Introduction

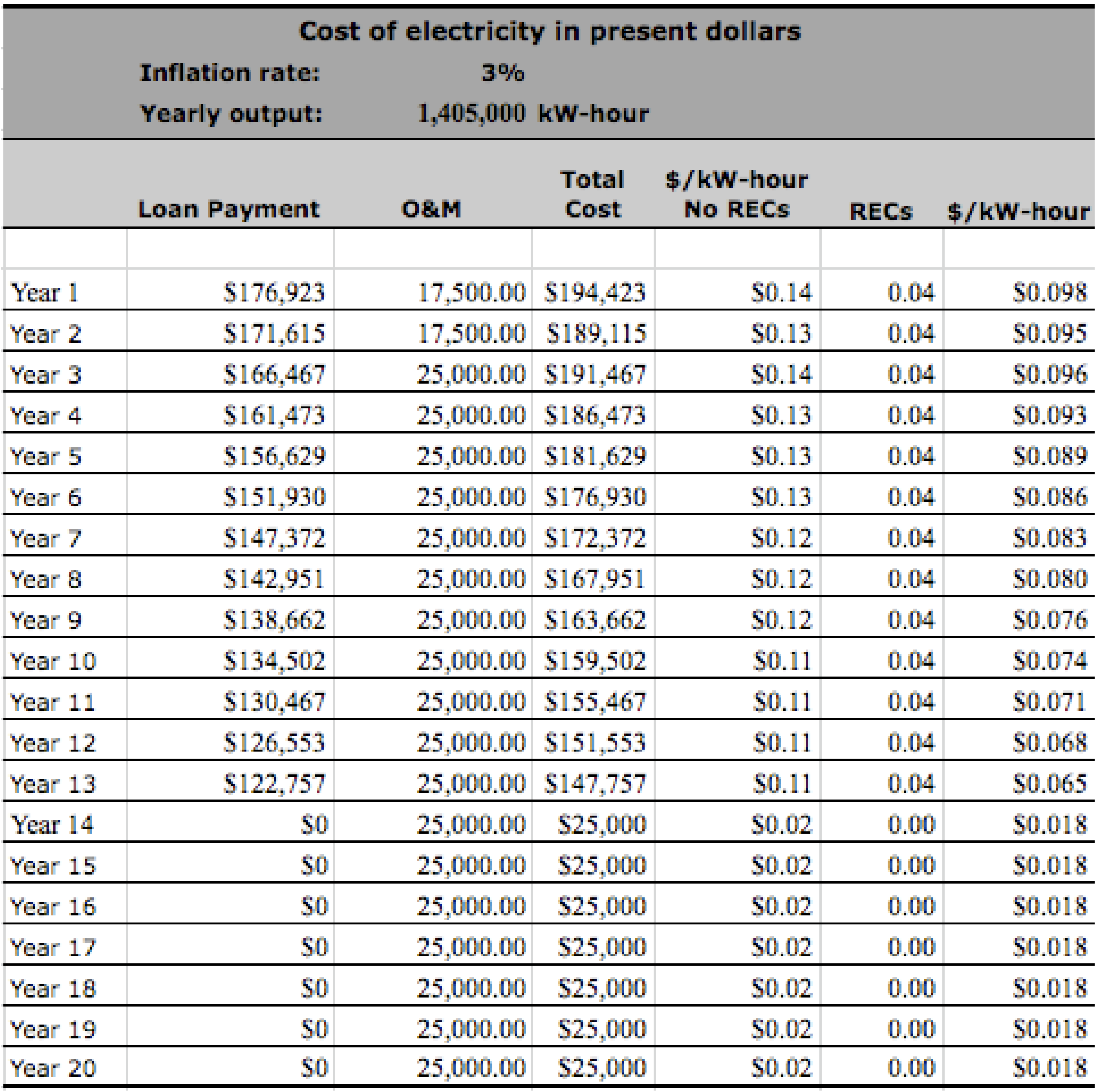
This report presents the findings of CREB's Technical Assessment of the economic feasibility for Barrington's Wind Energy Project. The findings are specific to the recommended contractor, Lumus, and the recommended turbine, the Elecon-Turbowind 600 kW. They are also specific to our particular financial and legislative conditions: namely, the availability of zero interest financing for the preponderance of the project and the existence of virtual net metering, which allows the project to obtain the non-peak market rate of electricity available to the high school for almost all of its production, and the (slightly lower) non-peak market rate of electricity available to the rest of the municipality for the remainder.

Economic Analyses

Diversification of Town Energy Portfolio

The turbine is expected to produce approximately 25% of the municipal energy at a non-peak rate averaging 9.8 cents per kWh for the next 13 years and then 2 cents per kWh for the remaining life of the term (conservatively another 7 years). See Figure 1. Current non-peak rates paid by Barrington High School are 15 cents per kWh. Barrington High School uses approximately one fifth of all municipal electricity.

The Barrington Wind Energy Project represents a diversification of the energy portfolio of the town. See Figure 2. Providing electricity is one of the basic services of society, and for this reason it is of value to improve the long-term price stability. The primary risk associated to the project – lower than expected production – is independent of the risks associated to electricity produced by coal, oil and natural gas – namely the serious risks associated to the underlying cost of fossil fuels and the secondary, but substantial, risk posed by potential carbon caps and other legislation.



Cost of electricity in present dollars

Inflation rate: 3%

Yearly output: 1,405,000 kW-hour

	Loan Payment	O&M	Total Cost	$/kW-hour No RECs	RECs	$/kW-hour
Year 1	$176,923	17,500.00	$194,423	$0.14	0.04	$0.098
Year 2	$171,615	17,500.00	$189,115	$0.13	0.04	$0.095
Year 3	$166,467	25,000.00	$191,467	$0.14	0.04	$0.096
Year 4	$161,473	25,000.00	$186,473	$0.13	0.04	$0.093
Year 5	$156,629	25,000.00	$181,629	$0.13	0.04	$0.089
Year 6	$151,930	25,000.00	$176,930	$0.13	0.04	$0.086
Year 7	$147,372	25,000.00	$172,372	$0.12	0.04	$0.083
Year 8	$142,951	25,000.00	$167,951	$0.12	0.04	$0.080
Year 9	$138,662	25,000.00	$163,662	$0.12	0.04	$0.076
Year 10	$134,502	25,000.00	$159,502	$0.11	0.04	$0.074
Year 11	$130,467	25,000.00	$155,467	$0.11	0.04	$0.071
Year 12	$126,553	25,000.00	$151,553	$0.11	0.04	$0.068
Year 13	$122,757	25,000.00	$147,757	$0.11	0.04	$0.065
Year 14	$0	25,000.00	$25,000	$0.02	0.00	$0.018
Year 15	$0	25,000.00	$25,000	$0.02	0.00	$0.018
Year 16	$0	25,000.00	$25,000	$0.02	0.00	$0.018
Year 17	$0	25,000.00	$25,000	$0.02	0.00	$0.018
Year 18	$0	25,000.00	$25,000	$0.02	0.00	$0.018
Year 19	$0	25,000.00	$25,000	$0.02	0.00	$0.018
Year 20	$0	25,000.00	$25,000	$0.02	0.00	$0.018

FIGURE 1: BASIC ECONOMIC ANALYSIS

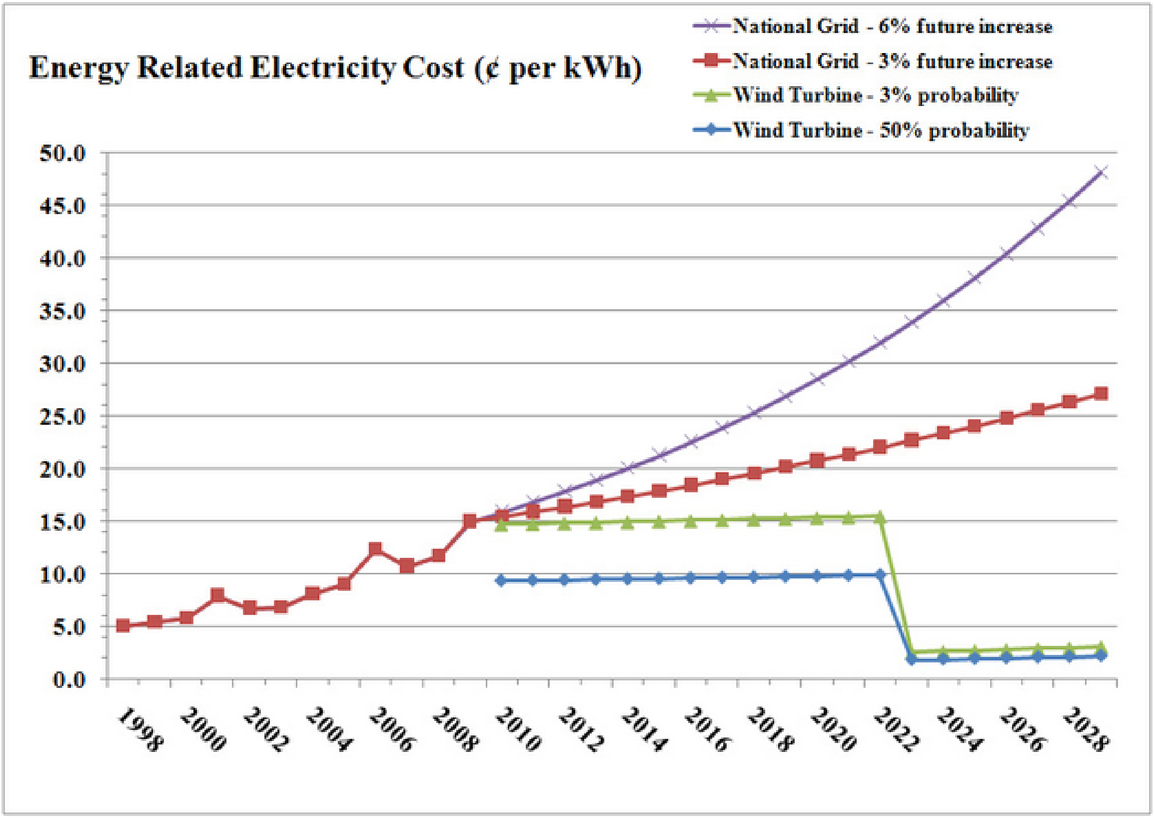


FIGURE 2: DIVERSIFYING SUPPLY

Error estimate

The single major source of uncertainty in the above analysis is the average energy production. The estimated annual energy production is 1,405,000 kWh and the estimated root mean square error of 16%. One standard deviation lower than expected energy production would result in a non-peak market rate of 12.1 cents per kW-hour for the first 13 years as opposed to 9.8 cents per kW-hour. Two standard deviations lower than expected would result in 16.3 cents per kW-hour for the 13 years, dropping to 3 cents per kWh for the remainder. Secondary sources of uncertainty include higher operating expenses, lower price for RECs (including price for RECs going to zero after some period of time), and construction contingencies. These uncertainties are discussed further below.

Cumulative Savings, Net Present Value, Time to Payback

Net present value (NPV), time to payback and cumulative savings all require an assumption about the future cost of retail electricity for the schools. For our model we consider two possibilities: the retail rate of electricity for the High School increasing at 3% – our assumed rate of inflation – or at 6%. A discussion of why we choose these values occurs below in the Analysis of Key Variables.

Because the future price of energy is uncertain, and because this uncertainty represents in itself a cost, the energy diversification analysis is preferred. At the same time it can be helpful to make educated guesses about possible outcomes and therefore we include these analyses. It is important to keep in mind that the second most significant variable for all of these analyses (after lifetime of the turbine) is the future price of energy and for these reasons the calculations are highly speculative.

The cumulative savings after 20 years with an energy rate increase of 3% is $3.4 million dollars and with an energy rate of increase of 6% is $5.6 million dollars. The NPV, assuming a discount rate of 4%, is $2 million with an energy rate increase of 3% and $3.3 million with a 6% increase. If the lifetime of the turbine is assumed to be 30 years instead of 20 years, the cumulative savings at 30 years at a 3% energy rate increase is $7.7 million and at 6% is $14.5 million. Similarly, NPV at 3% with a 30 year lifetime is $3.45 million with an energy rate increase of 3% and $6.6 million with a 6% increase.

Since the town will be spending some of its general funds in the construction of the turbine, the project will not be cash positive for approximately 2.5 years. The town is expected to use approximately $200,000 from its general funds in the construction of the turbine. In the cost model we use, these funds would be reimbursed over the course of 5 years. After 2.5 years, approximately $150,000 will have been replaced in the general funds and an additional $50,000 will have been generated in profits for the town. At this point, the initial outlay of $200,000 will have been recouped.

Analyzing the Uncertainty

The three major sources of uncertainty in calculating cumulative savings and NPV are the average energy production, the lifetime of the turbine and the rate of energy increase. These three sources of uncertainty overwhelm all others. All three sources of uncertainty have very different characteristics. Energy production, although greatly variable, is amenable to modeling and can be accurately assigned margin of error. The lifetime of the turbine is largely under control of the town: the primary reason turbine lifetime is set at 20 years is because it is assumed that technology will have improved to the extent that replacing the turbine at that point becomes economical. The future price of retail energy is neither amenable to modeling nor under the control of the town.

We examine the impact of secondary sources of uncertainty. Assume for example that

1) operation and maintenance costs $32,000 a year in present dollars,
2) RECs are 2 cents decreasing to 0 over the course of 10 years, and
3) construction contingencies cost the town $100,000.

The resulting net present value would be 85% of the original NPV. In comparison, if the wind speed is one standard deviation lower than expected the resulting NPV would be 75% of the original. And the NPV when energy rates stay flat with inflation at 3% is 65% of the NPV when energy rates increase at 6% a year.

Yearly Variation of Return

Average wind speed varies substantially year to year – often by 10%. For this reason, cumulative returns will not increase at a steady rate but rather will oscillate around the projected return.

Other Communities

Hull, MA and Portsmouth, RI are the closest towns with comparable turbines. Newburyport, MA is planning to install a 600 kW Elecon in December of this year, as well. The installed turbines at both Portsmouth Abbey and Hull have been economically successful: indeed, more successful than originally predicted.

The Portsmouth pro ject currently under construction had an economic feasibility study conducted by Advanced Technology Management (ATM). Of interest was that ATM advised Portsmouth that installation of a 600 kW turbine was economically risky (Net Present Value of $655,000 with 9 years of estimated negative cash flow) even though the wind resources in Portsmouth are significantly greater than those in Barrington. We describe the primary reasons for this disparity, in decreasing order of importance.

1) The Portsmouth financial model is based primarily on a calculation of net present value. They do not recognize the great uncertainty in future energy prices, nor do they recognize the benefit of price stability that wind energy provides. The real possibility of great volatility in energy prices has become more widely recognized in the year since the ATM report was written. We believe our more nuanced model is better: although we also provide NPV, we also provide an alternate perspective as well that does not rely on future energy price.
2) The Portsmouth model uses historical national averages to predict that energy prices will decline in the near term and then increase over 20 years at a net average rate of 1% (not even keeping up with inflation). For our calculation of NPV, we use historical averages in Rhode Island.
3) The Portsmouth model was developed prior to virtual net metering; therefore the Portsmouth model assumes a significant fraction of the energy is sold at wholesale as opposed to retail rates.
4) The Portsmouth energy data for its 600 kW turbine was based upon an average of 6.593 meters per second (at 50 meters), producing 1,541,000 kWhs. We are predicting an average annual wind speed of 6.0

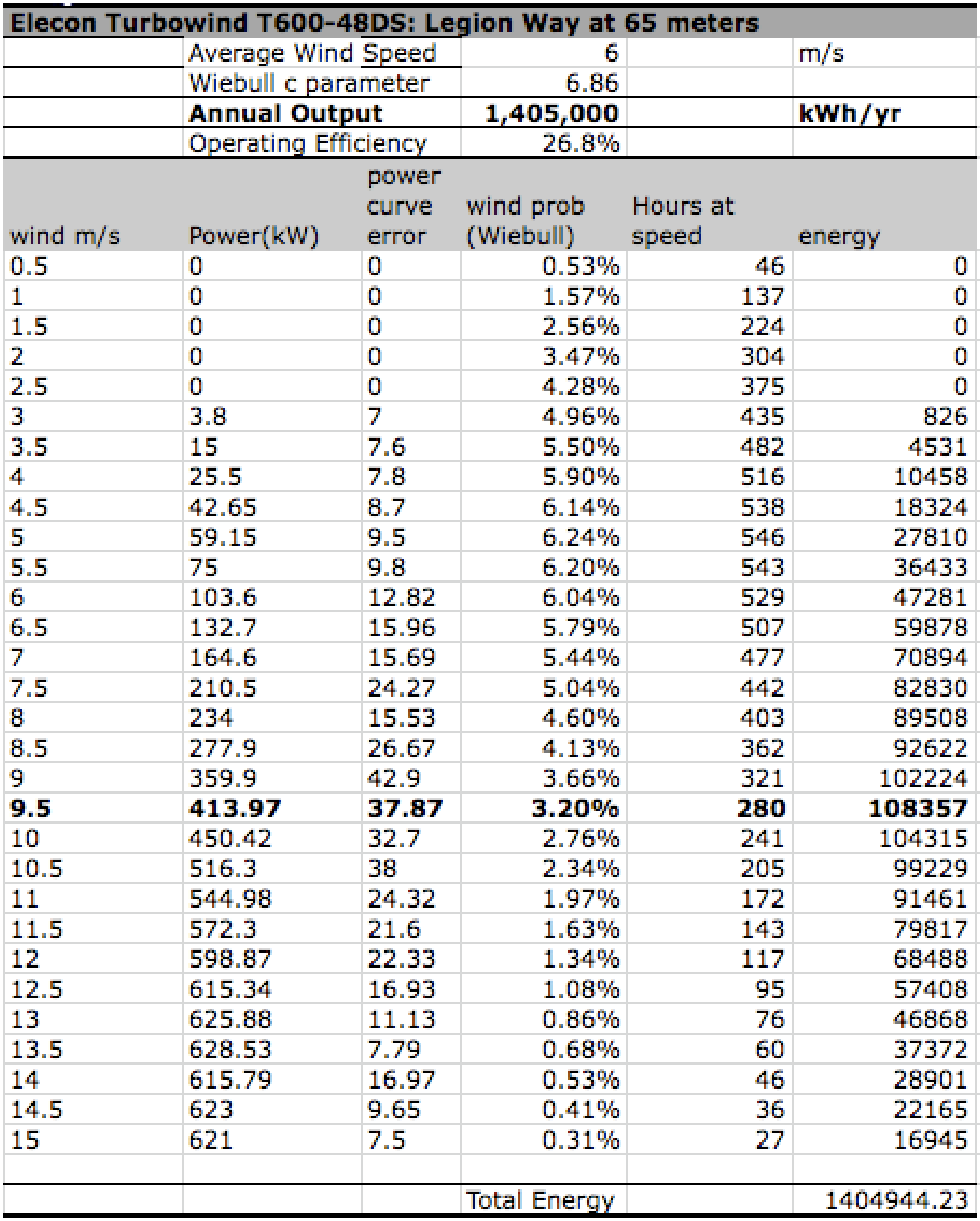
meters per second (at 65 meters), producing 1,405,000 kW-hours. The Elecon turbine we recommend has a better power curve (see below) than the one modeled by ATM.

Analysis of Key Variables

Average Annual Energy Production

The expected annual energy production is 1,405,000 kWhs. Fully 90% of this energy will be produced when the wind speed is above average, and more than half of the energy will be produced in the windiest 20% of the year. The energy present in wind increases as the cube of the wind speed. Therefore, it is optimal to configure a turbine for more energy capture at higher speeds, and the above facts do not indicate that the turbine is only appropriate for windier sites.

The energy output is calculated as follows. Using the parameters supplied by Truewind for the site we calculate the Weibull distribution for a year in intervals of 0.5 meters/second. In other words, for each wind speed 0, 0.5, 1, etc up to 15 m/s the Weibull model gives an expected number of hours annually at that speed. For example, the wind speed is expected to be between 9.5 and 10 m/s (21.4 and 22.5 mph) for 280 hours a year (see Figure 4). For each of these speeds we have a tested power output for the turbine. For example the power output at 9.5 m/s is 414 kW with an error of 38 kW and the power output at 10 m/s is 450 kW with an error of 33 kW. Combining this information, we see that the annual energy expected to be produced when the winds are between 9.5 and 10 m/s is 108,000 kWhs (assuming an even distribution of the speeds between 9.5 and 10 m/s), with an error from the power curve of 5000 kWhs. The expected annual energy production is the sum of the expected energy productions at each speed.



Elecon Turbowind T600-48DS: Legion Way at 65 meters					
	Average Wind Speed		6		m/s
	Wiebull c parameter		6.86		
	Annual Output		**1,405,000**		**kWh/yr**
	Operating Efficiency		26.8%		
wind m/s	Power(kW)	power curve error	wind prob (Wiebull)	Hours at speed	energy
0.5	0	0	0.53%	46	0
1	0	0	1.57%	137	0
1.5	0	0	2.56%	224	0
2	0	0	3.47%	304	0
2.5	0	0	4.28%	375	0
3	3.8	7	4.96%	435	826
3.5	15	7.6	5.50%	482	4531
4	25.5	7.8	5.90%	516	10458
4.5	42.65	8.7	6.14%	538	18324
5	59.15	9.5	6.24%	546	27810
5.5	75	9.8	6.20%	543	36433
6	103.6	12.82	6.04%	529	47281
6.5	132.7	15.96	5.79%	507	59878
7	164.6	15.69	5.44%	477	70894
7.5	210.5	24.27	5.04%	442	82830
8	234	15.53	4.60%	403	89508
8.5	277.9	26.67	4.13%	362	92622
9	359.9	42.9	3.66%	321	102224
9.5	**413.97**	**37.87**	**3.20%**	**280**	**108357**
10	450.42	32.7	2.76%	241	104315
10.5	516.3	38	2.34%	205	99229
11	544.98	24.32	1.97%	172	91461
11.5	572.3	21.6	1.63%	143	79817
12	598.87	22.33	1.34%	117	68488
12.5	615.34	16.93	1.08%	95	57408
13	625.88	11.13	0.86%	76	46868
13.5	628.53	7.79	0.68%	60	37372
14	615.79	16.97	0.53%	46	28901
14.5	623	9.65	0.41%	36	22165
15	621	7.5	0.31%	27	16945
			Total Energy		1404944.23

FIGURE 4

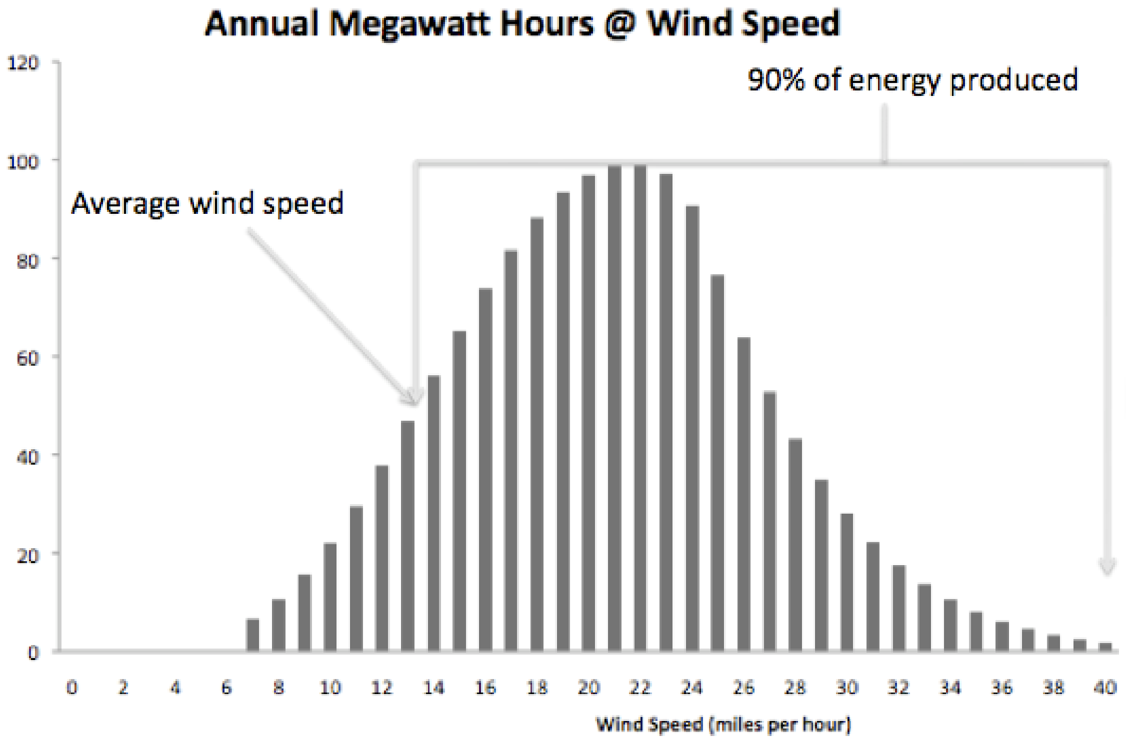


FIGURE 5

Error in Annual Energy Production

The annual energy production is estimated to have a root mean square error of approximately 15%. With a virtual met mast, this error could be lowered to 9.5%.

There are three sources of errors to be considered:

1. error in the average wind speed and Weibull parameters at this site and height
2. disparity in the Weibull model of wind distribution, and
3. error in the power curve of the turbine. With a virtual met mast, the first error is lessened and the second error is removed.

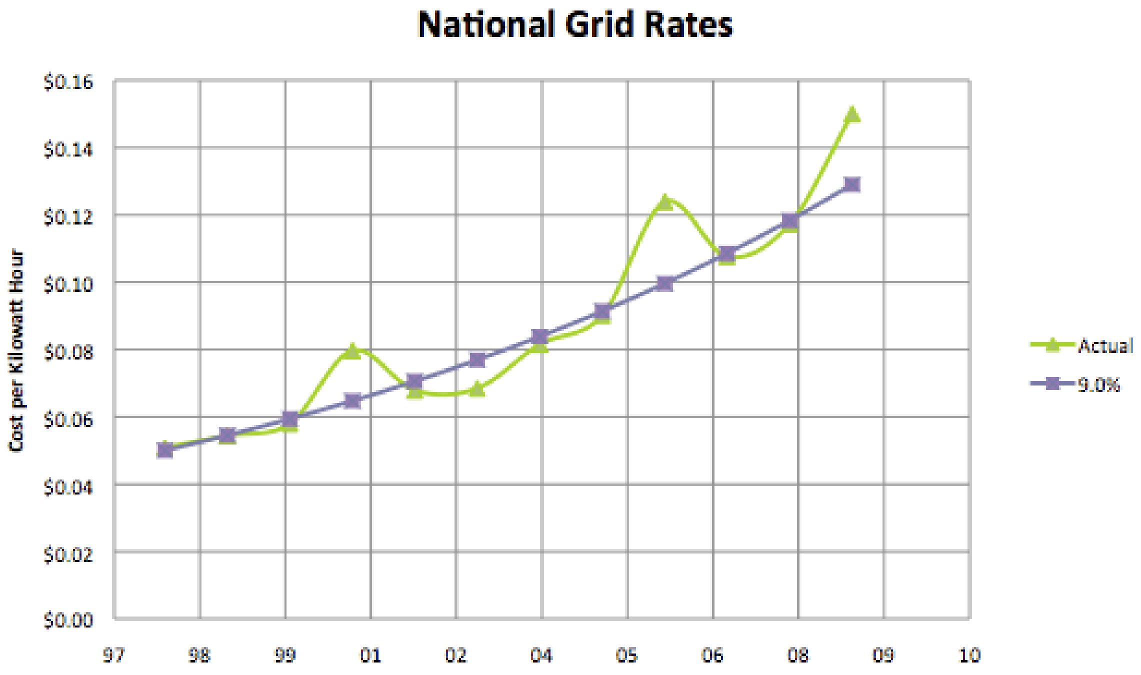
The root mean square error in the wind speed for the mesoscale AWS Truewind wind map is published as 7%. The resulting error in the energy production is approximately 14%. The error in wind speedcould be lowered to 3-4% by with the micrositing Virtual Met Mast, resulting in an error in energy production of approximately 8 %. Lumus Construction Inc has supplied us with results of testing the operating efficiency of the Elecon Turbowind turbine in the form of a table showing power output in kW, number of trials, and error in kW as a function of wind speed for speeds stepping up 0.5 m/s from 0 to 18 m/s (see Figures 7 and 8). The error in the power curve could account for a 4% discrepancy in final energy output.

In order to assess the accuracy of the Weibull distribution for predicting energy output, we looked at data collected from a meteorological tower at Field's Point by the Narragansett Bay Commission over a period of 18 months. Note that although we chose to use Rhode Island data for this calculation, we were not using this wind data to predict average wind speeds in Barrington; rather, we were using the data to help assess the accuracy of the Weibull model. Using the average speed and Weibull parameters associated to this data, we calculated the energy output via the method described above. We then calculated the energy output using the Elecon power curve data in conjunction with the distribution of hours at different wind speeds given directly by the meteorological data. The resulting two energy outputs were within 3% of each other. Although this only represents a single sanity check, we are confident that the wind model is reasonably accurate.

Future Energy Prices

The retail price of energy for non-peak rates procured by the Barrington School System will be 15 cents per kW-hour starting in January 2009. Over the past 11 years the rate of increase for this price has averaged 9%.

The rate for the town in general differs from the rate of the school system. We make the assumption that the entire load can be used to credit the school system.



Uncertainty in Future Energy Prices

FIGURE 6

The concept of standard deviation could very well be meaningless in the context of future energy rates, where black swan events and power law distributions appear to be the rule rather than the exception.

Federal No Interest Loan and Net Metering

Access to a zero-interest loan covering $2.1 million of the $2.4 million budget and the ability to sell electricity at retail as opposed to wholesale rates are critical to the financial feasibility. In the analysis the CREB is assumed to be a General Obligation Bond at zero interest with a 13 year maturity.

Non-recourse municipal loans can currently expect rates of approximately 6.5%. The current rate for the non-peak supply received by the High School is 12.4 cents per kWh, as opposed to the total non-peak rate market rate of 15 cents per kWh.

Uncertainties in Loan and Net Metering

The greatest uncertainty of the entire project is whether the town will choose to build, and if so, if it will reach this consensus before the no-interest loan expires in December 2009. In our opinion it is unlikely that the town will make a second attempt to procure zero interest financing for this project. The major risk is opportunity cost.

If net metering laws are changed it is possible the turbine would need to sell at wholesale as opposed to retail prices. This would add approximately 3 cents per kW-hour to costs. We do not see this as a likely turn of events, especially during the next decade. If net metering is rescinded after a successful decade, the project's success will not be in jeopardy.

If the virtual net metering legislation requires that the pumping station receive first priority, then approximately 200,000 kWh annually would be used to offset the pumping station. If the town electricity for the pumping station costs 3 cents less than the electricity for the schools, the profits would lower by approximately $6000 a year.

Lifespan of Turbine

Modern turbines are generally assigned a lifespan of 20 years.. Many of the turbines constructed in the early 80s – at a time when the industry learning curve was very high – are still operational today. The primary reason lifespan is set at 20 years is because the expectation is that technology will have improved enough in that timeframe to make it appropriate to replace the turbine with something newer.

One reason for building the Barrington turbine is to increase local and State acceptance of wind power. This motivation will be absent when choosing to replace one turbine with another. This increases the chance that a turbine, if built, will be left standing for longer than 20 years

Uncertainties in Lifespan of Turbine

As mentioned before, the uncertainties in the lifespan of the turbine are primarily under the control of the town: when does it become appropriate to replace the turbine with a newer version? There are also issues with repair. These issues are offset by insurance, a maintenance contract, warranties, and a repair budget.

Analysis of Secondary Variables

Renewable Energy Credits

Energy produced by wind turbines, like other sources of renewable energy, creates Renewable Energy Credits (RECs) which can be used for compliance with the Rhode Island Renewable Energy Standard. The primary customers for these RECs, therefore, are large electricity suppliers such as Constellation Energy and National Grid. Other potential buyers include People's Power & Light and Community Energy. The energy produced can also be used for RECs in certain other local States, depending on State legislation. Based on recent experience at other sites, we expect 3.5 cents per kW-hour decreasing to 0 over the next 10 years.

The demand for future RECs is highly dependent on legislation, and the supply is highly dependent on the success of local renewable energy. Indeed, it is our hope for the future of the planet that the REC market becomes saturated and the price drops to zero.

Uncertainty in RECs

The REC market is uncertain and this creates uncertainty in this variable.
For our model we assume 3.5 cents per kWh decreasing to 0 after the first ten years. We expect the margin of error to be approximately one cent.

Inflation rate and Discount Rate

We assume a rate of inflation of 3%. A higher rate of inflation will likely give better returns, and a lower rate will likely give worse returns – essentially because the debt decreases with inflation. The only cost that increases with inflation is operation & maintenance. The cost of electricity in present dollars therefore decreases with time, and the decrease is greater with greater inflation.

The discount rate is used to determine net present value and equivalent flat cost per kWh. This rate, which we assume is 4%, is the extent to which a dollar today is more valuable to the town than a dollar next year. A higher discount rate gives worse returns, essentially because it suggests the town could make a better investment with its money. It is of course relevant to note that the zero-interest loan is not available for arbitrary investment.

Operations and Maintenance

We estimate an insurance rider of approximately $6,500 to cover town liability increasing at 3% and a warranty/maintenance contract starting at $16,000 and increasing at 7%. In addition, we estimate $2000 annually for repairs not covered under warranty. Our total cost, therefore, is approximately $25,000 increasing at 7% annually.

Our estimate is based on the experience at Hull, where they have maintained their turbines under warranty.

In comparison, for a 600 kW project for installation at Portsmouth middle school Advanced Technology Management (ATM) predicted an operations and maintenance cost of $43,200 annually, increasing at the rate of inflation. This cost includes $20,000 for an operations & maintenance contract, $5,000 for a local administration allowance, $11,000 for insurance and an additional $7,200 set aside for contingencies.

Uncertainty in Operations and Maintenance

Warranties generally need to be renegotiated every 3-5 years.

Construction Costs

Construction costs are estimated to be $2,300,000. Details are included in the section on construction.

Uncertainty in Construction Costs

Uncertainty in construction costs are estimated at $100,000 in contingencies. Details are included in the section on construction.

We should note that if the decision to move ahead is not made prior to 2009, the construction costs may be substantially different (for example, Elecon is increasing the price of its turbines).

Other Credits

We assume $0 in other credits.

National Grid offers capacity credits for producers who supply electricity during peak demand. Production must be at 100 kW during peak demand in order to qualify, and there are administrative costs in setting up the credit that lessen the attractiveness for minimal return situations. At present it is unlikely to be profitable to apply for capacity credits for the turbine (note in particular that peak demand is often in the summer, when the wind tends to be lower). It is possible the turbine could be aggregated with other town sources in the future – for example, a consortium of electric vehicles along with the turbine – and qualify for capacity credits. Contribution from the turbine would likely be relatively minimal – on the order of $6,000 annually. The turbine also offsets New England health costs at approximately $6000 a year. There is a single, centrally-dispatched wholesale electricity market in New England. The entity operating this market, ISO New England, is mandated to efficiently dispatch generated electricity to meet electricity demand, subject to grid capabilities. Therefore, electricity generated by a Barrington turbine would offset electricity production at some mix of power plants in New England. The Barrington turbine would offset approximately 500 tons of CO2, 1000 pounds of NOx and 900 pounds of SOx. SOURCE One can compare this with the health cost analysis of the Army Corps of Engineers for Cape Wind to estimate offset health costs. SOURCE This benefit is externalized, and not likely to present direct economical benefit to the town.

Wind Resource Validation

Evolving Protocols and Best Practices, < 1 MW Case

Placement of a wind power facility is an engineering problem: there are constraints that need to be met in order to obtain a feasible solution. Decisions must be made without perfect information, and obtaining additional information must be considered in light of a) accuracy added and b) the costs both in terms of dollars and time. As the wind industry evolves, technologies improve, new technologies appear, and costs lower. As a result, best practices for solving the constraint problem evolve as well, for both large and small facilities.

For $25 million pro jects (and larger) with no fixed timeframe for financing, a suite of current technologies can be used – multiple met towers, SODAR, and micro-siting statistical models – for costs running between $50,000 and $100,000. The issue for larger pro jects again comes down to time and money. However, the specific questions for larger proejcts comes down to how many met towers for how many years, and how much SODAR.

For a community wind project less than 1 MW in size, placement of even a single met tower comes with substantial risks – both in the form of time taken and money spent. We argue that the risks outweigh the rewards.

Site Specific Data

AWS TrueWind Mesomap

Wind data from AWS Truewind's Mesomap technology has been independently validated with data from over 1000 stations worldwide with an established accuracy range of 5-7% in mean speed at hub height – and less than 5% in geographically simple locations.

[The error from the mesomap system] is comparable to the error margin associated with one year of measurements from a 50-meter mast. SOURCE

The statistical atmospheric models used by mesomap are essentially computational fluid dynamic models that have been configured to efficiently and accurately simulate atmospheric processes, based on empirical quantitative relationships between atmospheric and non-atmospheric (such as topographic) variables. The model produces reliable results without surface wind measurements, instead relying on numerical calculations based on a mesoscale weather model (Mesoscale Atmospheric Simulation System, or MASS) and a microscale wind flow model. The key metereological inputs to MASS are reanalysis and rawinsonde data; using these data as a starting point MASS simulates the evolution of the atmosphere for 366 different days, sampled from a 15-year historical period. The microscale windflow model then sharpens the resolution to 200 meters or finer, taking into account localized effects of large-scale terrain and surface roughness.

The leading error is grid resolution and local variations in vegetation and topography.

It is of note that mesomap technology is also useful after turbines are built, because it can be used to forecast future conditions. Forecasting wind power is critical for optimizing the operation of the grid, and high quality forecasting can improve the optimized economic performance of large wind farms by close to 50%. SOURCE

AWS Truewind SiteWind (VMM)

This micrositing model refines the mesomap model by using on-site measurements of the terrain. It also uses a higher resolution in both the mesoscale weather model and the microscale wind flow model. SiteWind technology is too computationally intensive to produce a worldwide atlas: 3 weeks are required to calculate the data for a particular location.

Sitewind technology will produce lower error than one year of measurements from a 50-meter mast. The cost is approximately $6000.

Meteorological Towers

Placement of a 40 or 50 meter meteorological tower to collect data for one or more years was the standard wind resource validation technique in the 1980’s, the 1990’s and most of the last decade. It continues to be the standard in many cases for procuring financing.

The root mean square error in predicting average wind speed for a turbine is approximately 7%. The primary reason for this error is that a single year is too short to cover wind variation – it is not unusual for annual average wind speeds to vary by as much as 10%. See Figure 7.

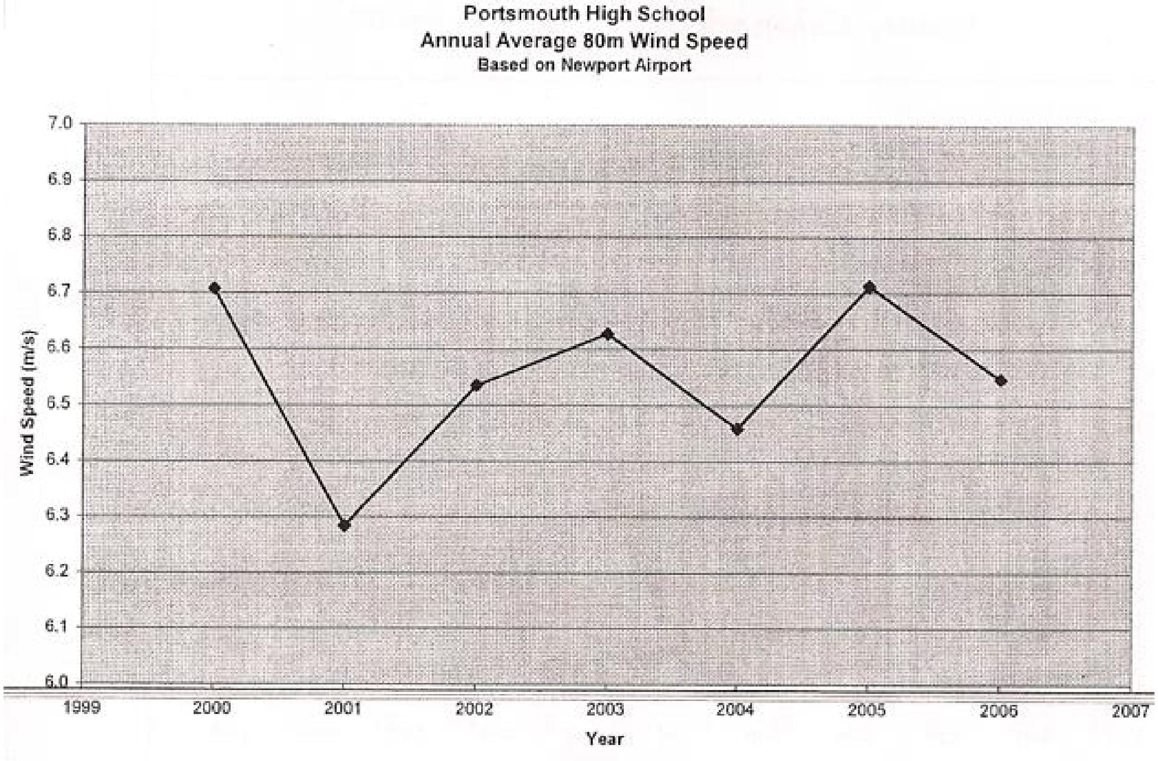


FIGURE 7

SODAR Measurements

SOnar Detection And Ranging, or SODAR, provides a complete vertical profile of horizontal wind speeds to a height of 200 meters with 10 meter vertical resolution. It works by emitting chirps at a frequency of 4500 Hz and then measuring the doppler shift in the echo. Windfarms often use SODAR for periods of 2-3 weeks in order to obtain highly accurate snaphots. These snapshots can be used in tandem with met towers and sitewind/mesomap models.

SODAR costs approximately $20,000 for a 2-3 week test. The testing can be very annoying to neighbors. Although we think it is appropriate technology for larger projects, we do not think it is appropriate for projects less than 1 MW, especially in urban-sited areas

Stakeholder Requirements for Wind Verification

The people with a stake in the pro ject include the entity providing the loan, the project developers, any pro ject owners, pro ject neighbors, the power suppliers, and the grid regulators. Banks often require installation of a meteorological tower prior to a loan, even for pro jects less than 1 MW in size. It is our opinion that standard practice should shift to requiring a SiteWind Virtual Met mast in order to procure a loan, given that the resulting accuracy is higher and the cost in terms of time and money is substantially lower. There is some evidence that this shift is underway:

> *Site-specific measurements using anemometers are considered by some to be the most reliable estimates of the wind resources for a project. However, they can be quite costly and require from one to several years to complete. Other methods also exist where large scale computer weather models are created to extrapolate wind conditions at a specific site from historical data. Many times these computer models of a sites wind resource can be less expensive than taking meteorological readings for a year or more.* **As scientists and lending institutions are beginning to understand weather modeling and the wind industry better this method of resource assessment is becoming more accepted by lenders**, *but sometimes they may require a combination of site specific meteorological measurements coupled with computer models from long-term weather data for validation of conditions at the site.* – windustry.org

National Grid, or other power suppliers required to buy the electricity, need to have a prediction of seasonal power production. They will generally not rely on a year of met data but rather require Sitewind technology in order to provide a reasonably accurate seasonal forecast.

If a community wishes to own a fraction of a windfarm in partnership with a developer, the developer will again generally not rely on meteorological data supplied by the community. Instead, they will verify the wind resources on their own or with the assistance of a third party (again, like AWS Truewind). It is of note that several of the bids in response to the Barrington RFP offered a developer/owner arrangement, although this was not mentioned in the RFP; this is essentially a vote of confidence in the wind resources at the proposed site. Finally, the town – both the council and the residents – want verification that the project is low risk. There is concern in Barrington over moving away from the protocol of a met tower. We hope that this report helps alleviate that concern. We also hope that the argument made here becomes widely endorsed by a variety of stakeholders involved in projects of this size.

Evolving Protocols and Best Practices (continued)

We recommend that banks and other financing entities move towards a protocol of AWS Truewind's SiteWind-generated Virtual Met Mast and away from the protocol of one year of meteorological data, for the reasons outlined above.

For the Barrington Project, further wind resource verification is not needed in order for the project to classify as low-risk and high-return. Refining of the data through a virtual met mast would lead to greater certainty in the forecast but, with a high level of confidence, would not change the basic picture.

Using the Weibull Distributino to Predict Energy Production

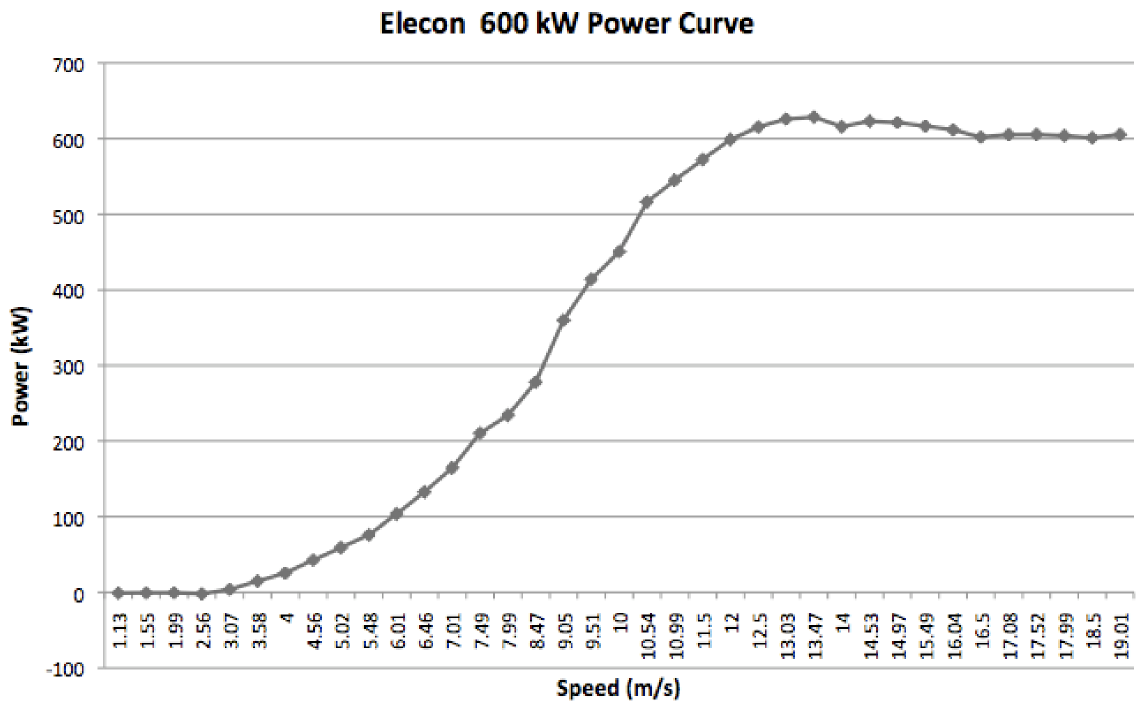
As described above, we use a Weibull distribution in order to to predict the distribution of wind speeds over a year. Weibull distributions fit wind speed distributions reasonably well, as long as the wind is not too extreme.

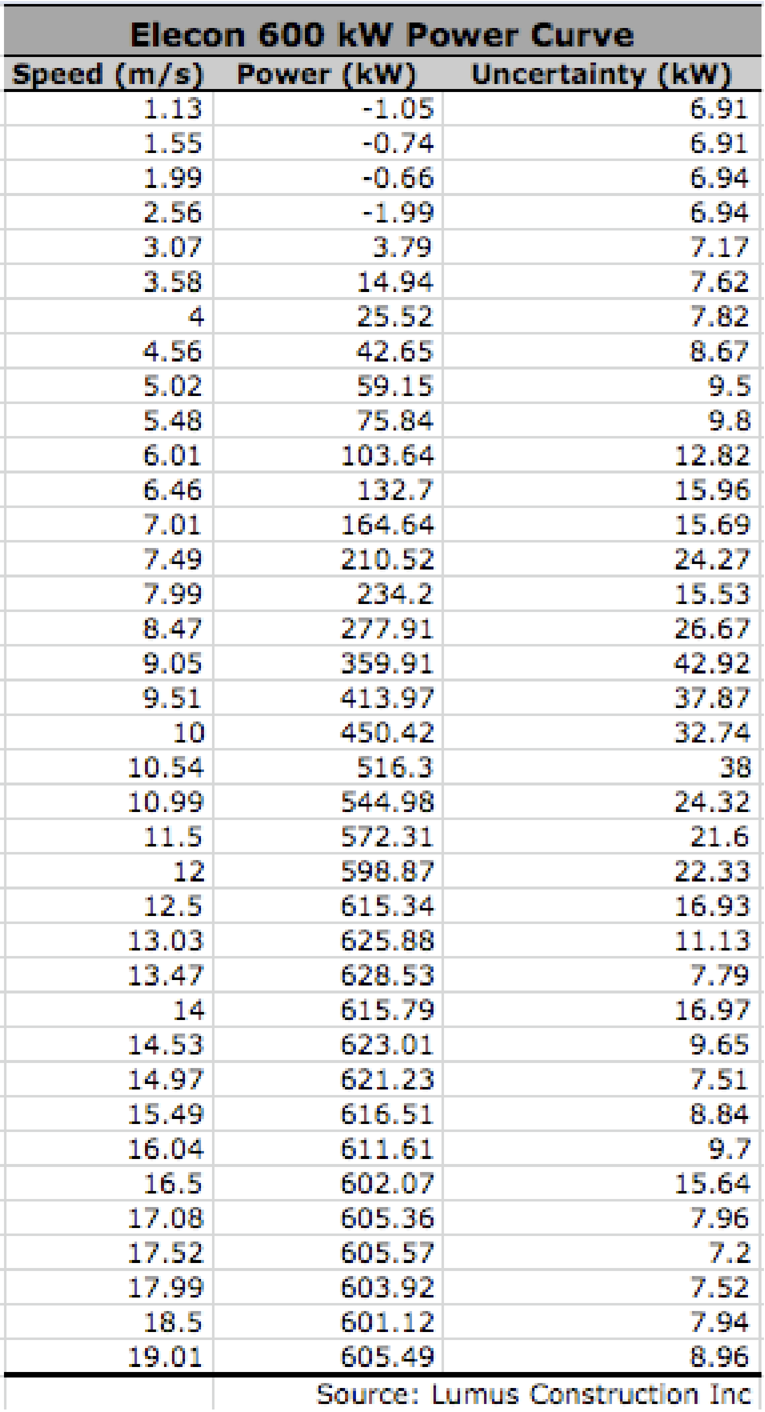
Power Curve of Wind Turbine

The energy efficiency of the Elecon/Turbowind turbine in 6 m/s winds is 26.8%: this is an excellent rating for this wind speed, and demonstrates that the turbine is appropriate for the location. Since efficiencies for 6 m/s are often closer to 18% to 22%, we felt it was highly important to obtain data backing up the power curve. Lumus provided us with this data: it is included as an appendix. See also Figures 8 and 9.

Other Projects

Portsmouth and Hull installed met towers for their first turbines. Neither Hull nor Portsmouth installed a met tower for their second turbine. We are looking for other data; specifically for examples of <1 MW projects that use the SiteWind VMM for wind resource validation.

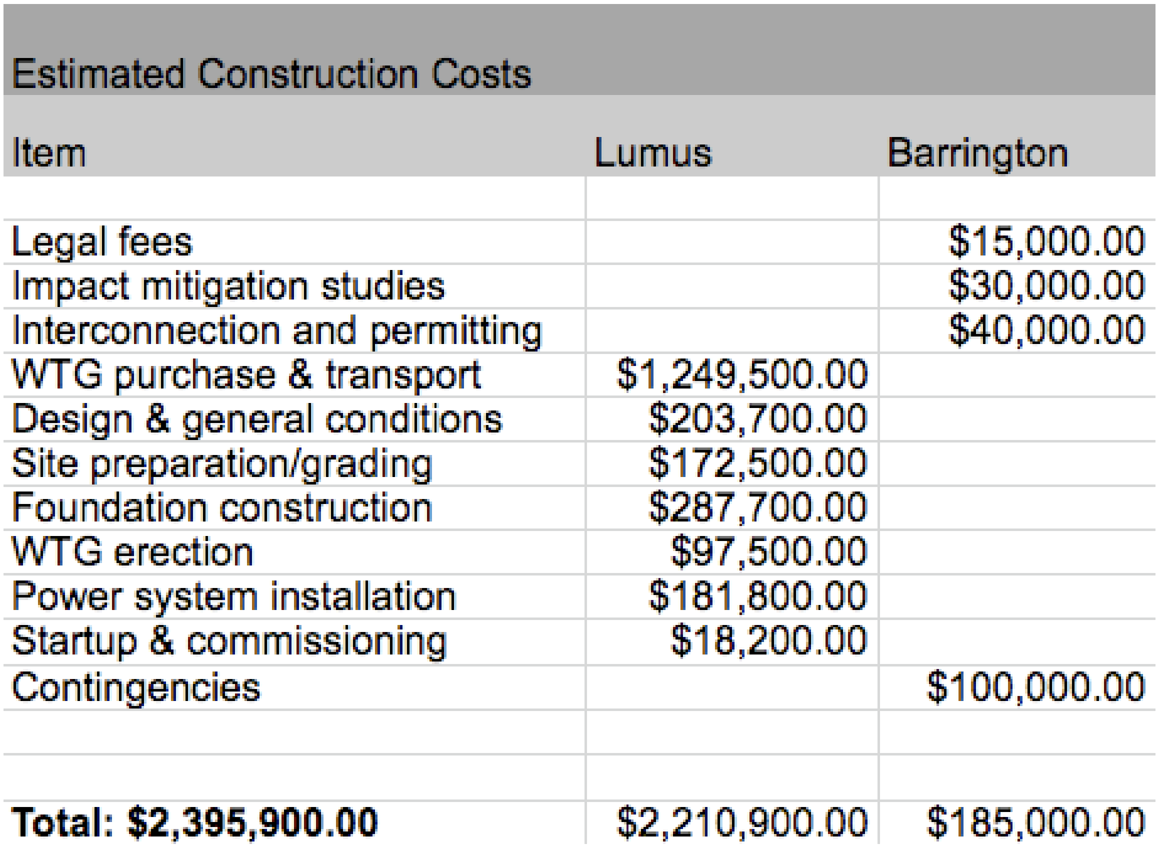

Elecon 600 kW Power Curve
Power (kW)
700
600
500
400
300
200
100
0
-100
1.13
1.55
1.99
2.56
3.07
3.58
4
4.56
5.02
5.48
6.01
6.46
7.01
7.49
7.99
8.47
9.05
9.51
10
10.54
10.99
11.5
12
12.5
13.03
13.47
14
14.53
14.97
15.49
16.04
16.5
17.08
17.52
17.99
18.5
19.01
Speed (m/s)



Elecon 600 kW Power Curve

Speed (m/s)	Power (kW)	Uncertainty (kW)
1.13	-1.05	6.91
1.55	-0.74	6.91
1.99	-0.66	6.94
2.56	-1.99	6.94
3.07	3.79	7.17
3.58	14.94	7.62
4	25.52	7.82
4.56	42.65	8.67
5.02	59.15	9.5
5.48	75.84	9.8
6.01	103.64	12.82
6.46	132.7	15.96
7.01	164.64	15.69
7.49	210.52	24.27
7.99	234.2	15.53
8.47	277.91	26.67
9.05	359.91	42.92
9.51	413.97	37.87
10	450.42	32.74
10.54	516.3	38
10.99	544.98	24.32
11.5	572.31	21.6
12	598.87	22.33
12.5	615.34	16.93
13.03	625.88	11.13
13.47	628.53	7.79
14	615.79	16.97
14.53	623.01	9.65
14.97	621.23	7.51
15.49	616.51	8.84
16.04	611.61	9.7
16.5	602.07	15.64
17.08	605.36	7.96
17.52	605.57	7.2
17.99	603.92	7.52
18.5	601.12	7.94
19.01	605.49	8.96

Source: Lumus Construction Inc



Estimated Construction Costs

Item	Lumus	Barrington
Legal fees		$15,000.00
Impact mitigation studies		$30,000.00
Interconnection and permitting		$40,000.00
WTG purchase & transport	$1,249,500.00	
Design & general conditions	$203,700.00	
Site preparation/grading	$172,500.00	
Foundation construction	$287,700.00	
WTG erection	$97,500.00	
Power system installation	$181,800.00	
Startup & commissioning	$18,200.00	
Contingencies		$100,000.00
Total: $2,395,900.00	$2,210,900.00	$185,000.00

Construction Costs

Estimated costs for construction are included in Figure 9. Lumus has verbally agreed to a fixed price for the construction costs for which it is responsible. The biggest unknown factor in the construction is what will be required for foundation work. Assuming the town chooses to go ahead with construction, the town could then take the legal steps necessary to make this a binding agreement, prior to construction.

With Lumus taking responsibility for variations in foundation costs, the biggest unknown factor in the construction becomes contingencies on the side of the town. The most likely contingencies will be various mitigations for environmental issues and delays in construction.

Lumus Construction Inc

Lumus Construction Inc is a construction company with 10 years of experience and over 400 completed contracts. They have received various awards for excellence, including a US Government ”Prime Contractor of the Year” in 2003 and several of the SBA’s ”Award of Excellence.” Lumus has been involved with wind pro jects for the last 4 years. SOURCE

Additional Wind Resource Studies

The committee estimates $0 for additional wind resource studies.

If the town council wishes to pursue additional site specific wind resource studies, the recommendation of the committee is to use the AWS Truewind virtual met mast. The cost for this service is approximately $6,000 and the time required is 3 weeks. Assuming the town chooses to move ahead, these studies would be required by National Grid in order to assess likely seasonal variations; therefore they are included below under interconnection studies.

A met tower will cost between $3000 and $20,000 depending on availability of a tower, on a loan and/or the availability of external funding, and would require at least one year for data collection. We do not recommend a met tower for the current project, for the reasons explained in the wind resources section above. At the same time we recognize that the town council may choose to pursue this option. If so, adjustments to the pricing would need to be made.

Bonding and Legal Fees

The committee estimates $15,000 for legal fees.

The cost associated with the creation of the municipal bond will be approximately $10,000. For reference, the letter of credit used for the Portsmouth Abbey turbine cost about $5,400. Another potential legal fee is the cost for drawing up a legal document with Lumus; we allocate $5000 for the creation of this contract.

Impact Mitigation Studies

The committee estimates $30,000 for impact mitigation studies.

Impact mitigation studies refer to a subset of noise, flicker, visual, and environmental studies undertaken during the permitting and foundation building phase of the construction, often by a third party expert. These studies can help identify problems and allow for the development of mitigating strategies. Costs for these services at other local urban-sited turbines have varied from approximately $6,000 to approximately $40,000. Some of these studies, most importantly a sound study, can be done prior to committing to the project; in this case the study becomes a feasibility instead of a mitigation study.

Interconnection and Permitting Fees

The committee estimates $40,000 for permitting and interconnection fees.

The primary permitting fees are those associated with interconnection. We expect these fees to range between $20,000 and $40,000, based on experiences at other sites. For example, interconnection costs for Portsmouth Abbey included $17,000 for AWS Truewind site specific data for the interconnection plan and $14,000 for National Grid's interconnection study. The CREB plans to pay close attention to the experience both at Portsmouth High School and at Mark Richey Woodworking in order to learn how best to work with National Grid and facilitate a smooth interconnection. Additional permitting processes include FAA and RI DEM permitting. Compared to interconnection fees, these costs are negligible.

Elecon Turbowind 600 kW Turbine Purchase and Transport

Lumus pricing for Elecon Turbowind 600 kW turbine and the 65 meter Vestas model tower is $1,249,500. This includes the manufacturer's commissioning costs, customs and transportation to the project site.

Engineering Design and General Conditions

Lumus pricing for engineering design and general conditions is $203,700. This item includes finalization of the electrical, civil, and structural drawings and associated site general conditions for management of the project.

Foundations and Sitework

Lumus pricing for foundations is $287,700, and their pricing for site preparation and grading is $172,500; the total for foundation and sitework is therefore $460,200. Sitework includes erosion control, excavation and backfill for the foundation, excavation for the electrical duct bank or pole line, construction of the crane pad, and a small gravel access road to the turbine. In terms of delivering the turbine and the crane, and all other equipment, the golf course provides sufficient room for maneuvering the turn off of Middle Highway onto Veteran's Way – this is the tightest turn. Legion Way has more than sufficient area for setting up the crane, assembling the blades and erecting the tower.

The Legion Way site is possibly on top of old landfill, and this presents an engineering challenge:

> *The fundemental problem with installing a wind turbine on a landfill is that the waste pile itself does not provide a very good support for the turbine's foundation. (Hull 2003).*

(Note that Hull II was successfully installed on top of a closed landfill.)

Although certain extenuating circumstances are not covered – toxic waste, environmental abatement, and burial grounds – Lumus has extensive history in foundation construction and fully intends to solve any standard foundation challenge and to work closely with stakeholders such as RI DEM.

Grading and foundation cost Portsmouth Abbey approximately $140,000. ATM estimates for Site surveys and preparation were $190,000 for the Portsmouth High School. Note that Lumus has set aside more than twice the amount used by Portsmouth Abbey and estimated for use at Portsmouth High School. We do not know how much Hull II foundations cost; we expect it cost more because of its landfill siting

Turbine Erection

Lumus pricing for turbine erection is $97,500. This includes crane rental.

Power System Installation

Lumus pricing for the installation of the power system is $181,800. This cov-ers all electrical equipment, including transformers, meters and switchgear, underground wiring to the building, conduit and wiring within the building, FAA lighting and SCADA connections. The metering equipment would need to be replaced with bi-directional equipment in order to create a primary metering arrangement. This could require the installation of two transformers, three current transformers, and a telephone line. Additionally, underground cable will need to be laid to complete the circuit. A three phase generator step-up transformer is needed to convert the voltage generated by the turbine to the 13.8 kV supply circuit existing at the Legion Way sewage center. Based on other local turbine projects, it is likely that National Grid will require the multifunction protective relay to be utility grade (a higher grade than industrial grade) whereas the multifunction relays included with some WTGs are industrial grade. Utility grade relays comply with IEEE C37.90 and C39.90.1. Examples of acceptable relays are the Basler Electric Company BE1-GPS100 and the Schweitzer Engineering Lab SEL-547. Cost estimates for electrical work at Portsmouth Middle School (600 kW turbine proposed) were $150,000. These included permitting and feasibility studies. Actual costs for the 600 kW Portsmouth Abbey Turbine were $137,000.

Startup and Commissioning

Lumus pricing for startup and commissioning is $18,200. This includes costs for startup, commissioning and testing of the system. Elecon also provides factory representation during startup; this is covered in the turbine cost.

Contingencies

Lumus is expected to be responsible for its own contingencies. Primary contingencies that could be experience by the town include environmental/noise mitigation. Another contingency is delay in construction. We allocate $100,000 for these contingencies.