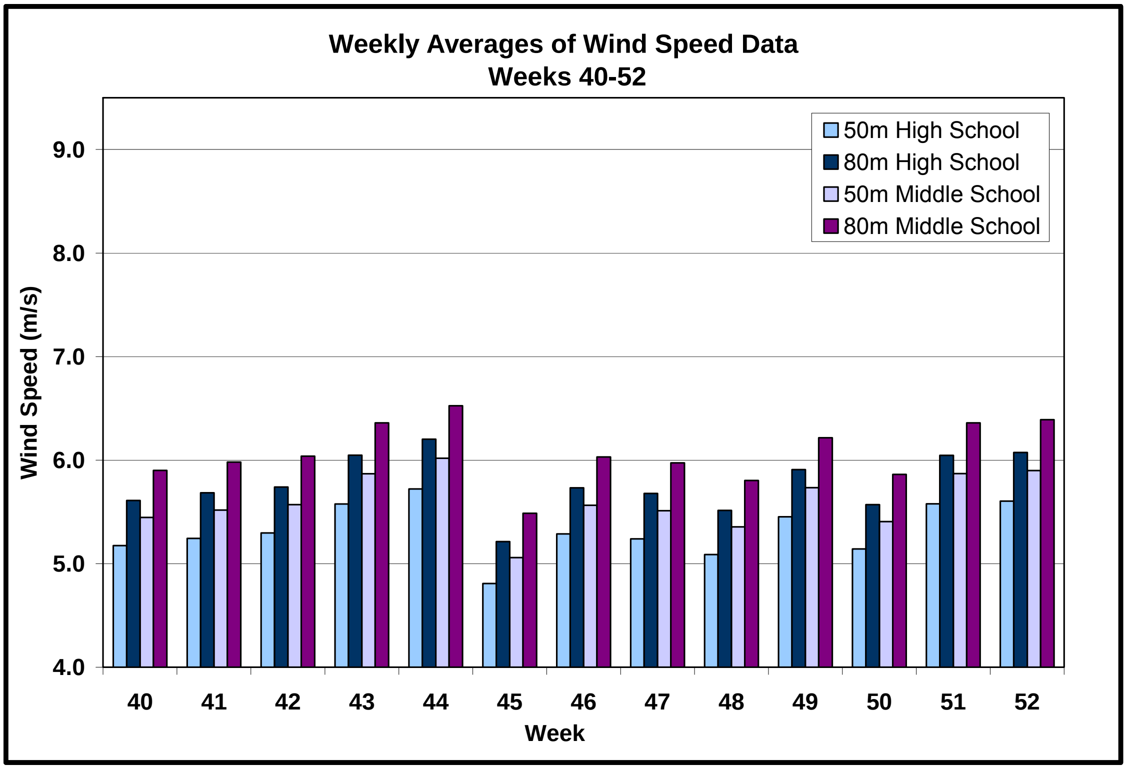

Figure 10. Weekly Averages of Wind Speed at the Potential Sites for Weeks 40 – 52

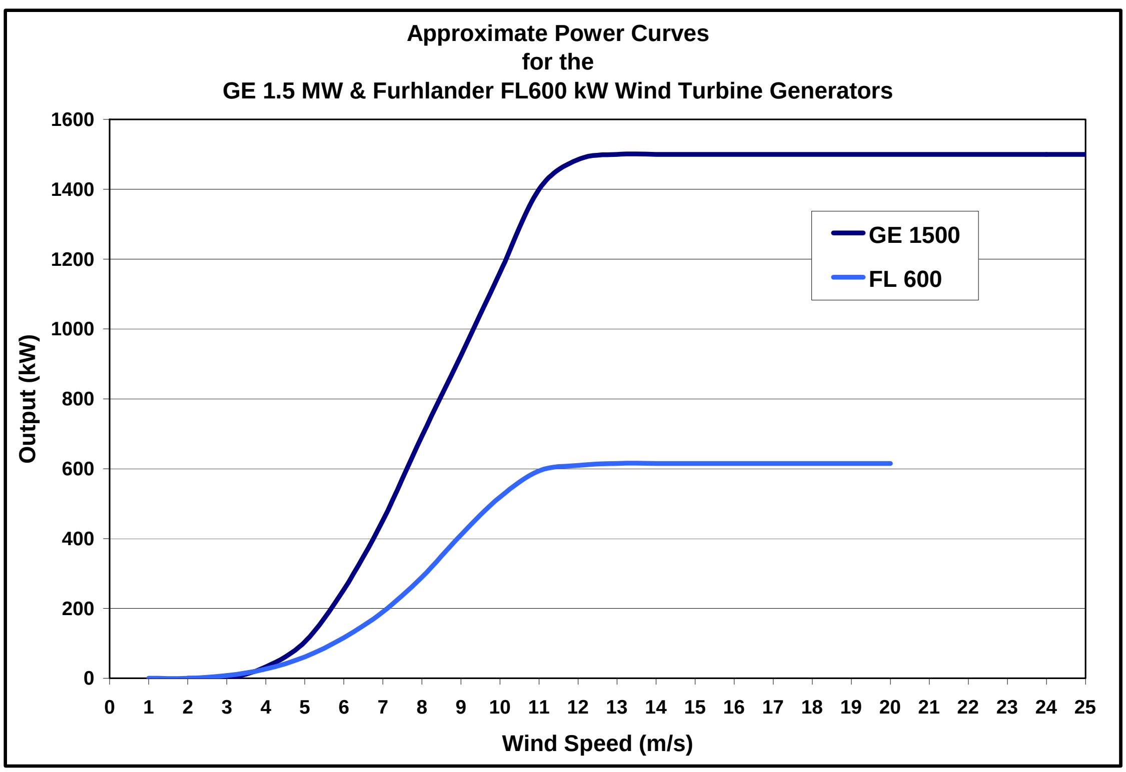

Figure 11. Candidate Wind Turbine Generator Assumed Power Curves

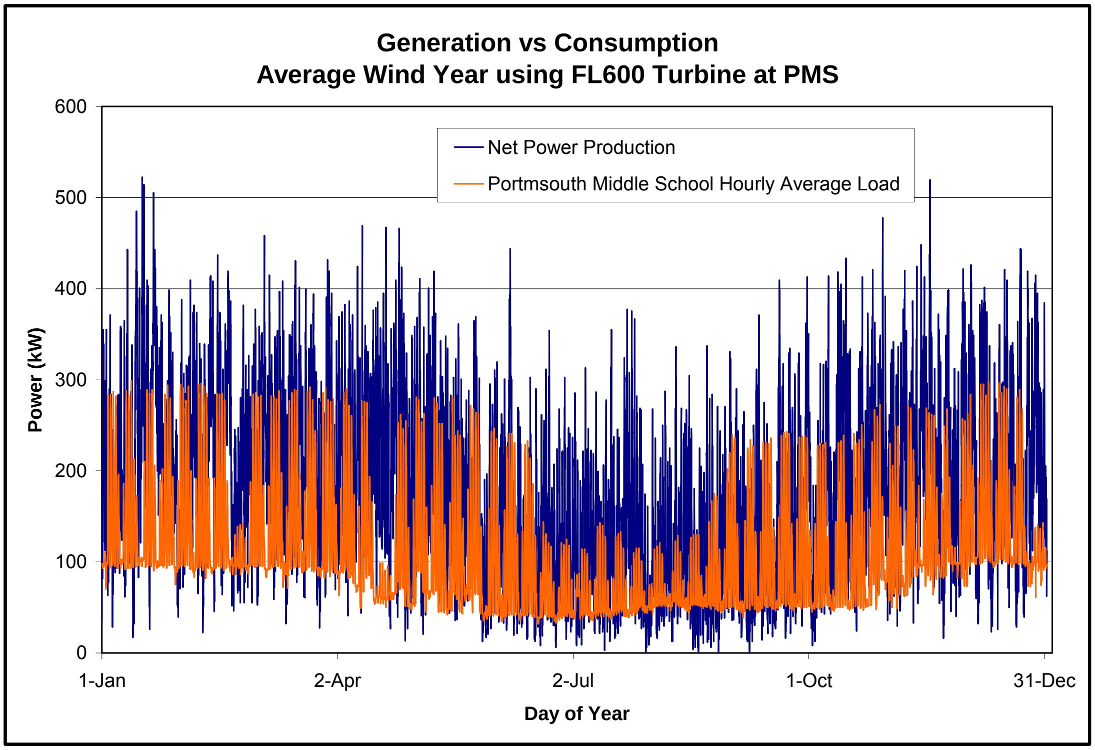

Figure 12. Generation versus Consumption at Portsmouth Middle School Assuming an Average Wind Year and a FL600 WTG

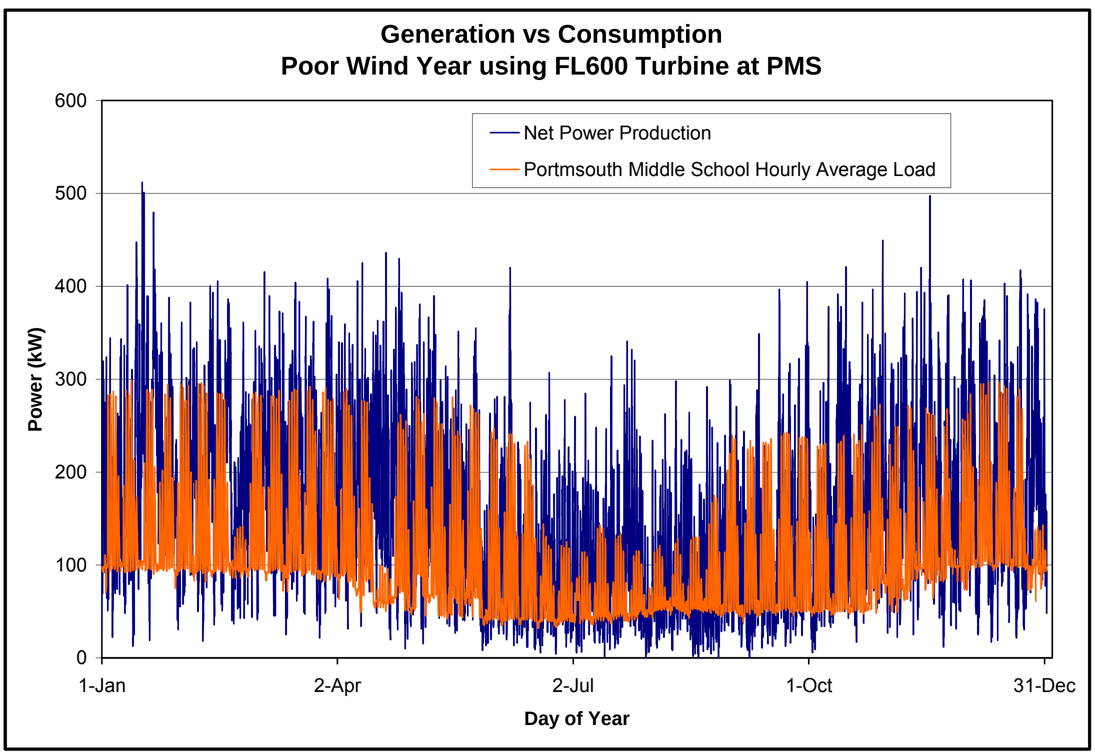

Figure 13. Generation versus Consumption at Portsmouth Middle School Assuming a Poor Wind Year and a FL600 WTG

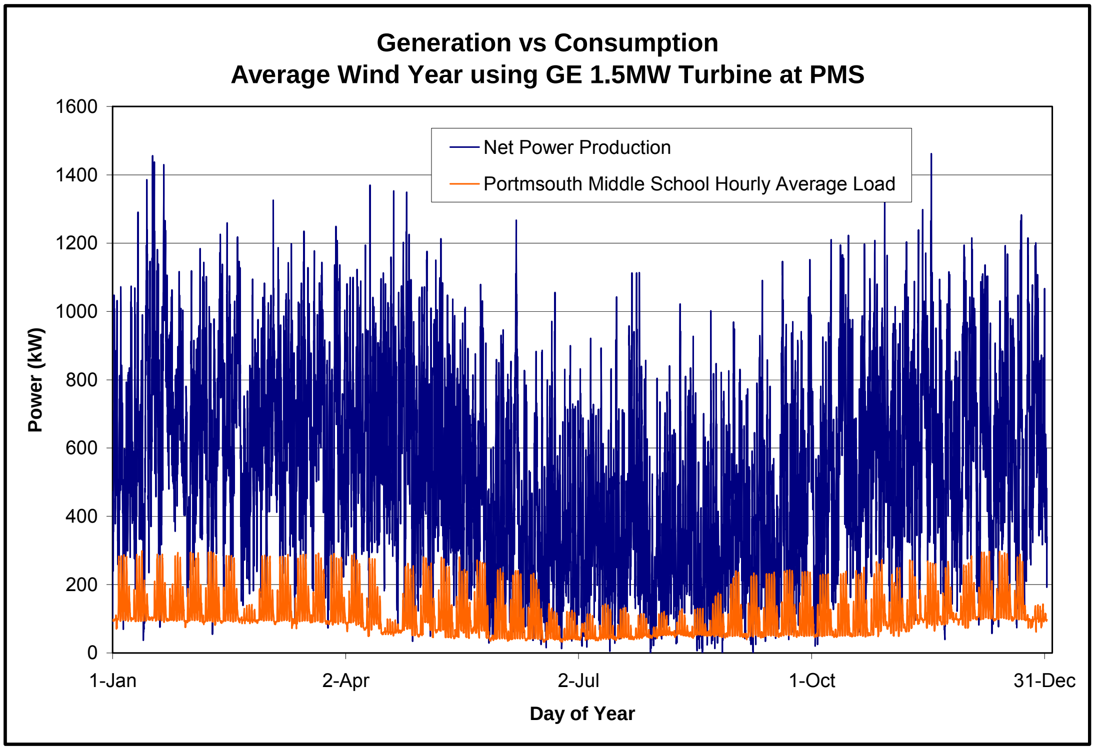

Figure 14. Generation versus Consumption at Portsmouth Middle School Assuming an Average Wind Year and a GE 1.5MW WTG

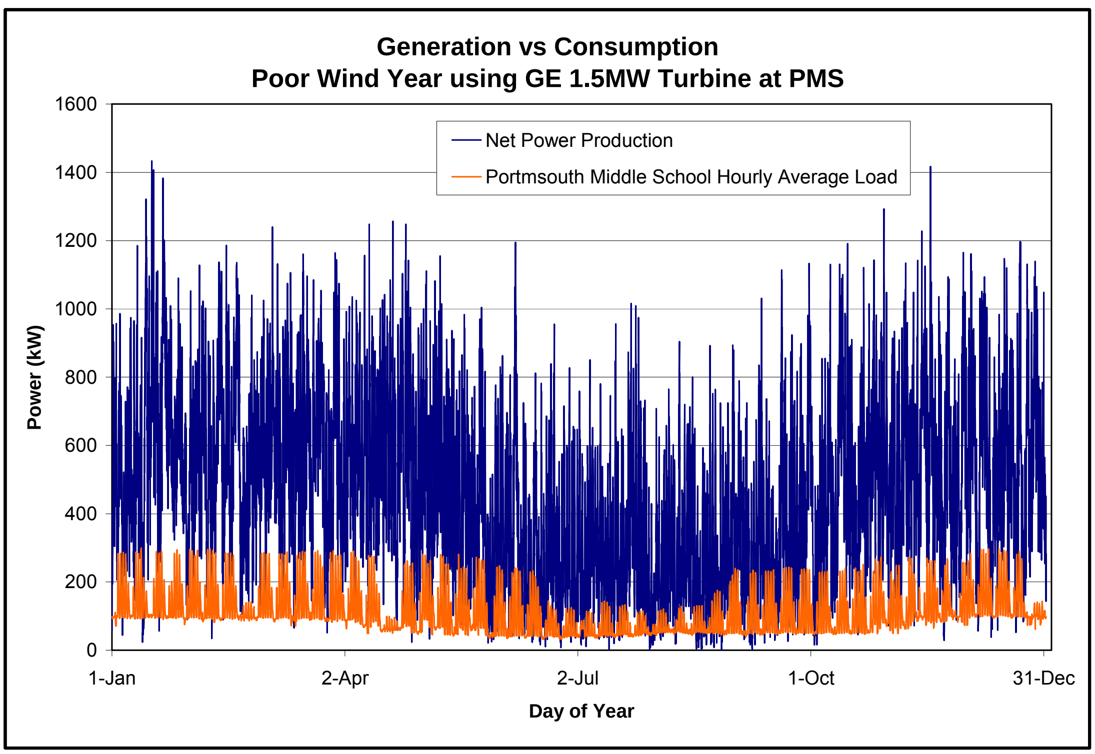

Figure 15. Generation versus Consumption at Portsmouth Middle School Assuming a Poor Wind Year and a GE 1.5MW WTG

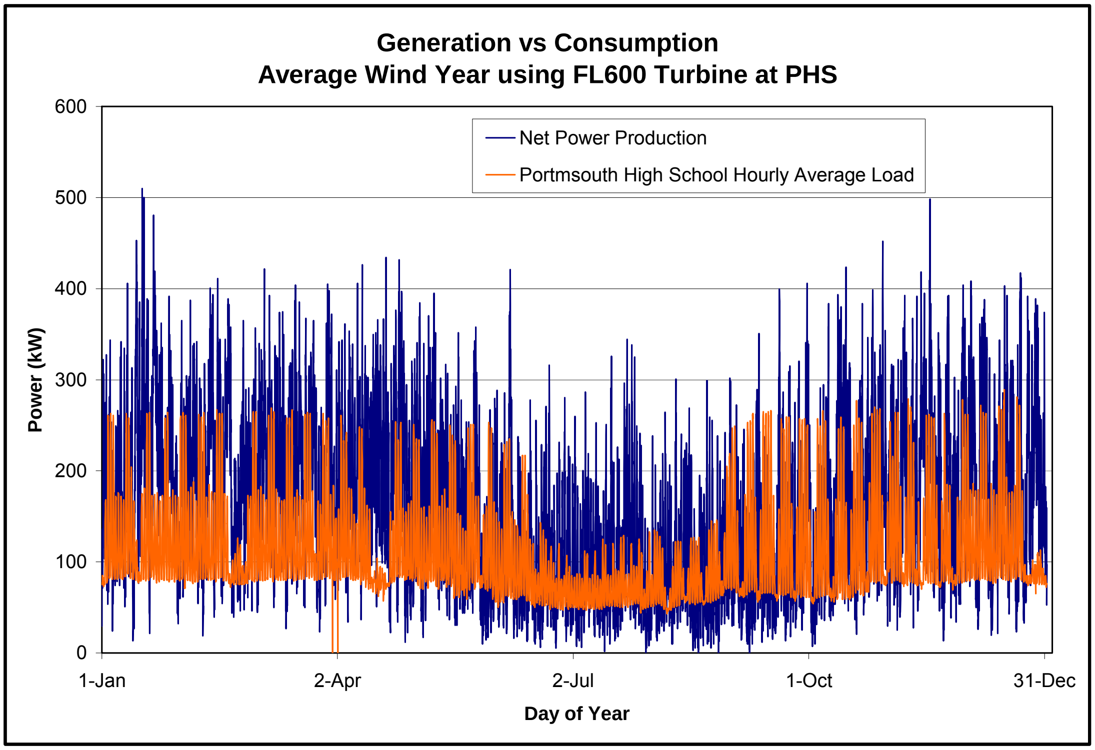

Figure 16. Generation versus Consumption at Portsmouth High School Assuming an Average Wind Year and a FL600 WTG

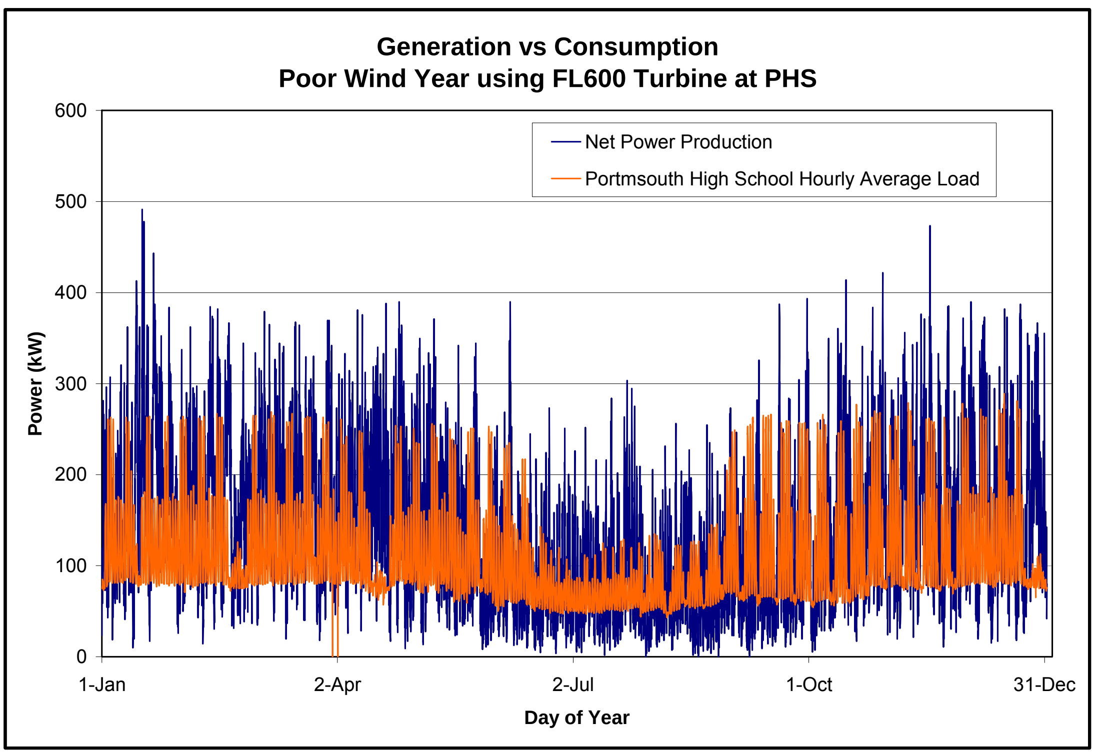

Figure 17. Generation versus Consumption at Portsmouth High School Assuming a Poor Wind Year and a FL600 WTG

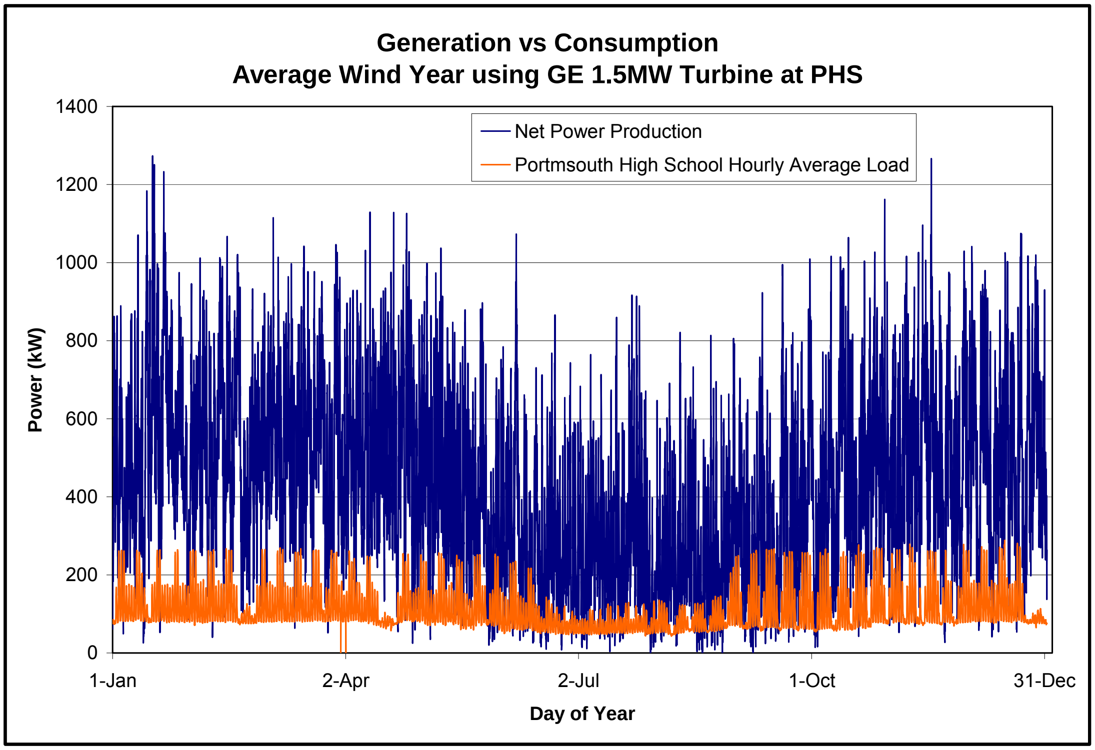

Figure 18. Generation versus Consumption at Portsmouth High School Assuming an Average Wind Year and a GE 1.5MW WTG

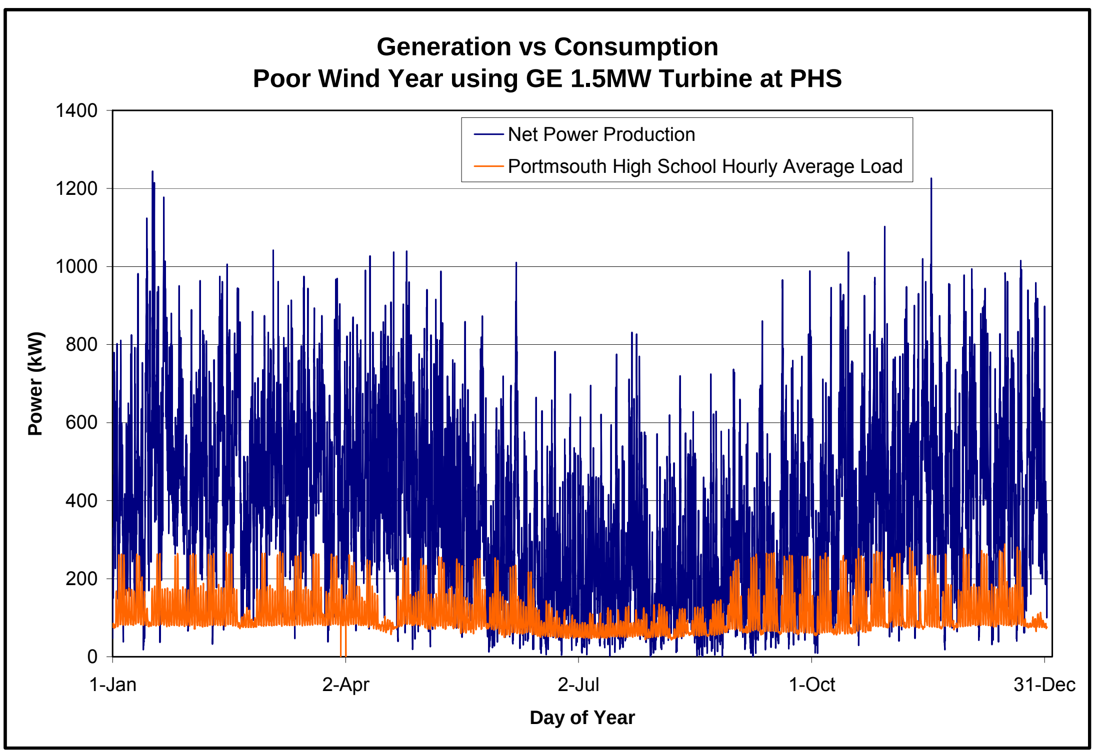

Figure 19. Generation versus Consumption at Portsmouth High School Assuming a Poor Wind Year and a GE 1.5MW WTG

ENERGY ANALYSIS

A comparative analysis of the energy generated by the two WTGs at the two schools was performed based on the estimates described in Section 2.4. These results were shown graphically in Figures 12 through 19 and the comparison of the net generation and electric load data is summarized in the Tables 4 and 5.

Table 4. Middle School Site Energy Summary

WTG Rating, kW	600	600	1500	1500
WTG Hub Height, m	50	50	80	80
Prediction Interval	P50	P90	P50	P90
Average Annual Load, kWh/yr	957,000	957,000	957,000	957,000
Total Net Wind Production, kWh/yr	1,541,000	1,350,000	4 ,124,000	3,623,000
WTG Net Capacity Factor	29%	26%	31%	28%
Wind Energy Used on Site, kWh/yr	824,000	784,000	937,000	923,000
Wind Energy Used on Site	53%	58%	23%	25%
Supply Energy Purchased, kWh/yr	132,000	172,000	19,000	34,000
Wind Energy Sold to Grid, kWh/yr	716,000	565,000	3,186,000	2,700,000
Wind Energy Sold to Grid	46%	42%	77%	75%

Table 5. High School Site Energy Summary

WTG Rating, kW	600	600	1500	1500
WTG Hub Height, m	50	50	80	80
Prediction Interval	P50	P90	P50	P90
Average Annual Load, kWh/yr	954,000	954,000	954,000	954,000
Total Net Wind Production, kWh/yr	1,386,000	1,206,000	3,719,000	3,261,000
WTG Net Capacity Factor	26%	23%	28%	25%
Wind Energy Used on Site, kWh/yr	795,000	752,000	922,000	903,000
Wind Energy Used on Site	57%	62%	25%	28%
Supply Energy Purchased, kWh/yr	159,000	202,000	32,000	51,000
Wind Energy Sold to Grid, kWh/yr	591,000	454,000	2,797,000	2,358,000
Wind Energy Sold to Grid	43%	38%	75%	72%

ELECTRICAL ENGINEERING REQUIREMENTS

EXISTING ELECTRICAL SUPPLY

PORTSMOUTH HIGH SCHOOL

The High School facility is supplied from an overhead 13.8 kV, three phase tap circuit from National Grid (NGRID). The 13.8 kV tap circuit terminates at a riser pole and supplies one (1) 13.8 kV – 120/208 volt, three phase, transformer via 13.8 kV fused cutout switches and approximately 750 feet of 13.8 kV underground cable from the top of the riser pole to the transformer.

The High School 13.8 kV – 120/208 volt transformer is an outdoor, three phase, padmount type transformer rated 500 kVA. The NGRID revenue metering equipment for Portsmouth High School is mounted on the padmount transformer and is supplied from current transformers located at the 120/208 volt secondary bushings of the padmount transformer. The riser pole, 13.8 kV cable, and the padmount transformer are owned and operated by NGRID.

PORTSMOUTH MIDDLE SCHOOL

The Middle School facility is supplied from an overhead 13.8 kV, three phase tap circuit from National Grid (NGRID). The 13.8 kV tap circuit terminates at a riser pole and supplies one (1) 13.8 kV – 480/277 volt, three phase, transformer via 13.8 kV fused cutout switches and approximately 450 feet of 13.8 kV underground cable from the top of the riser pole to the transformer.

The Middle School 13.8 kV – 480/277 volt transformer is an outdoor, three phase, padmount type transformer rated 300 kVA. The NGRID revenue metering equipment for Middle School is expected to be located at or near the 480 volt distribution panel within the school. The riser pole, 13.8 kV cable, and the padmount transformer are owned and operated by NGRID.

PROPOSED WTG ELECTRICAL INTERCONNECTION PLAN

The WTG (either the 600 kW or 1500 kW unit) is proposed to be connected to the NGRID 13.8 kV, three phase tap circuit that supplies each school. The connection to the 13.8 kV tap circuit is proposed to be located in the vicinity of the existing 13.8 kV riser pole that supplies each school. The NGRID revenue metering will have to be moved from the secondary of the NGRID padmount distribution transformers that supply each school to the overhead 13.8 kV tap circuit to allow the interconnection of the WTG to be on the school's side of the meter.

The generator output voltage is 585 – 690 volts (depending upon the generator model). Therefore, in order to connect the WTG to the 13.8 kV tap circuit, a three phase generator step-up transformer will be utilized to convert the generator voltage to the 13.8 kV supply circuit voltage. The generator step-up transformer will be located at the base of the WTG. The generator step-up transformer will be a three phase transformer and capable of carrying the maximum power output of the WTG plus a margin for the current associated with the generator reactive power consumption/production and an additional margin based on the maximum generator output multiplied by a rating factor of 125 percent. For the 600 kW unit, this calculation yields a three phase power rating of 789 kVA which can be accommodated by a transformer rated 750 / 845 kVA (55/65 degrees Celsius temperature rise). For the 1500 kW unit, this calculation yields a three phase power rating of 1,974 kVA which can be accommodated by a transformer rated 2,000 kVA.

At the High School, the WTG will be located approximately 600 feet from the point of interconnection to the 13.8 kV tap circuit. At the Middle School, the WTG will be located approximately 1,650 feet from the point of interconnection to the 13.8 kV tap circuit. The 13.8 kV interconnection circuit is proposed to consist of three (3), #2 AWG, aluminum cables (one (1), #2 AWG, aluminum cable per phase) with an ampacity of 120 amperes per phase.

The 13.8 kV generator interconnection circuit will be connected to the overhead 13.8 kV tap circuit via a 13.8 kV gang operated disconnect switch to provide a controllable switching point between the WTG and the NGRID 13.8 kV distribution system. The disconnect switch will provide an obvious point of disconnection that can be verified by visual observation. NGRID operations personnel will need access to manually open and padlock this disconnect switch in the open position to guarantee that the WTG will not energize their 13.8 kV distribution system while they are working on it or when they otherwise deem it necessary.
The WTG will be equipped with a main circuit breaker and a contactor that will automatically open upon a signal from the protective relay and control system that will be required by NGRID for interconnection of generation to their distribution system. The protective relays detect abnormal circuit conditions that would require the WTG to be disconnected from the rest of the 13.8 kV system. The protective relays that NGRID will require include over/under voltage

relays and over/under frequency relays. These protective relay functions are available in a single multifunction protective relay.

Recent project experience indicates that the supplying electric utilities are requiring the multifunction protective relay to be utility grade whereas the multifunction relays included with some WTGs are industrial grade. Utility grade relays comply with utility industry standards such as IEEE C37.90 and C37.90.1. Examples of utility grade protective relays that are acceptable include the Basler Electric Company BE1-GPS100 Generator Protection System and the Schweitzer Engineering Laboratories (SEL) SEL-547 Distributed Generator Interconnection Relay.

REVENUE METERING MODIFICATIONS

The existing NGRID revenue metering equipment for the High School and Middle School will have to be replaced with bi-directional (capable of measuring electrical power that flows in both directions) metering equipment that measures: (1) power supplied by NGRID to the school during periods when power consumption exceeds the wind turbine generation; and, (2) power supplied to the NGRID 13.8 kV distribution system during periods when the WTG production exceeds the consumption. In addition, a kWh meter will have to be installed at the output terminals of the WTG to measure the WTG energy production.

The required revenue metering modifications for the 13.8 kV interconnection plan will create what is referred to as a "primary metering" arrangement where the school will take delivery of power from NGRID at the 13.8 kV overhead supply tap to the school. It will involve the installation of new 13.8 kV instrument transformers that will convert the voltage and current at the 13.8 kV level to the voltage and current levels that can be safely connected to the new NGRID revenue meter. For that purpose, it is anticipated that NGRID will require the installation of two (2) potential transformers and three (3) current transformers at the new revenue metering location. NGRID may also require a dedicated telephone circuit to be provided as part of the primary revenue metering arrangement for their use.

OPERATION OF WTGS

Under normal electrical grid conditions and with sufficient wind, the WTG will automatically start and connect to the NGRID 13.8 kV distribution system. The WTG will begin to generate power and will ramp up towards full output as a function of the wind speed. As the wind subsides or becomes too excessive, the WTG will automatically stop generating and shutdown. Once wind conditions are favorable again, the WTG will automatically start and resume generation.

The WTG is only intended to operate when it is connected to an energized electrical grid. It is not intended to be a source of standby electrical power in the event of a power outage. The WTG includes sensors and protective relays that will detect abnormal circuit conditions as measured at the point of interconnection to the generator step-up transformer. The sensors and protective relays will cause the generator to automatically stop generating and shutdown until conditions return to normal.

NEXT STEPS

The final configuration of the WTG interconnection equipment will be subject to NGRID's review and analysis of the WTG impact on their distribution system. It will be necessary to prepare an interconnection application and submit it to NGRID with the required application fee. NGRID will review the application for completeness and prepare a proposal and cost estimate to perform an initial feasibility study. NGRID will perform the initial feasibility study review and, if the results are acceptable, NGRID will prepare a proposal and cost estimate to perform a subsequent impact study and detailed facility study. NGRID may also require the applicant to pay for modifications to the NGRID distribution system that are determined to be necessary, if any, to interconnect the WTG.

COST ESTIMATES

PROJECT COST ESTIMATES

The following planning level cost estimates have been developed for the two WTGs at both schools. The cost estimates are based on vendor budgetary quotations and other similar projects and are summarized in Table 6. The 600 kW WTG and associated equipment cost estimates are based on recent budgetary price estimates from Lorax Energy Systems, LLC for the Fuhrlander FL600 WTG. The costs were provided in Euros and converted to US dollars based on a recent exchange rate of 1.35 US $/Euro. The 1500 kW WTG cost estimates are based on budgetary estimates from GE for their model 1.5 sle WTG. The electrical cost estimates are based on the conceptual interconnection plans for the WTG as described in the previous section. The Utility Equipment Purchase is an allowance for the existing equipment that would be purchased from NGRID because the point of interconnection with the utility will change.

Table 6. Project Cost Estimate Summary

Item and Description	Middle School 600 kW Total Cost	Middle School 1500 kW Total Cost	High School 600 kW Total Cost	High School 1500 kW Total Cost
Mobilize	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Site Surveys	$ 25,000	$ 25,000	$ 25,000	$ 25,000
Clear and Grub	$ 12,000	$ 12,000	$ 12,000	$ 12,000
Site Preparation	$ 12,000	$ 12,000	$ 12,000	$ 12,000
Access Road (20 ft wide)	$ 50,000	$ 50,000	$ 50,000	$ 50,000
Foundations	$ 70,000	$ 140,000	$ 70,000	$ 140,000
WTG	$ 1,012,800	$ 2,350,000	$ 1,012,800	$ 2,350,000
WTG Duty	$ 22,800	NA	$ 22,800	NA
WTG Shipment	$ 52,000	Incl	$ 52,000	Incl
WTG Tower	$ 293,700	Incl	$ 293,700	Incl
WTG Tower Shipment	$ 25,300	Incl	$ 25,300	Incl
Electrical Interconnection	$ 196,000	$ 218,000	$ 122,000	$ 144,000
Utility Equipment Purchase	$ 50,000	$ 50,000	$ 70,000	$ 70,000
Engineering Allowance	$ 50,000	$ 75,000	$ 50,000	$ 75,000
Subtotal	$ 1,897,000	$ 2,957,000	$ 1,842,632	$ 2,903,000
<u>Contingencies</u>				
WTG and Tower	$ 70,000	$ 117,500	$ 70,332	$ 117,500
Other	$ 98,000	$ 121,400	$ 87,200	$ 110,600
Contingency Subtotal	$ 168,000	$ 238,900	$ 157,532	$ 228,100
Owner's Development Cost	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Total Project Cost	$ 2,165,000	$ 3,295,900	$ 2,100,163	$ 3,231,100
Total Project Cost, $/kW	$ 3,600	$ 2,200	$ 3,500	$ 2,150

A separate contingency was applied to the WTG and to the balance of plant cost. The contingency is low because the WTG is based on vendor budgetary quotations and the confidence level in the cost estimate is higher. The contingency in the balance of plant cost estimate is higher because only feasibility level design has been prepared and the confidence level is low. It should be pointed out that the cost of WTGs is currently at an all time high due to the extraordinarily high demand for WTGs at this time. It is generally expected that the cost of WTG will decrease if the Federal PTC is extended beyond 2008.

An estimate of the owner development costs has also been included in the capital cost estimate. These are cost for services required to develop the project prior to construction such as environmental permitting services, preliminary engineering services, electrical interconnection studies, and legal services.

The total estimated project cost is approximately $3,600 per kW for the 600 kW WTGs and $2,200 per kW for the 1500 kW WTGs, which is consistent with other similar projects and could change based on the final design, permit requirements, market conditions, and construction conditions. The cost estimate does not include sales tax.

O&M COST ESTIMATE

A feasibility level operation and maintenance (O&M) cost estimate was prepared for the each turbine. A summary of the estimate is presented in Table 7.

Table 7. O&M Cost Estimate Summary

Item and Description	600 kW	1,500 kW
O&M Contract (after first two years)	$20,000	$35,000
Administration Allowance	$5,000	$5,000
Insurance Premium	$11,000	$17,000
Land Lease/Property Tax Payments	NA	NA
Subtotal	$36,000	$57,000
Contingency (20%)	$7,200	$11,400
Total Annual O&M	$43,200	$68,400

The O&M contract is not required during the first two years of operation because the WTG would be covered by the manufacturer's warranty during this period. The annual Administration Allowance is expected to cover the administrative cost of operating and maintaining the units. The annual Insurance Premium is estimated based on 0.6 percent of the replacement cost. It is assumed that the projects would not incur a land lease or property tax payment because the WTG would be owned by the Town.

As a primary-metered customer, the NGRID revenue meter will be located at the 13.8 kV side of the distribution transformer that supplies each school. As a result, it is anticipated that the schools will have to purchase all NGRID equipment located on the load side of the meter including the 13.8 kV riser poles, fused cutouts, cables, and distribution transformers.

ECONOMIC ANALYSIS

INTRODUCTION

This economic analysis incorporates an appropriately detailed set of assumptions regarding estimated project production, fixed and variable costs, avoided electricity charges, and both power and Renewable Energy Credit (REC) revenue. Results are provided in the form of annual net cash flow, cumulative net cash flow and Net Present Value (NPV). The metrics Internal Rate of Return and Payback Period are not provided because the Town is not making an up-front cash contribution to the project. The following sections present the analysis methodology and results.

EVALUATION OF CREBS AND GENERAL OBLIGATION BOND

The Analysis assumes the turbine is owned by the Town, has a 20-year useful life, and is funded either by the Town's Clean Renewable Energy Bond[1] (CREB) allocation, or a combination of CREBs and a separate General Obligation Bond, in the event that total project costs exceed the Town's CREB allocation. The CREB is assumed to be issued as a General Obligation Bond with a 13 year maturity, which was derived using the methodology established by the IRS and the long-term adjusted Applicable Federal Rate as of August 1, 2007. In this Analysis, the CREB is repaid in equal principal amounts, as required by the Internal Revenue Service. The term of the additional General Obligation Bond, if any, was set to match the CREB. Capital, ongoing operations and maintenance, insurance and administrative expense assumptions are based on researched estimates, comparable projects and industry experience. Forecast electricity production from each turbine and historic electricity consumption from each school were compared on an hourly basis. The Analysis assumes electricity produced by the turbine is consumed by the applicable school (offsetting retail electricity prices) at all times of coincident supply and demand. It is assumed that the turbine is not a net metering installation, due to the current provision under Rhode Island's net metering law that all excess generation at the end of the applicable twelve-month period is granted to the utility at no cost. Rather, the Analysis assumes that all remaining production, as well as all Renewable Energy Credits (REC) are sold to the wholesale grid, at prices forecast as part of the market value of production component of this Analysis.

[1] Clean Renewable Energy Bonds are offered by the US Treasury. CREBs provide benefit equivalent to zero interest financing, while providing a tax credit (in lieu of interest) to bond holders.

MARKET VALUE OF PRODUCTION

The proposed projects have three major sources of market value: (1) avoided retail electricity charges, (2) wholesale electricity revenues and (3) Renewable Energy Credit (REC) revenue.[2]

WHOLESALE ELECTRICITY REVENUES

An all-hours average of forecasted wholesale electricity prices was derived by applying the forecast of delivered natural gas prices to the region to an average NEPOOL "market heat rate" – which is the ratio relating delivered market natural gas prices to market electric energy prices. While a number of factors influence the wholesale market electricity prices in Rhode Island, the predominant driver of price trends has been (and is expected to continue to be) the price of natural gas, which is the fuel for the marginal (price-setting) generator in ISO New England in the majority of hours. Through 2012, the natural gas price was projected using NYMEX Henry Hub[3] gas futures. From 2013 onward, the Henry Hub natural gas price forecast from the EIA's[4] Annual Energy Outlook (AEO) 2007 reference case was used, adjusted upward to reflect the historical relationship between the AEO forecast and the NYMEX as derived by Lawrence Berkeley National Laboratory. To reflect the difference in value between an all-hours average price and the intermittent production stream of a wind generator, a predictability adjustment was made to derate the market value of an intermittent production stream by an estimated $2.50 per MWh relative to a fixed firm block of energy. Finally, starting in 2009, the projected cost of a carbon allowance under the Regional Greenhouse Gas Initiative (RGGI) regime was added to energy prices. RGGI allowances will be required by most fossil fuel generators in the region, and the cost of such allowances will increase market electricity prices because this cost will be added to bid prices in the energy market.

AVOIDED RETAIL ELECTRICITY CHARGES

The relationship between long-term wholesale energy trends and market-based retail delivered electric generation service prices is fairly constant. The differentials between wholesale and retail generally reflect the cost of shaping, ancillary services and reserves. In this Analysis, the value of avoided retail electricity charges was derived using the wholesale values described in

[2] One additional potential source of revenue – from the Forward Capacity Markets – appears to be available for the portion of the turbine's electricity production that is consumed on-site in addition to that sold to the wholesale market, based on current market rules. However, the lack of clarity on this point, and the possibility that these rules could be modified in the future, has led to the more conservative assumption to exclude FCM payments for production consumed on-site as a source of stand-alone revenue. However, the value that the school would derive by avoiding retail electricity charges does include the benefit of avoiding the cost of FCM that is embedded in any competitive supplier's retail rate offerings.

[3] NYMEX is the New York Mercantile Exchange. Henry Hub is a highly liquid trading location in Louisiana. Most natural gas forecasts use the Henry Hub location as the basis for their analysis.

[4] EIA = Energy Information Administration, which is housed within the Department of Energy.

the previous section and these adjustments. Next, the estimated costs of purchasing installed capacity reserves (in the Forward Capacity Market) to serve load was included, and the cost of complying with the Renewable Portfolio Standard was added. The sum of these components was adjusted upward for transmission and distribution losses. The combined result is an estimate of the competitive market generation service price. By generating electricity on-site, the schools will also be able to avoid some, but not all, of their transmission- and distribution-related charges. Examples of non-bypassable charges (e.g. those charges the customer will always pay regardless of their source of electricity) include the "Customer Charge" and the "Transition Charge." That portion of peak demand calculated to be avoided due to the operation of the wind turbine were also avoided. Of critical importance, this Analysis assumes that the Portsmouth wind project falls within the current exemption from back-up rates[5]. Notably, the customer should not expect to avoid their total electricity bill, even in a month in which 100 percent of electricity consumption is met by the on-site generator. Again, it is assumed that the turbine is not a net metering installation. Retail electricity charges are avoided only at times of coincident turbine production and school demand.

REC REVENUES

A wind generator in Rhode Island is eligible to create and sell RECs which can be used for compliance with the Rhode Island Renewable Energy Standard. (Production delivered to the wholesale grid is also eligible in Massachusetts, while production on both sides of the meter is eligible for Class 1 RECs in Connecticut). The Rhode Island RES requirement started in 2007, so little market data is available. The design of the RI policy is substantially similar to the longer-running Massachusetts RPS, and therefore the prices for compliance RECs are projected to track closely. The REC revenue estimate was derived by applying conservative assumptions to a Sustainable Energy Advantage proprietary model of New England REC supply and demand.

Table 8 summarizes the wholesale, retail and REC prices which are described above and used in this Analysis.

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[5] The first 3 MW of customer-sited renewable generation is currently exempt from the application of backup rates to the displaced consumption. Currently, the only significantly-sized generator using this exemption is the Portsmouth Abbey wind turbine. This analysis assumed that either the Portsmouth turbines fall within this threshold or that the threshold is increased.

Table 8. Wholesale and Retail Electricity and REC Price Summary

Summary of Forecasted Wholesale Electricity, Retail Electricity and REC Prices: 2008 - 2027						
Year	Wholesale Electricity Forecast ($/MWh)	Avoided On-Site Electricity Charges: Middle School, FL 600 ($/MWh)	Avoided On-Site Electricity Charges: Middle School, GE 1.5 ($/MWh)	Avoided On-Site Electricity Charges: High School, FL 600 ($/MWh)	Avoided On-Site Electricity Charges: High School, GE 1.5 ($/MWh)	REC Price Forecast ($/MWh)
2008	$79.45	$127.16	$128.58	$126.54	$127.57	$57.49
2009	$81.50	$131.50	$132.96	$130.87	$131.92	$53.05
2010	$79.52	$134.68	$136.17	$134.03	$135.12	$42.83
2011	$76.57	$131.97	$133.50	$131.30	$132.42	$26.91
2012	$74.24	$129.91	$131.48	$129.23	$130.37	$27.82
2013	$67.23	$122.40	$124.01	$121.70	$122.87	$32.70
2014	$68.66	$124.86	$126.51	$124.15	$125.35	$31.15
2015	$69.15	$126.44	$128.13	$125.71	$126.94	$31.23
2016	$71.54	$130.16	$131.89	$129.41	$130.67	$29.31
2017	$75.20	$135.50	$137.28	$134.73	$136.02	$28.49
2018	$75.57	$137.19	$139.01	$136.40	$137.72	$30.46
2019	$76.35	$139.39	$141.25	$138.58	$139.93	$32.00
2020	$78.88	$143.77	$145.68	$142.94	$144.33	$32.45
2021	$80.41	$145.94	$147.90	$145.09	$146.51	$30.95
2022	$83.78	$149.95	$151.96	$149.08	$150.54	$27.10
2023	$87.14	$153.98	$156.04	$153.09	$154.58	$23.26
2024	$91.01	$159.30	$161.41	$158.38	$159.91	$23.26
2025	$92.63	$161.91	$164.07	$160.97	$162.54	$23.26
2026	$94.62	$165.00	$167.22	$164.04	$165.65	$23.26
2027	$97.55	$169.25	$171.52	$168.26	$169.91	$23.26

KEY ASSUMPTIONS

A summary of key assumptions for each project is provided in Table 9. Revenue and cost summaries are provided as levelized values (a single number that would have the same economic effect as the 20 years of projected values actually used on the Analysis) for easy comparison across projects.

Table 9. Projects Key Assumptions Summary

Selected Assumptions				
Project Assumptions	FL 600 @ Middle School	GE 1.5 sle @ Middle School	FL 600 @ High School	GE 1.5 sle @ High School
Installed Capacity	600 kW	1500 kW	600 kW	1500 kW
Total Installed Cost	$2,210,000	$3,340,900	$2,145,163	$3,276,100
Project Life	20 Years	20 Years	20 Years	20 Years
Financing Assumptions				
Total CREBs Financing	$2,210,000	$2,600,000	$2,145,163	$2,600,000
CREBs Tenor	13 Years	13 Years	13 Years	13 Years
Total Bond Financing	$0	$740,900	$0	$676,100
GO Bond Tenor	13 Years	13 Years	13 Years	13 Years
Revenue Assumptions				
Percent (%) of kWhs Consumed On-Site	53%	23%	57%	25%
Levelized On-Site Avoided Energy Price	13.52 ¢/kWh	13.68 ¢/kWh	13.44 ¢/kWh	13.56 ¢/kWh
Levelized Grid Sales Price	7.76 ¢/kWh	7.76 ¢/kWh	7.76 ¢/kWh	7.76 ¢/kWh
Levelized REC Price	3.55 ¢/kWh	3.55 ¢/kWh	3.55 ¢/kWh	3.55 ¢/kWh
Cost Assumptions				
Levelized Operating Expenses	2.94 ¢/kWh	1.69 ¢/kWh	3.27 ¢/kWh	1.87 ¢/kWh
Levelized Cost of Financing	11.03 ¢/kWh	6.75 ¢/kWh	11.91 ¢/kWh	7.3 ¢/kWh

RESULTS

The descriptions, tables and graphics below summarize the pro forma cash flows for each of the four combinations evaluated: 600 kW WTG at the Middle School; 1,500 kW WTG at the Middle School; 600 kW WTG at the High School; and 1,500 kW WTG at the High School.

Each table provides a summarized statement of cash flows. Pro forma estimates of all three sources of revenue and savings (wholesale electricity sales, REC sales and avoided electricity charges), operating costs, debt service (both principal and interest) and annual net cash flow are provided. The avoided electricity charges column represents the gross savings to the Town. Due to the need to cover expenses and repay project debt, the net (or realized) savings to the Town are represented by annual net cash flows. Finally, each table shows the net present value of the cumulative net cash flows – offering the Town an opportunity to consider the overall, 20-year benefit of the proposed project in today's dollars.

600 KW WTG AT MIDDLE SCHOOL

Under the conditions and assumptions described for the installation and operation of a 600 kW WTG at the Middle School, the project is forecast to produce a present value of approximately $650,000 of net benefit for the Town over its lifetime, assuming the long-term average wind speed (P50) and a 4 percent discount rate, as prescribed by the Town. Importantly, however, this benefit does not flow in equal annual amounts. Further, some years forecast a negative net cash flow, denoting that the Town will need to rely either on the accrual of the previous years' positive cash flows or on other revenue sources in order to cover the wind project's expense and debt obligations. In this scenario, cash flow in the first three years is positive enough to cover the negative cash flow in the following nine years. Cumulative cash flow does not turn negative under the assumptions used in this Analysis. However, reviewers of this analysis should take note of the forecasted $4,000 of cumulative cash flow in year 12 and be keenly aware that any slight increase in project cost, or decrease in project revenues or wind resource would likely result in a negative cumulative cash flow during this period – denoting the need to tap other sources of Town revenue to support the wind project's expense and debt obligations. As a result, the installation of a 600 kW WTG at the Middle School represents the opportunity to create a source of net cash benefit to the Town when viewed over the project lifetime, but should not be expected to support itself in each year of operation. Table 10 offers a summary of the project's pro forma revenues, expenses and resulting net annual and cumulative cash flows.

Table 10. Revenues, Expenses and Cash Flow Summary for 600kW WTG at PMS

Summary Statement of Cash Flows							
Town of Portsmouth, RI							
Results for:	FL600 @ Middle School						
	Energy Revenue: Grid Sales	Avoided Electricity Charges	REC Revenue	Total Operating Expenses	Debt Service (P+I)	Project Annual Net Cash Flow	Cumulative Net Cash Flow
Year 0							
Year 1	$57,000	$105,000	$89,000	($26,000)	($170,000)	$55,000	$55,000
Year 2	$58,000	$108,000	$82,000	($26,000)	($170,000)	$52,000	$107,000
Year 3	$57,000	$111,000	$66,000	($47,000)	($170,000)	$17,000	$124,000
Year 4	$55,000	$109,000	$42,000	($47,000)	($170,000)	($11,000)	$113,000
Year 5	$53,000	$107,000	$43,000	($48,000)	($170,000)	($15,000)	$98,000
Year 6	$48,000	$101,000	$50,000	($48,000)	($170,000)	($19,000)	$79,000
Year 7	$49,000	$103,000	$48,000	($49,000)	($170,000)	($19,000)	$60,000
Year 8	$50,000	$104,000	$48,000	($50,000)	($170,000)	($18,000)	$42,000
Year 9	$51,000	$107,000	$45,000	($50,000)	($170,000)	($17,000)	$25,000
Year 10	$54,000	$112,000	$44,000	($51,000)	($170,000)	($11,000)	$14,000
Year 11	$54,000	$113,000	$47,000	($51,000)	($170,000)	($7,000)	$7,000
Year 12	$55,000	$115,000	$49,000	($52,000)	($170,000)	($3,000)	$4,000
Year 13	$57,000	$118,000	$50,000	($53,000)	($170,000)	$2,000	$6,000
Year 14	$58,000	$120,000	$48,000	($53,000)	$0	$173,000	$179,000
Year 15	$60,000	$124,000	$42,000	($54,000)	$0	$172,000	$351,000
Year 16	$63,000	$127,000	$36,000	($55,000)	$0	$171,000	$522,000
Year 17	$65,000	$131,000	$36,000	($56,000)	$0	$176,000	$698,000
Year 18	$66,000	$133,000	$36,000	($56,000)	$0	$179,000	$877,000
Year 19	$68,000	$136,000	$36,000	($57,000)	$0	$183,000	$1,060,000
Year 20	$70,000	$140,000	$36,000	($58,000)	$0	$188,000	$1,248,000
						Cumulative Cash Flow	**$1,248,000**
						NPV @ 4%	**$655,000**

As described above, projected net cash flow will vary year to year based on actual electricity production, market-based wholesale and retail electricity prices, REC prices, and actual operating expenses. The repayment of CREBs principal is required to occur in equal amounts. Figure 20 compares the gross revenue and savings to the cumulative cost of financing and operations for each year of the proposed project's expected life. The period of time during which the Total Revenue + Savings line drops below the stacked area which represents the project's total annual cost (from year four through year twelve, inclusive) corresponds to the negative annual net cash flow values in the table above.

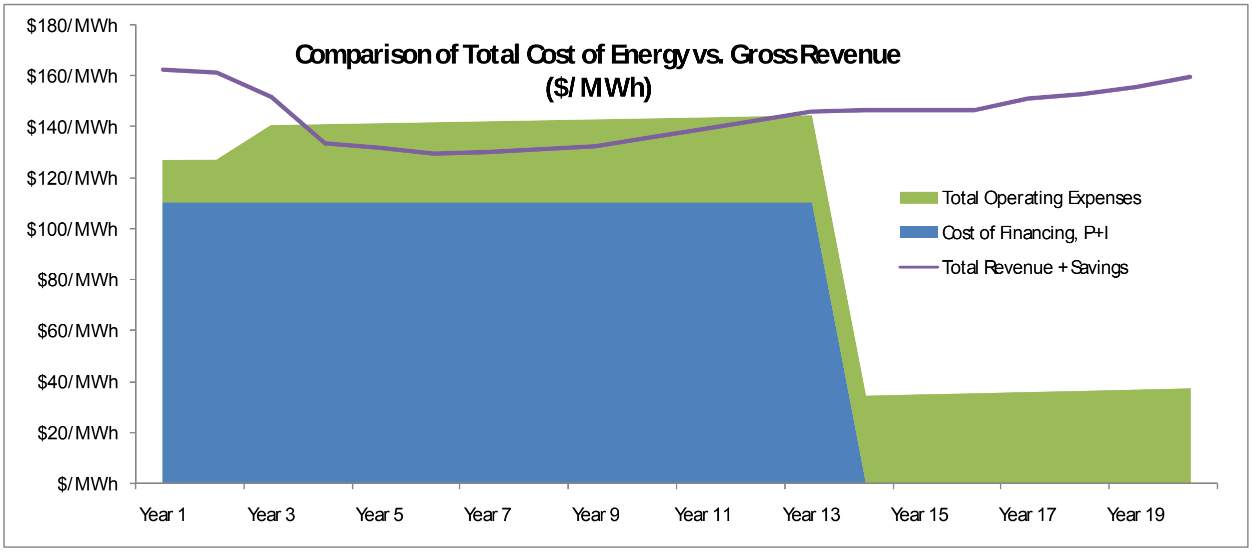

Figure 20. Comparison of Total Cost of Energy to Gross Revenue for 600kW WTG at PMS

The cash flows reflected here are dependent on the specific assumptions used in the Analysis. Different cash flows will be generated under different assumptions.

1500 KW WTG AT MIDDLE SCHOOL

Under the conditions and assumptions described for the installation and operation of a 1,500 kW WTG at the Middle School, the project is forecast to produce a present value of approximately $3,200,000 of net benefit for the Town over its lifetime, assuming the long-term average wind speed (P50) and a 4 percent discount rate, as prescribed by the Town. This project produced the greatest amount of benefit out of the four modeled scenarios. While the shape of the profile of the annual cash flows is similar to the FL 600 case, there are no years in which annual net cash flow is projected to be negative. The cash flows drop in the year four through year twelve period due to the forecasted drop in REC prices, and the trough in forecasted wholesale power prices, during this period and the continuing need to service project debt through year 13. The installation of a 1,500 kW WTG at the Middle School represents the opportunity to create a source of net cash benefit to the Town both annually and over the project lifetime. Table 11 offers a summary of the project's pro forma revenues, expenses and resulting net annual and cumulative cash flows.

Table 11. Revenues, Expenses and Cash Flow Summary for 1,500kW WTG at PMS

Summary Statement of Cash Flows							
Town of Portsmouth, RI							
Results for:	GE 1.5 sle @ Middle School						
	Energy Revenue: Grid Sales	Avoided Electricity Charges	REC Revenue	Total Operating Expenses	Debt Service (P+I)	Project Annual Net Cash Flow	Cumulative Net Cash Flow
Year 0							
Year 1	$253,000	$120,000	$237,000	($36,000)	($278,000)	$296,000	$296,000
Year 2	$260,000	$125,000	$219,000	($36,000)	($278,000)	$290,000	$586,000
Year 3	$253,000	$128,000	$177,000	($73,000)	($278,000)	$207,000	$793,000
Year 4	$245,000	$125,000	$111,000	($74,000)	($278,000)	$129,000	$922,000
Year 5	$237,000	$123,000	$115,000	($74,000)	($278,000)	$123,000	$1,045,000
Year 6	$214,000	$116,000	$135,000	($75,000)	($278,000)	$112,000	$1,157,000
Year 7	$219,000	$119,000	$128,000	($76,000)	($278,000)	$112,000	$1,269,000
Year 8	$221,000	$120,000	$129,000	($77,000)	($278,000)	$115,000	$1,384,000
Year 9	$228,000	$124,000	$121,000	($78,000)	($278,000)	$117,000	$1,501,000
Year 10	$240,000	$129,000	$117,000	($79,000)	($278,000)	$129,000	$1,630,000
Year 11	$241,000	$130,000	$126,000	($80,000)	($278,000)	$139,000	$1,769,000
Year 12	$244,000	$133,000	$132,000	($81,000)	($278,000)	$150,000	$1,919,000
Year 13	$251,000	$137,000	$134,000	($82,000)	($278,000)	$162,000	$2,081,000
Year 14	$256,000	$139,000	$128,000	($83,000)	($1,000)	$439,000	$2,520,000
Year 15	$267,000	$142,000	$112,000	($84,000)	$0	$437,000	$2,957,000
Year 16	$278,000	$147,000	$96,000	($85,000)	$0	$436,000	$3,393,000
Year 17	$290,000	$151,000	$96,000	($87,000)	$0	$450,000	$3,843,000
Year 18	$295,000	$154,000	$96,000	($88,000)	$0	$457,000	$4,300,000
Year 19	$302,000	$157,000	$96,000	($89,000)	$0	$466,000	$4,766,000
Year 20	$312,000	$161,000	$96,000	($90,000)	$0	$479,000	$5,245,000
						Cumulative Cash Flow	**$5,245,000**
						NPV @ 4%	**$3,233,000**

As described above, projected net cash flow will vary year to year based on actual electricity production, market-based wholesale and retail electricity prices, REC prices, and actual operating expenses. The repayment of CREBs principal is required to occur in equal amounts, and the supplemental General Obligation Bond assumes a mortgage style amortization with equal payments (comprised of varying amounts of principal and interest). Figure 21 compares the gross revenue and savings to the cumulative cost of financing and operations for each year of the proposed project's expected life. Total Revenue + Savings are projected to remain above Total Expenses for each year of project operation.

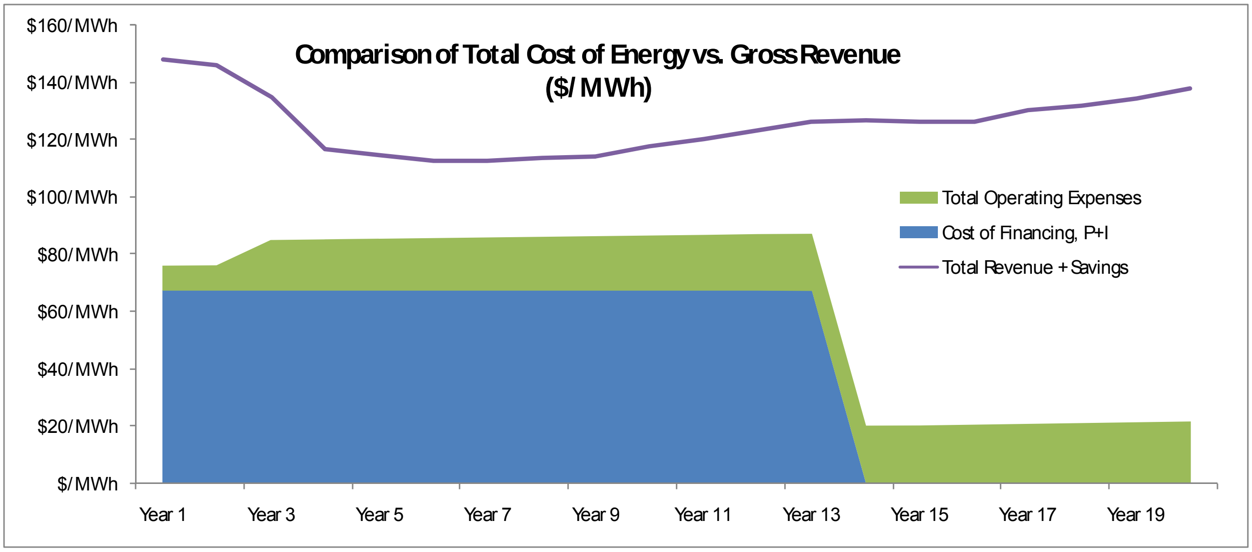

Figure 21. Comparison of Total Cost of Energy to Gross Revenue for 1500kW WTG at PMS

The cash flows reflected here are dependent on the specific assumptions used in the Analysis. Different cash flows will be generated under different assumptions.

600 KW WTG AT HIGH SCHOOL

Under the conditions and assumptions described for the installation and operation of a 600 kW WTG at the High School, the project is forecasted to produce a present value of approximately $440,000 of net benefit for the Town over its lifetime, assuming the long-term average wind speed (P50) and a 4 percent discount rate, as prescribed by the Town. Like the FL 600 installation studied for the Middle School, this benefit is not equally distributed, and negative cash flow is present from year three through year 13 in this case. Further, there is projected to be a cumulative negative net cash flow beginning in year five and continuing through in year 14. During this period, the Town will need to rely on both the accrual of the previous years' positive cash flows and on other Town revenue sources in order to cover the wind project's expense and debt obligations. As a result, the installation of a 600 kW WTG a the High School represents the opportunity to create a modest amount of net cash benefit to the Town when viewed over the project lifetime, but should not be expected to support itself in each year of operation. Table 12 offers a summary of the project's pro forma revenues, expenses and resulting net annual and cumulative cash flows:

Table 12. Revenues, Expenses and Cash Flow Summary for 600kW WTG at PHS

Summary Statement of Cash Flows							
Town of Portsmouth, RI							
Results for:	FL600 @ High School						
	Energy Revenue: Grid Sales	Avoided Electricity Charges	REC Revenue	Total Operating Expenses	Debt Service (P+I)	Project Annual Net Cash Flow	Cumulative Net Cash Flow
Year 0							
Year 1	$47,000	$101,000	$80,000	($26,000)	($165,000)	$37,000	$37,000
Year 2	$48,000	$104,000	$74,000	($26,000)	($165,000)	$35,000	$72,000
Year 3	$47,000	$107,000	$59,000	($47,000)	($165,000)	$1,000	$73,000
Year 4	$45,000	$105,000	$37,000	($47,000)	($165,000)	($25,000)	$48,000
Year 5	$44,000	$103,000	$39,000	($48,000)	($165,000)	($27,000)	$21,000
Year 6	$40,000	$97,000	$45,000	($48,000)	($165,000)	($31,000)	($10,000)
Year 7	$41,000	$99,000	$43,000	($49,000)	($165,000)	($31,000)	($41,000)
Year 8	$41,000	$100,000	$43,000	($50,000)	($165,000)	($31,000)	($72,000)
Year 9	$42,000	$103,000	$41,000	($50,000)	($165,000)	($29,000)	($101,000)
Year 10	$44,000	$107,000	$39,000	($51,000)	($165,000)	($26,000)	($127,000)
Year 11	$45,000	$108,000	$42,000	($51,000)	($165,000)	($21,000)	($148,000)
Year 12	$45,000	$110,000	$44,000	($52,000)	($165,000)	($18,000)	($166,000)
Year 13	$47,000	$114,000	$45,000	($53,000)	($165,000)	($12,000)	($178,000)
Year 14	$48,000	$115,000	$43,000	($53,000)	$0	$153,000	($25,000)
Year 15	$50,000	$119,000	$38,000	($54,000)	$0	$153,000	$128,000
Year 16	$52,000	$122,000	$32,000	($55,000)	$0	$151,000	$279,000
Year 17	$54,000	$126,000	$32,000	($56,000)	$0	$156,000	$435,000
Year 18	$55,000	$128,000	$32,000	($56,000)	$0	$159,000	$594,000
Year 19	$56,000	$130,000	$32,000	($57,000)	$0	$161,000	$755,000
Year 20	$58,000	$134,000	$32,000	($58,000)	$0	$166,000	$921,000
						Cumulative Cash Flow	**$921,000**
						NPV @ 4%	**$440,000**

As described above, projected net cash flow will vary year to year based on actual electricity production, market-based wholesale and retail electricity prices, REC prices, and actual operating expenses. The repayment of CREBs principal is required to occur in equal amounts. Figure 22 compares the gross revenue and savings to the cumulative cost of financing and operations for each year of the proposed project's expected life. The period of time during which the Total Revenue + Savings line drops below the stacked area which represents the project's total annual cost (from year four through year 13, inclusive) corresponds to the negative annual net cash flow values in the table above.

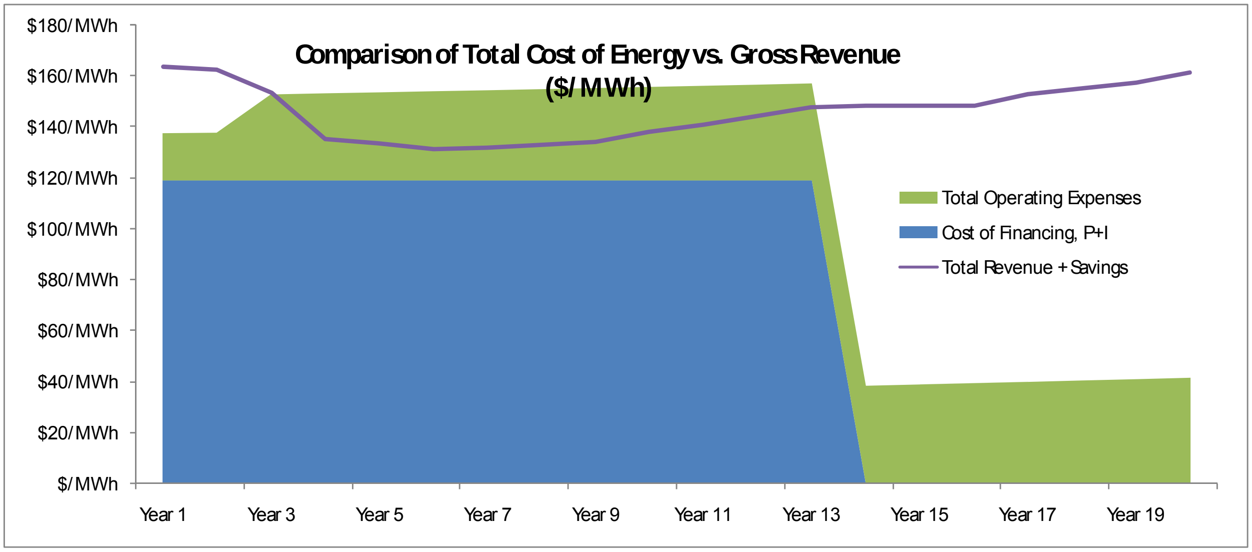

Figure 22. Comparison of Total Cost of Energy to Gross Revenue for 600kW WTG at PHS

The cash flows reflected here are dependent on the specific assumptions used in the Analysis. Different cash flows will be generated under different assumptions.

GE 1.5 SLE AT HIGH SCHOOL

Under the conditions and assumptions described for the installation and operation of a 1,500 kW WTG at the High School, the project is forecast to produce a present value of approximately $2,600,000 of net benefit for the Town over its lifetime, assuming the long-term average wind speed (P50) and a 4 percent discount rate as prescribed by the Town. This project ranks second to the installation of the same turbine at the Middle School in terms of forecasted NPV benefit. The shape of the profile of the annual cash flows is similar to the other cases, again due to the expected drop in REC prices after the second year of operation, and the forecasted trough in wholesale electricity prices. There are no years in which annual net cash flow is projected to be negative, however. The installation of a 1,500 kW WTG at the High School represents the opportunity to create a source of net cash benefit to the Town both annually and over the project lifetime. Table 13 offers a summary of the project's pro forma revenues, expenses and resulting net annual and cumulative cash flows:

Table 13. Revenues, Expenses and Cash Flow Summary for 1,500kW WTG at PHS

Summary Statement of Cash Flows							
Town of Portsmouth, RI							
Results for:	GE 1.5 sle @ High School						
	Energy Revenue: Grid Sales	Avoided Electricity Charges	REC Revenue	Total Operating Expenses	Debt Service (P+I)	Project Annual Net Cash Flow	Cumulative Net Cash Flow
Year 0							
Year 1	$222,000	$118,000	$214,000	($36,000)	($271,000)	$247,000	$247,000
Year 2	$228,000	$122,000	$197,000	($36,000)	($271,000)	$240,000	$487,000
Year 3	$222,000	$125,000	$159,000	($73,000)	($271,000)	$162,000	$649,000
Year 4	$215,000	$122,000	$100,000	($74,000)	($271,000)	$92,000	$741,000
Year 5	$208,000	$120,000	$103,000	($74,000)	($271,000)	$86,000	$827,000
Year 6	$188,000	$113,000	$122,000	($75,000)	($271,000)	$77,000	$904,000
Year 7	$192,000	$116,000	$116,000	($76,000)	($271,000)	$77,000	$981,000
Year 8	$194,000	$117,000	$116,000	($77,000)	($271,000)	$79,000	$1,060,000
Year 9	$200,000	$120,000	$109,000	($78,000)	($271,000)	$80,000	$1,140,000
Year 10	$210,000	$125,000	$106,000	($79,000)	($271,000)	$91,000	$1,231,000
Year 11	$211,000	$127,000	$113,000	($80,000)	($271,000)	$100,000	$1,331,000
Year 12	$214,000	$129,000	$119,000	($81,000)	($271,000)	$110,000	$1,441,000
Year 13	$221,000	$133,000	$121,000	($82,000)	($271,000)	$122,000	$1,563,000
Year 14	$225,000	$135,000	$115,000	($83,000)	($1,000)	$391,000	$1,954,000
Year 15	$234,000	$139,000	$101,000	($84,000)	$0	$390,000	$2,344,000
Year 16	$244,000	$143,000	$87,000	($85,000)	$0	$389,000	$2,733,000
Year 17	$255,000	$147,000	$87,000	($87,000)	$0	$402,000	$3,135,000
Year 18	$259,000	$150,000	$87,000	($88,000)	$0	$408,000	$3,543,000
Year 19	$265,000	$153,000	$87,000	($89,000)	$0	$416,000	$3,959,000
Year 20	$274,000	$157,000	$87,000	($90,000)	$0	$428,000	$4,387,000
						Cumulative Cash Flow	**$4,387,000**
						NPV @ 4%	**$2,664,000**

As described above, projected net cash flow will vary year to year based on actual electricity production, market-based wholesale and retail electricity prices, REC prices, and actual operating expenses. The repayment of CREBs principal is required to occur in equal amounts, and the supplemental General Obligation Bond assumes a mortgage style amortization with equal payments (comprised of varying amounts of principal and interest). Figure 23 compares the gross revenue and savings to the cumulative cost of financing and operations for each year of the proposed project's expected life. Total Revenue + Savings are projected to remain above Total Expenses for each year of project operation.

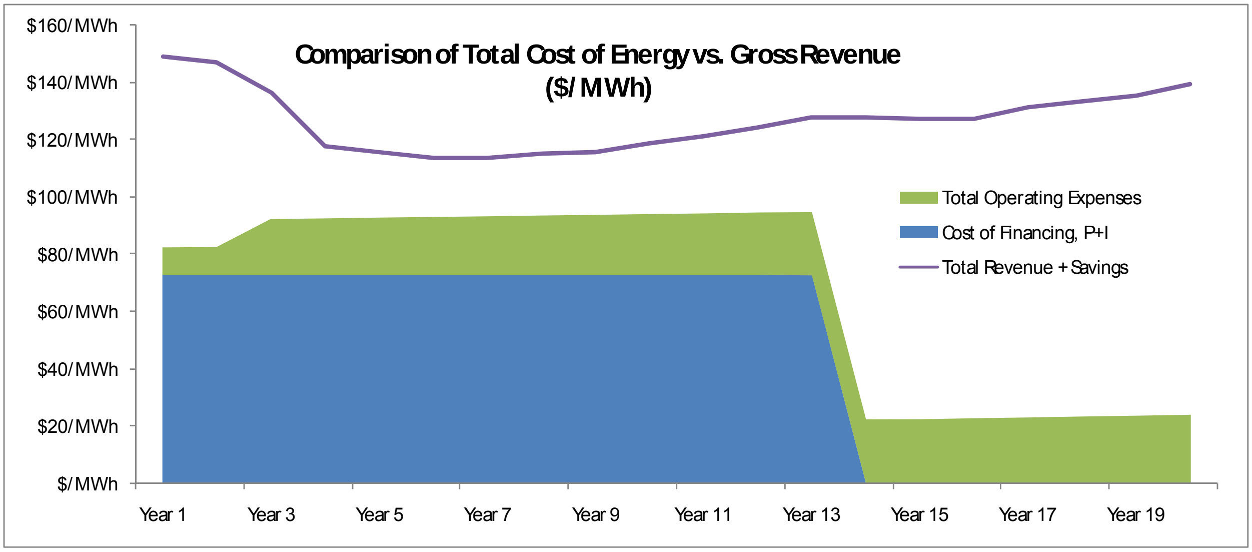

Figure 23. Comparison of Total Cost of Energy to Gross Revenue for 1500kW WTG at PHS

The cash flows reflected here are dependent on the specific assumptions used in the Analysis. Different cash flows will be generated under different assumptions.

SENSITIVITY ANALYSES

In a thorough financial due diligence, sensitivity analyses are conducted to evaluate how changes in a single assumption impact the overall result of the economic forecast. This Analysis includes the following three sensitivity analyses:

1. Varying project Net Present Value (NPV) with change in electricity production
2. Varying project NPV with change in turbine prices
3. Varying project NPV with change in forecasted wholesale electricity prices

VARYING PROJECT NPV WITH CHANGE IN EXPECTED ELECTRICITY PRODUCTION

The table below summarizes the differences in the Town's expected NPV using both the long-term average (referred to as "P50") electricity production forecast (for a turbine at the Middle School and High School) and a lowe r(referred to as "P90") production forecast (for a turbine at the Middle School and High School) for which there is a 90 percent chance that actual electricity production will be equal to or greater than the forecast. In the P90 case, both 600-kW projects return a modest 20-year NPV which may not meet the Town's requirement for anticipated return. Please note that NPVs represented here vary only the forecasted wind resource. All other project costs are held constant. Therefore, while it is appropriate to interpret the term P90 (for example) as "a 90 percent chance that electricity production will be equal to or greater than the amount used to generate this NPV" it does not necessarily hold that there is also a 90 percent chance that the NPV will be equal to or greater than the values presented in Table 14, due to the potential variability in costs and revenues.

Table 14. Summary of Sensitivity to Changes in Production

Sensitivity Analysis: Varying NPV with change in production		
	Wind Resource	
	P50	P90
FL 600 @ Middle School	$655,000	$252,000
GE 1.5 sle @ Middle School	$3,233,000	$2,469,000
FL 600 @ High School	$440,000	$136,000
GE 1.5 sle @ High School	$2,664,000	$1,961,000

VARYING PROJECT NPV WITH CHANGE IN EXPECTED TURBINE PRICES

Table 15 summarizes the differences in the Town's expected NPV varying turbine prices 15 percent above and below the cost estimates researched for this Analysis.

Table 15. Summary of Sensitivity to Changes in Turbine Prices

Sensitivity Analysis: Varying NPV with change in turbine prices			
	Base Case - 15%	Base Case	Base Case + 15%
FL 600 @ Middle School	$807,000	$655,000	$448,000
GE 1.5 sle @ Middle School	$3,600,000	$3,233,000	$2,866,000
FL 600 @ High School	$590,000	$440,000	$180,000
GE 1.5 sle @ High School	$3,031,000	$2,664,000	$2,297,000

VARYING PROJECT NPV WITH CHANGE IN FORECASTED WHOLESALE AND RETAIL ELECTRICITY PRICES

Table 16 summarizes the differences in the Town's expected NPV by varying wholesale electricity prices by 10 percent in either direction from the Base Case. This sensitivity analysis not only tests the effect of wholesale electricity prices that diverge from the Base Case forecast, but also includes the impact of such divergences on avoided retail electricity charges.

Table 16. Summary of Sensitivity to Changes in Wholesale and Retail Electricity Prices

Sensitivity Analysis: Varying NPV with change in wholesale & retail prices			
	Base Case - 10%	**Base Case**	**Base Case + 10%**
FL 600 @ Middle School	$447,000	$655,000	$821,000
GE 1.5 sle @ Middle School	$2,793,000	$3,233,000	$3,673,000
FL 600 @ High School	$199,000	$440,000	$577,000
GE 1.5 sle @ High School	$2,267,000	$2,664,000	$3,061,000

IMPACT OF ZERO-INTEREST FINANCING

This Analysis assumes 100 percent debt financing for all considered projects. For the 600-kW projects, the Town's $2.6M CREBs allocation will be sufficient to cover total project installed cost. For the 1.5-MW projects, supplemental financing will be required. The Analysis assumes this additional capital is supplied by a General Obligation Bond at 5 percent interest. Should the Town secure this additional capital (approximately $700,000) in the form of an interest free loan, the NPV of each 1.5-MW project would increase by approximately $200,000.

OVERALL FINANCIAL ANALYSIS ASSESSMENTS

At projected wholesale, retail, and REC prices, the installation of a GE 1.5 sle WTG at the Middle School provides the largest net present value for the Town. The installation of the same turbine at the High school also offers the opportunity for a substantially positive net present value. The degree of economic benefit for these two project configurations will depend on actual electricity and REC prices, project costs and wind speeds. These projects will be able to absorb some fluctuation in actual revenues. While the 1.5-MW WTGs are expected to out-perform the 600-kW WTGs, it is important to remember that the 1.5-MW WTGs are more capital intensive and will require a General Obligation Bond issuance in addition to the CREBs issuance. The need for a General Obligation Bond requires additional administrative effort to complete the financing. (The cost of such effort is already included in this Analysis).

The opportunity to install a 600 kW at either the Middle School or High School deserves careful scrutiny. The Analysis offers a positive NPV in both the P50 and P90 wind resource cases. However, both cases experience multiple years of negative cash flows, and the P90 case experiences multiple years of negative cumulative net cash flows, denoting that the project must rely on other sources of revenue to support itself and repay project debt. Due to the relatively low 20-year NPV and cumulative negative cash flows in the middle years, these projects have less ability to absorb cost, revenue and wind resource changes than the 1.5-MW projects.

Conclusions and recommendations

Applied Technology and Management (ATM) has completed a limited feasibility study of locating a wind turbine generator (WTG) at the Portsmouth Middle School or the High School for the Town of Portsmouth (the Town). The study evaluated two different sized WTG's at both of the two locations identified by the Town. The study included a detailed wind resource analysis, using the longer term Newport Airport weather data. A detailed energy use analysis compared the average hourly WTG energy production with the average hourly energy consumption at each school. A financial analysis was then performed to assess annual net cash flow, cumulative net cash flow and Net Present Value (NPV) to the Town for the four turbine cases. The financial analysis included the use of the Town's Clean Renewable Energy Bond (CREB) award and other available financial incentives and the value of the energy produced from the WTG to the Town.

The results of the feasibility study indicate that, within the scope of the study, no fatal flaws would prevent the development of a WTG project at either school. The wind resource is greater at the Middle School than at the High School, with an average annual wind speed of 7.08 m/s and 6.74 m/s, respectively. The resulting WTG net capacity factor is expected to range from 29 to 31 % (depending on the size of the WTG) at the Middle School and 26 to 28 % at the High School.

The energy use is nearly the same at both schools, with an annual average of a little greater than 950,000 kWh/yr. Between approximately 25 and 55 % of WTG electrical output would be used by the Schools, for the 1500kW and 600kW WTG's, respectively. The remaining WTG electric output would be sold to a retail electric supplier, such as Constellation New Energy.

The cost of developing a WTG project is roughly the same at both schools, totaling approximately $2.1 M for a 600 kW WTG and approximately $3.2 M for a 1500 kW WTG. A WTG located at the Middle School is more economically attractive because the wind resource is stronger at the Middle School and the electric loads and capital costs are essentially the same for both schools. A large WTG will provide more economic benefit than a smaller turbine. However, funding in addition to the $2.6 M

CREBS award will be required to pay for the cost of developing the higher cost 1500 kW WTG project.

At the projected electricity and REC values, the development of a 1500 kW WTG at the Middle School appears to be the most economically attractive option for the Town. The degree of economic return will depend on actual electricity and REC prices, project costs and wind speeds over the life of the project. These projects should be able to absorb some fluctuation in actual revenues and are projected, overall, to meet the Town's economic criteria. It should be noted that the option of installing a 600 kW WTG at the schools deserves careful scrutiny. While the analysis offers a positive NPV, the 600 kW project will likely experience multiple years of negative cash flows requiring that the project rely on other sources of revenue to support itself and repay incurred project debt.

While the feasibility analysis focused on WTG's of 600 and 1500 kW by consensus of the ATM and Town project team, a unit between the two may best match the needs and uses of the Town. The 600 and 1500 kW analyses should bracket both the technical and economic feasibilities, but the intermediate values may not lie on a straight line between the two points.

The Town should also stay abreast of the wind turbine market. The demand for WTGs currently exceeds supply. Turbine pricing has increased significantly over the past few years due to increases in commodity prices and because of increases in demand. Currently, most manufacturers state that they cannot provide a turbine before 2009. Prices and availability may change and prices my come down if Federal incentives are extend.

To confirm the feasibility of developing a WTG project at either school, an environmental and permitting review must be performed. In addition, further utility electrical interconnection analyses will be required to confirm the cost to interconnect with the electric utility.